Benefit-Cost Analysis Sustainment and Enhancements

Draft Standard Economic Value Methodology Report

Version 11.0

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Purpose: The information and analysis contained in this report is intended for use when conducting an economic analysis for FEMA's grant programs. Any application outside of this intended purpose is not endorsed by FEMA.

Revision History

Version	*Date*	*Revisions/Updates*
4.0	May 2011	Consolidated individual papers prepared in 2008 for FEMA's Benefit Cost Analysis Re-engineering effort into one report (economic values were not updated)
5.0	August 2011	Updated value of lost time to reflect changes to average hourly wage for 2011 Updated values for the electric, wastewater, and water service to account for Gross Domestic Product (GDP) temporal changes for 2011
6.0	December 2011	Updated value of statistical life and the related injury values to inflate the results to current (2011) dollars
7.0	August 2013	Updated value of lost time to reflect changes to average hourly wage for 2013 Updated values for the electric, wastewater, and water service to account for GDP temporal changes for 2013 Changed the residential displacement costs methodology from a square footage basis to General Services Administration (GSA) lodging and meals per diem rates Added National Flood Insurance Program (NFIP) and Increased Cost of Compliance (ICC) claim payments avoided as a new benefit
8.0	July 2016	Updated value of lost time to reflect changes to average hourly wage for 2016 Updated values for the electric, wastewater, and water service to account for GDP temporal changes for 2016 Updated value of statistical life and the related injury values to inflate the results to current (2016) dollars Updated fire and response statistics used for the loss of fire station calculation to use the most recent available data (as of 2014) Updated crime statistics used for the loss of police station calculation to use the most recent available data (as of 2014) Updated the non-residential displacement values for rental and disruption costs to reflect updated HAZUS data
9.0	June 2020	Updated value of lost time to reflect changes to an average hourly wage for 2019 Updated values for the electric, wastewater, and water service to account for GDP temporal changes for 2019 Updated value of statistical life and the related injury values to inflate the results to current (2019) dollars

Version	*Date*	*Revisions/Updates*
9.1	August 2021	Minor changes to correct errors in examples for loss of emergency medical services and loss of hospital services
10.0	September 2021	Updated the value of statistical life and updated injury weightings by using different methodologies
11.0	September 2022	Updated Value of Lost Time and Traffic Delays for Roads and Bridges to reflect changes to average hourly wage as of December 2021 Updated values for the electric, wastewater, and water service to account for GDP temporal changes as of December 2021 Added Communications and Information Technology to the list of utilities that have standard economic values Updated values for Cost of Food at Home and NFIP Federal Policy Fee

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1. Introduction

This document describes the methodologies for developing the standard economic values used in the Federal Emergency Management Agency (FEMA) Benefit-Cost Analysis (BCA) Toolkit Version 6.0 and later. This document is intended to describe how the standard default values were developed and is not intended as guidance for using the values in the BCA Toolkit. Guidance on how to use the values in the software can be found in the BCA Toolkit Help Content, BCA training course, or by contacting or emailing the FEMA BC Helpline at BCHelpline@fema.dhs.gov. This report consolidates the individual papers originally prepared in 2008 to document the economic values and updates values that are used in the BCA Tool Version 6.0. To stay current with economic conditions, values in this report are updated on a periodic basis.

Table 1 shows the standard economic values that have been updated in this September, 2022 version of the methodology report. More detailed information about the updated values is provided in the relevant portions of Section 2 of this report.

Table 1: Updated Standard Values

Standard Economic Value	*Former Value*	*Updated Value*
Value of Lost Time	$34.72	$38.07
Traffic Delays for Roads and Bridges	$32.18	$35.60
Loss of Electric Services	$174	$182
Loss of Wastewater Services	$58	$60
Loss of Potable Water Services	$114	$116
Loss of Communications/IT Services	—	$130
Cost of Food at Home	$7/person/day	$9/person/day
NFIP Federal Policy Fee	$50/year	$47/year

2. Economic Values

2.1. Value of Lost Time

Assessing the value of lost time is straightforward and consistent with economic theory applied in a variety of fields, including recreational and transportation economics. Lost time can be incurred by individuals who must take pre-disaster preventative measures, evacuate their homes or business, clean up or repair damage, manage insurance claims, experience increased travel time due to bridge or road closures, and deal with other disaster-related matters. The economic concept is that personal time has value, regardless of formal employment compensation. Therefore, it can be argued that one hour of work is equal to one hour of leisure time because the "opportunity cost"[1] of a leisure hour is equal to the wage earned for an hour of work time.

Table 2 shows how the Value of Lost Time economic value has changed over time.

Table 2: Value of Lost Time Changes

Year Updated	*Value*[a]	*Source*[b]
2001	$21.16	US Department of Labor, Bureau of Labor Statistics, 2000
2007	$27.31	US Department of Labor, Bureau of Labor Statistics, 2006
2009	$28.11	US Department of Labor, Bureau of Labor Statistics, 2008
2011	$30.07	US Department of Labor, Bureau of Labor Statistics, 2011 (March)
2016	$33.94	US Department of Labor, Bureau of Labor Statistics, 2016 (March)
2020	$34.72	US Department of Labor, Bureau of Labor Statistics, 2019 (December)
2022	$38.07	US Department of Labor, Bureau of Labor Statistics, 2021 (December)

[a] This value is the "Total employer compensation costs for private industry."
[b] The month and year indicates the specific quarterly data release from the Bureau of Labor Statistics at http://www.bls.gov/news.release/pdf/ecec.pdf. This date may be different than the "Year Updated" value because of the time lag that is inherent in government-provided economic statistics.

[1] An opportunity cost is the cost of an alternative that must be foregone in order to pursue a certain action. In other words, it is the benefits received by taking an alternative action.

The 2022 hourly rate of $38.07 (BLS, 2022a) should be used to measure the value of hours spent by individuals on disaster-related activities (i.e., pre-disaster preventative measures, evacuation, clean up or repair of damage, managing insurance claims) that are not accounted for in a separate part of the BCA modules.

2.2. Traffic Delays for Roads and Bridges

This section presents the methodology used in the BCA Toolkit to estimate the value of delays due to road and bridge closures. The methodology builds on estimates for the value of lost time (described above) and is consistent with the methodology applied by the U.S. Department of Transportation (DOT) in calculating the benefits of reducing travel time.

The DOT distinguishes between business or commercial travel time and personal and recreational time. While commercial travel time is reimbursed at 100 percent of the wage rate, the DOT values personal travel time (including commute time) at 50 percent of the wage rate (FHWA, 2007). Travel time in recreational economics is generally valued at one-third of the wage rate, though some studies use 50 percent of the wage rate, similar to DOT (Champ et al., 2003). The full wage rate is not typically used to measure personal travel or recreation travel because it is assumed that individuals benefit from the travel (e.g., a scenic drive), or they are willing to accept the travel time in order to gain something (e.g., a higher paying job).

FEMA determined that requiring BCA Toolkit users to distinguish business/commercial travel delay time from personal/recreational travel delay time would place an unnecessary burden on the user. Additionally, because the value of travel delay is based on a per-person wage rate basis and not a per-vehicle basis, users would have to identify the number of people in each affected vehicle. To simplify this benefit calculation, the BCA Toolkit uses an average vehicle occupancy to capture time costs caused by delays due to road and bridge closures. This average should be applied to all vehicles, regardless of the vehicle type, purpose of the trip, and number of persons in each vehicle.

According to the Bureau of Transportation Statistics[2] (DOT, 2020), 88 percent of all miles traveled on the Nation's roadways were from personal passenger vehicles, with the remaining 12 percent being commercial vehicles. The 2017 National Household Travel Survey (FHWA, 2017) determined that the average number of persons per vehicle was 1.67. This average vehicle occupancy value was unchanged from the previous National Household Travel Survey from 2009 (FHWA, 2009). Employing the national average hourly wage of $38.07 (BLS, 2022a), average number of persons per vehicle of 1.67 and DOT's methodology for per-hour value of time, the equation below was used to determine the hourly value of time per vehicle:

[2] Passenger vehicles defined as the "Light duty" vehicle rows, divided into the "Highway, Total" value for 2020.

$$\left[\left(\%personal_{passenger} * (wage_{rate} * 0.5)\right) + (\%commercial * \ wage_{rate})\right] * persons_{per_{vehicle}} \quad (1)$$

$$= \left[\left(0.88 * (\$38.07 * \ 0.5)\right) + (0.12 * \$38.07)\right] * 1.67 = \$35.60$$

Therefore, a value of $35.60 is applied per vehicle per hour to account for the lost time cost of road and bridge closures or delays as a result of a disaster.

2.3. Displacement Time and Cost

2.3.1. Residential

LODGING

Prior to BCA Toolkit Version 5, the methodology for residential displacement cost was a standard value of $1.44 per square foot per month (sf/mo). The methodology was changed for BCA Toolkit Version 5 because the displacement cost value was difficult for subapplicants to understand, especially if they were seeking to determine if the $1.44/sf/mo value was reasonable for their community. Additionally, there was uncertainty whether the $1.44/sf/mo value was a true reflection of reality given the increasing displacement costs, especially for very long-term displacements involving FEMA-supplied trailers.

The new methodology for residential displacement costs involves the lodging per diem rates published by the U.S. General Service Administration (GSA). The lodging per diem rates are a more reasonable reflection of the variable lodging costs than a national average based on a residence's square footage. The GSA publishes and updates lodging per diem rates for locations in the continental United States (CONUS). These rates are available by entering the city/state or zip code here: https://www.gsa.gov/travel/plan-book/per-diem-rates (GSA, 2022). For areas that are not studied in detail, the GSA applies a Standard Rate, which is updated annually. For FY2023, the Standard Rate is $98 per room per day. Locations outside of the CONUS (OCONUS) including Alaska, Hawaii, and US territories and possessions have values determined by the US Department of Defense here: http://www.defensetravel.dod.mil/site/perdiemCalc.cfm (DOD, 2022).

For locations that have lodging per diem with a seasonal variation, the lodging per diem is auto-calculated as the average value for all 12 months. It is assumed that an entire family will fit into one hotel room. In the case of large families being displaced, the subapplicant should provide documentation for a reasonable number of hotel rooms and multiply the daily lodging per diem value by the number of occupied rooms.

Lodging taxes may also be included in the lodging rate since it is a cost paid by displaced residents. Depending on the location, lodging taxes may be collected by the State, multi-county, county, city, or sub-city levels of government, and some locations may also charge a sales tax.

MEALS AND INCIDENTAL EXPENDITURES

When displaced, food is more expensive than when eating at home. Prior to BCA Toolkit Version 5, this increased cost for basic provisions was not considered in the displacement value. The GSA per diem rate for meals and incidental expenditures (M&IE) will be used for each person displaced in the residence. Like the lodging per diem, the GSA determines a Standard Rate for the M&IE per diem, which is subject to change annually. For FY2023, the standard rate is $59 per person per day. For the meals portion, the per diem rate is a combination of expected maximum values for three separate meals per day. Incidental expenditures account for smaller out-of-pocket expenses such as tips and transportation to get food, but also for increased general expenses of living out of a hotel room such as a local calling charge, laundry, and related items.

To be a true reflection of the increased cost of food, the M&IE per diem rate should be reduced by an average cost for eating meals at home. The U.S. Department of Agriculture (USDA) publishes a monthly Cost of Food at Home value for children, men, and women of different ages and different levels of food plans. The USDA published a report for a thrifty meal plan (USDA, 2022[a]) and a combined report for low-cost, moderate-cost, and liberal meal plans (USDA, 2022b). Because there is a wide variation in average at-home food expenses among these categories, the methodology calls for taking an average value for the 60 values for the most recently published month at the time of the update research.

The first value for the Cost of Food at Home was $7.10 per person per day came from the average of the 60 values for the month of June 2013 and a value of $7.00 per person per day was used in the Tool. As of April 2016, the Cost of Food at Home was $7.38. As of February 2020, the Cost of Food at Home was $7.47 and as of March 2022, the value was $8.83. It is recommended that the cost of food at home be increased to $9.00 per person per day (i.e., $8.83 rounded to the nearest dollar).

2.3.2. Non-Residential

Displacement time is a category of damages that accounts for the duration for which people are forced to evacuate their business or other structure type. The source of the baseline estimates used in the BCA Toolkit for displacement time and cost is the Hazards U.S. (HAZUS) software (FEMA, n.d.), a risk assessment software for analyzing potential losses from disasters.

The displacement cost consists of a one-time disruption cost along with a recurring monthly rental cost for the duration of the displacement. The rental and disruption costs are calculated based on a building per square-foot/content inventory dataset compiled by nationally recognized cost-estimating software and Applied Technology Council (ATC) Reports 12 and 25. Table 3 shows both the standard one-time and the monthly per-square-foot values for each of the commercial and public structure classifications adopted by FEMA and used in the BCA Toolkit (FEMA, undated).

For example, the recovery time from when a structure is damaged by flooding until it can be reoccupied is a function of the physical restoration time, contractor availability, hazardous materials (hazmat) removal processes, inspections, and permits and approvals. HAZUS provides estimates of the flood-specific restoration times for structures of different occupancy classes based on depth of flooding. In the HAZUS model, flood depths shown in Table 4 are generally evaluated in increments of 4 feet to coincide with likely physical repair strategies.

The total displacement cost is estimated by adding the disruption cost and the rental costs. This can be expressed in the equation below:

$$Displacement\ Cost = (Disruption\ Cost\ x\ ft^2) + (Rental\ Cost\ x\ ft^2 x\ Displacement\ Time\ in\ Months) \quad (2)$$

The default displacement time in the BCA Toolkit is based on the combination of physical restoration time and recovery time estimates for structures affected by flooding.

Table 3: Rental Costs and Disruption Costs by Occupancy Class[1]

No.	*Label*	*Occupancy Class*	*Rental Cost ($/sq.ft./mo.)*	*Disruption Costs ($/sq.ft.)*
1	RES1	Single Family Dwelling (Residential)	0.68	0.82
2	RES2	Mobile Home (Residential)	0.48	0.82
3-8	RES3a-f	Multi Family Dwelling (Residential)	0.61	0.82
9	RES4	Temporary Lodging (Residential)	2.04	0.82
10	RES5	Institutional Dormitory (Residential)	0.41	0.82
11	RES1	Nursing Home (Residential)	0.75	0.82
12	COM1	Retail Trade (Commercial)	1.16	1.09
13	COM2	Wholesale Trade (Commercial)	0.48	0.95
14	COM3	Personal and Repair Services (Commercial)	1.36	0.95
15	COM4	Professional/Technical/Business (Commercial)	1.36	0.95
16	COM5	Banks (Commercial)	1.70	0.95
17	COM6	Hospital (Commercial)	1.36	1.36
18	COM7	Medical Office/Clinic (Commercial)	1.36	1.36
19	COM8	Entertainment and Recreation (Commercial)	1.70	N/A
20	COM9	Theaters (Commercial)	1.70	N/A
21	COM10	Parking (Commercial)	0.34	N/A
22	IND1	Heavy (Industrial)	0.20	N/A

No.	Label	Occupancy Class	Rental Cost ($/sq.ft./mo.)	Disruption Costs ($/sq.ft.)
23	IND2	Light (Industrial)	0.27	0.95
24	IND3	Food/Drugs/Chemicals (Industrial)	0.27	0.95
25	IND4	Metals/Mineral Processing (Industrial)	0.20	0.95
26	IND5	High Technology (Industrial)	0.34	0.95
27	IND6	Construction (Industrial)	0.14	0.95
28	AGR1	Agriculture (Agricultural building)	0.68	0.68
29	REL1	Church/Membership Organization (Religious)	1.02	0.95
30	GOV1	General Services (Government)	1.36	0.95
31	GOV2	Emergency Response (Government)	1.36	0.95
32	EDU1	Schools/Libraries (Education)	1.02	0.95
33	EDU2	College/Universities (Education)	1.36	0.95

[1] Source: Flood Model Hazus®-MH Technical Manual: https://www.fema.gov/media-library-data/20130726-1820-25045-8292/hzmh2_1_fl_tm.pdf (Table 14.10)

Table 4: Recovery Time by Occupancy Type and Flood Depth[1]

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Retail Trade	0’–4’	n/a[2]	7 to 13	1	2	3	0	13	19
Retail Trade	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Retail Trade	8’–12’	n/a	25	1	2	3	0	31	31
Retail Trade	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Retail Trade	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Wholesale Trade	0’–4’	n/a	7 to 13	1	2	3	0	13	19
Wholesale Trade	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Wholesale Trade	8’–12’	n/a	25	1	2	3	0	31	31
Wholesale Trade	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Wholesale Trade	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Personal and Repair Services	0’–4’	n/a	3 to 6	1	2	3	0	9	12
Personal and Repair Services	4’–8’	n/a	6 to 9	1	2	3	0	12	15

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Personal and Repair Services	8’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Personal and Repair Services	8’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Professional/ Technical/ Business Services	0’–4’	n/a	6 to 10	1	2	3	0	12	16
Professional/ Technical/ Business Services	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Professional/ Technical/ Business Services	8’–12’	n/a	19	1	2	3	0	25	25
Professional/ Technical/ Business Services	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Professional/ Technical/ Business Services	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Banks/Financial Institutions	0’–4’	n/a	6 to 10	1	2	3	0	12	16
Banks/Financial Institutions	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Banks/Financial Institutions	8’–12’	n/a	19	1	2	3	0	25	25
Banks/Financial Institutions	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Banks/Financial Institutions	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Hospital (With Basement)	(-8)’–(-4)’	n/a	6	1	2	3	0	12	12
Hospital (With Basement)	(-4)’– 0’	n/a	12	1	2	3	0	18	18
Hospital (With Basement)	0’–4’	n/a	18	1	2	3	0	24	24
Hospital (With Basement)	4’–8’	n/a	24	1	2	3	0	30	30
Medical Office/Clinic	0’–4’	n/a	6 to 10	1	2	3	0	12	16
Medical Office/Clinic	4’–8’	n/a	10 to 15	1	2	3	0	16	21

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Medical Office/Clinic	8’–12’	n/a	19	1	2	3	0	25	25
Medical Office/Clinic	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Medical Office/Clinic	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Entertainment and Recreation	0’–4’	n/a	7 to 13	1	2	3	0	13	19
Entertainment and Recreation	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Entertainment and Recreation	8’–12’	n/a	25	1	2	3	0	31	31
Entertainment and Recreation	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Entertainment and Recreation	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Theaters	0’–4’	n/a	7 to 13	1	2	3	0	13	19
Theaters	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Theaters	8’–12’	n/a	25	1	2	3	0	31	31
Theaters	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Theaters	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Parking	> 0’	n/a	0	1	0	0	0	1	1
Heavy Industrial	> 0’	n/a	1 to 3	1	2	0	1	5	7
Light Industrial	> 0’	n/a	1 to 2	1	2	0	0	4	5
Food/Drugs/ Chemicals	0’–4’	n/a	6 to 10	1	2	3	1	13	17
Food/Drugs/ Chemicals	4’–8’	n/a	10 to 15	1	2	3	1	17	22
Food/Drugs/ Chemicals	8’–12’	n/a	19	1	2	3	1	26	26
Food/Drugs/ Chemicals	12’ +	Outside 100-year Floodplain	12	1	2	3	1	19	19
Food/Drugs/ Chemicals	12’ +	Inside 100-year Floodplain	18	1	2	3	1	25	25
Metals/Minerals Processing	0’–4’	n/a	6 to 10	1	2	3	2	14	18
Metals/Minerals Processing	4’–8’	n/a	10 to 15	1	2	3	2	18	23
Metals/Minerals Processing	8’–12’	n/a	19	1	2	3	2	27	27

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Metals/Minerals Processing	12' +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Metals/Minerals Processing	12' +	Inside 100-year Floodplain	18	1	2	3	0	24	24
High Technology	0'–4'	n/a	7 to 13	1	2	3	2	15	21
High Technology	4'–8'	n/a	13 to 19	1	2	3	2	21	27
High Technology	8'–12'	n/a	25	1	2	3	2	33	33
High Technology	12' +	Outside 100-year Floodplain	12	1	2	3	2	20	20
High Technology	12' +	Inside 100-year Floodplain	18	1	2	3	2	26	26
Construction	> 0'	n/a	1 to 2	1	2	0	0	4	5
Agriculture	> 0'	n/a	1 to 2	1	2	0	2	6	7
Churches/ Membership Organizations	0'–4'	n/a	7 to 13	1	2	3	0	13	19
Churches/ Membership Organizations	4'–8'	n/a	10 to 15	1	2	3	0	16	21

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Churches/ Membership Organizations	8’–12’	n/a	25	1	2	3	0	31	31
Churches/ Membership Organizations	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Churches/ Membership Organizations	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
General Services	0’–4’	n/a	6 to 10	1	2	3	0	12	16
General Services	4’–8’	n/a	10 to 15	1	2	3	0	16	21
General Services	8’–12’	n/a	19	1	2	3	0	25	25
General Services	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
General Services	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Emergency Response	0’–4’	n/a	6 to 10	1	2	3	0	12	16
Emergency Response	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Emergency Response	8’–12’	n/a	19	1	2	3	0	25	25

Occupancy	*Flood Depth (feet)*	*Location*	*Physical Restoration Time (months)*	*Dry-out and Cleanup Add-on (months)*	*Inspection, Permits, Approvals Add-on (months)*	*Contractor Availability Add-on (months)*	*Hazmat Delay Add-on (months)*	*Recovery Time Min (months)*	*Recovery Time Max (months)*
Emergency Response	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Emergency Response	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Schools/Libraries	0’–4’	n/a	6 to 10	1	2	3	0	12	16
Schools/Libraries	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Schools/Libraries	8’–12’	n/a	19	1	2	3	0	25	25
Schools/Libraries	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Schools/Libraries	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24
Colleges/ Universities	0’–4’	n/a	6 to 10	1	2	3	0	12	16
Colleges/ Universities	4’–8’	n/a	10 to 15	1	2	3	0	16	21
Colleges/ Universities	8’–12’	n/a	19	1	2	3	0	25	25
Colleges/ Universities	12’ +	Outside 100-year Floodplain	12	1	2	3	0	18	18
Colleges/ Universities	12’ +	Inside 100-year Floodplain	18	1	2	3	0	24	24

[1] Source: Flood Model Hazus®-MH Technical Manual: https://www.fema.gov/sites/default/files/2020-09/fema_hazus_flood-model_technical-manual_2.1.pdf (Table 14.12)
[2] Location values with "n/a" denote the recovery time is dictated by flood depth and not whether the building is inside or outside of a 100-year floodplain.

2.4. Life Safety

Life safety is the value of lives saved and injuries prevented resulting from mitigation measures. A review of existing literature has found different values used by different government agencies and even multiple values used within one agency. The current Value of Statistical Life (VSL)[3] is from a DHS memo (Houser, 2021), which recommends using a VSL of $11.6 million with a base year of 2020. Future updates of the VSL should inflate the value of $11.6 million in 2020 dollars to a current-year dollar value and then round that value to the nearest one hundred thousand dollars. The official guideline for determining and using a reasonable VSL is found in Office of Management and Budget (OMB) Circular A-4. Last updated in 2003, Circular A-4 (The White House, 2003) documented the results of a literature search and recommended VSL values between $1 million and $10 million. The OMB further clarified that most federal agencies are using VSLs between $5 million and $9 million and that values outside of this range would be difficult to justify (OMB, 2010). The 2021 DHS memo (Houser, 2021) is an improvement on Circular A-4 because it presents the results of a more recent analysis that includes real income gains in addition to inflation over time. Historically, the VSL values and methodologies used in the calculations within FEMA's BCA Tool have changed as follows:

- From 2008 to 2012, Versions 4.5.5, and 4.8 of the BCA Toolkit used a VSL of $5.8 million provided by the Federal Aviation Administration (FAA).

- In 2012, the methodology was changed for Version 5 in order to create a standard methodology rather than using comparative literature review and to incorporate research completed on behalf of the Department of Homeland Security (Robinson, 2008). The Robinson report (2008) depends on the research of W. Kip Viscusi, which established a value of $4.7 million with 1997 as the base year. Periodic updates after 2012 for BCA Toolkit Versions 5.0 and 5.2 used this methodology and increased the VSL to $6.1 million and $6.6 million, respectively. When updated in 2016 for BCA Toolkit Version 5.3, the VSL was inflated to the full-year 2015 value of $6.9 million. When updated in 2020 for BCA Toolkit Version 6.0, the VSL was inflated using the CPI Inflation Calculator (BLS, 2022b) to December 2019, which resulted in a value of $7.5 million.

- The new methodology using the Houser memo (2021) was implemented in September 2021 in an update to BCA Toolkit Version 6.0.

Nonfatal injuries are far more common than fatalities. In principle, the resulting losses in quality of life, including both pain and suffering and reduced income, should be calculated for various injury levels that could be avoided because of a hazard mitigation project. Because detailed willingness-to-

[3] VSL is defined as the value of improvements in safety that result in a reduction by one in the expected number of fatalities (U.S. DOT).

pay estimates covering the entire range of potential disabilities are unobtainable, a standardized method is used to interpolate values of expected outcomes, scaled in proportion to the VSL.

Relative value coefficients for preventing injuries of varying severity and duration are based on the Abbreviated Injury Scale (AIS), which categorizes injuries into levels, ranging from AIS 1 (Minor) to AIS 5 (Critical), with AIS 6 being Unsurvivable. (For more information about the research conducted to determine these values, see reports by Miller, Brinkman, and Luchter [1989] or by Rice, et al [1989].) This valuation technique relied on a panel of experienced physicians to relate injuries in each AIS level to the loss of quality and quantity of life. A narrative description for the AIS classes is provided in Table 5.

Table 5: AIS Injury Level Categories[1]

AIS Code	*Injury Severity Level*	*Selected Injuries*
1	Minor	Superficial abrasion or laceration of skin; digit sprain; first-degree burn; head trauma with headache or dizziness (no other neurological signs).
2	Moderate	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.
3	Serious	Major nerve laceration; multiple rib fracture (but without flail chest); abdominal organ contusion; hand, foot, or arm crush/amputation.
4	Severe	Spleen rupture; leg crush; chest-wall perforation; cerebral concussion with other neurological signs (unconscious less than 24 hours).
5	Critical	Spinal cord injury (with cord transection); extensive second- or third- degree burns; cerebral concussion with severe neurological signs (unconscious more than 24 hours).
6	Unsurvivable	Injuries, which although not fatal within the first 30 days after an accident, ultimately result in death.

[1] Source: FAA, 2021

Federal agencies such as the FAA, DOT, and National Highway Traffic Safety Administration (NHTSA) calculate an economic value for avoiding different AIS scale injuries by using the relative value coefficients as a fraction of the VSL. By following this method, FEMA is able to establish an economic value for the various injury levels that could be avoided—and therefore counted as benefits—from a hazard mitigation project. These economic values are shown in Table 6. Values are rounded to the nearest thousand dollars. The Economic Value is calculated as the VSL, multiplied by the Fraction of VSL. The Fraction of VSL values used from 2008 to 2021 were taken from the FAA (FAA, 2007). In September 2021, they were updated to match the FAA (2021) and DOT (2021) fractional values. The BCA Toolkit uses the following values for the different hazard types.

Table 6: AIS Injury Severity Levels, Fraction of VSL, and Economic Values (2020 Dollars)

AIS Code	*Description of Injury*	*Fraction of VSL*[1]	*Economic Value*
AIS 1	Minor	0.003	$ 35,000
AIS 2	Moderate	0.047	$ 545,000
AIS 3	Serious	0.105	$ 1,218,000
AIS 4	Severe	0.266	$ 3,086,000
AIS 5	Critical	0.593	$ 6,879,000
AIS 6	Unsurvivable	1.000	$ 11,600,000

[1] Sources: FAA, 2021 and DOT, 2021

2.4.1. Tornado

The Tornado Module uses a modified version of Table 6. Based on post-disaster research conducted by the Tornado Expert Panel, which is made up of experts on tornadoes and injuries and fatalities from hazards, the panel members determined that the six AIS categories needed to be reduced to four, as shown in Table 7. Prior to 2016, the methodology used an average of AIS Codes 5 and 6 for the "Unsurvivable" value. To maintain consistency with the other modules, in 2016 the methodology was changed so that the Unsurvivable value was just AIS Code 6.

Table 7: Injury Classes Used in the Tornado Module

Injury Classes	*AIS Code*[1]
Unsurvivable	6
Hospitalized	3,4,5
Treat and release	1,2
Self-treat	1

[1] Source: FEMA, 2008a

The associated costs for each AIS Code from Table 6 were used to develop the cost for injuries and fatalities to match the injury classes used in the Tornado Module shown in Table 6. Table 8 lists each of the injury classes based on the economic values provided in Table 6 with values rounded to the nearest thousand dollars. Multiple AIS codes represent the average values of the codes listed.

Table 8: Cost of Injury and Unsurvivable Values Used in the Tornado Module

Injury Severity Levels	*AIS Code*	*Economic Value*
Unsurvivable	6	$ 11,600,000
Hospitalized	3,4,5	$ 3,728,000
Treat and release	1,2	$ 290,000
Self-treat	1	$ 35,000

2.4.2. Earthquake

The Earthquake Structural and Nonstructural modules also use a modified version of the AIS Injury Severity Levels. Each module uses injury rates corresponding to the severity of physical damage computed in each module. During development of the FEMA BCA Toolkit (Version 4), it was decided that the injury classifications used in the previous version of the FEMA BCA Toolkit (Version 3) would remain the same. These injury classes are shown in Table 9.

Table 9: Injury Classes Used in the Earthquake Modules

Injury Classes	*AIS Code*[1]
Unsurvivable	6
Major	2,3,4,5
Minor	1

[1] Source: FEMA, 2008b and FEMA, 2008c

The associated cost for each AIS Code from Table 6 was used to develop the cost for injuries and fatalities to match the injury classes used in the Earthquake modules. Table 10 lists each of the injury classes and the rounded values based on Table 6. The "Major" Injury Severity Level value is an average of the economic values of the four listed AIS Code values.

Table 10: Cost of Injury and Unsurvivable Values Used in the Earthquake Module

Injury Severity Levels	*AIS Code*	*Economic Value*
Unsurvivable	6	$ 11,600,000
Major	2,3,4,5	$ 2,932,000
Minor	1	$ 35,000

2.4.3. Wildfire

The Wildfire module uses the values of Unsurvivable ($11,600,000), "Major injuries," and "Minor injuries." As shown in Equation 3 below, the methodology for major injuries is to average the values for AIS Codes 2 through 5, which equals $2,932,000. The minor injury (AIS Code 1) is $35,000.

$$\text{Major Injuries} = \frac{(545{,}000+1{,}218{,}000+3{,}086{,}000+6{,}879{,}000)}{4} = \$2{,}932{,}000 \quad (3)$$

$$\text{Statistical Value of All Injuries} = \frac{(35{,}000+2{,}932{,}000)}{2} = \$1{,}501{,}000 \quad (4)$$

2.5. Loss of Fire Station Services

Fire stations may provide a wide range of services, such as firefighting, search and rescue, public shelter, and emergency medical services (EMS). The methodology presented estimates the social cost for a loss of a fire station's services, also referred to as a "loss of function." Specifically, the methodology estimates how the temporary loss of function of a fire station will affect fire losses (human injuries and mortality, direct financial loss to property, and indirect losses). When a fire station offers public shelter during emergencies, a separate category should be added to account for any benefits. The impact of a loss of EMS is discussed in a separate section of this document.

This methodology assumes that if a fire station (for example, Fire Station A) is temporarily shut down, then the closest fire station (Fire Station B) will serve the population usually served by Fire Station A.

A universal measure used across public safety functions is response time. Intuitively, the relationship between response time and a fire department's success is clear: the sooner a fire company arrives at a fire scene, the better the chance of a successful outcome. Different studies have found a significant relationship between the response time and the resulting fire losses (Tomes, 2007; Ignall et al., 1978; Hogg, 1973).

Response time has a positive relationship with distance: the shorter the distance between the fire station and the fire scene, the shorter the response time. When Fire Station A is out of service, forcing Fire Station B to serve a larger geographical area, the average response time will increase. With the increase in the response time, fire losses will increase as well.

The steps to estimate the loss-of-function impact of firefighting services are:

1. Determine the fire station that would temporarily replace the fire station that is out of service
2. Establish the distance between the two fire stations
3. Estimate the population served by the non-operating fire station (Fire Station A)
4. Determine the dollar loss expected due to the shutdown

To determine the expected dollar loss (Step 4 above), a series of calculations need to be performed.

a. *Estimate the number of fire incidents (I) in the area served by the non-operating fire station (Fire Station A).* The population served as determined in Step 3 above is used to obtain this number. Because obtaining specific data for a fire station may be difficult, a national average is used. According to the National Fire Protection Association (NFPA), the total number of fires in the United States in 2014 was 1,298,000 (Ahrens, 2016). The 2015 U.S. population estimate given by the U.S. Census Bureau is 322,755,353 (U.S. Census Bureau, 2020).

Therefore, the number of incidents per capita is equal to 0.0040 per year, or 4.0 incidents per 1,000 people.[4]

b. *Estimate the average response time in the area before and after the fire station shutdown.* For the situation before the fire station shutdown, it is assumed that the response time is equal to the national average. According to the U.S. Fire Administration (2006), the median response time for structure fires is 5 minutes.[5] The extra response time will be approximated using the distance between the two fire stations established in Step 2 above. The following formula developed by the New York City Rand Institute in the 1970s (Chaiken et al., 1975) is used to determine the relationship between expected response time (RT) in minutes and the distance (D) in miles:

$$RT = 0.65 + 1.70D \quad (5)$$

Hence, the response time (in minutes) after the fire station shutdown (RT_{After}) will be estimated to be:

$$RT_{After} = 5 + (0.65 + 1.70D) \quad (6)$$

c. *Determine the probability of a no-loss incident before and after the fire station shutdown*. This is the probability of an event having zero losses as a function of the response time. The estimate was obtained from Air Force Protection Cost Risk Analysis (Air Force Civil Engineer Support Agency, 1994). The study used data from the National Fire Incident Reporting System for 760,000 nationwide records from 1989 to investigate the effect of response time on dollar losses and the amount of damages.[6] The probability of a zero dollar loss (*P0*) is given by the following formula:

$$P_0 = 0.456 - 0.00264RT \quad (7)$$

d. *Determine the average property dollar loss per incident before and after the fire station shutdown.* This is a function of the response time. The relationship was also obtained from the Air Force Protection Cost Risk Analysis study (1994).[7] The dollar loss (*DL*), in 1993 dollars, is given by:

$$DL = 3{,}845 + 431RT \quad (8)$$

[4] No studies were found regarding how a natural disaster will affect the number of fire incidents.

[5] Because this value has a considerable impact on the benefit estimate, when available, reliable local data may be used instead; proper documentation to justify their use should be provided.

[6] Only data for fixed property were analyzed to obtain these estimates. According to NFPA data for 2006, even though structure fires only account for 32 percent of total fires, they represent 85 percent of property damage, 88 percent of civilian injuries, and 83 percent of civilian deaths.

[7] This relationship was calculated using data for residential structures. NFPA data show that residential structure fires represent 78 percent of all structure fires.

e. Calculate the increase in the property dollar loss due to the fire station shutdown. This is done using the following formula:

$$\Delta\$property\ loss = \left[\left(1 - P_{0After}\right)DL_{After} - \left(1 - P_{0Before}\right)DL_{Before}\right] \times I \quad (9)$$

Where:

P_{0After} and $P_{0Before}$ are the probabilities of a no-loss incident after and before the fire station shutdown, respectively

DL_{After} and DL_{Before} are the average dollar loss per incident after and before the fire station shutdown, respectively

I is the number of fire incidents in the area served by the fire station. Because the number of incidents is in per-year terms, the increase in the dollar loss is also in per-year terms

a. *Add indirect losses.* NFPA adds 10 percent for indirect loss as a fraction of direct loss in residential fires (Hall, 2014). Indirect losses refer to the costs of temporary housing, missed work, and lost business:

$$\Delta\$total\ property\ loss = \Delta\$property\ loss \times 1.10 \quad (10)$$

Estimate the losses related to mortality and human injuries. According to NFPA estimates, direct and indirect property losses due to fire totaled $14.9 billion (in 2011 dollars), while the total dollar losses for deaths and injuries were estimated to be $31.7 billion (Hall, 2014).[8] That gives a ratio of 2.13 in losses for deaths and injuries per dollar of property loss. The losses for mortality and human injuries can be obtained by multiplying the total property loss calculated in Step e by 2.13:

$$\Delta\$mortality\ and\ injuries = \Delta\$total\ property\ loss \times 2.13 \quad (11)$$

b. *Update the values to current-year dollars.* Because the relationships used to estimate the dollar losses are in 2011 dollars, it is necessary to adjust this value for inflation variation between 2011 to the current year.

c. *Obtain the total dollar loss due to the fire station shutdown.* This is done by adding the estimates obtained in Steps f (total property loss) and g (mortality and human injuries losses):

$$\Delta\$total\ loss = \Delta\$total\ property\ loss + \Delta\$mortality\ and\ injuries \quad (12)$$

[8] This estimate was obtained using the values of $5 million per death and $166,000 per injury as 1993 values, then inflating to current dollar values. The report offers a value of $31.7 billion in 2010, which is $32.7 billion in 2011 dollars.

Application of the Methodology: An Example

Consider a situation where Fire Station A is shut down due to a flood event. The information needed to estimate the social cost of the shutdown is the following:

1. Fire Station B will cover the geographical area usually covered by Fire Station A.
2. The population served by Fire Station A is 30,000 people.
3. The distance between the two fire stations is 5 miles.

These are the steps to determine the increase in the dollar losses due to the shutdown:

a. *The number of fire incidents* (I) in the affected area will be equal to:

   30,000 x 0.004 = 120 incidents per year.

b. *Response time* will be equal to:

   before the shutdown (RT_{Before}): 5 minutes

   after the shutdown (RT_{After}): [5 + (0.65 + 1.70 x 5 miles)] = 14.15 minutes

c. The probability of a no-loss incident (P_0) will be equal to:

   before the shutdown ($P_{0Before}$): (0.456 – 0.00264 x 5) = 0.4428

   after the shutdown (P_{0After}): (0.456 – 0.00264 x 14.15) = 0.4186

d. The dollar loss per incident will be equal to:

   before the shutdown (DL_{Before}): (3,845 + 431 x 5) = $6,000

   after the shutdown (DL_{After}): (3,845 + 431 x 14.15) = $9,944

e. The increase in the dollar loss due to the fire station shutdown will be equal to:

   [(1 – 0.4186) x 9,944 – (1 – 0.4428) x 6,000] x 120 = $292,589 per year, or $802 per day of lost service (in 2011 dollars).

f. *After adding the indirect losses*, the daily dollar loss will be equal to:

   $802 x 1.10 = $882 per day in 2011 dollars.

g. *Updating* this value to 2020 dollars gives:

   $882 x 1.1542 = $1,018 per day of lost service.

h. The losses for deaths and human injuries will be equal to:

   $1,018 x 2.13 = $2,168 per day of lost service.

i. Total losses will be equal to:

$1,018 + $2,168 = $3,186 per day of lost service.

2.6. Loss of Emergency Medical Services

In a life-threatening situation, timely emergency care is a key factor that affects the chances of survival. If the shutdown of an EMS provider such as a fire station causes a considerable increase in the EMS response time, there may be a cost in lives. The methodology presented estimates the social cost for a loss of an EMS provider, which is the potential cost in lives resulting from the increased response time. To measure changes in EMS response times, the methodology assumes that if an EMS provider (for example, Fire Station A) is temporarily shut down, then the closest EMS provider (Fire Station B) will temporarily serve the population served by Fire Station A.

Different medical studies have analyzed the link between mortality and EMS response times (for example, see Blackwell and Kaufman, 2002). However, all the studies that estimated a "survival function" focus on cardiac arrests.[9] As suggested by Erkut et al. (2007), the reason for choosing cardiac arrests in this type of study is that cardiac arrest calls are of the highest priority, and, according to the researchers, those victims are the most "savable"; the response to cardiac arrest calls is the most accurate measure of emergency medical performance. Current EMS response time standards are based on cardiac arrest survival studies, and these calls account for a considerable portion of high-priority EMS calls.

This methodology uses the results obtained by Valenzuela et al. (1997). This particular study was selected because it is based on data from the United States and used a larger database compared to other studies.[10] The study used data from the EMS systems of Tucson, AZ (population, 415,000; area, 406 km²), and King County, WA (population, 1,038,000; area, 1,399 km²). The Tucson data were collected from 1988 through 1993, and the King County data were collected from 1976 through 1991. The authors estimated a survival function that included the time interval from collapse to cardiopulmonary resuscitation (CPR), and the time interval from collapse to defibrillation. The estimated survival function is the following:

$$Survival\ probability = \left(1 + e^{-0.260+0.106 I_{CPR}+0.139 I_{Defib}}\right)^{-1} \quad (13)$$

Where:

[9] A "survival function" measures the probability of survival for a patient as a function of the response time of an EMS vehicle to the patient.

[10] Some of the mentioned studies used data from Canada, the Netherlands, and the United Kingdom.

Survival probability = survival probability after out-of-hospital cardiac arrest due to ventricular fibrillation

I_{CPR} = time interval from collapse to CPR

I_{Defib} = time interval from collapse to defibrillation

The steps to estimate the impact of losing an EMS provider are the following:

1. Determine the EMS provider that will temporarily replace the EMS provider that is out of service
2. Establish the distance between the two
3. Estimate the population served by the non-operating EMS provider
4. Determine the dollar loss expected due to the shutdown

To determine the expected dollar loss (Step 4 above), a series of calculations need to be performed.

a. *Estimate the number of cardiac arrests treated by EMS in the affected area.* These numbers were obtained using the population served as determined in Step 3.[11] Because obtaining specific data for an area may be difficult, a national average was used instead. The American Heart Association estimates that in the United States, EMS treats 36 to 81 out-of-hospital cardiac arrests per 100,000 people (American Heart Association, 2013).[12] The middle point of that estimate is 63.8 per 100,000 people. Therefore, the number of cardiac arrests treated in the affected area (e.g., the area served by EMS Provider A) can be approximated as:

$$Number\ of\ cardiac\ arrests\ per\ year\ treated\ by\ EMS = \frac{population\ served_{Fire\ Station\ A} \times 63.8}{100{,}000} \tag{14}$$

b. *Estimate the average EMS response time in the area before and after the shutdown*. In the United States, response times are typically different for urban and rural areas. For the situation before the shutdown, it is assumed that the response time is equal to the national average. According to the National EMS Information System (n.a., 2016), the 50th Fractile

[11] No studies were found regarding how a natural disaster will increase the mortality rate from cardiac arrests. Even if that data were available, it would need to be established how an increased distance to a hospital would affect the increase in the mortality rate.

[12] No national data could be obtained about EMS calls. In 2001, the National Association of State EMS Directors, in conjunction with the National Highway Traffic Safety Administration (NHTSA) and the Trauma/EMS Systems program of the Health Resources and Services Administration's (HRSA) Maternal Child Health Bureau created a national EMS database known as NEMSIS (National EMS Information System). It is expected that in future years national data related to EMS would be available through this system.

Elapsed Time By Urbanicity of EMS Service Area for cardiac arrest calls is 6 minutes for urban, 7 minutes for suburban, 8 minutes for rural, and 9 minutes for wilderness.[13]

c. The extra response time will be approximated using the distance between the EMS providers established in Step 2 above. The following formula, developed by the New York City Rand Institute in the 1970s (Chaiken et al., 1975), is used to determine the relationship between expected response time (*RT*) in minutes and the distance (*D*) in miles:

$$RT = 0.65 + 1.70D \tag{15}$$

Hence, the response time after the EMS provider shutdown (RT_{After}) will be estimated to be (in minutes):

$$RT_{After} = 6 + (0.65 + 1.70D) \text{ for urban} \tag{16}$$

$$RT_{After} = 7 + (0.65 + 1.70D) \text{ for suburban} \tag{17}$$

$$RT_{After} = 8 + (0.65 + 1.70D) \text{ for rural} \tag{18}$$

$$RT_{After} = 9 + (0.65 + 1.70D) \text{ for wilderness} \tag{19}$$

d. *Determine the probability of survival before and after the shutdown.* This is done using the survival function given in equation (6). It is assumed that a call is placed to EMS as soon as the patient experiences cardiac arrest, and that all EMS units are equipped with defibrillators and staff who are trained to use them. Following Valenzuela et al. (1997), it is also assumed that the time interval to EMS-initiated CPR (I_{CPR}) is equal to the EMS response interval plus 1 minute, and the time interval to defibrillation (I_{Defib}) is equal to the EMS response time plus 2 minutes. The survival probabilities before and after the shutdown are given by the following formulas:

- Before shutdown:

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(6+1)+0.139\times(6+2)}\right)^{-1} \text{ for urban} \tag{20}$$

[13] The definition of each category is based on an "Urban Influence" coding system used by the United States Department of Agriculture (USDA) and the Office of Management and Budget (OMB). These codes take into account county population size, degree of urbanization, and adjacency to a metropolitan area or areas. The categories are defined as follows:

- Urban: counties with large (more than 1 million residents) or small (less than 1 million residents) metropolitan areas.
- Suburban: micropolitan (with an urban core of at least 10,000 residents) counties adjacent to a large or small metropolitan area.
- Rural: non-urban core counties adjacent to a large or small metropolitan area (with or without town).
- Wilderness: non-core counties that are adjacent to micropolitan counties (with or without town).

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(7+1)+0.139\times(7+2)}\right)^{-1} \text{ for suburban} \quad (21)$$

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(8+1)+0.139\times(8+2)}\right)^{-1} \text{ for rural} \quad (22)$$

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(9+1)+0.139\times(9+2)}\right)^{-1} \text{ for wilderness} \quad (23)$$

- After shutdown:

$$Survival\ probability_{After} = \left(1 + e^{-0.260+0.106\times(RT_{After}+1)+0.139\times(RT_{After}+2)}\right)^{-1} \text{ for urban, suburban, rural, and wilderness} \quad (24)$$

e. *Calculate the increase in the number of deaths from cardiac arrests due to the increased EMS response time.* The survival probabilities obtained in Step d, and the number of cardiac arrests estimated in Step a, will be used to approximate the potential increase in the number of deaths:

$$Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{Before} = Number\ of\ cardiac\ arrests\ per\ year\ treated\ by\ EMS \times \left(1 - survival\ probability_{Before}\right) \quad (25)$$

$$Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{After} = Number\ of\ cardiac\ arrests\ per\ year\ treated\ by\ EMS \times \left(1 - survival\ probability_{After}\right) \quad (26)$$

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest = Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{After} - Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{Before} \quad (27)$$

f. *Assign a dollar value to the potential cost in lives due to the increased EMS response time*. This methodology uses the Value of Statistical Life of $11,600,000 from the Life Safety section above. Hence, the potential cost in lives can be estimated using the following formula:

$$Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ EMS\ response\ time = \frac{(Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest)}{365} \times \$11{,}600{,}000 \quad (28)$$

Application of the Methodology: An Example

Consider a situation where EMS Provider A in a suburban area is shut down due to a flood event. The information needed to estimate the social cost of the shutdown related to EMS is the following:

1. EMS Provider B will cover the geographical area usually covered by EMS Provider A.

2. The population served by EMS Provider A is 30,000 people.
3. The distance between the two providers is 5 miles.

These are the steps to estimate the potential dollar losses due to the EMS loss of function:

a. The number of cardiac arrests treated by EMS in the affected area is equal to:

$$Number\ of\ cardiac\ arrests\ per\ year\ treated\ by\ EMS = \frac{30{,}000 \times 63.8}{100{,}000} = 19.1 \tag{29}$$

b. The average EMS response time in the area before and after the EMS provider shutdown are equal to:

$$RT_{Before} = 7\ min \tag{30}$$

$$RT_{After} = 7 + (0.65 + 1.70 \times 5) = 16.2\ min \tag{31}$$

c. The probabilities of survival before and after the shutdown are equal to:

$$Survival\ probability_{Before} = \left(1 + e^{-0.260+0.106\times(7+1)+0.139\times(7+2)}\right)^{-1} = 0.1372$$

$$Survival\ probability_{After} = \left(1 + e^{-0.260+0.106\times(16.2+1)+0.139\times(16.2+2)}\right)^{-1} = 0.0164 \tag{32}$$

d. The increase in the number of deaths from cardiac arrests due to the increased EMS response time is equal to:

$$Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{Before} = 19.1 \times (1 - 0.1372) = 16.4795$$

$$Number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest_{After} = 19.1 \times (1 - 0.0164) = 18.7868$$

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ cardiac\ arrest = 18.7876 - 16.4795 = 2.3073 \tag{33}$$

e. The *dollar value* of the potential cost in lives due to the increased EMS response time is equal to:

$$Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ EMS\ response\ time = \frac{2.3073}{365} \times \$11{,}600{,}000 = \$73{,}327\ per\ day \tag{34}$$

2.7. Loss of Hospital Services

The methodology presented estimates how the temporary loss of function of a hospital affects the users of the Emergency Department (ED). This methodology assumes that if a hospital (for example, Hospital A) is temporarily shut down, then its users will choose the second nearest hospital (Hospital B) in case of an emergency. It also assumes that only patients using the ED, whether they are admitted to the hospital or not, will be affected by the temporary hospital shutdown. This is because most non-emergency patients will likely reschedule their hospital admission if the hospital is temporarily closed. For this reason, the impacts estimated in this paper should be allowed only for mitigation activities that sustain emergency room services, rather than the whole hospital building.

It should be noted that this methodology does not cover the emergency response actions taken by the hospital (e.g., evacuation procedures) to reduce the potential loss of property or life of patients (e.g., intensive care unit [ICU] patients who require specialized care). The actions taken by the hospital and associated impacts should be addressed separately when estimating the total impacts of an event.

The cost to users in this methodology can be disaggregated into three parts:

A. *The cost of the extra distance to get to the hospital*: If Hospital A is temporarily shut down, the population served by this hospital will have to use Hospital B instead. This implies driving a longer distance, and consequently incurs a higher cost in terms of time, fuel, and other costs of the trip.

B. *The cost of additional waiting time at the hospital*: The increased patient load at Hospital B will cause delays in treatment. This extra time affects users of both Hospital A and Hospital B.

C. *The potential cost in lives of the extra time to get to the hospital*: In a life-threatening situation, timely emergency care is a key factor that affects the chances of survival. If the increase in distance to the nearest hospital is long enough, the cost in lives may need to be considered in the analysis.

The steps to estimate the impacts of losing hospital services are the following:

1. Determine which alternate hospital (Hospital B) will temporarily replace the hospital that is out of service (Hospital A)
2. Establish the distance between the hospitals
3. Estimate the population served by each hospital
4. Determine the dollar loss due to the shutdown in terms of:
    a. The cost of traveling the extra distance to Hospital B
    b. The cost of extra waiting time at Hospital B

c. The potential cost in lives due to the increased distance to Hospital B for Hospital A's patients

To estimate the dollar loss (Step 4 above), a series of calculations need to be performed:

a. Cost of traveling the extra distance to the hospital:

i. *Estimate the extra travel time due to the hospital shutdown*: It is assumed that, on average, the additional travel distance for the non-operating hospital (Hospital A) patients will be equal to the distance between the non-operating hospital and the second nearest hospital (Hospital B). Hence the extra travel distance will be approximated through the distance between both hospitals established in Step 2. It is assumed that the trip to the hospital implies a round trip (a trip to the hospital and a trip from the hospital), so the travel time is multiplied by 2 (based on Capps et al., 2006). The extra travel time can be approximated using the formula developed by the New York City Rand Institute in the 1970s (Chaiken et al., 1975) to estimate the relationship between time (*T*) in minutes and distance (*D*) in miles:

$$T(minutes) = 0.65 + 1.70\ D(miles) \quad (35)$$

Then the formula to estimate the extra distance will be:

$$Extra.travel\ time\ (hours) = \frac{0.65+1.70 \times Distance\ between\ hospitals\ (miles)}{60} \times 2 \quad (36)$$

ii. *Estimate the number of daily ED visits to the non-operating hospital:* The population served determined in Step 3 will be used to obtain this number. Since obtaining specific data for a hospital may be difficult, a national average will be used instead. According to the National Center for Health Statistics of the U.S. Department of Health and Human Services (CDC, 2011), the number of visits to Eds in 2011 was 136.3 million, or 44.5 visits per 100 persons. Additionally, during an emergency (such as a hurricane or tornado) the number of ED visits may increase. There are different studies analyzing the effect of natural disasters on the use of Eds. The results vary depending on the event magnitude. For this analysis, the results obtained by Smith and Graffeo (2005) on the impacts of Hurricane Isabel (a Category 2 hurricane that hit the mid-Atlantic region in 2003) were used. The purpose of this study was to investigate the impact of the hurricane on the number and type of ED patient visits. The results showed that during the subsequent 4 days post-landfall, there was an increase in average daily aggregate ED visits of 25 percent. This number will be used to increase the number of visits per day for both hospitals.

Therefore, the number visits to the non-operating hospital can be approximated as:

$$Number\ of\ visits\ per\ day_{Hospital.A} = \frac{0.445 \times population\ \ served_{Hospital\ A}}{365} \times 1.25 \quad (37)$$

Determine the cost of the extra distance to get to the hospital: It is assumed that the trip to the hospital will involve two people per patient (patient and companion). Additionally, the cost of time is estimated using the average employer cost for employee compensation per hour from the U.S. Department of Labor. The employer cost in December 2021 was $38.07 per hour. Finally, the cost of the extra mileage is estimated using the Federal government mileage reimbursement rate for January 1 to June 30, 2022, which is $0.585 per mile for passenger vehicles.[14] The cost of traveling the extra distance to the hospital is given by the following formula:

$$\begin{aligned} &Cost\ of\ extra\ distance \\ &\qquad = Extra\ travel\ time \times \$38.07 \times (number\ of\ visits\ per\ day \times 2) \\ &+\$0.585 \times (distantace\ between\ hospitals \times 2) \times number\ of\ visits\ per\ day \end{aligned} \tag{38}$$

b. Cost of extra waiting time at the hospital:

i. *Estimate the number of ED visits per year for both hospitals.* These numbers can be estimated using the population served as determined in Step 3, the average number of ED visits per year (44.5 per 100 people in 2011, as discussed in Step a.ii.), and the increase in the number of visits during the disaster:

$$Number\ of\ ED\ visits\ per\ year_{Hospital\ A} = Population\ served_{Hospital\ A} \times 0.445 \times 1.25 \tag{39}$$

$$Number\ of\ ED\ visits\ per\ year_{Hospital\ B} = Population\ served_{Hospital\ B} \times 0.445 \times 1.25 \tag{40}$$

ii. *Estimate the waiting time increase at the replacing hospital for both groups of patients*: This can be obtained using a relationship between the number of ED users and waiting time. Such a relationship was estimated using data from the survey *Emergency Department Pulse Report* (Press Ganey Associates, 2007). This survey analyzes the experiences of more than 1.5 million patients treated at more than 1,500 hospitals in the United States. The survey shows that the average waiting time at the ED increases as the number of patients increases. Using that information, a regression analysis was conducted to obtain the relationship between waiting time and the number of patients, measured as the number of annual visits to EDs[15]:

$$Waiting\ time\ per\ patient\ (in\ hours) = 2.49 + 0.000042 \times number\ of\ visits\ per\ year \tag{41}$$

The extra waiting time for both groups of patients (Hospital A users that will have to use Hospital B due to the shutdown, and Hospital B users) can be estimated using the following formulas:

[14] The extra mileage cost is included because only 4.2 percent of the patients visiting EDs use emergency medical transport (Institute of Medicine of the National Academies, 2006).

[15] The regression R^2 is equal to 0.9910.

$$Waiting\ time\ per\ patient_{Hospital\ A} = 2.49 + 0.000042 \times number\ of\ visits\ per\ year_{Hospital\ A} \tag{42}$$

$$Waiting\ time\ per\ patient_{Hospital\ B} = 2.49 + 0.000042 \times number\ of\ visits\ per\ year_{Hospital\ B} \tag{43}$$

$$Waiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} = 2.49 + 0.000042 \times \left(number\ of\ visits\ per\ year_{Hospital\ A} + number\ of\ visits\ per\ year_{Hospital\ B}\right) \tag{44}$$

The waiting time increases per patient are then calculated:

$$Waiting\ time\ increase\ per\ patient_{Hospital\ A\ patients} = Waiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} - Waiting\ time\ per\ patient_{Hospital\ A} \tag{45}$$

$$Waiting\ time\ increase\ per\ patient_{Hospital\ B\ patients} = Waiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} - Waiting\ time\ per\ patient_{Hospital\ B} \tag{46}$$

iii. *Calculate the cost of the extra waiting time*: As in Step a.iii, it is assumed that the trip to the hospital involves two people per patient, and that the cost of time is estimated using the average employer cost for employee compensation per hour from the U.S. Department of Labor ($38.07 per hour in December 2021). The cost per day of the extra waiting time at the hospital would be:

$$Cost\ of\ waiting\ time\ increase = waiting\ time\ increase\ per\ patient_{Hospital\ A\ patients} \times \left(\frac{number\ of\ visits\ per\ year_{Hospital\ A}}{365}\right) \times 2 \times \$38.07 + waiting\ time\ increase\ per\ patient_{Hospital\ B\ patients} \times \left(\frac{number\ of\ visits\ per\ year_{Hospital\ B}}{365}\right) \times 2 \times \$38.07 \tag{47}$$

c. Potential cost in lives due to the increased distance to hospital:

After conducting an extensive literature search, only one study could be found that analyzed the link between mortality and distance to a hospital (Buchmueller et al., 2005). The study uses data from the Los Angeles County Health Surveys for 8,000 cases between 1997 and 2003 to test the effect of distance on mortality from emergency (i.e., acute myocardial infarction [AMI] and unintentional injuries)[16,17] and non-emergency conditions (i.e., cancer or chronic heart disease). The results show that increased distance to the nearest hospital is associated with an increase in deaths from AMI and unintentional injuries, but not from the other causes for which timely emergency care is less important. The results are the presented in Table 11:

Table 11: Percentage Change in Number of Deaths Due to a Mile Increase in Distance to the Hospital[1]

	AMI	*Unintentional Injuries*
Increase in the number of deaths due to a 1-mile increase in distance	6.04 percent	6.14 percent

[1] Source: Buchmueller et al. (2005).

The steps to determine the potential cost in lives are the following:

i. *Estimate the number of deaths from AMI and unintentional injuries in the affected area:* These numbers were obtained using the population served as determined in Step 3.[18] Because obtaining specific data for an area may be difficult, a national average was used. The National Center for Health Statistics of the U.S. Department of Health and Human Services publishes the *National Vital Statistics Report*, which contains data on death rates and causes of death. The last report available contains data for 2013 (CDC, 2016). The death rate in 2013 was 821.5 per 100,000 population, while the death rates for AMI and unintentional injuries were 50.9[19] and 41.3 per 100,000 population, respectively. Therefore, the number of deaths in the affected area (i.e., the area served by Hospital A) can be approximated as:

$$Number\ of\ deaths\ per\ year\ due\ to\ AMI = \frac{population\ served_{Hospital\ A} \times 50.9}{100{,}000} \quad (48)$$

[16] AMI are covered by the *International Classification of Diseases*, Tenth Revision (ICD-10) codes I21-I22, and unintentional injuries are covered by codes V01-X59 and Y85-Y86.

[17] Unintentional injuries are: 1) transport accidents and their consequences, and 2) other external causes of accidental injury and their consequences.

[18] No studies were found regarding how a natural disaster will increase the mortality rate from AMI and unintentional injuries. Even if that data were available, it would need to be established how an increased distance to a hospital would affect the increase in the mortality rate.

[19] The data for AMI could not be updated from 2005 to 2013 because for the 2013 data grouped AMI together with all heart diseases. Please see: http://www.cdc.gov/nchs/data/nvsr/nvsr65/nvsr65_02.pdf. Acute Myocardial Infarction is coded as "I21–I22" (Table A, page 4), while "Diseases of the heart" includes codes I00–I09, I11, I13, and I20–I51 (Table 1, page 18). No documentation could be found that breaks out AMI from other heart diseases.

$$Number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = \frac{population\ served_{Hospital\ A} \times 41.3}{100{,}000} \quad (49)$$

ii. Calculate the increase in the number of deaths from AMI and unintentional injuries due to the increased distance to the hospital: The percentages provided in Table 11, the estimates obtained in the previous step, and the distance between Hospital A and Hospital B will be used to approximate the potential increase in the number of deaths:

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ AMI = number\ of\ deaths\ per\ year\ due\ to\ AMI \times 0.0604 \times distance\ between\ Hospital\ A\ and\ Hospital\ B \quad (50)$$

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries \times 0.0614 \times distance\ between\ Hospital\ A\ and\ Hospital\ B \quad (51)$$

iii. *Assign a dollar value to the potential cost in lives due to the increased distance to the hospital:* This methodology uses the VSL developed in the Life Safety section above. The September 2021 estimate for the VSL is \$11,600,000. Hence, the potential cost in lives can be estimated using the following formula:

$$Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ distance\ to\ hospital = \frac{(Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ AMI)}{365} \times \$11{,}600{,}000 + \frac{(Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries)}{365} \times \$11{,}600{,}000 \quad (52)$$

The total dollar loss due to the hospital shutdown then is obtained as the sum of items I, II, and III:

$$Total\ dollar\ loss = Cost\ of\ extra\ distance + Cost\ of\ waiting\ time\ increase + Cost\ in\ lives\ due\ to\ the\ increased\ distance\ to\ hospital \quad (53)$$

Application of the Methodology: An Example

Consider a situation where Hospital A is shut down due to a flood event. The information needed to estimate the social cost of the shutdown is the following:

1. Hospital B will serve the geographic area usually served by Hospital A.
2. The distance between the hospitals is 10 miles.
3. The population served by Hospital A is 10,000 people, and the population served by Hospital B is 30,000 people.
4. These are the steps to determine the dollar losses due to the shutdown:

a. Cost of travelling the extra distance to the hospital

i. The extra travel time due to the hospital shutdown is equal to:

$$Extra\ travel\ time = \frac{0.65+1.7\times 10}{60} \times 2 = 0.6\ hours \quad (54)$$

ii. The number of daily ED visits to Hospital A is equal to:

$$Number\ of\ visits\ per\ day_{Hospital\ A} = \frac{0.445\times 10{,}000}{365} \times 1.25 = 15.24\ visits\ per\ day \quad (55)$$

iii. The costs of traveling the extra distance to the hospital is equal to:

$$\begin{aligned} &Cost\ of\ extra\ distance = 0.6 \times \$38.07 \times (15.24 \times 2) \\ &+\$0.585 \times (10 \times 2) \times 15.24 = \$875\ per\ day \end{aligned} \quad (56)$$

b. Cost of extra waiting time at the hospital

i. The number of ED visits per year for both hospitals are equal to:

$$\begin{aligned} &Number\ of\ ED\ visits\ per\ year_{Hospital\ A} = 10{,}000 \times 0.445 \times 1.25 = 5{,}563 \\ &Number\ of\ ED\ visits\ per\ year_{Hospital\ B} = 30{,}000 \times 0.445 \times 1.25 = 16{,}688 \end{aligned} \quad (57)$$

ii. The *waiting time increase at the replacing hospital* for both groups of patients is calculated following these steps:

$$\begin{aligned} &Waiting\ time\ per\ patient_{Hospital\ A} = 2.49 + 0.000042 \times 5{,}563 = 2.7 \\ &hoursWaiting\ time\ per\ patient_{Hospital\ B} = 2.49 + 0.000042 \times 16{,}688 = 3.2 \\ &hoursWaiting\ time\ per\ patient_{Hospital\ B\ with\ Hospital\ A\ shut\ down} \\ &\qquad = 2.49 + 0.000042\ \times (5{,}563 + 16{,}688) = 3.4\ hours \\ &Waiting\ time\ increase\ per\ patient_{Hospital\ A\ patients} = 3.4 - 2.7 = 0.7\ hours \\ &Waiting\ time\ increase\ per\ patient_{Hospital\ B\ patients} = 3.4 - 3.2 = 0.2\ hours \end{aligned} \quad (58)$$

iii. The cost of the extra waiting time is equal to:

$$\begin{aligned} &Cost\ of\ waiting\ time\ increase \\ &\qquad = 0.7 \times \left(\frac{5{,}563}{365}\right) \times 2 \times \$38.07 + 0.2 \times \left(\frac{16{,}688}{365}\right) \times 2 \times \$38.07 \\ &\qquad = \$1{,}509\ per\ day \end{aligned}$$

(59)

c. Potential cost in lives due to the increased distance to hospital

i. The number of deaths from AMI and unintentional injuries in the affected area is equal to:

$$Number\ of\ deaths\ per\ year\ due\ to\ AMI = \frac{10{,}000 \times 50.9}{100{,}000} = 5.09 \tag{60}$$

$$Number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = \frac{10{,}000 \times 41.3}{100{,}000} = 4.13 \tag{61}$$

ii. The increase in the number of deaths from AMI and unintentional injuries due to the increased distance to the hospital is equal to:

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ AMI = 5.09 \times 0.0604 \times 10 = 3.074$$

$$Increase\ in\ the\ number\ of\ deaths\ per\ year\ due\ to\ unintentional\ injuries = 4.13 \times 0.0614 \times 10 = 2.536 \tag{62}$$

iii. The *dollar value* of the potential cost in lives due to the increased distance to the hospital is equal to:

$$Cost\ in\ lives\ per\ day\ due\ to\ the\ increased\ distance\ to\ hospital = \frac{3.074}{365} \times \$11{,}600{,}000 + \frac{2.536}{365} \times \$11{,}600{,}000 = \$178{,}290\ per\ day \tag{63}$$

The total dollar loss due to the hospital shutdown is equal to:

$$Total\ dollar\ loss = \$875 + \$1{,}509 + \$178{,}290 = \$180{,}674\ per\ day \tag{64}$$

2.8. Loss of Police Services

The methodology presented estimates the cost to society of a temporary loss-of-function of a police station. The estimation of this cost has two main components. The first is to measure how a reduced police presence would affect the population of that area. The second is to assign a dollar value to those effects.

It should be noted that this method only accounts for the effects of a reduced police presence resulting from the loss of a police station. In many situations, activities typically conducted at a police station can be assigned to another police station with no apparent loss of service to the community. However, during a catastrophic event, such as a flood in the community, there may be an increased cost for emergency response activities, including an increase in overtime for police officers. This method does not account for emergency response activities; these costs should be considered separately with proper documentation.

It is widely accepted that impaired police activity could potentially result in an increase in crime. The first component mentioned above can be approximated by the relationship between the number of police officers per capita and the crime rate. Many studies tried to estimate the impact of police force size on crime (Goodman and Mann, 2005; New York City Area Consortium for Earthquake Loss Mitigation, 2003; Levitt, 2002; Levitt, 1998). This methodology uses the results obtained by Evans and Owens (2007). The Evans and Owens study used panel data for 2,074 cities and towns for the period 1990–2001. They found a statistically significant relationship between the number of police officers and both property crime (such as burglaries, auto thefts, and larceny) and violent crime (such as murders, rapes, robberies, and aggravated assaults). Table 12 shows the estimated elasticities; that is, the percentage change in different types of crime generated by a percentage change in police force. For example, a value of -2 means that a 1 percent reduction in the number of police officers will cause an increase of 2 percent in that type of crime.

Table 12: Impact of Number of Police Officers on Crime Rate[1]

Type of Crime	*Percent Change in Crime Rate Generated by a 1-percent Change in Police Force*
Property Crimes	
Burglary	-0.59
Motor Vehicle Theft	-0.85
Larceny	-0.08
Violent Crimes	
Robbery	-1.34
Murder	-0.84
Rape	-0.42
Assault	-0.96

[1] Source: Evans and Owens, 2007

The second component is the cost of crime to society. This methodology uses the costs of crime estimated by McCollister (2010), which provides economic values for the cost of crime in 2008 dollars. The approach used for estimating the cost of crime to society includes tangible costs and intangible costs. Tangible costs may include direct victim costs, mental health costs, and criminal justice system costs. Intangible costs include estimates of pain and suffering. Table 13 shows the costs of crime that were used. The economic values shown in Table 13 were inflated from McCollister's May 2008 dollars to December 2019 dollars using the Bureau of Labor Statistics CPI calculator.

Table 13: Total Cost of Crime in 2019 Dollars[1]

Type of Crime	*Total Cost*
Property Crimes	
Burglary	$7,665
Motor Vehicle Theft	$12,778
Larceny	$4,190
Violent Crimes	
Robbery	$50,189
Murder	$10,655,737
Rape	$285,614
Assault	$126,950

[1] Source: McCollister, 2010

The steps to estimate the loss-of-function impact of police services are the following:

1. Determine the number of police officers working at the police station before shutdown
2. Estimate the population regularly served by the police station
3. Establish the number of police officers that would serve the affected area after the police station shutdown
4. Determine the expected dollar loss due to the shutdown

To determine the expected dollar loss (Step 4 above), a series of calculations need to be performed:

a. Determine the number police officers per capita in the area served by the police station before the station shutdown (Ppc_{Before}): The number of police officers and the population served, determined in Steps 1 and 2, respectively, will be used to obtain these numbers:

$$Ppc_{Before} = \frac{Police\ officers_{Before}}{Population} \quad (65)$$

b. Obtain the number of police officers per capita after the police station shutdown (Ppc_{After}): To calculate this value, the number of police officers determined in Step 3 ($Police\ officers_{After}$) will be used:

$$Ppc_{After} = \frac{Police\ officers_{After}}{Population} \quad (66)$$

c. Calculate the percent change in the number of police officers per capita: This is done using the values obtained in Steps a and b:

$$\Delta\%Ppc = \frac{Ppc_{After} - Ppc_{Before}}{Ppc_{Before}} \times 100 \quad (67)$$

d. *Calculate the percent change in the number crimes per capita (Cpc)*: For each crime, this is done using the crime elasticities (i.e., the percent change in crime generated by a 1 percent change in the police force) provided in Table 12 and the percent change in the number of police officers obtained in Step c:

$$\Delta\%Cpc = \Delta\%Ppc \times crime\ elasticity \quad (68)$$

e. *Estimate the number of crimes in the area*: This can be calculated using data from the Uniform Crime Reporting (UCR) Program, provided yearly by the U.S. Department of Justice, Federal Bureau of Investigation (FBI). Because crime rates vary considerably across and within States, it is suggested to use data from Table 5 of the UCR Program (FBI, 2014), which provides crime data by State disaggregated between metropolitan and non-metropolitan areas. For every State, the data are presented as shown in Table 14.[20]

The following are the steps to determine the number of crimes in the area:

i. Determine if the affected area is in a metropolitan statistical area (MSA), a city outside a metropolitan area, or a nonmetropolitan county.[21]

ii. For each For each of the crimes, obtain the crime rates per 100,000 inhabitants per year using the "estimated total" number of crimes in Table 5 of the UCR Program:

$$Crime\ rates\ (per\ 100{,}000\ inhab.) = \frac{Estimated\ total}{Population} \times 100{,}000\ per\ year \quad (69)$$

Using the example in Table 14, if the area is in an MSA, then the robbery rate would be equal to:

$$Crime\ rate\ (per\ 100{,}000\ inhab.)_{Robbery} = \frac{4{,}228}{3{,}692{,}100} \times 100{,}000 = 114.5\ per\ year \quad (70)$$

[20] Only violent crime data are shown in this example.

[21] An MSA contains a principal city or urbanized area with a population of at least 50,000 inhabitants. MSAs include the principal city, the county in which the city is located, and other adjacent counties that have, as defined by the OMB, a high degree of economic and social integration with the principal city and county as measured through commuting. In the UCR Program, counties within an MSA are considered metropolitan. Nonmetropolitan (rural) counties are those outside MSAs that are composed of mostly unincorporated areas.

Table 14: Example of Crime Statistics for the State of Alabama[1]

Measure	*Population or Percentage of Population*	*No. Violent Crimes*	*No. Murders and Nonnegligent Manslaughters*	*No. Forcible rapes*	*No. Robberies*
Metropolitan Statistical Area					
Population of area	3,692,100	n/a	n/a	n/a	n/a
Percentage of area actually reporting	95.5%	16,204	232	1,033	4,131
Estimated total	100.0%	16,702	236	1,076	4,228
Cities Outside Metropolitan Areas					
Population of area	529,129	n/a	n/a	n/a	n/a
Area actually reporting	93.3%	2,605	17	214	363
Estimated total	100.0%	2,769	18	226	386
Nonmetropolitan Counties					
Population of area	628,148	n/a	n/a	n/a	n/a
Area actually reporting	99.4%	1,247	22	133	86
Estimated total	100.0%	1,256	22	134	87
Alabama State Total	**4,849,377**	**20,727**	**276**	**1,436**	**4,701**
Rate per 100,000 inhabitants	n/a	427.4	5.7	29.6	96.9

[1] Source: FBI, 2014

iii. For each of the crimes, calculate the number of crimes per year that occur in the affected area:

$$Number\ of\ crimes\ per\ year = \frac{Crime\ rate \times population\ served}{100{,}000} \quad (71)$$

a. *Calculate the change in the number of crimes*: For each crime, this is obtained by multiplying the number of crimes estimated in Step v and the percent change in crime estimated in Step iv:

$$\Delta number\ of\ crimes = Number\ of\ crimes\ per\ year \times \Delta\%Cpc \quad (72)$$

b. *For each crime, assign a dollar value to the change in the number of crimes*: This is done by multiplying the change in the number of crimes obtained in Step vi and the cost of crime provided in Table 13:

$$Cost\ of\ crime\ increase_i = \Delta number\ of\ crimes_i \times\ cost\ of\ crime_i \tag{73}$$

c. *Obtain the total dollar loss due to the police station shutdown*: The total cost per year is obtained by adding the costs of each of the crimes:

$$Total\ cost\ per\ year = \sum_i cost\ of\ crime\ increase_i \tag{74}$$

The total cost per day is equal to:

$$Total\ cost\ per\ day = \frac{Total\ cost\ per\ year}{365} \tag{75}$$

Application of the Methodology: An Example

Consider a situation where Police Station A, located in an MSA in Missouri, is shut down due to a flood event. The information needed to estimate the social cost of the shutdown is the following:

1. The number of police officers working at the police station before the shutdown was 100.
2. The population regularly served by the police station is 50,000.
3. The number of police officers that would serve the affected area after the police station shutdown is 80.

These are the steps to determine the increase in the dollar losses due to the shutdown:

a. The number of police officers per capita before the station shutdown (Ppc_{Before}) is equal to:

$$Ppc_{Before} = \frac{100}{50{,}000} = 0.002\ police\ officers \tag{76}$$

b. The number of police officers per capita after the police station shutdown (Ppc_{After}) is equal to:

$$Ppc_{After} = \frac{80}{50{,}000} = 0.0016\ police\ officers \tag{77}$$

c. The percent change in the number of police officers per capita is equal to:

$$\Delta\%Ppc = \frac{0.0016 - 0.002}{0.002} \times 100 = -20\% \tag{78}$$

d. Using the elasticities provided in Table 12, the *percent changes in the number of crimes per capita (Cpc)* are the following:

$$\Delta\%Cpc_{Burglary} = \Delta\%Ppc \times (-0.59) \tag{79}$$

$$\Delta\%Cpc_{Auto\ Theft} = \Delta\%Ppc \times (-0.85) \tag{80}$$

$$\Delta\%Cpc_{Larceny} = \Delta\%Ppc \times (-0.08) \tag{81}$$

$$\Delta\%Cpc_{Robbery} = \Delta\%Ppc \times (-1.34) \quad (82)$$
$$\Delta\%Cpc_{Murder} = \Delta\%Ppc \times (-0.84) \quad (83)$$
$$\Delta\%Cpc_{Rape} = \Delta\%Ppc \times (-0.42) \quad (84)$$
$$\Delta\%Cpc_{Assault} = \Delta\%Ppc \times (-0.96) \quad (85)$$

e. The *number of crimes in the area* is estimated using the crime data published by the UCR Program from the FBI. The latest data available is for 2014. Table 5 (FBI, 2014) includes the following data for the State of Missouri, as shown in Tables 15 and 16:

Table 15: Example of Crime Statistics for the State of Missouri, Part 1[1]

Measure	*Population or Percentage of Population*	*No. Violent Crimes*	*No. Murders and Nonnegligent Manslaughters*	*No. Forcible Rapes*	*No. Robberies*
Metropolitan Statistical Area					
Population of area	4,507,971	n/a	n/a	n/a	n/a
Area actually reporting	99.9%	22,257	348	1,441	5,295
Estimated total	100.0%	22,258	348	1,441	5,295
Cities Outside Metropolitan Areas					
Population of area	665,780	n/a	n/a	n/a	n/a
Area actually reporting	99.6%	2,649	22	160	255
Estimated total	100.0%	2,658	22	160	256
Nonmetropolitan Counties					
Population of area	889,838	n/a	n/a	n/a	n/a
Area actually reporting	100.0%	1,940	33	105	41
Missouri State Total	**6,063,589**	**26,856**	**403**	**1,706**	**5,592**
Rate per 100,000 inhabitants	n/a	442.9	6.6	28.1	92.2

[1] Source: FBI, 2014

Table 16: Example of Crime Statistics for State of Missouri, Part 2[1]

Area	*No. Aggravated Assaults*	*No. Property Crimes*	*No. Burglaries*	*No. Larceny Thefts*	*No. Motor Vehicle Thefts*
Metropolitan Statistical Area					
Area actually reporting	14,612	140,143	27,421	98,371	14,351
Estimated total	14,613	140,163	27,424	98,387	14,352
Cities Outside Metropolitan Areas					
Area actually reporting	2,155	24,487	4,085	19,441	961
Estimated total	2,163	24,581	4,101	19,515	965
Nonmetropolitan Counties					
Area actually reporting	1,706	11,493	3,733	6,720	1,040
Missouri State Total	**18,482**	**176,237**	**35,258**	**124,622**	**416,357**
Rate per 100,000 inhabitants	308.4	2,906.5	581.5	2,055.3	269.8

[1] Source: FBI, 2014

i. The affected area is in an MSA.

ii. The *crime rates* (per 100,000 inhabitants) are estimated to be:

$$Crime\ rates_{Burglary} = \frac{27{,}424}{4{,}507{,}971} \times 100{,}000 = 608.3\ per\ year$$

$$Crime\ rates_{AutoTheft} = \frac{14{,}352}{4{,}507{,}971} \times 100{,}000 = 318.4\ per\ year$$

$$Crime\ rates_{Larceny} = \frac{98{,}387}{4{,}507{,}971} \times 100{,}000 = 2{,}182.5\ per\ year$$

$$Crime\ rates_{Robbery} = \frac{5{,}295}{4{,}507{,}971} \times 100{,}000 = 117.5\ per\ year$$

$$Crime\ rates_{Murder} = \frac{348}{4{,}507{,}971} \times 100{,}000 = 7.7\ per\ year$$

$$Crime\ rates_{Rape} = \frac{1{,}441}{4{,}507{,}971} \times 100{,}000 = 32.0\ per\ year$$

$$Crime\ rates_{Assault} = \frac{14{,}613}{4{,}507{,}971} \times 100{,}000 = 324.2\ per\ year$$

iii. The *number of crimes per year* in the affected area is calculated as:

$$Number\ of\ crimes\ per\ year_{Burglary} = \frac{608.3 \times 50{,}000}{100{,}000} = 304.2\ per\ year$$

$$Number\ of\ crimes\ per\ year_{Auto\ Theft} = \frac{318.4 \times 50{,}000}{100{,}000} = 159.2\ per\ year$$

$$Number\ of\ crimes\ per\ year_{Larceny} = \frac{2{,}182.5 \times 50{,}000}{100{,}000} = 1{,}091.3\ per\ year$$

$$Number\ of\ crimes\ per\ year_{Robbery} = \frac{117.5 \times 50{,}000}{100{,}000} = 58.8\ per\ year$$

$$Number\ of\ crimes\ per\ year_{Murder} = \frac{7.7 \times 50{,}000}{100{,}000} = 3.9\ per\ year$$

$$Number\ of\ crimes\ per\ year_{Rape} = \frac{32.0 \times 50{,}000}{100{,}000} = 16.0\ per\ year$$

$$Number\ of\ crimes\ per\ year_{Assault} = \frac{324.2 \times 50{,}000}{100{,}000} = 162.1\ per\ year$$

f. The change in the number of crimes is equal to:

$$\Delta number\ of\ crimes_{Burglary} = 304.2 \times -20\% \times (-0.59) = 35.9\ per\ year$$
$$\Delta number\ of\ crimes_{Auto\ Theft} = 159.2 \times -20\% \times (-0.85) = 27.1\ per\ year$$
$$\Delta number\ of\ crimes_{Larceny} = 1091.3 \times -20\% \times (-0.08) = 17.5\ per\ year$$
$$\Delta number\ of\ crimes_{Robbery} = 58.8 \times -20\% \times (-1.34) = 15.8\ per\ year$$
$$\Delta number\ of\ crimes_{Murder} = 3.9 \times -20\% \times (-0.84) = 0.7\ per\ year$$
$$\Delta number\ of\ crimes_{Rape} = 16.0 \times -20\% \times (-0.42) = 1.3\ per\ year$$
$$\Delta number\ of\ crimes_{Assault} = 162.1 \times 20\% \times (-0.96) = 31.1\ per\ year$$

g. Using the estimates provided in Table 13, the *dollar values for the change in the number of crimes* are the following:

$$Cost\ of\ crime\ increase_{Burglary} = 35.9 \times \$7{,}665 = \$275{,}174$$
$$Cost\ of\ crime\ increase_{Auto\ Theft} = 27.1 \times \$12{,}778 = \$346{,}284$$
$$Cost\ of\ crime\ increase_{Lacerny} = 17.5 \times \$4{,}190 = \$73{,}325$$
$$Cost\ of\ crime\ increase_{Robbery} = 15.8 \times \$50{,}189 = \$792{,}986$$
$$Cost\ of\ crime\ increase_{Murder} = 0.7 \times \$10{,}655{,}737 = \$7{,}459{,}016$$
$$Cost\ of\ crime\ increase_{Rape} = 1.3 \times \$285{,}614 = \$371{,}298$$
$$Cost\ of\ crime\ increase_{Assault} = 31.1 \times \$126{,}950 = \$3{,}948{,}145$$

h. The total dollar loss due to the police station shutdown would be equal to:

$Total\ cost\ per\ year_{2019\ dollars} = \$13{,}266{,}228\ per\ year$; or

$$Total\ cost\ per\ day_{2019\ dollars} = \frac{\$13{,}266{,}228}{365} = \$36{,}346\ per\ day$$

2.9. Loss of Electric Services

The methodology currently used by FEMA for calculating the direct economic impacts of losing electricity services follows five steps to perform benefit-cost analysis of hazard mitigation projects for electric power systems:

4. Estimate the physical damages to the electric power system in dollars
5. Estimate the functional downtime (system days of lost service)
6. Obtain the number of people served by the electric power utility
7. Calculate the economic impacts of lost electric power service, using the per capita economic impacts and the affected population

In the 2009 BCA Tool update, an additional step of determining the revenue loss to the electric power utility was discontinued because of the concern it was double-counting impacts. As a general rule, double counting can be avoided by not attributing losses to more than one entity in the case of private goods (Rose, 2004) (e.g., avoiding counting utility sales as a loss to both the utility company and its customers).

The sections below discuss the methodology used to estimate the economic impacts of the lost electric power service (Step 4 above) to economic activity and residential customers.

2.9.1. Impacts to Economic Activity

In general, the original methodology outlined in FEMA's original economic valuation document *What Is a Benefit?* Is similar to the methodologies employed in other studies of the electricity industry (Greenberg et al., 2007; Kunreuther et al., 2006; Greenberg, 2005; Chang et al., 1996).

The 2009 BCA Tool update changed the way the direct economic impact of loss of electric service was calculated. The new process uses national Gross Domestic Product (GDP) dollar values in order to estimate the economic impact to commercial and industrial customers. The dollar numbers were combined with importance factors for each economic sector, which were determined by ATC Publication 25, Appendix D (FEMA, 1991). The importance factors published by the ATC-25 are widely used in this type of study, and the values in the document have not been updated since 1991.

Table 17 shows the estimation of the impact to economic activity per capita per day using GDP data and the ATC-25 factors. The table contains GDP sector value added figures for December 2021 (BEA, 2022) as the most recent annual GDP data available.

Table 17: Loss of Electric Service Impact to Economic Activity

Economic Sector[1]	*Electric Power Importance Factor[2]*	*GDP 2021 (in billions of dollars)[1]*	*GDP per Capita per Day[3]*	*Economic Impact per Capita per Day of Lost Service in 2021[4] Dollars*
Agriculture, Livestock[5]	—	—	—	—
Mining[5]	—	—	—	—
Utilities	0.80	$380.6.8	$3.137	$2.51
Construction	0.40	$958.80.8	$7.903	$3.16
Manufacturing – Nondurable	0.98	$1,177.63	$9.706	$9.51
Manufacturing – Durable Good[7]	0.99	$1,385.7	$11.421	$11.31
Wholesale Trade	0.90	$1,383.09	$11.399	$10.26
Retail Trade	0.90	$1,385.58	$11.420	$10.28
Transportation, Warehousing	0.30	$642.6	$5.296	$1.59
Information	0.90	$1,300.77	$10.721	$9.65
Finance, Insurance, Real Estate, Rental, and Leasing	0.90	$4,885.0	$40.263	$36.24
Professional & Business Services	0.90	$2,973.4	$24.507	$22.06
Education, Healthcare, Social Assistance	0.80	$1,932.9	$15.931	$12.75
Arts, Entertainment, Recreation, Accommodation, and Food Services	0.80	$839.6	$6.920	$5.54
Other Services, Except Government	0.90	$447.9	$3.692	$3.32
Government	0.60	$2,772.6	$22.852	$13.71
TOTAL	**n/a**	**$22,465.9**	**$185.168**	**$151.87**

[1] Source: Bureau of Economic Analysis.

[2] Source: FEMA Publication 224 (FEMA, 1991)

[3] Population data from US Census Bureau (December 31, 2021): 332,402,978.

[4] Rows in this column calculated as Electric Power Importance Factor * GDP per Capita per Day. Total value is summation of each row and is subject to rounding.

[5] — = Agriculture, livestock, and mining data excluded from the analysis because they are not relevant for municipal systems.

[6] Weighting value of 0.98 averaged the eight sub-sectors with the following values: food/beverage/tobacco products (0.90), paper products (1.00), printing and related support (1.00), chemical products (0.90), textiles/textile product mills (1.00), apparel/leather/allied products (1.00), petroleum/coal products (1.00), and plastic/rubber products (1.00).

[7] Weighting value of 0.99 averaged the nine sub-sectors with the following values: wood & furniture (1.00), nonmetallic mineral products (1.00), primary metal manufacturing (0.90), fabricated metal products (1.00), machinery (1.00), computer/electronic (1.00), equipment/appliances/etc. (1.00), transportation equipment (1.00), and miscellaneous equipment (1.00).

2.9.2. Impacts to Residential Customers

This methodology for this variable was revised in the 2009 update by using a contingent valuation method instead of using questionable electric service statistical data. The contingent valuation method relies on consumers' responses to a survey questionnaire to estimate the willingness-to-pay (WTP) for a good or service. In this case, the analysis examines the WTP to avoid power outages. This method has been employed in several studies to measure the impact of lifeline interruptions (Layton et al., 2005; Devicienti et al, 2004). The data used in this paper was obtained from the study *A framework and review of customer outage costs: integration and analysis of electric utility outage cost surveys* prepared by Lawton, Sullivan, Van Liere, Katz, and Eto for the Department of Energy (2003). The authors analyzed six large-scale studies conducted by five major electric utilities over 15 years to assess the value of electric service to their residential customers. There was a total of 11,368 respondents that determined the amount they would be willing to pay in order to avoid an outage of a certain duration. The average WTP to avoid a 12-hour outage is $26.27 in 2002 dollars (Table 5-2, p. 36). Projecting that amount for a 24-hour outage, and updating the value to December 2019 dollars, the cost per day becomes $75.05. Because the WTP is calculated at a household level, this estimate needs to be adjusted so it is expressed in per capita terms. According to 2015 Families and Living Arrangements data from the U.S. Census, the average household occupancy is 2.54 people (U.S. Census Bureau, 2020). Therefore, the per capita WTP can be estimated at $29.78.

In the United States, the average person is heavily dependent upon electricity in his or her daily life, and technological advances make this dependency even more critical. Yet little research—WTP or otherwise—has been done to place an economic value on electric service. The two most relevant research papers in the field are cited in the paragraph above and have publication dates of 2004 and 2005, now at least 15 years old. Additionally, there is a concern that the methodology outlined in the previous paragraph assumes that the WTP for electric service is a linear function. A residential customer might place an incrementally higher value on avoiding a 24-hour outage versus a doubling factor for a 12-hour outage. There is some research that finds that this is not a linear function (Carlsson and Martinsson, 2004); however, more research is needed to determine actual value numbers that could be used in the BCA Tool.

2.9.3. Summary

Table 18 summarizes the proposed values to measure the economic impact of loss of electric power. It is recommended that the total economic impact of $181.65 be rounded to the nearest dollar, $182.

Table 18: Economic Impacts of Loss of Electric Power Per Capita Per Day (in 2021 dollars)

Category	*Economic Impact*
Impact on Economic Activity	$151.87
Impact on Residential Customers	$29.78
Total Economic Impact (rounded to nearest dollar)	**$182**

Based on changes in methodologies used and changes with updated values, Table 19 summarizes the historical changes in the value of electric service. The "Initial Value" was provided by the FEMA publication *What is a Benefit?*[22] The "BCAR Updated Value" sought to update the Initial Value during the Benefit-Cost Analysis Reengineering in 2007. The "2008 Updated Value" changed the methodology for electric service loss of function, and the variables that changed are marked as "Discontinued". Starting with the 2008 Updated Value column, the values are provided for how the same methodology resulted in different values of service. The values were updated in 2013, 2016, and 2019.

Table 19: Evolution of Electric Service Value Used in the BCA Toolkit

Value Category	*Initial Value*	*BCAR Updated Value*	*2008 Updated Value*	*2013 Updated Value*	*2016 Updated Value*	*2019 Updated Value*
Average Price per Kilowatt-Hour (national)	6.47 cents	8.72 cents	—[1]	—[1]	—[1]	—[1]
Direct Economic Impact on Residents	$30 to 35	—[1]	—[1]	—[1]	—[1]	—[1]
Disruption of Activity per Day	3 to 4 hours	3 to 4 hours	—[1]	—[1]	—[1]	—[1]
Cost of Activity Disruption per Day	$63 to $85	$82 to $109	—[1]	—[1]	—[1]	—[1]
Per Capita, Per Day Direct	$93 to $110	$82 to $109	—[1]	—[1]	—[1]	—[1]
Best Estimate for Residential Customers	$101	$95	—[1]	—[1]	—[1]	—[1]

[22] This document was first made available to BCA analysts in 2001 and is no longer in use.

Value Category	*Initial Value*	*BCAR Updated Value*	*2008 Updated Value*	*2013 Updated Value*	*2016 Updated Value*	*2019 Updated Value*
Per Capita, Per Day Direct Regional Economic Impact (Impact on Economic Activity)	$87	$113	$102	$106	$121	$144
Impact on Residential Customers	none	none	$24	$25	$27	$30
Total Economic Impacts	**$188**[2]	**$208**[2]	**$126**	**$131**	**$148**	**$174**

1 This category was discontinued

2 These Total Economic Impacts = Best Estimate for Residential Customers + Per Capita, Per Day Direct Regional Economic Impact (Impact on Economic Activity) + Impact on Residential Customers

2.10. Loss of Wastewater Services

The methodology presented estimates the value of loss of wastewater service. The loss of wastewater service measures the impact to the economic activity of the country as a whole and for residential customers. The methodology applies to the loss of service resulting from the closure of, or damage to, a wastewater treatment facility. It may not be appropriate to use this methodology to estimate the losses from events that affect a localized area (e.g., it is not appropriate to use the Total Economic Impact standard value from Table 20 below for a break in the wastewater line servicing a residential neighborhood). Localized loss of service situations should be evaluated separately to account for the full impacts to both economic activity and residential customers.

2.10.1. Impacts to Economic Activity

The direct economic impact of loss of wastewater is estimated using GDP data and the importance factors published in ATC-25 (FEMA, 1991). The importance factors published by ATC-25 are widely used in this type of study. These studies typically use GDP data (or Gross State Product data, when studies are focused on a smaller geographic area) to estimate the economic impact to commercial and industrial customers.

Table 20 shows the estimation of the impact to economic activity per capita per day using GDP data and the ATC-25 factors.

2.10.2. Impacts to Residential Customers

According to current FEMA guidelines, the loss of wastewater service for a short time (a few hours or a few days) does not impose significant economic impacts on residential customers. FEMA assumes that a temporary loss of wastewater service entails a total or partial loss of capacity to treat

Table 20: Loss of Wastewater Service Impact to Economic Activity

Economic Sector[1]	*Wastewater Service Importance Factor[2]*	*GDP 2021 (in billions of dollars)[1]*	*GDP per Capita per Day[3]*	*Economic Impact per Capita per Day of Lost Service in 2021*
Agriculture, Livestock[5]	—	—	—	—
Mining[5]	—	—	—	—
Utilities	0.24	$380.6	$3.137	$0.75
Construction	0.20	$958.8	$7.903	$1.58
Manufacturing – Nondurable	0.65	$1,177.6	$9.706	$6.31
Manufacturing – Durable Goods[7]	0.75	$1,385.7	$11.421	$8.57
Wholesale Trade	0.10	$1,383.0	$11.399	$1.14
Retail Trade	0.20	$1,385.5	$11.420	$2.28
Transportation, Warehousing	0.10	$642.6	$5.296	$0.53
Information	0.20	$1,300.7	$10.721	$2.14
Finance, Insurance, Real Estate, Rental, and Leasing	0.20	$4,885.0	$40.263	$8.05
Professional & Business Services	0.20	$2,973.4	$24.507	$4.90
Education, Healthcare, Social Assistance	0.80	$1,932.9	$15.931	$12.75
Arts, Entertainment, Recreation, Accommodation, and Food Services	0.80	$839.6	$6.920	$5.54
Other Services, Except Government	0.20	$447.9	$3.692	$0.74
Government	0.20	$2,772.6	$22.852	$4.57
TOTAL	n/a	**$22,465.9**	**$185.168**	**$59.85**

[1] Source: Bureau of Economic Analysis.

[2] Source: FEMA Publication 224 (FEMA, 1991)

[3] Population data from U.S. Census Bureau (December 31, 2021): 332,402,978.

[4] Rows in this column calculated as Electric Power Importance Factor * GDP per Capita per Day. Total value is summation of each row.

[5] — = Agriculture, livestock, and mining data excluded from the analysis because they are not relevant for municipal systems.

[6] Weighting value of 0.65 averaged the eight sub-sectors with the following values: food/beverage/tobacco products (0.70), paper products (0.80), printing and related support (0.30), chemical products (0.80), textiles/textile product mills (0.70), apparel/leather/allied products (0.50), petroleum/coal products (0.50), and plastic/rubber products (0.50).

[7] Weighting value of 0.75 averaged the nine sub-sectors with the following values: wood & furniture (0.50), nonmetallic mineral products (0.50), primary metal manufacturing (0.80), fabricated metal products (0.80), machinery (0.80), computer/electronic (0.90), equipment/appliances/etc. (0.60), transportation equipment (0.80), and miscellaneous equipment (0.60).

wastewater without affecting the residential disposal of sewage or other wastewater. Residential customers would likely be willing to pay some value to avoid the water pollution of passing untreated sewage through the wastewater system directly into the receiving stream. However, no research value could be found that placed an economic value on wastewater service to customers. Therefore, even though no value was assigned for the loss of wastewater to residential customers, it is unlikely that a real economic value of $0 would be placed on wastewater service. In the BCA Tool, communities are encouraged to include the impacts on residential customers in situations where a cost is incurred or where the impacts can be documented. For example, a city may need to provide portable toilets to residents if a sewer line to a residential neighborhood is severed.

2.10.3. Summary

Table 21 summarizes the values to measure the economic impact of loss of wastewater services and shows the recommended value of $60. Over time, this value has increased from $58 in 2019, $49 in 2016, $45 in 2013, and $41 in 2009.

Table 21: Economic Impact of Loss of Wastewater Service per Capita per Day (in 2021 dollars)

Category	*Economic Impact*
Impact on Economic Activity	$59.85
Impact on Residential Customers	$0
Total Economic Impact (rounded to nearest dollar)	$60

2.11. Loss of Water Services

The methodology presented estimates the value of loss of potable water service. The loss of water service measures the impact to the economic activity of the country and for residential customers.

2.11.1. Impacts to Economic Activity

The direct economic impact of loss of water is estimated using GDP data and the importance factors published in ATC-25 (FEMA, 1991). The importance factors are widely used in this type of study. These studies typically use GDP data (or Gross State Product data, when studies are focused on a smaller geographic area) to estimate the economic impact on commercial and industrial customers.

Table 22 shows the estimation of the impact on economic activity per capita per day using GDP data and the ATC-25 factors.

Table 22: Loss of Water Service Impact to Economic Activity

Economic Sector[1]	*Water Service Importance Factor*[2]	*GDP 2021 (in billions of dollars)*[1]	*GDP per Capita per Day*[3]	*Economic Impact per Capita per Day of Lost Service in 2021 Dollars*[4]
Agriculture, Livestock[5]	—	—	—	—
Mining[5]	—	—	—	—
Utilities	0.40	$380.6	$3.137	$1.25
Construction	0.50	$958.8	$7.903	$3.95
Manufacturing – Nondurable Goods[6]	0.60	$1,177.6	$9.706	$5.82
Manufacturing – Durable Goods[7]	0.70	$1,385.7	$11.421	$7.99
Wholesale Trade	0.20	$1,383.0	$11.399	$2.28
Retail Trade	0.20	$1,385.5	$11.420	$2.28
Transportation, Warehousing	0.20	$642.6	$5.296	$1.06
Information	0.20	$1,300.7	$10.721	$2.14
Finance, Insurance, Real Estate, Rental, and Leasing	0.20	$4,885.0	$40.263	$8.05
Professional & Business Services	0.20	$2,973.4	$24.507	$4.90
Education, Healthcare, Social Assistance	0.40	$1,932.9	$15.931	$6.37
Arts, Entertainment, Recreation	0.80	$839.6	$6.920	$5.54
Other Services, Except Government	0.20	$447.9	$3.692	$0.74
Government	0.25	$2,772.6	$22.852	$5.71
TOTAL	n/a	**$22,465.9**	**$185.168**	**$58.11**

1 Source: Bureau of Economic Analysis.

2 Source: FEMA Publication 224 (FEMA, 1991)

3 Population data from U.S. Census Bureau (December 31, 2021): 332,402,978.

4 Rows in this column calculated as Electric Power Importance Factor * GDP per Capita per Day. Total value is summation of each row.

5 — = Agriculture, livestock, and mining data excluded from the analysis because they are not relevant for municipal systems.

6 Weighting value of 0.60 averaged the eight sub-sectors with the following values: food/beverage/tobacco products (0.70), paper products (0.60), printing and related support (0.30), chemical products (0.80), textiles/textile product mills (0.70), apparel/leather/allied products (0.50), petroleum/coal products (0.50), and plastic/rubber products (0.50).

7 Weighting value of 0.70 averaged the nine sub-sectors with the following values: wood & furniture (0.50), nonmetallic mineral products (0.50), primary metal manufacturing (0.90), fabricated metal products (0.80), machinery (0.60), computer/electronic (0.90), equipment/appliances/etc. (0.60), transportation equipment (0.60), and miscellaneous equipment (0.60).

2.11.2. Impacts to Residential Customers

The methodology used to estimate the economic impact of water supply disruptions was to develop a demand curve for potable water and measure the "welfare loss" associated with a loss of supply. The method of this approach is to obtain the WTP to avoid water supply interruptions, which is defined as the amount of money that residential customers would pay to avoid a loss of water service of a given duration. The mechanism to estimate the consumer's WTP is the integration of a demand curve for water services. This method has been employed in several studies to measure the impact of lifeline interruptions (Dalhuisen et al., 2003; Jenkins et al., 2003; Devicienti et al., 2004). The specification of the demand curve, and hence the welfare loss, was developed in the study *Estimating business and residential water supply interruption losses from catastrophic events* by Brozovic et al. (2007).

The daily welfare loss for a consumer experiencing a loss of water service is given by:

$$W = \frac{\eta}{1+\eta} P_{baseline} Q_{baseline} \left[1 - \left(\frac{BWR}{Q_{baseline}} \right)^{\frac{1+\eta}{\eta}} \right] \quad (86)$$

Where:

W = economic impact per capita per day

$P_{baseline}$ = the average water price when there are no interruptions

$Q_{baseline}$ = the average amount of water consumed when there are no interruptions

BWR = Basic Water Requirement, which represents the minimum amount of water per capita per day required for drinking and basic sanitation

η = the price elasticity of the water demand, defined as $\eta = \left(\frac{dQ}{dP}\right)\frac{P}{Q}$, which measures the change in the quantity demanded of water in response to a change in the price of water

Based on results obtained in different empirical studies, the residential price elasticity of the demand for water is assumed to be equal to -0.41. The average price for water was obtained from a survey conducted by the American Water Works Association (2015) that gathered data from 231 water utility services nationwide. This reports states that the "average" customer pays an average of $34.28 per 1,000 cubic feet (7,480.52 gallons). This figure converts to $4.58 per 1,000 gallons, which is the unit of measurement required for the equation. The average quantity of water consumed was estimated to be 160 gallons per person per day, 23 and was obtained from the *Residential end*

[23] 91 gallons per capita from outdoor uses and 58.6 gallons per capita from indoor uses

uses of water study conducted by the AWWA Water Research Foundation (2016).[24] Finally, the BWR is assumed to be equal to 6.6 gallons per person per day, as defined by Gleick (1996) and the United Nations (UNESCO, 2006) as the minimum needed for drinking and basic sanitation. Most research on basic water requirement is grounded in Gleick's work, which recommends a value between 30 and 50 liters per day of basic water need, which equates to 7.9 to 13.2 gallons per day. Gleick recommended 5 liters per day for drinking water and 20 liters per day for sanitation. The combined value of 25 liters per day equals 6.6 gallons per day, which is the value used in the equation. Inserting the values into the equation, the average individual welfare loss equals $49.54 per capita per day.

According to the International Bottled Water Association, the average price of domestic bottled water was $1.20 per gallon in 2014 (International Bottled Water Assoc., 2014) and has remained steady due to industry competition since 2011. At 6.6 gallons per capita per day, this equates to $7.92 of bottled water required to meet basic water requirements in a post-disaster situation.

The average individual welfare loss equals $49.54 per capita per day. Adding the cost to meet basic water needs of $7.92, the economic impact for residential consumers was estimated as $57.46 per capita per day.

2.11.3. Summary

Table 23 summarizes the values to measure the economic impact of loss of water service. It shows that the economic impact of water service is $115.57 per person per day and is recommended rounded to the nearest dollar, $116 per person per day. This represents an increase from $114 in 2019, $105 in 2016, $103 in 2013, and $93 in 2009.

Table 23: Economic Impact of Loss of Water Service per Capita per Day (in 2021 dollars)

Category	*Economic Impact*
Impact on Economic Activity	$58.11
Impact on Residential Customers	$57.46
Total Economic Impact (rounded to nearest dollar)	**$116**

[24] The study collected data from 23 U.S. cities and included records from a random sample of 1,000 residential customers for each of the cities.

2.12. Loss of Communications/Information Technology Services

The methodology presented estimates the value of loss of communications and information technology (IT). The loss of communications/IT service measures the impact to the economic activity of the country and for residential customers.

2.12.1. Impacts to Economic Activity

The Communications importance factors were determined by subject matter experts at the Department of Homeland Security Cybersecurity and Infrastructure Security Agency. Table 24 shows the estimated impacts on economic activity per capita per day using GDP data and the economic sector importance factors.

Table 24: Loss of Communications/Information Technology Service Impact to Economic Activity

Economic Sector[1]	Communications/IT Importance Factor[2]	GDP 2021 (in billions of dollars)[1]	GDP per Capita per Day[3]	Economic Impact per Capita per Day of Lost Service in 2021[4] Dollars
Agriculture, Livestock[5]	—	—	—	—
Mining[5]	—	—	—	—
Utilities	0.90	$380.6	$3.137	$2.82
Construction	0.10	$958.8	$7.903	$0.79
Manufacturing – Nondurable	0.26[6]	$1,177.6	$9.706	$2.52
Manufacturing – Durable Good	0.32[7]	$1,385.7	$11.421	$3.65
Wholesale Trade	0.80	$1,383.0	$11.399	$9.12
Retail Trade	0.80	$1,385.5	$11.420	$9.14
Transportation, Warehousing	0.70	$642.6	$5.296	$3.71
Information	1.00	$1,300.7	$10.721	$10.72
Finance, Insurance, Real Estate, Rental, and Leasing	0.80	$4,885.0	$40.263	$32.21
Professional & Business Services	0.80	$2,973.4	$24.507	$19.61
Education, Healthcare, Social Assistance	0.70	$1,932.9	$15.931	$11.15
Arts, Entertainment, Recreation, Accommodation, and Food Services	0.40	$839.6	$6.920	$2.77

Economic Sector[1]	Communica-tions/IT Importance Factor[2]	GDP 2021 (in billions of dollars)[1]	GDP per Capita per Day[3]	Economic Impact per Capita per Day of Lost Service in 2021[4] Dollars
Other Services, Except Government	0.50	$447.9	$3.692	$1.85
Government	0.80	$2,772.6	$22.852	$18.28
TOTAL	**n/a**	**$22,465.9**	**$185.168**	**$128.34**

[1] Source: Bureau of Economic Analysis.
[2] Source: Determined by subject matter experts at the DHS Cybersecurity and Infrastructure Security Agency
[3] Population data from U.S. Census Bureau (December 31, 2021): 332,402,978.
[4] Rows in this column were calculated as Communications/IT Service Importance Factor * GDP per Capita per Day.
[5] — = Agriculture, livestock, and mining data are excluded from the analysis because they are not relevant for municipal systems.
[6] Weighting value of 0.26 averaged the eight sub-sectors with the following values: food/beverage/tobacco products (0..30), paper products (0.20), printing and related support (0.25), chemical products (0.30), textiles/textile product mills (0.20), apparel/leather/allied products (0.10), petroleum/coal products (0.30), and plastic/rubber products (0.40).
[7] Weighting value of 0.32 averaged the nine sub-sectors with the following values: wood & furniture (0.10), nonmetallic mineral products (0.20), primary metal manufacturing (0.20), fabricated metal products (0.20), machinery (0.30), computer/electronic (0.50), equipment/appliances/etc. (0.50), transportation equipment (0.50), and miscellaneous equipment (0.40).

2.12.2. Impacts to Residential Customers

As noted, the estimation of loss of communication/IT service calculated in the Economic Valuation Proposal for a Loss of Communications document does not specifically address the residential WTP assessment. By conducting a review of previously conducted WTP studies about Internet service, the following studies were identified with associated findings:

- Savage (2005) used a 2002 nationwide survey of United States residences and reported that "Consumers are willing to pay up to $16.54 (per month) for a more reliable service. Speed is the next most important attribute with a discrete improvement in speed valued at $11.37. Always-on is the third most important attribute with a WTP of $5.07."

- Rosston, et al. (2011), conducted surveys in 2009 and 2010 and found that speed and reliability are important features of Internet service. Results suggest the representative household would be willing to pay $59 per month for a basic service, $79 per month for a reliable service, $85 per month for a premium service, and $98 per month for a premium plus service.

- In a 2018 study, Liua et al. (2018) found that WTP is a function of both download speed (megabits per second [Mbps]) and latency (milliseconds [ms]). Results are presented for nine download speeds, ranging from $17.63 per month for 10 Mbps up to $88.86 per month for 500 Mbps without latency.

- In a 2020 study, Lai, et al, evaluated the disparity between rural and urban areas and found that the mean WTP for residents is between $0.06/Mbps and $0.10/Mbps per month for broadband.

The WTP for Internet service from these studies, as shown in Table 25, were converted to 2020 dollars. All of these values are in terms of monthly fees. The WTP ranges from less than $10 per month for minimal service to more than $100 per month for extremely fast Internet service. This suggests a WTP for basic Internet service of less than $2.00 per day. However, these studies were designed to assess WTP for various levels of service rather than to assess WTP to avoid loss of service.

Recently, the FCC established the Emergency Broadband Benefit (EBB) program (https://www.fcc.gov/emergency-broadband-benefit-media-resources) to assist households struggling to afford Internet service during the COVID-19 pandemic. This program offers $50 per month to qualified households, which equates to $1.64 per day. This value can be assumed to represent the value of basic Internet service.

Table 25: Willingness to Pay for Monthly Internet Service

Author	*Year*	*Attribute*	*WTP per Month ($)*	*WTP per Month (2020 $)*	*WTP per Day (2020 $)*
Savage	2002	Service	5.07	7.17	0.24
		More Speed	11.37	16.07	0.53
		More Reliability	16.54	23.38	0.77
Rosston	2010	Basic	59.00	68.81	2.26
		Reliable	79.00	92.14	3.03
		Premium	85.00	99.13	3.26
		Premium Plus	98.00	114.29	3.76
Yu-Hsin	2018	10 Mbps	17.63	17.85	0.59
		25 Mbps	53.39	54.07	1.78
		50 Mbps	55.76	56.47	1.86
		75 Mbps	65.04	65.87	2.17
		100 Mbps	69.90	70.79	2.33
		150 Mbps	76.55	77.53	2.55
		300 Mbps	82.51	83.56	2.75
		500 Mbps	88.86	89.99	2.96
		1000 Mbps	88.15	89.27	2.94
Lai	2020	10 Mbps	8.00	8.00	0.26
		25 Mbps	20.00	20.00	0.66

Author	*Year*	*Attribute*	*WTP per Month ($)*	*WTP per Month (2020 $)*	*WTP per Day (2020 $)*
		50 Mbps	40.00	40.00	1.32
		75 Mbps	60.00	60.00	1.97
		100 Mbps	80.00	80.00	2.63
		150 Mbps	120.00	120.00	3.95
		300 Mbps	240.00	240.00	7.89
		500 Mbps	400.00	400.00	13.16

2.12.3. Summary

Table 26 summarizes the values to measure the economic impact of loss of communications and internet technology service. It shows that the economic impact of communications/IT service is $129.98 per person per day and is recommended rounded to the nearest dollar, $130 per person per day.

Table 26: Economic Impact of Loss of Communications/Information Technology Services per Capita per Day (in 2021 dollars)

Category	*Economic Impact*
Impact on Economic Activity	$128.34
Impact on Residential Customers	$1.64
Total Economic Impact (rounded)	**$130**

2.13. Reduced Flood Insurance Administrative Costs and Fees

A transaction cost is the fee for making an economic exchange. For flood insurance, transaction costs include all of the material and labor costs associated with the general administration of a policy and transaction costs to administer an insurance claim or Increased Cost of Compliance (ICC) claim. As a result of a flood mitigation project, there may be an associated reduction in the number of claims submitted to the National Flood Insurance Program (NFIP) for private and public properties with a flood insurance policy (FEMA, 2011). The NFIP experiences a reduction in the cost to administer a NFIP flood insurance policy when an insured property is acquired and maintained as open space in perpetuity. Additionally, there is a reduction in claim fees if the resultant flood damages are reduced through mitigation activities such as elevation or flood reduction projects. Such savings in transaction costs is a project benefit. This benefit was first calculated in 2013 and incorporated into the BCA Toolkit with Version 5.0. To be eligible for this benefit, the sub-applicant must provide documentation that the structure being mitigated has an NFIP policy.

2.13.1. General NFIP Policy Administration

According to the October 2021 NFIP Flood Insurance Manual (FEMA, 2021), each NFIP policy contains a “Federal Policy Fee” that the policyholder must pay on each new or renewal policy to defray certain administrative expenses incurred in carrying out the NFIP. According to Appendix I of the manual, a value of $47 is used for the Federal Policy Fee. This fee will be eliminated in the event a flood acquisition or if relocation eliminates the need for an insurance policy.

2.13.2. NFIP Claim Fees

All NFIP Insurance Claim Fees are based on Building Replacement Value multiplied by the percent of damage determined from Depth-Damage Functions (DDF). This benefit will be automatically added to the DDF calculation if the “NFIP policy” box is checked. Table 24 shows the relationship between claim/damage cost and claim-processing fees for claims after August 24, 2017, which is the most recently published data (FEMA, 2019). If the mitigated structure has a NFIP policy, the new methodology will assign a NFIP claim value from Table 24 based on the total damage value (structure and contents) for each flood depth.

Table 27: Relationship Between NFIP Claim Fee and Damage Cost[1]

Claim/Damage Cost Range	*Fee*
$0.01 – $1,000	$525
$1,000.01 – $5,000	$800
$5,000.01 – $10,000	$1,035
$10,000.01 – $15,000	$1,175
$15,000.01 – $25,000	$1,275
$25,000.01 – $35,000	$1,475
$35,000.01 – $50,000	$1,750
$50,000.01 – $125,000	3.4% but not less than $1,750
$125,000.01 – $300,000	2.6% but not less than $4,250
$300,000.01 – $1,000,000	2.4% but not less than $7,800
$1,000,000.01 and higher	2.2% but not less than $24,000

[1] Source: FEMA, 2019

2.13.3. Increased Cost of Compliance Claim Administration

For an insured structure that experiences substantial damage[25] from a flood event, an ICC claim can be filed. Like the claim administration, there is a transaction cost avoided when an insured structure is mitigated. This benefit will be automatically added to the DDF calculation if the "NFIP policy" box is checked in the BCA Toolkit. Table 25 shows the relationship between claim/damage cost and claim-processing fees for claims after September 1, 2004, which is the most recently published data (FEMA, 2019).

Table 28: Relationship Between ICC Claim Fee and Damage Cost[1]

Claim/Damage Cost Range	*Fee*
$0.01 – $1,000	$300
$1,000.01 – $2,500	$425
$2,500.01 – $5,000	$500
$5,000.01 – $7,500	$575
$7,500.01 – $10,000	$650
$10,000.01 – $15,000	$750
$15,000.01 – $25,000	$850
$25,000.01 – $30,000	$1,000

[1] Source: FEMA, 2019

According to NFIP data received from FEMA (personal communication, November 10, 2011), from January 2008 to June 2011, FEMA has closed 3,250 ICC claims averaging $21,879. According to Table 25, this average claim amount results in a fee of $850. This value should be included in the BCA Tool for substantially damaged structures with a NFIP insurance policy.

If the mitigated structure has a NFIP policy, the methodology is to add $850 for each flood depth that calculates a substantial damage scenario.

[25] As defined by the NFIP, "substantial damage" refers to a loss of at least 50 percent of the structure's market value. Structures that are substantially damaged must come into compliance with the local floodplain management ordinance, which typically means the structure must be elevated or demolished. ICC funds can be used for these activities.

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4. Acronyms

AIS	Abbreviated Injury Scale
AMI	Acute Myocardial Infarction
ATC	Applied Technology Council
BCA	Benefit-Cost Analysis
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BRV	Building Replacement Value
CONUS	Continental United States
CPI	Consumer Price Index
CPR	Cardiopulmonary Resuscitation
DDF	Depth-Damage Functions
DOT	Department of Transportation
ED	Emergency Department
EMS	Emergency Medical Service
FEMA	Federal Emergency Management Agency
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
GSA	General Services Administration
HAZUS	Hazards U.S.
ICC	Increased Cost of Compliance

ICU	Intensive Care Unit
M&IE	Meals and Incidental Expenses
MSA	Metropolitan Statistical Area
NEMSIS	National Emergency Medical Service Information System
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NHTSA	National Highway Traffic Safety Administration
OCONUS	Outside of the Continental United States
OMB	Office of Management and Budget
UCR	Uniform Crime Reporting
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
VSL	Value of Statistical Life
WTP	Willingness to Pay