Attachment 13. BCA Technical Memorandum

City of Gastonia Water Treatment Plant,
Resilient Power - FY2022 BRIC

TECHNICAL MEMORANDUM

FEMA Building Resilient Infrastructure and Communities Grant Program

City of Gastonia, Water Treatment Plant – Resilient Power

Benefit-Cost Analysis Memorandum

January 5, 2023

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1 Introduction

FEMA requires that all projects funded through the Building Resilient Infrastructure and Communities (BRIC) program are cost-effective and designed to increase resilience and reduce risk of injuries, loss of life, and damage and destruction of property, including critical services and facilities. This technical report documents that the Water Treatment Plant – Resilient Power Project submitted by the City of Gastonia under the BRIC Fiscal Year 2021 application cycle satisfies applicable cost-effectiveness requirements in compliance with OMB Circular A-94 using FEMA benefit-cost analysis (BCA) methods and tools. The technical memorandum covers the proposed mitigation activity, BCA approach including pre-mitigation and post-mitigation losses, benefits to disadvantaged populations, and analysis results. Analysis documentation also includes a completed FEMA BCA Toolkit Version 6.0, and a BCA Report.

2 Proposed Mitigation Activity

As detailed in the project application, the City of Gastonia proposes to design and install permanent emergency backup power generation at the Two Rivers Water Treatment Plant (WTP). With WTP expansions constructed in 2012 and 2019 to meet increasing water demands, the existing generator on site no longer meets the power requirements to provide continuous water treatment in the event of a power outage. Consequently, there has been seven instances of power interruption that has caused loss of water treatment over the past three years (Appendix E). The City of Gastonia proposes to construct two generators at Two Rivers WTP to provide 100 percent emergency power generation. In addition, the City will install an automatic-transfer switch to match the power demands of the generator.

Table 1 Water Treatment Plant Location

Facility Name	Location Description	Latitude, Longitude
Two Rivers Water Treatment Plant	Gastonia, North Carolina 28052	35.265936, -81.185139

2.1 Project and Maintenance Costs

Table 2 provides total project and annual maintenance costs for implementing the proposed mitigation activity. Project costs were estimated in accordance with FEMA Hazard Mitigation Assistance (HMA) Guidance. Annual maintenance costs include those associated with the following activities (Appendix C):

- Electrical repairs;
- Inspections/Emissions Testing;
- Periodic start-ups; and
- Minor repairs.

Table 2. WTP –Community Lifeline Emergency Power Generation, Project and Maintenance Costs

Mitigation Activity	Project Cost	Annual Maintenance Cost

Water Treatment Plant, Emergency Power Generation	$6,380,800	$21,048.21

3 Benefit-Cost Analysis Approach

3.1 Modeled Events

In accordance with the FEMA BCA Reference Guide and Supplement, expected loss data may be used to calculate benefits to be used in a BCA. This approach involves calculating losses based on expected power outages at the facility. Outage data and recurrence intervals used in this BCA are taken from historic outage data provided by the City of Gastonia and were based on a methodology provided by the FEMA BCA Helpline (Appendix D). For the purpose of this analysis three recurrence intervals were determined using a methodology pre-approved by FEMA. This is consistent with FEMA's "expected" damages approach as detailed in the FEMA BCA Reference Guide and Supplement.

3.2 Project Useful Life

According to the Federal Insurance and Mitigation Administration (FIMA) Job Aid on the Eligibility of Generators, FEMA identifies the project useful life for generators and accompanying equipment as 19 years. *As such a useful life of 19 years was used for the Community Lifeline Emergency Power Generation Project in the BCA Toolkit.*

3.3 Software and References

The FEMA BCA Toolkit Version 6.0 was used to obtain the Benefit-Cost Ratio (BCR) for the proposed mitigation activities included in the scope of work for the project. The following narrative provides the methodology used to obtain the BCR. Following the FEMA BCA Reference Guide and Supplement, this analysis uses engineering assessment and statistical determinations of likely occurrence and associated damages during expected events. The Damage Frequency Assessment Module (DFA) was used within the FEMA BCA Toolkit to prepare this BCA. The DFA Module is the most appropriate module in the BCA Toolkit for utilities and other critical services, such as water utilities. For the purposes of this analysis, the DFA Module was used to assess the benefits of water service at Two Rivers Water Treatment Plant.

3.4 Economic Value of Water Service

3.4.1 Population Served

The Two Rivers WTP services the entire population of the City of Gastonia as well as municipal customers in Cramerton, Bessemer City, High Shoals, Ranlo, Stanley, Kings Mountain, Belmont, Lowell and Clover, S.C. The service population for the Two Rivers WTP Is provided in Table 3 and is based on the utility service area and U.S. Census Bureau data (2020).

Table 3: Two Rivers Water Treatment Plant, Population Served

Facility	Total Service Population
Two Rivers Water Treatment Plant	120,237

Source: City of Gastonia, U.S. Census Bureau

3.4.2 Value of Critical Service

FEMA provides standard values for water service in the FEMA BCA Toolkit. The economic value of water service is defined in the Benefit-Cost Analysis Sustainment and Enhancements Standard Economic Value Methodology Report, dated June 2020. The report provides a $114 value for the economic impact per capita per day for loss of water services in 2020 dollars. It is important to note the importance associated with the value for standard economic impact of loss of water services:

- "In the context of emergency planning, disaster response, and disaster recovery, utilities are often characterized as lifelines. This characterization reflects the great importance that such systems have on the functioning of modern society. For example, loss of function of water or wastewater systems generally has direct economic impacts on a community that are far larger than the cost of repairs of the physical damages alone. Electric power, potable water and wastewater systems are subject to physical damages from natural disasters such as earthquakes, hurricanes and floods. More importantly, however, such systems are subject to loss of function; that is, loss of utility service. Such loss-of-function disruptions often have major negative impacts on affected communities. Hazard mitigation projects for utility systems may eliminate or reduce physical damages in future disasters. However, in many cases, an important motivation or even the primary motivation in undertaking hazard mitigation projects for utility systems is not to reduce the physical damages alone, but rather to reduce the tremendous impacts that the loss of function of such systems may have on the affected communities (What is a Benefit?, FEMA, 2001).
- "(l)loss of service costs may be the most important loss component to consider for critical facilities." Furthermore, "Critical facilities, and the functions they perform, are the most significant components of the (critical infrastructure) system that protect the health, safety, and well-being of communities at risk (FEMA 543, 2007)."
- "In considering critical infrastructure from the public perspective, the primary concern is the length of time and quantity of service denied and the economic consequences of service denial to the critical facility's direct suppliers and customers. In addition to these "direct" losses, the community suffers "indirect" losses through reduced economic activity in general, i.e., to the suppliers' suppliers and customers' customers, and so on. Because infrastructures serve other infrastructures, failure of one can cause a "cascade" of others' failing. Further, because people may reside in one service area, work in another, and receive medical treatment or shop in a third, the entire metropolitan region is usually affected by major outages serving only a portion of the region (RAMCAP, 2010)."

3.4.2.1 Calculating Critical Service

The value of service provide by the Two Rivers WTP is provided as a per capita per day figure as noted in this section. The per day service of the TWP can be calculated as follows:

Service Population x Service Value Per Capita Per Day=Per Day Service Value

Table 4 indicates the per day value of treatment service provided by each pump station using the FEMA standard value of $114.00 per capita for water service. This calculation is completed automatically by the BCA Toolkit 6.0 and should be considered conservative, as it does not represent the value of the critical assets within the pump station.

Table 4 Two Rivers WTP, FEMA Standard Value Per Day

Facility	Estimated Service Population	Per Day Service Value
Two Rivers WTP	120,237	$13,707,018

Source: City of Gastonia, FEMA Benefit-Cost Analysis Sustainment and Enhancements Standard Economic Value Methodology Report

3.5 Determining Losses (Pre-Mitigation)

3.5.1 Expected Power Outages

The DFA module is based on establishing relationships between expected damages at the WTP in question and the return frequencies that caused these damages. For the purposes of this BCA, analysts used recorded historic outage dates and durations (Appendix E) at the Two Rivers WTP to develop assumed likelihoods of recurring events over the PUL of the generator. Outage events since 2018 were used to account for the instance in which the existing generator became insufficient to meet water treatment requirements (seven events). Table 5 identifies anticipated outages per recurrence interval based on this analysis.

Table 5: WTP Anticipated Outages per Recurrence Interval, Pre-Mitigation

Likelihood of Event	Chance of Event Occurrence (%)	The WTP Anticipated Outage Time (Days)	Reasoning of Determination
Frequent Event	100%	0.04 day (1 hours)	It is anticipated that based on outage history records, the facility will experience multiple outages resulting in 1 hour of outage time.
Possible Event	33%	0.17 day (4 hours)	It is anticipated that the facility will experience at least one outage through the PUL of the generator that will result in approximately 4 hours of outage time.
Less Likely Event	17%	1 day (24 hours)	The City of Gastonia provided record of outages which demonstrated 24 hours of total outage time and stand as the longest experienced outage of the Two Rivers WTP to causing water treatment disruption.

Since the PUL of the generator is 19 years based on the FEMA Fiscal Year '15 HMA Guidance, recurrence intervals should be adjusted to reflect the probability of a power outage occurring due to a storm event through this length of time. To refine these recurrence intervals, analysts utilized percent chance probabilities of loss provided in Table 6-1: Probability of Natural Hazard Event Occurrence for Various Periods of Time found within the FEMA P-55: Coastal Construction Manual (Appendix F). Using the information provided by this table, analysts were able to determine more accurate recurrence intervals for an event frequency through the PUL of the generator. The formula used to derive this information is as follows:

1 / 1 – (1-Pa)n = RI

Where:
Pa = Percent Chance of Failure
n = 1 / Project Useful Life
RI = Recurrence Interval in Years

The overall results of this analysis are indicated in Table 6 below and include the appropriate recurrence intervals used in the BCA module to produce the Two Rivers WTP BCR.

Table 6. Two Rivers WTP, Recurrence Interval Determinations

Likelihood of Event	Chance of Event Occurrence (%)	Determined Recurrence Interval (yr.) *
Frequent Event	100%	1
Possible Event	33%	48
Less Likely Event	17%	106

Note: Assumes a Project Useful Life of 19 years the FEMA Fiscal Year '15 HMA Guidance

3.5.2 Loss of Function - Potable Water Service

Based on the information discussed in this technical memorandum, the per day service of water service for Two Rivers WTP can be calculated as approximately $13,707,018. The calculation indicates the per day value of water treatment service provided by the Two River WTP. This calculation is completed automatically by the BCA Toolkit 6.0. With a total value of service per day, using the anticipated outage durations identified above (based upon historical outages), water service would result in the following loss of function values (Table 7).

Table 7: Water Service Loss of Function Values per Recurrence Interval and Anticipated Outage Time, Two Rivers WTP

Recurrence Interval (yr.)	Two Rivers WTP Anticipated Outage Time (days)	Water Total Loss of Function Value ($)
1	0.04	$548,281
48	.17	$2,330,193
106	1	$13,707,018

Source: FEMA BCA Toolkit 6.0

3.6 Level of Protection (Post-Mitigation)

Per the methodology provided in this technical memorandum, the proposed mitigation project will provide a level of protection slightly above the mitigation of the "less likely" event scenario or the 106-year recurrence interval. Therefore, it can be assumed that the impacts at the Two Rivers TWP will be similar to or worse than the 106-year event if power outages exceed this threshold. This identified level of protection is reflected in the BCA at the 107- year storm damages after mitigation (Table 8).

Table 8: Two Rivers WTP, Loss of Function Values per Post-Mitigation Recurrence Interval

Likelihood of Event	Recurrence Interval (yr.)	WTP Anticipated Outage Time (days)	Potable Water Total Loss of Function ($)
Less Likely Event	107	1	$13,707,018

Source: FEMA BCA Toolkit 6.0

4 Analysis Results

The benefit-cost ratio (BCR) for the project is listed in Table 9. Costs included in the determination of the BCR include maintenance costs over the project useful life of the mitigation project. Given that this project benefits a disadvantaged population within the City of Gastonia and climate change impacts, analysts deemed FEMA's Alternative Cost-Effectiveness Methodology for Fiscal Year 2022 BRIC and FMA to be appropriate. Because the analysis performed **at a 7% discount rate yielded a BCR of 1.87** and the analysis performed **at a 3% discount rate yielded a BCR of 2.56**, analysts deemed the project to be cost-effective. This BCR is considered a conservative estimate as additional benefits such as cascading impacts to community lifelines dependent on water service (hospitals, fire, etc.), cost of emergency protective measures, and potential stagnant water contamination costs were not included in this analysis. The BCA Report is provided in Appendix A.

Table 9: Water Treatment Plant – Resilient Power Project, BCA Results

Description	Benefits	Costs	BCR
Water Treatment Plant – Resilient Power	$17,087,748	$6,598,346	2.56

Source: BCA Toolkit 6.0

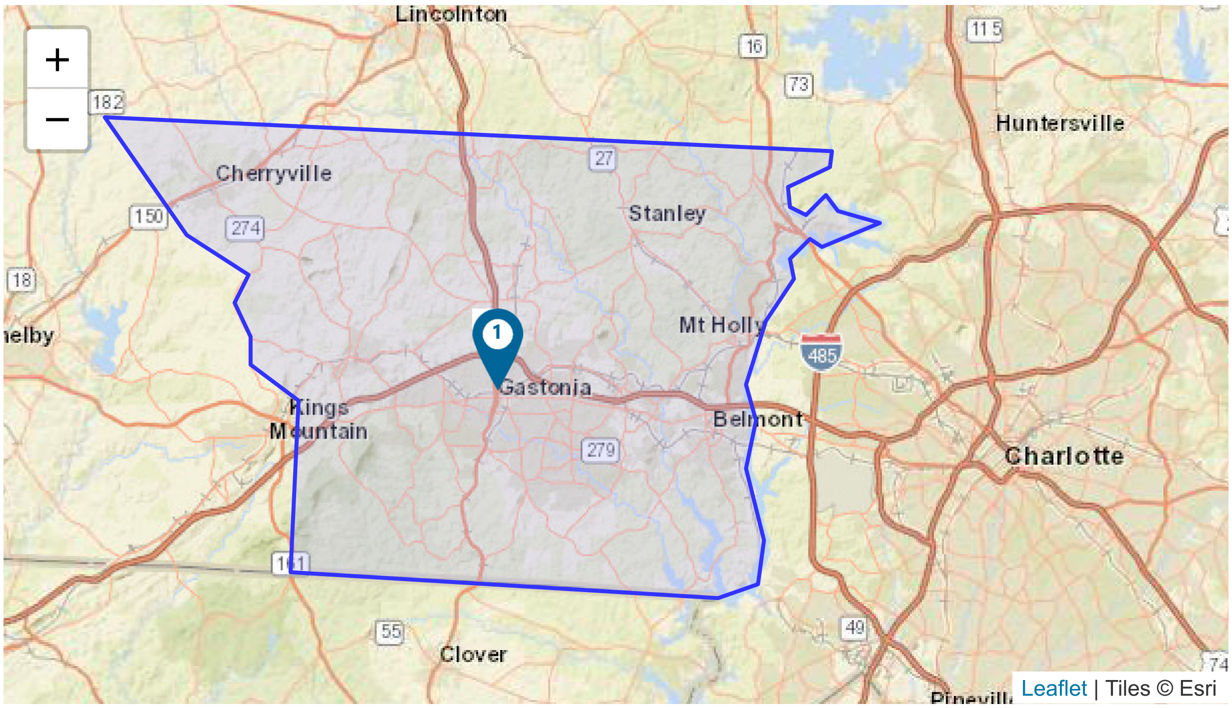
Appendix A
Benefit Cost Analysis Report

Benefit-Cost Calculator

V.6.0 (Build 20230103.1822 | Release Notes)

Benefit-Cost Analysis

Project Name: Water Treatment Plant – Resilient Power



				Using 7% Discount Rate			Using 3% Discount Rate (For FY22 BRIC and FMA only)		
Map Marker ▲	Mitigation Title	Property Type	Hazard	Benefits (B)	Costs (C)	BCR (B/C)	Benefits (B)	Costs (C)	BCR (B/C)
1	Other @ 35.2659360; -81.1851390		DFA - Infrastructure Failure	$ 12,329,972	$ 6,598,346	1.87	$ 17,087,748	$ 6,682,290	2.56
TOTAL (SELECTED)				**$ 12,329,972**	**$ 6,598,346**	**1.87**	**$ 17,087,748**	**$ 6,682,290**	**2.56**
TOTAL				**$ 12,329,972**	**$ 6,598,346**	**1.87**	**$ 17,087,748**	**$ 6,682,290**	**2.56**

Property Configuration

Property Title:	Other @ 35.2659360; -81.1851390
Property Location:	28052, Gaston, North Carolina
Property Coordinates:	35.265936, -81.185139
Hazard Type:	Infrastructure Failure
Mitigation Action Type:	Other
Property Type:	Utilities
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Other @ 35.2659360; -81.1851390

Project Useful Life (years):	19
Project Cost:	$6,380,800
Number of Maintenance Years:	19 Use Default:Yes
Annual Maintenance Cost:	$21,048

Damage Analysis Parameters - Damage Frequency Assessment

Other @ 35.2659360; -81.1851390

Year of Analysis was Conducted:	2022
Year Property was Built:	1920
Analysis Duration:	103 Use Default:Yes

Utilities Properties

Other @ 35.2659360; -81.1851390

Type of Service:	Potable Water
Number of Customers Served:	120,237
Value of Unit of Service ($/person/day):	$116 Use Default:Yes
Total Value of Service Per Day ($/day):	$13,947,492

Professional Expected Damages Before Mitigation

Other @ 35.2659360; -81.1851390

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
1	0.04	0	0	0	0	0	557,900
48	0.17	0	0	0	0	0	2,371,074
106	1	0	0	0	0	0	13,947,492

Annualized Damages Before Mitigation

Other @ 35.2659360; -81.1851390

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
1	557,900	1,126,178
48	2,371,074	65,554
106	13,947,492	131,579
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	16,876,465	1,323,311

Professional Expected Damages After Mitigation

Other @ 35.2659360; -81.1851390

	POTABLE WATER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Impact (days)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
107	1	0	0	0	0	0	13,947,492

Annualized Damages After Mitigation

Other @ 35.2659360; -81.1851390

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
107	13,947,492	130,349
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	13,947,492	130,349

Benefits-Costs Summary

Other @ 35.2659360; -81.1851390

Total Standard Mitigation Benefits:	$12,329,972
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$12,329,972
Total Mitigation Project Cost:	$6,598,346
Benefit Cost Ratio - Standard:	1.87
Benefit Cost Ratio - Standard + Social:	1.87

Appendix B

Project Useful Life

Eligibility of Generators as a Fundable Project by the Hazard Mitigation Grant Program and Pre-Disaster Mitigation Program

Background

Generators are emergency equipment that provide a secondary source of power to a facility. Generators and related equipment (e.g., hook-ups) are eligible provided that they are cost effective, contribute to a long-term solution to the problem they are intended to address, and meet all other program eligibility criteria.

PDM: A generator that is a stand-alone project can be considered for PDM funding if the generator protects a critical facility. Generators and/or related equipment purchases (e.g., generator hook-ups) are eligible when the generator directly relates to the hazards being mitigated and is part of a larger project.

HMGP: A generator that is a stand-alone project can be considered for regular HMGP funding if the generator protects a critical facility. Critical facilities may include police and fire stations, hospitals, and water and sewer treatment facilities. A generator that is a component of a larger project (e.g. elevation of a lift station) is also eligible for regular HMGP funding and the use of aggregation is permitted. Portable generators are eligible provided that they meet all HMGP requirements as described in 44 CFR Section 206.434.

Frequently Asked Questions

General Eligibility and Application Development

How does the information in this Job Aid differ from current practice?

This Job Aid, along with the 2015 Hazard Mitigation Assistance (HMA) Guidance, establishes that the purchase and installation of generators for the protection of critical facilities is an eligible, stand-alone project type under the Hazard Mitigation Grant Program (HMGP) as well as the Pre-Disaster Mitigation Program (PDM), and is no longer limited to the 5 Percent Initiative under HMGP. Generators that constitute a functional portion of an otherwise eligible mitigation solution (critical or not) remain eligible.

Are generators still eligible under the 5 Percent Initiative?

Yes. If there is insufficient data to evaluate a generator project using a standard, HMA-approved Benefit-Cost Analysis (BCA) method the project may be eligible under the 5 Percent Initiative, as described in current HMA Guidance. To perform this evaluation a narrative description of the project's cost-effectiveness must be provided in lieu of a BCA. However, when data is available to perform a standard HMA-approved BCA the standard method must be used.

Are eligible critical facilities limited to those listed in this Job Aid?

No. The critical facilities listed in this Job Aid are not exhaustive. Eligible critical facilities are generally meant to include, but not be limited to, facilities such as hospitals, fire stations, police stations, and water and waste water treatment plants.

Is the purchase of generators for residential structures an eligible activity?

- **Recurrence Determination:** Recurrence information used in the analysis may vary by location or by cause of power failure, such as wind or flood.
- **Other Benefits:** Other benefits (or costs avoided) may be included if they are addressed by the generator project

What information is needed to perform a BCA for generator projects?

Information needed for performing the BCA will vary by facility. However, the following inputs are **required** to run the BCA module. For **all BCAs** performed, the subapplicant must provide all of the following:

- The total project cost
- Useful life (19 years for generators)
- Estimated yearly maintenance costs
- The frequency of the event used in the analysis that would cause a power failure demonstrating the need for a backup power source (generator)
- The number of days that service was affected (without power)

In order to calculate the value of services (benefits to society) the following inputs **must** be included for each specified facility type:

- For Water or Waste Water Services the subapplicant must provide the following:
  - The number of customers affected by the power outage at the treatment plants
- For Hospitals the subapplicant must provide the following:
  - The number of people served by the hospital
  - The distance in miles between the hospital being analyzed and the hospital that would treat these people in the event the hospital was inoperative
  - The number of people normally served by the alternate hospital
- For Police Stations the subapplicant must provide the following:
  - The type of station (metropolitan, city, or rural)
  - The number of people served by the police station
  - The number of officers that work at the station and would serve the same area if the station were shut down as a result of a disaster
- For Fire Stations the subapplicant must provide the following:
  - The number of people served by the station
  - The type of area served by the fire station (urban, suburban, rural, wilderness)
  - The distance in miles to the nearest fire station that would provide protection for the area normally served by the fire station affected
  - If applicable, emergency medical services provided by the fire station

Appendix C

Annual Maintenance Costs

Project Implementation

Identify long-term maintenance needs and expected cost

The twenty year annual on-going maintenance requirements for proposed backup generators is reflected in “Table 2” located in the appendix. The table estimates over a twenty year life the proposed generators will experience a total expenditure of $399,915.95.

Table 2
Twenty Year On-Going Maintenance Requirements For (2) New Backup Power Generators

Year	Annual Maintenance	Extended Warranty	Emissions Testing	Annual Cost
1	$5,000.00		$7,500.00	$12,500.00
2	$5,250.00	$35,000.00		$40,250.00
3	$5,512.50			$5,512.50
4	$5,788.13		$7,875.00	$13,663.13
5	$6,077.53			$6,077.53
6	$6,381.41			$6,381.41
7	$6,700.48	$36,750.00	$8,268.75	$51,719.23
8	$7,035.50			$7,035.50
9	$7,387.28			$7,387.28
10	$45,000.00		$8,682.19	$53,682.19
11	$7,756.64			$7,756.64
12	$8,144.47	$38,587.50		$46,731.97
13	$8,144.47		$9,116.30	$17,260.77
14	$8,551.70			$8,551.70
15	$8,551.70			$8,551.70
16	$8,979.28		$9,572.11	$18,551.39
17	$8,979.28	$40,516.88		$49,496.16
18	$9,428.25			$9,428.25
19	$9,428.25		$10,050.72	$19,478.96
20	$9,899.66			$9,899.66
	Total Expected 20 Year Expenditures			**$399,915.95**

Appendix D

BCA Helpline Response - Approved Methodology

From: McGettigan,Gina [mailto:Gina.Mcgettigan@associates.fema.dhs.gov]
Sent: Tuesday,October 01,2013 11:50 AM
To: BCHELPLINE
Cc:
Subject: RESPONSE: Generator BCA's

Thank you for your phone call requesting information on conducting a Benefit Cost Analysis for a mitigation project utilizing a generator.
During the telephone conversation on 09/30/2013 it was determined that the main focus of your question was assistance with calculating
a recurrence interval for after mitigation damages for the generator project. As we discussed on the phone the following is an appropriate
method for determining the recurrence interval:

Determine the project useful life (PUL)
Determine the percent chance of the mitigation measure failing over the PUL
Use the following formula to determine the recurrence interval:
1/(1-(1-(percent chance of failure))^(1/PUL))1/?1-(1-percent chance of failure)?^(1/((PUL))) =Recurrence Interval in years

Using the example of a 30-year PUL with a 26 percent chance of failure,the recurrence interval will be 100 years

1/?1-(1-.26)?^(1/((30))) = 100 years

Using Microsoft Excel to conduct the calculations this value can be rounded to the nearest whole number using the function
=ROUND(1/(1-(1-(percent chance of failure))^(1/PUL)),0)

A spreadsheet which includes the values and results using these calculations and notes describing the determination of the percent chance
of failure over the project useful life can be attached to the BCA as documentation.

If you have any additional questions regarding Benefit-Cost Analysis,please contact the FEMA BCA Helpline at BCHelpline@fema.dhs.gov
or 1-855-540-6744.

Gina McGettigan
URS Corporation,Contractor

Appendix E

Two Rivers WTP Historic Outage Dates and Durations

Table 1 Two Rivers Utilities Water Plant Backup Power Failures 2018-Current				
Date	**Issue**	**Equip. Outage Duration**	**Incident**	**Impact**
7/16/2021	Gen. Failed to Switch to Utility	24 hrs.	Thunderstorms	Disruption of Drinking Water Production
5/2/2021	Gen. Failed to Start	2 hrs.	Tornado Warnings	Disruption of Drinking Water Production
4/23/2021	Gen. Failed to Start	1 hr.	Multiple Power Utility Interruptions	Disruption of Drinking Water Production
4/5/2021	Gen. Failed to Start	24 hrs.	Thunderstorms	No Back up power
3/18/2021	Gen. Failed to Start	36 hrs.	Thunderstorms	No Back up power
10/29/2020	Gen. Failed to Start	4 hrs.	Multiple Power Utility Interruptions	Disruption of Drinking Water Production
4/8/2020	Gen. Failed to assume load	3hrs.	Thunderstorms	Partial Plant Operation
10/31-11/5/19	Generator failed to start	96 hrs.	Thunderstorms (initially)	No Back up power
10/28/2019	Generator would not shut down	2 hrs.	Thunderstorms	Disruption of Drinking Water Production
5/30/2019	Generator shut down prematurely	1 hr.	Thunderstorms	Disruption of Drinking Water Production
5/10/2019	Generator failed to start	48 hrs.	Power Utility Interruption	No Back up power
9/16/2018	Generator failed to start	2 hrs.	Power Utility Interruption	Disruption of Drinking Water Production
5/24/2018	Generator failed to start	48 hrs.	Thunderstorms	No Back up power

Appendix F

FEMA P-55: Coastal Construction Manual Excerpt

6 Fundamentals of Risk Analysis and Risk Reduction

A successful building design incorporates elements of risk assessment, risk reduction, and risk management. Building success as defined in Chapter 1 can be met through various methods, but they all have one thing in common: careful consideration of natural hazards and use of siting, design, construction, and maintenance practices to reduce damage to the building. Designing in areas subject to coastal hazards requires an increased standard of care. Designers must also be knowledgeable about loading requirements in coastal hazard areas and appropriate ways to handle those loads. Failure to address even one of these concerns can lead to building damage, destruction, or loss of use. Designers should remember that the lack of building damage during a high-probability (low-intensity) wind, flood, or other event cannot be construed as a building success—success can only be measured against a design event or a series of lesser events with the cumulative effect of a design event.

CROSS REFERENCE

For resources that augment the guidance and other information in this Manual, see the Residential Coastal Construction Web site (http://www.fema.gov/rebuild/mat/fema55.shtm).

A critical component of successful building construction in coastal environments is accurately assessing the ***risk*** from natural hazards and then reducing that risk as much as possible. Accurate risk assessment and risk reduction are directly tied to correctly identifying natural hazards relevant to the building site. Before beginning the design process, it is important to understand and identify the natural hazard risks associated with a particular site, determine the desired level of protection from those hazards, and determine how best to manage ***residual risk***. Design professionals must communicate these concepts to building owners so

Table 6-1. Probability of Natural Hazard Event Occurrence for Various Periods of Time

Length of Period (Years)	Frequency – Recurrence Interval					
	10-Year	25-Year	50-Year	100-Year	500-Year	700-Year
1	10%	4%	2%	1%	0.2%	0.1%
10	65%	34%	18%	10%	2%	1%
20	88%	56%	33%	18%	4%	3%
25	93%	64%	40%	22%	5%	4%
30	96%	71%	45%	**26%**	6%	4%
50	99+%	87%	64%	39%	10%	7%
70	99.94+%	94%	76%	**51%**	13%	10%
100	99.99+%	98%	87%	63%	18%	13%

The percentages shown represent the probabilities of one or more occurrences of an event of a given magnitude or larger within the specified period. The formula for determining these probabilities is $P_n = 1-(1-P_a)^n$, where P_a = the annual probability and n = the length of the period.

The bold blue text in the table reflects the numbers used in the example in this section.

6.2 Reducing Risk

Once the risk has been assessed, the next step is to decide how to best mitigate the identified hazards. The probability of a hazard event occurrence is used to evaluate risk reduction strategies and determine the level of performance to incorporate into the design. The chance of severe flooding, high-wind events, or a severe earthquake can dramatically affect the design methodology, placement of the building on the site, and materials selected. Additionally, the risk assessment and risk reduction strategy must account for the short- and long-term effects of each hazard, including the potential for cumulative effects and the combination of effects from different hazards. Overlooking a hazard or underestimating its long-term effects can have disastrous consequences for the building and its owner.

WARNING

Meeting minimum regulatory and code requirements for the siting, design, and construction of a building does not guarantee that the building will be safe from all hazard effects. Risk to the building still exists. It is up to the designer and building owner to determine the amount of acceptable risk to the building.

Although designers have no control over the hazard forces, the siting, design, construction, and maintenance of the building are largely within the control of the designer and owner. The consequences of inadequately addressing these design items are the impetus behind the development of this Manual. ***Risk reduction*** is comprised of two aspects: ***physical risk reduction*** and ***risk management through insurance***.

Eliminating all risk is impossible. Risk reduction, therefore, also includes determining the ***acceptable level of residual risk***. Managing risk, including identifying acceptable levels of residual risk, underlies the entire coastal construction process. The initial, unmitigated risk is reduced through a combination