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Unit 2: Benefits and Costs of Resilience Projects

Hazard Mitigation Cost Effectiveness Analysis Course

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U.S. Department of Transportation
Federal Transit Administration

Unit Objectives

1) Follow a five-step process for estimating costs of a proposed resilience project.
2) Understand eligible project costs and costs required in a benefit-cost analysis (BCA).
3) Identify benefits associated with a proposed resilience project.
4) Determine net present value of resilience project benefits using benefit computation process.
5) Recognize and use BCA terms.

Resilience Project Cost Estimation Process for BCA – Five Steps

1) Estimate total project initial cost.
2) Develop an estimate of annual operation & maintenance (O&M) costs.
3) Develop an estimate of costs associated with interruption of transit service during project construction/implementation.
4) Adjust the estimate to account for project timing and currency of the data used in the estimate.
5) Review and confirm the total BCA project cost.

Step 1: Estimate Total Project Initial Cost

Total project initial cost estimate includes the following costs:

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

Step 2: Develop O&M Costs

Operation & maintenance (O&M) costs:

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

Step 3: Develop Estimated Service Interruption Costs

Costs associated with interruption of transit service during project construction/implementation:

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

Step 4: Adjustments for Project Timing and Data Currency

In some cases, project costs may need to be adjusted to account for project timing and data currency. This involves the following steps

1) Review the resilience project cost estimate to ensure current construction prices are reflected.
2) Review the resilience project cost estimate to ensure current transit data such as average daily ridership data are reflected.
3) Adjust the resilience cost estimate values as needed.

Remember that project costs may escalate over the time between grant approval and actual project construction.

Step 5: Review and Confirm Final BCA Project Cost

Questions to consider regarding the final BCA project cost:

- Includes all tasks in the proposed scope of work?
- Includes quantity of work and unit cost for each task?
- Includes minimal (less than 20%) of listed line items as lump sums?
- Includes general contractor and ancillary costs?
- Escalated forward to reflect project construction time?

Resilience Project Benefits

- Benefits are avoided damages and losses associated with a proposed project.
- Focus on net social benefits
- Categories of benefits for transit resilience projects:
  - Physical damage costs
  - Response and recovery costs
  - Other damage costs
  - Economic impacts from the loss of transit function

Physical Damage Costs

Permanent repair or replacement

- Fixed Structures
  - Transit stations
  - Tracks
  - Maintenance facilities
  - Substations
- Rolling Stock
  - Rail cars
  - Buses
  - Ferries

Source: Metropolitan Transportation Authority


Source: Metropolitan Transportation Authority

Source: FEMA P-942 (PANYNJ)

Response and Recovery Costs

Temporary measures

- Emergency repairs
- Temporary facilities or alternate transit services
- Equipment rental

Source: Metropolitan Transportation Authority

Other Damage Costs

Other costs that may not be included under physical damages or response and recovery

- Debris removal and disposal
- Environmental cleanup costs
- Emergency management costs

Source: Metropolitan Transportation Authority

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Economic Impacts from Loss of Transit Service

- Focus on the value of lost time rather than lost transit revenue
- The HMCE Tool provides a standard value for lost transit service
- Other impacts may include:
  - Additional travel time on alternate transit mode
  - Additional travel time and mileage in personal vehicle

Source: Metropolitan Transportation Authority

Computing Resilience Project Benefits

- Computing benefits requires looking at damages and losses twice:
  - First, pre-resilience (the as-is situation)
  - Second, post-resilience (residual damages)
- Additionally, computing benefits takes into account the following key factors:
  - Hazard frequency (recurrence interval) and severity
  - Economic factors including the useful lifetime of the mitigation project and the time value of money

Hazard Frequency (Recurrence Interval) and Severity

- Hazard frequency, or recurrence interval, is a statement of the probability that a hazard event of a certain severity (magnitude) will occur in a given period of time.
- For flood hazards, the floodplain mapping management has been based on the 1-percent-annual-chance flood, commonly called the “100-year flood” or “base flood”.
- The 1-percent-annual-chance flood – also known as a 100 year recurrence interval flood - has a 1% chance, or a probability of (1/100) = 0.01 of being equaled or exceeded in any given year.

Hazard Frequency (Recurrence Interval) and Severity (continued)

Recurrence intervals and probabilities of occurrences

Recurrence interval, in years	Probability of occurrence in any given year	Percent chance of occurrence in any given year
100	1 in 100 (0.01)	1
50	1 in 50 (0.02)	2
25	1 in 25 (0.04)	4
10	1 in 10 (0.10)	10
5	1 in 5 (0.20)	20
2	1 in 2 (0.50)	50

Source: USGS website (http://ga.water.usgs.gov/edu/100yearflood.html)

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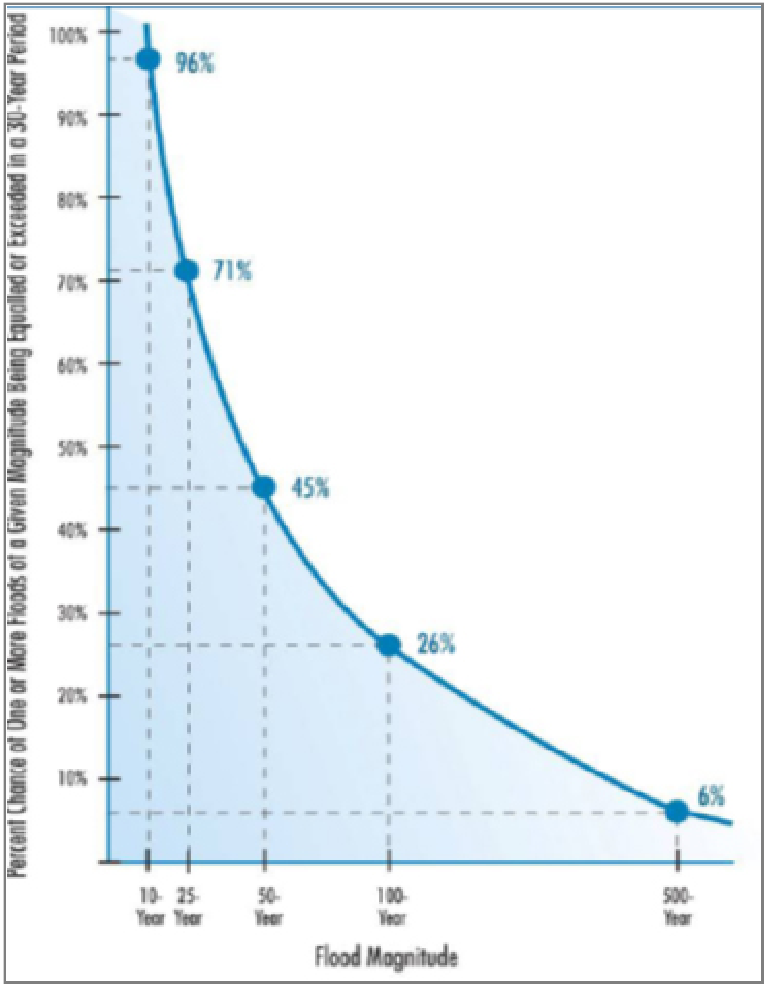
Hazard Frequency (Recurrence Interval) and Severity (continued)

- Occurrence at a specific location does not alter the probability of future occurrences
- As the length of the period increases, so does the probability that an event of a specific magnitude or greater will occur.



Source: FEMA 577 (USGS Bulletin 17B)

Economic Factors: Project Useful Life

Project Useful Life: The estimated time period over which the resilience project will maintain its effectiveness.

Project Useful Lifetimes for Common Projects

Type of Project	Project Useful Life
Acquisition or relocation	100 years
Public transit facility projects	50 years
Public transit infrastructure projects	50 years
Equipment	5 to 30 years

Economic Factors: Project Useful Life (continued)

Project Useful Life is not the same as Project Effectiveness

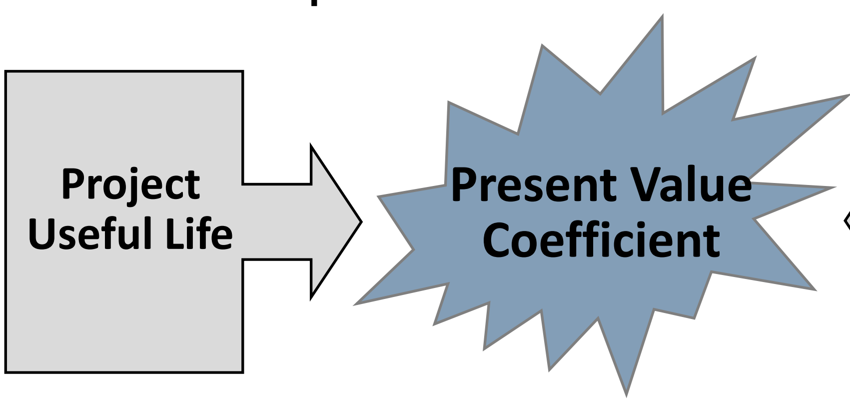
Project Useful Life	**Project Effectiveness**
Length in years of how long the project will physically last	Recurrence interval in years of the level of protection the project provides

Economic Factors: Discount Rate

- Time Value of Money: The amount of goods that can be purchased with a given amount of money typically decreases over time.
- Discount Rate: An interest rate used to determine the time value of money. For Federally funded mitigation projects, the discount rate is determined by the U.S. Office of Management and Budget (OMB) = 7.00%.

Economic Factors: Present Value Coefficient

- Net Present Value: The value "today" of money that you will save in the future, and the basis for Federal Program benefit-cost analysis.
- Present Value Coefficient: Combined effect of the discount rate and the useful lifetime of a resilience project. The PVC is used to bring annualized costs and benefits to the net present value.



Economic Factors: Present Value Coefficient (continued)

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

<u>Where:</u>

PVC = Present Value Coefficient

r = Discount Rate (7.00%)

T = Project Useful Life (years)

Simplified Example

Estimate benefits for the following example project

- **Project:** Construct a flood barrier system to protect a transit station up to the 500-year flood level.
- **Project Cost:** $10 million
- **Project Useful Life:** 50 years
- **Discount Rate:** 7.00%

Source: Metropolitan Transportation Authority

Simplified Example: Pre-Resilience

Recurrence Interval (Years)	*Annual Probability*	Total Damages	Annualized Damages
5	*0.200*	$3,000,000	$600,000
10	*0.100*	$4,000,000	$400,000
50	*0.020*	$6,000,000	$120,000
100	*0.010*	$8,000,000	$80,000
500	*0.002*	$12,000,000	$24,000
		Sum of Annualized Damages	**$1,224,000**

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Simplified Example: Post-Resilience

Recurrence Interval (Years)	*Annual Probability*	Total Damages	Annualized Damages
5	*0.200*	$0	$0
10	*0.100*	$0	$0
50	*0.020*	$0	$0
100	*0.010*	$0	$0
500	*0.002*	$12,000,000	$24,000
		Sum of Annualized Damages	**$24,000**

Simplified Example: Project Benefits

Recurrence Interval (Years)	*Annual Probability*	Total Reduced Damages	Annualized Reduced Damages
5	*0.200*	$3,000,000	$600,000
10	*0.100*	$4,000,000	$400,000
50	*0.020*	$6,000,000	$120,000
100	*0.010*	$8,000,000	$80,000
500	*0.002*	$12,000,000	$0
		Total Reduction in Annual Damages	**$1,200,000**

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Simplified Example: Benefit-Cost Analysis Results

Description	Computation	Result
Total Reduction in Annual Damage	See Previous Slide	\$1,200,000
Present Value Coefficient *(50 year PUL, 7.00% discount rate)*	$\frac{[1 - (1+0.07)^{-50}]}{(0.07)}$	13.80
Total Project Benefits	(\$1,200,000 x 13.80)	\$16,560,000
Total Project Cost	See Previous Slide	\$10,000,000
Benefit-Cost Ratio (BCR)	$\frac{(\$16,560,000)}{(\$10,000,000)}$	**1.66**

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Conclusion: BCA is all about risk

HAZARD (FREQUENCY & SEVERITY)	x	ASSET EXPOSED TO HAZARD	=	HAZARD RISK (DOLLARS)
Probability of Damage		**Value and Vulnerability of Asset Exposed to Hazard**		**Severity of Threat to Built Environment**

- In high risk situations, hazard events are frequent or severe, and the project is more likely to be cost-effective
- In low risk situations, hazard events are infrequent or minor, and the project is less likely to be cost-effective

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Questions and Answers