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Guide Brief 13 –
Resilience Gaps –
Identifying and Prioritizing Closure of Resilience Gaps

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Guide Brief 13: Resilience Gaps – Identifying and Prioritizing Closure of Resilience Gaps

Applicable Section(s) of Guide:	Volume 1, Section 5.3, Prioritize Potential Solutions and Develop Implementation Strategy, p. 51

Purpose and Scope

This Guide Brief aims to assist collaborative planning teams with Step 4, Plan Development, by supporting communities in identifying resilience gaps using the performance goals tables. These performance goals focus on system function rather than individual component performance. The document discusses approaches to prioritize actions that address those gaps and/or mitigation measures to close those gaps. Both are essential aspects of developing an overall resilience plan.

The intended user of this Guide Brief is an analyst or resilience planning team member who helps set priorities for the overall community or for a specific building cluster or infrastructure system.

Section 2 illustrates an example of using performance goals tables to identify resilience gaps. A performance goals table for buildings or infrastructure systems can be used in the same way. Section 3 discusses considerations for evaluating various alternatives for closing resilience gaps. Section 4 discusses three methods for prioritizing resilience gaps that communities can apply.

1. Introduction

The first step in developing a community resilience plan is identifying the gaps between the anticipated performance and the desired performance of building clusters and supporting infrastructure systems. This step is followed by prioritizing mitigation and recovery approaches to address those gaps.

After resilience gaps are prioritized based on the importance of the gaps themselves, adjustments may need to be made to the list of priorities based on additional criteria. For example, if a mitigation measure is very expensive, the gap may move down the list of priorities. Additionally, the feasibility and practicality of the solutions may also affect the prioritization.

While there is no single correct way to approach this task, this Guide Brief reviews a number of possible approaches, considering such concepts as:

1. Economic, social, and environmental elements
2. When the improvement would affect the restoration and recovery process

3. How existing assets may influence decisions
4. The overall importance of the infrastructure in meeting critical needs of the community (particularly in post-event circumstances).

The Riverbend example in Chapter 9 of the Guide develops a number of gap closure projects, all of which are carried forward in that example. Completing all the proposed projects may be possible, but prioritization is always an important aspect of community resilience planning. The National Institute of Standards and Technology (NIST) Economic Decision Guide for Buildings and Infrastructure Systems (EDG) [Gilbert et al. 2015] investigates two competing Riverbend bridge mitigation approaches from an economic perspective.

2. Identify Resilience Gaps

This section provides an example of identifying a resilience gap (desired versus anticipated performance) by inspecting the completed performance goals table and comparing desired goals with anticipated performance using one infrastructure system, the wastewater system.

Table 1 shows an example for wastewater infrastructure. In the table, desired performance goals are color-coded for 30 % (orange), 60 % (yellow) and 90 % (green) recovery. The anticipated performance can be estimated for 30 %, 60 %, or 90 %, or for other levels desired by the user. In this example, the anticipated performance for 90 % restoration is designated with an X (blue) in the table. Each desired performance goal and the anticipated performance for the wastewater system is listed below the design hazard performance in terms of days, weeks, or months.

The wastewater infrastructure subsystems (treatment, trunk lines, etc.) and functions (backbone collection, flow equalization, etc.) are shown in this example. The performance goal for critical facilities and emergency shelters has the shortest recovery time, with a goal of 30 % restoration in 1 to 3 days, 60 % in 1 to 4 weeks, and 90 % in 4 to 8 weeks. The anticipated performance for 90 % restoration (i.e., the estimate for when 90% restoration will be achieved) is 4 to 24 months. The gap is the difference between the 90 % goal (4 to 8 weeks), and anticipated performance for 90 % restoration (4 to 24 months) [see Gap A in Table 1]. Converting the 90 % goal to months, it becomes 1 to 2 months (4 to 8 weeks). The gap is then 3 to 22 months (4 to 24 months minus 1 to 2 months).

The analyst could also evaluate the gap between the lower recovery percentage goals (e.g., the desired 30 % performance and achieving 30 % performance). These lower recovery percentage goals could be important recovery of function for critical facilities.

Table 1. Wastewater infrastructure performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Wastewater Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Treatment Plants										
Treatment plants operating with primary treatment and disinfection	R, S			60%	90%				X	
Treatment plants operating to meet regulatory requirements	R, S				30%			60%	90%	X
Trunk Lines										
Backbone collection facilities (major trunkline, lift stations, siphons, relief mains, aerial crossings)	R, S			30%		60%	90%			X
Flow equalization basins	R, S			30%		60%	90%			X
Control Systems										
SCADA and other control systems	R, S				30%		60%	90%		X
Collection Lines										
Critical Facilities										
Hospitals, EOC, Police Station, Fire Stations	R, S			30%	90%	←	GAP A	→	X	
Emergency Housing										
Emergency Shelters	R, S			30%	90%	←	GAP B	→	X	
Housing/Neighborhoods										
Wastewater collection to trunk lines	R, S				30%	60%	90%		X	
Community Recovery Infrastructure										
All other clusters	R, S				30%		60%		90%	X

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

4 Indicate levels of support anticipated by plan
R = Regional; S= State; MS=Multi-State; C = Civil (Corporate/Local)

The next step by the analyst is to summarize wastewater performance goals in the summary resilience table for building clusters and infrastructure systems. Table 2 (Table 9-17 in Volume 1) summarizes performance gaps for four categories of community resilience – critical facilities, emergency housing, housing/neighborhoods, and community recovery. Bring Gaps A and B, the gaps for critical facilities and emergency housing, from Table 1 forward to Table 2.

Table 2 summarizes the impact of physical infrastructure on the building clusters that support societal functions (i.e., critical facilities, emergency housing, housing/neighborhoods, and community recovery). Table 2 allows community members to see what the anticipated performance of building cluster and infrastructure systems would be and which societal functions the performance expectations would impact. An example of a significant gap in Table 2 is the anticipated poor building performance for critical facilities (Gap C). Alternative strategies can be proposed that may include mitigation, or plans to use temporary buildings brought in immediately following the hazard event. Gaps A and B, identified for wastewater in Table 1 is also shown in Table 2.

Table 2. Summary resilience table of performance goals for design earthquake

Disturbance [1]	
Hazard Type	Earthquake
Hazard Level	Design
Affected Area	Community
Disruption Level	Moderate

Restoration Levels [2,3]	
30%	Function Restored
60%	Function Restored
90%	Function Restored
X	Anticipated Performance

Summary Resilience Table	Design Hazard Performance								
	Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Buildings	90%	←			GAP C		→	X	
Transportation		90%	X						
Energy		90%	X						
Water			90%		X				
Wastewater				90%	←	GAP A	→	X	
Communication	90%			X					
Emergency Housing									
Buildings				90%					X
Transportation			90%	X					
Energy			90%	X					
Water			90%		X				
Wastewater				90%	←	GAP B	→	X	
Communication				90%	X				
Housing/Neighborhoods									
Buildings						90%			X
Transportation			90%	X					
Energy			90%	X					
Water				90%				X	
Wastewater						90%		X	
Communication				90%			X		
Community Recovery									
Buildings								90%	X
Transportation				90%	X				
Energy			90%	X					
Water				90%				X	
Wastewater								90%	X
Communication				90%			X		

Footnotes:

1 Specify hazard type being considered
Specify hazard level – Routine, Design, Extreme
Specify the anticipated size of the area affected – Local, Community, Regional
Specify anticipated severity of disruption – Minor, Moderate, Severe

2 30% | 60% | 90% Desired restoration times for percentage of elements within the cluster

3 X Anticipated performance for 90% restoration of cluster for existing buildings and infrastructure systems
Cluster recovery times will be shown on the Summary Matrix

3. Considerations for Prioritizing Gap Closure

3.1. Introduction

After identifying the resilience gaps of building clusters and supporting infrastructure systems, consider how to prioritize efforts to close these gaps. Starting with the desired response times of the various performance goals themselves may be a good option, where the most important performance goals have the shortest desired response time. The response timeframe categories are emergency response, temporary restoration/community stabilization, and long-term restoration phases.

When improving resiliency it is critical to consider the time it takes to restore critical functions so people can live and work in a community. Communities can develop a multi-dimensional decision matrix that addresses a wide range of social, economic, physical, and environmental considerations, possibly weighing the various parameters considered. Some examples of these considerations include:

- Interdependencies of the various building clusters and infrastructure systems
- Hazards and uncertainties
- Cost
- Equity
- Political feasibility
- Environmental impacts
- Time in terms of emergency response, temporary recovery, or long-term recovery
- Available assets
- Other observations – largest gaps, low hanging fruit

Some of these considerations can be combined, and most overlap to some extent. The triple bottom line (see Section 3.5) includes economic, social, and environmental considerations. Some assessments may go into much greater detail. For example, benefit cost analyses can have many elements that quantify the benefits in terms of losses avoided, and costs of mitigation projects.

There is no right or wrong approach to prioritization, and results will likely differ from community to community even when the same gaps are present. Communities use the results of the completed decision matrix to help allocate resources to drive gap closures.

3.2. Dependencies

The primary component required to provide each service (e.g., healthcare) likely requires supporting infrastructure (e.g., hospital) and, without that infrastructure, the primary component by itself may be of limited value. For example, a hospital building in perfect condition is of limited value if the energy infrastructure is out of service. This dependency needs to be considered during prioritization.

The desired performance of the primary component and the infrastructure systems on which it depends should be consistent. That is, the infrastructure system(s) should be functional no later than the desired performance of the primary component itself. Moreover, consider how the primary function and supporting functions can be delivered. For example, a hospital should be able to operate as a self-contained unit using a standby generator and stored water for approximately 72 hours (3 days) before the power supply and potable water system are restored.

3.3. Hazards and Uncertainty

Because the occurrence of hazard events varies geographically, each community needs to identify the probability of each individual hazard occurring for itself. Hazard information is available for common hazards such as earthquake, flood and wind from the U.S. Geological Survey (USGS), Federal Emergency Management Agency (FEMA) and American Society of Civil Engineering Standard 7 (ASCE 7), and are referenced within the Guide. In the Guide, hazards are grouped as *routine*, *design*, or *extreme* events. Scientists in the community use their best judgment estimating the probability each type of hazard will occur. Having these estimated probabilities of occurrence allows the community to perform an economic analysis.

The results of a benefit-cost analysis, discussed in Section 3.4, are highly sensitive to those probabilities. Benefits, in terms of losses avoided, are converted to annualized losses. Losses from a 500-year flood scenario are divided by 500; for a 100-year flood, divide by 100. The Hazus technical manuals, which provide detailed information, and annualizing losses for hazard events over a range of recurrence intervals, are available from FEMA at https://www.fema.gov/media-library/assets/documents/24609. However, where there is limited or unclear data, the estimates can be very uncertain. In recent years, for example, multiple 100-year floods have occurred in one year.

Statistical approaches are available to help address these uncertainties, as discussed in Appendix C of the NIST Economic Decision Guide.

3.4. Economics

Community planners can use an economic analysis, referred to as a *benefit-cost analysis* (BCA), to determine whether a project makes economic sense or to compare multiple projects. Specifically, communities need to determine whether investing money in a project will ultimately deliver a positive return on that investment by avoiding losses. In a BCA, benefits are evaluated in terms of co-benefits and losses avoided; costs are evaluated in terms of the cost of building, operating, maintaining and retiring the infrastructure project.

Benefits, co-benefits, and losses avoided may include:

- Benefits in terms of the improved functionality of an infrastructure project not directly associated with its hazard performance
- Direct damage and associated repair costs to a facility
- Indirect losses, such as interruption in the lives of residents and business operations
- Environmental impact (e.g., contamination resulting from a hazard event)

One example of an indirect loss is loss of life. The US Army Corps of Engineers (USACE) placed a value on the loss of life as part of losses avoided if, for example, a flood protection project is constructed. Another indirect loss might be impact of outage time on employers having to shut down if the various infrastructure systems are not functional.

The costs in the categories identified in the bulleted list above need to be quantified to provide a complete economic assessment. The costs could include the planning, design, and construction cost of a facility designed for flood control. For the same project, the cost could also include the impact on a community, such as costs associated with displaced neighborhoods.

The results of a BCA are presented in terms of present value. Everything is converted to current values through discounting at the time the project is undertaken. The hazard event return period is one of the most significant factors in the analysis, in calculating the present worth of the losses avoided. Take into account the probability of occurrence, or the recurrence interval of an event. Divide the losses avoided by the recurrence interval, in years, to get the present value. The present worth of the proposed resilience project when analyzed against hazard events that occur regularly, such as every ten years, can be high compared to events that only occur every 100 or 500 years. Of course, the less probable events are likely to be more damaging, so analysis should be done over a range of return periods corresponding to the routine, design, and extreme hazard events, as well as no occurrence of a hazard event

A BCA is useful but, in many cases, resilience projects may not be economically justified, that is, where the benefit is less than the cost. It may require a community policy to dictate building requirements. For example, building codes contain many provisions that may not result in a BCA benefit (or have not undergone a BCA evaluation). Another example would be a city building seismic upgrade requirement for instances when the cost of a building's general upgrade exceeds 50 % of its value. In this case, the city may have adopted a policy to generally reduce earthquake loss-of-life or injury without doing a BCA.

NIST, the Federal Emergency Management Agency (FEMA), and the USACE all have benefit/cost analysis methodologies.

The NIST Economic Decision Guide (EDG). The NIST Economic Decision Guide (EDG) lays out the steps in developing a BCA for resilience planning alternatives. Appendix A of the EDG steps through an example that compares two solutions for bridge rehabilitation/replacement in Riverbend. One solution upgrades the existing bridge, while the other solution constructs a new bridge nearby. The example develops costs of the bridge upgrade and the new bridge. The replacement cost of the existing bridge is evaluated, including the indirect costs associated with traffic delays. The uncertainty of the hazard event is also addressed. The example recommends the new bridge solution because it has a greater present value. The evaluation does not explicitly take into account a comprehensive assessment of social or environmental considerations.

Federal Emergency Management Agency (FEMA). FEMA developed a detailed economic analysis methodology to support their Hazard Mitigation Program (https://www.fema.gov/benefit-cost-analysis). It is a very structured methodology with data available for the most common hazards. Because users need to be familiar with the methodology to use it, FEMA provides training classes throughout the country and provides extensive documentation to support the process.

Grant applicants are required to prepare a detailed BCA in support of their projects. The package includes a toolbox to assist the user, stepping through a spreadsheet populating it cell-by-cell. The grant applicant is allowed to use the structured methodology or an alternate approach that is more applicable to a particular project. FEMA uses the results of these BCAs to rank grant applications submitted for funding.

The methodology is straightforward and readily used by professionals with engineering backgrounds. The methodology is widely used because, if successful, the community gets FEMA Hazard Mitigation Planning (HMP) grant money. However, the FEMA methodology does not allow incorporation of social or environmental issues into the model, unless they are quantified economically.

USACE. The USACE has used BCA for decades, particularly for their large dam and waterways projects. They established standardized values for many parameters, including the value of a life. Their methodology follows the classic build for a BCA, but allows extensive flexibility in its application (https://planning.erdc.dren.mil/toolbox/index.cfm). While the USACE methodology often takes into account social and environmental impacts, they must be quantified economically.

3.5. Triple Bottom Line

In some cases, communities decide that using economic justification alone is too limiting. The triple bottom line methodology was developed in recent decades for project justification, combining economic and non-economic considerations:

- ***Economic* –** Addresses economic impacts in term of indicators such as benefits and costs, internal rate of return, savings to investment ratio, and return on investment
- ***Social impacts* –** Addresses social impacts, social needs, and recovery times, all in quantitative terms
- ***Environmental* –** Addresses environmental impacts in terms of subjective indicators, such as sustainability, low impact on the natural setting and wildlife, community friendly, etc.

In these cases, non-economic criteria are quantified in non-economic terms that subsequently combine with economic evaluation results to reach a decision.

3.6. Time

Consider time in terms of emergency response, temporary recovery, or long-term recovery. For example, it may be appropriate to depend on an inexpensive work-around in the short-term. In the longer-term, replacement of the building or infrastructure system components could be integrated with other project drivers, such as capacity, decreased functionality, etc.

Another aspect of time is that the longer services are not provided and the communities needs are not met, the more likely it is that sections of the population will leave the area. Such relocations, even if they are temporary, can have a detrimental impact on the economy of the community and its recovery.

3.7. Interim Solutions

Some suggest that the highest gap closure priority should be assigned to the largest gaps. While this may be a consideration, the discussion above points to many other concepts that communities should consider first. The least expensive approaches to gap closure (e.g., low hanging fruit) could be given a high priority if they can be implemented without interfering with other projects. Temporary solutions may be part of the overall mitigation strategy to allow other needed improvements to be completed.

3.7.1. Incorporating Federal Aid

Some communities believe post-event federal grants for restoration are their insurance policy. However, while such funds are helpful, they are often not sufficient to support full recovery of community functions.

For instance, FEMA and U.S. Department of Housing and Urban Development (HUD) have specific rules for awarding mitigation and recovery grant funding. These rules may affect decisions on how to prioritize closure of gaps. A more comprehensive approach is for the community to have recovery plans in place prior to a hazard event that can include the award of any federal resources, so that the full context of recovery options are considered.

3.7.2. Collaboration of Infrastructure Systems

Collaboration of infrastructure systems on strategies and plans to address overall community needs for the future, and during recovery, will improve resilience through identification of potential issues and possible solutions. For example, infrastructure support for critical facilities, such as hospitals, fire and police stations, and shelters, needs to be addressed by all supporting infrastructure providers. The availability of functional critical facilities is crucial to community recovery.

3.7.3. Available Assets

All communities have limited assets available to proceed with projects to close resilience gaps. Typical asset categories include financial, personnel, and relationships.

Financial. Financial assets are capital raised through borrowing (e.g., selling bonds). Repaying bonds would be covered by taxes (e.g., property, gas, income) or user fees (income from selling water). Local financing may pay for earthquake structural upgrade of the city hall or the city-owned bridge crossing the river, but it would not be used for mitigating the hazard vulnerability (e.g., tornado winds) of a manufacturing facility.

Personnel. Availability of personnel can be problematic. The community needs adequate staff to manage gap closure. Staff must manage mitigation projects (related to financial), acquire grants, and interact with other stakeholders (e.g., state government, private sector) that may undertake closure of performance gaps in the systems they own. On the same note, a staff grant-writing specialist can pursue various grant opportunities but would have limited capability to manage a bridge design project.

Relationships. Relationships with other stakeholders can influence a community's ability to close some gaps. The community has preexisting relationships with community stakeholders that are not under their control. In some cases, these can be relationships with private sector or other government entities that are stakeholders in the community. Stakeholders can include other government-owned facilities (e.g., state highway, VA hospital etc.) and privately owned stakeholder facilities (e.g., hospitals, communications companies, power companies).

In some cases, these other stakeholders may focus more on profitability than resilience. Some locally-owned businesses may be more receptive to investing in the community resilience plan, while remotely owned businesses possibly have limited interest. Influential community politicians and business owners may have influence in convincing a communications company or power provider to close a performance restoration gap, but it would seem to be of limited value to try to prioritize gap closure for privately owned utility service providers in the same group as publicly owned facilities.

4. Ranking and Prioritizing Solutions

4.1. Introduction

To prioritize resilience alternatives, quantify and rank all considerations—social, environmental, economic— in a single rating system. The rating system should have a weighting system. For example, different attributes of social impacts could be plugged into a spreadsheet and calculated. Unfortunately, the importance of social and environmental issues and their relationship to economic impacts is based on community values and will be different for each community.

The subsections below briefly describe methodologies developed by various resilience-focused organizations. These example approaches have some merit for supporting the process of ranking and prioritizing solutions. While the methodologies have some limitations (e.g., only address a single hazard type), they provide a reasonable starting point for this activity. Additional methodologies, such as multi-criteria decision analysis [e.g., see Gregory and Keeney 1994; Porthin et al. 2013; Scrieciu et al. 2014; Wardekker et al. 2016] and other optimization techniques where multiple criteria are simultaneously optimized, also provide useful support for prioritization.

4.2. The Community Resilience Building Workshop Program

The Nature Conservancy developed the Community Resilience Building Workshop [2017] over the last decade to assist communities in developing actionable resilience plans. This ground-up process involves community stakeholders who participate in the planning and, ultimately, implementation of the resulting priority actions. The program envisions 6 months of data gathering and preparation that culminate in a single workshop of engaged stakeholders. It is a facilitated approach, centered on a risk matrix, that leverages the experience of participants. The program, process, a variety of tools, and case study examples are available at www.communityresiliencebuilding.com.

The process is similar to the six steps outlined in the Guide. It characterizes a community in terms of infrastructural, societal, and the environmental components impacted by hazard events, as well as other features that make the community stronger against hazards. It characterizes the hazards to be considered and identifies the community's vulnerabilities and strengths using a variety of trigger questions. Participants develop a set of proposed actions to improve resiliency for each of the three components, based on their experience and intuition. They prioritize each action (high, medium, or low) and assign a level of urgency (ongoing, short-term, long-term). The process begins with small groups considering various aspects of the community. The entire workshop participates in a voting process to select the 3 to 5 highest priority actions.

Dozens of communities (e.g., Bridgeport and Madison, CT) have used the workshop to develop a list of highest priority actions, although the process is heavily dependent on the experience and intuition of the participants that attend. The process of forming the planning team and gathering data for the risk matrix will benefit greatly from the systematic approach offered in the Guide.

On the surface, it appears this technique would work well for small counties, suburban, and single industry communities where the intuitive thinking and decision making of a group of community stakeholders would derive competent action items. The size, complexity, and diversity of urban cities and large counties will likely need a more systematic approach that benefits from some level of analytical evaluation.

4.3. NIST Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems

The NIST EDG standard methodology for evaluating alternate investments aims to improve resilience in terms of future streams of costs and benefits where benefits are characterized as cost savings and damage loss avoidance. It also explores topics related to non-market values and uncertainty.

As shown in Figure 1 and discussed in detail below, the EDG provides a 7-step process for considering alternate methods of increasing community resilience:

1. ***Select Candidate Strategies.*** Identify the gaps between desired and anticipated performance. Use these gaps to identify a list of potential solutions. The Guide characterizes possible solutions as either *administrative* or *construction*. The administrative solutions are cost neutral, although some, such as land use planning, have long-term economic impact. Construction solutions have immediate cost and long-term benefits. Prioritizing construction solutions should focus on analyzing costs and benefits related to both individual projects and building clusters/infrastructure systems.
2. ***Define the Investment Objectives and Scope.*** At a minimum, consider all factors to which you can easily assign a value. Make sure to include factors that can be assigned indirect cost and benefit. For example, a community may consider improving its residential construction to allow residents to shelter in place in lieu of providing emergency and interim housing for all displaced individuals

3. ***Identify Benefits and Costs.*** The cost and benefits will likely need to be estimated for both individual projects, such as rehabilitation of a public building, and community-wide mitigation programs. For publically owned buildings and community mitigation programs, count the cost of providing temporary solutions as losses until restoration projects are concluded, based on the performance table.
4. ***Identify non-market (non-economic) considerations.*** The EDG provides a detailed listing of the performance levels for all building clusters and infrastructure systems and their link to the social institutions. Use this linkage to develop an estimate of the cost (losses) related to non-market considerations.
5. ***Define Analysis Parameters.*** Make assumptions related to time horizon, discount rate, and risk tolerance in a manner consistent with the particular analysis. Community-based mitigation policies will likely require different assumptions than those used for individual buildings and systems.
6. ***Perform the Economic Evaluation.*** While not specifically covered in the EDG, consider alternate methods to set priorities for mitigation programs based on the analysis results.
7. ***Select Strategies.*** Many hazard events considered in the EDG are low probability-high consequence events that have traditionally been omitted from BCAs. Yet, when the hazard does occur, the true losses are recognized and they far outweigh the costs. The Guide's performance goals tables provide a very detailed estimate for anticipated events. Attempt to judge the impact of the expected damage and lost functionality in the ultimate ranking, along with the cost of providing temporary repairs. Using this information along with a Triple Bottom Line analysis can assist in that process.

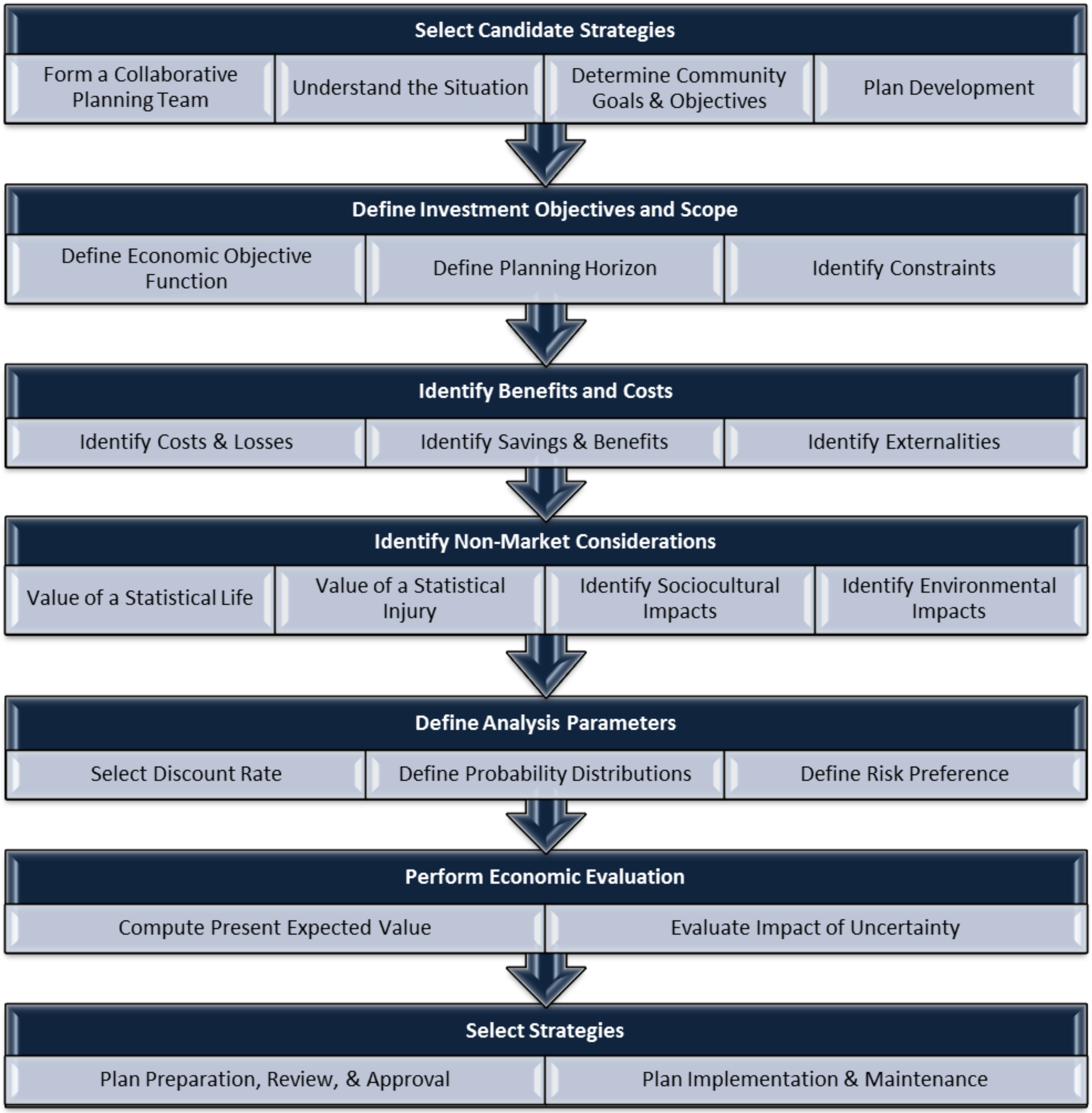

Figure 1. Flow chart illustrating elements of NIST Economic Decision Guide

From a community resilience planning perspective, the EDG is well suited for applications by urban cities and large counties. Its ability to look rationally at the cost and benefit of a large number of specific potential programs is needed to get an accurate assessment of each program's priority.

4.4. Boulder County Collaborative Resilient Design Performance Standard

The communities in Boulder County, Colorado, formed a Collaborative after the floods of 2013 to spearhead a regional, community-appropriate plan for successful recovery. The Collaborative received a sub-allocation of the Community Development Block Grant Disaster Recovery (CDBG-DR) funds from the US Department of Housing and Urban Development (HUD) with the stipulation that they use funds to build-back-better based on resilience performance standards. Since such standards do not exist, the Collaborative developed a standard [Boulder County CDBG-DR Collaborative 2016] based on the Guide, with the help of a consulting team. The resulting standard provides NIST-inspired performance goals integrated into the Colorado State Resiliency Framework. This standard was created as part of the process to complete their application for repair-rebuilding projects and all future building and infrastructure system projects.

The standard includes three steps:

1. Determine the hazard level for the project, all applicable local state and federal construction standards, and the specified performance level in terms of the return to function goal and the target functionality goal (30 %, 60 %, or 90 %).
2. Complete a resilient design performance standard matrix that integrates resilience practices with sustainability practices and the Colorado State Resiliency Framework. A scorecard is provided that combines all attributes of the desired integration. Scoring is based on:
   - ***Co-Benefits.*** Provides solutions across multiple sectors and addresses multiple problems
   - ***High Risk and Vulnerability.*** Addresses reduction in risk
   - ***Economic Benefit Cost.*** Makes good financial investments considering both direct and indirect returns
   - ***Social Equity.*** Provides solutions that consider the impact on vulnerable populations
   - ***Technical Soundness.*** Reflects best practices that have been tested and proven
   - ***Innovation.*** Advances new approaches and techniques
   - ***Adaptive Capacity.*** Includes measures that can cover uncertainty in conditions
   - ***Harmonize with Existing Activities.*** Builds on existing efforts that are environmentally friendly, sustainable, and complementary to the natural setting
   - ***Long-Term Lasting Impact.*** Creates long-term gains and benefits for present and future generations
3. Present a business case to document compliance.

The Boulder County Integrated Design Standard established a minimum score to declare when a project was built-back-better and eligible for HUD funding. In the context of this discussion, the scoring system establishes the relative merits of a community’s construction solutions and prioritizes implementation.

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