3. Community Disaster Resilience for the Built Environment

3.1. Community Level Disaster Resilience

Communities come in varying sizes and shapes and they all face a wide range of opportunities, challenges, and hazards. A community can be as small as a neighborhood and as large as a nation. For the purposes of this framework, a community is defined as an area under the jurisdiction of a local governance structure , such as incorporated cities and counties.

Boosting community disaster resilience is best initiated at the neighborhood level, organized around a well-orchestrated community effort and supported, as needed, by state and national efforts and sufficient physical infrastructure (NRC 2012). As described in Chapter 2, community disaster resilience begins by recognizing the social needs during recovery that will provide the basis for establishing performance goals for recovering the physical infrastructure. Rebuilding infrastructure will encourage and allow the members of the community to stay and support the recovery.

Physical infrastructure provides the foundation for community disaster resilience. A strong foundation provides the tools and systems needed by the people, businesses and government to restore the neighborhoods, care for vulnerable populations, and restore the community's economy. Chapter 2 defines what is needed in terms of the social infrastructure during the three phases of recovery: emergency response, restoration of the workforce, and community recovery.

To understand what is needed from the physical infrastructure for each of those phases, a disaster resilient physical infrastructure is defined by performance level and restoration time needed for clusters of like functions. Those definitions, which become the metrics for resilience, are used to compare to the existing conditions to define gaps that represent opportunities for improvement.

Every community is different and will approach the development of a community resilience plan from a different perspective, tolerance for risk, and planning process. The vitality and usability of the plan depends of its unique adaptation to its community. Implementation will require a broad base of support, which can only be derived from a similar broad base of planning support.

3.1.1. Community Disaster Resilience for the Built Environment

The term resilience means the ability to prepare for and adapt to changing conditions, and withstand and recover rapidly from disruptions. As it relates to the physical infrastructure, resilience means the ability of a building or system cluster to return to full occupancy and function, as soon as it is needed, to support a well-planned and expedited recovery. After identifying the social needs and the building or infrastructure system cluster needs, the next priority is to identify how soon each is needed. The timing will depend on both the type and intensity of the disturbance, the age and composition of the community, and available assistance from neighboring communities, region and state.

Achieving and maintaining community resilience is an ongoing effort that involves planning and mitigation before the disturbance; emergency response and long-term reconstruction and recovery after the disturbance. This framework defines a process for developing a plan that will inform actions before, during, and after disasters occur.

Beginning in 2007, the San Francisco Planning and Research Association (SPUR) pioneered this style of resilience planning. Their work focused at the community level and specifically considered what San Francisco needed from policies and programs to become a Disaster Resilient City (www.spur.org). SPUR's work produced multiple policy papers and recommendations covering the broad issues of disaster resilience. Their policy recommendations focused on what is needed before the disaster, for disaster response, and after the disaster, as shown in Table 3-1.

The Oregon Seismic Safety Policy Advisory Commission led a planning effort in 2012-13 that followed the SPUR concepts and defined actions by Oregon communities needed to survive and bounce back from a magnitude 9.0 Cascadia earthquake and tsunami (http://www.oregon.gov/OMD/OEM/osspac/docs). The plan determined the impacts of the earthquake statewide, defined acceptable time frames to restore functions needed to accelerate state-wide recovery, and recommended changes in practices and policies, that if implemented over the next 50 years, will allow Oregon to reach desired resilience targets.

Communities will benefit from determining the levels of disaster resilience required for their physical infrastructure. This is best done for several levels of disturbance for each of the prevalent hazards. Accordingly, each individual building or system will derive its resilience goals and performance levels from those defined for its cluster by the community.

[Note to reviewers: In a future draft, this section will include an example from a flood planning effort, perhaps Grand Forks, ND.)

Table 3-1: The SPUR Plan for San Francisco

SPUR's Resilient City Initiative	
Before the Disaster	Our Before the Disaster work has focused on key questions related to disaster planning. What do we need to be doing now to make sure that our built environment can recover quickly from a major earthquake? Which existing buildings need to be retrofitted, and to what standard of performance? How do we encourage better performance from new buildings? How do we strengthen our infrastructure so that our buildings are serviceable after an earthquake? SPUR addresses these and other questions in four Before the Disaster papers published in the February 2009 edition of the *Urbanist*.
Disaster Response	Disaster Response focuses on activities during the days and weeks following a catastrophic event, including damage assessment, ensuring the safety of responders, communications and control, evacuation, public health and safety and restoration of vital systems. SPUR has recently completed a paper on the culture of preparedness, which focuses on disaster planning and preparedness in San Francisco's neighborhoods.
After the Disaster	Our After the Disaster task force is asking several key questions: After a catastrophe, are we prepared to rebuild our city to a state even better than it was before? What plans and systems of governance does San Francisco need if it is to be effectively positioned to rebuild? What lessons can be learned from recovery experiences in lower Manhattan, New Orleans, Haiti, Chile, China, and beyond? This task force will be working to complete major papers on long-term recovery, covering the topics of transportation, governance, planning, and housing.

3.1.2. Diversity of Communities

Just as the prevalent hazards are different across the country, so are the communities with respect to their age, composition, and capabilities. The initial process of developing a disaster resilience plan requires an estimation of how quickly a community needs to recover from each of the prevalent hazards in order to maintain its population, workforce, and economic viability. Hurricane Katrina demonstrated that New Orleans was not resilient because of the impact the flood damage had on the long-term housing of the workforce. Other cities may be sufficiently resilient for all but extreme events, because of their location, inherently resilient government, ability to meet social needs, and redundancy in their built environment. The 1994 Northridge earthquake's impact on the cities in the San Fernando Valley was a good example of inherent resilience. Decades of good building codes prevented all but a few casualties, yielded a rapidly repairable physical infrastructure, and the availability of housing just outside the damage zone, allowed the workforce to return quickly.

From among the many metrics that give communities their distinguishing characteristics, the following serve to illustrate the impact on each and how they may inform the development of a resilience plan. Each needs to be considered by the plan developers as they seek to adapt ideas and needs from the work of other communities for their own use.

- ***Attitudes*** – Communities that have experienced a natural disaster learn from the experience. If the resulting recovery effort is orderly and successful, they develop a sense of contentment with their status quo, even if the experience was based on a moderate event. If the resulting recovery was challenged, drawn out and less than successful in the short term, they move more aggressively toward a resilient state in the reconstruction process. A "window of opportunity" opens for 1 to 2 years, during which people are interested in preparedness activities and making big changes to their planning processes and codes. Communities that have not experienced a severe hazard are unlikely to proactively develop disaster resilience plans.

- ***Age of the Community*** – Age brings mature and sophisticated social structures, efficient and informed governance, historically significant landmarks, deep rooted cultural values, and more. It also brings an aging physical infrastructure that contributes to the resilience gaps. With more and larger gaps comes the challenging task of determining the priorities for closing the gaps in an orderly manner.
- ***Architecture and construction*** – Not all buildings and systems are built alike. Vulnerability to damage depends on the construction materials, the structural, non-structural and architectural systems, the quality of construction, the size and shape of the building or system, and its age. There are hundreds of permutations of architecture and construction styles that vary by community and impact the communities' resilience. For example, in San Francisco, the multi-family apartment buildings of the 20s and 30s are a unique construction style particularly vulnerable to moderate and larger earthquakes. The over 6,000 buildings represent a significant amount of housing that will be uninhabitable after a moderate or large seismic event and will create a demand for interim housing that cannot be provided within the city limits. As a result, one of San Francisco's early resilience programs is a mandatory program to retrofit these buildings to a shelter-in-place level.
- ***Vulnerable, at-risk populations*** – At-risk persons will likely need the most assistance after a disaster. Due to a lack of resources, physical strength, capabilities, etc., they are least capable of taking care of themselves and generally live and work in the oldest, most hazardous buildings. At-risk persons include the elderly, disabled, chronically ill, poor, et al. The sizes and compositions of these at-risk populations vary greatly across communities, as does the need and/or desire to care for them. If not taken into consideration, the emergency response resources needed to care for them will be overextended, which may potentially reduce the ability to execute an orderly recovery.
- ***Economic drivers*** – The financial health of a community depends largely on the availability of good jobs and a strong set of economic drivers. The vulnerability of the economy to a disaster depends on the transportability of its industries: Knowledge-based industries can move quickly if the workforce or needed physical infrastructure is not quickly restored; research and development industries are more rooted, because of the related laboratory and test facilities; manufacturing is deeply rooted and hard to move; most tourism is permanent and only needs to be restored. The restoration times and priorities built into a community's disaster resilience plan need to recognize the mobility of the key industries that support their economy.
- ***Financial Conditions*** – Communities are faced with broad-ranging demands for expanded governance and new programs aimed at addressing deficient conditions. Each program requires staff support and funds to achieve the desired outcome. Disaster resilience, which is one of many community needs, requires support for the emergency responders, planners and building officials, who need the bandwidth and capacity to develop and implement disaster resilient plans. The speed of recovery depends on those plans and the ability to implement them under recovery conditions.
- ***Codes, standards, administration, and enforcement*** – Strong local building codes are a key tool for building the right kind of physical infrastructure and requiring retrofitting at opportune times. A community's history with the adoption, administration and enforcement of codes will have a significant influence on the degree of "inherent" resilience present in the physical infrastructure. There must be a commitment to funding these activities for the resilience plan to be effective.
- ***Priorities for emerging public policies*** – Communities face opportunities that bring new public policies and priorities. A transparent and holistic community disaster resilience plan, with informed recovery plans and prioritized mitigation options, offers the opportunity for a community to balance the cost and benefit of moving toward becoming resilient with other competing opportunities and demands.
- ***Resources*** – Ongoing efforts to encourage development and achieve sustainability through energy efficiency and alternate energy generation have created a variety of new funding mechanisms.

Community backed bonds, locally-crafted loan programs, and in California, Mello-Roos parcel taxes, are being used to finance buildings needing mitigation. Tax incentives can also be enacted as a means of using public funds to underwrite mitigation activities that are needed for community resilience. The lack of immediate funding, however, should not overly influence the content of the disaster resilience plan. The plan should point to the need for new funding solutions for the long term.

- ***Governance Structure*** – While resilience planning begins at the neighborhood level, the process and structure needed to build up to a community level plan will depend on the community governance structure. For a community that is an incorporated City, the plan will be self-contained and represent the needs of multiple neighborhoods served by the City departments and agencies. If the community is an unincorporated portion of a county, the plan will benefit from the capabilities of multiple neighborhoods and the interaction, interdependence, and mutual assistance inherent in the other communities that form the unincorporated areas of the county. In both cases, communities will need to look outside their jurisdictions to understand and plan for/around their dependence on others in their region.

3.1.3. Acceptable Risks

Today, acceptable risks in the built environment can be inferred from the national model building codes, standards, and guidelines. Because of their development process, they are the best mechanism for defining a minimum, uniform, consensus definition of acceptable risk as it applies to the built environment. Standard and guideline writers bring their personal experiences to the development process. They normalize the experience for application to other vulnerable regions via various metrics and formulations, and develop guidance for designing to an acceptable level. The codes, standards, and guidelines provide the benchmark used as a starting point for selecting the hazards, hazard levels, and determining recovery times to be incorporated in the disaster resilience plan.

Each community's current construction standards are a measure of the risk they have accepted with regard to the built environment, though this decision is often based on other factors such as costs. For this reason, community construction practices and the degree of compliance with the latest national standards vary dramatically across the nation. The lack of experience with a damaging hazard and the lack of understanding about the level of damage expected when a significant hazard event occurs often lead to misconceptions of vulnerability. Communities should recognize their vulnerabilities based on the national experience, not just on their experiences with local disruptions, which is best done by adopting and enforcing the national model building codes.

The resilience planning process needs to consider the consequence of the performance expectations imbedded in current design codes, as an indicator of what should be expected for the existing construction. Since the need is focused at the community level, the plan does not insist that all buildings meet the required performance levels for its cluster; rather, the cluster as a whole should meet the needed performance. Are there enough newer buildings in a cluster, that compensate for the older buildings, to meet the goal? A community's level of acceptable risk will likely be based on those levels.

3.1.4. Implementing Community Resilience Planning

A community resilience plan should be developed by a group of interested citizens, a Chamber of Commerce or similar business-related organization, in collaboration with the local governance structure. Because of the holistic nature of the plan and the need to be fully supported during implementation, developing a plan is best done as a public-private partnership between the Mayor's office, community departments, agencies, and organizations, business groups, the professional community, and related non-government organizations.

- ***The Mayor's Office*** provides leadership, encourages collaboration between departments, and serves as the link to the stakeholders in organizing, compiling, and vetting the plan throughout the community. The office also serves as the point of contact for interactions with neighboring communities within the region and the State using a "survivor-centric approach" that is focused on making the process as easy as possible.

- ***City Council or Board of Supervisors*** represents the diversity of community opinion, adopts the needed plans, and enacts legislation establishing the needed mandatory mitigation efforts.
- ***Department of Building and Safety*** identifies appropriate codes and standards for adoption; provides plan check and inspection services as needed, to assure proper construction; provides post event inspection services aimed at restoring functionality, as soon as possible. The Department should also develop and maintain a GIS-based mapping database of all community social and economic metrics, their relationship and interconnection to the physical infrastructure, and the location of key vulnerabilities.
- ***Department of Public Works*** is responsible for the publicly owned buildings and roads, and identifies emergency response and recovery routes.
- ***Public Utilities Commission*** is responsible for the publicly owned systems and assists in developing recovery goals.
- ***Planning Department*** identifies post-event recovery opportunities that will improve the city's layout and is accomplished through repair and reconstruction projects and future development.
- ***Emergency Management Department*** identifies what is needed from the physical infrastructure to streamline response and recovery including defining a set of standardized hashtags to facilitate community-wide information transfer
- ***Chamber of Commerce, Community Business Districts, Building Owners, and Managers*** provide the business perspective on recovery in terms of their needs for workforce, buildings, utilities, and other Infrastructure systems, as well as how their needs should influence the performance levels selected.
- ***Service and Utility Providers*** hold the keys to rapid recovery and should work together to understand the community needs and proprieties for recovery, and the interdependencies they share.
- ***Architects and Engineers*** bring the design and performance capabilities for the physical infrastructure and assist in the development of suitable standards and guidelines, as needed. They are the best resource for information on the existing built environment.

Implementing a resilience plan for the physical infrastructure is a long-term effort that requires constant attention, monitoring, and evolution. Because of the cost and the need to transform the governance, real estate, and construction cultures, it can easily take up to 50 years or more to fully implement. Fortunately, once the resilience performance goals for buildings and systems are adopted, all new construction can be built in compliance at very little additional cost. Studies have shown that the increased costs range from 0 to 5%. Unfortunately, this alone will only have a long-term impact, since the vast majority of buildings and systems will not conform until replaced or retrofitted. Retrofitting existing facilities to the new goals has been shown to be generally cost prohibitive. However, the resilience plan allows the resilience gaps related to clusters of buildings or systems to be judged in terms of relative importance and mitigated as appropriate.

3.2. Pathway to Community Resilience

Figure 3-1 shows a flow chart of the Community Resilience Planning process. Among the first steps to becoming a disaster resilient community are defining: 1) the hazards to be planned for; 2) the size and intensity expected for each one, based on the social needs defined in Chapter 2; 3) the clusters of buildings and infrastructure systems that form the foundation of response and recovery and community plans; and 4) the desired performance of each cluster. When a hazard occurs, each building and system must perform in a manner that protects the occupants from serious injury or death. In addition to safety, communities need to determine how soon these clusters of buildings and systems will be used to support recovery. That decision will depend on the social needs, the size of the area affected and the level of disruption experienced.

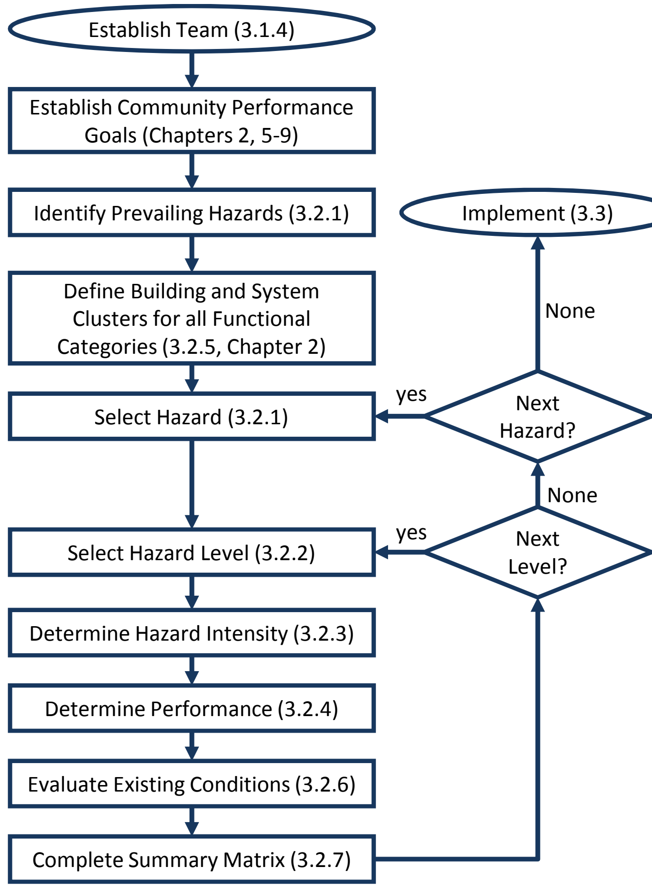

Figure 3-1: Flow Chart for Developing Resilience Plan

Given a set of performance goals organized around hazards, building and infrastructure system clusters, and levels of disruption, communities need to develop and implement a resilience plan that begins with defining the existing conditions. These conditions are measured in terms of safety, usability, and repair times. Comparing the performance of the existing built environment to the performance goals identifies the opportunities for mitigation. Those opportunities involve both specific construction projects and a variety of non-construction related programs.

The outcome of planning is summarized in a *Summary Resilience Matrix*, as defined in Section 3.2.7.

3.2.1. Hazard Events

Developing the physical infrastructure needed to support a disaster resilience community begins with the identification of the hazards to be considered. This framework recognizes that resilience planning is best done at three levels for events that are routine, expected, and extreme. The definition of each level depends on the traditional characterization of the hazard, the type of physical infrastructure under consideration, a community's tolerance for damage, and the need to mandate repairs in a timely manner.

Communities should select their prevailing hazards to be considered in their framework related to the physical built environment, such as:

- ***Wind*** – storms, hurricane, tornadoes
- ***Earthquake*** – ground shaking, faulting, landslides, liquefaction
- ***Inundation*** – riverine flooding, coastal flooding, tsunami
- ***Fire*** – building and wildfire
- ***Snow or Rain*** – freeze or thaw
- ***Man-made*** – blast, vehicular impact

3.2.2. Hazard Levels for Resilience Planning

For each of the hazards selected, communities should determine the following three levels of hazard intensity or magnitude for use in the framework. Each should be defined in the same terms that are used for design.

- ***Routine*** – Hazard level is below the expected (design) level and occurs more frequently. Buildings and systems should remain fully useable and not experience any significant damage that would disrupt the flow of normal living.
- ***Expected*** – Design hazard level. Buildings and systems should remain functional at a level sufficient to support the response and recovery of the community. This level is based on the design level normally used for buildings.
- ***Extreme*** – Maximum considered occurrence based on the historic record and changes anticipated due to climate change. Critical facilities and infrastructure systems should remain functional. Other building and infrastructure systems should perform at a level that protects the occupants and allows them to egress without assistance. In addition, emergency response plans should be based on scenarios that represent this extreme level.

Table 3-2 contains the definitions that SPUR used for the three levels of seismic hazard they recommended for San Francisco resilience planning.

Table 3-2: Sample Hazard definition for earthquakes developed by SPUR for San Francisco

Routine	***Earthquakes that are likely to occur routinely.*** Routine earthquakes are defined as having a 70% probability of occurring in 50 years. In general, earthquakes of this size will have magnitudes equal to 5.0 – 5.5, should not cause any noticeable damage, and should only serve as a reminder of the inevitable. San Francisco's Department of Building Inspection (DBI) uses this earthquake level in their Administrative Bulletin AB 083 for purposes of defining the "service level" performance of tall buildings.
Expected	***An earthquake that can reasonably be expected to occur once during the useful life of a structure or system.*** It is defined as having a 10% probability of occurrence in 50 years. San Francisco's Community Action Plan for Seismic Safety (CAPSS) assumed that a magnitude 7.2 earthquake located on the peninsula segment of the San Andreas Fault would produce this level of shaking in most of the city.
Extreme (Maximum Considered Earthquake)	***The extreme earthquake that can reasonably be expected to occur on a nearby fault.*** It is defined as having a 2% probability of occurrence in 50 years. The CAPSS defined magnitude 7.9 earthquake located on the peninsula segment of the San Andreas Fault would produce this level of shaking in most of the city.

The American Society of Civil Engineers (ASCE) Standard 7-10 *Minimum Design Loads for Buildings and Other Structures* defines the hazard levels for use in design nationwide. Table 3-3 presents suggested design hazard levels for buildings and facilities based on ASCE 7-10. Note that the extreme level is currently defined for seismic loads, but not for other loads. A scientific basis for other extreme loads that is consistent with current design practice needs to be developed. Communities may define the size of a hazard they want to consider for each level, based on the table or based on other information available to them.

Table 3-3: Design Loads for Buildings and Facilities (ASCE 7-10)

Hazard	Routine	Expected	Extreme
Ground Snow	50 year	300 to 500 year[1]	TBD
Rain	[2]	[2]	[2]
Wind – Extratropical	50 year	700 year	3,000 year[3]
Wind – Hurricane	50 to 100 year	700 year	3,000 year[3]
Wind – Tornado	[3]	[3]	[3]
Earthquake[4]	50 year	500 year	2,500 year
Tsunami	50 year	500 year	2,500 year
Flood	100 year	100 to 500 year	TBD
Fire – Wildfire	[4]	[4]	[4]
Fire –Urban/Manmade	[4]	[4]	[4]
Blast / Terrorism	[5]	[5]	[5]

[1] For the northeast, 1.6 (the LRFD factor on snow load) times the 50-year ground snow load is equivalent to the 300 to 500 year snow load.
[2] Rain is designed by rainfall intensity of inches per hour or mm/h, as specified by the local code.
[3] Tornado and tsunami loads are not addressed in ASCE 7-10. Tornadoes are presently classified by the EF scale. Tsunami loads are based on a proposal for ASCE 7-16.
[4] Hazards to be determined in conjunction with design professionals based on deterministic scenarios.
[5] Hazards to be determined based on deterministic scenarios. Reference UFC 03-020-01 for examples of deterministic scenarios.

3.2.3. Hazard Intensity

The impact of hazards depends on more than just size and frequency. Impact also depends on the size of the area affected, the extent of civilization in the affected area, and the community's ability to respond. The size of the area depends on the particular hazard, as does the distribution of the intensity. The extent of the built environment in the affected area will determine the amount of disruption caused. A wild fire in the wilderness areas of the California Sierra Nevada Mountains, where there is little population, can burn multiple square miles of forest with little disruption. The 1992 Oakland Hills firestorm covered only 1520 acres, but killed 11, destroyed nearly 4,000 homes and apartments, and caused $1.5 billion in damage. The area was small, but the population and built environment were extensive, and the disruption was severe.

For purposes of this framework, affected area and disruption are defined in terms of the Community seeking to develop a Resilience Plan.

Table 3-4: Affected Area and Disruption Level

	Category	Definition
Affected area	Localized	Damage and lost functionality is contained within an isolated area of the community. While the Emergency Operations Center (EOC) may open, it is able to organize needed actions within a few days and allow the community to return to normal operations and manages recovery.
	Community	Significant damage and loss of functionality is contained within the community, such that assistance is available from neighboring areas that were not affected. The EOC opens, directs the response and turns recovery over to usual processes once the City governance structure takes over.
	Regional	Significant damage occurs beyond community boundaries. Area needing emergency response and recovery assistance covers multiple communities in a region, each activating their respective EOCs and seeking assistance in response and recovery from outside the region.
Disruption Level	Minor	All required response and recovery assistance is handled within the normal operating procedures of the affected community agencies, departments, and local businesses with little to no disruption to the normal flow of living. Critical facilities and emergency housing are functional and community infrastructure is functional with local minor damage.
	Moderate	Community EOC activates and all response and recovery assistance is orchestrated locally, primarily using local resources. Critical facilities and emergency housing are functional and community infrastructure is partially functional.
	Severe	Response and recovery efforts are beyond the authority and capability of local communities that are affected and outside coordination is needed to meet the needs of the multiple jurisdictions affected. Professional services and physical resources are needed from outside of the region. Critical facilities and emergency housing have moderate damage but can be occupied with repairs, community infrastructure is not functional for most needs.

3.2.4. Performance Goals

Performance goals are a combination of performance levels and restoration times. Standard definitions for performance levels that cover safety and usability are needed to assure uniform development of community plans and the codes, guidelines, manuals of practice, and analytical tools that support them. Recovery times are needed to identify the extent of temporary facilities and systems, as well as prioritizing recovery based on the interdependencies of the buildings and systems. Recovery times are needed based on stages of recovery that address immediate needs, such as temporary facilities, and longer term needs, such as the sequence of infrastructure systems restoration which considers interdependencies between buildings and infrastructure systems

3.2.4.1. Performance Levels for Buildings

To assure that a community framework is compatible with others nationwide, and to inform the building standards development process, common definitions of performance are needed for facilities and infrastructure systems. Setting goals for both safety and usability as metrics are important for new construction and the retrofitting of existing facilities and infrastructure systems. For new construction, such goals can minimize the cost of mitigation by planning for repairs. For existing construction, it determines the clusters of facilities and infrastructure systems that need to be retrofitted to perform as expected. Table 3-5 provides standard definitions for the performance levels that should be used.

Table 3-5: Performance Definitions for Buildings

Category	Performance Standard
A. Safe and operational	These are facilities that suffer only minor damage and have the ability to function at near capacity without interruption. Essential facilities such as hospitals and emergency operations centers need to have this ability.
B. Safe and usable during repair	These are facilities that experience moderate damage to their finishes, contents and support systems. They will receive "green tags" and will be safe to occupy. This level of performance is suitable for "shelter-in-place" residential buildings, neighborhood businesses and services and buildings needed for emergency operations.
C. Safe and not usable	These facilities meet the minimum safety goals, but a significant number will remain closed until they are repaired. These facilities will receive yellow tags. They are suitable for facilities that support the community's economy. Demand for business and market factors will determine when they will be repaired or replaced.
D. Unsafe – partial or complete collapse	These facilities are dangerous, given the occurrences of the prevalent hazard because of the extent of damage that will lead to casualties.

3.2.4.2. Restoration Times for Clusters and Systems

Restoration times will vary with the hazard under consideration. At this point, accuracy is not important and generalized time frames such as days, weeks, and months are sufficient. Disaster response and recovery traditionally is organized around the following three basis phases. The time frames shown are suggestions and may not be applicable for all plans.

Table 3-6: Restoration Time Categories

Phase	Name	Time Frame	Condition of the built environment
I	Response	0 to 3 days	Initial response and staging for reconstruction
II	Workforce	1 to 12 weeks	Workforce housing restored – ongoing social needs met
III	Community	4 to 36+ months	Reconstruction in support of economic recovery

For Building Clusters. While individual buildings are assigned performance levels as noted above, the performance of a cluster of buildings depends on how many of the buildings in the cluster are restored and usable. For purposes of planning, it is worthwhile to set goals for three levels of cluster recovery in terms of the percentage of buildings recovered.

Table 3-7: Building Performance Standards

Category	Performance Standard
30% Restored	Minimum number needed to initiate the activities assigned to the cluster
60% Resorted	Minimum number needed to initiate usual operations
90% Restored	Minimum number needed to declare cluster is operating at normal capacity

For Infrastructure Systems. The recovery of infrastructure systems needs to be measured in terms of its ability to restore service as a percentage of full capacity. While the components of the system are measured and rated in terms of the performance levels defined above, the overall performance of the system needs a system-wide categorization based on restoration of service.

Table 3-8: Infrastructure Performance Standards

Category	Performance Standard
I	Resume 90% service within days 100% within weeks
II	Resume 90% service within weeks 100% within months
III	Resume 90% service within months 100% within years

3.2.5. Identify Building and Infrastructure Clusters for Each Phase

For each of the three response and recovery periods, the clusters need to be defined in terms of buildings and the infrastructure systems. The basis for inclusion depends on the hazard, the community, and the intensity of the hazard level under consideration. Refer to Chapters 5 through 9 for specific guidance on how to define the clusters of facilities and support systems needed for each phase of each hazard with consideration given to at least the following clusters. Refer to Chapter 4 for guidance on considering the interdependencies of buildings, their dependency on the physical infrastructure and the interdependencies of the infrastructure systems.

Table 3-9: Clusters by Recovery Phase

Phase	Cluster
1. Response	**Critical Facilities**
	1. Hospitals 2. Police and Fire Stations 3. Emergency Operations Centers 4. Disaster Debris and Recycling Centers 5. Related Infrastructure Systems
	Emergency Housing
	1. Public Shelters 2. Residential Shelter-in-Place 3. Food Distribution Centers 4. Nursing Homes, Transitional Housing 5. Animal Shelters 6. Soup Kitchen (Community Food Banks) 7. Emergency Shelter for Response and Recovery Workforce 8. Related Infrastructure Systems, including Recharging Stations and Banking Facilities
2. Workforce	**Housing/Neighborhoods**
	1. Essential City Services Facilities 2. Schools 3. Medical Provider Offices 4. Neighborhood Retail 5. Daycare Centers 6. Houses of Worship, Meditation, and Exercise 7. Buildings or Space for Social Services (e.g., Child Services) and Prosecution Activities 8. Temporary Spaces for Worship 9. Temporary Space for Morgue 10. Temporary Spaces for Bath Houses 11. Temporary Spaces for Markets 12. Temporary Spaces for Banks 13. Temporary Spaces for Pharmacies 14. Food Distribution from Local Grocery Stores (location known by community) 15. Related Infrastructure Systems
3. Community	**Community Recovery**
	1. Residential Housing Restoration 2. Commercial and Industrial Businesses 3. Non-Emergency City Services 4. Resilient Landscape Repair, Redesign, Reconstruction, and Repairs to Domestic Environment 5. Water Pollution from Severe Flooding 6. Cradle-to-Cradle for Temp Housing – no debris when new housing comes on line 7. Related Infrastructure Systems

3.2.6. Estimating the Vulnerability of the Existing Buildings and Infrastructure Systems

The majority of buildings and infrastructure systems in service today have been designed to serve their intended functions on a daily basis, given the normal environmental conditions in which they operate. The designs are provided by experienced architects and engineers following their communities standards of practice. The standards of practice for design are continually evolving due to failures that occur. Failures lead to improved design procedures that often start as guidelines and sometimes are formalized into consensus-based design standards.

In the early 20th century, communities started requiring minimum qualifications for engineers through licensure and began adopting building codes to set minimum standards of performance in the interest of protecting public safety. Since the latter half of the 20th century, this interest has grown beyond public safety to include resilience. For example, the 1971 San Fernando, California earthquake lead to the requirement that California's hospitals be designed to remain functional, in so far as practical, after a major earthquake.

Current design practices related to achieving resilience for the expected or extreme prevailing hazards are very uneven. The technologies needed to determine the expected performance of existing buildings and infrastructure systems are available and constantly being improved. Technologies related to building evaluation for seismic conditions is maturing and is in its third generation. On the other hand, methods are just emerging for estimating infrastructure system performance and restoration times.

Architects and engineers deal with buildings and infrastructure systems one building or system at a time. The resilience levels achieved by each design should be compatible with the goals of the community resilience plan. While it would be ideal to retrofit or replace all buildings and systems that do not meet those goals, it is neither necessary nor practical. What is important is that a community has a critical mass of buildings and systems to support recovery in the short term, when taken as a whole. There is a need to evaluate and rate how long it will take for a cluster to return to service and compare that to the resilience goal.

As the last step in developing a disaster resilience plan, a community needs to evaluate each of its designated recovery clusters and estimate how long it will take to reach the designated goal for each level of the prevailing hazard. This information can be recorded on the summary matrix.

3.2.7. Summary Resilience Matrix

A matrix-based presentation of the many facets of a community resilience plan has been developed for use with this framework. It includes a Detailed Infrastructure System Resilience Matrix for each of the infrastructure components, including buildings and infrastructure systems. These are summarized into a single page Summary Resilience Matrix that gives an overview of the anticipated response and recovery demands placed on the built environment. One set of matrices is intended to be used for each hazard and hazard level. Table 3-10 is a Summary Resilience Matrix for a single example application and is offered as an illustration. The related individual matrices for each of the components are discussed in Chapters 5 through 9.

Table 3-10: Summary Matrix

Disturbance		
(1)	Hazard	Any
	Hazard Level	Expected
	Affected Area	Community
	Disruption Level	Moderate

Restoration times		
(2)	30%	Restored
	60%	Restored
	90%	Restored
(3)	X	Current

Functional Category: Cluster	Overall Recovery Time for Hazard and Level Listed								
	Phase 1 – Response			Phase 2 -- Workforce			Phase 3 -- Community		
	Days 0	Days 1	Days 1-3	Wks 1-4	Wks 4-8	Wks 8-12	Mos 4	Mos 4-36	Mos 36+
Critical Facilities									
Buildings	90%								
Transportation		90%							
Energy						90%			
Water			90%						
Waste Water				90%					
Communication	90%								
Emergency Housing									
Buildings			90%						
Transportation			90%						
Energy							90%		
Water			90%						
Waste Water				90%					
Communication				90%					
Housing/Neighborhoods									
Buildings				90%					
Transportation					90%				
Energy							90%		
Water				90%					
Waste Water					90%				
Communication				90%					
Community Recovery									
Buildings								90%	
Transportation								90%	
Energy							90%		
Water				90%					
Waste Water								90%	
Communication				90%					

Footnotes:

1 Specify hazard being considered
Specify level -- Routine, Expected, Extreme
Specify the size of the area affected - localized, community, regional
Specify severity of disruption - minor, moderate, severe

2 30% 60% 90% Restoration times relate to number of elements restored within the cluster

3 X Estimated 90% restoration time for current conditions based on design standards and current inventory

3.3. Mitigation and Recovery Strategies

The disaster resilience planning exercise described above and summarized in the matrices provides a comprehensive picture of the gaps between what is needed from the physical infrastructure to support response and recovery and what currently exists for all the prevalent hazards and hazard levels considered. Communities should consider and balance their opportunities for mitigation and for recovery processes. Mitigation before the event costs money, but reduces demands during recovery and can speed up the overall recovery process. Streamlining recovery processes can reduce the need for mitigation.

Mitigating the gaps can be done in a number of ways, from altering the expectations to relying on more external assistance, to adding redundancies, to mandatory retrofit and/or reconstruction programs that add robustness. For some hazards, such as flooding, the threat can be redirected.

Cost is always an issue with regard to funding mitigation activities. While the initial planning is complex and requires the interaction of a large number of people, it is the first and most cost effect step in the process. Once the plan is in place, there are a number of low-cost, non-construction activities that can be done at low cost and will have significant long-term benefit. There are also a series of construction related activities that can significantly improve community resilience.

3.3.1. Non-Construction Strategies

Implementing a Community's Disaster Resilience plan related to the physical infrastructure should begin with evaluating and validating the following activities or initiating them as needed. Each is a low-cost activity that can be extensions on existing programs.

1. Organize and maintain a resilience office lead by a Chief Resilience Officer that collaborates with and learns from the Rockefeller 100 Resilience Cities program. Orchestrate community engagement through this office and solicit buy-in.
2. Incorporate the resilience plan in the Community Safety Element of the General Plan.
3. Adopting the latest national model building codes and standards for the physical infrastructure.
4. Insist on the development of codes and standards that are compatible with resilience planning and set transparent performance goals.
5. Assure the effectiveness of the building department in enforcing current codes and standards during permitting and construction inspection to assure that the latest processes are being followed.
6. Develop processes and guidelines to be deployed for post-event assessments and repairs.
7. Collaborate with adjacent communities to promote common understanding and opportunities for mutual aid during response and recovery.
8. Elevate the level of inter-system communication between the infrastructure community's providers and incorporating the interdependencies in their response and recovery plans.

3.3.2. Construction-Related Strategies

1. Prioritize gaps identified between the desired and expected performance of infrastructure clusters, as summarized in the Resilience Matrix for the prevailing hazards.
2. For each gap, identify the guidelines and standards used to assess deficiencies in individual public and private buildings and systems and processes. Define the gap in a transparent and publicly available method and announce the result.
3. Include retrofitting of public buildings to achieve the resilience goals in the capital planning process and make it a part of the prioritization process.
4. Develop incentives to encourage new construction be built to the resilient standards and for deficient existing construction to be retrofitted.
5. Support national efforts to improve code-based design standards that match the resilience metrics defined in this framework.
6. Identify building and infrastructure system clusters that need to be retrofitted under mandatory programs and implement the retrofitting through local ordinances. Develop and announce viable funding opportunities and include some level of public funding.