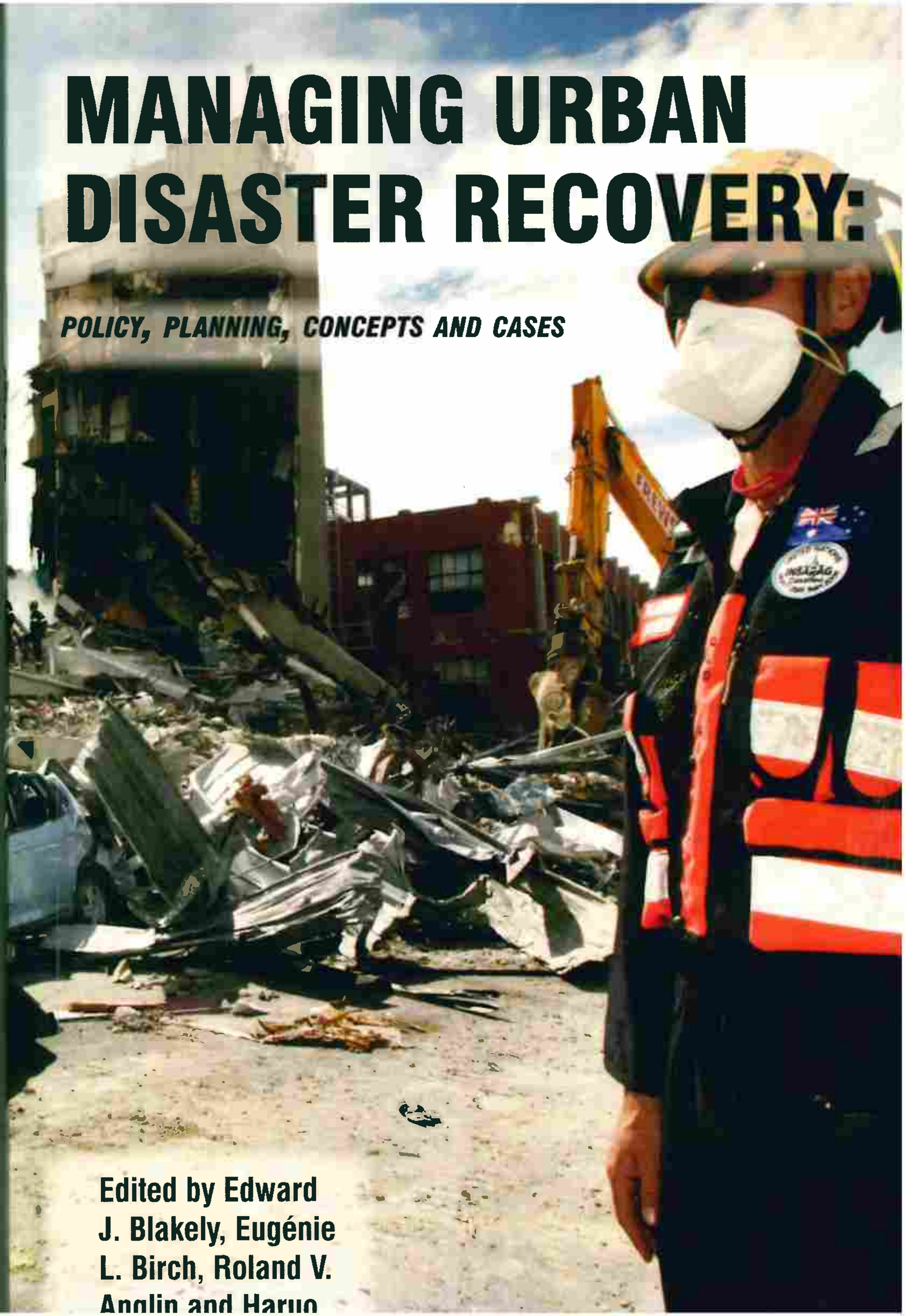
# MANAGING URBAN DISASTER RECOVERY:

## POLICY, PLANNING, CONCEPTS AND CASES



Edited by Edward J. Blakely, Eugénie L. Birch, Roland V. Anglin and Haruo in New Orleans East, have weak real estate markets and little demand for properties, so a lot can sit vacant for years.

The government's main effort to help owners rebuild after Katrina was the Road Home Program. Funded by the federal government and implemented by the State of Louisiana, it gave owners the option of receiving a grant to fix the property, selling the property to the state or using a grant to relocate to a different property in Louisiana. While the program has helped thousands of residents rebuild, it has been criticized for moving slowly and for lack of transparency.

Properties that were sold to the state have been transferred to the New Orleans Redevelopment Authority (NORA). NORA first offered to sell these properties to adjacent homeowners who can use them to increase their lot size. If neighbors don't purchase the properties, they are bundled together and sold to for-profit and non-profit developers, or used for green space.

NORA also has the power to expropriate abandoned properties. However, this powerful tool was weakened when Louisiana voters, fearful of government land grabs after Katrina, approved a constitutional amendment that put burdensome requirements on the expropriation process.

New Orleans has also launched a three-million dollar effort to maintain vacant lots until they are redeveloped. Property owners are charged for the cost and payments are put back into the program. However, this funding will only last for several years and city officials will struggle with lot maintenance for longer than that.

### Lessons learned

Significant lessons learned include:

1. The city was criticized for not making enough of an effort to locate and notify property owners. Officials should adopt extensive notification requirements and ensure that they have enough staff to meet these standards.
2. Officials should include neighborhood groups in the decision-making process about what properties should be demolished. These citizens have a good sense of what properties are impeding recovery and can help find property owners.
3. If demolition funds are limited, focus on stabilizing major thoroughfares. These thoroughfares have a larger effect on recovery than isolated residential areas.

### DISCUSSION QUESTIONS

1. Many cities do not reach their former populations post-recovery, so how can – and should – demolitions be used with this knowledge?
2. Demolition creates a negative image of a community; how can you turn this around?



# Chapter 9: Restoring Infrastructure

Peter M. J. Fisher and Michael Neuman*

Restoring infrastructure is perhaps the central precursor to recovery. Without transport, power, telecommunications, water and sewerage services, proper governance cannot be reinstated, hospitals and clinics will remain on their knees, businesses cannot restock and recover, homes cannot be rebuilt and reoccupied, nor schooling recommence. Life and work cannot restart without functioning infrastructure of all types, whether provided by the private or public sectors.

Yet as our modern infrastructure systems become increasingly complex and interconnected, the process of restoration, and particularly the process of prioritizing restoration, becomes increasingly challenging.

For example, early reconstruction of transport links is needed to ship in the supplies and recovery personnel needed to begin the restoration process, with local access necessary to allow people to reach health care facilities. At the same time, immediate repair of water supply is critical for medical treatment, as well as sanitation. But electricity is usually essential in order to restore water supply, as it powers drinking water pumps and water treatment plants.

Meanwhile, coordinating the effective restoration of any services without access to a working telecommunications system is close to impossible.

In these challenging circumstances, how best to prioritize infrastructure recovery tasks? And how best to balance the need to restore services as quickly as possible against the need to build in greater systemic resilience against future disasters?

*Figure 1: Railway track and bridge destroyed by the Black Saturday firestorm outside*

## Defining infrastructure

Infrastructure is a term applied to a system of physical facilities that underpin human life and settlement. Whether distributed or centralized and whether in public or private ownership, these systems support urban development and economic activities in countless ways and are deeply embedded in society and our daily lives (*Neuman 2005*).

In the context of disaster recovery, the core infrastructures in urban settings are:

- Utilities – gas and electricity, water supply and sewerage;
- Civil engineered works – roads, bridges, dams, drains, canals, seaports, airports, subways and railways; and
- Telecommunications – line and cell telephones, cable networks, internet-broadband radio and television.

Hospitals and clinics can also be considered core infrastructure as they are lynchpins of the early stages of disaster recovery. Facilities such as schools, universities, libraries, police, and emergency services, which form the balance of a community's infrastructure, are also of great significance to social recovery (see, for example, the discussion of the role of schools in Chapter 5).

However, as restoration of these forms of infrastructure is reliant on the prior re-establishment of the core infrastructure described above, we classify these community facilities as 'secondary infrastructure', and they are not the main focus of this chapter.

Another secondary form of infrastructure which should not be overlooked is so-called 'green infrastructure' – trees, river systems, parks and other natural habitats that are often ignored owing to the focus on hard infrastructures. This green infrastructure is soft-wired into many built environments, providing therapeutic and ecological services such as cooling of built environments, water filtration, abatement of run-off, and pollination of crops. The importance of maintaining and restoring green infrastructure can be seen in both the Hurricane Katrina and Grand Forks flood disasters.

## The two stages of infrastructure recovery: immediate and long-term

While in practice there is no clear dividing line between when the immediate phase of recovery ends and the long-term phase begins, thinking about these two stages as distinct processes is helpful, as they present some different challenges.

### Immediate infrastructure recovery

Infrastructure recovery that falls into the immediate category is often restored within hours or days of the disaster occurring. As a result, re-establishment of this



overlap period between the rescue and recovery phases – rather than a true recovery task. Common tasks during this period include:

- Reconnecting electricity, gas and water supply chains and telecommunications services that may have been deliberately disconnected for safety reasons, or have sustained only light damage;
- Clearing otherwise serviceable roads/waterways/access routes of debris, in order to allow rescue and restoration access; and
- Establishing temporary infrastructure to compensate where more significant infrastructure damage has been sustained (see the box below for examples of the kinds of temporary infrastructure that can be very useful in these circumstances).

The exact nature of these immediate restoration tasks will depend on a range of factors, such as type and severity of disaster and size and nature of the affected area, including factors like weather conditions, range of access options and demographics of the local community etc.

Another factor will be the degree of damage to particular types of infrastructure (is it possible to quickly restore, or is a full rebuild required). A further aspect that will affect immediate restoration tasks is if the impact has traveled out from the central/localized damage points in the affected area, thereby creating secondary affected areas (for example, damage such as a broken water main or a knocked out power station can cause problems in areas far from a disaster's epicenter).

Ownership of the infrastructure affected is a further consideration – is it publicly or privately owned? In the latter case, the restoration may be automatically undertaken by private providers with little direct involvement by relevant authorities.

These immediate restoration/recovery tasks tend to occur with little debate, as soon as possible. As a result, this kind of infrastructure restoration may have been completed before an official recovery manager is appointed. However, the interconnected nature of infrastructure means that decisions made during these early stages will necessarily shape the options available for rebuilding infrastructure during the longer-term recovery period.

For example, the early installation of high quality, effective temporary infrastructure may enable greater flexibility in restoring long-term infrastructure, by allowing the time to develop more resilient solutions rather than simply restoring the status quo.

### Long-term infrastructure recovery

The process of long-term infrastructure recovery offers opportunities to install new-generation equipment and facilities and to move away from old methods of organization. For example, rather than centralized wastewater treatment, a transition can be made toward distributed wastewater treatment, or to on-tap treatment for

## EXAMPLES OF TEMPORARY INFRASTRUCTURE

Inherent to a restoration strategy will be the provision of temporary infrastructures, before repair or replacement by a permanent element. The Bailey Bridge (a portable pre-fabricated truss bridge) and the pontoon bridge, both used by the military to cross watercourses, are classic examples of this kind of temporary infrastructure. More contemporaneous examples include portable diesel or solar generators and water treatment systems. Electric generators, medical field tents, and water tank trucks are a few other instances of temporary infrastructures, usually provided by the private sector. Satellite communications technology can also prove invaluable where copper- and mobile-based telecommunications infrastructure has been incapacitated.

Excess standard size shipping containers (Figure 2) are excellent; they are easily transportable among many modes of transportation and are of sufficient size, durability and low cost to serve a wide range of purposes in disaster recovery, including temporary shelter. Arranging "on demand" access to such units in advance of a disaster can allow infrastructure recovery to proceed in faster and more efficient fashion.

***Figure 2:** A mobile water treatment system is one possible temporary infrastructure use for shipping containers*
*Source: Peter Chamberlain, South East Water*

self-reliance and resilience in disaster recovery. Likewise, recovery offers an opportunity to adjust infrastructure to take into account pre-existing changes in the urban environment. For example, after the 1989 Loma Prieta earthquake, San Francisco chose not to rebuild the waterfront Embarcadero Freeway. This decision acknowledged the systemic changes that had occurred in the city – particularly those of local neighborhood renewal and gentrification, and improvements to public transportation systems – that meant the freeway was no longer considered appropriate or necessary infrastructure.

Of course, there will be constraints – most notably time and funding – that will limit the extent to which such changes can be implemented. Nonetheless, disaster recovery is a most opportune time to revisit conventional design in the light of technological advancement and changing urban contexts. Disruption is a given in any infrastructure upgrade; using externally caused disruptions as a chance to undertake systems upgrades allows something good to come out of a disaster. At the very least,



As discussed in more detail below, there is also a rare opportunity to eliminate or reduce dangerous interdependencies within or between infrastructure networks.

While a city with excellent public transport or sea freight access may not consider rebuilding roads to be particularly important, others – like auto-reliant Los Angeles after the Northridge earthquake – will consider freeways a top-level priority (*GAO 2008*). This local specificity makes identifying a general scheme of priorities to be followed in all disaster recoveries challenging. Nonetheless, it is possible to identify factors that should be considered in any urban infrastructure recovery planning process, whatever the size, location or nature of the disaster. While these factors may ultimately be given very different priority in different disasters, it is nonetheless essential that they be taken into account. In addition to the factors discussed above in the context of immediate restoration, some of the key considerations are:

- How long and how challenging the debris removal and demolition process will be;
- Whether, and how soon, temporary infrastructure needs to be replaced;
- The likelihood/expected frequency of a recurrence of the disaster (thus dictating the need for building in greater system resilience);
- What local-scale weaknesses exist in different types of replacement infrastructure;
- What network-scale weaknesses exist between different types of replacement infrastructure;
- The funding available for infrastructure recovery; and
- Specific cross-recovery considerations, i.e. the relationship between infrastructure and other aspects of recovery, particularly housing and the economy, which may also be reshaped in the aftermath of the disaster.

### Debris removal and demolition

Re-establishment of all infrastructure relies on timely and effective long-term debris removal and demolition processes. These clean-up activities can present economic, social and political challenges that need to be carefully considered. In the case of large-scale disasters, such as Hurricane Katrina and the 2011 Japanese tsunami, debris removal and demolition can take months, or even years, meaning a strategic approach is required to ensure this does not interfere more than necessary with the process of rebuilding essential infrastructure.

### Transition from temporary to permanent infrastructure

The extent to which temporary elements are replaced will depend upon policy decisions as to whether the affected areas are to be rebuilt, and the cost-effectiveness of permanent replacement. It also relates to the degree of centrality required for the permanent infrastructure. For example, water supply and sewage treatment infrastructure is typically highly centralized, while temporary provisions are frequently distributed systems. Importantly, these temporary systems may be more resilient in the face of a recurrence of a disaster, and should therefore in some cases

## Resilience

Resilience means a reduced likelihood of damage and failures to critical infrastructure, systems and components; lowered consequences in terms of fatalities, physical damage and economic and social impacts; and reduced time for restoration to pre-disaster levels. Resilience enables infrastructure to withstand a recurrence of the event or multiple but different events. The Multidisciplinary Center for Earthquake Engineering Research (MCEER) constructed the following methodological framework around the concept of resilience:

### MCEER'S FRAMEWORK OF RESILIENCE (2008)

The concept of disaster resilience considers four fundamental properties:

***Robustness:*** Strength, or the ability of elements, systems, and other units of analysis to withstand a given level of stress or demand without suffering degradation or loss of function;

***Redundancy:*** The extent to which elements, systems, or other units of analysis exist that are substitutable, i.e. capable of satisfying functional requirements in the event of disruption, degradation, or loss of function;

***Resourcefulness:*** The capacity to identify problems, establish priorities, and mobilize resources when conditions exist that threaten to disrupt some element, system, or other established priorities and achieve goals; and

***Rapidity:*** The capacity to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruption.

This framework includes four Dimensions of Resilience:

***Technical:*** The ability of physical systems (including all interconnected components) to perform to acceptable/desired levels when subject to disaster;

***Organizational:*** The capacity of organizations - especially those managing critical facilities and disaster-related functions – to make decisions and take actions that contribute to resilience;

***Social:*** Consisting of measures specifically designed to lessen the extent to which disaster-stricken communities and governmental jurisdictions suffer negative consequences due to loss of critical services due to disaster; and

***Economic:*** The capacity to reduce both direct and indirect economic losses resulting from disasters.

Thus, resilience objectives should result in specific tasks that improve performance in each of these dimensions, thereby lessening negative impacts on communities.

## Local scale weaknesses

Different components of each piece of infrastructure can have different susceptibilities. For example, potable water supplies requiring high levels of system integrity will have different susceptibilities when sourced from dams as opposed to groundwater or desalination plants. Resilience requires infrastructure to be selected so that the impact of these local scale weaknesses is minimized, reflecting a close understanding of the local area, particularly specific geographic considerations. Thus, when rebuilding infrastructure after a disaster, intricately engineered infrastructure components should be selected according to their degree of inbuilt hardiness in the face of the specific extreme conditions they are likely to confront. What works for one city may be the worst possible option for another. The objective should be to build safer and



## Network scale weaknesses

One of the key challenges of restoring infrastructure is that close ties exist between different infrastructures, and even within a given class of infrastructure. So, for example, railways cannot be restored without access roads leading to the damaged tracks, and highways are needed to ferry in components. There will also be network interdependencies. Recent work (*Buldyrev 2010, Fisher 2010*) on how a cascade of failures involving interdependent networks can occur, highlights the need to reconsider this interdependence when designing robust networks. If this risk is not addressed, a random failure can have catastrophic results. On the fragility of complex networks, Vespignani (*2010*) has noted:

> *Life as we know it in the modern world is more and more dependent on the intricate web of critical infrastructure systems. The failure or damage of electric power, telecommunications, transportation and water-supply systems would cause huge social disruption, probably out of all proportion to the actual physical damage. Although urban societies rely on each individual infrastructure, recent disasters ranging from hurricanes to large-scale power outages and terrorist attacks have shown that the most dangerous vulnerability is hiding in the many interdependencies across different infrastructures. Relatively localized damage in one system may lead to failure in another, triggering a disruptive avalanche of cascading and escalating failures.*

Special measures may be needed to isolate networks so that they can continue to function when there are failure points in related networks, or to isolate parts of a single network when there are failure points elsewhere in the same network. Disaster recovery plans and scenario planning offer scope to design out dangerous interdependencies between services like water, power and telecommunications. The interconnectivity of parallel complex systems requires interoperability, which comes from considering all the systems together, in addition to considering their individual components.

## Budgetary restraints

The overall cost of infrastructure improvements will almost always be a limiting factor. In this regard, the criteria that emerge from undertaking a systematic prioritization process will help decide optimal funding sequences. Differences will inevitably exist as to what is practicable in advanced economies vis-à-vis developing economies. Relocating telecommunications, power cabling, water and sewerage mains in a utilities tunnel deep under earthquake-prone zones, as has occurred in Tokyo, would unfortunately be impossibly expensive for many developing countries. But where rebuilding using such disaster-minded infrastructure is achievable, there is a real prospect of lessening cascade failures in the event of a recurrence.

In addition, infrastructure replacement can be a good opportunity to get the private sector, and private financing, involved in recovery efforts. Arrangements such as public-private partnerships (PPPs) offer a mechanism to encourage new economic development while ensuring sufficient financing to provide the public with resilient, environmentally friendly new infrastructure developments.

## Cross-recovery considerations

Interconnections need to be taken into account not only in determining new relationships between different pieces of infrastructure, but in considering how any new infrastructure fits with broader recovery goals. If the recovery strategy involves a new location or a fundamental shift in the region's economic focus, it will not be appropriate to simply rebuild the same infrastructure as before. For example, as discussed in Chapter 7, the loss of port traffic to Kobe resulting from the 1995 earthquake meant that the city needed to realign its economy permanently towards high-tech industries. In these circumstances, a shift of priorities occurred away from further development of the port infrastructure. Similarly, the decision to move the city center in Adapazari City, Turkey, to safer ground (see Chapter 8) necessitated the creation of an entirely new urban infrastructure system.

## Pre-disaster infrastructure planning

This web of issues presents a real long-term planning challenge, the magnitude of which will depend in large part on whether the affected town or city has undertaken pre-disaster infrastructure planning. While this is true in all areas of disaster recovery, the complexity of modern infrastructure systems means pre-disaster planning is perhaps more important to infrastructure recovery than any other area. For this reason, while the planning period is generally outside the remit of this book, it is worth making an exception to note a few key preparatory steps that can make infrastructure recovery far simpler.

First, it is important to know what infrastructure exists, and what state it is in. A disaster recovery plan should be able to draw upon pre-existing digital mapping of the location (GPS coordinates) and an inventory of components likely to have been impacted by the event, including their capacity and durability.

This type of inventory is costly and time-consuming to prepare, yet is essential for proper recovery. The use of geospatial raster data processing software such as LIDAR permits preparation, display and enhancement of images and provides answers to specific geographical questions. However, given that this requires a significant degree of intergovernmental and inter-utility coordination, and much lead time, the application of such infrastructure mapping systems varies widely even across developed countries.

Second, it helps to have a pre-existing infrastructure priority agenda which can assign a recovery order to follow. This includes planning around whether to restore various infrastructures to a pre-existing or higher standard. This prioritization process should also consider what should not be done at all; that is, whether any



The demarcation of high risk regions – coastal frontage, flood plains, areas prone to hurricane/typhoon/cyclonic disturbance or a regional predisposition of vegetation to wildfire – is a useful part of this process.

A third requirement is an inventory of resources that can be drawn on for the recovery process (i.e. machinery type, location, owner and contact details). Stand-by equipment is needed until repair of or replacement by a permanent element. Another vital requirement is the pre-determination of infrastructure recovery roles: who does what.

Included here are not only a personnel/managerial inventory, but also a communications strategy that enables all public and private infrastructure players to communicate effectively and continuously in the face of the possible damage to all extant communications networks. This includes back-up systems with all pertinent persons and entities being pre-authorized and with their contact information programmed into existing and back-up systems.

Finally, preventive work can be undertaken in the form of pre-disaster mitigation. Both the private and public sectors should be engaged in this exercise, and should partner so that one does not impede the other during actual recovery. Key here is a retrofit of core or critical infrastructures to make them more resilient to the rising number and increasing severity of hazardous events.

There are compelling reasons to try to decouple or at least decentralize power, transport and telecommunication networks, many of which are becoming more and more interconnected, thus exposing communities to the possibility of cascading failures. There are numerous examples of when such pre-disaster work has successfully enhanced resilience, including the wildfire design standards used for houses in Australia, the United States, Greece and Spain, and the tsunami/storm surge structures constructed in Japan and Sri Lanka.

## Lessons for infrastructure recovery

Fixing infrastructure it is a priority in overall recovery, as recovery operations depend critically on infrastructure, especially power, water, transportation and telecommunications. Mere replacement of the system that existed prior to the disaster is not always sufficient for a range of reasons. Most systems around the world today are under capacity, and thus under-serve their communities. They are also suffering from maintenance backlogs. Their condition is typically old and deteriorating. Replacement with new and improved systems that respond to new demands and new criteria are essential. The new criteria include energy efficiency, carbon neutrality, sustainability, resiliency, and incorporate demand management measures to reduce unnecessary consumption. Resiliency may entail decentralization of centralized systems by distributing components of the infrastructure into a redesign of the overall network. This may involve the intelligent decoupling of integrated systems. This redesign of the network needs to be considered carefully, to balance the potentially competing aims of decoupling for resilience with integration for sustainability.

reduces waste and pollution. The opportunity to introduce such improvements is one of the few positive outcomes of a natural disaster.

The rising toll of damage from extreme weather events alone is a compelling reason to build a greater degree of resilience into existing infrastructure, especially in known high risk locations. Such planning may represent an extraordinary opportunity to lower the risk substantially in some settlements, thereby lessening the overall recovery workload. GPS driven data assembly, software assisted mapping and real time satellite monitoring further add to the ability to limit ongoing disruption and restore infrastructure to an improved level. And, if not before, then certainly in the wake of a disaster, there is an opportunity to modernize systems by reengineering infrastructures, their facilities and equipment, as well as using nature services as 'free' infrastructure.

## FURTHER READING

### The cases and resources section for this chapter includes:

- A prioritization matrix by Fisher and Neuman considering the different types of infrastructure discussed in this chapter, and some of the challenges associated with their restoration;
- Two vignettes about the Grand Forks flood, the first looking at infrastructure recovery priorities (Johnson), the second looking at how green infrastructure was enhanced to increase resilience (GAO);
- A case study by Hanna which demonstrates the challenges of the post-disaster clean-up process, which is often required before infrastructure recovery can proceed; and
- A final, timely reminder by Fisher of why infrastructure recovery planning is so important, entitled "Building for a cantankerous planet".

### PROTECTING AND RESTORING INFRASTRUCTURE: A CHECKLIST FOR RECOVERY MANAGERS

**PRE-EVENT**

- Compile an inventory of machinery type, location, owner and contact details.
- Generate a map showing locations of infrastructure and their at-risk status.
- Provide for real-time monitoring of key items of equipment that is protected from being destroyed in the disaster itself.
- Retrofit items with a level of protection where the hazard or hazards are known.
- Acquaint rescue organizations such as fire services with all of above.

**POST-EVENT**

- Assess the state of various infrastructure categories by remote sensing and on-ground surveillance.
- Provide for temporary restoration through portable equipment etc. This allows time for a more comprehensive assessment of permanent infrastructure recovery priorities.
- Consider all relevant factors to determine the extent of permanent restoration.
- Assign priorities for restoration.



# Cases and Resources for Chapter 9

## Rebuilding infrastructure in Grand Forks

### General infrastructure

Laurie Johnson [*excerpted from Johnson 2009*]

When the devastating floods struck the city in April 1997, the City of Grand Forks owned and maintained the City's water, wastewater and stormwater systems; electricity, gas and telecommunications were privately managed. Infrastructure rehabilitation was a major component of the city's six month recovery plan (prepared in June 1997 and adopted by the City Council in early July 1997). The plan outlined programs to: "Complete the clean-up, repair, and rehabilitation of the City's infrastructure and restoration of public services to pre-flood conditions before November 1, 1997" (*City of Grand Forks 1997*). The City's six-month programs aimed to:

- Expedite repair of the damaged water treatment plant, restoring running water in 13 days and drinkable water in 23 days; full restoration took over one year to complete;
- Complete repairs (to pre-flood conditions) of the water distribution and treatment systems;
- Clean, repair and rehabilitate the street network; and
- Initiate repair and rehabilitation of the stormwater and sewer systems.

In all, about $42 million in local, state and federal funds were spent to repair or replace damaged sewer and water lines, streets and other infrastructure (*City of Grand Forks 2008*). The City of Grand Forks' Recovery Briefing Book (*2006*), developed for other disaster-impacted cities by the current and former leaders on lessons learned from the 1997 flood, recommends: "Turning on the basic infrastructure to homes," such as electricity and potable water, since this is the first sign of a return to normalcy for most residents.

To do this, cities will need: "Many contractors and structured plans that address neighborhoods – or grids – one at a time since these utilities require that each home/property must be occupied or monitored to avoid additional damage" (*City of Grand Forks 2006*).

In the rebuilding, the City installed Global Positioning System (GPS) monitoring devices and the city developed centimeter-accurate GIS drawings of the distribution lines for the water, stormwater and sewer systems (*DLT Solutions 2008*). It also established a wireless network to help automate the city's water storage and pump facilities (*City of Grand Forks 2008*). Also, in 1999, a pavement maintenance database of street-level photographs was developed for every road in the City taken by a van

## Green infrastructure

*[excerpted from GAO 2008]*

After the flooding, Grand Forks and East Grand Forks took steps to address their cities' lack of an adequate flood-control infrastructure to help reduce damage from future flooding of the Red River. The US Army Corps of Engineers assisted both cities in the construction of new flood protection consisting of levees and floodwall systems. The Grand Forks levees have a diversion channel to redirect water around to the west side of the city. Its flood walls were elevated an additional three feet, making it possible to add clay to levy to provide more protection in the event of severe flooding. In East Grand Forks, officials explained that the city built a nonpermanent floodwall that can be taken down and assembled when needed, because of concerns about keeping the city open to the view of the river.

In December 1998, Grand Forks and East Grand Forks jointly agreed to create a 'greenway,' which would manage the impact of rising river water, as well as providing a natural space located between the levee system and river banks for recreational uses. For example, the greenway includes trails, golf courses, boat-ramps, campgrounds, athletic fields, and a wildflower garden. These infrastructure improvements, including the greenway and permanent river dikes, have successfully reduced property damage in subsequent floods. During a severe flood in 2006, Grand Forks only incurred minor infrastructure and property damage, as compared to the damage suffered in the 1997 flooding.

## Prioritising infrastructure – further considerations

Peter Fisher and Michael Neuman

The table on the following page suggests priorities for recovery of items within each category, followed by commentary as to the possible bearing of each on recovery. As noted in the chapter, one of the key challenges of restoring infrastructure is that close ties exist between different infrastructures, and even within a given class of infrastructure. There will also be local considerations which will affect prioritization decisions. Nonetheless, this matrix may provide a helpful starting point for this important process.



| Infrastructure | Components | Restoration priority | Rationale/Explanation |
|---|---|---|---|
| Hospitals & clinics | Buildings<br>Equipment<br>Helicopter pads | High<br>High<br>High | Mental health services also extremely important |
| Roads | Streets<br>Highways<br>Bridges<br>Tunnels<br>Fuel | High<br>High<br>High<br>Medium<br>High | Where these access hospitals, clinics etc<br>To move in supplies/equipment<br>For supply of restoration vehicles |
| Airports | Runways/tarmacs<br>Terminals | High<br>Medium | Sufficient to move in equipment<br>Helicopter pads important if no airport near affected area |
| Ports | Wharfs/piers<br>Cranes | Medium<br>Medium | May be set far away from the affected area |
| Railways | Stations<br>Freight terminals<br>Roadbeds<br>Bridges<br>Tunnels | Low<br>High<br>High<br>High<br>High | Not needed for freight movement |
| Water | Dams<br>Treatment plants<br>Aqueducts<br>Pipe networks | Medium<br>High<br>High<br>High | Longer disablement possible<br>Portable plants can substitute<br>Water essential for hospitals, infrastructure cooling as well as personal use |
| Telecommunications | Phone lines<br>Internet cabling<br>Cell phone towers<br>TV and radio towers | Medium<br>Medium<br>High<br>Medium | Cell phones as alternative<br>Wireless as alternative |
| Electricity | Power stations<br>Transmission lines<br>Substations<br>Distribution lines | High<br>High<br>Medium<br>Medium | Portable generators possible in local neighborhoods but permanent supplies are needed for core infrastructure such as pumping drinking water, wastewater treatment plants, railways, etc. |
| Gas | Gas plants<br>Supply Mains<br>Local Networks | Medium<br>Medium<br>Low | |
| Sewerage | Pipe networks<br>Pumps<br>WWTPs (wastewater treatment plants) | Medium<br>Medium<br>Medium | High interdependence with water supply |
| Drainage | Culverts and pipes | Low | Up priority to H if health risk (disease), flooding or storm surge |
| Solid and Hazardous Waste | Trucks<br>Materials Recovery Facilities<br>Landfills<br>Toxics disposal | Medium<br>Low<br>Low<br>High | Links with trucks/vans |