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KNOWLEDGE NOTE 4-1

CLUSTER 4: Recovery Planning

Infrastructure Rehabilitation

GFDRR
Global Facility for Disaster Reduction and Recovery

THE WORLD BANK

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CLUSTER 4: Recovery Planning

Infrastructure Rehabilitation

Social infrastructure and public utilities are critical for quick and effective disaster response and recovery. Japan's rigorous seismic reinforcement of infrastructure has greatly reduced the effort required to restore essential facilities. Identification of priority infrastructure, legislation of financial arrangements for rehabilitation, and establishment of predisaster plans alongside the private sector have enabled prompt emergency response operations and facilitated a quick rehabilitation.

FINDINGS

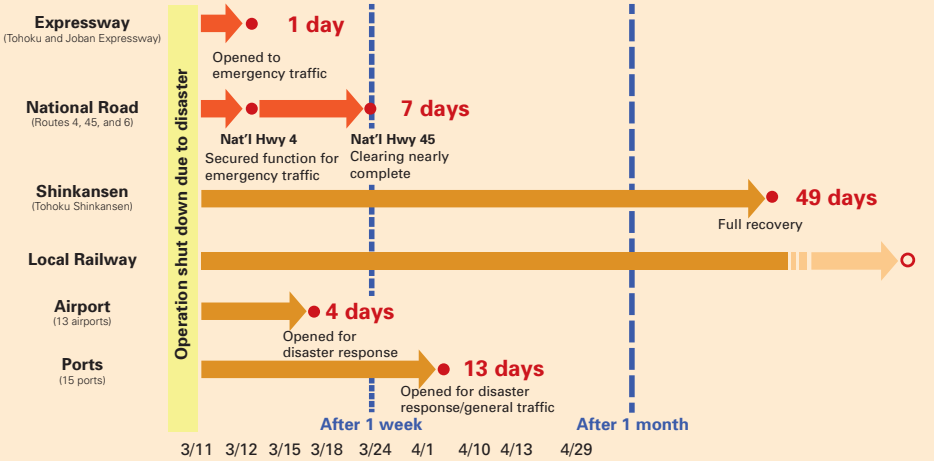
The Great East Japan Earthquake (GEJE) caused tremendous damage to infrastructure and public utilities in the eastern region of Japan. According to the Cabinet Office, damages to public utilities and social infrastructure were estimated to be about ¥1.3 trillion ($16 billion) and ¥2.2 trillion ($27 billion), respectively (KN 6-3).

Since damage to the road network was limited, and rehabilitation work was efficient, (figure 1) the main highways and roads to the affected areas were repaired within one week. Bullet train service was resumed within 49 days of the event. These developments, in turn, facilitated full-scale relief activities in the devastated areas. All of this was a huge improvement compared to the aftermath of the Hanshin-Awaji (Kobe) earthquake in 1995, when it took over one-and-a-half years for highway reconstruction and 82 days for the bullet train line to be repaired.

Roads. Some 15 expressway routes and 69 sections of the national highway system, mainly in the Tohoku region, were closed immediately after the earthquake. Many prefectural and municipal roads were also closed. Because they had been retrofitted, bridges on national roads or expressways were not damaged, but 20 bridges on prefectural and municipal roads collapsed or were severely damaged (KN 1-2).

The subsequent tsunami flooded approximately 100 kilometers (km) of national highway, and submerged three expressway interchanges and junctions. The tsunami also washed

FIGURE 1: **Securing emergency transportation**



Source: MLIT.

away five national road bridges. Massive amounts of debris brought in by the waves left many of the coastal roads unusable (figure 2).

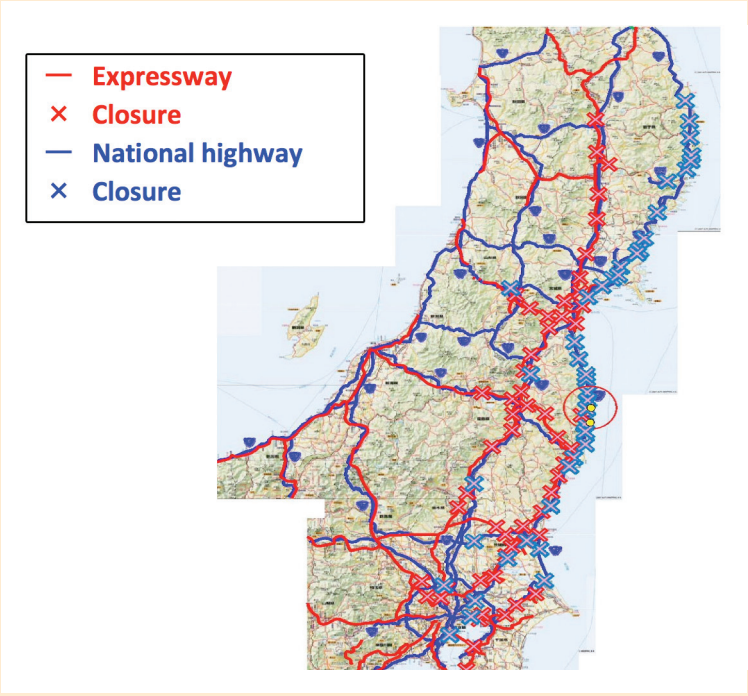
Railways. Railway facilities were also severely damaged, but various earthquake countermeasures, including the seismic reinforcement of railway facilities, prevented most of them from breaking down and causing fatalities. Some 325 km of railway were damaged, mostly by the tsunami. Damage included the displacement or washing away of railroad tracks, power poles, bridges, and stations; the collapsing of earthen embankments; and damage to platforms.

Airports. The Sendai Airport, the major airport in the Tohoku region, is located about 1 km from the Pacific coast at an elevation of 4 meters above sea level. The tsunami hit the airport and flooded the runway, the first floor of the terminal building, and the airport access railways (figure 3).

Ports. Fourteen international and other major ports and 18 local ports were severely damaged by the tsunami and unable to function. Numerous ports that support the region's fishing industry were also destroyed. The tsunami and the earthquake together destroyed much of the port infrastructure. Debris from the tsunami washed into the port area, preventing ships from entering.

Damages to public utilities. Public utilities were severely damaged by the earthquake and tsunami. About 2.3 million houses were left without water supply after the earthquake, and the sewerage systems were destroyed in the coastal cities and towns in an area spanning some 550 km.

FIGURE 2: **Status of expressways and national highways immediately after the earthquake**



Source: MLIT.

FIGURE 3 (left): **Sendai Airport after the tsunami**
FIGURE 4 (right): **Manhole raised by liquefaction in Urayasu City.**





Source: MLIT and Urayasu City..

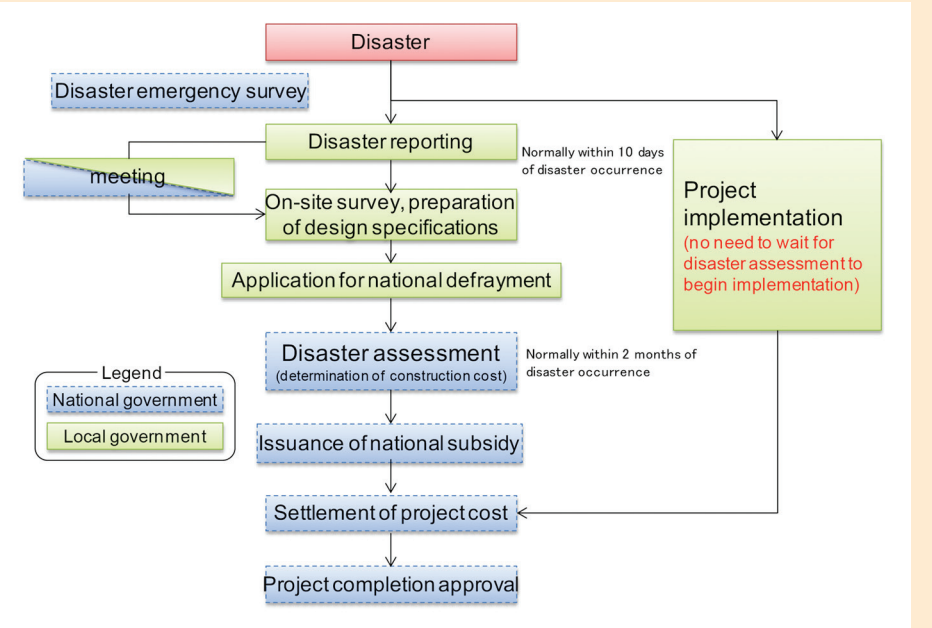
Wastewater treatment plants were damaged at 63 locations, 48 of which had to stop operating because of tsunami inundation. The condition of six wastewater treatment plants near the Fukushima Daiichi Nuclear Power Station is still unknown because of access restrictions. In Urayasu city, Chiba, sewerage systems were severely damaged by liquefaction (figure 4).

The number of houses left without electricity reached 8.5 million. Several nuclear and conventional power plants, including the Fukushima Daiichi Nuclear Power Station, went offline after the earthquake, reducing the region's total power generation and supply capacity. The capacity of the Tokyo Electric Power Company (TEPCO) was reduced by about 40 percent from 50 gigawatts (GW) to about 30 GW, not enough to meet the typical 40 GW peak-time demand for that season.

INFRASTRUCTURE REHABILITATION PLANNING AND IMPLEMENTATION

Concerned organizations were able to start rehabilitation work immediately after the earthquake and tsunami, to a large extent subsidized by the national government under the National Government Defrayment Act for Reconstruction of Disaster Stricken Public Facilities (enacted in 1951). This act applies to a variety of transport systems and other infrastruc-

FIGURE 5: **Steps in infrastructure rehabilitation**



Source: MLIT.

ture such as rivers, coastal facilities, *sabo* facilities, roads, ports and harbors, parks, and sewerage systems. The typical course of rehabilitation project implementation is illustrated in figure 5. In the aftermath of a disaster, local governments report their infrastructure damage to the national government, usually within 10 days of occurrence, with a request for a national subsidy. Upon receipt of the application, the national government conducts a disaster assessment within 2 months of the disaster and approves the subsidy. To ensure quick rehabilitation, local governments can begin implementing their projects immediately after the disaster occurs, even before applying for the subsidy.

The national government subsidizes two-thirds of the project costs, and much of the local government's share is covered by national tax revenues. Thus, local governments actually cover only 1.7 percent of the costs at most. This local government share decreases as the severity of the disaster increases. In the case of the GEJE, the costs were so large that the local government share was minimal.

To ensure the quick rehabilitation of infrastructure, the national government enters into predisaster agreements with the private sector, ensuring that in the event of a disaster, the needed workforce will be mobilized quickly, without burdensome contracts and paperwork. Such arrangements are made between government field offices and private companies or private sector associations, and they cover such postdisaster activities as construction, engineering consulting, surveying, telecommunications, and broadcasting.

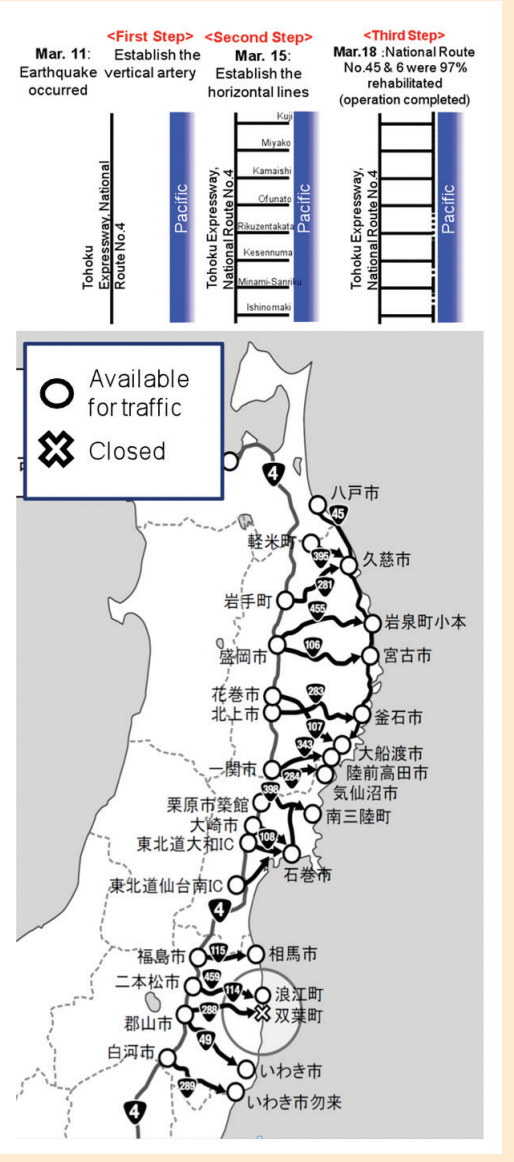
Roads: Operation Toothcomb. Transportation infrastructure is critical for delivering relief supplies. After the GEJE, roads were recovered early on to secure an emergency transportation network. Immediately after the earthquake on March 11, the Ministry of Land, Infrastructure, and Transport (MLIT) deployed a strategic initiative to make sure that the entire length of the Tohoku Expressway and National Route 4 was passable to traffic. This major artery runs south to north from Tokyo to Aomori along the inland part of the region, which suffered relatively little damage. Next, 16 routes were opened up, stretching out from various points on this major north-south artery and reaching east to the coastal areas that were worst hit by the tsunami. The plan was called Kushinoha Sakusen, or Operation Toothcomb, because of the shape of the road network (figure 6 and 7). From the next day, the operation began clearing debris from the emergency roads that run eastward from the inland arterial highway—national route 4 (running north-south)—connecting them to the Pacific coast. By March 15, four days after the earthquake, 15 eastward access roads were usable, and by March 18, 97 percent of the national coastal highways were accessible.

Furthermore, 13 days after the earthquake the entire Tohoku Expressway, the main expressway connecting the Tohoku region to central Japan, was open to general traffic.

The quick rehabilitation of roads was possible for a number of reasons:

- The seismic reinforcement of road structures had helped minimize damage.
- There was a clear focus on opening up the 16 eastward routes by concentrating the workforce on them first.
- The authorities used their predisaster agreements to mobilize contractors immediately after the disaster.

FIGURE 6: **Operation Toothcomb**



Source: MLIT.

FIGURE 7: **Clearing of roads**



Source: MLIT.

Ports and navigation passages. The MLIT requested contractors to begin clearing navigation passages so that disaster relief vessels could enter ports. The operations began in 14 principal ports on March 14, the day after the lifting of the tsunami warnings. This included removing debris as well as ensuring the safe passage of emergency relief vessels (figure 8). By March 15, 4 days after the earthquake, all 14 ports were either entirely or partially usable, and began accepting vessels delivering emergency supplies and fuel. At Sendai's Shiogama Port in Miyagi Prefecture, the first oil tanker entered 10 days after the earthquake, reducing the fuel shortage in the disaster-affected areas.

Railways. The Tohoku Shinkansen (bullet train) resumed operations between Tokyo and Nasushiobara (the southern section) on March 15, and between Shinaomori and Morioka (the northern section) on March 22. By April 29, the entire Tohoku Shinkansen line was in operation, as were most of the other railways except for those along the coast. The rehabilitation of the coastal railways, especially the Joban Line that runs through an area 20 kilometers from the Fukushima Daiichi Nuclear Power Station, has still not happened.

FIGURE 8: **Clearing of navigation passages**



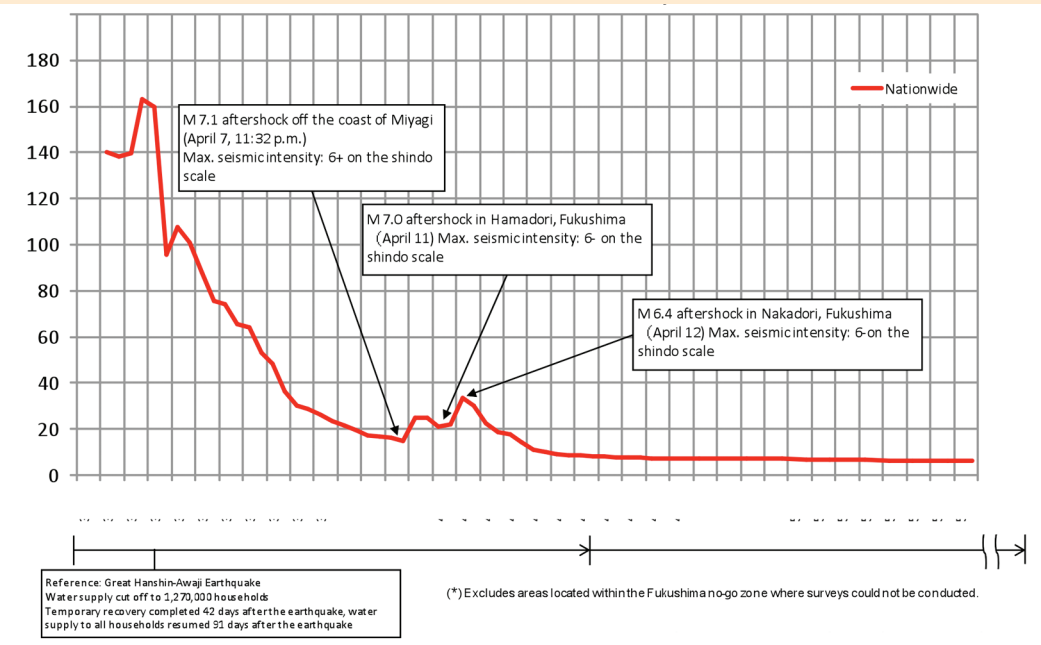
Source: MLIT.

Many are currently being evaluated for possible rehabilitation along with the reconstruction of the towns and cities. The Sanriku Railway, which runs along the coast, is expected to resume its operation in April 2014.

Sendai Airport. The Sendai Airport rehabilitation operation began two days after the earthquake, and by March 15, four days after the earthquake, the airport was being used by rescue and emergency supply rotorcraft. Fixed-wing aircraft were able to use it by the following day, allowing the US Army to bring in emergency supplies. The airport was available for commercial services on April 13.

Water supply systems. Although water supply services were resumed for about 90 percent of residents within 1 month of the disaster, the aftershocks on April 7 and 11 temporarily increased the number of households without water (figure 9). The Japan Water Works Association (JWWA) set up emergency headquarters to arrange for relief teams. The Ministry of Health, Labor and Welfare, JWWA, and 400 water utilities nationwide provided assistance to the affected areas by dispatching emergency teams with water supply trucks and machinery. They also helped conduct investigations for the restoration and reconstruction of water works.

FIGURE 9: **Water works rehabilitation**



Source: Cabinet Office (based on data from the Ministry of Health, Labour, and Welfare).

Sewerage systems. Of the 120 disaster-affected wastewater treatment plants, those with minor damage (95 facilities) were rehabilitated and have recovered their predisaster capacities. Sixteen treatment plants are still inoperable because the tsunami destroyed their infrastructure and equipment. The 13 facilities that are accepting influent sewage have been providing primary treatment only, consisting of settlement and disinfection.

The reconstruction planning for the sewerage systems is the responsibility of the local municipalities. However, some 6,575 personnel have been dispatched from national or local municipalities in other regions to support their rehabilitation efforts. Sanitation is a major challenge in a disaster. Higashimatsushima City in Miyagi Prefecture did not have enough toilets for the people staying at evacuation centers. The city installed "manhole" toilets, paid for by a national subsidy system for promoting earthquake proofing of sewerage systems across the country. These toilets, which can be easily and quickly installed, were well received, especially by the elderly.

Electricity services. About 90 percent of the power services were recovered within one week of the disaster; however, the aftershocks on April 7 and April 11 temporarily increased the outages (figure 10). Because of its reduced power supply capacity, the TEPCO implemented rolling blackouts in its service areas, including Tokyo, between March 14 and 28.

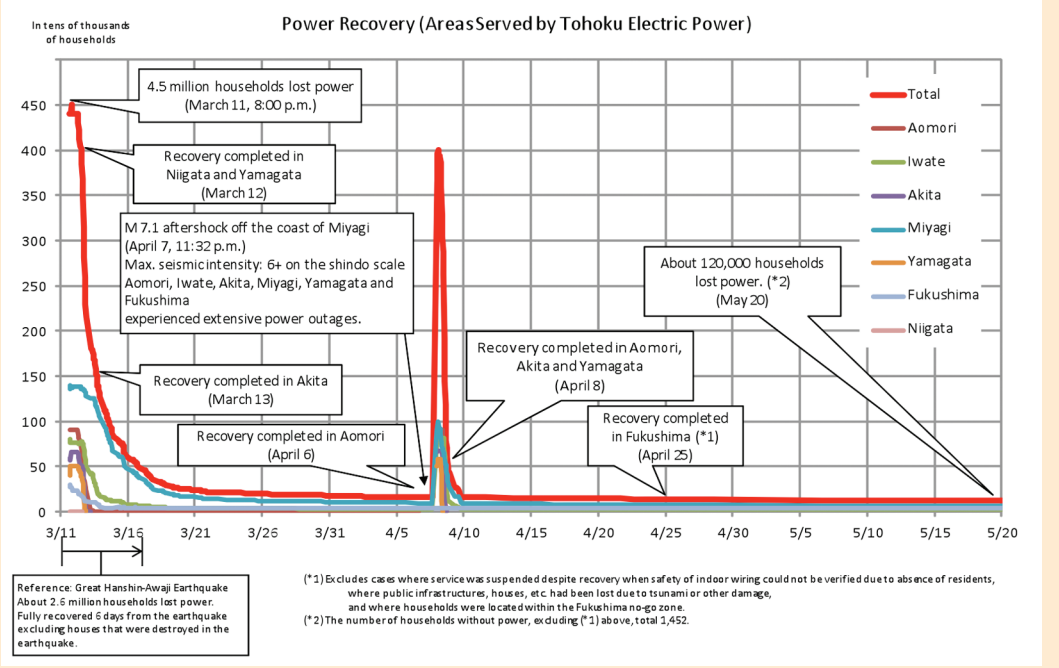
BOX 1: **Rapid rehabilitation of sewerage system in Rikuzentakata City**



In Rikuzentakata City in Iwate Prefecture, the wastewater treatment plant was severely damaged by the tsunami. But within its service area 400 houses located on higher ground had survived the tsunami. When water supply services resumed, the sewage generated by these 400 houses had nowhere to go. Following a proposal by a private company, the city decided to introduce a movable membrane bioreactor unit, which was quickly installed and began operating within a month.

Source: MLIT.

FIGURE 10: **Electricity rehabilitation**



Source: Cabinet Office (based on data from Tokyo Electric Power Company).

LESSONS

- Quick emergency response initiatives, such as Operation Toothcomb, contributed greatly to the prompt rehabilitation of transportation networks and the starting of relief activities.
- Identifying the routes to be recovered first and prioritizing resources and manpower accordingly, was an effective approach to rehabilitating transportation networks.
- Agreements, made with the private sector before the disaster, to provide emergency response operations were effective in quickly mobilizing the needed workforce.
- Experts and equipment dispatched from national and local governments contributed to prompt rehabilitation.
- Rigorous implementation of the seismic reinforcement of infrastructure prevented excessive damage to structures, minimizing the effort required to restore their functions.
- At the time of a disaster, sanitation can be a major challenge. Resumption of water supply services without adequate sanitation led to sanitation and hygiene problems.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Effective emergency and rehabilitation operations depend on social infrastructure and public utilities. The following arrangements are required if rehabilitation works are to be started and completed promptly.

Establish financial arrangement mechanisms. Budget-sharing mechanisms between local governments and the central government should be established in advance. Negotiating between governments only after a disaster has occurred will delay rehabilitation work. Such negotiations should cover:

- Procedures for applying for a subsidy to the central government.
- The cost-sharing ratio of rehabilitation works, shared between national and local governments.
- Criteria for which types of disasters—and at what scale—require which mechanisms.
- Establishment of a body of experts and responsible organizations at the central government level.
- Team formulation and procedures for damage assessment.

Arrange predisaster agreements with the private sector. Prearranged agreements with the private sector allow for quick mobilization of the needed rehabilitation workforce.

Government agencies can skip the procurement process and start work immediately. These agreements should include (i) the designated responsibilities of governments and private companies for rehabilitation work, (ii) a government guarantee of payment for the work involved, and (iii) procedures for project requests from the government.

Arrange support teams. Emergency support teams should be established during normal times (KN 3-1). Rehabilitation requires enormous additional resources from local governments, which are already burdened by the aftermath of disaster. Emergency teams from other government agencies can assist those local governments affected by disaster.

Develop disaster-resilient infrastructure. If infrastructure and utilities are planned and developed to mitigate potential disaster damage, the effort and time required for rehabilitation can be minimized. Retrofitting bridges can reduce both damage and rehabilitation efforts (KN 1-2).

Identify key infrastructure. Transportation or communication networks that are critical to emergency operations should be identified before the disaster and given priority during the rehabilitation efforts.

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