Chapter 1

General Issues

Disasters are mostly caused by natural phenomena, even if many of their consequences must be attributed to human actions or negligence.

In order to control or minimize natural hazards, it is essential to know the characteristics of common adverse natural phenomena and how they impact on our environment. The study and proper management of such hazards is also a prerequisite for developing operational, planning, training and simulation programs.

These actions, which will be examined at greater length in the pages that follow, comprise several stages:

1. Becoming familiar with, analyzing, and assessing the presence of natural hazards and their effect on the equipment and infrastructure of the area under study, based on the vulnerability associated with such phenomena;
2. Estimating the potential impact of natural hazards on routine as well as longer-term development activities, and on the components of water supply and sewerage systems;
3. Devising and adopting measures to reduce vulnerability and mitigate the effects of hazards;
4. Programming emergency operations.

Types of Hazards

Depending on their origin, hazards can be of two types:

a) Those related to natural events, i.e., physical phenomena arising in nature;

b) Those caused by human activity.

This classification cannot be employed rigidly, since we often find interactions between natural phenomena and human actions. For instance, a landslide may be caused by erosion as a result of deforestation, by failures in channeling runoff or wastewater, or by settlements in unstable areas.

Another way of classifying hazards is by the way they occur:

a) Sudden onset, as in the case of earthquakes;

b) Gradual onset, as in the case of drought.

The various types of hazards manifest themselves as events that can have adverse effects and can potentially lead to an emergency or even reach the level of a disaster. However, it is common for the classifications above to be applied to disasters.

Following is a summary of the main characteristics of some hazards of natural origin.

Earthquakes

Dislocations in the earth's crust, the main cause of earthquakes, deform the rocks below the earth's surface and build up energy that is suddenly released in the form of seismic waves that shake the surface.

Earthquakes are one of the most serious hazards, given their enormous destructive potential, the extension of the areas affected, and the impossibility of forecasting their occurrence.

The main effects of an earthquake, depending on its magnitude, are:
- Fault lines along rocks and below the surface;
- Sinking of the surface;
- Avalanches, landslides, and mudslides;
- Liquefaction.

Earthquakes are classified according to their magnitude and intensity. Seismic magnitude refers to the amount of energy released, which is usually measured using Richter's logarithmic scale. Intensity is measured by the degree of destruction, normally using Mercalli's modified scale, which goes from I (intensity detected only by highly sensitive devices) to XII (total destruction).

The significance and type of damage relate to the magnitude of the earthquake and the area covered, the degree to which buildings and infrastructure are seismic resistant, and the quality of soil where structures are located.

An earthquake has a specific magnitude, but its intensity varies depending on the location of the area under study with respect to the epicenter, the geological characteristics of a site, as well as materials used for structures.

Following are some of the types of damage that an earthquake can inflict on water supply and sewage systems:
- Total or partial destruction of intake, transmission, treatment, storage, and distribution systems;
- Rupture of transmission and distribution pipes and damage to joints between pipes or tanks, with consequent loss of water;
- Interruption of electric power, communications, and access routes;
- Deterioration of the water quality at the source due to landslides and other phenomena;
- Reduction in yields from groundwater sources and flow in surface water sources;
- Changes in the exit point of groundwater or in the phreatic level;
- In coastal areas, inland flood damage due to the impact of tsunamis. Introduction of salt water into coastal aquifers.

Volcanic eruptions

Volcanic eruptions result from the release of energy caused by the movement of magma near the earth's surface. The volume and magnitude of the eruption varies depending on the quantity of gases, the viscosity of the magma and the permeability of the ducts and chimneys of the volcano. The frequency of these phenomena is highly variable: some volcanoes erupt continually, while others remain dormant for thousands of years.

Two kinds of eruptions constitute volcanic hazards:

- *Explosive eruptions.* These occur when gases dissolved in molten rock (or magma) expand and escape into the air. The force of escaping gas violently shatters solid rocks.
- *Effusive eruptions.* Here it is the flow of lava, and not the explosions themselves, that constitute the major threat. Lava varies in its composition and quantity.

A volcanic eruption can generate associated events that can have more severe consequences than the eruption itself. The following are two examples:

- Seismic events due to volcanic action;
- Avalanches, landslides, and mudflows (or lahars).

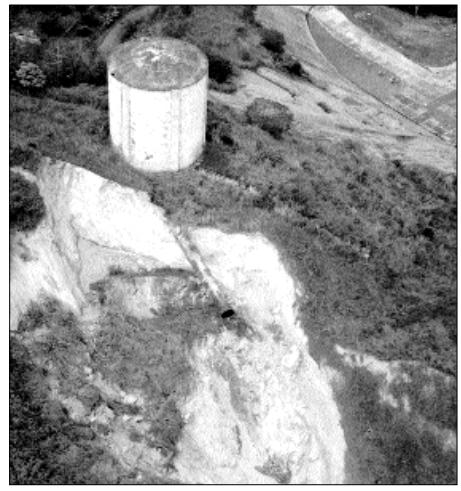
Needless to say, the eruption itself can be quite destructive, ejecting ashes, toxic gases, rocks and lava, sometimes over large distances.

The main potential effects of volcanic eruptions on water supply and sewerage systems are the following:

- Total destruction of the infrastructure in the areas directly affected by pyroclastic flows and surges. These flows tend to follow valleys and can destroy everything in their path;
- Obstruction with ash of surface water intakes, intake screens, transmission pipes, flocculators, clarifiers, and filters;
- Deterioration of the water quality at surface intakes and open reservoirs due to ash falls;
- Contamination of rivers, streams and springs in lahar deposition areas;
- Destruction of access roads to system components, communications and power lines;
- Fires;
- Collapse of or damage to structures due to ash accumulation.

Landslides

Landslides are the result of sudden or gradual changes in the composition, structure, hydrology or vegetation of sloping terrain. They are often closely linked to primary hazards such as earthquakes or water saturation caused by hurricanes or intense rainfall. In urban areas they are also associated with human actions such as providing drinking water services to communities located on slopes with unstable soil. Leaks in these systems lead to excessive moisture in the soil and can result in landslides. The situation can be critical when drinking water is supplied without providing proper sewerage at the same time.



Landslide at storage tank.

J. Grases, 1998

The magnitude of the impact of landslides depends on the volume of the mass in motion and its speed, as well as the extension of the unstable zone and the disintegration of the mass in motion.

Landslides can often be predicted, since they can be preceded by cracks and undulations in the terrain.

The most common effects of landslides are the following:

- Blockage or damage to roads along slopes;
- Changes in the normal flow of surface waters, such as rivers and streams, may result in dams or accumulations of water. Rupture of the dam can cause the violent discharge of great volumes of water or mud;
- Soils may sink or be displaced altogether, affecting houses, schools, roads and other structures.

Effects of landslides to be prevented in areas where water supply and sewerage system components are located include:

- Changes in the physical or chemical characteristics of intake water, which will affect treatment;
- Total or partial destruction of the works, particularly intake and transmission components in the path of active landslides;
- Contamination of the water at surface intakes located in mountainous areas;
- Indirect impacts due to the blocking of roads and the disruption of power and communications;
- Blockage of sewage systems due to buildup of mud and stones.

Hurricanes

Depending on wind speeds, these natural phenomena are called tropical depressions (winds up to 63 km/h accompanied by changes in atmospheric pressure), tropical storms (winds between 64 and 119 km/h accompanied by intense rainfall), or hurricanes (wind speeds of 120 km/h or higher, accompanied by heavy rainfall and significant changes in atmospheric pressure).

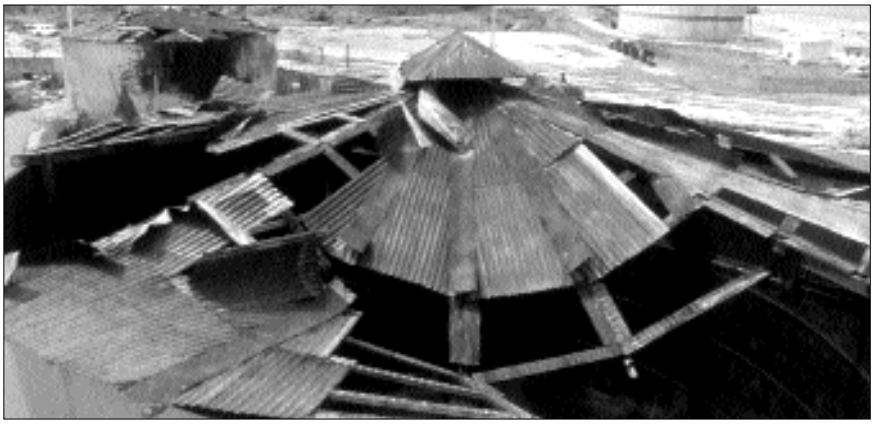
Hurricanes arise from the interaction of hot, humid air coming from the ocean and cold air. These currents gyrate and travel at speeds between 10 and 50 km/h, with an erratic trajectory. Some models are now available to predict the possible course of hurricanes, which can be adjusted as the event unfolds.

Hurricanes may have the following effects:

- Damage to power lines, including the collapse of posts and high-tension towers as a result of the high winds;
- Damage to infrastructure located near waterways;
- Damage to homes due to the strong winds, particularly in coastal areas;
- An increase in precipitation that may give rise to severe urban flooding.

The impact of hurricanes on water supply and sewerage systems can include the following effects:

- Partial or total damage to facilities, command posts and buildings, including broken windows, damaged roofs, and flooding;
- Rupture of mains and pipes in exposed areas, such as over rivers and streams;
- Rupture or disjointing of pipes in mountainous areas due to landslides and water torrents;
- Rupture and damage to tanks and reservoirs;
- Damage to electrical transmission and distribution systems.

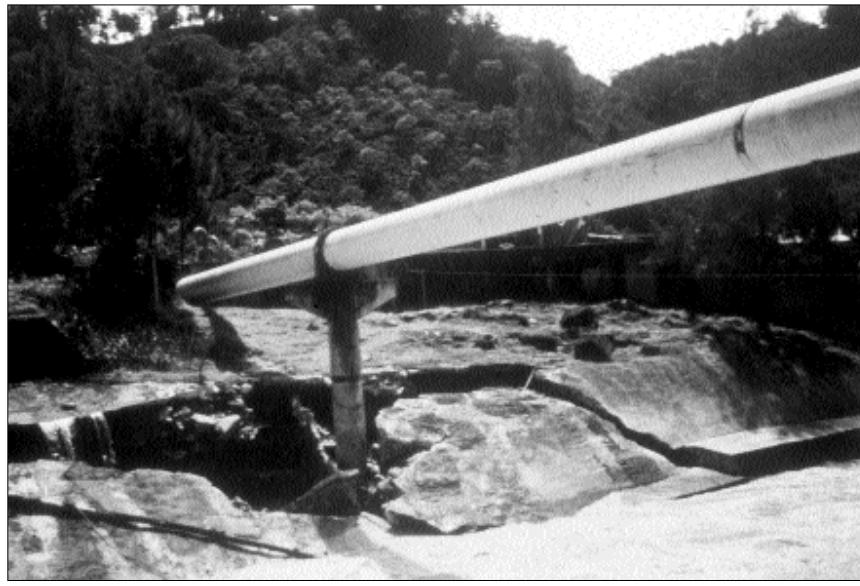


Damage to the roof of a water tank sustained during a hurricane.

PAHO/WHO

Floods

Floods are the result of excessive rainfall, unusually high sea levels, or the rupture of dams and dikes. Increasingly, floods result from human activity causing environmental degradation, deforestation, and inappropriate land use. On the other hand, some floods are the result of the geomorphology and climatology of water catchment areas.



Flood damage to the bridge supporting the main water pipe of the Orosi system in Costa Rica in October 1999. Some 500 tons of concrete were displaced.

A. Rodríguez

The magnitude of the effects of floods is related to the level reached by the water, its speed, and the geographical area covered. Other significant factors are the design quality of the installations and the type of soil on which they are built.

The usual impacts of floods are the following:

- Damage or destruction of housing built close to waterways;
- The flooding of urban areas—even entire cities—built in low-lying areas, affecting the economy and the provision of services;
- Accumulation of water in low-lying areas, creating breeding opportunities for disease-carrying insects.

The main effects of floods on water supply and sewerage systems are the following:

- Total or partial destruction of river water intakes;
- Damage to pumping stations close to flooding waterways;
- Blockage of components due to excessive sedimentation;
- Loss of intake due to changes in the course of rivers and streams;
- Rupture of exposed pipes across and along rivers and streams;
- Contamination in water catchment areas;
- Power cuts, road blockages, and disruption of communications;
- Intrusion of salt water into continental aquifers, contaminating or reducing the availability of groundwater.

Drought

Droughts are prolonged dry periods during natural climatic cycles, caused by a complex set of hydrometeorological elements that affect the soil and the atmosphere. They do not necessarily start when it stops raining, since enough water might have been stored in dams or in the ground to maintain the hydric balance for some time.

Among the effects of drought are the following:

- Reduction of surface water due to lack of rainfall, putting agriculture and animal husbandry at risk;
- Changes in the fauna where waterways are affected;
- Changes in the standard of living due to the negative impact of drought on the economy.

The potential impact of drought on water supply and sewerage systems includes the following effects:

- Loss or reduction of surface- and groundwater sources and deterioration of water quality;
- A decline in water levels at intake points and in storage facilities;
- The need to distribute water with water trucks, affecting quality and increasing costs;
- Damage to the system due to lack of use;
- Accumulation of solid matter in sewage systems.

Table 3 summarizes the impact of these adverse events on water supply and wastewater systems, as well as the severity of the impact.

Table 3. Magnitude of effects caused by hazards

Effects on water supply and sewerage systems	Earthquake	Volcanic eruption	Landslide	Hurricane	Flood	Drought
Structural damage to system infrastructure	●	○	●	●	●	○
Rupture of mains and pipes	●	○	●	◐	●	○
Obstructions in intake points, intake screens, treatment plants and transmission pipes	○	●	◐	◐	●	○
Pathogenic contamination and chemical pollution of water supply	◐	●	○	●	●	○
Water shortages	◐	◐	○	○	○	●
Disruption of power, communications and road system	●	○	◐	●	◐	◐
Shortage of personnel	●	◐	◐	◐	◐	○
Lack of equipment, spare parts and materials	●	○	◐	●	●	○

Symbols used: ● **Severe effect** ◐ **Moderate effect** ○ **Minimal effect**

Hazard Assessment

As will be seen further on, one of the key steps in vulnerability analysis is identifying and assessing the hazards prevalent in the area where the water agency's or company's systems are located, which calls for a review of the company's historical records and a description of the damage suffered by each system over time.

If the assessment reveals a high level of risk—such as the possibility of a major earthquake—it is best to hire specialists to carry out a seismic risk assessment of the system's structures. In any case, disaster planning available through professional evaluation will always be of use.

Assessments must be carried out for each of the hazards to which the site is exposed, and should consider the likely frequency, intensity, the area of impact and the potential damage. The highest priority should be assigned to those hazards most likely to affect the agency or company, its physical structures and its services.

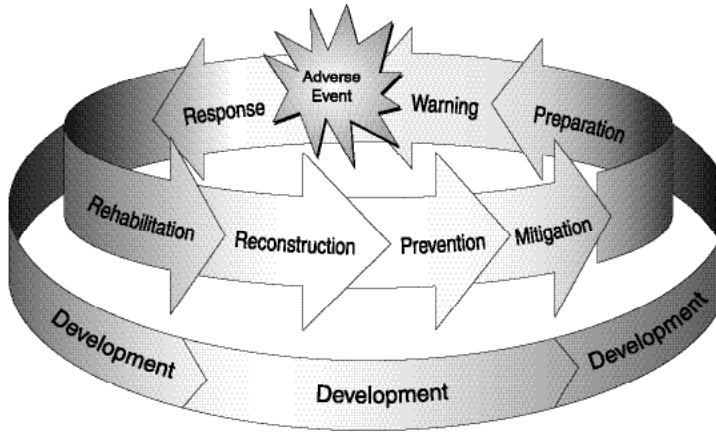
A given hazard may not affect the company's systems but rather the environment, including the population (which will logically include many of the firm's employees) as well as other companies or institutions that provide key services, such as electrical utilities or telecommunications networks. There may likewise be certain hazards that can affect some of the components of the system without affecting the company's customers.

The Disaster Cycle

The disaster cycle includes different stages, which can be summarized as three phases or periods:

- **Before the disaster,** which may be a period of calm or a declared state of alert depending on the event being analyzed;
- **During the disaster,** a stage that may be very brief or very long depending on the characteristics of the phenomenon;
- **After the disaster,** in which the focus is on recovering from the impact of the disaster, and which may be a short-, medium- or long-term endeavor.

Since it is difficult to identify precisely the beginning and end of each of these phases, it is preferable to speak of the different stages in the disaster cycle, which are summarized in the following figure.



Planning for emergency operations—also known as preparedness—involves designing a series of activities that, properly executed, should make it possible to prepare in advance for a disaster and respond promptly once it occurs. It is important to identify the activities to be carried out at each stage of the disaster cycle, particularly those involving the stage prior to the event, and the response stage, which must include the uninterrupted operation and maintenance of water supply and sewerage systems.

In planning for emergencies and disasters, the stage before an adverse event is the most important. It is then that one can anticipate the performance of the company and the physical components of water supply and sewerage systems.

Three sets of activities prior to the occurrence of a disaster or emergency are required:

- Prevention
- Mitigation
- Preparedness

After the disaster has occurred it is time for response activities, which may involve search and rescue, relief, and aid to the victims. Water supply and sewerage companies and agencies must respond quickly and effectively by implementing the emergency plan, and by trying to maintain the largest possible volume of water in the storage tanks until the actual condition of the systems can be verified.

The following set of activities is required after the onset of a disaster:

- Response
- Rehabilitation
- Reconstruction

The rehabilitation of water supply and sewerage systems is of crucial importance, since the speed with which these services can be restored will have a significant impact on the health of the population.

With reconstruction, the essential thing is for the company to incorporate prevention and mitigation measures when designing the new construction or retrofitting plans, so as to prevent the same weaknesses the systems had before the disaster.

Vulnerability Analysis and Measures for Prevention and Mitigation

Vulnerability analysis involves assessing the risks of physical, operational, or administrative damage to the various components of water supply and sewerage systems in the face of potential hazards. The results of the assessment should indicate those hazards threatening the entire system, as well as those that would affect only certain components.

After completing the assessment, one should have all the information required to carry out specific activities to reduce possible damage to the system through the prevention and mitigation program. If a given component cannot be modified to reduce its vulnerability, this contingency should be noted in the emergency plan. Since it takes time to carry out prevention and mitigation measures, the emergency plan must reflect current conditions, including those structures that are being retrofitted to reduce their vulnerability. Annex 1 presents two matrices identifying impacts of various hazards on water supply and sewerage components and measures that can be taken to mitigate these effects.

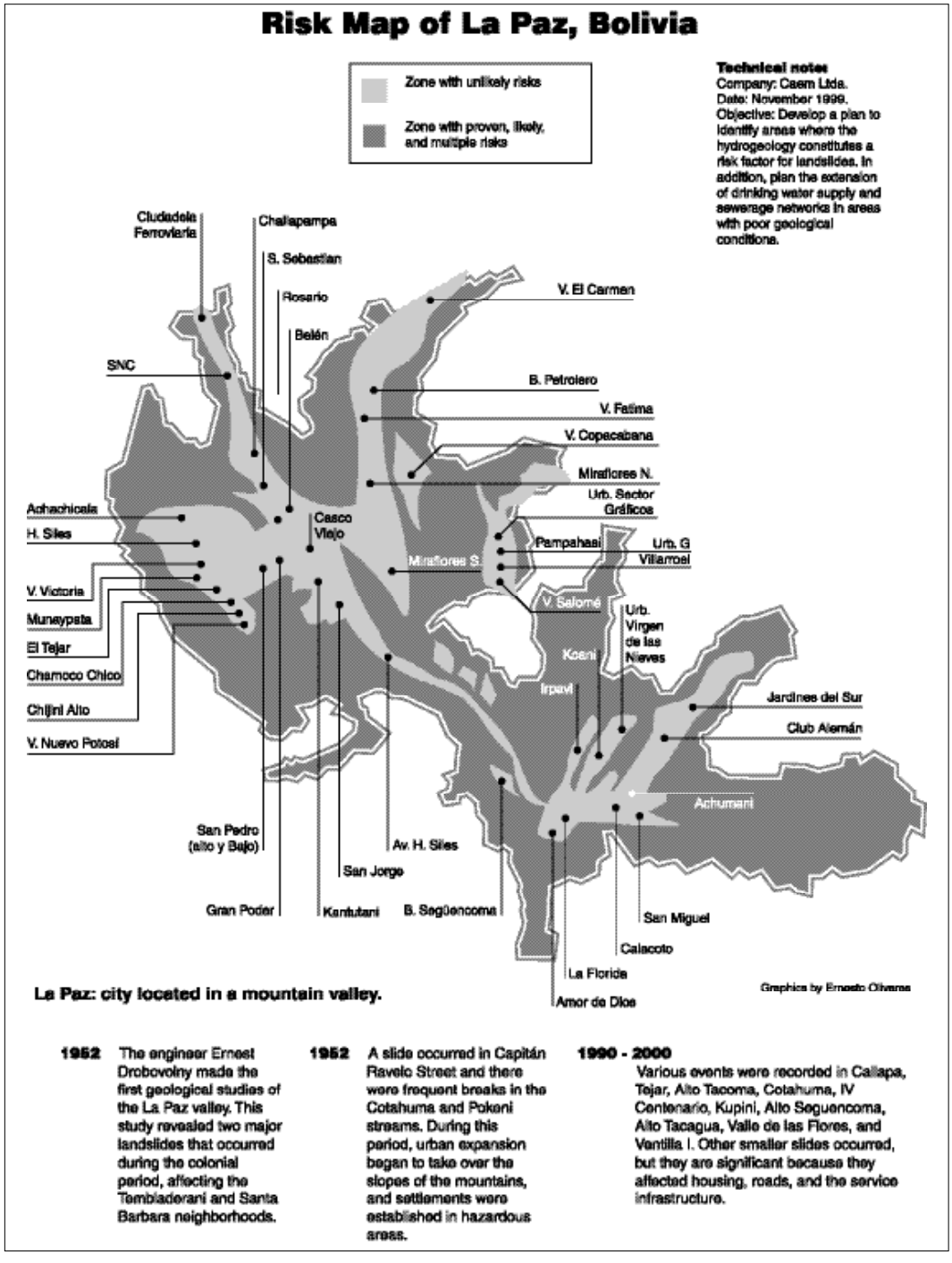
Vulnerability Analysis

As already noted, vulnerability assessment is the starting point for effectively reducing the impact of disasters through prevention and mitigation programs as well as the design of emergency plans. This section presents some guidelines in this regard.[6]

The methodology for carrying out vulnerability analysis is based on the use of up-to-date and reliable information. One of the first steps is the collection of data about the components of the system, including information about the operational methods as well as the building plans of the structures to be protected. Attention must be paid to all the potential hazards in the vicinity of the system.

This first step makes it possible to present all the relevant information in

[6] For more information please see the book *Natural Disaster Mitigation in Drinking Water and Sewerage Systems: Guidelines for Vulnerability Analysis* (Washington D.C.: PAHO, 1998).



Hazard map prepared by Aguas del Illimani, La Paz, Bolivia, 2000.

maps or diagrams that clearly identify the existing hazards and the areas that might be affected.

The results of the physical vulnerability analysis of the system's components can thus be represented in diagrams specifying the most vulnerable or critical components. These diagrams should be produced with the assistance of the most experienced and technically capable personnel of the company, and of external consultants, private or academic, if needed.

When the system's plans are annotated to indicate the most vulnerable components and superimposed on the hazard maps, a system risk plan can be produced for each of the likely hazards.

In addition to the above, it is customary and advisable to procure hazard maps produced by universities, civil defense institutions, national emergency commissions, or professionals in each of the relevant fields.

The following is a summary of the steps that must be taken to carry out a vulnerability analysis. Although reference is made to the drinking water supply system, the steps are also applicable to sewerage systems.

1. Identify the relevant national or regional disaster reduction institutions, as well as the legislation and standards regarding emergencies and disasters.
2. Describe the area under study: location, climate, urban infrastructure, public health services, geological, geomorphologic and topographic data, level of socioeconomic development, etc.
3. Identify and describe each of the components of the system and their subcomponents.
4. Identify and provide a functional description of the system (flow volume, level, pressure, quality of the service).
5. Identify the system's operational aspects (capacity, demand, deficit or surplus volume).
6. Identify and describe the administration and response capacity of the company or agency responsible for the system under study.
7. Determine hazard parameters and hazard assessment, taking into account the likely impact on the system.
8. Estimate the system's vulnerability based on the determination of the likely effects of the emergency on the system's components.
9. Quantify the capacity of each component and subsystem to operate in certain conditions, bearing in mind quantity, quality, and continuity (operational vulnerability).
10. Identify the critical and vulnerable components of the system that may

affect capacity to meet basic demand, and of the priority points of supply (physical vulnerability).

11. Estimate the organizational response capacity (organizational vulnerability).
12. Determine the mitigation, preparedness and emergency measures required to reverse the impact of the hazard on the system's components in administrative, operational, and physical terms.
13. Determine the minimum demand of the population in priority supply points, both during and after the impact of a disaster.
14. Draft the final report and vulnerability maps. Several reports can be produced to cover the various hazards that can affect the system.
15. Develop the Emergency Plan and the Prevention and Mitigation Programs.

For each of the hazards, steps 7 through 13 should be repeated.

The vulnerability of a drinking water supply or sewerage system is analyzed from three points of view:

- **Physical:** Estimation of the possible damage to infrastructure components;

- **Operational:** Assessment of the surplus or remaining capacity to provide the needed services, including an estimate of the time required to rehabilitate the systems.

- **Organizational:** Determination of the institutional or company response capacity, bearing in mind the organization, its expertise, and its other resources.

In some cases it may prove necessary to consider the cultural and socioeconomic characteristics of the community that benefits from the water supply and sewerage services, since improper use of the systems contributes to their vulnerability.

Each vulnerability analysis is related to a specific hazard, and this determines the structures and equipment that are susceptible to direct damage (for instance, the flooding of a pumping station) or indirect damage (failures in power supply).

The internal features of the company that support operations and maintenance (for instance, transportation, communications, and the supply of materials) must be analyzed, as well as features outside of the company (electrical power, telephone services, firefighters, and so on).

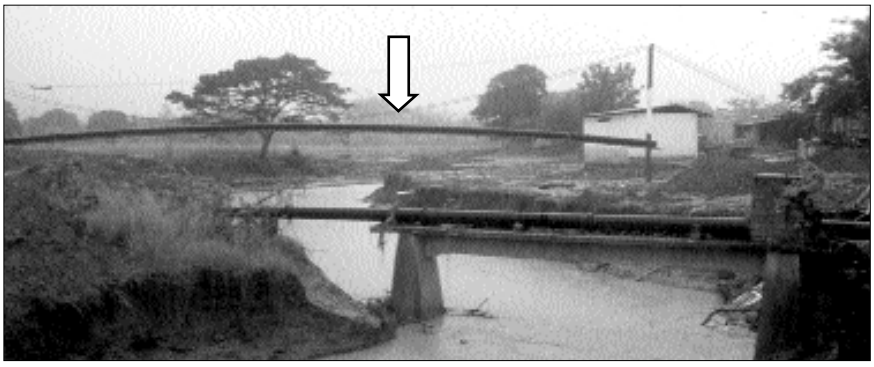
The organization of the company or institution is often the most vulnerable element to hazards if there is a lack of effective preparedness and training to confront emergency situations. Other factors are the obstacles to rapid response, such as bureaucratic barriers to prompt outsourcing or direct purchasing.

Within the organization, operations and maintenance activities are the most important during an emergency, since it will be necessary to work at a fast pace, with additional burdens and under pressure.

In order to systematize the key facts needed to produce a qualitative estimate of current vulnerability based on the information mentioned above (both regarding hazards and the water supply and sewerage systems), one option is to produce tables or diagrams regarding such matters as rehabilitation times, immediate surplus or remaining capacity, and the impact of potential disasters on the services in the area under study.[7]

Prevention and Mitigation Measures

The correct application of prevention and mitigation measures requires strong corporate or institutional will to support emergency planning. The effects of a hazard cannot be reduced without allocating the necessary resources. Even a modest, but continuing, budgetary allocation can produce significant results.



This photograph shows the effects of flooding during El Niño in Ecuador in 1999. The construction of a river overpass is a mitigation measure for piping.

C. Osorio, 1998

After carrying out the vulnerability assessment, the next step is to identify the most effective prevention and mitigation measures. This will make it possible to program the necessary actions to reduce the potential impact of any given hazard on the system. Such measures must include devising emergency operations, signing agreements with other institutions, preparing and carrying out the necessary training activities, allocating material and other resources, and choosing the most important retrofitting projects to reinforce the current system components.

[7] PAHO, *Natural Disaster Mitigation in Drinking Water and Sewerage Systems: Guidelines for Vulnerability Analysis*, Washington D.C., 1998.

Preventive measures reduce the vulnerability of systems. Exposed piping in Ecuador.

A. Rodriguez, 1998

Operations and maintenance activities provide an outstanding opportunity to incorporate mitigation measures into daily, routine actions.

The efficient use of resources calls for good administrative practices based on up-to-date staff training, particularly if new techniques or equipment are to be used. Training must take place at all levels of the company so as to maximize the use of resources.

The execution of a prevention program in companies responsible for water supply and sewerage systems will be effective if the following issues are borne in mind:

- The timely application of preventive measures based on the most likely and severe potential disasters and the availability of appropriate information in the short term;
- Integration of measures in a single program containing different levels or areas of execution based on existing resources;
- The identification of the key areas where the application of preventive measures is most needed and hence most urgent;
- Appropriate management of resources and their timely application;
- The introduction of preventive measures in the everyday activities of the agency or company.

Measures involving physical actions and establishment of standards require the greatest financial investment. They include improvements to existing infrastructure, new construction, and the implementation of improved design and building codes.

The creation and promotion of a culture of prevention and mitigation in the workplace ensures that the adoption of measures to improve potentially vulnerable structures can be carried out in a planned, progressive fashion, both in times of calm and during states of alert.

Other measures—particularly preventive ones—involve the institutional actions needed to respond to emergency situations (including the drafting of an emergency plan). Preventive maintenance, professional training in new operational methods, and the signing of agreements with other bodies are some of these actions. Such measures ordinarily do not demand major investments.

Even as the prevention and mitigation measures are being implemented, the components identified as most vulnerable should be included in the emergency plan, so that the company has a clear idea of how to respond in an emergency or disaster.

The Road to Disaster Mitigation

A proactive program enables a company to organize its activities in such a way as to begin planning for emergencies and disasters long before they occur, for instance by designating who should be in charge of this effort.

As noted elsewhere, responding to emergency situations in water supply and sewerage systems calls for the participation of the company's technical and operational units and the various support units, as well as from representatives of other organizations involved in environmental health and hazard management.

An obvious first step is to appoint a Central Emergency Committee (described in greater detail in Chapter 2), which would focus on strategic decision making both before, during, and after an emergency or disaster, as well as an emergency and disaster response office or unit, and/or some other technical committee, to serve as a tactical coordination mechanism under the guidance of the Central Emergency Committee. The second task is to become familiar with the hazards in the region, the weaknesses of the systems, and the goals that are to be pursued, keeping in mind the available resources.

The following section describes key activities, organized in four sequential stages, for developing and applying the emergency and disaster prevention, mitigation and response program.

A. Design of the Emergency and Disaster Prevention and Response Program

As the preliminary results of the vulnerability analysis become available, it is possible to start working on the Emergency and Disaster Prevention and

Response Program. Such a program must include:

- National and institutional standards for emergency situations;
- Description of the water supply and sewerage systems;
- Vulnerability analyses;
- Prevention and mitigation measures;
- Emergency operations plans;
- Annexes and supporting documents.

These components of the program must be incorporated sequentially, based on the information obtained and the resources available. It should be apparent that such a program covers all aspects of emergency and disaster situations, from the legal framework to the vulnerability assessments, as well as the Emergency Operations Plans. Once the program has been drafted, it must be approved by company or agency authorities and immediately released to all employees.

It must be stressed that such a program has to be carried out immediately after the weaknesses of the components and the system as a whole are known in sufficient detail, with the resources available at that time. As the program is being designed, the various operational levels should draft their own operative emergency plans, specifying the procedures for their application, as will be shown below.

The water supply and sewerage agency or company should include in this program administrative and normative aspects, the terms of reference for the vulnerability analyses, the prevention and mitigation measures to be taken, and the Emergency Operations Plans—all this in order to provide the greatest possible degree of security in the provision of water supply and sewerage services—in terms of quality, quantity and continuity—in the event of an emergency or disaster.

All actions outlined in the program must be mandatory for each of the departments of the company or agency to which they apply. The Emergency and Disaster Prevention and Response Program is, in general terms, a strategic document that should specify exactly who within the company or agency will carry out which actions when responding to emergencies and disasters. Once again, the operative program must consider the concrete, specific aspects of each of the potential hazards identified in the vulnerability analyses.

Finally, we should mention that it is important for the organizational structure of the company or agency to change as little as possible in the event of an emergency, so that employees can continue to carry out routine activities, even though the pace of work will increase in order to respond to the disaster situation.

B. Compiling and Evaluating Necessary Information

Given the nature of the work normally carried out by a water supply and sewerage company or agency, its response to an emergency or disaster is often considered adequate. However, there is no assurance that the decisions taken are the best ones. Even if the affected systems are brought back into operation, the facilities will not necessarily be more secure or able to withstand future disasters in the most cost-effective fashion.

The emergency and disaster plan must be based on the most reliable and up-to-date information available. Only then will there be a reasonable degree of certainty that the decisions taken in an emergency or disaster are the most appropriate, both technically and financially. The following is a checklist of the basic information needed to plan emergency response in water supply and sewerage systems.

Company or Agency Information

1. Technical information
   - Up-to-date description of the systems, including manuals, tables, figures, plans, maps, flow charts, etc.;
   - Official register of water supply and sewerage networks and up-to-date technical files;
   - Operational procedures, make-up of maintenance and other teams, fields of specialization of staff, etc.;
   - Background information on previous disaster experiences, rupture of mains, major maintenance jobs, labor strikes, etc.;
   - Projects under development and technical studies.

2. Administrative information
   - Description of human, material, and financial resources of the company or agency;
   - Organization of the company or agency (objectives, goals and strategies);
   - Legal framework;
   - Current technical and business plans;
   - Commercial information, including information on the expansion of the service;
   - Personnel training programs.

3. Operational information
   - Availability of heavy machinery;
   - Inventory and condition of vehicles;
   - Inventory of equipment (pumps, compressors, soldering equipment, etc.);
   - Personal protection equipment;
   - Stock of spare parts and chemical products.

Information from other institutions and bodies

1. Legislation and regulations pertaining to disasters at the local level (provincial, departmental) and the national level;

2. Information on hazards, including:
   - Earthquakes, hurricanes, floods, landslides, etc. (provided by civil defense, firefighters, municipalities, universities and other institutions);
   - Land use, urban planning (provided by environmental groups, universities, etc.).

3. Information on support and rehabilitation projects.
   - Construction companies, equipment and material suppliers, consultants;
   - Fuel suppliers, owners of water trucks and privately owned drinking water wells;
   - Information on other water supply and sewerage companies, both national and international;
   - Information on priority supply points, including:
     - Hospitals, health centers, Red Cross, firefighters, the police;
     - Shelters, military barracks, prisons, markets, schools;
   - National emergency commission or civil defense.

Since this information cannot be improvised, enough time should be assigned to collecting it, verifying its reliability, and analyzing it.

C. Vulnerability Analysis of Systems and Mitigation Measures

Once the components of the water supply and sewerage systems have been identified and described, as well as the potential hazards prevalent in the region, the process of vulnerability analysis should begin.

Some practical aspects to bear in mind at this stage are the following:

- Those responsible for the analysis must be identified;
- While the information is being analyzed, any gaps in the information must be identified and filled through additional data collection;
- The relevant human resources involved in the analysis must be identified, both those within and outside of the company;
- The training needs of the staff must be defined;
- The hazards must be described;
- The strengths and weaknesses of the system and its components must be identified;
- Prevention and mitigation measures and works must be defined, based on the early draft of the vulnerability analysis regarding each of the major hazards;
- Specialized studies (such as risk maps of the region) must be ordered, if needed;
- A financial assessment of the costs of prevention and mitigation measures must be undertaken.

D. Implementation and Evaluation of the Program

The directors of the company or agency must approve the Emergency and Disaster Prevention and Response Program so that it can be implemented as soon as necessary. They must also approve the budgetary allocations required to carry out the prevention and mitigation measures specified in the program, as well as to support the professional training process and follow up on it to make sure it achieves its objectives.

The directors should also establish a periodic review and evaluation process regarding the Emergency Operations Plan, for which they can use emergency drills and simulations at the relevant levels of participation. They must also review regularly the legal framework in order to propose the necessary adjustments to the relevant national, provincial, or municipal legislative bodies.

Since each prevention and mitigation measure that is carried out modifies the conditions that are the basis of the program, it must be revised as often as needed to make sure it remains up-to-date and reflects the current situation.