

## II. DRINKING WATER AND SANITATION

### A. INTRODUCTION

In light of the region's epidemiological indicators, mortality rates are closely related to infectious diseases that, to a large degree, depend on the quality of water consumed and on access to adequate sanitation services. When this situation turns critical during disasters, post-disaster activities must concentrate on rehabilitating services that might otherwise constitute sources of epidemics; special attention must be paid to water quality, sanitary removal of excreta and solid waste management.

The search for solutions to restoring water supply must take into account each potential resource, its capacity, its proximity to a drainage system and all potential causes of chemical contamination.

Under normal circumstances, inadequate human waste treatment methods negatively affect the health of the population. In a disaster, removal and treatment of human waste acquires increased relevance in avoiding the transmission of infectious diseases, and it constitutes a public health priority.

Damage in this sector depends not only on the intensity of the disaster, but also on vulnerability, a special characteristic of each component of the entire system. To put it differently, a disaster of a given magnitude and type may cause very different damage to different systems, or to different components of one system. The vulnerability of a system basically depends on four factors: its geographical location, the quality of engineering design, the quality of construction (including technology, equipment and materials used) and the quality of facility operation and maintenance.

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Most components of water and sanitation systems require proper operation and systematic maintenance over time; their absence would make the systems less resistant to damage and would hinder repairs when a disaster occurs. In turn, good operating and maintenance require effective organization, with workshops, spare parts and drainage layout plans, which significantly help to size, assess and repair more quickly and at a lower cost any damage produced by a disaster. Hence, operating and maintenance departments of affected systems will be a key source of information for the assessment team.

### B. ASSESSMENT PROCEDURE

The assessment process requires, as a prerequisite, the definition of the area affected by the disaster. The water and sanitation specialist must also determine what institutions are involved in the sector and the role each of them plays. The water and sanitation sector requires a multi-disciplinary and holistic approach to the dialectic relationships among its component elements. At the same time, each service or subsector (water supply, sanitary sewage disposal and solid waste collection and disposal) requires special assessment procedures. The assessment team must obtain information on the individual policies to be applied in each of the subsectors, as well as each one's degree of development.

On the technical level, the assessment team should collect basic information and detailed maps of the affected systems, which will be essential for the necessary field evaluations and verifications. After the assessment is concluded, it should be possible for the water and sanitation specialist to prepare a table showing the most accurate and summarized information on damage and losses to the subsystems, as indicated in the following table.

Table 1  
DAMAGE AND LOSSES IN THE WATER AND SANITATION SECTOR  
(In thousands of dollars)

Component	Damage			Sector		Effect on the balance of payments
	Total	Direct	Indirect	Public	Private	
<b>Total</b>						
<b>Water supply systems</b>						
<i>Urban systems</i>						
Infrastructure						
Rehabilitation expenses						
Diminished utility revenue						
Higher production costs						
<i>Rural systems</i>						
Infrastructure						
Rehabilitation expenses						
<b>Waste water disposal systems</b>						
Infrastructure						
Rehabilitation expenses						
Diminished utility income						
Higher production costs						
<i>Rural systems</i>						
Infrastructure						
Rehabilitation expenses						
Wells and latrines						
Solid waste systems						
Rehabilitation expenses						
Diminished utility revenue						

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### C. INFORMATION REQUIREMENTS

The water and sanitation specialist should strive to obtain all available information on the subjects listed below as a basis for the assessment.

#### 1. Drinking water supply systems

- Organization of the entire water supply subsector: service provider utilities, municipalities and regulatory and governing bodies;
- Pre-disaster water service coverage levels (urban and rural);
- Breakdown of the population served by collective and individual systems (such as collective water systems, individual wells, multi-family systems);
- Identification of the urban and rural systems affected by the disaster;
- Determination of whether the disaster affected the water supply treatment process and identification of any resulting need for additional chemicals/reagents or equipment;

- Characteristics of the systems affected by the disaster:
  - Population served before the disaster (number of domestic connections, average levels of water consumption, etc.);
  - Water supply rates, existing subsidies, billing collection effectiveness, etc.;
  - Pre-disaster production levels;
  - Water production capacity after the disaster; and
  - Estimated time required for rehabilitating all affected systems;
- Blueprints of all affected systems;
- Characteristics of damage sustained by all affected systems:
  - Description of damage sustained by different equipment/components of the affected systems;
  - Construction techniques and materials used in the systems' components; and
  - Accessibility to different components in the affected systems;
- Temporary organization of the water and sanitation service provider utilities, to meet population's needs until full services are re-established;
- Identification of measures undertaken to rehabilitate systems; and
- Costs of materials, construction, equipment, chemicals/reagents and other inputs required for the rehabilitation and reconstruction of systems.

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## 2. Wastewater disposal systems

- Organization of the sewage disposal subsector: service provider utility, municipalities, etc;
- Coverage levels of the urban and rural sewage disposal and sanitation systems prevailing before the disaster;
- Breakdown of the population served by collective and individual systems (latrines and septic tanks);
- Identification of urban and rural systems affected by the disaster;
- Characteristics of the systems affected by the disaster;
  - Population served before the disaster (number of household connections, etc.);
  - Sewage disposal rates, subsidies and billing effectiveness (include any link to billing for drinking water);
  - Pre-disaster wastewater treatment levels;
  - Post-disaster treatment capacity; and
  - Estimated time required to rehabilitate affected systems.
- Characteristics of damage to the affected systems:
  - Description of damage to equipment/components of the affected systems;
  - Construction techniques and materials used in sanitation systems; and
  - Accessibility of affected systems;
- Temporary organization of water and sanitation utilities for meeting the population's needs until services are re-established;
- Identification of measures required for the rehabilitation of systems; and
- Costs of materials, construction, equipment, chemicals/reagents and other inputs needed for system rehabilitation and reconstruction.

### 3. Solid waste collection and disposal

- Description of existing local utility for the collection, processing and final disposal of solid domestic waste;
- Characteristics of damage to the service's assets (trucks, access roads to towns and dumps, etc);
- Geographical coverage and beneficiaries of these services before the disaster;
- Identification of measures required for the rehabilitation of affected systems; and
- Costs of materials, construction, equipment, chemicals/reagents and other inputs needed for system rehabilitation and reconstruction.

## D. SOURCES OF INFORMATION

The water and sanitation specialist should enlist the assistance of all institutions and sources that may have basic information required for the damage and loss assessment, such as the following:

- Governing bodies and regulatory institutions, and water and sanitation services provider utilities:
  - \*Municipalities responsible for operating and maintaining water and sanitation systems and services; and
  - \*Ministry of health, housing or public works, when they have jurisdiction over the water and sanitation sector;
- National or departmental associations of municipalities.
- Water and sanitation utilities whether national, state, municipal, private, mixed or community managed:
  - \*Their annual reports in particular;
  - \* Local water and sanitation management boards,
- Non-governmental organizations (NGOs) that usually construct rural water systems (CARE, Save the Children, OXFAM, Catholic Relief Services, etc.) and then transfer the systems to be self-managed by the community itself;
- National Chapters of the Inter-American Association of Sanitary and Environmental Engineering (AIDIS);
- UNDP, UNICEF and PAHO/WHO reports on the state and coverage of water and sanitation services, normally issued once every ten years.

## E. DESCRIPTION OF DAMAGE

### 1. Direct damages

The water supply and sanitation specialist should be able to describe all direct damages sustained by the systems that make up the sector, as described below.

**Drinking water supply systems.** Ascertain the following:

- Damage to infrastructure and equipment of urban systems, preferably broken down by component;

- Damage to infrastructure and equipment of rural systems, preferably broken down by component; and
- Loss of stocks (chemicals, stored water, spare parts, other assets).

**Wastewater disposal systems.** Obtain the following information:

- Damage to infrastructure and equipment of urban systems, preferably broken down by component;
- Damage to infrastructure and equipment of rural systems, preferably broken down by component; and
- Loss of stocks (chemicals, spare parts, equipment, etc.).

**Solid waste disposal systems.** Ascertain the following information:

- Damage to infrastructure and equipment;
- Damage to access routes to facilities or dumps for final waste disposal; and
- Impact on waste disposal dumps.

## 2. Indirect losses

Here again, the water and sanitation specialist should obtain all information relevant for estimating indirect losses in the three subsectors.

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**Drinking water supply systems.** The following data would be required:

- Activities related to rehabilitation (distribution of water by tanker truck or other means, purchase of equipment and machinery, repairs, changes in water treatment processes, use of materials and inputs kept in stock ready for rehabilitation efforts, personnel overtime);
- Reductions in potable water output (as it relates to intake, treatment, storage or distribution facilities);
- Reduction of operational costs due to the partial functioning of systems;
- Increase in potable water production costs;
- Losses due to income not received (water not billed, suspension of service, etc.); and
- Insurance coverage.

**Wastewater disposal systems.** The following information is essential for estimating indirect losses:

- Activities related to rehabilitation (network inspection work, acquisition of equipment and machinery, repairs, etc.);
- Reduction in wastewater treatment capacity;
- Increases in wastewater treatment costs;
- Losses due to income not received; and
- Insurance coverage.

### Solid waste disposal systems

- Losses due to income not received
- Decrease in solid waste collection and disposal costs; and
- Insurance coverage.

## F. QUANTIFICATION OF DAMAGE AND LOSSES

### 1. Direct damages

To facilitate their quantification, we suggest that damages be grouped in accordance with the following components.

- First damage should be identified by type of system:
  - Potable water supply systems;
  - Wastewater disposal systems; and
  - Solid waste disposal systems.
- Second within each city and individual system, damage should be grouped by component or subsystem; for example, for the potable water supply system of a city:

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- Water intake facilities (intake A, intake B, etc.);
- Pumping stations (station 1, station 2, etc.);
- Water treatment plants (plant 1, plant 2, etc.);
- Main lines to storage tanks;
- Storage tanks (tank A, tank B, etc.);
- Distribution networks; and
- Other components, to be defined in each case.

The total damage to the potable water system of each city may then be obtained by summing the individual component damages.

A list of damage sustained by each subsector (water supply, wastewater disposal, and solid waste disposal) should be prepared, with a breakdown by materials, equipment or facilities. A procedure similar to the one described below could be adopted:

- A summary description for each damaged component should be made including its main elements, the type of damage and the approximate amount of work or material affected, in appropriate measurement units. For each damaged component, the following should be indicated:
  - Type of work and/or materials required;
  - Unit construction prices at replacement value (UP); and
  - Cost of repairs, estimated as a percentage (R%) of the unit reconstruction price described above.

- The estimate of the percentage (R%) to which facilities, materials or equipment may be damaged should be obtained directly from the service provider utility, or on the basis of a weighted estimate that would take into consideration whether the facility, material or equipment can be repaired or partially reconstructed or must be totally reconstructed or replaced. If there is a chance that the damage can be repaired, the cost of the damage should be estimated as a percentage (R%) of the total cost of said facility, material or equipment. If the facility has to be totally rebuilt or replaced, R should be taken to be 100%.
- The initial R% can be based on estimates provided by personnel from the utility that is responsible for each system, or from other sources, but the final figures adopted should be those calculated by the water and sanitation specialist on the assessment team on the basis of information he/she collected during the field mission.

In addition, one must take into account the cost of demolition, dismantling and debris removal in the manner described below.

- For each system component (identified in accordance with the above recommendations), a determination must be made as to whether reconstruction or repair will be required prior to demolition, dismantling or debris extraction. If such prior work is needed, an indication should be made of the approximate amount of work or material to be demolished and removed, in the appropriate unit of measurement, which as far as possible should be the same unit as the one used to quantify the damage to this item.
- A description should be made of the work or main activities considered part of demolition, dismantling and debris removal (adopting a single unit price for each item).
- The degree of difficulty and costs involved in work and materials should be taken into consideration. For example, distinctions should be made between the “demolition” of a reinforced concrete storage facility and the “dismantling” of asbestos cement pipes, whose joints can be much easier to take apart and which could be partially recovered and re-used.
- If an accurate estimate of prices under this heading is not possible, a criterion similar to that indicated in the previous point should be adopted, where the cost of “demolition and removal of debris” should be expressed as D% of the unit price. However, D% is not necessarily equal for each item, owing to the varying degrees of difficulty of demolition or removal.
- If part of the material can be recovered as a result of demolition or dismantling, whether for re-use by the same utility or for sale, its remaining value should be estimated as a percentage (V%) of the unit price of said material when new. These results should be deducted from demolition, dismantling and debris-removal costs.

If the disaster directly affects the warehouses or other storage facilities where spare parts, chemicals, reagents and water tanks are kept, this must be taken into consideration. The water and sanitation specialist should consider all available sources to ascertain the amount and unit prices of the materials in question.

Unit prices to be used in damage assessment can usually be obtained from recent feasibility studies or from the unit price lists normally used by the utility that provides the affected services. In this case, the date the lists were made should be ascertained so that, when necessary, adjustments for inflation can be made. The unit prices to be used can also be based on estimated unit prices derived from direct surveys or suitable local sources. "Comparative unit prices" available for the region that can also be used for comparisons with the two previous points, and used instead of them, when necessary.

No matter where the list or estimate of unit prices is obtained, it should include the labor content and the percentage of domestic and imported materials as a percentage of total unit prices. This will make it possible to distinguish the total amount of direct damage, the value of imports and their corresponding effect on the balance of payments.

22 Water supply, wastewater disposal and storm drainage systems include a wide array of facilities, materials and equipment. The cost of some of these facilities may easily be estimated on the basis of unit price lists. Such is the case of water pipes, whose unit price can be expressed in linear meters either for the simple purchase of the pipe or for their complete installation. The costs of other types of facilities (e.g., potable water treatment plants) that include components employing varied technologies and prices should be estimated based on a total price for the facility.

## 2. Indirect losses

Indirect disaster effects usually last throughout the rehabilitation and reconstruction period or until facilities return to normal operation. These effects include the water supply utilities' income shortfall (owing to reduced billings as they supply less water) and to increased water leakage from yet-to-be-repaired pipelines. They also extend to the higher operational costs the utility must assume to ensure the temporary provision of water until normal service is re-established. The negative impact on health should also be included. An agreement should be reached with the health sector specialist in order to avoid duplications or omissions in this regard.

### a) Drinking water supply systems

i) **Rehabilitation of normal operations.** Depending on its magnitude, a natural disaster may affect very large geographical areas that might include cities of various sizes, towns and rural areas. The random nature of the disaster and its ramifications might require a broad range of activities for rehabilitating services; these involve costs that should be included as indirect damage (in addition to the repairs of direct damage). These rehabilitation activities include the following:

- Pipeline repairs, using plastic patches or jackets, provisional by-pass pipelines and also works to divert flows away from holes in order to avoid losses of water in damaged pipe networks;

- Use of existing stocks or reserves of equipment, materials, chemicals and reagents;
- Increased chlorine concentration in already chlorinated water, with temporary functioning of chlorination facilities for untreated water and for storage tanks and preventive chlorination in deep and shallow wells in both urban and rural areas;
- Use of other existing potable water sources such as the deep wells of private factories, businesses or sports facilities (this calculation includes water connections to the network, the supply of power to pumping equipment, etc.);
- Temporary conversion of existing water storage facilities –such as swimming pools, factory and business storage tanks– as well as fiberglass and plastic tanks to store and distribute drinking water;
- Temporary use of tanker trucks or other vehicles pressed into service for delivering drinking water to the population;
- Activities required to implement, when necessary and possible, temporary rationing of drinking water in the network;
- Increasing water pressure in the network to avoid contamination of the potable water, which might be essential even in the event of increased water leakage;
- Preparation and delivery of instructions to the population on preventive measures for the use of water (boiling, for example), rationing timetables, tanker truck routes, water distribution points, etc; and
- The cost of alternative means for the public to acquire/purchase water (e.g.; the premium paid for such water, health problems).

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ii) **Estimating the cost of rehabilitating services.** Rehabilitation activities vary greatly owing to the wide range of potential disasters and the peculiarities of each region. In order to simplify matters, one should begin by grouping these costs into a limited number of categories:

Increased labor costs. This item includes any increases in costs of professional, technical, administrative and manual labor employed in rehabilitation operations, over and above the normal payroll levels. They may be estimated as follows, bearing in mind that the affected utility company would already have some estimates on the matter:

- Prepare a simplified list of personnel categories employed in this type work, indicating their unit cost in each category (person-months, person-days, as applicable);
- Estimate the “number of person-units” in each category that will be required for the rehabilitation operations during the entire period they are expected to last; and
- Multiply these values and add the subtotals to obtain total losses.

Estimated cost of works and repairs. This point includes any costs not included under the previous item. It should include all materials, transport, fuel and so forth, that may be used in works and repairs. Only a fraction of the total value of equipment, machinery, pipe and valves installed on a temporary basis is to be included in these estimates, which would include an amortization estimate ( $r\%$ ), whose value will depend on the use made of such elements during the rehabilitation.

A list of the main material works performed should be made, including a summarized description of each work or other material costs; the approximate volume of each work, materials or item; the unit price of each; and any overhead expenses and profits (where appropriate).

Estimated cost of using water sources or intake works not belonging to the public water utility. This involves expenses that have to be paid in accordance with special agreements with third parties.

Use of tanker trucks for drinking water distribution. Tanker trucks may deliver water in order to alleviate problems in those areas where the disaster disrupted normal service. Estimates should take into account such factors as the capacity of trucks engaged to deliver water and the rates charged per delivery.

**iii) Reductions in drinking water production.** The disaster may reduce the volume of water tapped from any source for treatment and delivery to the public. This shortfall may be the result of direct damages such as:

- A drought-induced decrease in water availability;
- Contamination of water sources; and/or
- Damage to intake facilities, pumping stations or other equipment.

**24 iv) Reductions in the distribution capacity of drinking water systems.** Damage to major pipelines that convey drinking water to cities or intermediate facilities (such as treatment plants, pumping stations, storage reservoirs, etc.) may impair the system's overall delivery capacity. Damage to secondary pipelines or to distribution networks may partially affect drinking water distribution capacity. Damage to domestic connections and/or interior networks of buildings, houses, factories, markets and the like may curtail local delivery capacity. Damage to pumping stations may also affect the system's total or partial water conveyance capacity.

**v) Reductions in the regulation and storage capacity of drinking water systems.** Any reduction in water regulation capacity diminishes the ability of a system to meet demand over time and avoid losses to water sources. This item includes any damage to a system's regulation and/or storage capacity, as well as damage to minor, industrial, commercial or domestic reservoirs.

**vi) Reduced consumption of drinking water.** Consumption in affected cities and towns may be partially or totally curtailed by the supply constraints noted above (e.g., direct damage to the potable water supply system) and/or the displacement of the consuming public. Should the sanitary quality of the water be undermined, residents would be forced to boil water. Obviously, a fall in supply and/or demand would reduce utility billings and revenues.

**vii) Increased water production costs.** These usually result from an elevation of existing water intake points or the need to draw on alternative sources; an increase in the daily volume of water production to compensate for leakage in either the main pipelines or in the distribution networks; and/or higher power and other input costs.

viii) **Lost income** (water not billed, temporary suspension of supply, etc.). To estimate the extent to which billings have declined (or the probable reduction in water sold to consumers in cities and towns located in the disaster area), one must determine the main factors responsible for the shortfall.

ix) **Impact on public health** because water flows have become inadequate, inconsistent or of inferior quality. The impact on health, particularly on that of children and the elderly, can vary and should be analyzed under the health sector.

#### b) Wastewater disposal systems

Three main types of indirect losses may be sustained, by wastewater disposal and storm drainage systems.<sup>1</sup>

i) Increased health-risk levels and reduced quality of life. Apart from the fall in the level of hygiene that may result from the lack of sufficient drinking water, the lack of sanitary or storm drainage may pose significant public-health risks for the following reasons:

- Wastewater disposal systems cannot be used in those areas that do not have a potable water supply because water is essential to flush away excreta and other waste;
- Breaks and blockages in the sewage disposal network will likely result in wastewater flowing to the surface of streets, increasing the risk of disease and epidemics either by direct contamination or by the action of vectors.
- Any problems at wastewater treatment plants might further pollute the water resources into which effluents are discharged; and
- The risk of flooding increases when rainwater drains are damaged.

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ii) Rehabilitation involves a wide array of activities including pipe repairs, the laying of provisional pipelines or drains and the digging of drainage ditches. These also may include maneuvers involving valves, gates and other facilities to divert flows from wastewater or rainwater pumping stations and to expel wastewater that has flooded plants, chambers or ditches. The cost of maneuvers and rehabilitation works for sewers should be estimated in the same fashion as drinking water.

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<sup>1</sup> In some instances, the same system is used to evacuate both wastewater and storm runoff. In other localities, separate systems exist.

iii) Decreased income from wastewater billings. How the disaster affects billings for wastewater disposal services depends on how billing is normally done in the affected cities. Where the charge is computed as a percentage of water supply billings, losses should be estimated using the following formula:

$I_t$  = total decrease in water supply billings in the city;  
 $a\%$  = percentage (%) overcharge in water supply bills included to pay for the wastewater disposal service;  
 $s\%$  = percentage of population having both water supply and wastewater system in relation to the total population having water supply connection.

Hence, the decrease in billing for wastewater disposal services will be obtained as

$$\Delta f_a = I_t \times (a\%) \times (S\%).$$

However, there could also be an additional segment of the population that cannot make use of the wastewater disposal service because it is broken. This loss might be estimated as an additional percentage ( $Z\%$ ) to the one indicated above, in the following manner:

$$\Delta f_a = (Z\%) \times (\text{Normal billing for waste water disposal service})$$

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When the cost for use of the wastewater disposal service is a flat rate for connecting to the system, the loss in billings can be estimated by applying a percentage to the overall billing for the city.

Given:

$F_a$  = total monthly billing for wastewater disposal service for the entire city;  
 $F_a/30$  = average daily billing;  
 $g\%$  = estimated billing percentage not charged due to the disaster;  
 $p$  = length of the period during which irregular or no service is provided, in days

Then:

$$\Delta f_a = (g\%) \times p \times (F_a/30), \text{ in US\$/period}$$

Where no charge is made for wastewater disposal service, the utility's revenues would not be affected.

## G. MACROECONOMIC EFFECTS

All items, information, background and procedures necessary to assess the water supply and sanitation sector's impact on the country's macroeconomic performance are described below.

### 1. Effects on gross domestic product

#### a) Reduced output

This refers to the reduction in production of water that occurs from the time the disaster occurs until normal production capacity is restored. The lost production should be estimated as the shortfall in utility revenues resulting from the reduced volume of water billed to the users, plus any increase in the cost of providing the service because of water produced that fails to reach consumers due to leaks in networks or other reasons.

It is possible to estimate how long it will take to resume normal supply and billings in light of the scale and characteristics of direct damages and the financial, repair and reconstruction capacity of the corresponding water-supply utilities.

A table should be prepared for each affected city and/or utility, the following data:

- The reduction in drinking water volumes billed each month to users from the time of the disaster until service is likely to be normalized;
- Any variations in average rates charged to the public for the volume of drinking water delivered;
- The shortfall in the utility's monthly revenue (the difference between pre- and postdisaster billings); and
- Any added costs associated with the population having to acquire water by other means.

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#### b) Projected sector performance prior to the disaster

The macroeconomic specialist may have access to such data for the entire country and the affected area. However, in Latin America and the Caribbean, the only such projections normally to be found involve the volume of water tapped, treated or lost through network leaks in urban areas, so it might be more practical to estimate the sector's GDP based on the volume of water billed to consumers. We recommend that the water and sanitation specialist, in close cooperation with the macroeconomics specialist, carry out the following tasks;

- Analyze national accounts and consult all institutions overseeing the sector in order to obtain, where possible, data on changes in GDP for the previous five years, together with a forecast by the corresponding officials on the sector's expected performance for the current year had the disaster not occurred; and
- Analyze any changes in the sector's strategies that would allow the service to be restored and further developed.

## 2. Effects on gross investment

These include the following three items:

### a) Projects under execution and other projected investments that must be suspended or postponed, or whose funds must be reassigned to meet disaster-related needs

This information should be summarized in a table identifying the main projects affected and the investment envisaged for each one. Finally, an estimate is to be made of the expected reductions in investment for each project as a result of the disaster, in the current and succeeding years.

### b) Losses of stock

A table must be prepared showing losses of stock (such as water stored in reservoirs and/or in storage tanks, chemicals and reagents for the treatment of water), as well as losses of materials and spare parts stored and/or available in facilities that were under construction.

### c) Financial requirements for repair or reconstruction

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The background for developing this item will mainly come from the direct damage lists and assessment, providing total and itemized costs for the damage. Based on that information, a table comprising the following information can be prepared:

- A list of affected works, broken down by systems, subsystems and main facilities and indicating the overall cost of the damage to each one. This list should separately identify works in the different cities and companies (if there is more than one responsible for the service in the same city), as well as for rural areas.
- A forecast of investment needed in the succeeding years for repairing said damages. The forecast should reflect the relative urgency of the respective works, the engineering capacity of the country and/or utility, and possible sources of financing. Special regard should be given to weighing the relation between national project execution capacity and new construction demands, and domestic capacity for covering the post-disaster surge in demand for reconstruction-related inputs vis-à-vis imports.

The water and sanitation specialist should make special reference to any expected requirement and capacity limitations for reconstruction and repair and make appropriate recommendations (as time and information limitations permit).

### 3. Effect on the balance of payments

The water and sanitation specialist should provide basic information on indirect losses so that the macroeconomic specialist may calculate the effects of the disaster on the current account. The information listed below should be included.

#### a) Decreased exports of goods and services

Since drinking water is very rarely exported, this item would not normally be taken into consideration. However, if an affected country normally exports engineering services related to the sector, the increased internal demand determined by the disaster might reduce or eliminate the export capacity for such services over a period of time. The reduced value of this export should be expressed as follows:

M\$<sub>s</sub> = decreased value of exports of services, in a given period;  
 M\$<sub>O</sub> = decreased value of exports of services, in the year of the disaster;  
 M\$<sub>1</sub> = idem for the year following the disaster; and  
 M\$<sub>2</sub> = idem for the second year following the disaster

Therefore:  $M\$s = (M\$O + M\$1 + M\$2)$

#### b) Increased imports

To estimate the value of this item, imports required for rehabilitation and reconstruction of direct damages should be taken into consideration. Such imports may be obtained from the summation of the imported components of direct damage estimates made previously.

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To estimate increased imports, the following procedure might be used:

Given:

I<sub>dd</sub> = increased imports as a result of direct damage;  
 I<sub>dd0</sub> = idem, during the year of the disaster;  
 I<sub>dd1</sub> = idem, during the year following the disaster; and  
 I<sub>dd2</sub> = idem, during the second year (etc.) following the disaster  
 (as applicable)

Thus:  $I_{dd} = I_{dd0} + I_{dd1} + I_{dd2}$

#### c) Donations

This item includes international assistance for the sector consisting of donations in kind, equipment, materials and machinery. Although these donations will probably occur in the period immediately after the disaster (year 0), there should be an indication of whether donations are expected in the following years.

**d) Reductions in international debt servicing**

If a reduction in interest payments has been granted by creditors, due note should be made of it under the year in which it occurs.

**e) Insurance and re-insurance**

Increasingly, both the assets and revenues of the water and sanitation sector are domestically insured against disaster risks. Should that be the case, estimates must be made of insurance payments due after the disaster, as well as the expected amounts of reinsurance to be received from abroad, since these will have an effect on the country's balance of payment.

**4. Effects on public finances**

A disaster might disrupt public finances in several ways, as described below.

**a) Decline in tax revenues due to lower production of goods and services**

If water and sanitation billings are subject to taxation and if, utility revenues decline as a result of the disaster, the corresponding fiscal or municipal revenue will also diminish. To estimate these tax revenue shortfalls, due consideration should be given to the following:

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- Declines in revenues due to decreased billing and water losses; and
- Information on the percentage (p%) and value of said taxes as estimated by the utilities.
- The value of lower taxes may then be estimated as follows:

$$M_i = M_{i0} + M_{i1} + M_{i2} = \text{lower tax revenue in years 0, 1 and 2.}$$

**b) Decline in public utility revenues**

Lower billings due to a decreased supply of drinking water, as indicated above, results in decreased revenues for the affected utilities.

Thus:

$$M_f = M_{f0} + M_{f1} + M_{f2} = \text{Lower billing for years 0, 1 and 2.}$$

**c) Increased outlays for reconstruction and damage repair**

Information required to estimate this effect on public finances should be obtained from tables included in the previous example on gross investment.

Let:  $M_{gi}$  = higher outlays in reconstruction investment.

Then:  $M_{gi} = M_{gi0} + M_{gi1} + M_{gi2} = \text{idem, year 0 + year 1 + year 2}$

## 5. Effects on prices and inflation

Damage caused by the disaster may have a bearing on changes in the prices of water and construction materials required to repair damages in the sector. This would depend on several factors, including the magnitude of the disaster and the amount of damage caused.

### a) Possible change in the price of water

The cost of water may vary as a result of a disaster for several reasons. Among them:

- Water production costs may vary owing to the need to change the place or type of water resource intake, the type or types of treatment plants or the conveyance or elevation of the water, or because of a drawdown in groundwater levels;
- If the resulting difference in costs compared to those before the disaster is absorbed by the utility through subsidies, there should be no effect on the price to the public.

Information on these matters should be provided by the water utility. However, it is unlikely that they could be reasonably certain of the exact impact on pricing so soon after the disaster, so the analyst must also make possible trend projections. If the cost increases as a result of the factors indicated above, the relationship between the new cost per cubic meter and the previous cost, or the expected variation in the new price to the public, should be indicated.

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### b) Possible effects on the price of construction materials.

Heightened demand for construction materials in this sector and throughout the economy in the wake of a disaster is likely to exert significant pricing pressures. Therefore, the assessment team as a whole should analyze the situation concerning a possible increase in construction material prices.

From the point of view of the water and sanitation sector, it would be useful to have an estimate of the increased demand for the main materials that will be involved in repair and reconstruction during the years following the disaster. The specialist should also develop an idea of the domestic production capacity, its relation to the increased demand and the capacity to import said materials. In addition, consideration should be given to possible price controls adopted by the government.

## H. OTHER EFFECTS

### 1. Possible effects on employment

As in the case of the energy sector, the growing use of technology and equipment implies that the water and sanitation sector employs a limited amount of personnel for the operation of its networks. A disaster is thus likely to have a very limited effect on employment and personal income in this sector. In fact, personal income of utility enterprises may actually increase during the rehabilitation period due to the payment of overtime.

The water and sanitation specialist should work in close cooperation with the employment specialist of the assessment team to arrive at the overall effects that the disaster may have on employment and income, ensuring that figures for the water and sanitation sector are duly included and not duplicated in the latter's global estimates.

The following paragraphs describe possible effects on employment for the sector.

#### a) Effects due to replacement of facilities and infrastructure

32 Since availability of drinking water is essential to the population, destroyed facilities and other infrastructure must be replaced as quickly as possible. The technology and design of the new facilities might require a different number or type of personnel for purposes of operation and maintenance. Any differences in employment arising from technological changes must be duly noted.

#### b) Effects occurring during the reconstruction and repair stage

Employment requirements during the emergency phase fall outside the scope of the assessment described in this Handbook. However, any of the following possible impacts on employment during the reconstruction process should be indicated:

- Employment levels could remain unchanged if reconstruction efforts absorb workers who were laid off when projects begun prior to the disaster were cancelled or suspended;
- Employment could increase if normal projects and activities are maintained while additional workers are hired for reconstruction and rehabilitation projects; or
- The employment scenario could be mixed, with only a percentage of pre-disaster development projects being canceled or postponed.

The disaster may have an impact on the investment decisions of government officials and the drinking water utilities, so the water and sanitation specialist should obtain the relevant information from these institutions for estimating any variations in employment for years 0 1, and 2 (if reconstruction works require more time, more years must be added).

These employment projections must be consistent with the time-frames and investment projections made earlier with regard to reconstruction requirements.

## 2. Differential effects on women

Any damage to drinking water systems in rural and marginal urban areas has a differential effect on women, who generally bear the burden of obtaining water for household consumption where no domestic water connections are available.

When a family or community well or spring is rendered useless as a source of drinking water because of contamination or silting, women are forced to dedicate greater time and effort to obtaining water from more distant locations, thus increasing their reproductive workload.

The section on the differential impact of disasters on women in Volume Four of this Handbook explains in detail how this increase in reproductive work can be estimated through field surveys. The water and sanitation specialist should work in close cooperation with the gender specialist in making such estimates.

## 3. Impact on the environment

Any change in the availability or quality of the water resource used by the drinking water supply system constitutes an environmental modification that has negative effects on people's health and well-being. The same is true of sanitation problems caused by disruption of wastewater disposal and solid waste management systems. While the chapter on environmental matters in Volume Four deals with these issues, the estimation of related costs falls within the purview of the water and sanitation specialist, who should coordinate with the environment specialist to ensure that all the relevant information is effectively obtained and that there is no double accounting.

## APPENDIX XVIII

### ESTIMATING LOSSES IN THE DRINKING WATER AND SANITATION SECTOR CAUSED BY THE JANUARY 13, 2001, EARTHQUAKE IN EL SALVADOR<sup>2</sup>

On January 13, 2001, an earthquake that registered 7.6 on the Richter scale struck El Salvador. Its epicenter was located off the Pacific coast, approximately 100 kilometers southeast of the city of San Miguel. The quake was felt throughout El Salvador and in some neighboring countries, but the regions suffering the greatest damage were the departments of Usulután, La Paz and San Vicente.

The earthquake, which was followed by numerous and powerful aftershocks, took a significant toll on the poorest segments of the population, especially their housing, basic services, education and access to healthcare. All productive sectors and the country's basic infrastructure were affected.

Most of the information required for evaluating the water and sanitation sector was provided by the Administración Nacional de Acueductos y Alcantarillados (ANDA), the Pan - American Health Organization/World Health Organization and the Ministry for Public Health and Social Services.

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#### 1. Drinking water and sanitation

Prior to the earthquake, El Salvador supplied potable water to 86.8% of the urban population (2,951,565 inhabitants) and to 25.3% of its rural residents (830,130 inhabitants). Sanitation services were available to 85.9% of urban residents (2,727,160 inhabitants) and to 50.3% of the rural population<sup>3-4</sup>.

The above service breakdown implies overall (urban and rural) coverage of 60.4% for drinking water and 68.3% for sanitation. Such services are supplied by ANDA, municipal governments and the health ministry, as well as local and international NGOs that are largely focused on covering demand in rural areas.

##### a) Drinking water supply

According to ANDA damage reports, water storage tanks and distribution systems were the components of urban service networks hardest hit by the quake. The extent of damage varied widely, ranging from cracked walls, weakened support structures (beams, towers) and the settling of surface-level facilities.<sup>5</sup>

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<sup>2</sup> ECLAC, *El terremoto del 13 de Enero de 2001 en El Salvador. Impacto socioeconómico y ambiental*, Mexico City, February 2001.

<sup>3</sup> Dirección de Planificación, *Boletín estadístico* N°21, ANDA, San Salvador, 1999.

<sup>4</sup> OPS/OMS – UNICEF, *Evaluación global de los servicios de agua y saneamiento – Informe analítico*, San Salvador, July 2000.

<sup>5</sup> ANDA, *Información preliminar de agua potable y alcantarillado sanitario a nivel nacional – Ocasionado por el sismo del 13/01/2001*, San Salvador, 2001.

In the San Salvador metropolitan area and other regions serviced by ANDA, varied degrees of impact on flows from wells and pumping stations were reported. Meanwhile, weakened slopes and the resulting landslides led to ruptured water mains, especially near hillsides, and water supply was suspended for days or even weeks before the breaks were repaired. There were also reports of damage to electric equipment and water treatment plants, but in most cases these were repaired and service was reestablished quickly.

Unfortunately, it was not possible to obtain information on the extent to which services were suspended or impaired in municipalities not covered by the ANDA system.

Thirty-two out of approximately 400 rural drinking water systems reported varying degrees of damage that largely consisted of the uncoupling or breaking of water mains, especially near inclines and ravines or in areas where the land was otherwise unstable. Where the walls of shallow wells were damaged, they had to be cleaned or alternate water sources had to be found. According to estimates, approximately 10 400 household shallow wells were in need of repair or reconstruction after the quake, and most of those were to be found in the countryside or in marginal urban neighborhoods.

According to data from ANDA and other relevant institutions, roughly 500 000 urban residents temporarily lost access to drinking water; that is equivalent to 15% of those normally receiving this service. In rural areas, 9.1% of service recipients, or 75 626 inhabitants,<sup>6</sup> were similarly affected.

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During the emergency stage, tanker trucks were used to deliver properly chlorinated water, and portable water treatment equipment was deployed to areas where normal service had been affected. By February 8, tanker trucks had distributed 18 968 cubic meters of drinking water.

In addition to the emergency measures cited above, ANDA, municipal authorities and local water boards went to work immediately of the quake to restore damaged networks, prioritizing those supplying urban areas and those rural systems for which the cost of repairs could be immediately covered by local water boards or ANDA. Work was strictly focused on restoring service as quickly as possible, so some repairs further magnified vulnerability, especially along ravines where there were reports of landslides. Some inclines that were left unstable by the quake remain highly susceptible to future tremors, human intervention and rainfall that could inflict damage as great or greater than that of the original earthquake.

#### b) Sanitation systems

While ANDA reported no damage to wastewater disposal facilities and municipalities have yet to publish any relevant information in this regard, the assessment team assumed that any damage would become apparent over the course of sanitation-system operations. Depending on where sewerage lines ran, and their proximity to water mains, there was a remote possibility that potable water could have been contaminated.

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<sup>6</sup> Gerencia de Sistemas Rurales, *Informe de daños a sistemas rurales de agua potable hasta el 29/01/2001*, ANDA, San Salvador, 2001.

Latrines, which are the main form of sanitation system in the rural sector and in marginal urban communities, sustained considerable damage or were totally destroyed, especially in the hardest hit areas. According to data on the number of rural dwellings that were destroyed and the extent of such sanitation systems in the countryside, it was estimated that approximately 63 000 latrines were damaged.

c) Solid waste disposal

Municipalities provide solid waste collection and disposal services. During the field visits it was impossible to obtain any information concerning the state of these services. COMURES (the National Council of Municipalities of El Salvador) intends to collect information on this matter sometime in the future.

2. Estimated damage and losses

Direct damage to drinking water and sanitation systems was estimated at 13.1 million dollars. Indirect losses –which involve greater expenses and fewer revenues for the sector’s utilities– were estimated at 3.3 million dollars. Total damages and losses thus reached 16.3 million dollars. The international community provided one million dollars in emergency assistance. Meanwhile, the temporary suspension of service implied estimated savings of approximately 525 000 dollars in state subsidies to ANDA (see table 1 below).

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Table 1  
SUMMARY OF DAMAGE AND LOSSES IN THE SAN SALVADOR EARTHQUAKE OF  
JANUARY 2001  
(Thousands of US dollars)

Item	Total damage	Direct damage	Indirect losses	Impact on balance of payments
<b>Total</b>	<b>16,340.0</b>	<b>13,062.0</b>	<b>3,278.0</b>	<b>8,500.0</b>
<b>1. Urban systems</b>	<b>8,363.0</b>	<b>6,200.0</b>	<b>2,163.0</b>	<b>5,000.0</b>
- Infrastructure damage <sup>7</sup>		6,200.0		
- Emergency relief <sup>8</sup>			663.0	
- Low income			1,500.0	
<b>2. Rural systems</b>	<b>7,977.0</b>	<b>6,862.0</b>	<b>1,215.0</b>	<b>3,500.0</b>
- Damage to rural water systems		362.0		
- Emergency relief <sup>7</sup>			1,215.0	
- Damage to shallow wells		500.0		

<sup>7</sup> Reconstruction costs include those for repairing public sector buildings damaged by the earthquake.

<sup>8</sup> Includes an increase in operational expenses.