II. Asbestos cement pipe, with Gibault joints, type 20, installed

	U P US$/lm	M O	M.N	C.I	G.G
a) D = 100 mm	12	20%	30%	30%	20%
b) D = 150 mm	20	"	"	"	"
c) D = 200 mm	32	"	"	"	"
d) D = 250 mm	41	"	"	"	"
e) D = 300 mm	67	"	"	"	"

III Cast iron pipe, with socket-cord joint, installed

D = 400 mm

U P. = US$ 100 lm

M.O. = 20%

M N. = 10%

C I. = 50%

G G. = 20%

IV. Compressed cement pipe, installed

	US$/lm	M.O.	M.N	C.I.	G.G
a) D = 175 mm	14	30%	50%	-	20%
b) D = 200 mm	18	30%	50%	-	20%
c) D = 300 mm	30	30%	50%	-	20%
d) D = 500 mm	70	30%	50%	-	20%

v. **Semi-buried tank, of reinforced concrete**

Volume = 1 000 m^3 (estimated at US$80/$m^3$)

U P = US$ 80 000 M.O. = 25%

M.N. = 40%

C.I. = 15%

G.G = 20%

vi. Administration of building, brick walls, with reinforced concrete pillars, rafters and floors

U P = US$ 250/m2 M.O. = 20%

M.N. = 50%

C.I. = 10%

G G. = 20%

vii. **Demolition and debris removal of collapsed sections**

U P = US$ 20/m2 M.O. = 80%

G.G = 20%

C. INDIRECT DAMAGE

1. Definition and general observations

a. Definition of indirect damage

According to the criteria proposed in this manual, indirect damage is defined as those goods and services which it will be impossible to obtain as an effect of the direct damage caused by the disaster These may last the entire period of time necessary for reconstruction, repair and re-establishment of normal operations of the works in question They also include reduced drinking water company income, due to reduced billing (arising from reduced service) and losses of water, due to as yet non-repaired direct damage, and increased operating costs incurred by drinking water companies for temporary water supply activities, which will last indefinitely, depending on delays in reconstruction

b. General observations

Indirect damage depends on the effects of direct damage impact on the functioning of systems As well, different types of direct damage may cause the same or similar indirect damage.

2. Main indirect damage to drinking water supply systems

Direct damage may have the following main effects, either separately or in combination:

i. reduced production or collection of drinking water;

ii. reduced drinking water treatment capacity,

iii. reduced capacity to channel drinking water,

iv reduced capacity to control and store drinking water;

v. reduced drinking water consumption. All these factors may generate higher costs or reduced system income. Each of these categories is explained, as follows:

a. Reduced production or collection of drinking water

This refers to the reduction in the normal production or collection of drinking water in the intakes or collectors customarily used by the system This may be caused by diverse types of direct damage, such as, for example

i reduced capacity of water sources (due to drought, for example);

ii contamination of sources;

iii. damage suffered by works, plants, machinery or collector equipment,

iv. damage to electrical lines or in the supply-line of fuel necessary for the operation of pump machinery or collector equipment and,

v. other damage.

b. Reduced drinking water treatment capacity due to damage

i to treatment, filter, chlorinating, etc plants,

ii to the energy supply of those plants;

iii. to the supply of inputs,

iv excessive water sediments, damage to sources, which make it necessary to reduce the flow treated,

v other damage;

c. Reduced capacity to channel drinking water

i. arising from damage to pipe lines or other types of main channels which carry water to cities or to intermediate installations (such as treatment plants, pumping stations, tanks, etc), thus affecting the overall channeling capacity of the system,

ii. damage to pipe lines or secondary channels and/or distribution networks, which partially affect the capacity to channel drinking water;

iii. damage to domestic connections and/or interior networks in buildings, houses, industries, markets, etc. which affect, locally or domestically, the capacity to channel and deliver drinking water,

iv. damage to pumping or re-pumping stations, which are necessary to the overall or partial channeling capacity of the system,

v other damage;

d. Reduced capacity to control and/or store drinking water

Reduced regulation capacity diminishes, in turn, the capacity to deliver water, in response to variations in demand throughout the day, with greater impact during peak demand, which leads to the loss of water not stored.

i. due to damage to main regulation and/or storage tanks of a system which will affect overall water supply;

ii damage to secondary tanks;

iii. damage to lesser tanks, be they industrial, commercial or domestic,

iv other damage.

e. Reduced drinking water consumption

i The consumption of drinking water in affected cities and towns may be reduced or cease as a result of the damage indicated above It is most probable that a combination of those factors will cause a reduction in the water supply, lower pressure and even lower sanitary quality, making it necessary for the population to boil water prior to direct consumption.

ii. Consumption of drinking water may also be reduced, even if direct damage to the drinking water supply system does not occur, if the disaster has left housing damaged and unserviceable.

iii It is evident that reduced supply and reduced consumption will mean reduced billings and lower revenue for the corresponding services

3. Higher operating costs

These higher costs will mainly be caused by:

i. increased production costs for m^3 of water –affecting all or some of system water– due to, for example:

- higher than normal pumping heights in collectors;
- higher operating costs in emergency collectors, used to (totally or partially) replace those used normally;

ii. increased daily production to compensate for abnormal losses in conduits,

iii. higher energy costs and for other inputs,

iv combinations of the above.

In order to calculate higher water production costs, the following should be considered:

a. Case A: Only one collector

	Before the disaster	After the disaster
Average cost for production of m^3, in $/m^3$	Mo	Ms
Average volume, produced daily, m^3/day	Vo	Vs
Average daily cost, in $/day	Do=Vo x Mo	Ds=Vs x Ms

Therefore, the higher daily cost will be:

(1) d=(Ds-Do) = (Vs x Ms) - (Vo x Mo); in \$/day

and the cost for a period of (p) days, which the situation will supposedly last, will yield.

(2) P=d x p, in \$/period.

By way of example, suppose:

i Before the disaster. Mo = US\$ 0.02/m^3

Vo = 10 000 m^3/day

In which, Vo = volume for an average day for some 40 000 persons, with 250 lt/day/inhabitants

ii. After the disaster Ms = US\$ 0.035 m^3

Vs = 12 000 m^3/day (in this case, greater volume is supposed, in order to compensate for intermediate losses)

iii Higher daily cost: d = Vs * Ms - Vo * Mo = US\$ 220/day

iv If the emergency situation lasts p = 30 days, the higher cost during that time will be:

p = 30 * 220 = US\$ 6 600

b. Case B: Diverse collectors

If there are several collectors, each with different production volumes and costs per m^3, average costs can be obtained, as follows.

	Before the disaster	After the disaster
Cost m^3, in each collector: \$/m^3	m1, m2, mn	M1, M2, Mr
Daily volume, per collector: m^3/day	v1, v2, vn	V1, V2, Vr
Daily cost, per collector: \$/day	Vn x mn	Vr x Mr
Number of collectors	n	r
then:		
Total daily volume, m^3/day	Vo= $\sum$ Vn	Vs= $\sum$ Vr
Total daily cost, \$/day	Do= $\sum$ VnxMn	Ds= $\sum$ VrxMr
Average cost per m^3, \$/m^3	Mo=Do/Vo	Ms=Ds/Vs

Therefore, the higher daily cost will be

(3) d= (Ds-Do)= (Σ Vn x Mn- Σ Vr x Mr), in $/day. This equation is similar to (i) above.

and in a period of (p) days:

(4) P= d x p = (Ds-Do) x p, in $/period. Similar to (2) above.

c. Case C: Higher cost of pumping water

One of the most frequent causes of higher water production costs is the increased cost of raising water (due to factors such as those indicated above). It is worth recalling here how pumping costs are calculated[15] (taking only electric energy into account, in this case, because other factors either have little impact or are considered elsewhere). Calling:

Q pump flow in lt/sec.

H total height in meters (including loss of load)

N. total yield (wire-water) of pump equipment

k cost of K W H. in $/KWH[16]

M elevation cost of 1 m^3 to H height, in $/$m^3$

V: volume raised per hour = 3 6 x Q, in m^3/hour

Nh number of daily pump hours

V: daily volume raised = 3.6 x Q x Nh, in m^3/day

D elevation cost per day = M x V, in $/day.

Then, the pumping cost per m^3, to H height, is:

(5) $$M = \frac{0.736xk}{75 \times 3\,6 \; xN} xH = 0.002726 \frac{K}{N} H$$

Estimating an average yield of M = 0 68, gives:

(6) M = 0 004 x k x H, in $/$m^3$

[15] See Herman House Método de diseño económico para un sistema de abastecimiento que incluye elevación del agua. Congreso Nacional de Hidráulica de México, 1976

[16] If raised by internal combustion pump, the equivalent KWH cost is to be used here

I. By way of example, suppose that, prior to the disaster:

H = 100 mts. (height)

k = US$ 0 05 per KWH

Q = 500 lt/sec

Nh = 20 pumping hours daily

So that, prior to the disaster (with the figures of this example):

$M0 = 0\ 004 \times K \times H = 0.004 \times 0.05 \times 100 = 0.02$ dollar/m^3

$V0 = 3.6 \times Q = 3\ 6 \times 500 = 1\ 800$ m^3/hour

$V0 = 3.6 \times Q \times Nh = 3.6 \times 500 \times 20 = 36\ 000$ m^3/day[17]

$D0 = M \times V = 0.02 \times 36\ 000 = 720$/US$/day

II. Supposing that, after the disaster, only height has changed so that now

Hs x 140 mts

$$Ds = \frac{140 \times 720}{100} = \text{US\$ } 1\ 008/\text{US\$/day}$$

Then, the higher daily cost will be:

d = (Ds - Do) = 1 008 - 720 = 288 US$/day

If that situation lasts p = 30 days, the higher cost, caused only by increased height, will be.

P = (Ds - D) x p = 288 x 30 = US$ 8 640 of higher cost for that period

III. The value P, indicated above, supposes that the yield "N" of the pumping equipment has not changed; however, in the probable event that yield is less, supposing 70% (0 07) of previous yield, will give:

$$Ms = \left(\frac{1}{0\ 7} \times M\right) = 1\ 428 \times 0.02 = 0.0286 \text{ Dollar/m}^3$$

[17] The daily average consumption of some 120 thousan persons, aproximately.

and the higher daily cost and for the entire period will increase by the same proportion

P' = 8 640 x 1 428 = US$ 12 338, higher cost for the period

4. Estimating other emergency operating costs

a. Emergency operating activities

Depending on its intensity, a natural disaster may cover vast zones, including cities of different size, towns and rural areas. The factor of chance, proper to the disaster, and the variety of situations which arise may require a very wide range of emergency service activities, implying costs which should be processed as indirect damage (beyond the repair of direct damage). Among this type of activity are:

i. Emergency repair of pipe lines, using patches or plastic sleeves, installing temporary by-pass pipe lines or conduits, as well as maneuvers to channel run-off, in order to avoid water loss in damaged pipe lines, using emergency valves and tubing, etc.

ii Increased chlorine concentration in flows already being chlorinated Installation of emergency chlorination stations for flows not previously chlorinated. Preventive chlorination of deep and shallow, urban and rural wells

iii. Use of other available collectors of drinking water such as, for example, the deep wells of industries, commerce or sports complexes, etc. Included here are hydraulic inter-connections to the network, the energy supply for pumping equipment, etc

iv. Preparation of available depositories as emergency drinking water tanks, such as swimming pools, industrial and commercial depositories, etc Moreover, the use of fiber glass, plastic, etc tanks, for storing and distributing drinking water to the population.

v Use of tank trucks, towed cisterns, trucks with tanks loaded on flat beds, etc. to distribute drinking water to the population

vi. Activities and maneuvers to establish rationing of the water in the network, when necessary and possible.

vii Hydraulic maneuvers to increase pressure in the network, if necessary to avoid contamination of drinking water (sometimes indispensable, even though water losses increase, through leaks)

viii Elaboration and delivery of instructions for the population, with regard to cautionary measures in the use of water (boiling, for example), rationing schedules, tank truck routes, distribution points, etc.

b. Estimate of emergency operating costs

The different situations created by natural disasters, together with the diversity of regional or local situations, make it possible to appreciate the wide range of emergency activities possible and the variability of their magnitude For a rough estimate of the costs of these activities, it is necessary to simplify the problem, grouping costs in a limited number of categories:

i **Estimate of extraordinary expenses in wages and salaries**. Included here are the costs for professional, technical, administrative and operating personnel occupied in emergency operations, as indicated. The procedure for this estimate is as follows:

- make a simplified list of the categories of personnel occupied in those activities, indicating the unit cost in each category (man-hour, man-day, or man-month, as appropriate);
- for each category, the "number of man-units" required for emergency activities, while the emergency lasts, should be estimated;
- the values of (i) and (ii) should be multiplied and partial totals should be added together, as indicated in the following example (with supposed values and %)

(a) Personnel	(b) Category	(c) $/day/each	(d) Number man/days	(c) x (d) Sub-totals / $
Engineers or Professionals	A	60	30	1 800
	B	50	70	3 500
Technicians	A	30	90	2 700
	B	20	120	2 400
Administrators	a	20	60	1 200
	b	15	90	1 350
	c	12	-	-
Operators	a	14	1 000	14 000
	b	12	1 200	14 400
	c	10	1 500	15 000
S1 = Subtotal 1				56 350
I1 = Unforeseen = 30% x S1				16 905
S2 = Subtotal 2.				73 255
General expenses (20% x S2)				14 651
Profit (if relevant) (%U) x S2				
T = Sum Total				87 906

This exercise should be performed separately for cities, regions or for organisms responsible for drinking water (which may embrace regions or the whole country), as proves possible and advisable in each case. They may also be separated according to who assumes the costs, be it the drinking water service, the government or some other entity.

ii **Estimate of work done on installations and emergency repairs** This section involves the preparation of an estimated budget of costs not included in the previous section; and, thus, refers to the materials, their transportation, fuel, energy, etc. used in emergency works and repairs The equipment, machinery, pipe and valves which are installed in temporary fashion, but which can be removed after the emergency has passed, should be considered at only a percentage of their total value, which should include amortization (r%), estimated according to the use made of those elements during the emergency To perform this cost estimate, a list of the main works undertaken should be made, including: a brief description of each work or other materials cost[18]; the approximate quantity of each work or category; the unit price of each category, general costs and profit (if relevant).

Example:

In this example, supply and transportation of all materials and their installation are included.[19]

Item N°	Summary of emergency works	Unit	Quantity	Unit Price (US$)	Totals US$
	Supply and installation of pipe and valves				
1	Steel pipe D = 400 mm	lm	200	180	36 000
2	Steel pipe D = 300 mm	lm	500	130	65 000
3	Steel pipe D = 200 mm	lm	2 800	100	280 000
4	Valves D = 300	No.	2	630	1 260
5	Valves D = 200	No.	8	240	1 960
		S_1 = Subtotal	384 220		
		General expenses (20%) x S1=			76 844
		Profit (0%) x S_1			–
		TOTAL			461 064

[18] This refers to costs such as energy, transportation, etc.

[19] Unit prices and % are supposed, only by way of example.

Supposing that the recovery of 200 mm pipe, which cost US$ 60/lm[20], with an expected 15% rate of amortization and, thus, implying the recovery of 85% x 60 x 2 800 = 142 800.

Then: value to be recovered -142 800

Thus, the real cost of those emergency works would be: $ 318 264.

iii. **Estimate of costs for use of collectors which are not public drinking water service property**. The use of collectors which are not public drinking water service property involves expenses which should be faced in accordance with the appropriate agreements.

For example, a case in which the Public Service only covers electric energy costs, incurred for pumping water

It was stated above that the cost of a m^3, raised to H height, is·

$M = 0.004 \times k \times H$, in $\$/m^3$, in which k = KWH cost

H = height in meters.

If it is supposed that the collector used yields a flow: Q, in lt/sec., during Nh = hours of pumping daily for a period of· p = days of use of this collector,

then:

$V = (3\ 6 \times Q \times Nh)$ = volume raised daily, in m^3/day

$D = (3.6 \times Q \times Nh) \times M$ = cost of raising water daily, in $/day

$P = p \times D$ = cost of raising water in period "p"

By way of example, suppose.

Q = 50 lt/sec
k = US$/ 0 05 per KWH
H = height of 60 mts.
Nh = 16 hours of pumping daily

Then

$M = 0\ 012$ US$/$m^3$

$V = (3\ 6 \times Q \times Nh) = (3.6 \times 50 \times 16) = 2\ 880$ m^3/day

$D = M \times V = 0.012 \times 2\ 880 = 34\ 56$ US$/day

[20] This is the unit cost for the purchase of the pipe itself, apart from installation costs

In a 30 day (p) period

P = D x P = 34.56 x 30 = US$ 1 036 80 = cost for (p) period

For a case in which an agreed upon price per cubic meter will be paid, suppose all factors of the previous exercise, adding only the agreed upon price for a cubic meter of water:

M = US$0.02

D = Ma x V = 0.02 x 2 880 = 57 60 $/day

P = p x Ma x V = 30 x 0.02 x 2 880 = US$ 1 728, cost for the period.

iv. **Use of tank trucks for water distribution**. The distribution of water by tank truck may aid areas not supplied through the public network In order to calculate this cost, the following should be considered. diverse types of truck under contract to distribute water, to be paid a per-trip rate, according to their freight capacity. This should be done as follows.

C1 = number of type 1 trucks (id. for other types)

t1 = rate per trip for truck 1 (id. for other types)

n1 = Number of daily trips for truck 1 (id. for other types)

d1 = t1 x n1 x c1 = daily cost for type 1 trucks.

p1 = number of days in use

P1 = p1 x t1 x n1 x c1 = total cost of use of type 1 trucks.

P = p x t x n x c = total cost of use of tank trucks

The following example supposes the use of 10 cubic meter capacity tank trucks, which make 30 Km trips to pick up and distribute water. The cost, per cubic meter and per trip, is US$0.90; therefore, the rate is US$/9/trip (A value which includes transportation and distribution). If the company's own trucks or municipal vehicles are used, the apparent cost may seem somewhat less. That rate does not include the cost of the water.

If n = 10 daily trips, per tank truck, are made
and there are c = 5 tank trucks working
during p = 30 days

the daily cost of transportation (to distribute some 500 cubic meters, daily) will be·

d = c * t * n = S$ 450 daily

and the cost for 30 days will be·

Ct = c * t * n * p = US$ 13 500

If there are other trucks with other rates, cost estimates should be made for each type and, then, those subtotals should be added together

5. Lower income from reduced billing and loss of water

In order to estimate the amount of reduced billing (probable reduction of water sold to consumers in cities and towns included in the disaster zone), it is necessary to weigh the effect of the main factors which lead to lower water consumption through the normal supply system Those main factors have been identified and explained in the preceding chapter.

a. Estimate of the impact of reduced production or collection of drinking water

Call

Vo = Average daily volume, produced before the disaster, in m^3/day,

vs = Average daily volume, produced after the disaster, in m^3/day,

Eo = Monthly volume produced, before the disaster, in m^3/month,

Fo = Monthly volume billed, before the disaster, in m^3/month;

Fs = Monthly volume billed, after the disaster, in m^3/month.

It is known that Fo usually involves a volume smaller than Eo, due to leaks in the network and unpaid consumption.

Call

(7) R= Fo/Eo, then Fo = R x Eo (in which R is less than 1)

If the disaster had the exclusive effect of reducing water production (for example, in a drought), the new monthly billing would be approximately.

(8) Fs = R x Eo x (Vs/Vo) = Fo x Vs/Vo in m^3/month: so that the reduced monthly income will be·

$\Delta I = (Fo - Fs) \times Mf$ in \$/month

in which Mf = average value of m^3 billed.

(9) $\Delta I = (Fo - Fs) \times Mf = Fo\,(1 - Vs/Vo) \times Mf$

and lower daily income = $\dfrac{\Delta I}{30}$

and, due to reduced production of water, in a "p" period of days, the loss of income will be

$$(10)\ \Delta Ip = p \frac{F}{30} (1 - Vs/Vo), \text{ in } \$$$

b. Impact of reduced treatment capacity

When treatment capacity is reduced and it is necessary to continue to consume all the water produced, the effect will not be a reduction of income, but rather diminished water quality.

If treatment capacity is the bottle neck, in the sense that only treated water can be consumed, equation (10) is to be applied, in which:

Vo = average daily volume of water treated, before the disaster

Vs = average daily volume of water treated, after the disaster.

c. Impact of reduced channeling capacity, due to damage and leaks

Water leaks caused by damage to pipe and joints imply that water is not reaching its habitual consumers, who, therefore, cannot be billed. It is known that even before the disaster, a certain quantity of the water produced was being lost through leaks. This value should be ascertained for each city (it is usually around 25 or 30% of the water produced). The damage caused by the disaster, specially if it was an earthquake of a certain magnitude, will necessarily augment that loss

Moreover, as noted above, only a fraction of the new loss will be apparent. In this case, the following procedure should be employed·

i. The most important leaks will probably be visible on the surface. In those cases, the breaks should be excavated and appraised

   Suppose that leaks 1,2, etc. have been discovered. For leak 1:

   q1 = estimated loss for leak 1, in lt/sec.

   v1 = 24 x 3.6 x q1 = volume lost daily, in m^3/day

   d1 = number of days during which water is lost (before damage is repaired)

   r1 = v1 x d1 = 24 x 3.6 X q1 x d1 = total volume lost through leak 1, in m^3.

   If there are several leaks, it will be necessary to add

   $R = \sum r$ = total volume of known water lost, during the period.

ii. Moreover, there are probably invisible leaks, these should be estimated as a percentage (j%) of the total volume produced

Estimate of reduced revenue, resulting from the losses indicated here

- due to identified losses Volume "R", lost

(11) Delta I'r = R x Mf, in $

- due to losses estimated as j % of the volume produced

(12) Delta I"r = J % x (Vs xp) x Mf, in $

d. Impact of water distributed without charge

Emergencies usually imply that a certain quantity of water is distributed to the population in ways different from the usual (tank trucks, etc.). Water distributed in this way, that is, without charge, will also have some impact on reduced billing.

Call:

ve = average daily volume, in m^3/day, distributed during the emergency,

pe = number of days this is done;

Mf = average price of m^3 billed

(14) Ve = ve x pe = total volume distributed during the period;

Then, reduced billing for this reason will be

(15) Delta Ie = Ve x Mf.

e. Impact of reduced consumption due to housing having been abandoned by inhabitants and the suspension of other activities

Normal consumption of drinking water may also decrease when, as a result of the disaster, housing has been left abandoned, and/or schools, industries, businesses and other activities cease to function That decrease will be equal to the normal consumption of those system users

To estimate that decrease, the following procedure is recommended:

i. make a rough calculation of the percentage of housing abandoned (due to damage or other causes), with regard to total housing in the corresponding city,

ii. estimate the percentage of activities in the city which have ceased to function, based on economic sector information

Those estimates will make it possible to weigh the percentage (W%) of reduced daily consumption.

Call:

Fo = average monthly value in US$/month, of billing for the whole city, before the disaster

Fo/30 = average daily billing

W% = percentage of total billing, before the disaster, estimated for current "non consumption" in (ZONE W)

$dw = (w\%) \times \frac{Fo}{30}$ normal average daily billing in zone W

pw = number of days the "non consumption" in zone W will last.

The, the reduced income will be:

(16) $\Delta \; Iw = pw \times (w\%) \times \frac{Fo}{30}$ in US$/period

f. Summary of reduced billing income for different reasons

The preceding equations are to be joined together:

i Due to reduced water production in collectors or treatment plants

(10): $\Delta \; Ip = p \times \frac{Fo}{30} (1 - \frac{Vs}{Vo})$

ii. Due to leaks: identified and estimated:

(12). $\Delta \; I'r = R \times Mf$

(13): $\Delta \; I''r = (j\%) \times (Vs \times p)$,

iii. Due to water distribution in alternate, emergency ways

(15) $\Delta \; Ie = Ve \times Mf$

iv The total impact of reduced income (on billing during the period) will be:

(16): $\Delta \; It = (\Delta \; I p + \Delta \; I'r +$ Delta $I''r + \Delta \; Ie + \Delta \; Iw)$, in US$/period.

6. Indirect damage to the sanitary and storm sewer system[21]

Three main types of indirect damage to these systems may occur:

a. Increased levels of health risks and reduced quality of life

Together with the reduced levels of hygiene implied by the lack of drinking water, the lack of sewage service may pose serious health risks for the population, given the combination of diverse factors:

i It will not be possible to use the sewer system in areas left without drinking water, because –as is known– water is necessary to sweep away excrement and sewage The wastes which accumulate in those areas may be a source of contamination for the population

ii. Breaks and clogging of the sewer system will probably bring sewage to street level, with increased risk of disease and even of epidemics, due to direct contamination or via flies and rats

iii. Problems in sewage treatment plants may lead to increased contamination of the water courses into which they discharge.

iv. The need to establish emergency camps for those who were obliged to leave their homes generates the need to construct improvised latrines. entailing a sharp reduction in normal hygiene levels and increased risk of disease (the cost of emergency latrines, which should be addressed in the organization of the emergency phase, is not included here).

v. Risk of flooding by rain water, when rains occur while storm sewers remain unrepaired.

b. Activities and maneuvers for emergency operations

Among the many different activities to be undertaken to face the emergency, it is worth mentioning the emergency repair of pipe lines, the installation of temporary pipe lines or sewers; and the digging of drainage ditches, etc The manipulation of valves, gates, and other installations, in order to channel run-off, for example, in drinking water or storm sewer pumping stations, as well as the installation of pumps to remove sewage from plants, chambers or flooded ditches must also be mentioned.

[21] In different cities, there may be joint systems, in which the same pipe lines serve as sanitary sewers an as storm sewers, or there may be separate or mixed systems.

The costs of all kinds of emergency maneuvers and works related to sewers should be calculated in the way described above for drinking water.

c. Lower income from sewage billing

The way in which the disaster will impact billing for sewage services will depend on the way it is usually done in the affected cities.

i When sewage billing is a percentage of the drinking water bill, the procedure should be the following:

It = lower total drinking water billing in the city, to be obtained through equation (16).

a% = percentage (%) added to the drinking water bill to pay for sewage service;

s% = percentage of population with drinking water and sewage, with respect to the total population with water.

Then, reduced sewage billing will be

(17) Δ fa = It x (a%) x (S%).

However, there may also be other persons who cannot use their sewers, due to breaks in the system, this should be calculated as an additional percentage (Z%), so that:

Delta f'a = (Z%) x (normal sewage billing)

ii. When the charge is fixed, the estimate should be made on the basis of reduced revenue collected, as a percentage of the overall total for the city.

Call

Fa = monthly total billed for sewage for the whole city

Fa/30 = daily average billing

g% = estimated of percentage not collected, due to the disaster.

p = Number of days of suspended service

Then:

(18) Δ fa = (g%) x P x (Fa/30), in US%/period

iii. When there is no charge for sewage, there will, of course, be no corresponding reduction of income.

D. SECONDARY EFFECTS

In this section, the necessary elements, information, background data, and ways of making estimates for the global evaluation of the effects of the disaster on the Drinking Water and Sewage sector, in terms of the macroeconomic variables of the country, are presented

1. Impact on the gross domestic product

a. Lower production. This refers to the lower volume of water produced, from the moment of the disaster, and the lower production foreseen (and scheduled) for the period of damage repair and the recovery of normal productive capacity For this calculation, lower production should be estimated as a smaller quantity of billed water, because normally there is a certain quantity produced which never reaches the consumer, due to leaks and other causes. The following procedure is recommended.

i. On the basis of the information of point 5 of section C, lower income due to lower billing should be estimated, since the disaster and up to the period considered in this point

ii. Depending on the significance and characteristics of the direct damage (identified earlier) and according to the capacity of the corresponding drinking water companies (financial and repair and reconstruction capacity), it will be possible to estimate the time needed to return production and billing to normal.

iii On the basis of that data, a chart should be prepared, which will include:

- lower monthly volume of drinking water billed, since the disaster and foreseen,
- the average sale price of that volume to the public,
- the reduced billing income, to date and foreseen,

iv. if the disaster involves various companies or cities, separate charts should be made for each.

b. Appraisal of sector operations, prior to the disaster

It is to be hoped that the general evaluator will have these data available at the national level, if possible, and specially for the affected area.

Macro-measurement of drinking water for Latin American cities is generally lacking, with only estimates of volumes collected and produced, or of losses through leaks, being available For this reason, it may be most practical to estimate sector GDP on the basis of volumes billed to customers Therefore

⇨ consult the national accounts and national institutions globally responsible for the sector, to obtain, if possible, data on the evolution of sector GDP for the previous 5 years, together with the appraisal of personnel responsible for sector operations, for the current year, as that perception existed prior to the disaster

2. Gross investment

In this point, the effort should be made to identify the following main types of effect:

a. Projects being implemented and other investments foreseen which must be suspended or postponed

This information should be summarized in a chart which identifies the main projects affected and the amount involved in each. Finally, the reduction in investments foreseen, in each project, due to the disaster, for the current and following years should be estimated.

b. Loss of stock

In this instance, a chart should be made, registering the loss of stock, such as water in tanks and/or dams, and the loss of stored and/or available materials and replacement parts of works under way.

c. Investment needed for reconstruction and damage repair

The data for this item will come, basically, from the lists and the evaluation of direct damage, treated earlier, from which total and subtotal costs of damage may be extracted. On the basis of that data, a chart should be elaborated, including:

i. a list of damaged works, grouped by system, sub-system (and main works), and indicating the global cost of the damage suffered by each. This list should identify the works corresponding to different cities, different companies (if there is more than one company responsible for this service in the same city) separately, as well as distinguishing urban from rural elements;

ii. then, mention should be made of the investment foreseen for the coming years, to repair that damage;

iii. by way of example, the data from chart 2, of direct damage to "Alborada" City, are used:

Sub-systems considered	Direct damage	Investment	Foreseen
		Year 1	Year 2
A) Las Gaviotas collector	13 150	13 150	–
b) Las Gav - City pipe line	28 600	28 600	–
C) D. W. distribution network	94 380	94 380	–
D) Administration building	117 500	17 500	100 000
E) Sewer network	126 000	80 000	46 000
F) Sewer discharge	386 400	186 400	200 000
TOTALS US$	766 030	420 030	346 000

The investment foreseen should reflect the relative urgency of the respective works, the engineering capacity of the companies and of the country, and the possibilities of financing Specially, on the one hand, the country's capacity to undertake the projects, in light of extraordinary demand, should be weighed, and, on the other, its capacity to supply the necessary inputs for reconstruction. With regard to the latter point, it is useful to relate the extraordinary demand arising from the disaster to normal domestic and import supply capacities.

It is recommended that sector evaluators make specific reference to the potential and limitations they are able to perceive, with regard to reconstruction and damage repair and make recommendations (within the existing time and information limitations).

3. Balance of payments

This point refers to data the sector evaluator should provide for the general evaluator, facilitating the calculation of the effects of the disaster on the current account of the balance of payments. It includes the following factors:

a. Lesser exports of goods and services

The exportation of drinking water is rare, so that this item is only exceptionally relevant. If it is pertinent (as, for example, in the supply of the Panama Canal Zone), the value of less water exported is:

M$a = reduced income from water exports, in a given time period

Mv = reduced volume exported, in a given year

T = Average charge of unit of volume utilized

Therefore M$a = Mv * T = (MvO + mMvl + Mv2) *

The time periods and volumes to be taken into account are:

MvO = from the moment of the disaster until the end of that year

Mv1 = the first year after the disaster

Mv2 = the second year after the disaster

If a country exports engineering services related to this sector, it may happen that greater domestic demand, arising from the disaster, will reduce or annul that export capacity for a certain time. The value of that reduced exportation of services should be expressed as follows:

M$s = reduced value of services exported, in a given period

MsO = reduced value of services exported, in the year of the disaster

Ms1 = id in the year following the disaster

Ms2 = id in the second year following the disaster

Therefore: M$s = (MsO + Ms1 + Ms2)

b. Increased imports

In order to estimate the value of this item, the following should be considered:

v the imports needed during the process of reconstruction and damage repair; these should be estimated on the basis of the sum of the imported components of each relevant category, which should have been inventoried and appraised already, as indicated above.

vi increased imports rooted in indirect costs and emergency activities, for example, fuels, as part of indirect costs and, perhaps, materials and equipment needed for emergency activities, which, later, will not be used in reconstruction and definitive repair works

vii. In order to estimate overall increased imports the following procedure should be applied.

Call:

Idd = increased imports due to direct damage (according to i)

Idd0 = id, during the year of the disaster

Idd1 = id, during the first year after the disaster

Idd2 = id, during the second year (etc) after the disaster (if relevant)

Iddi = increased imports due to indirect damage (according to ii)

Idi0 = id, during the year of the disaster

Idi1 = id, during the first year after the disaster (if relevant)

Idi2 = id, during the second year (etc) after the disaster (if relevant)

Thus. Idd = Idd0 + Idd1 + Idd2

Idi + Idi0 + Idi1 + Idi2

c. Donations

Included here are all donations in kind, equipment, material and machinery, which the sector receives from international aid Although they will probably be concentrated in the period immediately following the disaster (year 0), donations foreseen for the following years should be indicated

d. Reduced interest payments

If, due to the disaster, interest payments on sector debts are reduced, it is suggested that this be indicated for the year during which they occur.

4. Public finances

The disaster may affect public finances in different ways, as follows:

a. Lower tax revenues given reduced production of goods and services

If water and sewage bills are subject to tax and, as a result of the disaster, the corresponding companies' billing is lower, fiscal or municipal income will also decrease, with regard to this item. The estimate of this value should be based on:

i. estimates made under the heading: "Lower income from reduced billing and losses of water",

ii. consultation with drinking water companies with respect to the percentage (p %) of those taxes and the amounts;

iii with these data, the values for lower tax revenue should be estimated and expressed, as follows:

Mi = Mi0 + Mi2 = lower tax revenue in years 0, 1, 2.

b. Lower public company income

Reduced billing, due to lower sales of water, indicated in the previous point, imply lower income for the companies affected

Let.

Mf = Mf0 + Mf1 + Mf2 = lower billing in years 0, 1, 2.

c. Increased current expenses for companies, related to the emergency

These expenses are, basically, those included in points 3 and 4 Emergency expenses are usually made at the time of the disaster, and so will probably be included in year 0

MgE = MgE0 = Increased expenses due to the emergency, year 0.

d. Increased expenses due to investment in reconstruction works and damage repair

The relevant information for this aspect of public finances can be obtained, nearly completely, from charts similar to that of the previous example, related to gross investment.

If Mgi = increased expenses due to investment, then:

Mgi = Mgi0 + Mgi1 + Mgi2 = id, year 0 + year 1 + year 2

5. Prices and inflation

The damage caused by the disaster may affect (or not) the price of water or of the construction materials needed for damage repairs in that sector This will depend on diverse factors, beginning with the magnitude of the disaster and the extent of the damage it has caused

a. Possibilities of variations in the price of water

They are the following.

That the cost of producing water varies, due to the need to change the location or type of collector, or the type or types of treatment plants, the channel or height of the water; or due to lower aquifer levels.

If the price difference with respect to the price prior to the disaster is absorbed by the company, via subsidy, then there will be no impact on prices to the public.

Data on this matter should be supplied by the company responsible for the corresponding service. However, it is unlikely that, so soon after the disaster, a reasonable degree of certainty with regard to several of these factors will exist, so that estimates of future prices must be made on the basis of possible trends If costs rise, as a result of the factors indicated here, the relation between the new cost per cubic meter and the old price should be indicated, or the anticipated variation in the price to the public should be indicated

b. Possible impact on prices of construction materials

This is likely, due to increased demand, not only by this sector, but for use in repairs in other sectors, as well For this reason, this issue should be examined within the evaluation team, as a whole

From the perspective of the drinking water and sewage sector, it would be useful to have available an estimate of the increased demand for the main materials required for repair and reconstruction in the coming years; together with an estimate of domestic production capacity, in the face of increased demand, and the country's capacity to import those materials; and to consider whether or not the Government is going to impose price controls on those materials.

6. Possible impact on employment

In order to estimate this effect, the following factors should be considered:

a. Destruction of infrastructure

Given that the water supply is vital for the population, the installations destroyed will be repaired as soon as possible. However, it may happen that the technology and design of new infrastructure will require a different number of personnel than was previously necessary, for its construction, operation and maintenance. If deemed relevant, that difference should be included.

b. During the construction and repair period

Given that requirements during the emergency phase itself fall beyond the scope of this manual, only the possible impact on employment during the reconstruction period is examined

i. the employment rate may remain stable, due to the suspension of projects and works;

ii. it may rise, due to the demand for personnel for reconstruction and repair works and because normal projects and activities do not decrease,

iii. or a mixed situation may occur, because some projects are postponed, although not all.

What actually occurs will depend on governmental and drinking water company decisions Therefore, it is from those instances that the sector evaluator should obtain the necessary information for estimating variations in the employment rate for years 0, 1 and 2 (if works will continue beyond this period, more years should be added).

The employment levels required and the time periods indicated in this point should be coherent with those indicated in the previous point, on reconstruction investment needs

Chart 1
EXAMPLE OF SUMMARY INVENTORY OF DIRECT DAMAGE
"ALBORADA" CITY [1]

Detail of damaged works or material	Unit	Quantity damaged	Percentage estimate of damage (R=%)
I Drinking water supply system			
A) "Las Gaviotas" collector, 3 wells, 120 lt/sec.. Concrete well, 2 mt. in diametre, 25 mt. deep, cracks Asbestos cement pipe, with G joint, cracks and breaks.	ml	10	25%
a) D = 200 mm	ml	150	
b) d = 250 mm	ml	120	
Semi-buried concrete tank, of 1 000m^3: minor cracks and stucco	gl	1	10%
B) "Las Gaviotas-City" pipe line, L = 8,500 mts. of cast iron, D = 400 mm:			
a) Cast iron pipe, D = 400 mm, breaks	ml	540	40%
b) Cast iron pipe, D = 400 mm, leaks at joints	ml	700	10%
C) Drinking water distribution network (L total = 52 500 mts) Asbestos cement pipe, with damaged Gibault joints:			
a) D = 100 mm, leaks at joints	ml	2 900	15%
b) D = 250 mm, cracks and breaks	ml	2 800	30%
c) D = 300 mm, cracks and breaks	ml	3 200	30%
D) Service administration building			
a) Half of building collapsed	m^2	320	100%
b) Half of building with cracks and reparable damage	m^2	300	20%
II Sanitation sewer system (of Alborada)			
E) Sewer network (L = 29 000 mts.) Compressed cement pipe, damaged:			
a) D = 175 mm, severe damage, change necessary	ml	3 900	100%
b) D = 200 mm, repair joints and cracks	ml	2 600	50%
c) D = 300 mm, repair joints and cracks	ml	3 200	50%
F) Sewer discharge Aqueduct 500 mm, compressed cement, L = 16 200 mts			
a) D = 500 mm, broken; replace	ml	4 420	100%
b) D = 500 mm, reparable damage	ml	2 200	50%

[1] This damage inventory is for "Alborada" City, an imaginary construct of between 35 and 40 thousand persons, of whom approximately 80% have drinking water and 40%, sewage service.

Chart 2
EXAMPLE OF DIRECT DAMAGE EVALUATION
"ALBORADA" CITY [1]

Detail of damaged works or material	Unit	Quantity	R% damaged	P.U. $/unit.	Subtotals $/item
I. Drinking water supply system					
A) "Las Gaviotas" collector, 3 wells, 120 lt/sec.					
1. Concrete well, 2 mt. in diametre, 25 mt. deep, cracks	ml	10	25	500	1 250
2. Asbestos cement pipe					
a. D = 200 mm	ml	150	30	32	1 440
b. D = 250 mm	ml	120	50	41	2 460
3 Semi-buried tank	gl	1	10	80 000	8 000
B) "Las Gaviotas"-City pipe line					
4. a. D = 400 mm	ml	540	40	100	21 600
b. D = 400 mm	ml	700	10	100	7 000
C) Distribution network					
5 a D = 100 mm	ml	2900	15	12	5 220
b. D = 250 mm	ml	2800	30	41	34 440
c. D = 300 mm	ml	3200	30	57	54 720
D) Administration building					
6 a. Half of building collapsed	m^2	320	100	250	80 000
b. Half of building damaged	m^2	300	50	250	37 500
DRINKING WATER TOTAL					260 030
E) Sewer network					
Compressed cement pipe					
7. a. D = 175 mm	ml	3900	100	14	54 600
b. D = 200 mm	ml	2600	50	18	23 400
c D = 300 mm	ml	3200	50	30	48 000
F) Sewer discharge					
8. a. D = 500 mm, replace	ml	4420	100	70	309 000
b. D = 500 mm, repair	ml	2200	50	70	77 000
TOTAL SEWER SYSTEM					512 400

[1] This damage inventory is for "Alborada" City, an imaginary construct of between 35 and 40 thousand persons, of whom approximately 80% have drinking water and 40%, sewage service.