Rehabilitating small-scale piped water distribution systems after an emergency

WHO Regional Office for South-East Asia

This technical brief covers a process of rehabilitating small-scale piped water distribution systems (with pipe diameters up to 150mm) after natural disasters such as earthquakes, flooding, hurricanes, tornadoes, severe weather and fires. It does not cover disasters concerned with industrial pollution. This intervention aims at restoring supply to survival levels.

Step 1
Assess damage, isolate affected area and inform consumers.

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Step 2
Provide alternative supply to affected consumers.

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Step 3
Isolate pipeline in sections and repair obvious leaks. Pressure-test the section. If leakage is higher than optimal value, repeat repair procedures.

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Step 4
Clean and disinfect the repaired section.

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Step 5
Pressurise the section and test WQ. If WQ is bad, repeat cleaning and disinfenction procedures in Step 4. Otherwise commission section.

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Step 6
Carry out Steps 3 - 5 to all affected sections, starting with the section nearest the water source, and moving outwards.

Figure 1. Steps for cleaning and disinfecting a piped water distribution main in a post disaster situation

Step 1. Assessment and isolation

Find out who manages the water distribution network, and identify local staff who understand the distribution system. These staff should participate in the rehabilitation.

Inspect the distribution network as soon as possible. Assessment will be easier if there are updated drawings of the distribution network. Indentify:

- Number and location of visible breakage points
- Are the breakage points leaks, bursts, pipe fractures, pipe dislocations or complete pipeline section displacements?
- Proximity of the damage to the water source?
- Type of pipelines affected i.e., transmission mains, primary distribution mains, secondary distribution mains or tertiary distribution mains?
- Sizes and material of pipes affected?
- Extent of the affected area? Does it affect multiple supply zones?
- Is it possible to isolate the supply zones affected?

Monitor the basic water quality parameters and feedback from consumers.

The affected area(s) should be isolated from the rest of the distribution network. If flow control valves are not available, or cannot be traced, new valves should be installed. The affected consumers should be informed.

Step 2. Provide an alternative supply to affected consumers

Establish what capacity of the system has remained intact and is able to provide emergency requirements. Assess emergency water requirements based on basic lifeline supply. Establish procedures for emergency treatment, pumping and distribution for service of emergency supply. For example, this could be achieved through:

- Provision of tankered water to various locations in the residential areas.
- Using simple materials to construct emergency stand taps.

Step 3. Repair breakages

From the assessment of the damage carried out in Step 1, determine and acquire the resources (in terms of manpower, equipment and materials) required for the repair work. Start at or near a source of supply and work outwards into the distribution system. Repair the pipeline in a stepwise manner, one section after another. For example, referring to Figure 2, start with the section between SV1 and SV5, and move to the section between SV5 and SV6. Select a pipeline section that can easily be isolated by existing stop valves, of say 500m. The maximum length that can repaired, flushed and pressure-tested effectively is 1000 m. Before starting any repair work:

- Locate other underground utilities in the work area, and liase with their Maintenance Department, if necessary.
- As a safety precaution, find out what type of industries are nearby or which have ever used the site. If the soil is thought to contain hazardous wastes, the local responsible authority should be contacted for advice on further precautionary measures.

Isolate the section by shutting valves (such as SV1, SV2, SV3, WO1 and SV5 as shown in Figure 2) and close off all service connections. Arrange to install washout valves (such as WO1 shown in Figure 2), and fire hydrants (such as FH1 shown in Figure 2) if none can be traced in the selected section.

Route traffic away from the work area.

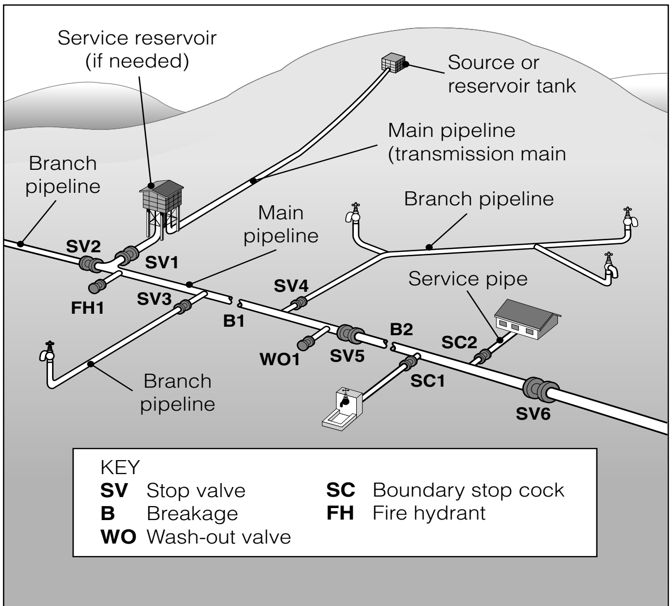


Figure 2. Pipework which makes up a distribution system

Excavate and expose the leaking/broken pipelines, ensuring that the excavated soil is piled by the side of the trench with enough clearance for traffic, but far enough from the trench such that the repair crew can safely walk between the trench and the excavated material.

Protect the repair crew from trenches collapsing in the course of repairs. This is achieved through trench shoring, as shown in Figure 3. The need for shoring depends on the following factors:

- Depth and width of trench
- Type of soil (clay, loam or sand)
- Soil conditions (compaction, moisture)
- Nearby activities that could cause vibration
- Length of time excavation is expected to be open

Use simple but effective methods of repair that will take the shortest time to restore services. Examples of simple methods are:

- The damaged section may be replaced by use of repair pipe clamps, as shown in Figure 4.
- Repair of cracks and breaks in steel pipes could be accomplished by welding.

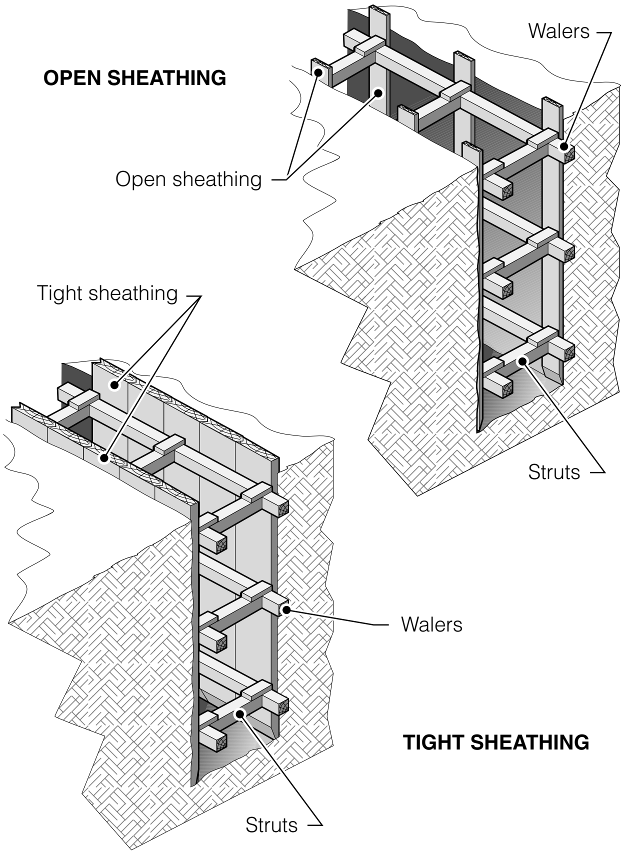


Figure 3. Types of shoring

Replace pipe support structures such as concrete anchorage and thrust blocks , if necessary.

Backfill the excavation with select material, and compact as necessary, initially leaving the pipe joints exposed for water pressure testing. Fill the repaired pipeline section with water, and let it sit idle for at least 24 hours before the pressure test starts. Increase the pressure up to a level of at least 50% higher than the normal operating pressure, and maintain this for at least 4 hours. The leakage is determined by measuring the amount of water needed to refill the pipeline. However some leakage is expected, and Table 1 shows a guideline of values of allowable leakage for pipes.

Examine the trench, and repair any joints if they show leakage.

If the repaired pipeline has passed the pressure test, backfill the pipe joints, and proceed to clean and disinfect the pipeline section.

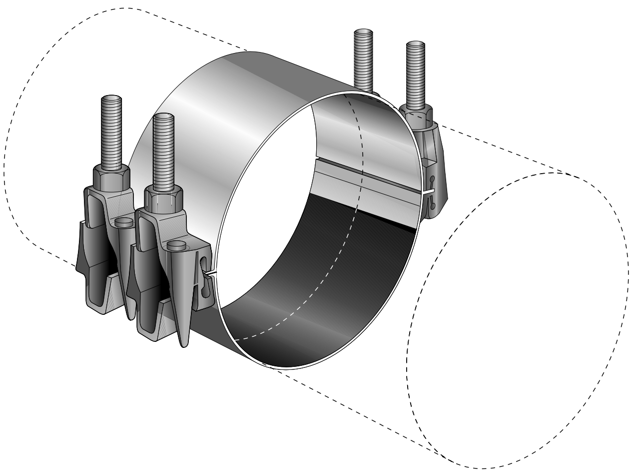


Figure 4. Pipe clamp

Table 1. Allowable leakage from pipes

Pipe diameter(mm)	Allowable leakage (litres per day per km)
50	166
75	249
100	332
150	498

Source: California State University, 1994

Table 2. Velocity and flow required for effective flushing

Pipe diameter(mm)	Velocity required (m/s)	Flow required (litres/sec)
50	1.3	2.7
75	1.6	7.2
100	1.8	15
150	2.2	41
200	2.6	83

Source: Institution of Water Engineers & Scientists, 1984

Step 4. Cleaning and disinfection

Pipe Flushing

Isolate the section to be flushed from the rest of the system.

Confirm if quantity to flush the repaired pipeline has sufficient pressure and water in the system. Table 1 shows guidelines for adequate velocities and flow. If there is insufficient water additional pumps and storage tanks will be needed.

Flush the section by opening the stop valve (SV1 on Figure 2) on the supply side slowly, and open the washout valve on the remote end (WO1).

Inject the water through the pipe section continuously for a period long enough to stir up deposits inside the water main and wash out all silt (about 15 minutes).

Direct flushing water away from traffic, pedestrians and private plots. Avoid erosion damage to streets, lawns and yards by use of tarpaulins and lead-off discharge devices. Avoid flooding which can cause traffic congestion.

Collect two water samples from each flowing hydrant, one at the beginning (about 2 to 3 minutes after the hydrant was opened) and the second sample when the dirty water is assumed to be clean (just before closing the hydrant). Test the water quality to ascertain return to normality. If the water quality is not yet satisfactory, repeat the procedure.

When the water quality has been restored to normal, slowly close the washout valve.

Pipe commissioning

Calculate the volume of water in the pipeline section to be disinfected, as shown in Box 1.

Acquire tanker(s) of volume equal to or higher than the calculated volume of the pipe.

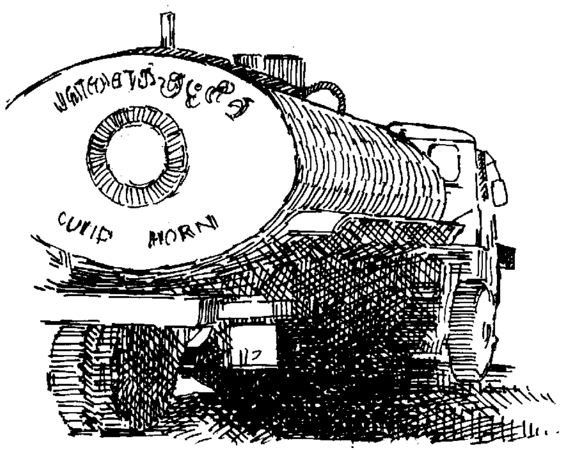
Prepare a chlorine solution of 25 mg/litre of free chlorine and mix it with clean water in the tanker (Box 2).

Keeping the pipeline isolated, set up the feed tanker at the injection site (labelled as FH1 in Figure 2).

Fill up the pipeline section with the chlorine solution. Keep the water in the pipeline for a minimum of 24 hours, during which time all valves and hydrants along the main should be operated to ensure their proper disinfection. Check the chlorine residual in the pipeline. If it has dropped significantly, repeat the disinfection procedure.

Flush the pipeline section with clean water until a chlorine residual of 0.2-0.8 mg/litre is achieved.

Reconnect the pipeline to the network and move onto the next section.



Box 1.
Calculating the volume of water in a pipeline

Example:
Diameter of the pipeline is 100mm, and the section is 500 m long. The volume (V) of water in the pipe will be:

$V = \pi d^2L/4 = 3.14*0.1*0.1*500/4 = 3.925\ m^3$

Box 2.
Preparing a chlorine solution

Example:
If we need 4000 litres of chlorine solution to fill the pipeline, we shall need (25 mg x 4000) = 100 grams of chlorine.

If the source of chlorine is High Test Hypo chlorite (HTH) powder, with say a chlorine concentration of 50%, then we need:

(100 g)/0.5 = 200 grams of HTH powder.

Mix the water and the powder thoroughly, before use

Resources

California State University, Sacramento School of Engineering (1994), *Water Distribution System Operation and Maintenance,* 3rd ed., USA: California State University, Sacramento Foundation

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