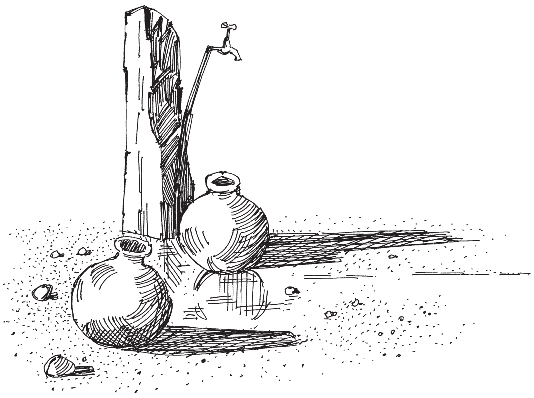
Rehabilitating small-scale piped water distribution systems

The damage caused by natural disasters to networks for piped drinking-water distribution can be widespread and extensive. It can range from minor breaks to complete loss of whole sections of the system. A systematic survey of the entire network is the only way of identifying the true extent of the damage. This may not be possible in an emergency where the priority is to re-instate a basic level of supply. This technical note examines these priorities and the process of rehabilitating small-scale piped water distribution systems.



Steps of rehabilitation

The first priority is to repair major breakages in the system. This will allow the re-instatement of a supply but with the knowledge that much of the water entering the network will be lost through breaks not yet fixed. Once the emergency supply is in place, work can begin to identify and repair smaller breaks. Figure 4.1 shows the steps for repairing major breaks in pipe networks.

Step 1: Assess the extent of the damage

Identify local staff with knowledge of the distribution system as their involvement in the rehabilitation will make the job much easier. Obtain any available drawings of the distribution network layout, including information about the size of pipes and positions of fittings such as valves and washouts. At the very least, obtain a plan of the community showing main roads and important buildings. For many parts of the world, suitable maps can be freely downloaded from the Internet. Inspect the whole of the piped network and mark on the plans the positions of all major damage, its nature (for instance whether it is a broken valve, a fractured pipe, a lost pipe section) as well as the type of pipe affected (see Figure 4.3). Focus on visible damage. It is likely that there will be damage underground but this can be dealt with later. Check the local stores to see if there are enough spare pipes and fittings of the correct size, and materials and equipment to begin the repairs. If not, order these immediately.

Step 2: Keep consumers informed

It is important to keep water users informed about what is happening and how you propose to deal with the situation (Figure 4.2). Let them know which sections of the network are affected, what you intend to do and when, and what they should do to protect their health and safety. Communication is an on-going responsibility and regular updates should be provided.

Figure 4.2. Keep the consumers informed

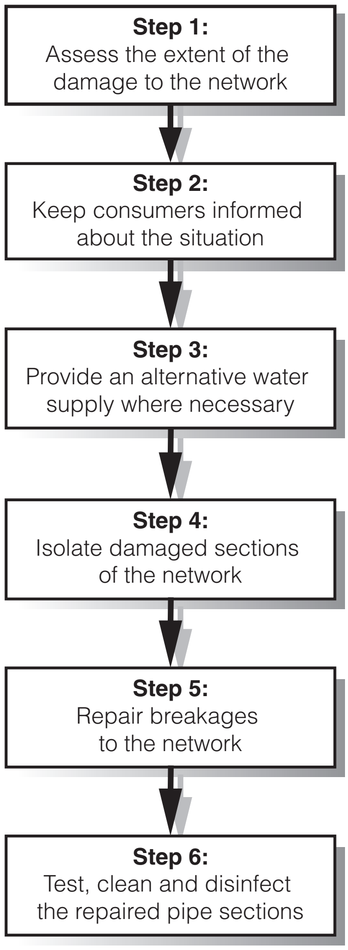


Figure 4.1.
Steps for rehabilitating a small-scale piped water distribution system

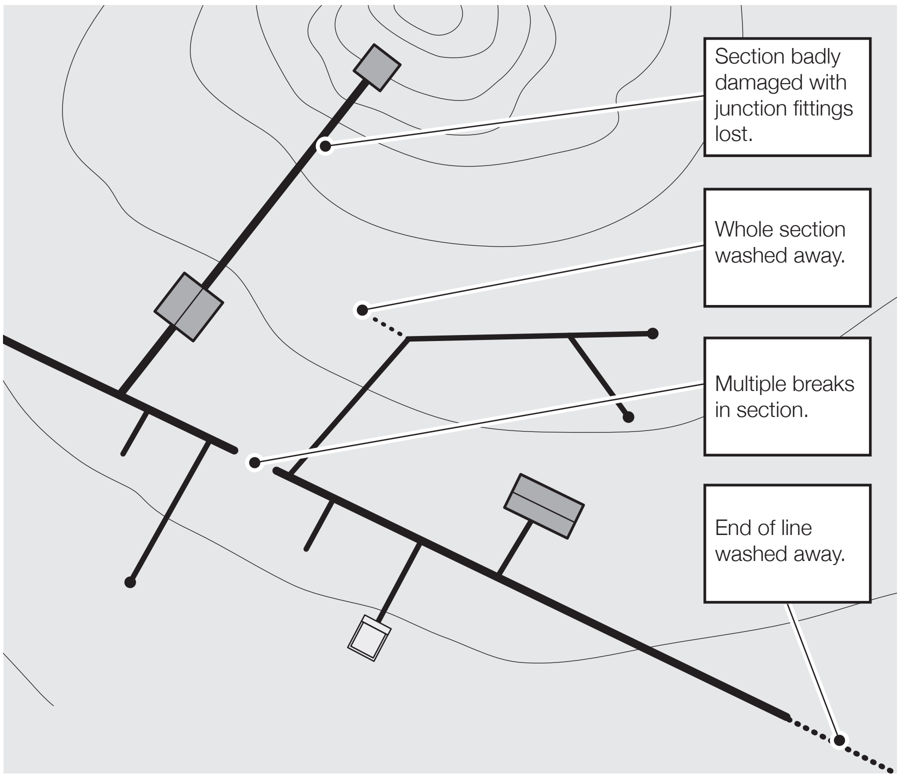


Figure 4.3.
Map of a piped distribution network with a record of damage

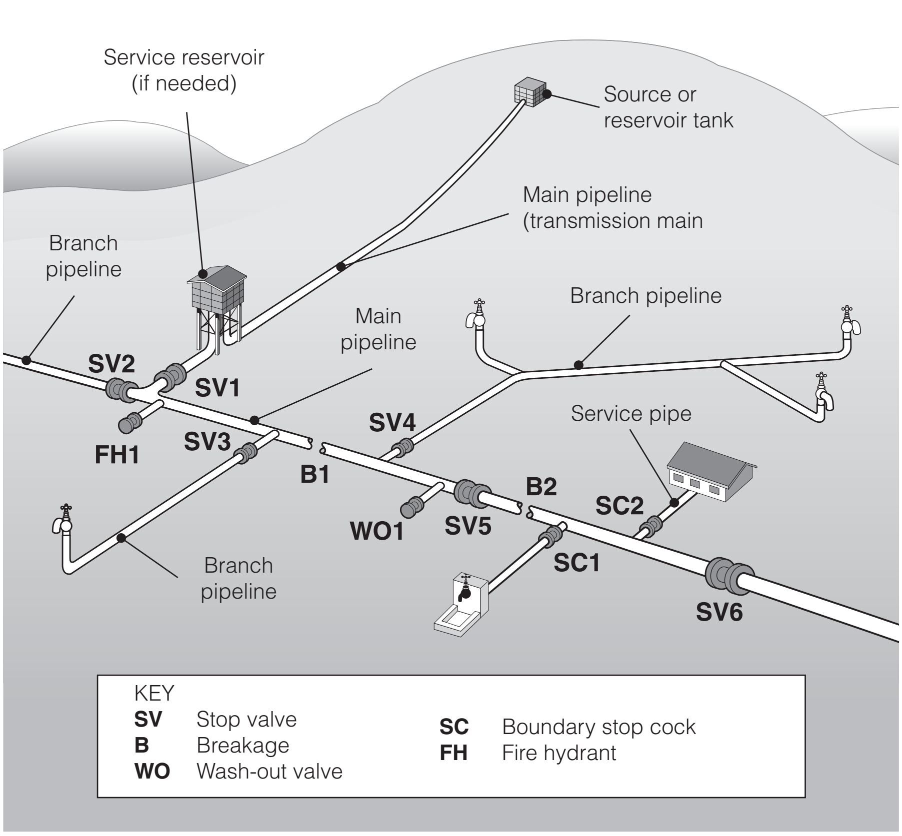


Figure 4.4.
Repair the pipeline in a planned and stepped manner

Step 3: Provide an alternative water supply

If damage to the network is major, and repairs will take more than a few hours, an alternative supply must be provided. This could take the form of bottled drinking water, water delivered directly by tanker (Figure 4.5), and water tankers delivering to temporary storage tanks. Combine this with advice about local sources of water (such as springs or wells) which might be used for other, non-drinking purposes.

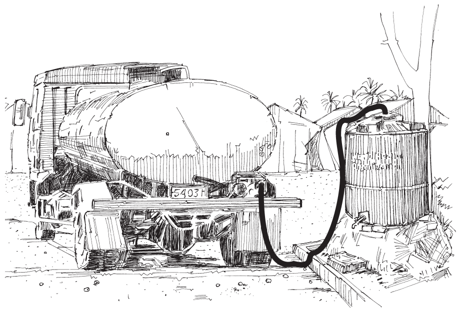


Figure 4.5.
Provide an alternative water supply

Provide information about simple household water treatment options and the availability of chemicals to disinfect local sources.

In all cases, water users must be informed about what is being done and how they can use the temporary system effectively.

Step 4: Isolate damaged sections of the network

The affected area or areas should be isolated from the rest of the distribution network. This will reduce water wastage and allow a supply to continue to unaffected areas. Isolation is usually undertaken using control valves. If they are not available, or cannot be traced, new valves will have to be installed.

Step 5: Repair breakages

Start at, or near, a source of supply and work outwards into the distribution system. Repair the pipeline in a stepped manner. For example, referring to Figure 4.4, start with the section between the source and the service reservoir.

Follow this repair by rehabilitating the main pipeline from SV1 to SV5, making sure to close valves SV2, 3 and 4 and any service connections first. Select a pipeline section that can be easily isolated by existing stop valves, of say 500 to 1000m apart.

Arrange to install washout valves (such as WO1), and fire hydrants (such as FH1) if none can be traced in the selected section.

Before starting any repair work:

- Locate other underground utilities at work in the area, and liaise with their maintenance departments, if necessary.
- Route traffic away from the work area.

Excavate and expose the broken sections of the pipelines. Protect the repair crew from trench collapse. This is normally not a problem with small diameter pipes but if the ground is very loose protect them by shoring the work area as illustrated in Figure 4.6.

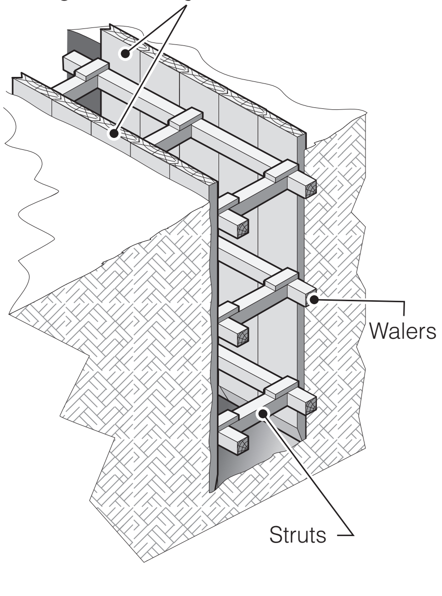


Figure 4.6. Shoring the work area

Use simple methods of repair that will take the shortest time to restore services.

Examples of simple methods:

- The damaged section may be replaced by use of repair pipe clamps, as shown in Figure 4.7.
- Repair of cracks and breaks in steel pipes by welding.
- If there are multiple breaks, it may be quicker and easier to replace the whole section with a new pipe. A temporary pipe run above ground is satisfactory for an emergency supply.

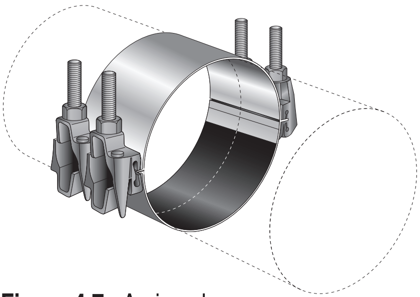


Figure 4.7. A pipe clamp

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

Backfill around the pipe with selected material such as dry sand or washed stone (Figure 4.8). The remainder of the excavation can be filled with the excavated soil. Leave the pipe joints exposed so that they can be observed during water pressure testing.

Figure 4.8. Backfilling

Step 6: Test, clean and disinfect the repaired pipe sections

Pipe testing

Partly open the upstream isolation valve and the downstream washout to fill the repaired pipeline section with water.

Once full, increase the pressure in the pipe by at least 50%. This is achieved by:

- closing the upstream valve and downstream washout;
- connecting a water pump between a water tanker and the upstream fire hydrant; and
- switching on the water pump and maintaining the high pressure for at least 4 hours.

Observe the pipe joints for leaks and repair if necessary. Check the amount of water being pumped from the tanker into the pipeline and compare with the figures given in Table 4.1. If the leakage is greater than recommended, it indicates other major leaks in the section. Sources of further information about ways of searching for hidden leaks are provided on page 4.4.

Cleaning

Connect a full tanker of clean water, via a water pump, to the upstream fire hydrant or washout for the section of pipe you are working on. Confirm the pump can deliver the quantity of water and pressure required to flush and clean the pipe.

Table 4.1. Allowable leakage from pipes

Pipe diameter (mm)	Normal allowable leakage (litres/ day/1000m)	Emergency allowable leakage (litres/ day/1000m)
50	165	330
75	250	500
100	330	660
150	500	1000

Source: California State University (1994)

Table 4.2 gives guidelines for adequate velocities and flow.

Open the hydrant connected to the pump and tanker. Turn on the pump. Gradually open the downstream washout valve until the flow rate reaches the required level. Pump until the water coming out of the washout is completely clean but not less than the time suggested in Table 4.2.

Table 4.2. Velocity and flow required for flushing

Pipe diameter (mm)	Velocity required (m/s)	Flow required (litres/sec)	Minimum flushing time for a 1000m pipe (mins)
50	1.3	2.7	770
75	1.6	7.2	625
100	1.8	15.0	555
150	2.2	41.0	455

Source: Adapted from Institution of Water Engineers and Scientists (1984)

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. When the water coming out of the pipe is clean, slowly close the washout valve before turning off the water pump.

Disinfection

Calculate the volume of water required to fill the section of pipe using Table 4.3. Acquire tankers of volume equal to, or higher than, the calculated volume of the pipe. As the tankers are being filled with clean water add 80g of High Strength Calcium Hypochlorite (HSCH) granules for every 1000 litres. (See Technical Note 3 for further information about the chlorination of tankers.)

Connect the water tanker to the up stream fire hydrant. Open the valves between the tanker and the pipe. Gradually open the down stream washout so that the chlorinated water replaces the clean water in the pipe (it may be necessary to pump water into the pipe).

Continue feeding water into the pipeline until chlorine can be strongly smelt in the water coming out of the washout. Close the washout valve but leave the inlet valves open so that chlorinated water can still enter to replace leakage. Leave the pipeline for 24 hours.

Disconnect the water tanker and open the upstream isolating valve.

Gradually open the downstream washout and monitor the water coming out until it no longer smells strongly of chlorine.

The pipe can then be returned to service.

Table 4.3. Quantity of water required to fill pipes of different diameters

Pipe diameter (mm)	Approximate water volume per 1000m of pipe (litres)
50	1,960
75	4,420
100	7,850
150	17,670

Further information

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

Bhardwaj V (Undated) Technical Brief – *Repairing Line Breaks.* National Drinking Water Clearing House. http://www.nesc.wvu.edu/ndwc/articles/OT/SP04/TechBrief_LineBreaks.pdf

AWWA (1999) *Water Distribution Operator Training Manual.* American Water Works Association, 2nd ed. Denver, Colorado. USA

Male, J. Walski, T.M. (1991) *Water Distribution Systems: A Troubleshooting Manual.* 2nd ed. Chelsea, MI Lewis Publishers, Inc, USA

IWES (1982) *Water Practice Manual 3: Water Supply and Sanitation in Developing Countries,* IWES London

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