CHAPTER 1
PLUMBING SYSTEMS

Plumbing is a system of piping, apparatus, and fixtures for water distribution and waste disposal within a building. This chapter covers the basic water supply and distribution system, the theater of operations water supply and distribution system, and sewerage system. Plumbing also includes installation and maintenance of these systems.

When architects design a building, they prepare a set of prints. The architect also prepares a set of specification sheets detailing the types and quality of materials to be used. Plumbers use the prints and specifications to lay out and plan the project.

Section I. Basic Water Supply and Distribution System

A water supply system receives, treats, and moves water to a water distribution system. Water may come from a stream or lake, from a deep or shallow well, or from a reservoir, which collects surface water. The water supply system purifies and pumps the water into a storage tank. After the water is purified, it is released into the distribution system. The distribution system is an arrangement of connected pipes (called a ***run)*** *that carries the water to its destination. This system usually has a means of heating some of this water.*

1-1. Plans. See Section I of Appendix A for information on construction plans, prints, and drawings and Section II for a list of symbols used on plans.

a. *Water Supply and Distribution Plans.* A plumber should be able to install a complete water supply system by using a plan together with standard and special detail drawings and a bill of material. A standard detail drawing will show the water heater and standard storage-tank connections. The plan will show the type of piping by size and fittings. See Appendix A, paragraph A-2 (page A-l).

b. *Utility and Building Waste System Plans.* See Appendix A, paragraph A-3 (page A-l).

c. *Unit Construction and Package Unit Prints.* Prints are used for structures and equipment in water supply and distribution systems. The type of print depends on whether the unit is constructed or is a package unit to be assembled in the field. See Appendix A, paragraph A-4 (page A-2).

1-2. Bills of Materials. The designer (architect) or draftsman usually prepares a bill of materials (BOM) when he prepares the original drawings. However, if no BOM accompanies field prints, the plumber must compile it. Appendix B gives instructions for preparing a BOM.

1-3. Water Supply Lines and Branches. The main water supply system provides potable cold water at the main at a pressure that meets National Plumbing Code standards. The water-service main for the plumbing installation tees (Ts) into the main water supply. The plumbing system must provide enough water for normal use at each outlet.

Fixture supply risers take water from the main supply to the fixtures on each floor level. Each fixture supply riser must have a diameter large enough to supply water to all the fixtures it connects. The size is determined by the design load for the riser. Refer to Table C-3 (page C-6) or C-4 (page C-7).

a. *Pipe Selection.* Cold-water systems may use galvanized-iron or galvanized-steel pipe, copper tubing, or plastic pipe. The material used depends on the—

- Amount of water to be supplied.
- Water pressure.
- Corrosion factor for different types of pipe in different temperatures.
- Cost.
- Availability.

b. *Pipe Size.* The size of water supply piping depends on the—

- Water pressure and friction loss through the length of the pipe.
- Number and kinds of fixtures installed (fixture demand).
- Number of fixtures in use at a given time (factor of simultaneous use).
- Type of flushing devices. (See Chapter 4, paragraph 4-2, pages 4-6 and 4-7.)

(1) *Friction Loss.* When a liquid flows through a pipe, layers move at different speeds, with the center layer moving fastest. This resistance to flow (called *friction loss)* varies with different types of pipe. Pipe friction, in turn, causes a drop in water pressure. In a small pipe, this friction loss is overcome by increasing the water pressure. If higher water pressure is not possible, increasing the pipe size can reduce friction loss. (See Appendix C for friction loss in different types of pipe.

(2) *Water Pressure.* Pressure in the main usually ranges from 45 to 60 pounds per square inch (psi). If the pressure is over 60 psi, a pressure-reducing valve must be placed in the water-service line at its entry to the building. The size of the water-service pipeline, the rate of use, the length of the line, and the outlet height in the system control the pressure available at the outlet.

(3) *Calculations for Sizing Pipe.* The minimum practical size for a water-service line is 3/4 inch. This size should be used even when calculations indicate a smaller one. Calculations for factoring loss of pressure in complex systems are beyond the range of this manual. For simple systems, use approximate figures to find the pipe size. Tables C-1 and C-2 (pages C-2 through C-5) give capacities and psi for galvanized-steel/iron pipe, copper tubing, and plastic pipe. Use these tables combined with maximum fixture demand and factor of simultaneous use to determine pipe sizes.

(a) Maximum fixture demand. The maximum fixture demand in gallons per minute (GPM) is the total amount of water needed to supply all fixtures at the same time. Estimate the maximum fixture demand by counting the number and type of fixtures in the plumbing system. Table 1-1 gives the maximum fixture demand for different fixtures.

Table 1-1. Fixture demand (in GPM)

Fixture	GPM
Water closet	45
Lavatory	7.5
Shower	15
Urinal	39.5
Slop sink	22.5
Laundry tub	15
Floor drain	7.5

EXAMPLE

What is the maximum fixture demand for a plumbing system consisting of 14 fixtures as follows: two water closets, four lavatories, two showers, three urinals, one slop sink, one laundry tub, and one floor drain? Use Table 1-1 and the following steps:

Step 1. Multiply the number of each fixture by the GPM of that type fixture (from Table l-l).

Step 2. Total these figures.

Result: A maximum fixture demand of 313.5 GPM.

Use the fixture demand (313.5 GPM) with the factor of simultaneous use to select the pipe size.

(b) Factor of simultaneous use. The factor of simultaneous use is the percentage of fixtures potentially in use at a given time (Table 1-2). It is an estimate of the total demand on a water supply system, expressed as water supply fixture units. Simultaneous use factors decrease as the number of fixtures in a building increases. Take the number of fixtures, using the higher number in the use-percentage range. For example, for five fixtures, use a probable demand of 50 percent, the higher figure in that range. The probable demand for 45 fixtures is about 25 percent. See example on page 1-4.

Table 1-2. Factor of simultaneous use

Number of Fixtures	Percent of Simultaneous Use
1-5	50-100
5-50	25-50
50 or more	10-25

If a table for the factor of simultaneous use is not available, estimate the probable demand by computing 30 percent of the maximum fixture demand in gallons.

Example

Continuing the above example, the 14 fixtures would have a simultaneous use of about 35 percent. Since the fixture demand was 313.5 GPM, the water-service line must have a capacity of 35 percent of 313,5 (110 GPM). What size pipe would you need for a 60-foot long pipeline with a pressure at the main of 45 psi?

Step 1. Read down the 60-foot column in Table C-1 (page C-3) or C-2 (page C-5) to **1 1/2-inch** diameter.

Step 2. Read across (left) to the psi column and establish the given as **45** psi.

Step 3. Read back to the 60-foot column. Table C-1 shows **150** GPM (the quantity that includes 110 GPM); Table C-2 shows **155** GPM.

Pipe Size: Either 1 l/2-inch galvanized, copper, or plastic piping would be large enough for the water-service line.

NOTE: *Remember, the minimum practical size for a water-service line is 3/4 inch. This size should be used even when calculations indicate a smaller size.*

c. *Installation.*

(1) *Main Water Supply Line.* The main water supply is a pipe, usually hung from a ceiling, with branches connected to serve the fixture risers. This supply has the same diameter as the water service from the main and is centrally located to provide short takeoffs to fixture supply risers throughout the building. To reduce friction loss, lay the main supply piping as straight as possible. The main supply pipe must not sag or trap water. It should be graded slightly, up to 1/4 inch per foot, dropping toward the meter. At the low end of the grade, place a drip cock or stop-and-waste valve for draining the pipe in winter. A drain pipe may be needed to carry the waste water from the opening in the valve to a floor drain or sump. If it is impossible to grade all the piping to one point, all parts that cannot be centrally drained should have separate drip cocks or stop-and-waste valves. The main supply pipe must be well supported to take its weight off the fittings and to prevent leaks.

(2) *Fixture Supply Risers.* Use reducing Ts to connect fixture supply risers to the main supply. Run the risers through the interior walls of the building. Tighten all joints before the partitions are finished. Pipe rests or clamps should be used to support vertical fixture supply risers at each floor level. (Fixture supply risers must not depend on the horizontal branches for support.) Horizontal fixture branches should be well supported and graded upward toward the vertical fixture supply risers.

(3) *Valves.* Install gate valves in each vertical supply riser, so that a section can be repaired without shutting off the water to other sections. Small gate valves on the supply of each fixture allow shutting off the water for faucet repairs.

d. *Testing for Leaks.* Inspecting for leaks is important. A leaky joint wastes water and causes costly damage to the building. In new construction, test the entire system for leaks before the floor and partitions are closed up. When performing this test, use the water pressure from the main that feeds the system. While the system is under pressure, inspect each joint for moisture. If a leak is detected in a joint, tighten the joint or replace it by cutting the pipe and connecting a new section with a union. When working with copper soldered joints or plastic solvent-weld joints, drain the pipe and then connect the joint. Copper compression joints can be tightened or replaced.

e. *Disinfecting the Piping System.* After installation or repair, plumbing pipes and other parts of a water-supply system carrying drinking water must be cleaned and disinfected before use. The first step is flushing the system to remove dirt, waste, and surface water. Then, each unit must be disinfected with a chemical such as a solution of hypochlorite or chlorine.

(1) *Dosage.* Under average conditions, use the dosages (in parts per million (ppm)) in Table 1-3. The chlorine dosage required to disinfect a unit depends on the—

- Contact time.
- Amount of organic chlorine-consuming material present.
- Volume of waler to be disinfectcd. Table 1-4 gives the volume of water for different sizes and lengths of pipe.

Table 1-3. Chlorine dosage

Unit	Minimum Dosage (ppm)
Pipe	50
Storage	50
Filter	100
Well	150

Table 1-4. Volume of water disinfected (by pipe size)

Pipe Diameter (in inches)	Volume Per Foot of Pipe (in gallons)
2	0.16
4	0.65
6	1.47
8	2.61
10	4.08
12	5.88
16	10.45
20	16.32

(2) *Application.* Use portable gas chlorinators to apply the liquid chlorine. Chlorine cylinders should not be connected directly to the mains because water may enter the cylinder and cause severe corrosion, resulting in dangerous leakage. A solution of hypochlorite is usually applied by measuring pumps, gravity-feed mechanisms, or portable pipe-disinfecting units. Use the following procedures:

Step 1. Flush all sections thoroughly at a velocity of at least 3 feet per second (fps) until all dirt and mud is removed.

Step 2. Stop all branches and other openings with plugs or heads properly braced to prevent blowouts.

Step 3. Insert the disinfectant into the mains through taps or hydrants at the ends of each section.

Step 4. Bleed out any air trapped in the line.

Step 5. Add the predetermined chlorine dosage as the main slowly fills with water.

Step 6. Continue feeding until the water coming from the supply end contains the desired amount of chlorine.

Step 7. Keep the chlorinated water in the unit for 24 to 48 hours.

Step 8. Flush the main until the water contains only the amount of chlorine normally in the supply.

Step 9. Analyze samples daily for bacteria until the analyses show no further need for disinfection. If the samples are unsatisfactory, dechlorinating is required.

f. *Maintenance and Repair.*

(1) *Corrosion.* Galvanic corrosion (resulting from a direct current of electricity) occurs in a plumbing system that includes two different kinds of metal pipe, such as galvanized pipe and copper pipe. See Chapter 3, paragraph 3-1 (pages 3-1 and 3-2) for reducing and repairing corrosion.

(2) *Scale.* Hard water contains a large amount of calcium and magnesium compounds, which prevent soap from lathering. This forms a scum that slows the flow of water. The scum deposits harden and form scale. See Chapter 3, paragraph 3-3 (page 3-4) for reducing and removing scale.

(3) *Frozen Pipes.* Water supply lines may freeze when exposed to temperatures below 32° Fahrenheit (F) (0° Celsius (C)). Outside pipes must be buried below the frost line. In northern zones, this is 4 feet or more. If the building temperature falls below freezing, inside pipes may also freeze, causing the pipe to break at the weakest point. See Chapter 3, paragraph 3-2 (pages 3-2 and 3-3) for the procedures for thawing frozen pipes.

1-4. Tapping the Water Main. Water mains are usually cast iron, 8 inches or more in diameter. If the main is less than 8 inches in diameter, taps should be 2 inches or smaller. Use Figure 1-1 and the following procedure to tap the water main:

Step 1. Dig to expose the pipe at the point where the tap is to be made. Dig as close to the top of the water main as possible.

Step 2. Clean all dirt and rust off the pipe at that point.

Step 3. Place the gasket of the water-main self-tapping machine on the pipe and set the saddle of the machine on the gasket.

Step 4. Wrap the chain around the pipe, and tighten it to clamp the water main self-tapping machine to the pipe.

Step 5. Remove the cap from the cylinder of the machine, and place the combination drill and tap in the boring bar.

Step 6. Reassemble the machine by putting the boring bar through the cylinder and tightening the cap.

Step 7. Open the flap valve between compartments.

Step 8. Start drilling the hole by applying pressure at the feed yoke and turning the ratchet handle until the drill enters the main.

Step 9. When the tap starts threading the hole, back off the feed yoke to prevent stripping the threads.

Step 10. Continue to turn the boring bar until the ratchet handle can no longer be turned without extra force.

Step 11. Remove the tap from the hole by reversing the ratchet. Then, back the boring bar out by turning it counterclockwise.

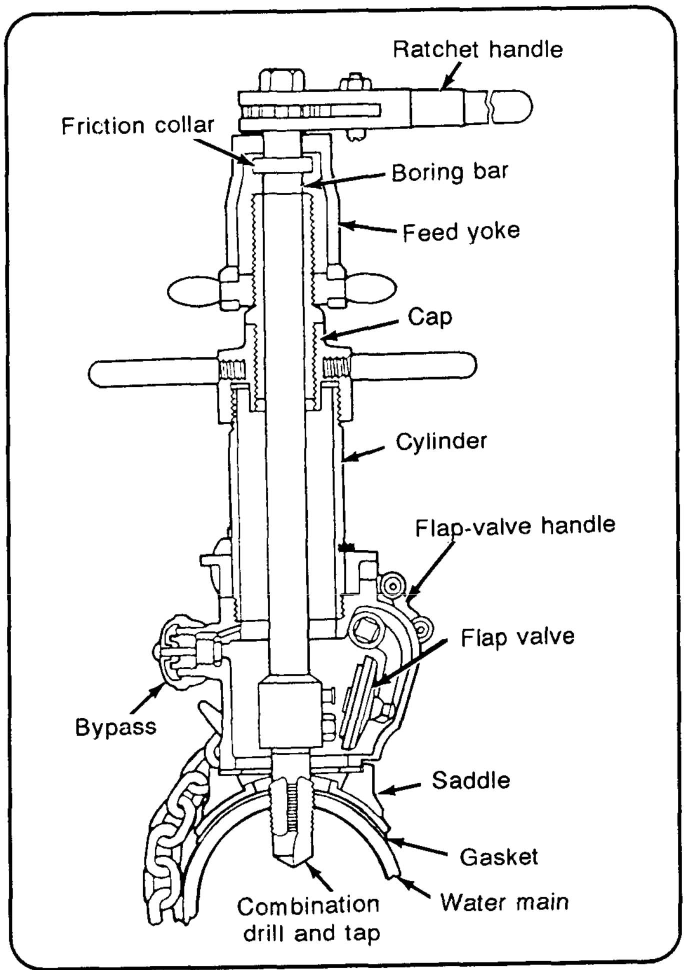


Figure 1-1. Tapping the water main

Step 12. Close the flap valve between the upper and lower compartments.

Step 13. Drain the water from the cylinder through the bypass.

Step 14. Remove the cap and drill tool, and place a corporation stop in the boring bar. The corporation stop should be closed.

Step 15. Repeat steps 6 and 7.

Step 16. Turn the ratchet handle to thread the corporation stop into the pipe.

Step 17. Repeat step 13.

Step 18. Remove the cap from the cylinder, and unbolt the boring bar from the corporation stop.

Step 19. Remove the lower chamber from the pipe.

Step 20. Inspect for leaks.

Step 21. If the corporation stop leaks, tighten it with a suitable wrench.

1-5. Installing Curb and Meter Stops. Curb and meter stops control the water entering the building. Figure 1-2 shows this installation.

a. *Curb Stop.* After tapping the water main and inserting the corporation stop, install the curb stop in a suitable position. It is usually set in a cast-iron stop box to provide easy access in the water service between the curb and the building.

The stop box has a variable telescopic length for use on different grades. When the water service is copper, join the curb stop to the service piping with a compression joint. After you install the curb stop, run the water-service line to the building and through the building wall to the inside of the basement. The water-service line may be laid in the same trench as the sewer; however, it is usually laid on a shelf of undisturbed, solid soil above the sewer line to prevent pollution of the water supply. It must be placed in the ground at a level deeper than the maximum depth of frost penetration.

b. *Meter and Meter Stop.* After running the water-service lines through the side of the building and closing the holes around the service pipe with waterproof cement, install the water meter and meter stop.

- *Meter stop.* The meter stop is a ground joint valve, which controls and shuts off the flow of water into the building. Place the meter stop as close to the service pipe entry as possible.
- *Water meter.* The water meter, installed near the meter stop, measures the amount of water used in the building.

Often the meter and stop are placed in a meter vault that replaces the stop box at the curb. In this case, you should place a stop-and-waste valve in the line where the water service enters the building.

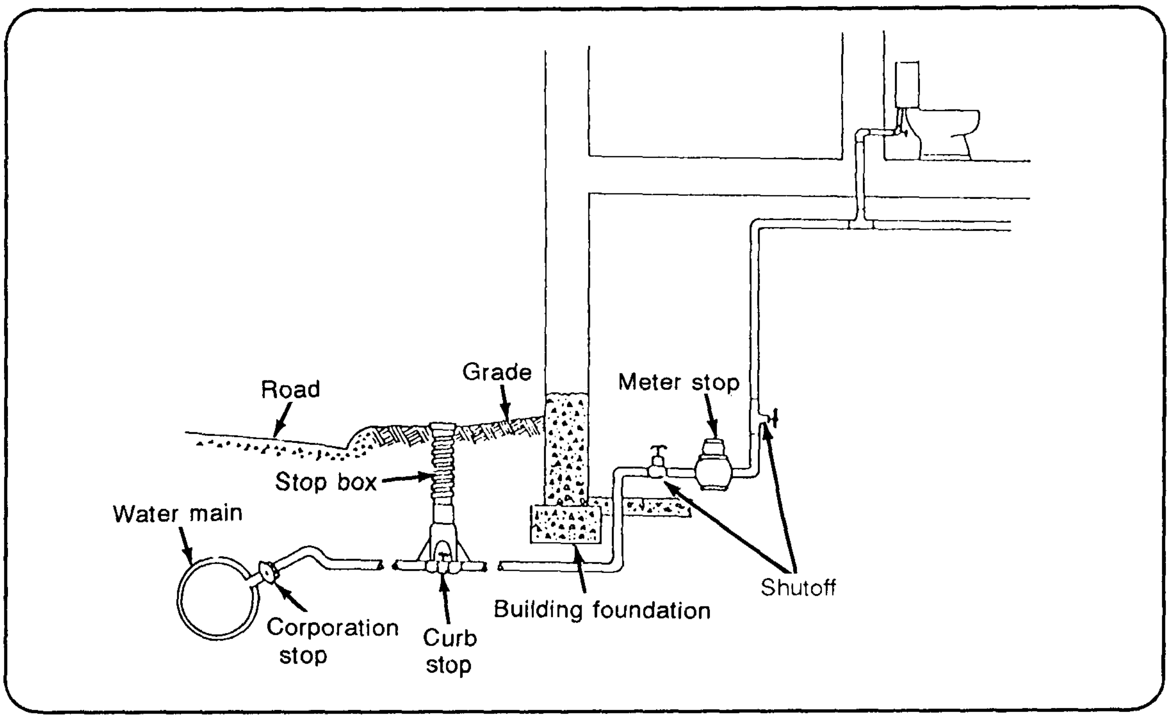


Figure 1-2. Curb and meter stops

1-6. Hot-Water Supply System. The hot-water system consists of a water heater and a piping system that runs parallel to the cold-water pipes to the plumbing fixtures (faucets) where hot waler is desired. A standard detail drawing will show the water heater and standard storage-tank connections. The water heater is fueled by gas, oil, electricity, or try the sun.

a. *Water Heaters.* Water heaters are classified into four categories: range boilers, gas, oil-burning, and electric. See Chapter 5 for water heaters.

b. *Pipe Selection.* The pipes used in hot-water systems are similar to those used in cold-water supply systems. Old hot-water systems used wrought-iron or steel pipe. Newer systems use chlorinated polyvinyl chloride (CPVC) plastic pipe, since CPVC resists corrosion.

c. *Pipe Size.* To size the hot-water main supply lines and the risers, follow the same procedure as for cold-water systems.

d. *Installation.* Installation begins with a water-heating device and the main supply line from that device. Grade the hot-water supply to a centrally located drip cock near the water heater. Water for the fixtures at various levels throughout the building is taken from the main hot-water supply by fixture supply risers. Each of the risers should have a valve.

(1) *One-Pipe System.* Buildings with a large floor area or with several floors need the supply of hot water to the fixture as soon as possible after the tap is opened. In a one-pipe system, such as that used for cold-water supply, a lag occurs from the time the hot--water lap is opened until the water travels from the water-heating device to the tap.

(2) *Two-Pipe System.* To overcome this time lag, use a two-pipe circulating water supply system (Figure 1-3). Hot water passes from the water heater through the main fixture supply risers and returns through a line to the water heater. This looped system circulates the hot water at all times. Warm water tends to rise and cold water tends to fall, creating circulation. The water within the loop is kept at a high temperature. When a tap is opened, hot water flows from the hot-water supply riser into the branch and out of the tap. The cold-water filler within the hot-water storage tank (water heater) has a siphon hole near the top of the tank. If reduced pressure occurs at point A, the siphon hole allows air to enter the cold-water filler. This breaks the vacuum and prevents back siphonage of hot water into the cold-water distribution system.

This circulating supply system (Figure 1-3) is an overhead-feed and gravity-return system and is likely to become air-locked. An air lock prevents circulation of the hot water.

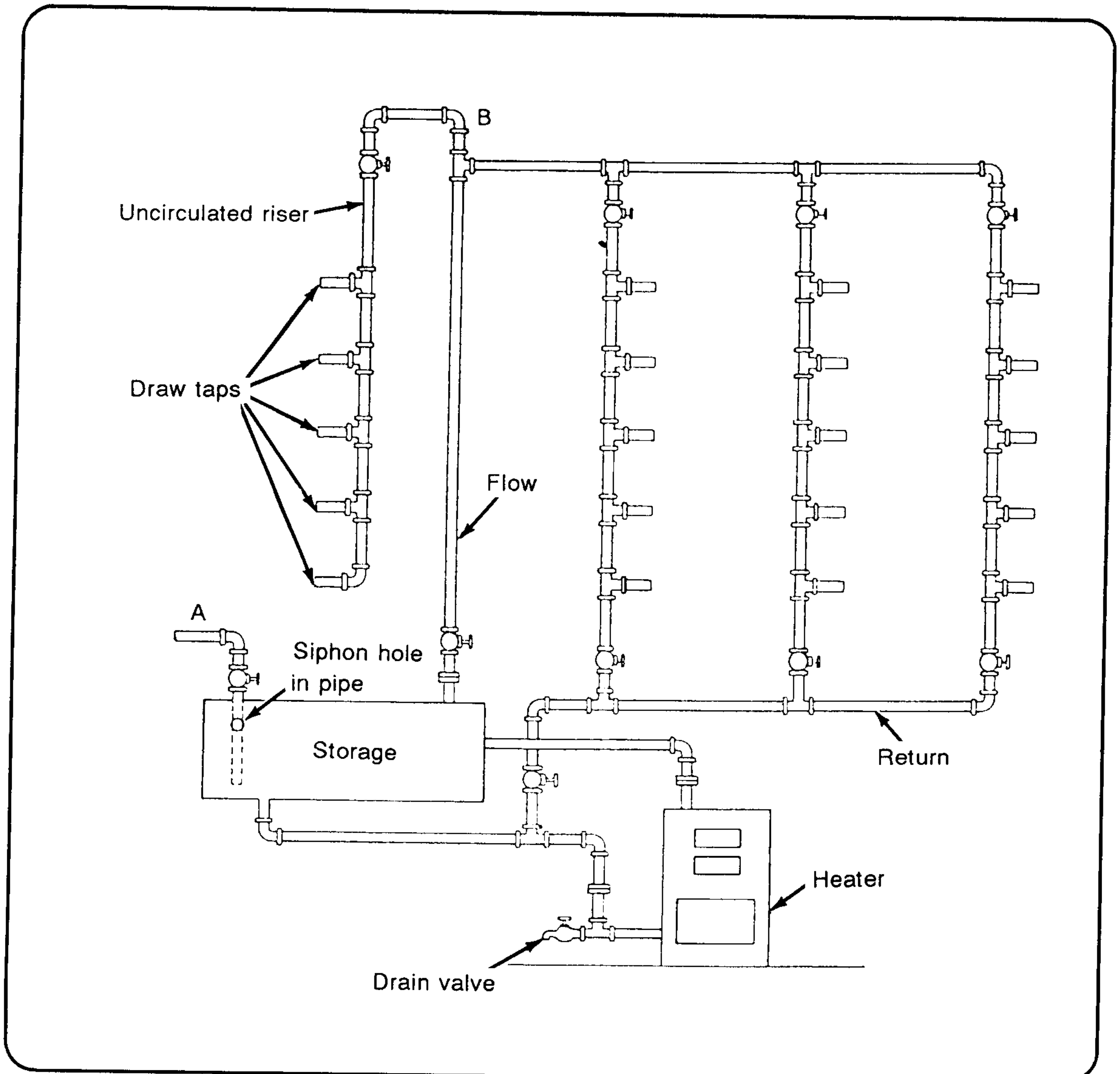


Figure 1-3. Circulating hot-water system (two-pipe)

Since air collects at the highest point (B of the distribution piping), the most practical way to relieve the air lock is to connect an uncirculated riser to the line at that point. The air lock is relieved when a fixture on the uncirculated riser is used.

c. *Maintenance and Repair.* Maintenance and repair of hot-water systems is similar to that of cold-water supply systems. Refer to paragraph 1-3f (page 1-6).

1-7. Fire-Protection Water Systems.

a. *Fire Hydrants.* Fire protection for buildings of fire-resistant construction is provided by fire hydrants. These are usually located at least 50 feet from each building or from the water distribution system within the building.

b. *Automatic Sprinkler Systems.* Automatic sprinkler systems are uscd for fire-resistant structures only when the value. the importance of the contents or activity, or the possibility of a fire hazard justifies a sprinkler system. Buildings of frame and ordinary construction that are more than two stories high and house troops will be protected by automatic sprinkler systems.

Section II. Theater of Operations Water Supply and Distribution System

In a theater of operations, there is always a chance t e Amy may have to take over the repair and operation of a municipal water system. Although most systems will be similar to those used in the United States, problems can be expected in obtaining replacement parts and operating supplies. Sizes and dimensions of basic components can be expected to differ from those in the United States and even require the use of metric tools. Also, certain nations may use differemt disinfecting methods than chlorine. Under these circumstances, the Army should consider hiring former local employees who are familiar with the equipment to operate and maintain the system.

1-8. Water Distribution Methods. After water is purified, it is released into the distribution system. The distribution of large quantities of water under tactical conditions will be by pipelines, trucks carrying bladders. and 5,000-gallon (18,900-liter) tanker trucks. Small quantities can be picked up from tank farms or storage and distribution points in 400-gallon (1,510-liter) water trailers or in refillable drums, 5-gallon (19-liter) cans, and in individual containers.

1-9. Plans and Installation. Figure A-1 (page A-3) shows a distribution system plan for a hospital area. The general location and size of the pipes are shown, together with the valves, sumps, water tank, and other fixtures. Generally, the symbols used on distribution system plans are the same as those for water plumbing. (See Appendix A (page A-10) for standard plumbing symbols.) The plumber who installs the system determines the location of pipes and other equipment to suit the climate and terrain, and according to National Plumbing Codes.

1-10. Design Procedures. See Appendix D for water distribution system design procedures used in the theater of operations.

Section III. Sewerage System

A sewerage system consists of the pipes and apparatus that carry sewage from buildings to the point of discharge or disposal. The system includes sewer pipe and conduits, manholes, flush tanks, and sometimes storm drain inlets. If it is not served by a processing plant, the system may include facilities for pumping, treating, and disposing of sewage.

1-11. Plans. Figure 1-4 shows a typical sewerage system and drain systems.

1-12. Sanitary Sewer and Drains.

a. *Building Drain.* The building drain receives the discharge of sanitary and domestic wastes (or soil and waste) from within the building.

b. *House Drain.* The house drain is located between and is connected to the building drain and the house sewer. The house drain, also called the *collection line,* receives the discharge of sanitary and domestic wastes from the building drain and carries it to the house sewer, as shown in Figure 1-4. The house drain may be underground or suspended from the basement ceiling.

c. *House Sewer.* The house sewer begins just outside the building foundation wall and ends at the main sewer in the street or at a septic tank (Figure 1-4). A house sewer carries liquid or waterborne wastes from the house drain to the main sewer lines. Sanitary sewers are not connected to the storm sewers, because the sanitary discharge must be treated before it is dumped into a stream or lake.

1-13. Storm Sewer and Drain. A storm sewer carries rain water and subsurface water. Since the discharge sewer is runoff water, treatment is not needed. The storm drain receives storm water, clear rain, or surface-water waste only (Figure 1-4).

1-14. Combination Drain. The combination system (Figure 1-4) receives the discharge of both the sanitary waste and the storm water from roofs and other exterior sources.

1-15. Industrial Drain. The industrial drain receives liquid waste from industrial operations. However, this type of drain is of little importance in theater of operations construction.

1-16. Pipes and Fittings. The pipes and fittings for sewer systems are standard to National Plumbing Codes and general usage.

a. *Pipe Selection.* Cast-iron soil pipe or plastic pipe is usually used for house sewers and drains. Bituminous-fiber pipe, when not prohibited, may be substituted for cast-iron pipe for the house sewer. Concrete or vitrified-clay pipe is found in older installations.

(1) *Vitrified-Clay or Concrete Sewer Pipe.* These pipes are connected with resilient joints, using a rubber sleeve and / or rigid joints by compressing rubber or neoprene rings. Vitrified-clay tile is highly resistant to all sewerage and industrial wastes. Concrete pipe may be manufactured with steel reinforcing; it comes in diameters of 12 inches to 108 inches.

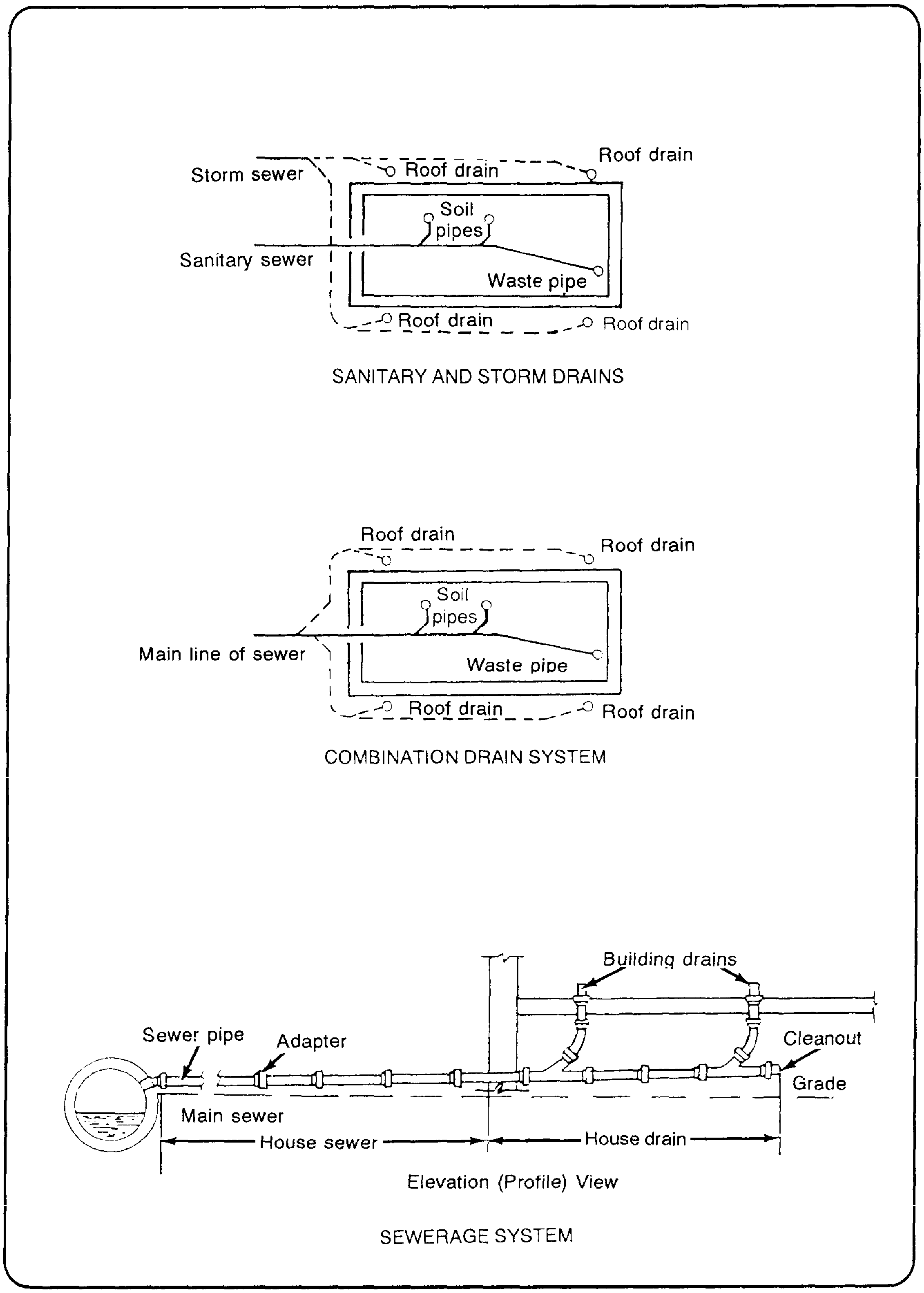


Figure 1-4. Sewer and drain systems

(2) *Cast-Iron Soil Pipe.* Cast-iron soil pipe is classified as follows:

- *Hub-(or Bell-) and-spigot.* Hub-and-spigot pipe comes in 5- and 10-foot lengths (in various diameters). It is connected with lead joints and / or mechanical compression joints.
- *Hubless.* Hubless pipe comes in 10-foot lengths (in various diameters). It is connected with a stainless steel band over a neoprene sleeve.

(3) *Plastic Pipe.* Acrylonitrile-Butadiene-Styrene (ABS) is grey or black plastic pipe used for storm or sanitary drainage, above and below ground. It is connected with solvent-cement joints. This pipe comes in 10- and 20-foot lengths in various diameters.

(4) *Cast-in-Place Concrete Conduit (Tube or Pipe).* This conduit is used when a pipe larger than 60 inches is needed to increase the capacity in a main, a trunk, or an outfall sewer. The drains arc arches or culverts reinforced concrete.

b. *Pipe Size.* Sewerage systems are usually constructed of pipe ranging in diameter from 4 to 36 inches. Both the house sewer and thc house drain must be leakproof and large enough to carry off the discharge of all plumbing fixtures. If either the sewer or the drain is too small, fixtures may overflow. The house sewer and house drain are usually the same size. Waste matter is forced through the house drain pipe by water. Therefore, the pipe must be large enough to carry out all water and waste discharged through it; but it must be small enough for the water to move rapidly, forcing the waste through to the sewer. A pipe sized to flow half full under normal use will have good scouring action, and it can carry peak loads when required.

(1) *Drainage Fixture Units.* The discharge of a plumbing fixture is figured in drainage fixture units (DFU). One DFU represents approximately 7.5 gallons of water (1 cubic foot) discharged per minute. The DFUs for standard fixtures are shown in Table 1-5.

(2) *Pipe Capacity.* Table 1-6 lists the capacity (in DFUs) of various pipe sizes for horizontal drains. This table is for cast-iron soil pipe, galvanized-steel / iron pipe, or plastic house drains, house sewers, and soil and waste branches. When using copper tubing (drain, waste, and vent (DWV) type) for above ground only, it may be one size smaller than shown on the table.

Table 1-5. Drainage fixture unit values

Fixture	Unit Value (DFUs)
Lavatory or washbasin	1
Floor drain	1
Kitchen sink	2
Bathtub	2
Laundry tub	2
Shower	2
Slop sink	3
Urinal	5
Water closet	6

To find the correct size of the pipe, plan the slope of the pipeline by counting the total number of DFUs emptying into a horizontal drain line.

c. *Pipe Support.* A base of solid, undisturbed earth provides enough support for house sewer and drain piping. This prevents future settling, which might cause the weight of the pipe sections to press too heavily on the joints. If the soil is loose, each joint should be supported on concrete, cinder block, or brick.

Table 1-6. Horizontal sanitary drain capacity (in DFUs)

Size of Pipe (in inches)	Slope (inches per foot)		
	1/8	1/4	1/2
1 1/4	1	1	1
1 1/2	2	2	3
2	5	6*	8*
3	15**	18**	21**
4	84	96	114
5	162	216	264
6	300	450	600
8	990	1,392	2,220
10	1,800	2,520	3,900
12	3,084	4,320	6,912

*No water closet will discharge into a pipe smaller than 3 inches (includes DWV-type copper tubing).
**No more than two water closets will discharge into any 3-inch, horizontal-branch house drain or house sewer.

EXAMPLE

For example, assume that a plumbing installation consists of two water closets, four lavatories, two shower heads, three urinals, one slop sink, one laundry tub, and one floor drain. Determine the discharge in DFUs from Table 1-5. Assume that the cast-iron house drain will have a slope 1/4 inch per foot.

Step 1. Multiply the number of each fixture by its DFU value from Table 1-5, for a total of 41 DFUs.

Step 2. Read down the l/4-inch column in Table 1-6. The fixture unit capacity next higher than 41 is 96.

Step 3. Read horizontally across to the left to 4 inches.

Result: The minimum pipe size required is 4 inches.

1-17. House Sewer.

a. *Installation.* Usually the first step in installing the house sewer is to connect the sewer thimble and then work back, grading up to the house drain. The hole cut in the sewer must be no larger than necessary to fit the sewer thimble. All joints must be supported. The thimble should be tapped in above the normal flow level. For example, if the street sewer is 24 inches in diameter and the normal flow is 50 percent, the tap should be at least 12 inches above the bottom of the pipe. Install the thimble with its discharge parallel to the direction of sewer flow. This prevents backflow during periods of high flow. Use the following installation procedures:

Step 1. Tap gently around the circumference of the main sewer to find the depth of flow for placing the thimble. A dull sound results from tapping below the sewer level, and a ringing sound results from tapping above the sewer level.

Step 2. Use the thimble as a pattern for marking the size of the hole with chalk.

Step 3. Make the cut on this line with a small cold chisel and an 8-ounce ballpeen hammer, as shown in Figure 1-5. Use light blows to prevent damage to the main sewer.

Step 4. Work around the cut until you reach a depth of 1/8 to 3/16 inch.

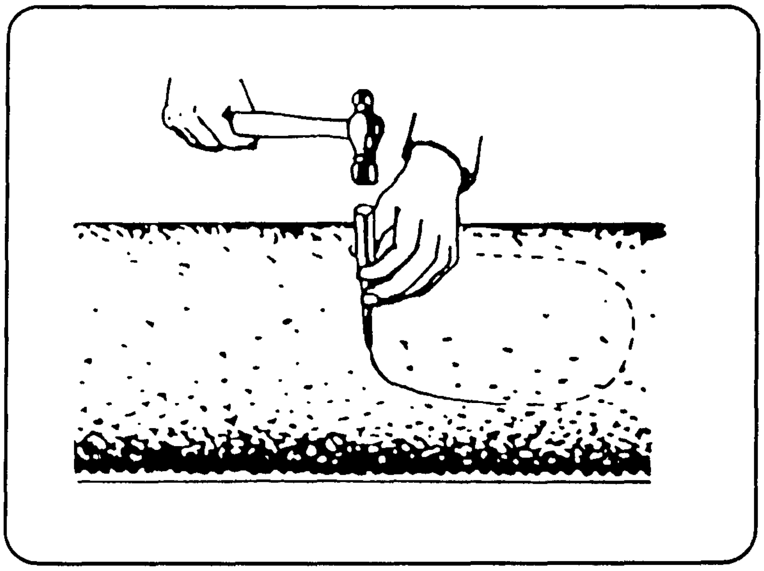


Figure 1-5. Cutting a hole in the main sewer

Step 5. Make a small hole in the center of the area to be removed. Always use light blows.

Step 6. Enlarge the hole into an oval shape as near the size of the sewer thimble as possible. Try the thimble in the opening frequently to see if it will fit without enlarging the hole.

Step 7. Place the thimble in the proper position and pack oakum around the edges of the flange.

Step 8. Complete the installation by packing a rich portland cement mortar (one part sand to one part cement) around the thimble. Use sufficient mortar under the thimble, on the bottom of the tap, and on the top and sides. Support the joint until the mortar sets.

NOTE: *The system must be tested after it is completed.*

b. *Grading.* When possible, house sewers should be graded to a slope of 1/4 inch per foot. Greater or lesser slope is permitted when necessary. Trenches for house sewers may be graded with surveying instruments or with a carpenter's level having a rising leg or a board under one end. For example, a l/4-inch-per-foot slope would be 1/2 inch for 2 feet using a 2-foot carpenter's level with a l/2-inch board under one end. If the pipe is sloped correctly, the level will read level anywhere on the pipe except the hub. The drain is graded toward the main sewer with the hub end of the pipe lying upgrade. A similar procedure uses an 8-foot board and a 4-foot level.

DANGER

All underground plumbing must be laid at least 12 inches from any underground electrical cable. Failure to do so could result in physical injury, death, and/or destruction of equipment.

1-18. Manholes. Manholes are entranceways to the sewer system (for cleaning, inspection, and repair). They are round and are constructed of cement with brick-and-mortar walls on a concrete slab. A removable heavy lid in a cast-iron ring closes the top. Figure 1-6 (page 1-18) is a section drawing of a round manhole. The base slab slopes from 10 to 9 inches. The lid is 2 1/3 feet in diameter by 3 1/4 inches thick. There are three shelves around the pipes in an opening measuring 3 feet 6 inches in diameter. (Precast concrete manholes are available, but the military plumber rarely installs this type.)

1-19. Sewage Disposal.

a. *Grease Traps.* Grease traps are placed in the flow line of the building sewer to catch grease and fats from kitchen and scullery sinks. (Solid grease usually clogs the waste pipes.) The box-type traps are made of brick, concrete, or metal, in various shapes and sizes. The grease trap should be set in the waste line as close as possible to the fixture. Figure 1-7 (page 1 -19) shows baffle walls, which control the flow. Baffle walls are placed in boxes to separate floating grease particles.

b. *Septic Tanks.* The septic tank (Figure 1-8, page 1 -20) speeds up decay of raw sewage. It may be concrete, stone, or brick, in box-section form. (Lumber is used when other materials are not available.) It should be watertight. The siphon chamber makes certain that liquid will flow from the chamber; however, the siphon chamber is not absolutely necessary. The baffle boards are usually 2-inch oak planks, which run entirely across the tank. The boards are suspended from hangers and extend several inches below the surface of the sewage. One board should be located 10 inches from the *inlet* pipe and the other about 4 inches from the *outlet* partition. They should have a manhole and cover to give access for cleaning and repair. Septic tanks must be designed to hold for 24 hours and not less than 16 hours, 70 percent of the peak water demand of that facility.

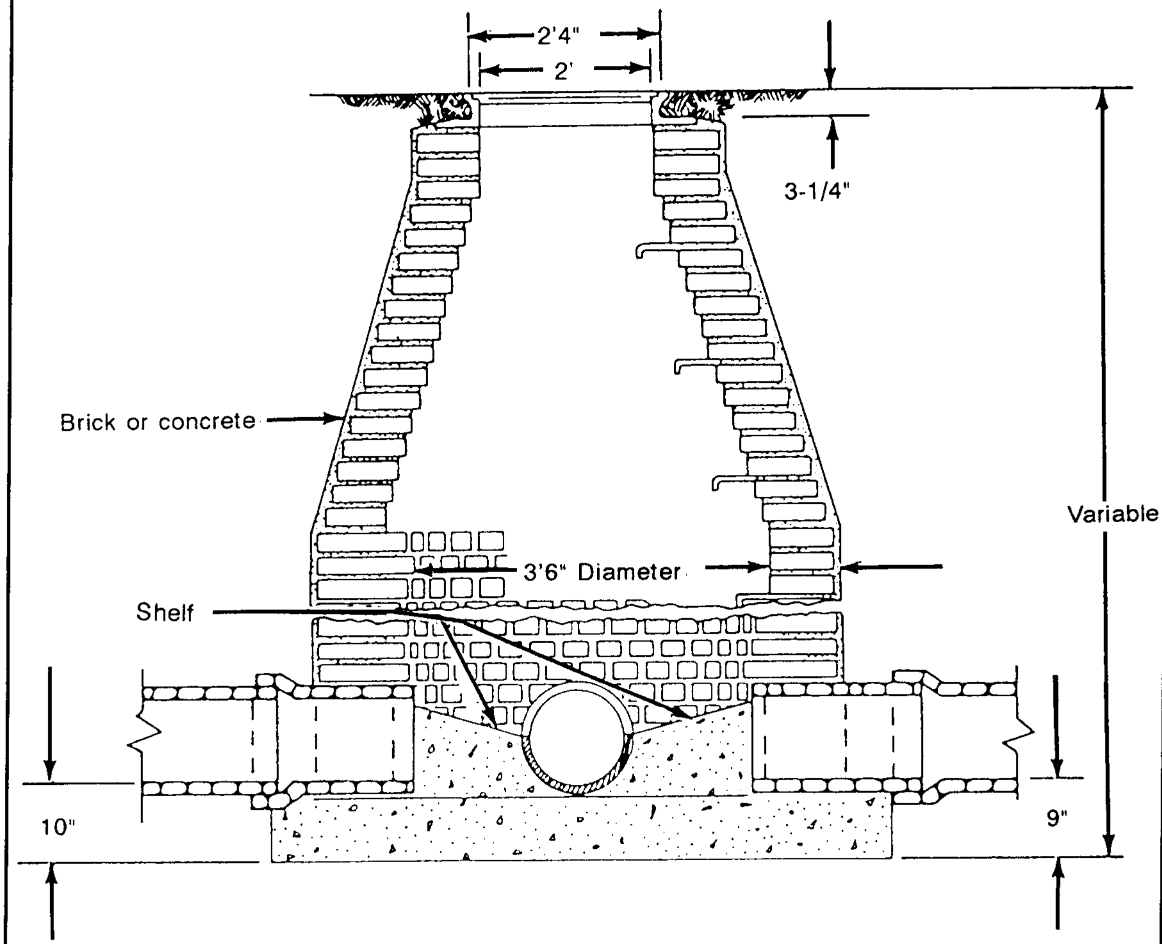


Figure 1-6. Round-manhole construction

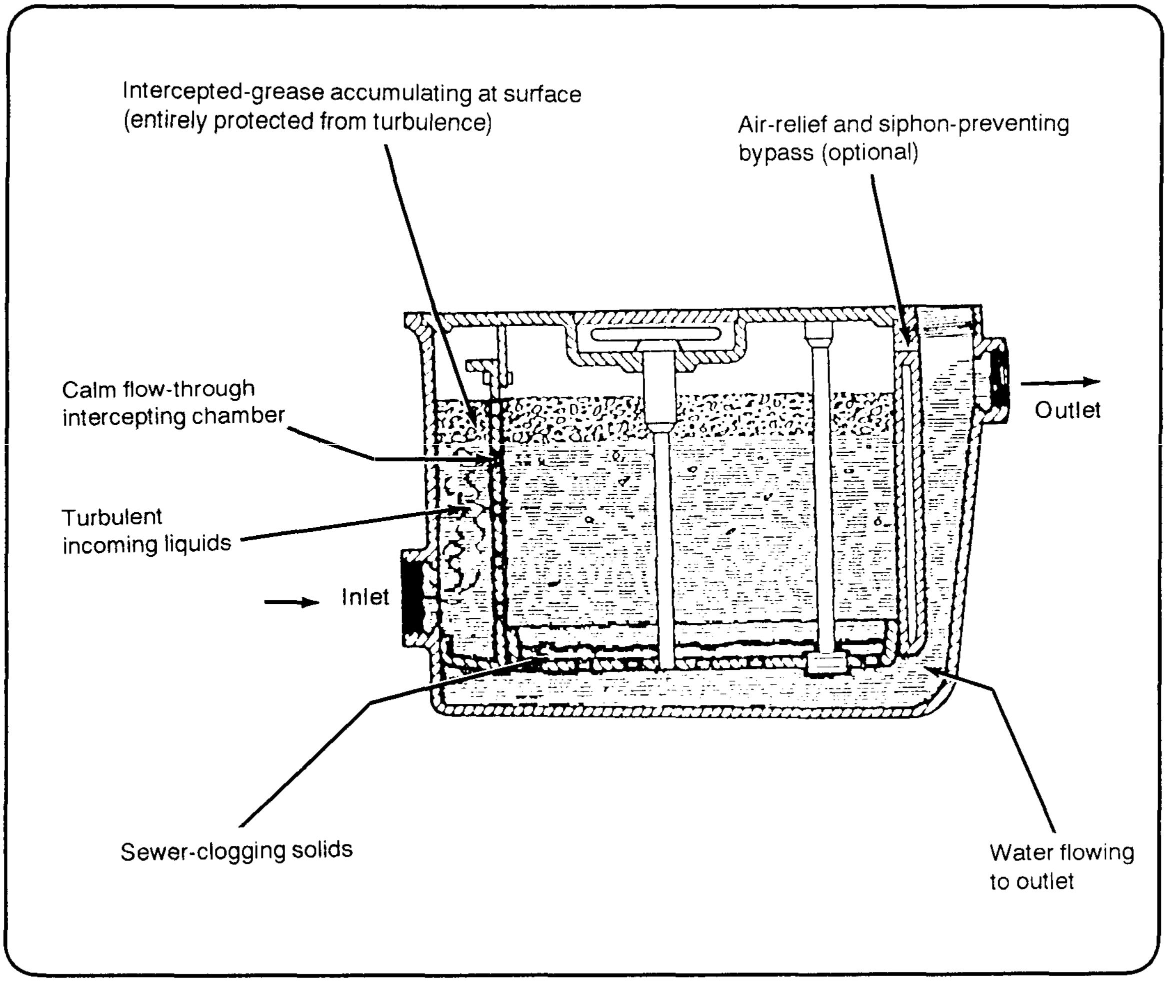
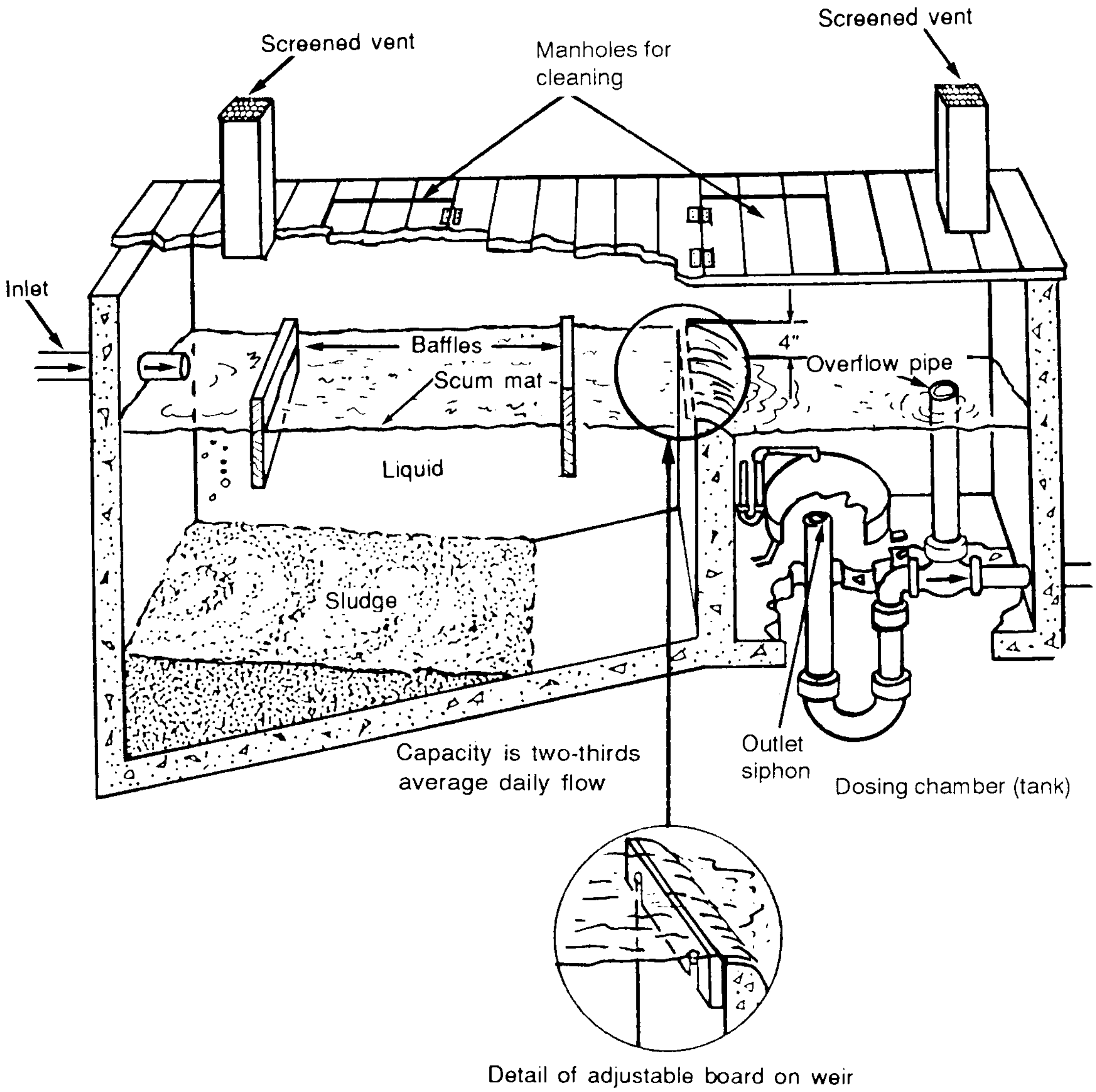


Figure 1-7. Grease trap

Figure 1-9 (page 1-21) shows a small sewerage system, which includes the septic tank. The distribution box, which permits equal flow to all lines of the disposal field, can be either wood, concrete, or brick. The diversion gate is usually wood with a handle slot, so it can be moved to change the sewage flow.

The system shown in Figure 1-9 (page 1-21) uses both a septic tank and a subsurface sand filter to dispose of sewage. A plumber needs both a plan and a profile (elevation) view of the system.

c. *Imhoff Tank.* If a septic tank cannot handle the load, an Imhoff tank may be used. Figure 1-10 (page 1-22) shows typical construction details. When a treatment plant is required, plans for a specific site should be prepared, taking into account soil conditions and features of the land surface. (The Imhoff tank is described in FM 5-163.)



NOTES:

1. Use the board cover only to retain heat in cold climate or to control fly nuisance.

2. When not required for dosing tile drain system, the dosing chamber and siphon are omitted.

Figure 1-8. Septic tank

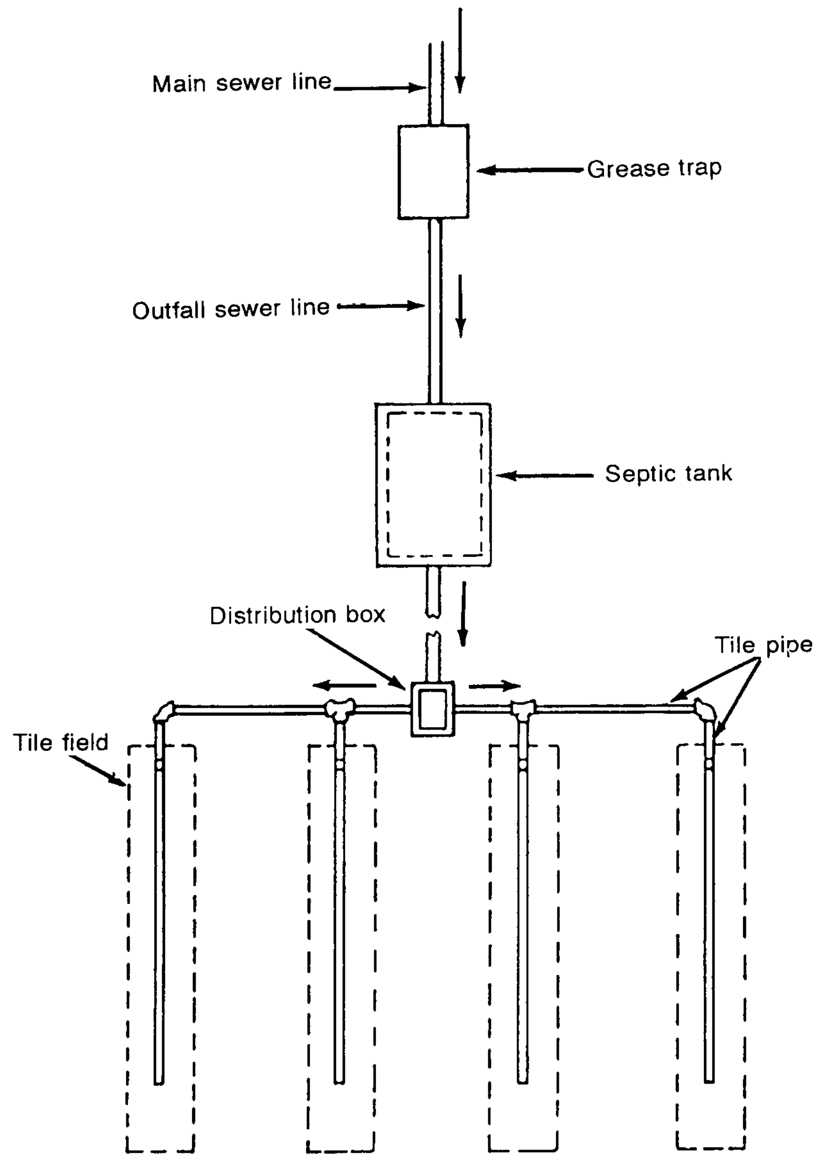


Figure 1-9. Small sewerage system plan

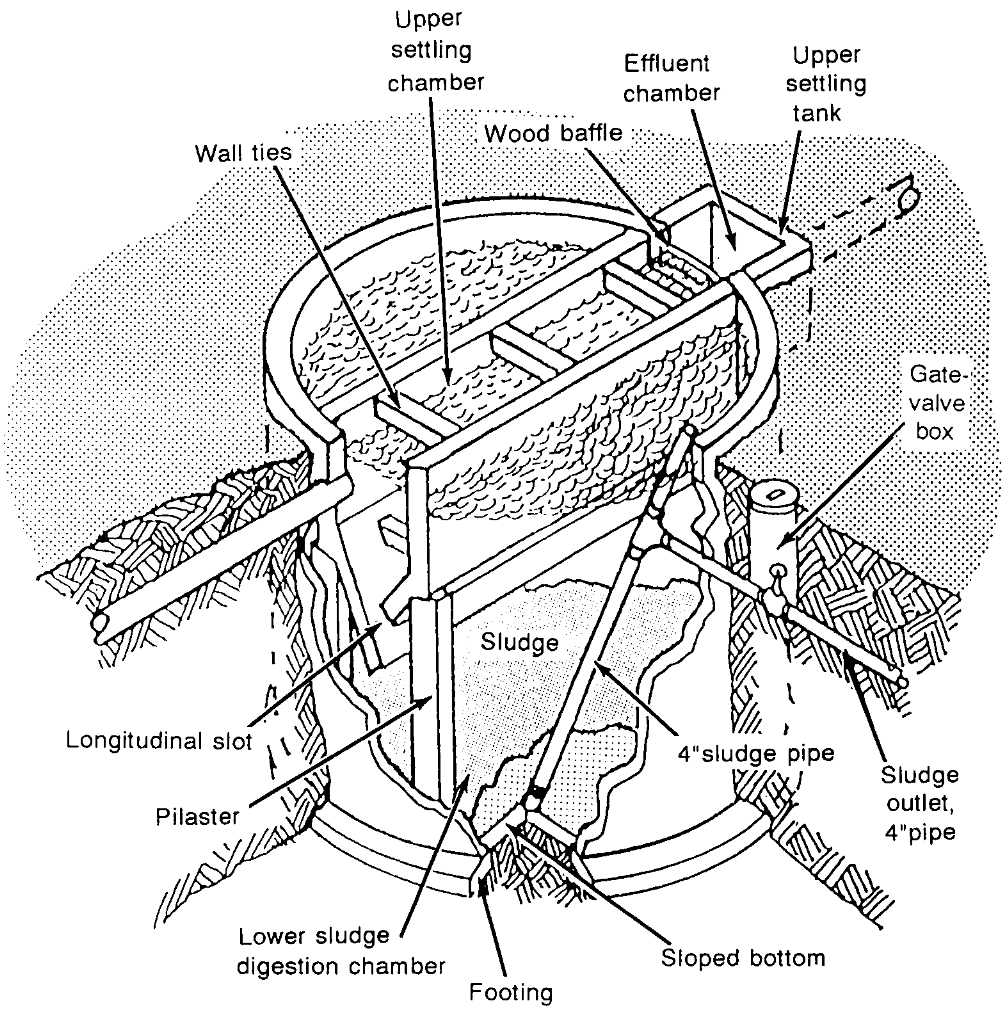


Figure 1-10. Cross sections of an Imhoff tank

1-20. Sewage Disposal Facilities.

a. *Drainage Bed.* The subsurface system is the most common type of drainage bed. A subsurface system is used where space and soil permit or where there is no stream or pond nearby. The following factors must be considered when laying the piping for a drainage bed:

- Lay of the land (topography).
- Depth of the potable water supply.
- Location of surface lakes and streams.
- Type of soil.

EXAMPLE

A subsurface irrigation system must handle 2,000 gallons per day (GPD), and the average time noted in the soil absorption test is 10 minutes. From Table 1-7, this corresponds to 1.7 GPD per square foot (sq ft).

The length of piping in a subsurface drainage bed depends on the type of soil and the volume of liquid to be treated. This is determined by a soil percolation test. Use the procedures in Figure 1-11 (page 1-24). To compute the length of the drainage lines, an average percolation rate is used. Table 1-7 gives soil absorption rates of the drainage lines.

$$\frac{2{,}000\ GPD}{1.7\ GPD/sq\ ft} = 1{,}180\ sq\ ft$$

If trenches are 18 inches wide (1.5 feet)—

$$\frac{1{,}180\ sq\ ft}{1.5\ sq\ ft} = 790\ \textit{ft of trench}\ \text{and}\ \textit{pipe}$$

Table 1-7. Soil absorption rates of drainage lines

Absorption (gallons per day)		
Time Required for Water Level to Fall 1 Inch (in minutes)	**Per Square Foot of Trench Bottom in the Field**	**Per Square Foot of Percolating Area in a Leaching Tank**
1	4.0	5.3
2	3.2	4.3
5	2.4	3.2
10	1.7	2.3
30	0.8	1.1
60	0.6	0.8

Soil Percolation Test

Step 1. Dig at least six test holes, 1-foot square, to a depth equal to that of the planned drainage bed.

Step 2. Place a layer of gravel in the bottom of the holes and fill the holes with water.

Step 3. If the soil is tight or has a heavy clay content, the test holes should stand overnight. If the soil is sandy and the water disappears rapidly, no soaking period is needed. Pour water into the holes to a depth of 6 inches above the gravel. The batter board acts as a reference line, and a ruler should be used to record the level of water in the hole below the batter board.

Step 4. Measure the water every 10 minutes over a 30-minute period. The drop in water level during the final 10 minutes is used to find the percolation rate of the soil.

- Soil that takes 30 minutes to absorb 1 inch of water needs 4 feet of drainage for each gallon of liquid.
- If a test hole needs more than 30 minutes to absorb 1 inch of water, the soil is not suitable for a subsurface drainage system.

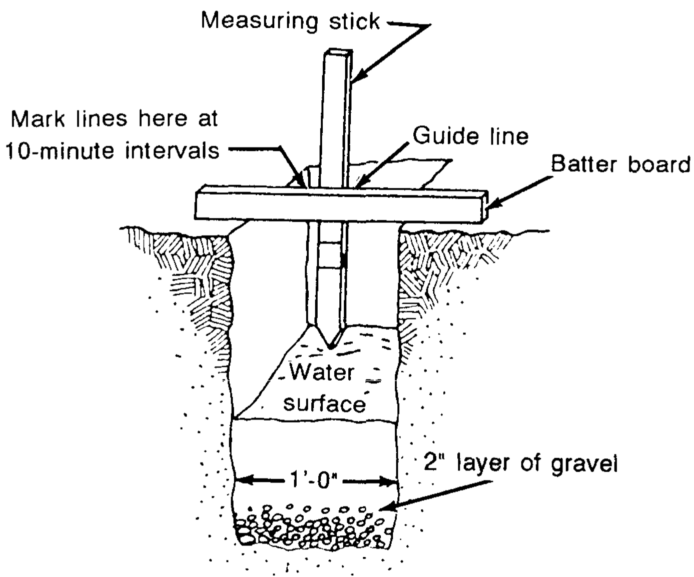


Figure 1-11. Soil percolation test

b. *Leaching Tanks.* Leaching tanks, cesspools, receive raw sewage or septic tank overflow. They can be made of 4- x 4-inch lumber or 5-inch round timber. Dry masonry may be used for wall construction when time and materials permit. Figure 1-12 shows the design for a small leaching tank.

c. *Sand-Filter Fields.* Piping of surface irrigation and subsurface sand-filter disposal systems is installed using plans and profiles. The plans and profiles are based on the area topography and a soil percolation test. The small sewerage system shown in Figure 1-9 (page 1-21) shows a sand-filter field. (Refer to FM 5-163 for a complete description of sand-filter fields.)

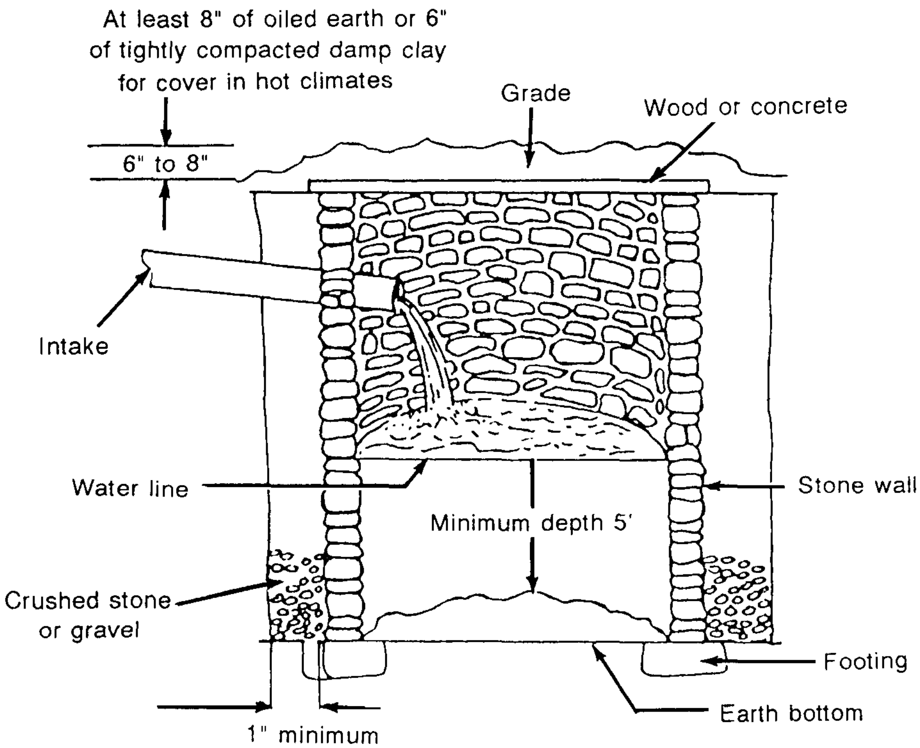


Figure 1-12. Design for a leaching tank