Water for the World

Designing Non-Conventional Absorption Disposal Systems
Technical Note No. SAN. 2.D.8

Non-conventional absorption disposal systems have been developed for soil conditions where absorption is slow and slight, or where ground water is close to the ground surface. Effluent from a septic tank discharges to special filter beds or into mounds of soil or sand for final discharge by drainage or evapotranspiration. Such methods are for desperation cases where usual soil absorption lines cannot work. Designing non-conventional systems requires the services of an experienced engineer or soil scientist. Designing involves selecting a system; selecting a location; calculating size; and determining materials, labor, and tools needed for construction. The products of the design process are (1) a location map similar to Figure 1, (2) design drawings of the absorption system similar to Figure 2 or 3, and (3) a detailed materials list similar to Table 1. These products should be given to the construction foreman before construction begins.

This technical note describes the elements involved in designing non-conventional absorption systems. Read the entire technical note before beginning the design process.

Useful Definitions

EFFLUENT - Settled sewage.

EVAPOTRANSPIRATION - The loss of moisture from the soil caused by direct evaporation and by the transpiration of moisture to the atmosphere by plants.

IMPERMEABLE - Not allowing liquid to pass through.

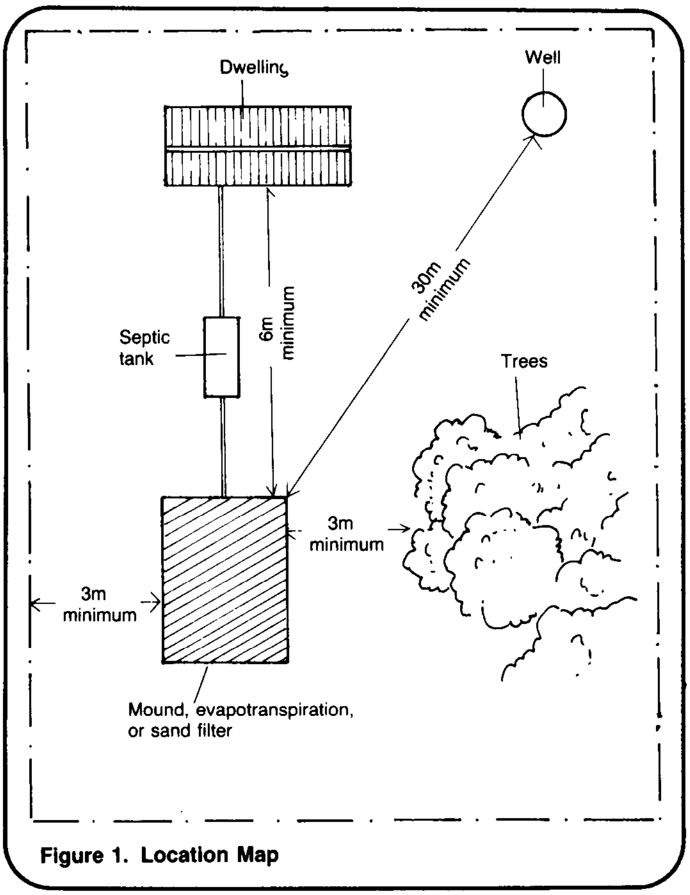

Figure 1. Location Map

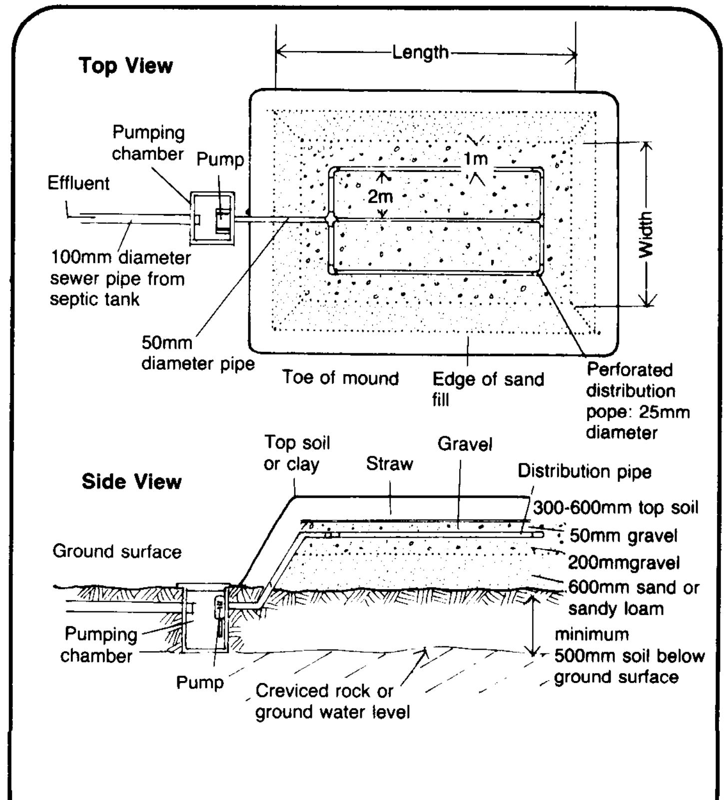

Figure 2. Mound System

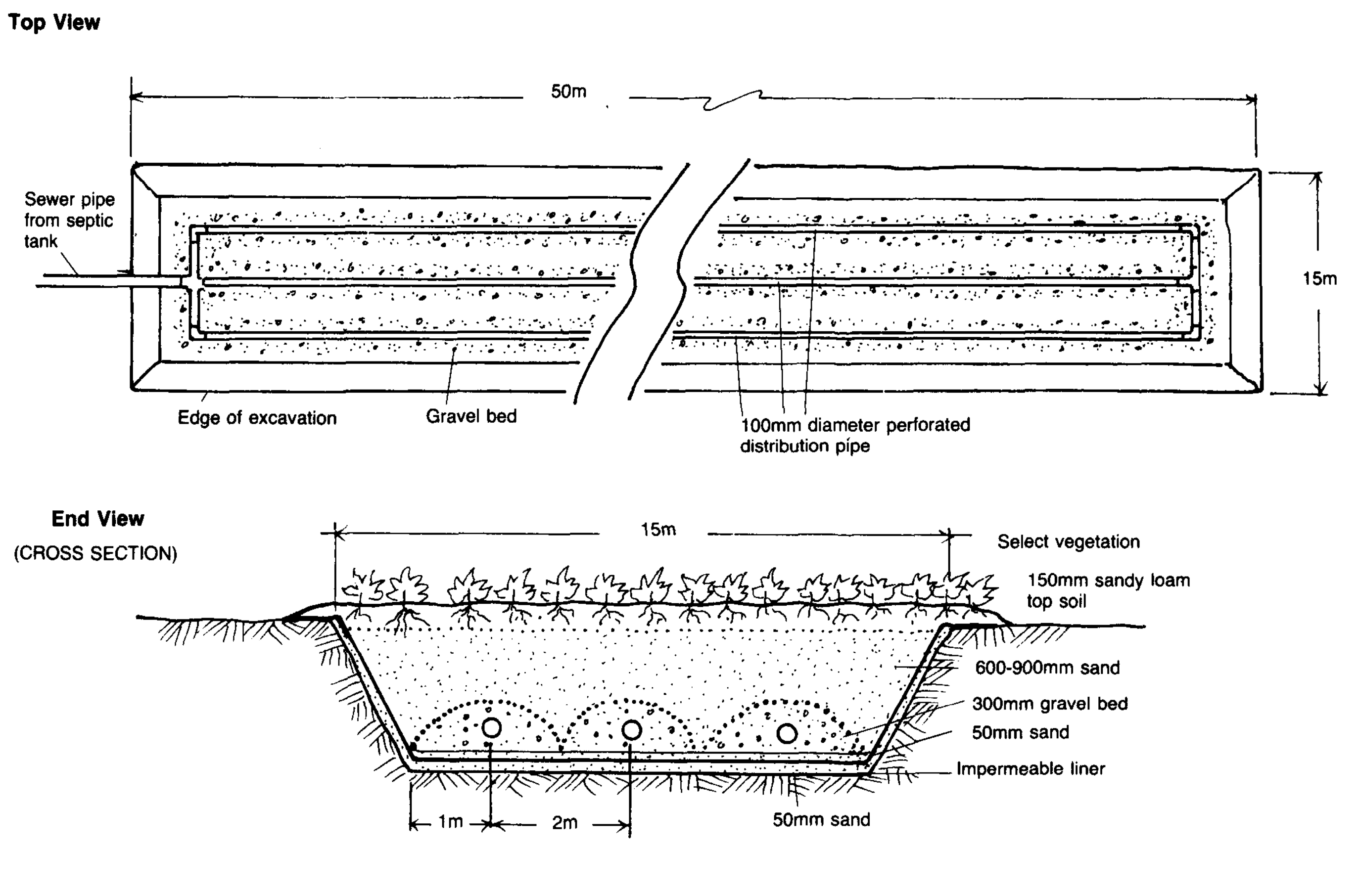

Figure 3. Evapotranspiration System

Table 1. Sample Materials List for Mound System, Evapotranspiration System, or Sand Filter

Item	Description	Quantity	Estimated Cost
Labor	Engineer or experienced construction foreman familiar with the system	1	____
	Surveyor, to lay out the system	1	____
	Workers	4-8	____
Supplies	Pump (capable of 110 liters per minute)	1	____
	Select filter sand; all must pass a 6mm screen; effective size 0.3-0.6mm; uniformity coefficient less than 3.5	____	____
	Gravel; 3-6mm in size	____	____
	Gravel; 18-36mm in size	____	____
	Fill sand	____	____
	Select vegetation	____	____
	Perforated pipe, 100mm diameter	____	____
	Perforated pipe, 25mm diameter	____	____
	Sewer pipe, 100mm diameter	____	____
	Impermeable synthetic liner	____	____
	Mortar	____	____
Tools	Shovels	4-8	____
	Wheelbarrows	2-4	____
	Trowel	2	____
	Containers for mixing mortar	2	____
	Surveying equipment	____	____

Total Estimated Cost = ____

Selecting a System

The three types of non-conventional absorption disposal systems are mound, evapo-transpiration, and sand filter. The engineer must have some experience with the particular system selected. Table 2 can be used in a general way as an aid in selecting a system.

Table 2. Comparison of Non-Conventional Absorption Disposal Systems

System	Important Design Features
Mound	Pump; supply of suitable soil
Evapotranspiration	Impermeable liner; sand, gravel, and topsoil; shallow-root vegetation; arid or semi-arid climate
Sand Filter	Sand that meets design specifications; area to discharge filtered effluent; pump or dosing siphon (depending on size of the system)

Selecting a Location

A non-conventional absorption system should be at least:

30m from the nearest water supply,
6m from the nearest building,
3m from any property line,
3m from bushes or trees.

Preferably, the system should be located so that there is a straight line from the building served, through the septic tank, to the absorption system. Thus there will be no bends or turns. If turns are necessary, mark the point permanenty with a steel or concrete post. See "Designing Septic Tanks," SAN.2.D.3.

When the site has been selected, prepare a location map similar to Figure 1, showing distances from the system to the septic tank, buildings, water supplies, property lines, trees, and any other prominent features. Give the map to the construction foreman before construction begins.

Designing a Mound System

There are a number of possible designs for a mound system. One design requires at least 500mm of soil above the groundwater level or creviced rock. The soil is covered with 600mm of sand or sandy loam, and then covered further by 200mm of gravel. Distribution pipes are laid on the gravel. The pipes are covered with another 50-100mm of gravel. The gravel is covered with straw, and the entire system is mounded with soil.

Effluent is discharged from a septic tank to a pumping chamber, and is pumped to the mound through distribution pipes. It filters down through the mound and into the natural ground. The ground may have a high groundwater level but it must be previous. Some of the effluent will leave the mound by evaporation and by action of plants and grass. No effluent should seep out from the edges of the mound.

Calculating Size. The size of the mound depends on the estimated daily flow of effluent. See "Estimating Sewage or Washwater Flows," RWS.2.P.2. The area of the sandy fill equals $0.04m^2$ times the daily flow expressed in liters:

$$\text{area} = \frac{0.40m^2}{\text{liter}} \times (\text{number of liters}) = m^2$$

For example, if the estimated daily flow of effluent is 1500 liters, the required area of the sandy fill equals:

$$\frac{0.04m^2}{\text{liter}} \times 1500 \text{ liters} = 60m^2$$

Worksheet A. Line 2.

The sandy portion of the mound system must be at least $60m^2$. One configuration for this area is 10m long by 6m wide. When the mound has been designed, prepare a drawing similar to Figure 2 and give it to the construction foreman.

Determining Materials, Tools, and Labor. The system requires a pump (usually electric) designed to move at least 110 liters per minute. The pump is housed in a waterproof pumping chamber made of reinforced concrete. The exact size and configuration of the pumping chamber should be determined by the engineer at the site. The chamber must be at least large enough to house the pump and have enough room for a maintenance person to enter and service the pump. Materials for the chamber include cement, sand, gravel, water, and reinforcing material see "Designing Septic Tanks," SAN.2.D.3 for details. The pump and its fittings and parts should be selected by the engineer and obtained from the pump manufacturer. The pump requires a power source. It is extremely difficult to operate a mound system without a continuous, dependable electricity supply.

The system requires 100m diameter sewer pipe from the septic tank to the pumping chamber, 50mm diameter pipe from the chamber to the mound, and 25mm perforated distribution pipe within the mound. The distribution pipes are laid in parrallel lines no more than 2m apart and no closer to the edge of the sand fill than 1.0m. The quantity of distribution pipe is best determined from the design drawings.

The approximate quantities of sandy soil and gravel in the mound can be calculated by multiplying the depth of the sand or gravel times the area of the sandy fill. In the previous example, these quantities are:

Worksheet A. For Calculating Quantities for Mound System, Evapotranspiration System, and Sand Filter

Type of system (check one): [X] mound [X] evapotranspiration [X] sand filter

1. Estimated daily flow of effluent (from SAN.2.P.2) = 1500 liters

Mound System

2. Required area = 0.04m^2/liter x Line 1 = 0.04m^2/liter x 1500 liters = 60 m^2

3. Sandy soil = depth of sand times length of fill times width of fill = 0.6 m x 10 m x 6 m = 36 m^3

4. Gravel = depth of gravel times length of fill times width of fill = 0.3 m x 10 m x 6 m = 18 m^3

Evapotranspiration System

5. Required area = $\frac{\text{Line 1}}{2.0 \text{ liters/m}^2}$ = $(\frac{1500}{2.0})$ = 750 m^2

6. Size of impermeable liner = (length times width) + 2 (length times depth) + 2 (width times depth) = (50 m x 15 m) + 2 (50 m x 1 m) + 2 (15 m x 1 m) = 750 m^2 + 100 m^2 + 30 m^2 = 880 m^2

7. Gravel = Length of distribution pipe times 0.14m^2 = 300 m x 0.14m^2 = 42 m^3

8. Sand fill = (length times width times depth) minus Line 7 = (50 m x 15 m x 1 m) - 42 m^3 = 750 m^3 - 42 m^3 = 708 m^3

Sand Filter

9. Required area = $\frac{\text{Line 1}}{50 \text{ liters/m}^2}$ = $(\frac{1500}{50})$ = 30 m^2

10. Filter sand = depth times length times width = 0.6 m x 7.5 m x 4.0 m = 18 m^3

11. Gravel (3-6mm) = depth times length times width = 0.075 m x 7.5 m x 4.0 m = 2.25 m^3

12. Gravel (18-36mm) = depth times length times width = 0.2 m x 7.5 m x 4.0 m = 6 m^3

sandy soil = 0.6m x 60m^2 = 36m^3;

Worksheet A, Line 3.

gravel = 0.3m x 60m^2 = 18m^3;

Worksheet A, Line 4.

The mound can be constructed by unskilled workers under the supervision of an experienced construction foreman. However, constructing the pumping chamber and installing the pump must be done by an experienced worker and checked by an engineer. When the necessary materials, tools, and labor have been determined, prepare a materials list similar to Table 1 and give it to the construction foreman.

Designing an Evapotranspiration System

There are a number of designs of an evapotranspiration system. In all of them, the settled effluent enters the distribution system and leaves by evaporation and the action of plants and grass. One design requires an excavation about 1.0m deep, at least 2.5m wide, and up to 50m long. The bottom of the excavation is covered with 50mm of sand to provide a supporting base. The bottom and sides are lined with an impermeable material, usually 0.25mm thick PVC plastic or other synthetic material that will not decompose. A

50mm layer of sand is spread over the liner. Distribution pipes are encased in gravel beds 300mm deep. The entire excavation is filled with sand and covered with about 150mm of sandy loam topsoil. Selected vegetation, usually of a type that uses a lot of water, is planted over the system.

Effluent is discharged from a septic tank to the system. It is drawn upward by capillary action and by the root system of the cover vegetation, and then dispersed by evaporation and transpiration.

Calculating Size. The size of the evapotranspiration bed depends on the estimated daily flow of effluent, on the evaporation rate in the region throughout the year, and to some extent on the type of vegetation used for cover. See "Estimating Sewage or Washwater Flows," SAN.2.P.2. Many systems can accept no more than 2.0 liters of effluent for every $1m^2$ of surface area. To calculate the required area for this type of system, divide the estimated daily flow of effluent by 2.0 liters/m^2:

$$\text{area} = \frac{\text{liters of flow}}{2.0\ \text{liters}/m^2} = m^2$$

For example, if the estimated daily flow is 1500 liters, the area required equals:

$$\frac{1500\ \text{liters}}{2.0\ \text{liters}/m^2} = 750m^2;$$

Worksheet A, Line 5.

The evapotranspiration system must cover at least $750m^2$. One shape for this area is 50m long by 15m wide. When the system has been designed, prepare a drawing similar to Figure 3 and give it to the construction foreman.

Determining Materials, Tools, and Labor. The system requires an impermeable, non-degradable lining, generally PVC, plastic or other synthetic membrane. The liner must cover the bottom and all four vertical sides of the excavation. The following equation can be used to calculate the approximate size of the liner based on excavation dimensions:

(length times width) + 2 (length times depth) + 2 (width times depth)

Sometimes a double liner is used, and the equation is multiplied by two. The approximate size of a single-layer liner in the previous example is:

$$(50m \times 15m) + 2\ (50m \times 1m) + 2\ (15m \times 1m) = 750m^2 + 100m^2 + 30m^2 = 880m^2;$$

Worksheet A. Line 6.

The system requires 100mm diameter sewer pipe from the septic tank to the evapotranspiration bed, and 100mm diameter distribution pipe within the bed. The distribution pipes are laid in parrallel lines 1.5-2.0m apart, and no closer to the sides of the excavation than 1m. The quantity of distribution pipe is best determined from the design drawings.

Each distribution pipe is laid in a bed of pea-sized (8-10mm) gravel. Each bed has a cross-sectional area of about $0.14m^2$. To estimate the required quantity of pea-sized gravel, multiply $0.14m^2$ times the total lengths of all beds. For example, if the combined lengths of the distribution pipe beds is 300m, the approximate quantity of gravel equals:

$$0.14m^2 \times 300m = 42m^3;$$

Worksheet A, Line 7.

The approximate quantity of sand required for the system equals the volume of the excavation minus the volume of the gravel. For example, if the system is 50m long, 15m wide, and 1m deep, and the volume of gravel is $42m^3$, the volume of sand equals:

$$(50m \times 15m \times 1m) - 42m^3 = 750m^3 - 42m^3 = 708m^2;$$

Worksheet A, Line 8.

The cover vegetation selected should be of a local variety and it should not have long roots which would interfere with the operation of the system. The vegetation should be approved by the engineer or soil scientist before it is planted.

An evapotranspiration system can be constructed by unskilled workers under the close supervision of an experienced construction foreman or engineer. When the necessary materials, tools, and labor have been determined, prepare a materials list similar to Table 1 and give it to the construction foreman.

Designing a Sand Filter

There are a number of designs for a sand filter. One design requires an excavation in clay or tight soil. The bottom of the excavation slopes toward the center and an underdrain is laid within a 100mm layer of washed gravel, 18-36mm in size. Above this is a 75mm layer of gravel, 3-6mm in size. Above the gravel is a 600-900mm layer of clean, coarse filter sand. The quality and size of the filter sand is critical to the operation of the system. Riverbed sand definitely may not be used. All the sand must pass through a 6mm sieve. The effective grain size should be between 0.3-0.6mm. The effective size means that 10 percent of the sand by weight must be smaller than that size. The uniformity coefficient should be 3.5 or less. This coefficient is the ratio between the size of seive that passes 60 percent of the sand by weight and the size of the seive that passes 10 percent of the sand by weight. The filter sand is covered with a 100mm layer of 18-36mm gravel. Perforated distribution pipes are headed in this gravel layer. The entire system is mounded with soil.

Effluent is discharged from a septic tank to the distribution pipes. The effluent filters down through the sand, collects in the underdrain, and is discharged to a dry ditch or waterway. for low daily volumes of wastewater, gravity flow to the filter lines may work. For full use of the bed, the distribution lines should be filled two or three times per day. That requires a dosing siphon and dosing tank between the septic tank and filter bed. See Figure 4. The alternative is to use a pump similar to that required for a mound system.

Figure 4 shows a dosing siphon. It is placed in a dosing tank alongside a septic tank. The volume of the dosing tank to the discharge level is about equal to the total volume of the distribution pipes in the sand filter. A dosing siphon provides uniform distribution in the absorption beds. As it usually discharges only two or three times per day, the beds have resting periods which are very beneficial for biological action.

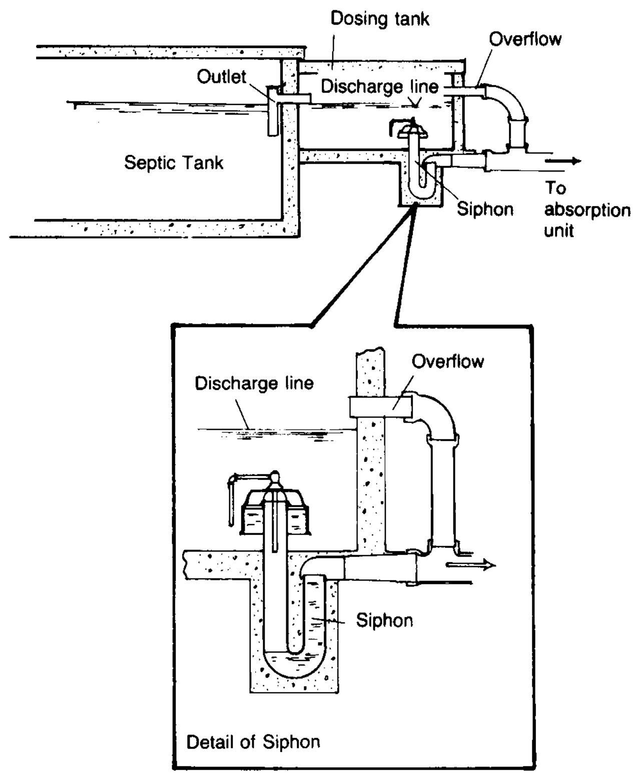

Figure 4. Siphon Installation

There are no moving parts. Discharge starts when a trapped volume of air is compressed to a point where there is a release of pressure starting the siphon. Sizing, dimensions and placement are critical. The underedge of the bell must be absolutely level, if the siphon is ever to start.

<u>Calculating Size</u>. The size of the and filter system depends on the estimated dialy flow of effluent and on the loading factor of 46.85 liters of effluent for every m^2 of surface area. See "Estimating Sewage or Washwater Flows," SAN.2.P.2.

For example, if the estimated daily flow of effluent if 1500 liters, the required area of the sand filter equals:

$$\frac{1500 \text{ liters}}{46.85 \text{ liters/m}^2} = 32.0\text{m}^2;$$

Worksheet A, Line 9.

The sand filter must cover at least 32.0m^2. One configuration for this area is 8.0m long by 4.0m wide. When the system has been designed, prepare a drawing similar to Figure 5 and give it to the construction foreman.

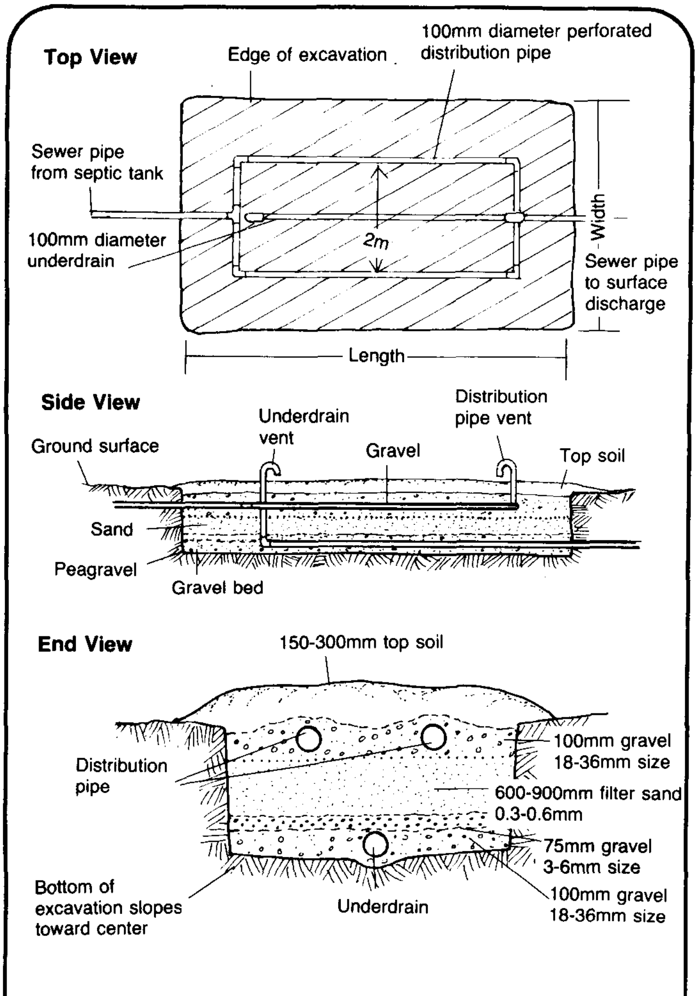

Figure 5. Sand Filter

Determining Materials, Tools, and Labor. This system requires a quantity of finely-graded, select filter sand, which passes through a 6mm screen, has an effective size of 0.3-0.6mm, and has a uniformity coefficient of less than 3.5. The approximate quantity of sand can be calculated by multiplying the depth of the sand layer by the dimensions of the excavation. In the previous example, if the depth of the sand layer is 600mm, the quantity needed equals:

$$0.6\text{m} \times 8.0\text{m} \times 4.0\text{m} = 19.2\text{m}^3;$$

Worksheet A, Line 10.

The approximate quantities of gravel are calculated in the same manner.

For gravel 3-6mm in size:

$$0.075\text{m} \times 8.0\text{m} \times 4.0\text{m} = 2.4\text{m}^3;$$

Worksheet A, Line 11.

For gravel 18-36mm in size (two 100mm layers):

$$0.2\text{m} \times 8.0\text{m} \times 4.0\text{m} = 6.4\text{m}^3;$$

Worksheet A, Line 12.

The system requires 100mm diameter sewer pipe from the septic tank to the sand filter, 100mm diameter perforated distribution pipe and underdrain within the system, and two 100mm diameter vent pipes. The quantity of pipes is best determined from the design drawings.

A pump and pumping chamber similar to that for a mound system is required, if the area of the filter is greater than 170m^2. A dosing siphon and chamber can be used.

A sand filter must be constructed under close supervision by an experienced construction foreman or engineer. The elevation and grade of the distribution pipes and underdrain are critical. They should be established by a surveyor.

When the necessary materials, tools, and labor have been determined, prepare a materials list similar to Table 1 and give it to the construction foreman.

In summary, non-conventional system--mound, evapotranspiration, sand filter--must be designed by an engineer experienced with them.