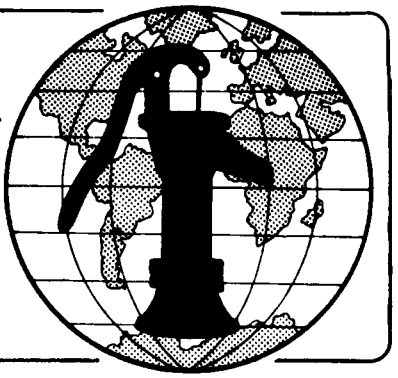
Water for the World



Methods of Storing Water

Technical Note No. RWS. 5.M

Water storage is often a necessary part of a rural water supply system. Storage ensures that a sufficient quantity of water without interruption is available to users. If no storage is used in piped distribution systems, the water source and the treatment and pumping systems must have sufficient capacity to meet the daily demand for water. Due to hourly changes in demand for water, it is economically and technically impossible for most systems to meet demand unless storage is provided. Not only is storage necessary for larger piped distribution systems, but it should be provided for individual families that capture rainfall for drinking water.

Three basic types of water storage reservoirs are available for use in rural areas. For individual supplies, household cisterns provide necessary storage. In large, piped distribution systems, either ground level or elevated storage reservoirs should be installed. This technical note describes each type of storage reservoir and explains under what conditions each should be used. Open reservoirs, such as those formed by dams, are not covered. Information about dams can be found in "Designing Small Dams," RWS.1.D.5.

Useful Definitions

EVAPORATION - Loss of surface water to the air as the surface water is heated by the sun and rises to the atmosphere as vapor.

FERROCEMENT - An economical and simple-to-use type of reinforced concrete made of wire mesh, sand, water and cement.

FRICTION - Resistance to flow caused by a moving object coming into contact with another substance; resistance to water flow caused by the water's contact with pipe.

HEAD - Difference in water level between the inflow and outflow ends of a water system.

PEAK DEMAND - The greatest demand or need for water by the users; peak demands usually occur in the morning and late afternoon.

TOPOGRAPHY - The land surface features of a region including elevation, location of water bodies and other prominent features.

Household Cisterns and Storage Facilities

Household storage jars and household cisterns can be used to collect rainwater. The choice depends on the following factors:

- the storage capacity needed,
- the availability of materials needed for construction,
- the economic resources available for each family, and
- the labor skills required.

Cisterns and storage jars can be constructed for use above or below ground using many different types of materials. Concrete, ferrocement, reinforced concrete, corrugated iron, and wood are all suitable materials as long as appropriate measures are taken to make structures watertight.

Figure 1a shows a typical cistern used in collecting water from roofs. The rectangular tank is made of reinforced concrete and located as close to the house as possible. However, it should be at least 10-15m from a latrine or other sewage disposal system and on higher ground than these facilities. Construction materials may be costly because cement and reinforcing rod must be purchased. In some cases,

costs can be lowered by using very hard bamboo for reinforcing if it is available. Rectangular tanks can be made of bricks and mortar. These materials may be more easily available and cheaper in rural areas.

Figure 1b shows a low-cost alternative cistern design. A circular, above ground cistern can be built from ferrocement using cement, sand, water and reinforcing wire mesh similar to chicken wire. In many rural areas, these materials are readily available which makes this type of reservoir attractive. Some skill is needed in using ferrocement.

A large capacity rectangular reinforced concrete or masonry tank can be constructed in the ground as shown in Figure 2. The design is similar to that shown in Figure 1a. Below ground storage offers several advantages:

- water is cool throughout the year,
- little or no loss of water through evaporation occurs,
- the ground offers good structural support for the reservoir walls, and
- space above ground is saved.

A major disadvantage of an underground storage is extraction of water. In above ground storage systems, simple tap arrangements can be used. When the reservoir is located below ground, a hand pump is needed to remove the water.

Jars can be used to store rainwater collected from roofs. Jars of various capacities made from clay or mortar without reinforcing make useful reservoirs. They are not expensive to make; they require basic skills that are known in most areas; and they use materials that are generally locally available.

Large storage jars as shown in Figure 3 can be made from reinforced mortar to capacities up to 4m^3 (4000 liters). The jars require no wire reinforcement. They are made with cement mortar and gunny cloth sewn

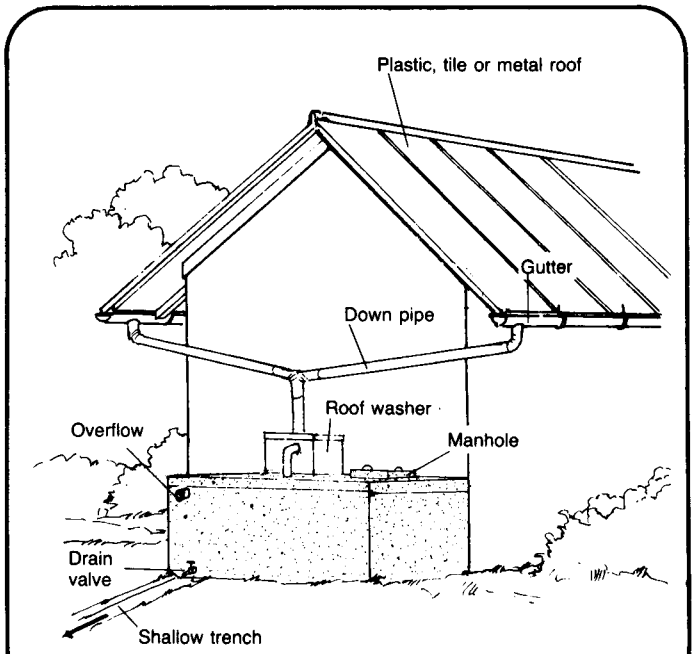


Figure 1a. Roof Catchment and Concrete Cistern

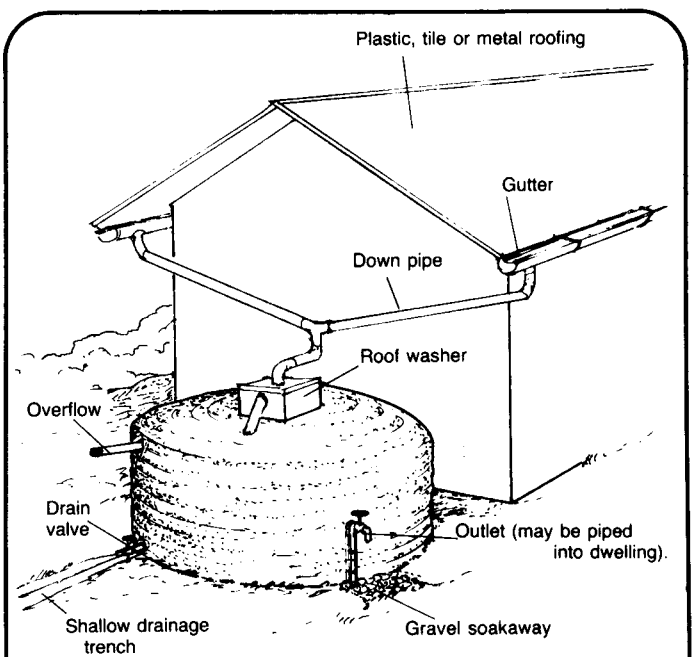


Figure 1b. Roof Catchment with Ferrocement Cistern

together. Although the capacities of the jars are not great, several jars can be built and covered to store water during the dry season. Long term water storage is not only useful to meet water demand during the dry season but it also improves the quality of water that is stored for several weeks.

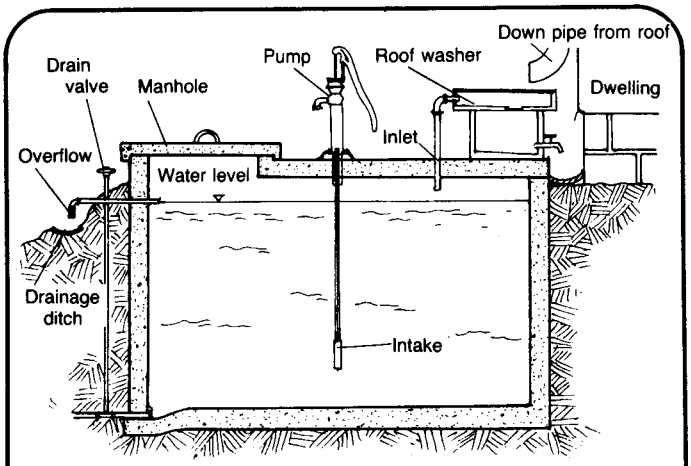


Figure 2. In Ground Storage for Roof Catchment

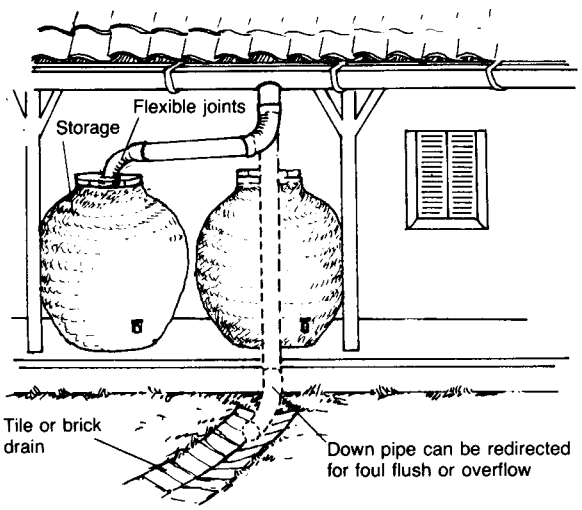


Figure 3. Flexible Down Pipe

Underground storage wells like the one in Figure 4 are molded directly into the ground by compacting the earth. The walls are lined with a layer of concrete or mortar or with plastic sheeting. A special inlet should be installed to direct water to storage and a hand pump used to extract the water. This type of unit can be used where the water table is low and the ground is firm.

Any of these storage devices are suitable for household systems. Large cisterns are very costly and not practical unless several families use the same one. To ensure that adequate

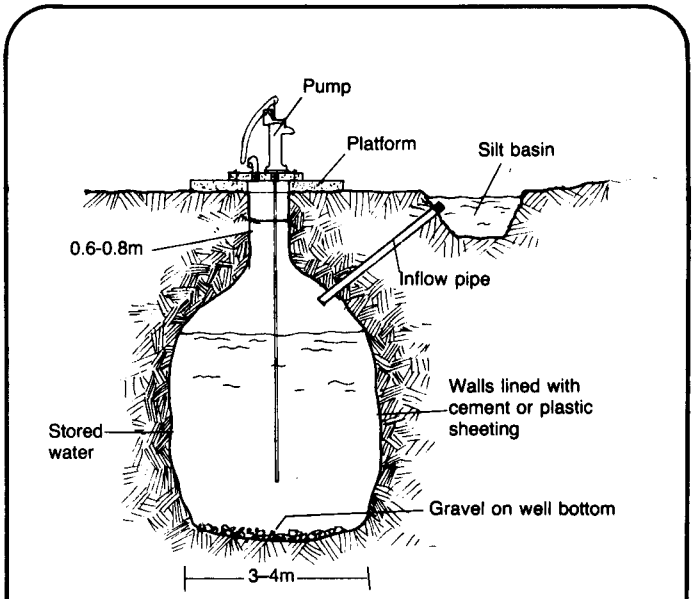


Figure 4. Underground Rainwater Storage Well

supplies of water are available during the entire year, cisterns should be well planned and designed. Information on designing cisterns is available in "Designing a Household Cistern," RWS.5.D.1.

Ground Level and Elevated Storage Facilities

When water is distributed to users through a piped distribution system, either by a pump or gravity flow, storage should be provided. A storage reservoir has the following advantages:

1. Allows the system to satisfy hourly variations and peak demand.

2. Provides for maintenance of adequate pressure throughout the distribution system.

3. Provides the means of repairing pipes or pumps between the supply source and storage without interruption of water service.

4. Where water is pumped to storage pumps can be run at a constant rate for a fixed period of time. Pumps that are smaller and cheaper than would be required if no storage were provided can be used, thereby reducing the cost of the distribution system.

5. The pipe running from the supply source to storage can be smaller than if a direct line from the source to the village were installed. The use of a smaller pipe lowers cost.

Two basic methods of storing water for distribution systems are ground level and elevated storage tanks. The choice depends on the topography of the area where the system is installed. Elevation is the most important factor influencing the choice between a ground or elevated tank. The bottom water level of the storage facility should be high enough so that there is sufficient force to move the water to all users. In technical terms, after allowance for friction loss in the distribution system, a minimum residual head of ten meters should be available at delivery points.

Ground Level Tanks. If high ground is available, close to the community, a ground level tank can provide a gravity supply at adequate pressure. The arrangement would be similar to that shown in Figure 5 where water is pumped from the source to the reservoir. From the reservoir, it flows by gravity to the users. The cost of installing a ground level storage reservoir is much lower than an elevated tank.

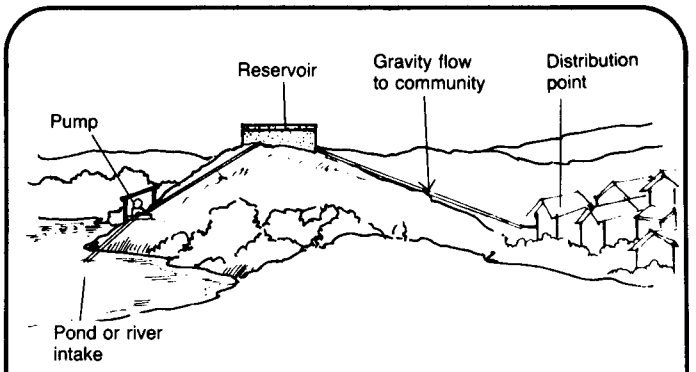
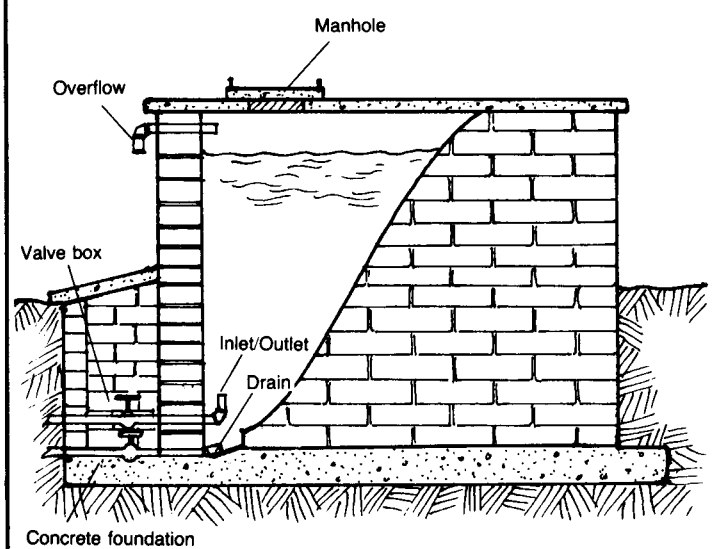
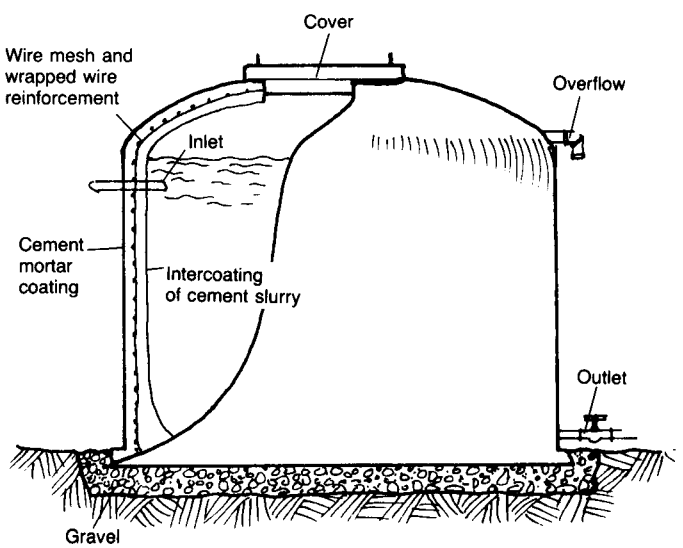


Figure 5. Locating Ground Level Storage Facility

Ground level storage tanks are generally made of masonry, concrete, reinforced concrete, steel sheeting or ferrocement. The choice of material depends on the capacity of the tank, the materials available, and the skills of available labor. Small capacity tanks of $5m^3$-$40m^2$ (5000-40000 liters) can be built from locally available materials such as brick and rock or from steel sheets. Small volume steel tanks can be purchased in some areas. Ferrocement tanks up to $40m^3$ in capacity can be economically installed in rural areas using local labor. Figure 6 shows an example of a circular ferrocement water tank and a rectangular masonry tank.



a. Rectangular Masonry Tank



b. Circular Ferrocement Tank

Figure 6. Small Water Reservoirs

Larger storage tanks of over $40m^3$ in capacity should be constructed of reinforced concrete to ensure their strength. Reinforced concrete reservoirs are normally rectangular in shape.

Ground level storage tanks can be buried partially or completely in the ground. The choice depends on the elevation of the water required. If the ground is not too hard, a typical construction method is to build the tank half below ground. The tank should be covered to protect the stored water from contamination and prevent the growth of algae, and it should have ventilation to allow air to escape from the reservoir when water enters.

Elevated Tanks. In flat areas where no suitable hills or high points are available for ground level tanks, elevated tanks are necessary. Figures 7 and 8 show typical elevated tanks designs. Figure 7 shows a small elevated tank serving several standpipes. Figure 8 shows a steel or reinforced concrete structure serving a larger community through house connections. Figure 9 shows possible locations for the storage tank. In 9a the tank is located near the source, away from the area to be served. In 9b, the storage is directly in the center of the service area and water is pumped a quarter distance from the source.

Elevated storage tanks are normally constructed of either reinforced concrete, brick or steel, with steel usually in the form of pressed plates. The material used for the tower depends on the size of the tank and available materials. Smaller capacity steel and brick tanks can be elevated on small brick or wooden towers. For greater reliability, brick is recommended.

Both large and small diameter steel tanks supported by steel towers are normally purchased from a manufacturer. In many areas, elevated storage tanks are made from reinforced concrete. The construction of reinforced concrete tanks is recommended for systems requiring a large storage capacity even through their construciton is expensive. Skilled labor is required,

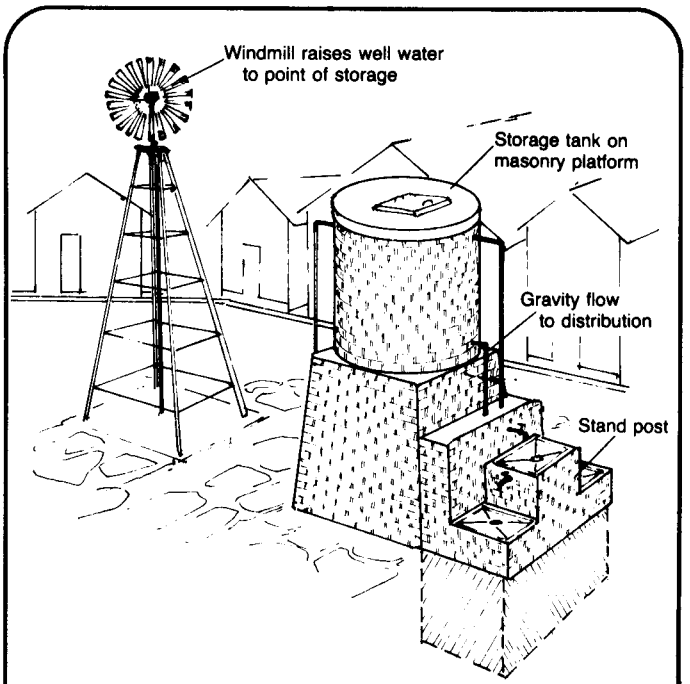


Figure 7. Storage and Distribution in Community

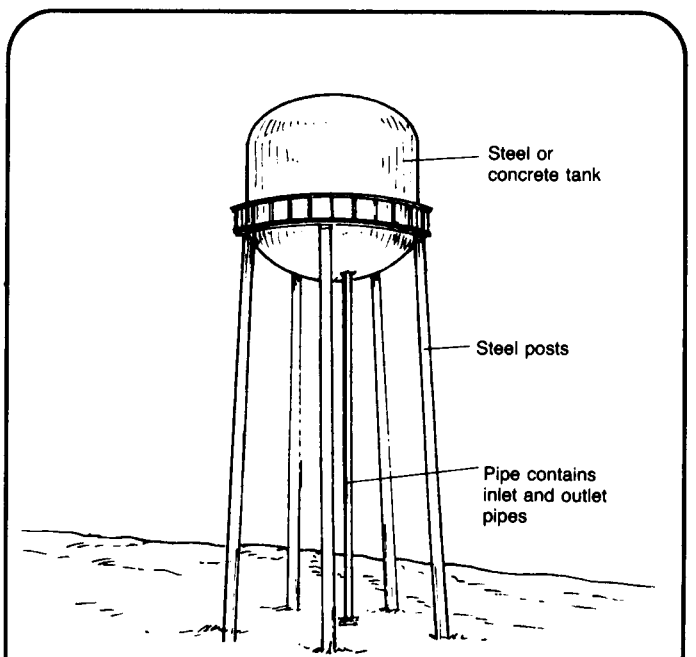
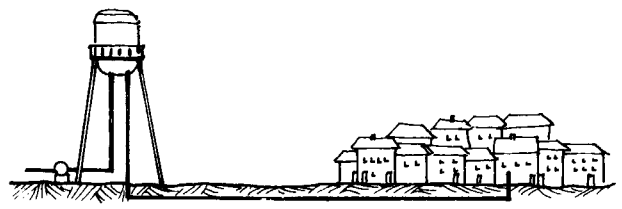
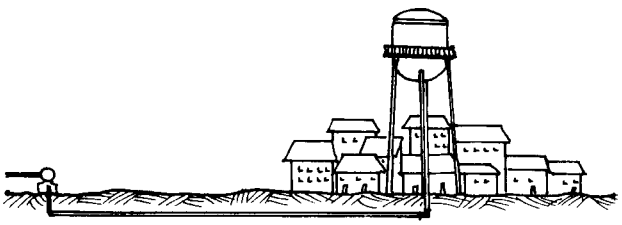


Figure 8. Typical Manufactured Elevated Storage Tank



a. Tank Near Water Supply



b. Tank Near Distribution Point

Figure 9. Locating Elevated Storage Tank

and supervision by an engineer is necessary. When a number of tanks are to be built in several villages in a region, forms and equipment can be reused and workers become skilled. Employment possibilities are created and money will probably be spent on nationally produced cement and other materials available locally. In many countries, steel tanks would have to be imported. Under these circumstances, the contruction of reinforced concrete tanks is more economical. The design of an elevated storage facility should be done by an engineer to ensure that strength of the structure.

Summary

Household cisterns and storage jars may be used by individual families to store water collected from roofs. Water stored in cisterns can be used as the principal source of water or as the secondary source if the primary one disappears during the dry season. The choice of household storage design depends on the needs of each individual family and on the materials, skills and economic resources available to each.

For community systems, large storage facilities are needed. The two principal types of storage tanks are ground level and elevated storage tanks. The choice between the two depends on local topographical conditions. Storage in ground level tanks should be the first choice if a site of sufficient elevation is available. For ground level reservoirs, the initial costs are lower, construction is less difficult and maintenance is easier. Where no suitable high land is available, elevated storage must be used. All water system normally need some type of storage capacity to ensure that there is always a sufficient quantity of water available to the users.