Design of Rural Water Supply Schemes
For Engineering Assistants

Training Module No: NWSDB/RWS/TR/04

NATIONAL WATER SUPPLY AND DRAINAGE BOARD

Prepared by Third ADB Assisted Water Supply & Sanitation sector Project
December 2008
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Day 1

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<th>Time</th>
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<tr>
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<td>11.00</td>
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<td>11.15 am</td>
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<td>1.00</td>
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<td>3.15</td>
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Water Sources

Day 2

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<td>10.00</td>
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<td>Session 3</td>
</tr>
<tr>
<td>11.00</td>
<td>Tea Break</td>
</tr>
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<td>11.15 am</td>
<td>Continuation of Session 3</td>
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<tr>
<td>12.45</td>
<td>Lunch Break</td>
</tr>
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<td>1.45</td>
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<td>3.45</td>
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## Water Treatment

### Day 3

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<td>10.45 am - 12.45 pm</td>
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<td>12.45 - 1.45 pm</td>
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<td>1.45 - 3.15 pm</td>
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<td>3.15 - 3.30 pm</td>
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<td>3.30 - 5.00 pm</td>
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### Day 4

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<td>Continuation of Session 4</td>
</tr>
<tr>
<td>10.00 - 10.15 am</td>
<td>Tea Break</td>
</tr>
<tr>
<td>10.15 - 11.15 am</td>
<td>Session 5</td>
</tr>
<tr>
<td>11.15 am - 12.45 pm</td>
<td>Continuation of Session 5</td>
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<tr>
<td>12.45 - 1.45 pm</td>
<td>Lunch Break</td>
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<td>1.45 - 2.15 pm</td>
<td>Continuation of Session 5</td>
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<td>2.15 - 3.15 pm</td>
<td>Discussion at the end of the session</td>
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### Introduction
Providing safe drinking water for the entire population in the country has become a challenging task of the Governments and all Sector Institutions.

The Government of Sri Lanka is already in the process of implementing several water supply programmes in order to achieve this challenging task. It is expected to cover the entire nation with provision for drinking water by year 2010.

Under this background, assisting and guiding to all sector institutions in the country has been identified as a key responsibility of the Government.

In this context the Third Water Supply & Sanitation (Sector) project implemented by the National Water Supply & Drainage Board is recognized as a major programme among several other water supply programmes. This project is funded by the Asian Development Bank and implemented in rural areas of 6 districts in Sri Lanka to provide water supply and sanitation facilities for rural population.

In most rural communities in Sri Lanka, the prevailing water supply conditions are very different from urban installations. Usually the number of people to be served by such a water supply scheme is small and the low population density makes piped distribution of the water costly. On the other hand, rural population often is very poor and, particularly in subsistence farming communities little money can be raised. Thus, in providing water supply systems to rural communities, factors such as organization, administration, community involvement and finance are properly blended in order to achieve an economical water supply system. However, the selection of suitable technology remains important since the other problems are compounded when techniques, methods and equipment are used that are not compatible with the conditions and situations of rural communities. Therefore this training module has been designed to provide a broad introduction into the technology of rural community water supplies. It provides information and guidance that should be most readily used by those having some
technical background in Civil Engineering, but with no formal training experience in water supply. Some theoretical explanations have been included but such material has been kept to a minimum.

Providing water and Sanitation for villages & small towns are carried out in three basic stages, designing, construction and operation & maintenance with the active participation of beneficiaries, partner organizations & community based organizations under this programme. Therefore by developing this module it is intended to improve knowledge & capability of the Engineering Assistants attached to the Rural Water Supply Section of National Water Supply & Drainage Board on Rural Water Supply Technology.

OBJECTIVES

The Main Objective of this training module is to impart a good knowledge and understanding to the Engineering Assistants of the Rural Water Supply Section of National Water Supply & Drainage Board on following subject areas

(1) Selection of intakes and water sources in designing rural water supply schemes.

(2) Water quality and its standards and how the standards apply to in designing of rural water supply schemes.

(3) Designing of treatment units.

(4) Different economical treatment layouts suitable for rural water supply schemes.

(5) Designing of Transmission & Distribution water lines.
SESSION 1

WATER SOURCES

Objective: 1. To make the participants aware of types of surface water sources & ground water sources.

2. To explain their identification, selection for water supply purposes and protection.

Duration: 4 ½ hrs

Handouts: Handout 1

Activities: 1. Ask the participants to name the types of surface water sources and types of wells, and list them out.

2. Explain how the sources are identified, selected for water supply purposes and protected from contamination, with the help of handout 1.
The first step in designing a water supply system is to select a suitable source or a combination of sources of water. The source must be capable of supplying enough water for the rural community. If not, another resource or perhaps several sources will be required.

1.1 Water Source Selection

The process of choosing the most suitable source of water for development into a public water supply largely depends on the local conditions.

- **Ground water as a source**

Generally for rural communities in Sri Lanka the best option is exploring ground water resources. For rural water supplies simple prospecting methods will usually be adequate, whereas larger supplies, more extensive geo-hydrological investigations using special methods and techniques are likely to be needed.

Dug wells can be appropriate for reaching ground water at medium depth.

Tube wells are generally most suitable for drawing water from deeper water-bearing ground strata. Dug wells often are within the local construction capabilities, whereas the drilling of tube wells will require more sophisticated equipment and considerable expertise. In some cases, drilling may be the only option available.
• **Surface water as a source**

If ground water is not available, or where the costs of digging a well or drilling a tube well would too high, it will be necessary to consider surface water from sources. Such as rivers, streams or lakes. Surface water will almost always require some treatment to render it safe for human consumption and use. The costs and difficulties associated with the treatment of water, particular the day to day problems of operation and maintenance of water treatment plants, need to be carefully considered.

• **Rain water as a source**

Where the rainfall pattern permits rainwater harvesting, and storage during dry periods can be provided. Thus *rainwater harvesting* may serve well for household and small-scale rural community supplies. However this source should be considered where rainfall is heavy in storms of considerable intensity, with intervals during which there is practically no or very little rainfall.
SESSION 2

WATER QUALITY

Objective:
1. To Introduce Physical, Chemical & Biological parameters used in water quality assessment and their effects on water users and analysis.
2. Comparison of surface water quality and ground water quality in accordance with the standards.

Duration: 2 hrs

Handouts: Handout 2

Activities: Discuss the parameters used to measure water quality, their effects on users, their standard values and surface and ground water quality, using handout 2.
An examination of water quality is has basically a determination of the organisms, and the mineral and organic compounds contained in the water.

The basic requirements for drinking water are that it should be:

a. Free from disease causing (Pathogenic) organisms
b. Fairly clear (low turbidity, little colour)
c. Containing no compounds that cause an offensive taste or smell
d. Containing no compounds that have an adverse effect acute or in the long term, on human health
e. Not of causing corrosion on encrustation of the water supply system, nor straining clothes others washed in it

The results of the studies and research on drinking water quality are laid down in practical guidelines which usually take the form of a table giving number of selected water quality parameters, the highest desirable level and the maximum permissible level. Such values should not be taken as absolute standards but as indicative only.

The most important parameter of drinking water quality is the bacteriological quality, i.e. the content of bacteria and viruses. It is not practicable to test the water for all organisms that it might possibly contain.

Therefore water is examined for a specific type of bacteria which originates in large numbers from human and animal excreta and whose presence in water is indicative of faecal contamination. Suitable indicator bacteria of faecal contamination are those coliforms known as E-Coli and faecal streptococci. Either one or both of these coliforms may be used as indicator organisms.
In almost all small rural water supply systems faecal bacteria are likely to be found. The following bacteriological quality criteria are generally applicable for small drinking water supplies.

- Coliform - Less than 10 per 100ml
- E-Coli - Less than 2.5 ml per 100ml

In reality there are cases where the water from rural community water supply is bacteriologically acceptable, yet unfit as drinking water due to excessive organic or mineral contents. The main problems are caused by Iron, Manganese, fluoride, nitrate, turbidity and colour. Following table gives guidelines for a number of these and other water quality parameters.

<table>
<thead>
<tr>
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<th>Measured as (units)</th>
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</thead>
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<td>Turbidity</td>
<td>FTH</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Colour</td>
<td>mg Pt/l</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Iron</td>
<td>mg Fe²⁺/l</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Manganese</td>
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<td>0.05</td>
<td>0.5</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>mg/l</td>
<td>500</td>
<td>2000</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mg NO₃⁻/l</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Nitrite</td>
<td>mg N/l</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sulphate</td>
<td>mg SO₄²⁻/l</td>
<td>200</td>
<td>400</td>
</tr>
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<td>mg F⁻/l</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg Na⁺/l</td>
<td>120</td>
<td>400</td>
</tr>
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<td>0.05</td>
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<td>0.05</td>
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<tr>
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</table>
For small rural water supplies which frequently are to be provided from individual wells where the water quality criteria given above, may have to be relaxed and should always be applied with common sense. When the choice of source and the opportunities for treatment are limited, the criteria should not in themselves be the basis for rejection of a ground water source having some what higher values for iron, manganese, sulphates or nitrates than in table. On the other hand care must be exercised in respect of toxic substances such as heavy metals. In other words, in all instances everything possible should be done to limit hazards of contamination of the water. Using relatively simple measures such as the lining and covering of a well, it should be possible to reduce bacterial content of water (measured as coliform count) to less than 10 per 100 ml, even for water form a shallow well. Persistent failure to achieve this and particularly if E-coil is repeatedly found, should as a general rule lead to condemnation of the supply.
Objective: 1. To make the participants aware of types of surface water sources & Ground Water Sources.

2. To explain how they are identified, selected for Water Supply Purpose and protected.

Duration: 4 ½ hrs

Handouts: Handout 1

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3.1 River water intake

The quality of river water will usually not differ much across the width and depth of the riverbed. The intake, therefore, may be sited at any suitable point where the river water can be withdrawn in sufficient quantity. Generally the design of a river water intake should be such that both clogging and scouring will be avoided. The suitability at the intake structure should be secured, even under flood conditions.

Type of intakes available

(a) Where the river transports no boulders or rolling stones (fig. 3.1)
When designing, the bottom of the intake structure should be at least 1m above the river bed to prevent any boulders or rolling stones from entering. A baffle may be needed to keep out debris and floating matter such as tree trunks at branches.

A river intake always requires a sufficient depth of water in the river bed. A submerged weir across the river may have to be constructed down stream of the intake to ensure that the necessary depth of water will be available, even in dry periods.
Frequently pumping is used for the intake of water from river sources. If the variation between the high and low water level in the river is not more than 3.5m - 4.0m, a suction pump is placed as shown below (fig. 3.3).

3.2 Typical Intake Construction for rural community supply

For small rural community water supplies system, the quantity of water needed being small, often very simple intake structures can be used. With a per capita water use of 30 litres/day and if the peak intake is 4 times the average water demand, 1000 people would require an intake capacity of only 1.4l/sec. A 150mm intake pipe would be sufficient to keep the entrance velocity of flow below 0.1 m/s. If an entrance we can reduce the flow velocity up to 0.5 m/s, a pipe diameter of 60mm is adequate for small capacity intakes, simple arrangements using flexible pipe can be used as shown below. (Fig. 3.4)
Objective: 1. To explain the participants designing of intakes.

2. To broaden the participants knowledge on selection, installation and operation & maintenance of pumps.

Duration: 4 1/2 hrs

Handouts: Handout 3, 4 & 5

Activities: 1. Explain the participants how to design intakes for various water sources discussed in session 1, with the help of handout 3 & 4.

2. Discuss with them types of pumps used in water supply and their selection, installation and operation & maintenance, with the use of handout 5.
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Type of intakes available

(b) Where the river transports no boulders or rolling stones (fig. 3.1)
(b) Where protection of intake is necessary (fig. 3.2)

When designing, the bottom of the intake structure should be at least 1m above the river bed to prevent any boulders or rolling stones from entering. A baffle may be needed to keep out debris and floating matter such as tree trunks at branches.

A river intake always requires a sufficient depth of water in the river bed. A submerged weir across the river may have to be constructed down stream of the intake to ensure that the necessary depth of water will be available, even in dry periods.
Frequently pumping is used for the intake of water from river sources. If the variation between the high and low water level in the river is not more than 3.5m - 4.0m, a suction pump is placed as shown below (fig. 3.3)

4.2 Typical Intake Construction for rural community supply

For small rural community water supplies system, the quantity of water needed being small, often very simple intake structures can be used. With a per capita water use of 30 litres/day and if the peak intake is 4 times the average water demand, 1000 people would require an intake capacity of only 1.4l/sec. A 150mm intake pipe would be sufficient to keep the entrance velocity of flow below 0.1 m/s. If an entrance we can reduce the flow velocity up to 0.5 m/s, a pipe diameter of 60mm is adequate for small capacity intakes, simple arrangements using flexible pipe can be used as shown below. (Fig. 3.4)
Screening of water is done by passing the water through closely spaced bars, gratings or perforated plates. Screening does not change the chemical or bacteriological quality of water. It serves to retain coarse material and suspended matter larger than screen openings. Even when screened out material forms a filtering mat deposits, the screening still is purely of mechanical nature.

Screens are used for various purposes such as;

a. Removal of floating and suspended matter of large size which otherwise might clog pipe lines damage pumps and other mechanical equipments or interfere with satisfactory operation of the treatment processes. Generally fixed screens are used for this purpose and they are cleaned on site by hand or mechanically.

b. Removal of suspended matter even of small size, to lighten the load on the subsequent treatment processes.

In particular they are used to prevent filters from becoming clogged to rapidly.

Bar screens usually consist of steel strips or bars spaced at 0.5 to 5m. If the amount of material expected to be screened out is small the bars are set quite steeply, at an angle 60°-75° to the horizontal, and cleaning is done by hand using rakes. If larger amounts will be retained, the cleaning by hand should still be feasible, to facilitate cleaning work, the bars should be place at an angle of 30°-45° to the horizontal. (fig. 4.1)
SESSION 4

WATER TREATMENT

Objective: 1. To explain the participants designing, operation & maintenance of the components of a water treatment plant.

2. To describe low cost water treatment options for rural water supply schemes.

Duration: 8 1/2 hrs

Handouts: Handout 6,7, 8,9,10, & 11

Activities: 1. Discuss with the participants components of a water treatment plant and explain their designing, operation & maintenance with the use of handout 6,7,8,9 & 10.

2. Describe low cost water treatment options for rural water supply schemes with the help of handout 11.
For smaller communities, manpower is the most readily available power for pumping water, particularly in rural areas. However if the necessary fuel or electricity supplies are available and secured, together with adequate maintenance and spare parts, centrifugal pumps can also accommodated to pump water.

In addition to man power and electricity /diesel driven pumps. We can use wind power or animal power to pump water to the community.

5.1 Power sources for pumping

a. A Manual pumping device (Hand pump) is any simple device powered by human power. They are capable of lifting relatively small amounts of water. Using human power for pumping water has certain features that are important under the conditions of small and rural communities.

(i) The capital cost of manually operated pump is generally low
(ii) the discharge capacity of one or more manual pumping devices is usually adequate to meet the domestic water requirements of a rural small community.
(iii) The power requirements can be met form within the user group

b. Electric Motors of Diesel Engines

Electric motors generally need less maintenance and more reliable than diesel engines. They are therefore, to be preferred as a source of power for pumping if a reliable electricity supply is available. In such cases electric motors can be used to drive pumps.
On the other hand, Diesel engines have the important advantage that they can operate independently at remote sites. The principle requirement is a supply of gasoil and lubricants and these, once obtained, can be easily transported to almost any place. Diesel engines, because of their capability to run independent of electrical power supplies, are especially suitable for driving isolated pumping units such as raw water intake pumps.

Main applications of pumps in small rural community water supply system

- Pumping water from wells
- Pumping water from surface water intakes
- Pumping water into storage reservoirs

5.2 Principle behind the selection of a pump driven by a electric motor or a diesel engine

When selecting a pump we must see whether the pump has the capacity to elevate water to the desired level in the desired optimum efficiency range.
As shown in fig (5.1) it is obvious that without a pump, it is impossible to elevate water from elevation A to Elevation B, so a pump is needed to elevate water from elevation A to elevation B and the energy to be generated is said to be $H_s$ meters for a unit weight of water. However this amount of energy is not sufficient to reach unit weight of water to the elevation B since percentage of energy given being taken to avoid friction along the pipelines. Therefore further energy is to be added in order to avoid friction along the pipeline.

If 
- $l$ - length of pipe line
- $v$- Velocity alone the pipe line
- $d$- Diameter of the pipe line
- $\lambda$ - A constant (usually we take as 0.04)
- $g$- acceleration due to gravity (usually we take as 9.81m/s$^2$)

Energy to be supplied by the pump due to friction is given by the following formula

$$\Delta H=H_f = \lambda \left( \frac{l}{d} \right) \frac{v^2}{2g}$$

Now, the total energy to be generated by the pump is $(H_s+H_f)$. In this context, if we draw the curve $(H_s + H_f) vs$ Discharge, $Q$ on graph paper following curve could be expected and this curve is referred to as the system head curve. (see fig.5.2)

However, pump has its own characteristic head development against the discharge and when the characteristic head that can be developed by the pump is plotted against discharge. Characteristic curve could be plotted as shown in fig. 5.2.

Pt A is referred as the operating pt and the next task is to check whether this point lies near the optimum efficiency or selected efficiency range. For this purpose, as shown in fig (5.2) the operating point A is checked, whether it lies on the selected range of the efficiency curve.
Hence, power of the pump "P" could be calculated.

\[ P = \left( \frac{Q_0H_0}{\theta} \right) \text{ Watts} \]
Objective: To explain the participants designing of transmission & distribution pipe lines.

Duration: 3 hrs

Handouts: Handout 12 & 13

Activities:
1. Explain the participants how to design a water transmission line with the use of handout 12.
2. Explain the participants how to design a water distribution network with the use of handout 13.
Objective: 1. To make the participants aware of types of surface water sources & Ground Water Sources.

2. To explain how they are identified, selected for Water Supply Purpose and protected.

Duration: 4 ½ hrs

Handouts: Handout 1

Activities: 1. Ask the participants to name the types of surface water sources types of wells and list the out.

2. Explain how the sources are identified, selected for water supply purposes and protected from contamination.
The purpose of water treatment is to convert the water taken from a ground or surface source the “raw water”, into a drinking water suitable for domestic use. Most important is the removal of pathogenic organisms and toxic substances such as heavy metals causing health hazards. Other substances may also need to be removed or at least considerably reduced. These include suspended matter causing turbidity, iron and manganese compounds imparting a bitter taste or staining laundry, and excessive carbon dioxide corroding concrete and metal parts, on the other hand in view of a rural small community water supply scheme, other water quality characteristics such as hardness, total dissolved solids and organic content would generally be less important. They should be reduced to acceptable levels but the extent to which the water is treated will be limited to economic and technical considerations.

6.1 Ground water quality and treatment

For most part, ground water originals from infiltrated rain water which after reaching the aquifer flows through the under ground. During infiltration, the water will pick up many impurities such as inorganic and organic soil particles, debris from plant and animal life, microorganisms, natural or man made fertilizers, pesticides, etc. During its flow under ground, however, a great improvement in water quality will occur. Ground water if properly withdrawn, will be free from turbidity and pathogenic organisms. When it originates from a clean sand aquifer, other hazardous or objectionable substances will also be absent. In these cases, a direct use of the water as drinking water may be permitted without any treatment. When the water comes from aquifer containing organic matter, oxygen will have been consumed and the carbon dioxide content of water is likely to be high. In cases where the amount of organic matter in the aquifer is high, the oxygen content maybe completely depleted. The water containing no oxygen (anaerobic water) will dissolve iron, manganese and heavy metals from the underground. Thorough treatment (for eg: Using Aerator) these substances can be removed.
6.2 Surface water quality and treatment

Surface water can be taken from streams, rivers, lakes or irrigation channels. Water in such surface sources originates partly from ground water outflows and partly from rainwater that has flowed over the ground to the receiving bodies of surface water. The ground water out flows will bring dissolved solids into the surface water. The surface runoff is the main contributor of turbidity and organic matter, as well as pathogenic organisms. In the surface water bodies, the dissolved mineral particles will remain unchanged but the organic impurities are degraded through chemical and micro bial processed. Sedimentation in impounded or slow flowing surface water results in removal of suspended solids. Pathogenic organisms will die off due to lack of food. Generally clear water from rivers, and lakes might require no treatment to make it suitable for drinking water. However taking into account the incidental contamination, Chlorination, as a safety measure should be provided when ever feasible.

Unpolluted surface water of low turbidity may be purified by slow sand filtration as a single treatment process, or rapid sand filtration followed by Chlorination only. Particularly in Rural Water Supply schemes slow sand filters have the great advantage since the local workmen can build them with locally available materials and without much expert supervision.
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Unpolluted surface water of low turbidity may be purified by slow sand filtration as a single treatment process, or rapid sand filtration followed by Chlorination only. Particularly in Rural Water Supply schemes slow sand filters have the great advantage since the local workmen can build them with locally available materials and without much expert supervision.
Aeration is the treatment process where by water is brought into intimate contact with air for the purpose of

(a) Increasing the oxygen content
(b) Reducing the carbon dioxide and
(c) Removing Hydrogen sulfide, methane and various volatile organic compounds responsible for taste and odour

Generally treatment results mentioned under (a) & (c) are always useful in the production of good drinking water.

Aeration is widely used for the treatment of ground water having too high an iron and manganese content. These substances impart a bitter taste to the water, discolor rice cooked in it and give brownish-black stains to clothes washed. The atmospheric oxygen brought into the water through aeration will react with the dissolved ferrous and Manganese compounds changing them into insoluble ferric and manganic oxide hydrates. These can be removed by filtration for the treatment of surface water, aeration would only be useful when the water has a high content of organic matter.

Aeration can be obtained in a number of ways for drinking water treatment it is mostly achieved by

(a) Dispersing the water through the air in thin sheets or fine droplets
   or
(b) by mixing the water with dispersed air

In view of rural water supply scheme a multiple tray aerator or a spray aerator could be used since it provides a simple and inexpensive arrangement and it occupies little space. Fig 7.1 shows a multiple tray aerator.
When designing a multiple tray aerator system following factors are considered

(a) No. of trays to be used
(b) Perforated bottom intervals
(c) Rate of water passing from the tray surface

Generally this type of aerator consists of 4-8 trays with perforated bottoms at intervals of 30-50 cm. Through perforated pipes the water is divided evenly over the upper tray, from where it trickles down at a rate of about 0.02m$^3$/sec/m$^2$ of tray surface. The
Spray Aerator

Spray aerators consist of stationary nozzles, connected to a distribution grid through which the water is sprayed into the surrounding air, at velocities of 5-7 m/s.

A very simple spray aerator is shown in fig 7.2, which the water discharging downwards through short pieces of pipe, of some 25cm length and with a diameter of 15-30 mm. A circular disk is placed a few centimeters below the end of each pipe, so that thin circular films of water are formed which further disperse into a fine spray of water droplets.
The main purpose of slow sand filtration is the removal of pathogenic organisms from the raw water, in particular the bacteria and viruses responsible for water-related diseases. Slow sand filters are also very effective in removing suspended matter from the raw water. However, the clogging of the filter bed may be too rapid necessitating frequent cleanings.

Slow sand filters have many advantages for use in rural communities. They produce clear water, free from suspended impurities and hygienically safe. They can be built with local materials using local skills and labour. Much of the complex mechanical and electrical equipment required for most other water treatment process can be avoided. Slow sand filters occupy more land and cleaning calls for ample labour, however in view of rural communities, these requirements generally should be no drawbacks.

8.2 Theory of slow sand filtration

In slow sand filters, the removal of impurities from the raw water is brought about by a combination of different processes such as sedimentation, adsorption, straining and, most importantly, bio-chemical and microbial actions. The purification processes start in the supernatant water but the major part of removal of impurities from the water and the microbial and bio chemical processes take place in the top layer of the filter bed (Schmitz decke-the filter skin or layer of deposited material that forms on top of a sand filter.)

Straining removes those suspended particles that are too large to pass through the pores of the filter bed. It takes place almost exclusively at the surface of the filter where the impurities are straining efficiency but it also increases the resistance against the downward water flow. Periodically the accumulated impurities have to be removed by scraping off the top layer. In this way the operating head of the filter bed is brought back to original value.
8.3 Principle of operation

Basically a slow sand filter consists of a tank, open at the top and containing the bed of sand. The depth of the tank is about 3 m and the area can vary from a few tens to several hundreds of square meters. At the bottom of the tank an under drain system (the “filter bottom”) is placed to support the filter bed. The bed is composed of fine sand, usually ungraded, free from clay and loam, and with as little as possible organic matter in it.

The filter bed normally is (1.0-1.2) m thick and the water to be treated (the “supernatant water”) stands to a depth of 1.0-1.5 m above the filter bed.

Generally, the slow sand filter is provided with a number of influent and effluent lines fitted with valves and control devices. These have the function of keeping both raw water level and the filtration rate constant.

8.4 Design considerations

For the actual design of a slow sand filter four dimensions have to be chosen in advance

a. the depth the filter bed
b. The grain size distribution of the filter material
c. The rate of filtration
d. The depth of supernatant water

As far as possible, these design factors should be based on experience obtained with existing treatment plants which use the same water source of water of comparable nature.

Following procedure could be suggested in order to design a slow sand filter which is capable to a rural water supply scheme
(a) For the initial design, the bed thickness is chosen at 1.0-1.2m. This is sufficient to allow for the necessary filter bed scrapings before the maximum thickness of 0.7m is reached.

(b) Analyse the grain size distribution of locally available sand and determine the effective size and coefficient of uniformity. (see fig 8.2)

Select sand with an effective size of about 0.2. When such sand is not available a coefficient of uniformity up to 5 may be accepted, and an effective size of the sand ranging from 0.15 to 0.35mm. Alternatively burnt rice husks of 0.3 to 1.0mm size are used.

(c) For the initial design fix the depth of supernatant water at between 1.0 m and 1.5 m
(d) Provide at least 2 and preferably 3 filter units. The combined surface area should be so large that with one filter out of operation for cleaning, the filtration rate in the operating units will not exceed 0.2m/hr.

(e) Provide space for additional filter units

(f) As soon as operations start, carefully note the length of the filter urns. An average filter run of about 2 months is most appropriate. When filter runs prove to be much longer, filtration rates can be raised allowing a greater plant output. If filter runs are shorter than expected, additional units will have to be constructed at an earlier date than was anticipated.

In slow sand filters water pressure under/below atmospheric (under-pressure) must be avoided under all circumstances as this might give serious problems. Air bubbles would form and accumulate in the filter bed increasing. The resistance against filtration flow. Air bubbles of large size may even break up the filter bed and create fissures through which the water would pass without adequate purification. The minimum allowable head loss over the filter bed at the minimum filtration rate. In order to make the occurrence of under-pressure completely impossible, and overflow weir way be provided in the effluent line. The difference in level between the supernatant water and overflow weir should not exceeded the maximum allowable head loss plus the head losses in the effluent piping, again for the minimum rate of filtration.

8.5 Construction

As regards the construction of a slow sand filter, various elements may be distinguished the most important being the filter tank, the filter bottom, the filter bed, the supernatant water and the influent and effluent lines. Attention should also be given to the layout of the slow sand filtration plant as a whole.
A very simple slow sand filter which suites to a rural water supply scheme, which is constructed in ground is shown in fig (8.3)

8.6 Cleaning

The time proven method of cleaning a slow sand filter is by scraping off the sand surface with hand shovels to remove the top layer of dirty sand over a depth of 1.5-2.0 cm. The scraped off mixture of sand and impurities is piled in ridges of the filter using barrows or hand-carts wheeled over wooden planks. It may also be taken out of the filter with the help of baskets hosted up with rope and tackle.

The penetration of the impurities in the filter bed is largely contained to the upper layer. Scraping away the top layer removes the major part of the clogging but some will remains the deeper layer of the filter bed. These deposits accumulate little by little and also penetrate gradually deeper into the filter bed. This could cause problems if the sand remains place for a long time. When after many scrapings the minimum filter bed thickness is reduced, it is therefore necessary to remove an additional 0.3m of the filter sand before the new sand is brought in. The removed sand layer contains all the organisms necessary for the proper biochemical functioning of the slow sand filter and should be placed on top of the new sand in order to promote the ripening process. (See fig 8.4)
9.1 Introduction

For rapid filtration, sand is commonly used as the filter medium but the process is quite different from slow sand filtration. This is so because much courser sand is used with an effective grain size in the range 0.4-1.2 mm, and the filtration rate is much higher, generally between 5-15 m$^3$/m$^3$/hr. Due to the course sound used, the process of the filter bed will be relatively large and the impurities contained in the raw water will penetrate deep into the filter bed. Thus the capacity of the filter bed to store deposited impurities is much more effectively utilized and even very turbid river water can be treated with rapid filtration. For cleaning a rapid filter bed, it is not sufficient to scrape off the top layer. Cleaning of rapid filters is effected by back washing. This is directing a high rate flow of water back through the filter bed where by it expands and is scoured. The back wash water carries the deposited cloggings out of the filter. The cleaning of a rapid filter can be carried out quickly, it need not take more than about half an hour. It can be done as frequently as required, if necessary each day.

In the treatment of groundwater, rapid filtration is used for the removal of iron and manganese. To assist the filtration process, aeration is frequently provided as a pretreatment to form insoluble compounds of iron & manganese.

However, because of their complex design and construction, and the need for expert operation rapid filters are not very well suited for application in rural community water supply scheme.

9.2 Roughing Filtration

Some time a more limited treatment than rapid filtration using a sand beds, can be adequate for treating the raw water. This can be obtained by using gravel or plant fibers as filter material. Roughing filter have large pores that are not liable to clog rapidly. A high rate of filtration up to 20 m/hr, may be used.
The large pores also allow cleaning at relatively low back-wash rates since no expansion of the filter bed is needed. The back washing of roughing filters takes a relatively long time, about 20-30 minutes.

Another possibility is the use of horizontal filter as shown in fig (9.1)

These have a depth of 1-2m subdivided into three zones, each about 5m long and composed of gravel with sizes of 20-30mm, 15-20mm, and 10-15mm. The horizontal water flow rate computed over the full depth will be 0.5-1.0 m/hr. A large area will be required, but the advantage is that clogging of the filter will take place very slowly, so that cleaning will be needed only after a period of years. This cleaning is carried out by excavating and washing the filter material after which it is put back in place.

On the other hand coconut fiber can be suggested to use as an alternative for using sand. In such a situation, filter bed is only 0.3-0.5m thick and the depth of the supernatant water is about 1m. The filter is operated at rates of 0.5-1.0m/hr which gives a length of filter run of several weeks. To clean the filter it is first drained after run of several weeks. To clean the filter it is first drained after which the coconut fibers are taken out and discarded. The filter is repacked with new material that has previously been soaked in water for 24 hours to remove as much organic matter as possible. Coconut fiber filters appear to be able to cope with considerable fluctuations in their loading while producing an effluent of almost constant quality. Using such filters overall turbidity removal can be expected between 60-80 percent.
10.1 Introduction

The single most important requirement of drinking water is that it should be free from any microorganisms that could transmit disease or illness to the consumer. Processes such as storage, filtration reduces to varying degrees the bacterial content of water. However these processes can not assure that the water they produce is bacteriological safe. Final disinfections will frequently be needed. In cases where no other methods of treatment are available, disinfections may be resorted to as a single treatment against bacterial contamination of drinking water.

Ground water obtained from shallow dug wells contains to be the major source of supply for rural communities. Most of surveys have revealed that dug wells become quite frequently contaminated. Surface water source such as pounds, canals and rivers are usually also polluted. While it is neither feasible nor always necessary to establish complete treatment of the water from these sources, proper disinfections should at least be provided in order to protect public health.

10.2 Chlorination technology for rural water supply

Disinfections by chlorination can give a satisfactory solution for rural & small community water supplies. Disinfections by gaseous chlorine is generally not feasible for small water supplies, due to the problems of applying small quantities of gas accurately and on a continuous basis. The choice is likely to fall on chlorine compounds.

(a) Bleaching Powder

Chlorinated lime or bleaching powder is a readily available and cheap chlorine compound. This chemical is easy to transport and not dangerous to handle and it is supplied in a suitable container. It is a free flowing white or yellowish powder containing about to 37 percent available chlorine. It is unstable and will lose chlorine
during storage. In the presence of moisture, bleaching powder becomes corrosive, it is necessary to use corrosion resistant containers made of wood, ceramic or plastic. These should be stored in a dark, cool and dry place. In order to minimize the loss of Chlorine a maximum percent of concentration is recommended for bleaching powder solution.

(b) Disinfections of open Dug wells

As open dug well will continue to be used in considerable numbers of sources of drinking water in rural communities, it is desirable to employ simple method for disinfecting the water of these wells.

(c) Pot Chlorination

An earthen pot of 7 to 10 liters capacity with 6 to 8 mm diameter holes at the bottom is half filled with pebbles and pea gravel of 20 mm size. Bleaching powder and sand (in a 1 to 2 mixture) is placed on top of the pea gravel and then pot is further filled with pebbles up to the neck (fig.10.1). The pot is then lowered into the well.

For a well from which water is taken at a rate of 1000-1200 l/day, a pot containing 1.5kg of bleaching powder should provide adequate chlorination for about one week.
Double pot system

When a single chlorination pot is used in a small house-hold well, it may be found to give too high a chlorine content to the water (i.e. over chlorination). In such situations, a unit consisting of two cylindrical pots one inside the other has been found to work well. (fig. 10.2)

The inner pot is filled with a moistened mixture of 1 kg of bleaching powder with 2 kg of course sand to a little below the level of the hole and is then place inside the outer pot. The mouth of outer pot is tried with a polythene sheet and the unit lowered into the well with the help of rope. Such a unit can be work effectively for 2-3 weeks in household wells of 4500 liters capacity from which water is withdrawn at a rate of 400-450l/day.
Proportioning Devices for pumped Supplies

When water from the source is pumped to an elevated service reservoir and supplied by gravity to the distribution system, a bleaching powder solution may be dosed as shown in fig 10.3.

From the bleaching powder solution prepared earlier and allowed to settle to impurities, is filled in the solution container. It should provide a supply sufficient for more than one-day air entry at the suction side of the pump must be prevented. It is necessary to close the solution feed line when the pump is stopped.
Surface water treatment

11.1 **Source:** Stream, river, lake, irrigation channel

**Water quality:** Slightly polluted, Medium turbidity

Surface water with medium turbidity should initially lowered to a desired value by using a rapid sand filter. (fig. 11.1). Typical layout is as shown in fig 11.2. With refer to this layout diagram, water treated from the rapid filter will then allowed to pass through sand filters, where turbidity can be reached to the desired standards. On the other hand, destruction of pathogens takes place while water passing through sand filters.
Treated water will then allowed to collect to a clear well under gravity. In order to distribute water to the consumers, filtered water pumps could be accommodated and using such pumps water can be pumped to a service reservoir and/or to consumers directly. Suppose if a service reservoir is used water can be delivered to higher elevations without any difficulty.

If the intake is located at a higher elevation compared with the distribution network, the above mentioned layout could be used excluding raw water pumps, filtered water pumps and the service reservoir.

If the water quality is slightly polluted with low turbidity, rapid sand filter is not needed. Therefore layout explained under fig. 11.2 could be used without a rapid filter. However, raw water pumps, filtered water pumps and a service reservoir could be selected while considering the elevations of the intake, treatment units (slow sand filter) and consumer end points.

**Ground Water Treatment**

11.2 **Source:** Ground water well (for eg: Dug well)

**Water quality:** Anaerobic, soft, corrosive with Iron and Manganese

Ground water could be extracted using a dug well or a tube well. To lift water a manual pump or an electric pump can be used (fig. 11.3). **If the water is without O₂ (Anaerobic)** it is essential to have a spray aerator to increase the oxygen content in water. Also aerator could be used to remove dissolved CO₂ (Softness). In addition ground water may contain Iron and Manganese. Using an aerator these Irons can be oxidized to form precipitates so that they could collect/trap in filters. If the water contains Iron and Manganese it is possible to have spray aerator followed with a rapid filter. (fig. 11.4)
However for rural water supply schemes, use of rapid filters is rare, because of its complex design & construction, and back washing process. It is uneconomical to use a wash water pump with considerable investment and high operating costs. In such a situation a good solution will be to use an elevated service reservoir for back washing filter. No separate pumps would be needed. A typical layout is shown in fig. (fig.11.5). This layout is ideal for a situation where water quality is anaerobic, soft and corrosive with having Iron and Manganese.

However if the ground water is not heavily contaminated with iron and manganese, rapid filter could be exempted. Also decision should make whether filtered pumps & a supply reservoir are constructed for distribution of water. If the consumer points are located at a considerably lower elevation, filtered water pumps are not required.
12.1 Introduction

Water transmission frequently forms part of a small community water supply scheme, in that they do not differ from large schemes. The water needs to be transported from the source to the treatment plant, if there is one, and onward to the area of distribution. Depending on the topography and local conditions, the water may be conveyed through

a. Free flow conduit (fig. 12.1)
b. Pressure conduits (fig. 12.2)
c. Combination of both (fig. 12.3)
Generally transmission of water will be either under gravity or by pumping.

Free flow conduits must be laid under a uniform slope in order to follow closely the hydraulic grade line.

**Note:** - The slope of the hydraulic grade line is the Hydraulic gradient. For open channels it is the slope of the water surface. For closed conduits under pressure (eg. pipe lines) the hydraulic grade line slopes according to the head loss per unit length of pipe.

Pressure pipelines can be laid up - and down hill as needed, as long as they remain a sufficient distance below the hydraulic grade line.

For rural community water supply purposes, pipe lines are most common means of water transmission but cannels, aqueducts and tunnels are also used. Whether for free flow or under pressure, water transmission conduits generally require a considerable capital investment. A careful consideration of all technical options and their costs is, therefore, necessary when selecting the best solution in a particular case.
Types of water conduits

Canals
Canals generally have a trapezoidal cross section but the rectangular form is more economical when canal traverses solid rock. Flow conditions are more or less uniform when a channel has the same size, slope and surface lining throughout its length.

Open channels have limited application in water supply practice in view of the danger that the water will get contaminated. Open channels are never appropriate for the conveyance of treated water but they may be used for transmission of raw water.

Aqueducts or tunnels
Aqueducts and tunnels should be of such a size that they flow about three quarters full at the design flow rate. Tunnels for free flow water transmission frequently are horseshoe shaped. Such tunnels are constructed to shorten the overall length of a water transmission route, and to circumvent the need for any aqueducts and conduits traversing uneven terrain. To reduce head losses and infiltration seepage, tunnels are usually lined. However, when constructed in stable rock they require no lining.

The velocity of flow in these aqueducts and tunnels ranges between 0.3-0.9m/s for unlined conduits and up to 2m/s for lined conduits.

Free flow pipelines
In free-flow pipe lines, there being no pressure, simple materials may be used. Glazed clay pipes, asbestos cement and concrete should be adequate. Theses pipelines must be closely follow the hydraulic grade line.

Pressure pipelines
Obviously, the routing of pressure pipeline is much less governed by the topography of the area to be traversed, than is the case with canals, aqueducts and free flow pipelines. A pressure pipeline may run up and down hill, there is considerable freedom in selecting the pipeline alignment. A routing along side
roads or public ways is often preferred to facilitate inspection (for detection of any leakage, unoperative valves, damage, etc) and to provide ready access for maintenance and repair.

12.2 Design Considerations

(a) Design Flow

The water demand in a distribution area will fluctuate considerably during a day. Usually a service reservoir is provided to accumulate and even out the water demand fluctuation. The service reservoir is supplied from the transmission main, and is located at a suitable position to be able to supply the distribution system (see fig. 12.4). The transmission main is normally designed for the carrying capacity that is required to supply the water demand on the maximum day at a constant rate basis. All hourly variations in the water demand during the day of maximum consumption, are then assumed to be leveled out by the service reservoir.

The number of hours the transmission main operates per day is another important factor. For a water supply with diesel or electric motor-driven pumps, the daily pumping often limited to 16 or less hours. In such a case the design flow rate for the transmission main needs to be adjusted accordingly.
(b) Design pressure

The design pressure, of course, is only of relevance for pressure pipe lines. Such pipe lines generally follow the topography of the ground quite closely. Follow the topography of the ground quite closely. The hydraulic grade line indicates the water pressure in the pipe line under operating conditions. The hydraulic grade line should lie above the pipe line, over its entire length, and for all rates of flow, in fact nowhere should the operating head of water in the pipe line be less than 4m (fig 12.5).

The pipe material must be selected to withstand the highest pressure that can occur in the pipeline. The maximum pressure frequently does not occur under operating conditions but it is the static pressure when the pipe is shut. In order to limit the maximum pressure in a pipe line and, thus, the cost of the pipes, it can be divided into sections separated by a break-pressure tank. The function of such a break-pressure tank is to limit the static pressure by providing an open water surface at certain places along the pipe line. The flow from the upstream section can be throttled when necessary.
12.3 Hydraulic design

For a given design flow rate (Q) the velocity of flow (V) and consequently the required size of the water transmission conduit may be computed using the following formulae.

(a) Open conduits

The Mannings formula is widely used in the hydraulic design of open conduits with free flow conditions.

\[ V = C R^{\frac{2}{3}} I^{\frac{1}{6}} \]

where: 
- \( V \) = Average velocity of flow in water conduit (m/s)
- \( C \) = Coefficient of roughness of conduit walls and bottom (mm)
- \( R \) = Hydraulic radius (m)
- \( I \) = Hydraulic gradient (m/m)

For design purposes, following table provides indicative values of the coefficient of roughness for various types of linings in clean straight channels.

<table>
<thead>
<tr>
<th>Type of Lining</th>
<th>Coefficient of roughness (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete, trowel finished</td>
<td>80</td>
</tr>
<tr>
<td>Masonry</td>
<td></td>
</tr>
<tr>
<td>• Neat cement plaster</td>
<td>70</td>
</tr>
<tr>
<td>• Brick work, good finish</td>
<td>65</td>
</tr>
<tr>
<td>• Brick work; rough</td>
<td>60</td>
</tr>
<tr>
<td>Excavated</td>
<td></td>
</tr>
<tr>
<td>• Earth</td>
<td>45</td>
</tr>
<tr>
<td>• Gravel</td>
<td>40</td>
</tr>
<tr>
<td>• Rock out, smooth</td>
<td>30</td>
</tr>
<tr>
<td>• Rock out, jagged</td>
<td>25</td>
</tr>
</tbody>
</table>
(b) Pipe lines

The most accurate formula for computing the head loss of water flowing through a pipe line is the Universal formula as shown below

\[ H = \left( \frac{8\lambda}{\pi^2 g} \right) \left( \frac{Q^2 L}{D^5} \right) = (i)L \]

Where

- \( H \) = Head Loss (m)
- \( L \) = Length of pipe line (m)
- \( \lambda \) = Friction coefficient
- \( D \) = Internal pipe diameter (m)
- \( Q \) = Flow rate (m\(^3\)/s)
- \( g \) = Gravitational factor (~9.8 m/s\(^2\))
- \( q \) = Hydraulic gradient (m/m or m/km)

The factor \( \lambda \) is the friction coefficient which is a function of the pipe wall roughness (K), the (kinematics) viscosity of water (\( \nu \)), the flow velocity (V), and the internal pipe diameter (D). However, it can be easily found using tables and monograms prepared for different values of pipe wall roughness.

12.4 Pipe Materials

Pipe lines frequently represent a considerable investment, and selection of the right type of pipe is important. Pipes are available in various materials, sizes, and pressures classes. The most common materials are cast iron (C.I), ductile iron, steel, asbestos cement (A.C), Poly Vinyl Chloride (P.V.C.) and High density polyethylene (P.E).

Apart from these, indigenous materials such as bamboo sometimes have limited application. The suitability of any type of pipe in a given situation is influenced by its availability on the market, cost, available diameters and pressure classes, and susceptibility to corrosion or mechanical damage.
Generally for pipelines of small diameter (less than 150 mm) P.E. and P.V.C may be the best. For medium size pipe lines (diameters upto 300 mm to 400 mm) asbestos cement should be considered. Cast Iron, ductile iron and steel are generally only used for large diameter mains, and also in cases where very high-pressures necessaries their use in small diameter pipes.

Following Table 12.1 lists the comparative characteristics of pipe materials for pipelines.

Table 12.1
Comparison of pipe materials

<table>
<thead>
<tr>
<th>Pipe material</th>
<th>P.V.C &amp; P.E</th>
<th>A.C Unlined</th>
<th>C.I and Unlined</th>
<th>D.I. Cement lined</th>
<th>Steel Unlined</th>
<th>Cement lined</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cost of pipe</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2 Availability of large diameters</td>
<td>-</td>
<td>+-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3 Mechanical strength</td>
<td>+-</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>4 Resistance against bursting when illegally tapped</td>
<td>+</td>
<td>-</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>5 Corrosion resistance</td>
<td>++</td>
<td>+-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

++: Very well suited
+: Well suited
+-: Suitable
-: Less suitable
13.1 Introduction

The water distribution system serves to convey the water drawn from the water source and treated when necessary, to the point where it is delivered to the users. In rural community water supply scheme the distribution system and any provision for water storage (eg. Service reservoir) will kept simple. Even so, it may represent a substantial capital investment and the design must be done properly.

Generally, the distribution system for a rural community water supply is designed to cater for the domestic and other residential water requirements.

Service reservoirs serve to accumulate and store water during the night so that it can be supplied during the day time hours of high water demand.

On the other hand, it is necessary to maintain a sufficient pressure in the distribution system in order to protect it against contamination by the ingress of polluted seepage water. For a rural community water supply scheme minimum pressure of 6m head of water should be adequate in most instances.

13.2 Types of distribution systems

There are basically two main types of distribution system:

1. Branched system (fig. 13.A)
2. Looped network system (fig. 13.B)
In general, branched systems are only used for small/Rural community supplies delivering the water mostly through public stand pipes and having few house connections, if any. For larger distribution systems looped network grids are more common.

Branched systems have the advantage that their design is straightforward. The direction of the water flow in all pipes and the flow rate can be readily determined. This is not so easy in the looped distribution network (or grid). Where each secondary pipe can be fed from two sides.

The number and type of the points (service connections) at which the water is delivered to the users, have considerable influence on the design of a water distribution system.

Types of service connections available are,

(a) House connection
(b) Yard connection and
(c) Public stand pipe

(a) **House connection** is a water service pipe connected with in-house plumbing to one or more taps
(b) **Yard connection** is quite similar to a house connection, the only difference being that the tap(s) are placed in the yard outside the house(s).

Generally plastic pipes (PVC or polyethylene), cost iron and galvanized steel pipes are used for both house connections and yard connections.
(c) **Public stand pipes** have long been in use for the distribution of water, and for reasons of costs and technical feasibility, they will have to continue serving this purpose for a long time to come. Each stand pipe is situated at a suitable point within the community area in order to limit the distance the water users have to go to collect their water.

Capacity of a standpipe normally is about 14-18-l/ minute at each outlet. Public standpipes can have one or more taps (see fig. 12.2)

Single tap and double tap standpipes are the most common types suited for rural areas. They are made of brickwork, masonry, concrete, or use wooden poles and similar materials.
Public standpipes are really the only practical option for water distribution at minimum cost to a large number of people who cannot afford the much higher costs of house or yard connections. The housing in fact, is frequently not suitably constructed to allow the installation of internal plumbing. Furthermore, it would often be impossible for a rural community to obtain the substantial capital for a water distribution system with house connections. Also, the costs of adequate disposal of the considerable amount of wastewater generated by a house-connected water supply service would place an additional heavy financial burden on the rural community. Consequently, public standpipes will have to be provided and the principle concern should be to lessen their inherent shortcomings as much as possible.

### 13.3 Design Considerations

The daily water demand in a community area will vary during the year due to seasonal pattern of the climate, the work situation (e.g., harvest time) and other factors such as cultural or religious occasions. The max daily demand is usually estimated by adding 10 to 30 percent to the average daily demand. Thus peak factor for daily water demand ($K_1$) is taken as 1.1 to 1.3.

The hourly variation in the water demand during the day is frequently much greater. Generally two peak periods can be observed, one in the morning and one in the afternoon (fig. 13-3)
The peak hour demand can be expressed as the average hourly demand multiplied by the hourly peak factor (K2). The hourly peak factor tends to be very high for small rural community, it is usually less for larger communities. Usually K2 is chosen in the 1.5-2.0 range. A water distribution system typically is designed to cater for the maximum hourly demand. This peak hour demand may be computed as

\[ K_1 \times K_2 \times \text{Average hourly demand} \]

### 13.4 Storage reservoir

If there would be no storage of water in the distribution area, the source of supply and the water treatment plant would have to be able to follow all fluctuations at the water demand of the community served. This is generally not economical, and sometimes not even technically feasible.

The design capacities of the various components of a water supply system are usually as shown in fig. 13.4
<table>
<thead>
<tr>
<th>System component</th>
<th>Design capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water source, raw water main water treatment plant</td>
<td>Peak day water demand</td>
</tr>
<tr>
<td>Distribution system</td>
<td>Peak hour water demand</td>
</tr>
</tbody>
</table>

The service reservoir is provided to balance the (constant) supply rate from the source/treatment plant with the fluctuating water demand in the distribution area. The storage volume should be large enough to accommodate the cumulative difference between water supply and demand.

**Example**

For a particular distribution area, the average daily water demand is estimated as 500,000l/day.

\[
Q_{\text{avg}} = 500,000 \text{ l/d}
\]

\[
Q_{\text{peak}} = 1.2 \times 500,000 = 600,000 \text{ l/d}
\]

\[
q_{\text{avg hour on peak day}} = \frac{600,000}{24} = 25,000 \text{ l/d}
\]

\[
q_{\text{peak hour}} = 1.8 \times 25,000 = 45,000 \text{ l/d}
\]

This estimated hourly demand is expressed as a percentage of the total demand over the peak day and plotted in cumulative water demand curve (fig. 13.5)
Constant supply is drawn in the same diagram as a straight line.

The required volume of storage can now be read from the graph.

For a constant –rate supply, 24-hour day, the required storage is represented by A-A' plus B-B' (About 28% of the total peak day demand)

If supply capacity is so high that daily demand can be met with 12 hours pumping a day, the required storage is found to be C-C' plus D-D' (about 22% of the total peak day demand).

The reservoir should be situated as close to the distribution area as possible. It should be situated at a higher elevation than the distribution area. If such a site is available only at some distance, the reservoir should place there fig 13.6 shows two possible arrangements.
In flat areas where no suitable hill sites or other high points for ground reservoirs are available, water towers or elevated tanks have to be used. In principle, such towers or tank should have the same storage volumes as a ground reservoir. However, water towers and elevated tanks have relatively small volumes because they are much more costly construct than a ground reservoir.

Ground reservoirs of some size are normally of reinforced concrete, small ones can be made of mass concrete or brick masonry. Elevated reservoirs are of reinforced concrete or brickwork on concrete columns. Example of a small service reservoir is shown in fig 13.7
13.5 Distribution System design

After establishing the general layout of a distribution system and its main components, the distribution area should be divided into a number of sectors according to topography, land use classification and density of population. Boundaries may be drawn along rivers roads, high points or other features which distinguish each sector. The distribution mains and secondary pipes can then be plotted in the plan.

Once all sectors are fixed, the population number for each sector can be estimated or computed from any data available. The water demand by sector is then computed using per capita water usage figures for domestic water consumption and selected values for the other, non-domestic water requirements. Having determined the draw offs in the nodal points, a flow distribution over the various pipes can be assumed and the required pipe diameters estimated. One may to make the first assumption for the required pipe diameters is to make imaginary sections over the entire distribution network.

The total water demand at the downstream end of the section being known, the selected design velocity of flows gives a first estimate of the total cross sectional area of the pipes that are cut by imaginary section (Fig. 13.8)
The individual pipes can then be so sized that together they would provide the required cross sectional area.

For the preliminary design of simple distribution systems, a quite simple method may be employed using the water consumption rate per linear meter of distribution pipe.

The following example illustrates this simplified design method. (Fig. 13.9)
Design data

Number of persons serve       =  1750
Total length of pipes         =  600m
Average daily water use       =  50l/day/person
Daily water demand peak factor K1 =  1.2
Hourly water demand peak factor K2 =  1.5

Calculation

Average flow of water carried by Q_{Avg} = 1750x50=87500 l/d
Distribution system
                               =  1.0 l/s
Peal flow carried by the system Q_{peak} = 1.2 x 1.5 x 1.0
                               =  1.8l/s
Water use rate per linear meter of distribution system

q_{unit} = 1.8/600=0.003 l/s/m

Multiplying the cumulative length of pipe for each individual section, with the unit flow rate gives the tentative design flow from which the pipe diameter can be computed for a selected velocity of flow. The maximum flow carried by plastic pipes is for a design velocity of 0.75 m/s tabulated in following Table 12.1

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Max. Flow (l/s)</th>
<th>Hydraulic gradient</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0.6</td>
<td>0.023</td>
</tr>
<tr>
<td>40</td>
<td>0.9</td>
<td>0.020</td>
</tr>
<tr>
<td>50</td>
<td>1.5</td>
<td>0.015</td>
</tr>
<tr>
<td>60</td>
<td>2.1</td>
<td>0.011</td>
</tr>
<tr>
<td>80</td>
<td>3.4</td>
<td>0.009</td>
</tr>
<tr>
<td>100</td>
<td>6.0</td>
<td>0.007</td>
</tr>
<tr>
<td>150</td>
<td>13.3</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Table 13.1: Maximum carrying capacity of plastic pipes (for V=0.75m/s)
Tentative determination of pipe size in distribution system

<table>
<thead>
<tr>
<th>Section</th>
<th>Length (m)</th>
<th>Cumulative length (m)</th>
<th>Design flow (l/s)</th>
<th>Pipe diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-C</td>
<td>80</td>
<td>80</td>
<td>0.24</td>
<td>30</td>
</tr>
<tr>
<td>B-C</td>
<td>80</td>
<td>80</td>
<td>0.24</td>
<td>30</td>
</tr>
<tr>
<td>C-F</td>
<td>100</td>
<td>260</td>
<td>0.78</td>
<td>40</td>
</tr>
<tr>
<td>D-E</td>
<td>100</td>
<td>100</td>
<td>0.30</td>
<td>30</td>
</tr>
<tr>
<td>E-F</td>
<td>80</td>
<td>180</td>
<td>0.54</td>
<td>30</td>
</tr>
<tr>
<td>F-C</td>
<td>160</td>
<td>600</td>
<td>1.86</td>
<td>60</td>
</tr>
</tbody>
</table>

### 13.6 Pipe materials

The pipes commonly used in small rural community water distribution systems are of Cast Iron (C.I), asbestos cement (A.C), rigid polyvinyl chloride (P.V.C.) and flexible polyethylene (P.E) plastic.

C.I. pipes have been and continue to be used in spite of their high initial cost because they have a long service life and require hardly any maintenance. C.I. is corrosion resistant even for water that is somewhat corrosive. For more protection a coating may be applied.

Asbestos cement pipes are very corrosion resistant, light and easy to handle. They are widely used in sizes up to 300mm mainly for secondary pipes and for low-pressure mains.
Table 13.2 is provided for ready reference on the available diameters and pressure classes for various types of pipes.

<table>
<thead>
<tr>
<th>Material</th>
<th>Class</th>
<th>Test pressure of m water</th>
<th>Working pressure m of water</th>
<th>Diameter Available size range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.I</td>
<td>A</td>
<td>120</td>
<td>60</td>
<td>50-900</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>180</td>
<td>90</td>
<td>50-900</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>240</td>
<td>120</td>
<td>50-900</td>
</tr>
<tr>
<td>A.C</td>
<td>5</td>
<td>50</td>
<td>25</td>
<td>80-300</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>100</td>
<td>50</td>
<td>80-300</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>150</td>
<td>75</td>
<td>80-300</td>
</tr>
<tr>
<td>P.V.C</td>
<td>2.5 kg/cm²</td>
<td>50</td>
<td>25</td>
<td>90-315</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>80</td>
<td>40</td>
<td>50-315</td>
</tr>
<tr>
<td></td>
<td>6.0</td>
<td>120</td>
<td>60</td>
<td>40-315</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>200</td>
<td>100</td>
<td>16-125</td>
</tr>
</tbody>
</table>

Table 13.2: Pipe material selection data
Handout 13

13.0 Typical layout diagrams for a Rural Water Supply Scheme

Surface water treatment

13.1 Source: Stream, river, lake, irrigation channel
Water quality: Slightly polluted, Medium turbidity

Surface water with medium turbidity should initially lowered to a desired value by using a rapid sand filter. (fig. 13.1). Typical layout is as shown in fig 13.2. With refer to this layout diagram, water treated from the rapid filter will then allowed to pass through sand filters, where turbidity can be reached to the desired standards. On the other hand, destruction of pathogens takes place while water passing through sand filters.
PROPOSED COURSE CONTENT

TITLE OF TRAINING COURSE: Design of Rural Water Supply Schemes

TARGET GROUP: Engineering Assistant- RWS Section

DURATION: Five (05) Days

CONTENT:

1. Course Introduction - 1hr
2. Rural Water Supply in Sri Lanka (An over view) - 1 ½ hrs
3. Handout 1
   A) Surface Water Sources (Types, Flow, Identification, Selection, Protection etc.) - 1 ½ hrs
   B) Ground Water Sources (Basic concepts of Ground Water Flow, Types of wells, Identification, 3hrs Selection, Development and Preservation, Maintenance of wells)
4. Handout 2
   (Physical, Chemical, Biological, Parameters, effects Standards, Analysis, Surface Water Quality and Ground Water Quality) - 02 hrs
5. Intakes:
   Design of;