SCI1210 ENVIRONMENTAL ENGINEERING – I
UNIT – V

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SLIDES – 1 to 35

General Requirements

- The objective of Water distribution system is to deliver water to individual consumers with appropriate quality, quantity and pressure.
- The distribution system describes collectively the facilities used to supply water from its source to the point of usage.
- The water should reach every consumer with the required pressure head.
- This may include extensive system of pipes, storage reservoirs, pumps and related appurtenances.
- The proper functioning of a water distribution system is critical to providing sufficient drinking water to consumers as well as providing sufficient water for fire protection
- Distribution system should be economical and easy to maintain and operate.

- For efficient distribution system adequate water pressure required at various points.
- Depending upon the level of source, topography of the area and other local conditions the water may be forced into distribution system by following ways :

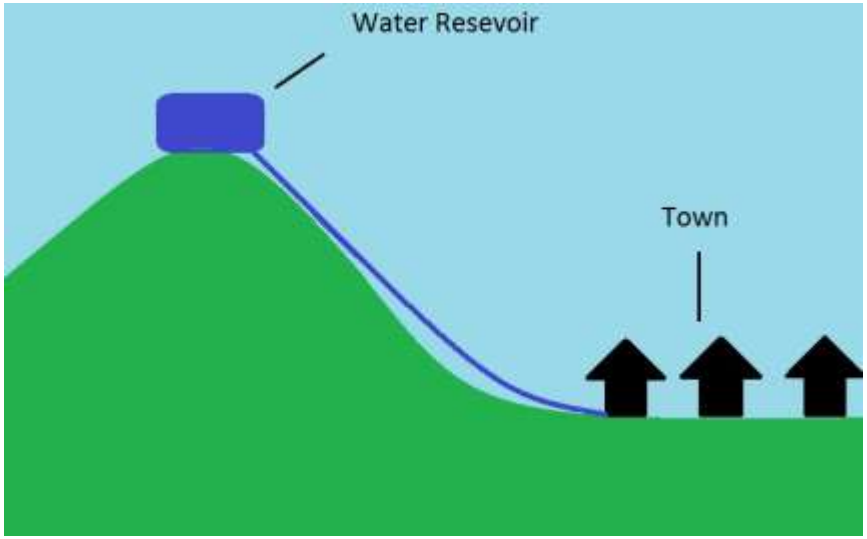
  Gravity system

  Pumping system

  Combined gravity and pumping system

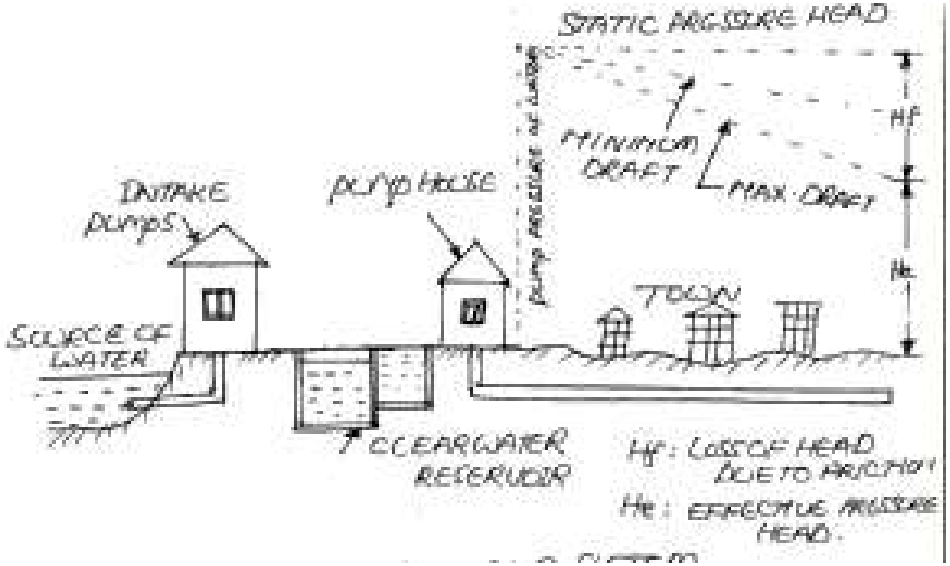
Gravity System

- Suitable when source of supply is at sufficient height.
- Most reliable and economical distribution system.
- The water head available at the consumer is just minimum required.
- The remaining head is consumed in the frictional and other losses.



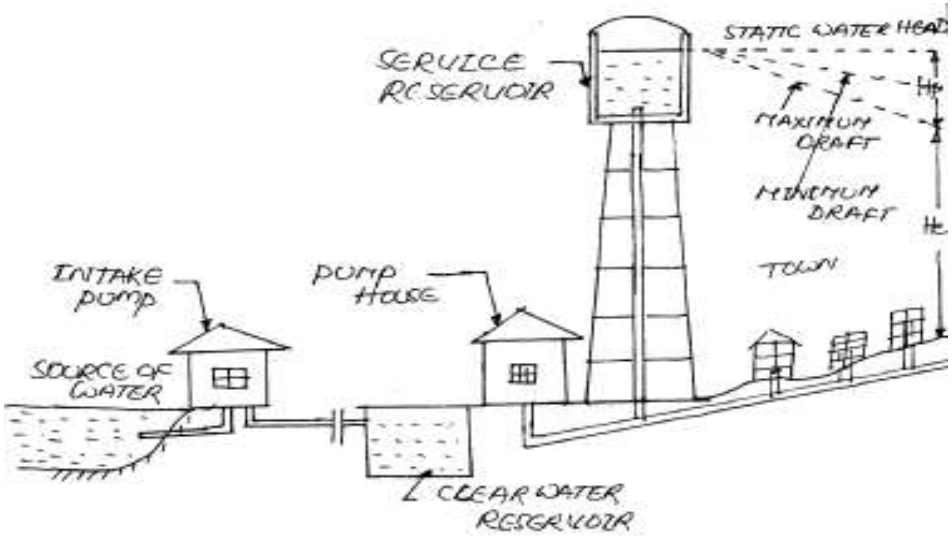
Pumping System

- Treated water is directly pumped in to the distribution main with out storing.
- Also called pumping without storage system.
- High lifts pumps are required.
- If power supply fails, complete stoppage of water supply.
- This method is not generally used.



Combined gravity and pumping system

- Most common system.
- Treated water is pumped and stored in an elevated distribution reservoir.
- Then supplies to consumer by action of gravity.
- The excess water during low demand periods get stored in reservoir and get supplied during high demand period.
- Economical, efficient and reliable system.



Layouts of Distribution Network

- The distribution pipes are generally laid below the road pavements, and as such their layouts generally follow the layouts of roads.
- There are, in general, four different types of pipe networks; any one of which either singly or in combinations, can be used for a particular place.

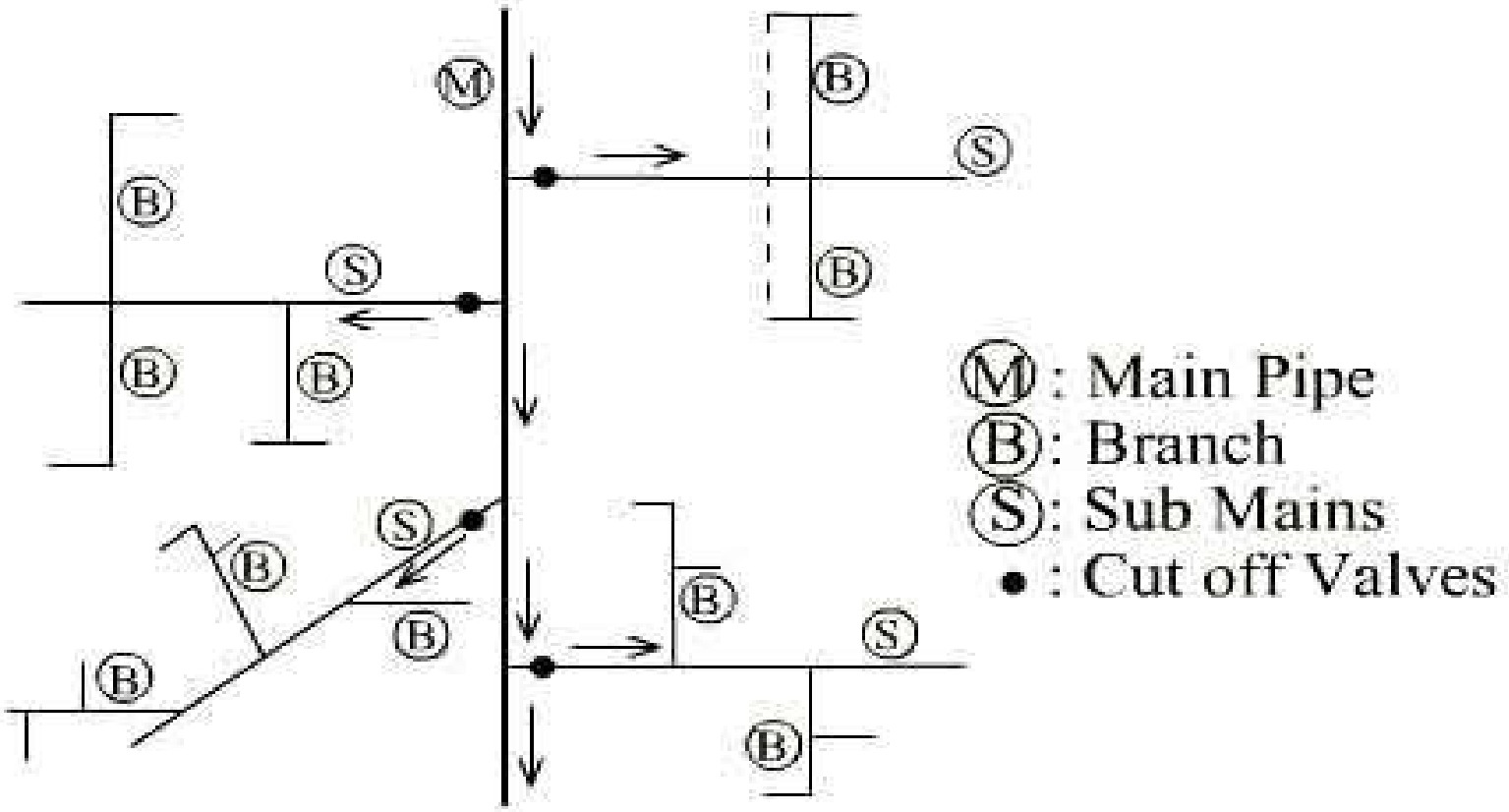
They are:

- ❖ Dead End System
- ❖ Radial System
- ❖ Grid Iron System
- ❖ Ring System

Dead End System

- It is suitable for irregular developed towns or cities.
- In this system one main starts from service reservoir along the main road.
- Sub-mains are connected to the main in both the directions along other roads.
- In streets, lanes and other small roads which meet the roads carrying sub-mains, branches and minor distributors are laid and are connected to mains.
- From these branches, service connections are made to individual houses.

Dead End or Tree System



Dead End System

Advantages

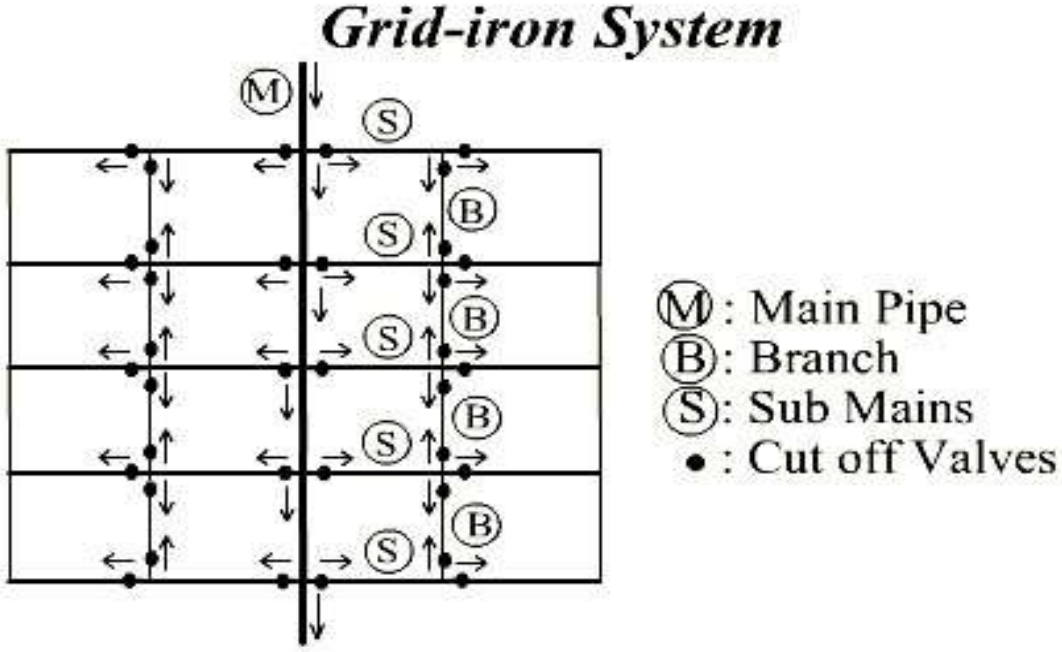
- Relatively cheap.
- Determination of discharges and pressure easier due to less number of valves.

Disadvantages

- Due to many dead ends, stagnation of water occurs in pipes.
- If pipe breaks down or is closed for repair, the whole locality beyond the point goes without water.

Grid Iron System

- It is suitable for cities with rectangular layout, where the water mains and branches are laid in rectangles.
- It is an improvement over dead-end system. All the dead ends are interconnected with each other and water circulates freely through out the system.



Advantages

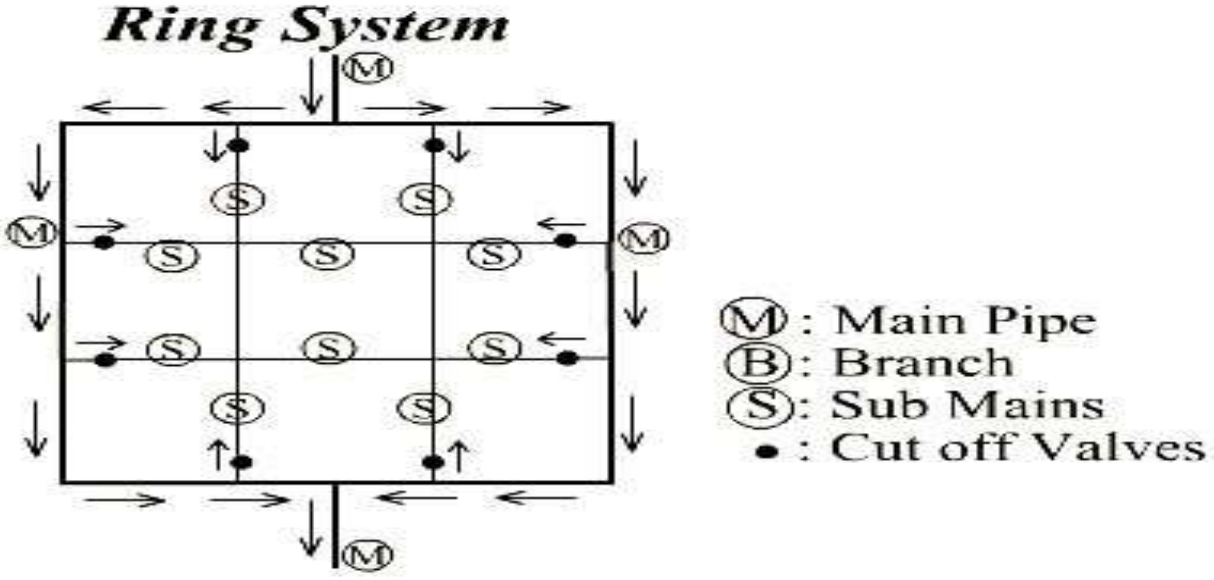
- Water is kept in good circulation due to the absence of dead ends.
- In the cases of a breakdown in some section, water is available from some other direction.
- In case of fire, more quantity of water diverted towards the affected area by closing the valves of nearby localities.

Disadvantages

- Exact calculation of sizes of pipes is not possible due to provision of valves on all branches.
- More number of valves and longer length of pipe is required in this system, thereby increase in the overall cost.

Circular or Ring System

- The supply main is laid all along the peripheral roads and sub mains branch out from the mains.
- This system also follows the grid iron system with the flow pattern similar in character to that of dead end system.
- So, determination of the size of pipes is easy.



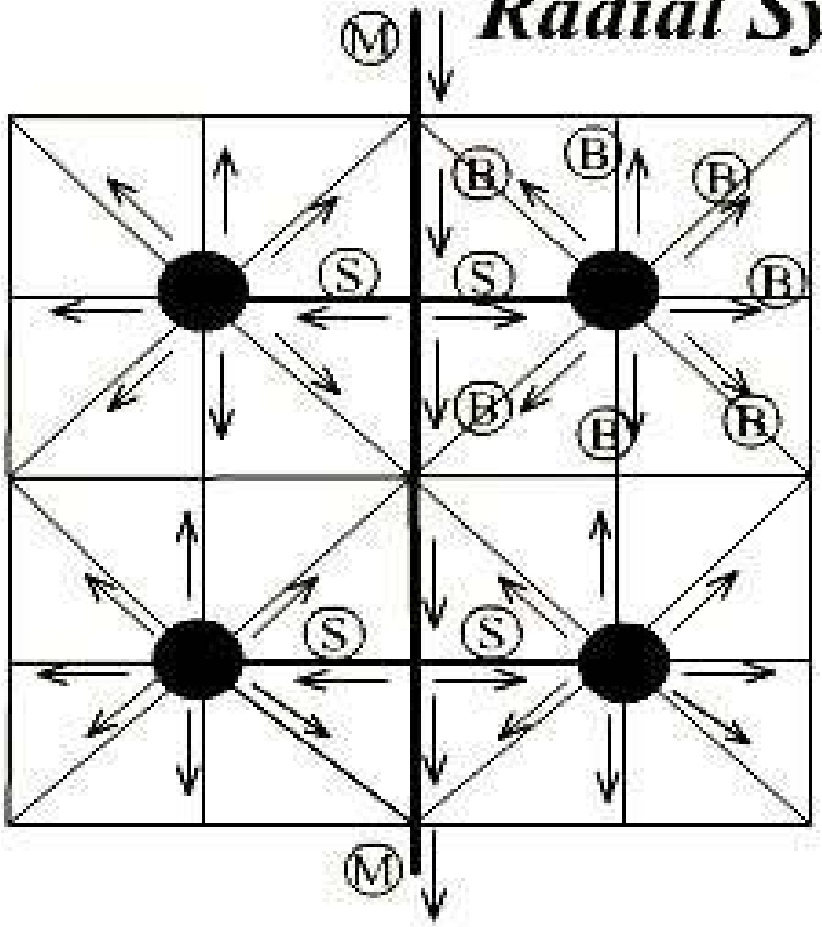
Radial System

- The area is divided into different zones.
- The water is pumped into the distribution reservoir kept in the middle of each zone.
- The supply pipes are laid radially ending towards the periphery.

Advantages:

- ❖ It gives quick service.
- ❖ Calculation of pipe sizes is easy

Radial System



● : Distribution Reservoirs

Storage and Distribution Reservoirs

- Distribution reservoirs, also called service reservoirs, are the storage reservoirs, which store the treated water for supplying water during emergencies (such as during fires, repairs, etc.) and also to help in absorbing the hourly fluctuations in the normal water demand.

Functions of Distribution Reservoirs

- ❖ to absorb the hourly variations in demand.
- ❖ to maintain constant pressure in the distribution mains.
- ❖ water stored can be supplied during emergencies.

Location and Height of Distribution Reservoirs

- ❖ should be located as close as possible to the centre of demand.
- ❖ water level in the reservoir must be at a sufficient elevation to permit gravity flow at an adequate pressure.

Types of Reservoirs

- Depending upon their elevation with respect to ground it may be classified into

1. Surface reservoirs
2. Elevated reservoirs

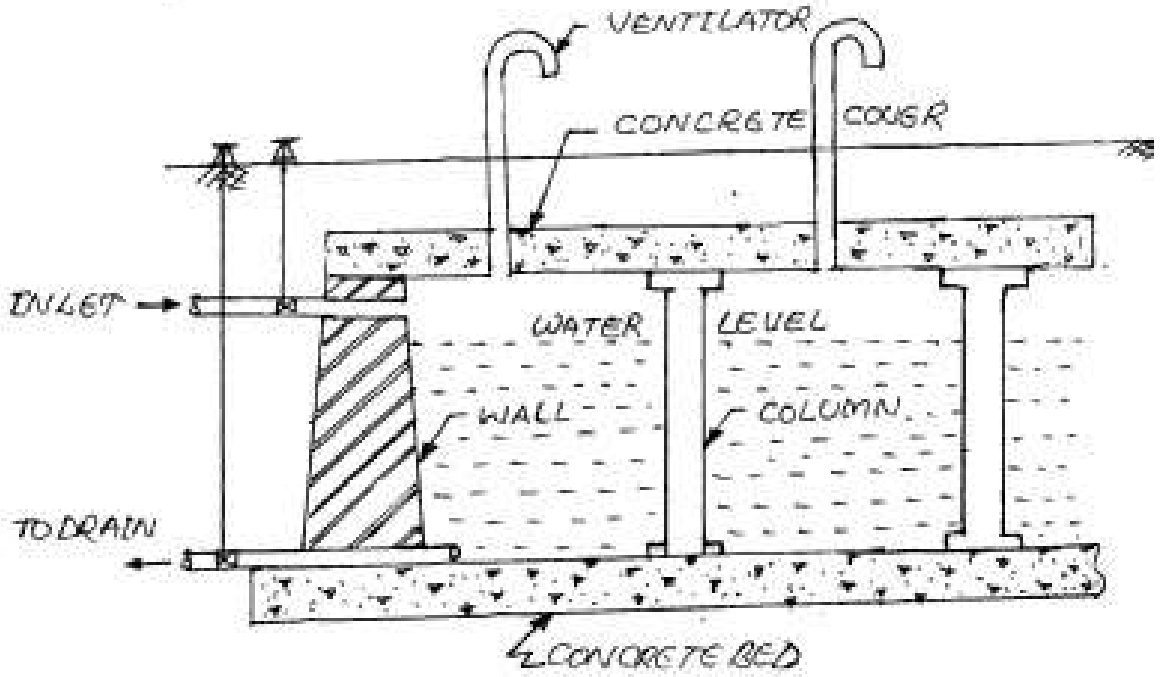
- Depending upon their material of construction it may be classified into

1. Steel Reservoir
2. R.C.C
3. Masonry

Surface Reservoir

- These also called ground reservoir. Mostly circular or rectangular tank.
- Under ground reservoirs are preferred especially when the size is large.
- These reservoirs are constructed on high natural grounds and are usually made of stones, bricks, plain or reinforced cement concrete.
- The side walls are designed to take up the pressure of the water, when the reservoir is full and the earth pressure when it is empty.
- The position of ground water table is also considered while designing these reservoirs.
- The floors of these reservoirs may constructed with R.C.C slab or square stone blocks resting on columns.

- To obtain water tightness bitumen compounds are used at all construction joints.
- At the top of roof about 60cm thick earth layer is deposited and maintained green lawns to protect the reservoir from cold and heat.
- For aeration of water and inspection, ventilation pipes and stairs are provided.



TYPES OF TANKS

R.C.C TANKS: R.C.C tanks are very popular because

1) They have long life
2) Very little maintenance
3) decent appearance

G.I. TANKS: G.I. tanks are generally in rectangular or square in shape. Now a days G.I. tanks are not preferring because

1) Life of the tank is less
2) Corrosion of metal
3) maintenance cost may be more

HDPE TANKS: Now a days HDPE tanks are very popular for storing less quantity of water and hence useful for residential purpose. The following are the advantages of HDPE tanks

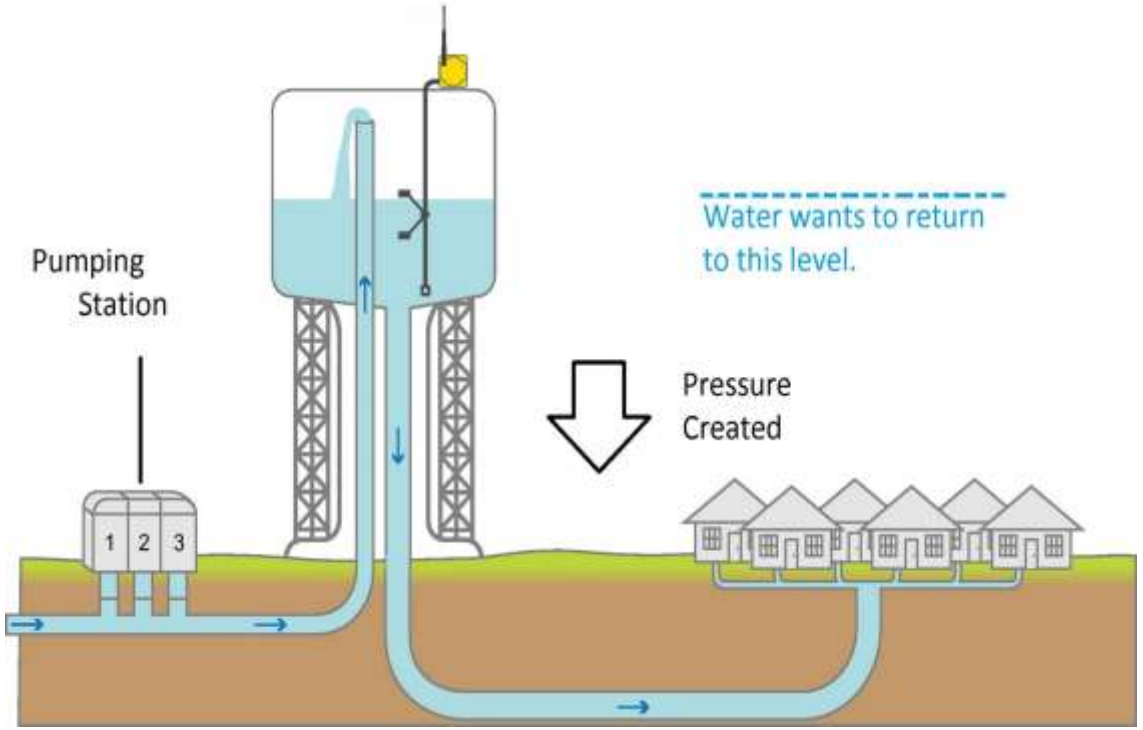
1) Handling is easy because of light weight
2) Cheap in cost
3) Maintenance cost is low
4) Cleaning of tanks are easy

Elevated Storage Reservoirs

- Elevated Storage Reservoirs (ESRs) also referred to as Overhead Tanks are required at distribution areas which are not governed and controlled by the gravity system of distribution.
- These are rectangular, circular or elliptical in shape.
- If the topography of the town not suitable for under gravity, the elevated tank or reservoir are used.
- They are constructed where combine gravity and pumping system of water distribution is adopted.
- These tanks may be steel or RCC.
- Now RCC is commonly preferred.

The accessories of ESR are-

- ❖ Inlet and outlet pipe, overflow pipe discharging into a drain
- ❖ Float gauge, indicating depth of water.
- ❖ Automatic device to stop pumping when the tank is full.
- ❖ A manhole and ladder.
- ❖ Ventilator for circulation of fresh air.



Storage Capacity of Distribution Reservoirs

- The total storage capacity of a distribution reservoir is the summation of:
- ***Balancing Storage*:** The quantity of water required to be stored in the reservoir for equalising or balancing fluctuating demand against constant supply is known as the balancing storage (or equalising or operating storage).
- ***Breakdown Storage*:** The breakdown storage or often called emergency storage is the storage preserved in order to tide over the emergencies posed by the failure of pumps, electricity, or any other mechanism driving the pumps.
- A value of about 25% of the total storage capacity of reservoirs, or 1.5 to 2 times of the average hourly supply, may be considered as enough provision for accounting this storage.

- ***Fire Storage*:** The third component of the total reservoir storage is the fire storage.
- This provision takes care of the requirements of water for extinguishing fires.
- A provision of 1 to 4 per person per day is sufficient to meet the requirement.
- When reserve storage is elevated, amount of fire reserve may be determined by

$$R = (F-P)\,T$$

R= Reserve storage (liters)

F= Fire demand, liters/min

P= Reserve fire pumping capacity, liters/min

T= Duration of the fire in min

The total reservoir storage can finally be worked out by adding all the three storages.

Appurtenances

- **Valves**

  Sufficient valves shall be provided on water mains so that inconvenience will be minimized during repairs. Valves should be located at not more than 500-feet intervals in commercial districts and at not more than 800-feet intervals in other districts.

- **Hydrants**

  Hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the National Fire Protection Association (NFPA)

- **Air Relief or Air Release Valves**

  At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of hydrants or air relief valves. Automatic air-relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

Analysis of Distribution Networks

- In the distribution system, for any closed network of the pipes, the following two conditions must be fulfilled:
    a) The quantity of water entering a junction, must be equal to the quantity of water leaving the same junction. In other words, the entering flow must be equal to the leaving flow i.e., the law of continuity must be satisfied.
    b) The algebraic sum of the pressure drops around a closed loop must be zero i.e., there shall be discontinuity in the pressure.
- There are various methods for analysis. The most widely used methods are:
    - Equivalent pipe method
    - Hardy Cross method

Hardy-Cross Method

- In this method , the corrections are applied to the assumed flow in each successive trial. The head loss in each pipe is determined by pipe flow formula. The successive corrections are made in flows in each pipe until the heads are balanced and the principle of continuity is satisfied at each junction.

  Now if Q_a be the assumed flow in a pipe and Q be the actual flow in pipe, then correction be

$$\Delta = Q - Q_a \quad \text{(or)}$$

$$Q = Q_a + \Delta \longrightarrow \quad (1)$$

If the head loss in pipe under reference is H_L it can be determined by the formula

$$H_L = k\, Q_a \longrightarrow \quad (2)$$

where k is a constant depending upon the size of pipe and its internal condition the head loss can also be determined by Hazen-William formula

$$H_L = k.\ Q^{1.85}$$

Now putting $Q = Q_a + \Delta$ [Substituting 1 in 2]

$$H_L = k\ (Q_a + \Delta)^x$$

$$= k\ (Q^x_a + x\ Q^{x-1}\ \Delta)$$ [neglecting terms with higer power of Δ]

In the closed network of pipe line, the total loss of head must be zero. Therefore,

$$\sum k(Q^x_a + x.\ Q^{x-1}_a.\ \Delta) = 0 \quad \text{or}$$

$$\sum(k.\ Q^x_a) = -\sum(k.\ Q^{x-1}_a.\ x.\ \Delta)$$

But the value Δ is very small for all pipes of network under consideration it can be taken out of summation, therefore

$$\sum(k.\ Q^x_a) = -\sum(k.\ Q^{x-1}_a.\ x)$$

$$\Delta = - \frac{\sum(k.\, Q^{x}_{a})}{\sum (k.\, Q^{x-1}_{a}.\, x)} \longrightarrow (3)$$

$$\Delta = - \frac{\sum H_L}{x.\, \sum(H_L/Q_a)} \longrightarrow (4)$$

In this equation the numerator is obtained by the algebraic sum of the head losses in the various pipes of the closed loop. +ve sign given to head loss in clockwise direction and –ve sign to those in anti-clockwise direction. The value of x is taken as 1.85 in this method. Minor loss is usually neglected.

Equivalent pipe method

- This method used in solving large network of pipes, in which it is convenient to replace different small loops by single equivalent pipes having same head loss.
- An equivalent pipe is an imaginary pipe in which the head loss and discharge are equivalent to the head loss and discharge for the real pipe system.
- There are three main properties of a pipe: diameter, length, and roughness. As the coefficient of roughness, C, decreases the roughness of the pipe decreases.
- For example, a new smooth pipe has a roughness factor of C = 140, while a rough pipe is usually at C = 100.
- To determine an equivalent pipe, you must assume any of the above two properties. Therefore, for a system of pipes with different diameters, lengths, and roughness factors, you could assume a specific roughness factor (most commonly C = 100) and diameter (most commonly D = 8"). The most common formula for computing equivalent pipe is the Hazen-Williams formula

Operation and Maintenance of Distribution Pipes

Comprehensive maps prepared for a scale of 60m/cm to 120 m/cm are used for O&M of distribution system. They provide an overall view of the system with location of reservoirs, pumping stations, valves and hydrants etc. Valve location maps apart from indicating their location also show the direction to open the valve, number of turns to open, make of valve and date of fixing of valve.

The efficiency and effectiveness of a water supply system depends on the operating personnel's knowledge of the variables that affect the continuity, reliability, and quantity of water supplied to consumers. The operational staff should be able to carry out changes in the hydraulic status of the system as required depending on those variables promptly and effectively. can match the demand for water. When operators change their shifts information on valve closure and opening must be exchanged.

- Routine operations shall be specified which are activities for adjusting the valves and operation of pumps to match the prevailing conditions (flows, pressures, levels and operation of pumps). Valve and pump operations will have to be controlled as per a schedule. The schedule shall contain procedures for operating the distribution system. It should contain procedures to obtain, process, and analyze the variables related to water flows, pressures and levels as well as the consequences of manipulating control devices, such as operation of valves and or pumps so that the hydraulic status of the system
- Operations other than routine viz. during breakdowns and emergencies have to be specified and should be carried out in specific circumstances when normal conditions change i.e. when flows, pressures and levels and operation of pumps change.

- A maintenance schedule is required to be prepared to improve the level of maintenance of water distribution networks and house connections through improved co-ordination and planning of administrative and field work and through the use of adequate techniques, equipment and materials for field maintenance.
- The schedule has to be flexible so that it can achieve team action with the available vehicles and tools.
- Co-ordination of activities is required for spares and fittings, quality control of materials used and services rendered.
- Training of maintenance staff shall include training to achieve better public relations with consumers apart from the technical skills.

Leakage in Distribution Network

- In most water-distribution systems, a large percentage of the water is lost in transit from treatment plants to consumers. Leakage occurs in different components of the distribution system: transmission pipes, distribution pipes, service connection pipes, joints, valves, and fire hydrants.
- Causes of leaks include corrosion, material defects, faulty installation, excessive water pressure, water hammer, ground movement due to drought or freezing, and excessive loads and vibration from road traffic. Leaks waste both money and a precious natural resource, and they create a public health risk.

- The primary economic loss is the cost of raw water, its treatment, and its transportation. Leakage leads to additional economic loss in the form of damage to the pipe network itself, e.g., erosion of pipe bedding and pipe breaks, and to the foundations of roads and buildings.
- Risk to public health can be caused by contaminants entering the pipe through leak openings if water pressure in the distribution system is lost.

Water Audits :

Water audits determine the amount of water loss in the distribution system. They can be performed on a network-wide basis or district by district. Network-wide audits provide an overall picture of water losses in the distribution system as a whole.

- For district audits, the distribution system is divided into small districts or zones having approximately 20 to 30 km of water main. Districts are isolated individually by turning off the appropriate valves except at control points where portable flow meters are installed to measure water flow over a 24-hour period.