Collection and Distribution of Water

• Deals with the transport of water from the source through the treatment plant to the consumers.

• It requires
  ▫ intake structures,
  ▫ transmission lines,
  ▫ distribution pipe networks and
  ▫ other essential accessories.
Intake structures
Key requirements of intake

- Reliability
- Of adequate size to provide the required quantity of water.
- Located to obtain the best quality water.
- Protected from objects that may damage equipment.
- Easy to inspect and maintain.
- Designed to minimize damage to aquatic life.
- Located to minimize navigational hazards.
Location for intake structures

• Avoid wastewater discharge points and pollution hazard

• Enable withdrawal of water from a range of levels

• Magnitude and direction of stream or current velocities should not affect the function and stability of the intake structure.

• Reliable access roads and power sources should be available

• should be near to treatment plant

• Major environmental impacts should be avoided
Surface water Intakes

- Floating intakes
- Submerged intakes
- Tower intakes
- Shore intakes
- Pier intakes
Reservoir Intake
Multi-level intake
Tower Intake

- Gate controls
- Water surface
- Open port
- Entry ports
- Closed port
- Outlet
Submerged Lake Intake
Intake Structures

Figure: an example of a lake intake
Unprotected river intake
Pumped river intake

Variation between high and low water level

Up to 3.5-4 m
River Intakes
River Intake components

- Major components
  - Screen inlet
  - Intake pipe
  - Intake sump
  - Suction pipe
  - Pumps
  - Gate and foot valves
  - access
Design Criteria for intakes

• Design capacity = $Q_{\text{max-day}}$

• Intake velocity should be $\leq 8 \text{ cm/s}$

• Vertical positions intake ports should be such that good quality water is withdrawn.

• Locate the top intake port at a distance not less than 2 m from the normal water level and the bottom port at least 1 m above the bottom.
Intake design

- **Volume of sump** → detention time. A detention time of at least 20min is recommended.

- At least two sumps - to avoid interruption of service.

- **Height** (with a freeboard about 0.5m)

- Location of the bottom of the sump should be > 1.5m below the lowest stream level or > 1m below stream bed.
Example 1: River Intake design

- Given the following information proportion a suitable river intake.
  - Daily demand 5000 m$^3$
  - Pump capacity: 50 l/s (working 8 hr/day)
Example 1 Solution

• Capacity of each pump daily = $8 \times 3600 \times 50 / 1000 = 1440 \text{ m}^3$

• Number of pumps = $5000 / 1440 = 3.47 \approx 4$

• Hourly flow of each pump = $5000 / (4 \times 8) = 156.24 \text{ m}^3 / \text{h}$

• Take detention time, $T_d = 20 \text{ min}$

• $\Rightarrow$ capacity = $T_d \times Q = (20/60) \times 156.24 = 52.08 \text{ m}^3$
Example 1 Solution

- Effective height of sump = 6.6 + 1.5 = 8.1 m
- Free board = 0.5 m
- Total sump height = 8.6 m
- If we use circular sump diameter = 2.86 m
PIPESLINES AND APPURTENANCES
Pipelines and appurtenances

The selection of pipe materials is based on

- carrying capacity
- strength
- ease of transportation and handling
- availability
- quality of water
- cost (initial and maintenance)
Pipelines and appurtenances

- **Cast iron pipes.**
  - highly resistant to corrosion, strong but brittle,
  - easy jointing, withstanding high internal pressure, long life
  - very heavy and difficult to transport
Pipelines and appurtenances

- **Steel pipe:**
  - strong, very light weight and can withstand higher pressure than cast iron pipes.
  - cheap, easy to construct and can be easily transported
  - cannot withstand external loads, affected by corrosion and are costly to maintain.
Pipelines and appurtenances

• *Cement-lined cast iron pipes.*
  ▫ cement protect against corrosion.
  ▫ very small coefficient of friction than unlined cast iron pipes.
Pipelines and appurtenances

- **Plastic pipes.**
  - corrosion resistant, light weight and economical.
  - Rigid (unplasticized) uPVC is stronger and can withstand much higher pressure for a given wall thickness.
Pipelines and Appurtenances

- **Valves:**
  - to isolate segments of a pipeline,
  - to regulate rate of flow,
  - to control pressure, and
  - to allow release or entry of air from pipe system.
Pipelines and Appurtenances

• *Factors considered in the selection of valves:*
  ▫ include purpose and operation,
  ▫ capacity required,
  ▫ head loss and rate of flow,
  ▫ cost,
  ▫ availability, etc.
Pipelines and Appurtenances

- **Shutoff (Isolation) valves:**
  - to stop the flow of water through a pipeline
  - spacing from 150 to 370m
  - a minimum of three of the four pipes connected at a junction are valved.
  - fire hydrant, in inlet, outlet, and by-pass lines
  - Gate valves and butterfly valves
Gate and butterfly valves

Gate Valve Closed  Gate Valve Opened  Butterfly valve

Gate valve  Butterfly valve
Pipelines and appurtenances

- **Check valves:**
  - Semiautomatic device and permits water flow only in one direction.
  - In the discharge pipes of centrifugal pumps → prevent backflow
  - In conjunction with altitude valves
Pipelines and appurtenances

Altitude valves:

- to automatically control the flow into and out of an elevated storage tank or standpipe to maintain desired water level elevations.
- include double-acting sequence valve, single-acting type, or differential altitude valve.
Pipelines and appurtenances

- **Air-release and vacuum valves:**
  - Air-release valves installed at high points of distribution piping, in valve domes, and fittings, and in discharge lines from pump to discharge the trapped air.
  - Vacuum valves are used to protect pipelines from collapse as they are emptied, by allowing air to enter the pipes.
Pipelines and appurtenances

- Location of Air-release and vacuum valves:
Pipelines and appurtenances

- Air-release and vacuum valves:
Pipelines and appurtenances

- **Pressure reducing valves (PRV).**
Pipelines and appurtenances

- Pressure sustaining valves (PSV)
Distribution systems

- Depending upon the level of the source of water and the city, topography of the area, and other local considerations,
  - Gravitational system,
  - Pumping without storage, and
  - Pumping with storage.
Distribution systems

- **Gravitational system:**
  - action of gravity without any pumping
  - most economical and reliable
  - for cities situated at foothills
Distribution systems

- **Pumping without storage:**
  - Treated water is directly pumped into the distribution mains without storing
  - High lift pumps operate at variable speeds to match variable water demand
  - Disadvantageous (power failure) no reserve flow
Distribution systems

- **Pumping without storage:**

  ![Diagram](link-to-diagram)
Distribution systems

- **Pumping with storage:**
  - Treated water is pumped at a constant rate → stored in elevated distribution reservoir → distributed to the consumers by the action of gravity
  - Excess water during low demand period gets stored in the reservoir → supplied during high demand periods.
  - Pumps work at uniform rate → high efficiency
  - Quite reliable (even during power failure)
Distribution systems

- *Pumping with storage:*

![Diagram of a water distribution system with a reservoir, pump, city, and elevated tank showing low demand, peak demand, and storage tanks.](image)
Pipeline layout options

(i) Economic layout

(ii) Uneconomic layout

(iii) Dual feed layout
Pipeline layout options

(i) Rise and fall trunk main

(ii) Use of elevated storage
DISTRIBUTION RESERVOIRS
Purpose of Distribution reservoirs

- Equalizing supply and demand
- Increasing operating convenience
- Leveling out pumping requirements
- Providing water during source or pump failure
- Maintaining pressure levels within acceptable ranges
- Providing water to meet fire demands
- Increase detention times
- Blending water sources
Equalizing demand and supply
Distribution reservoirs

- Maintaining pressure levels within acceptable ranges
Elevated tank location

A. Adjacent to Pump Station

- Hydraulic Gradient
- Minimum Acceptable Hydraulic Gradient

Service Area

Pump Station
Elevated tank location

B. Beyond Service Area

- Minimum Acceptable Hydraulic Gradient
- Hydraulic Gradient

Elevated Storage Tank

Pump Station

Service Area
Elevated tank location

C. Adjacent to Area With Lowest Pressure

Minimum Acceptable Hydraulic Gradient

Hydraulic Gradient

Elevated Storage Tank

Pump Station

Service Area
Distribution reservoir types

- Ground reservoirs
- Buried reservoirs
- Elevated reservoirs
- Stand pipes

- Can be made of
  - Concrete or masonry
  - Steel tank
Distribution reservoirs
Elevated concrete reservoir
Concrete water tower

- Up to 5000 m³
- Circular or rectangular
Distribution reservoirs

- **design considerations and details**
  - **Minimum capacity**: Equalizing storage + Emergency reserve (about 25%) + Fire storage.
  - **Location**: provide several smaller storage units
  - **Aesthetics**: visual impacts
  - **Ventilation**
  - **Overflow**
  - **Security and safety**
## Reservoir capacity

<table>
<thead>
<tr>
<th>Size (m$^3$)</th>
<th>Depth of water (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 3500</td>
<td>2.5 – 3.5</td>
</tr>
<tr>
<td>3500 – 15 000</td>
<td>3.5 – 5.0</td>
</tr>
<tr>
<td>Over 15 000</td>
<td>5.0 – 7.0</td>
</tr>
</tbody>
</table>

For rectangular concrete tank
Example 1

Design a service reservoir if $Q_{\text{daymax}}$ is 2400 m$^3$. Two pumps are working at constant rate of 150 m$^3$/hr. Determine for how many hours pumping should be done.
Solution

• **Step 1. Determine pumping hours**
  - Pumping hour = $Q_{d\text{max}}/(2 \times \text{pumping capacity})$
  - $= 2400/(2 \times 150)$
  - $= 8$ hrs for each pump

• **Step 2. Determine reservoir capacity**
  - **Balancing requirement**
    - Pumping is done for a total of 16 hrs $= 2400 \text{ m}^3$
    - But demand for 16 hrs is $2400 \times 16/24 = 1600 \text{ m}^3$
    - Excess that needs to be stored $= 2400-1600 = 800 \text{ m}^3$
Solution
Solution...

- Emergency requirement = \(0.25 \times 800 = 200\ m^3\)
- Ignore fire demand = 0
- Total reservoir volume = 1000 \(m^3\)
- Provide 2 reservoirs of each 500 \(m^3\)
- Take depth of 3.0 m
- X-sectional area = \(500/3.0 = 166.67\ m^2\)
- Taking circular tank diameter = 14.57 m
Example 2

A water supply system is proposed to be designed for a small town which has a maximum daily demand of 515 m$^3$/d. Estimate storage requirement if pumping is done for 12 hrs only (from 4 to 16). Use the following demand variation data.

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>0 - 4</th>
<th>4 - 8</th>
<th>8 - 12</th>
<th>12 - 16</th>
<th>16 - 20</th>
<th>20 - 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand as % of total daily demand</td>
<td>6.7</td>
<td>9.2</td>
<td>20.8</td>
<td>28.3</td>
<td>25</td>
<td>10</td>
</tr>
</tbody>
</table>
## Solution

### Pumping hours

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>0 - 4</th>
<th>4 - 8</th>
<th>8 - 12</th>
<th>12 - 16</th>
<th>16 - 20</th>
<th>20 - 24</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand as % of total daily demand</td>
<td>6.7</td>
<td>9.2</td>
<td>20.8</td>
<td>28.3</td>
<td>25</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Demand m³</td>
<td>34.51</td>
<td>47.38</td>
<td>107.12</td>
<td>145.75</td>
<td>128.75</td>
<td>51.50</td>
<td>515</td>
</tr>
<tr>
<td>Pumping rate m³</td>
<td>0</td>
<td>171.67</td>
<td>171.67</td>
<td>171.67</td>
<td>0</td>
<td>0</td>
<td>515</td>
</tr>
<tr>
<td>Excess m³</td>
<td>124.29</td>
<td>64.55</td>
<td>25.92</td>
<td>0</td>
<td>0</td>
<td></td>
<td>214.76</td>
</tr>
</tbody>
</table>

\[
\frac{515 \times 6.7}{100} = 34.51 \text{ m}^3
\]

\[
pumping\ rate = \frac{515\text{ m}^3 \times 4\ hr}{12\ hr} = 171.67\text{ m}^3\ per\ 4\ hrs
\]

Storage required = 214.76 + 0.25 x 214.76 = 268.45 m³ or 270 m³

Equalizing volume

Emergency volume
Solution

Excess pumped or Equalizing volume