AAiT

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Water Distribution Modelling
Lecture By Fiseha Behulu (PhD)

Lecture-1:
Components of Water Supply

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Contents of the Course

1. **Components of Water Supply**
2. Basic Principles of Pipe Flow (Hydraulics)
3. The Concept of Modeling
4. Model Calibration
5. Optimization in WDS
6. Water Hammer Theory
7. Water Supply Project Design (Application of Tools)

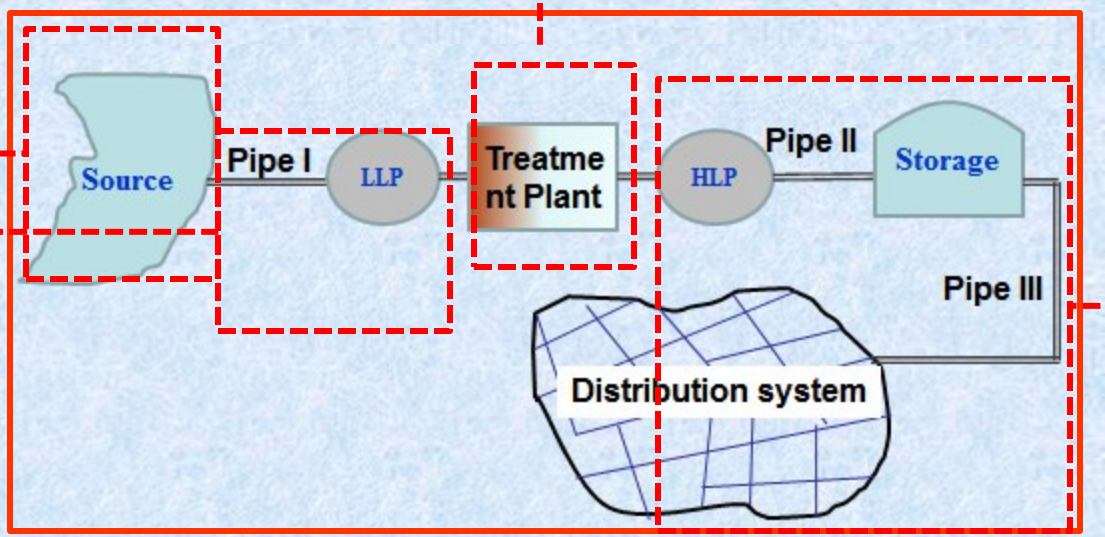
Topics

- Introduction
- Main Components of Water Supply
- Sources of Water Supply
- Demand for Water
- Distribution of Water (Layout and type)

Introduction

Main Components of Water Supply

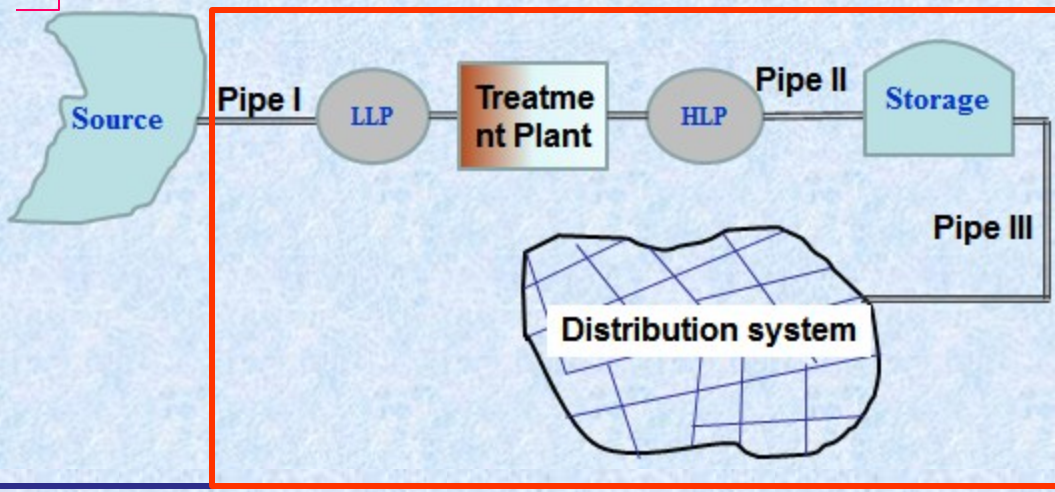
- A water supply system comprises the following main components
  - **Source** (either groundwater or surface water)
  - Raw water **collection structures** (intake structures, transmission line ...)
  - **Treatment plant**
  - **Distribution systems** (pipe, pumps, reservoir and others)



Introduction…

- **Main Components of Water Supply…**
  - Among others, 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**.

Regardless of size and complexity, the basic purpose of water distribution system is to deliver water from source to customer.

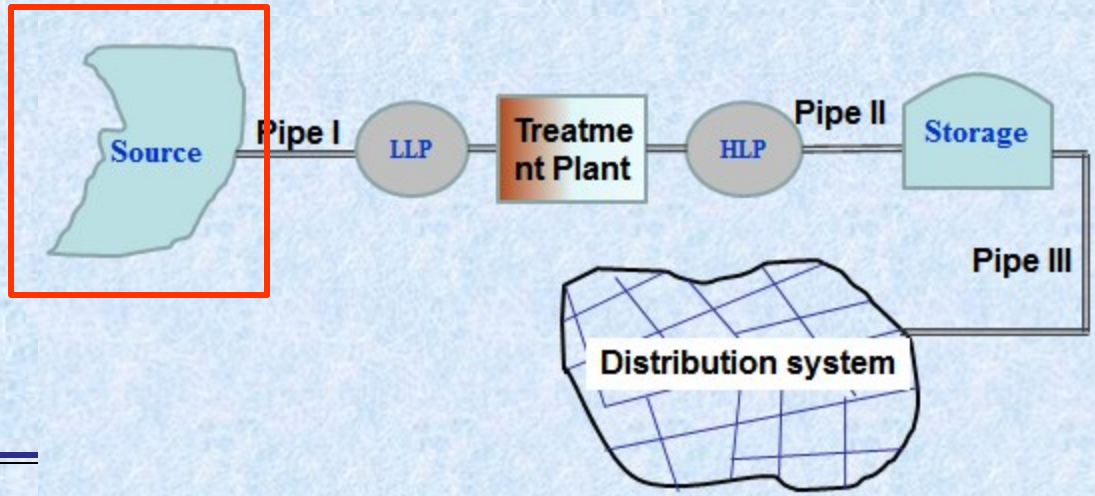


Introduction- Components of Water Supply

- **Main Components of Water Supply**
  - **Sources** can be from:
    - Groundwater
    - Surface Water

    } Thoroughly Dealt in Hydrogeology and Hydrology Courses
  - **Customers** are commonly end users associated with ***demand***
    - Domestic
    - Non domestic
  - Demand can vary over **time** and **Space** – **Needs Modeling.**

Regardless of size and complexity, the basic purpose of water distribution system is to deliver water from source to customer.



Introduction- Demand for Water

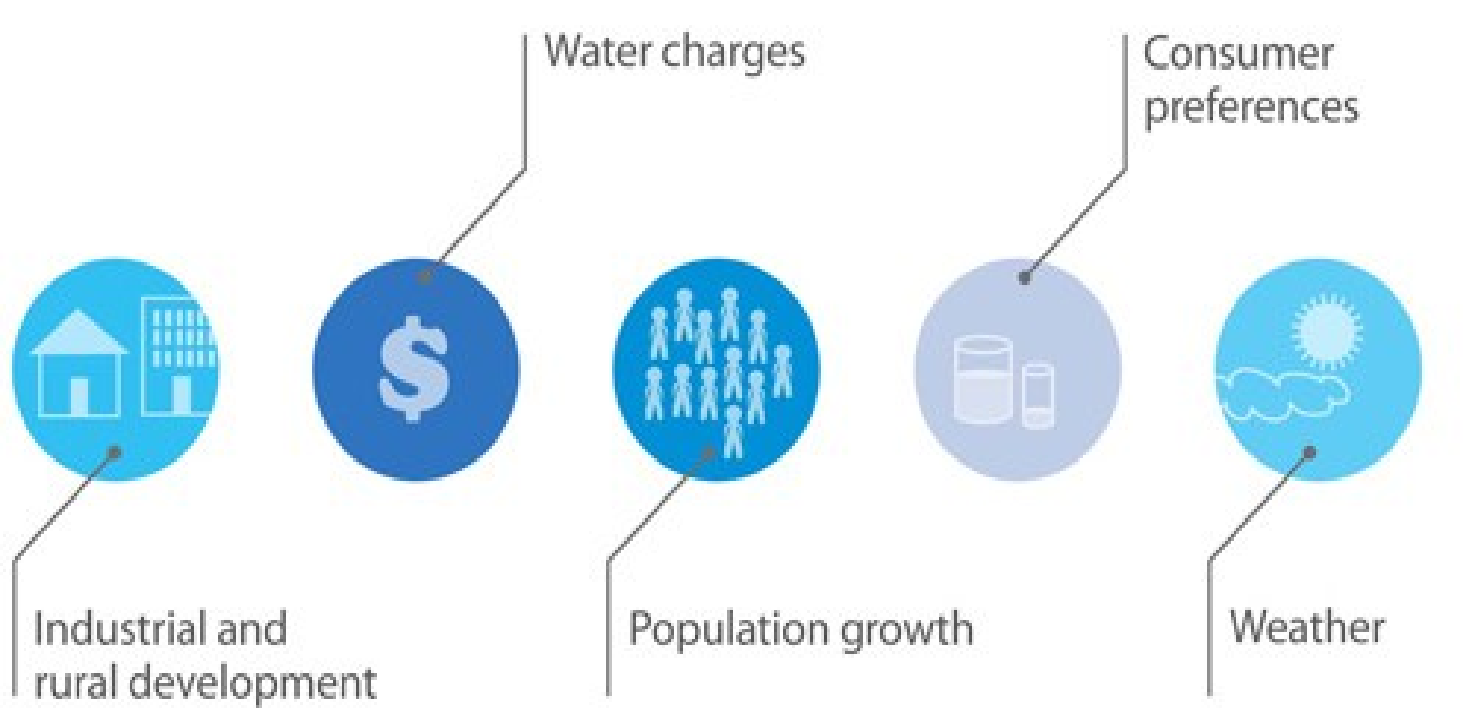
- **Water Demand –Definition**

" … the total volume of water necessary or needed to supply customers within a certain period of time"

(public utility perspective)

Introduction- Demand for Water…

- **Factors affecting Demand for Water**
  - Population (present and forecasted)
  - Weather and Climate
  - Water Price



Introduction- Demand for Water…

- **Water Demand- Forecasting**
  - The Purpose of forecasting is to
    - Size system capacity and raw water supply
    - Size and staging treatment and distribution improvement
    - Set water rate and budgeting of WDS
    - Operate and manage WDS

Introduction- Demand for Water…

Water Demand- Forecasting…

- Forecasting is made for different time horizons

Forecast Type	Forecast Horizon	Applications
Long-Term	Decades (10-50 years)	Sizing system capacity, raw water supply
Medium-Term	Years to decades (7-10 years)	Sizing, staging treatment and distribution system; Improvements, Investments, Setting water rates
Short-Term	Years (1-2 years)	Budgeting Program tracking and evaluation, revenue forecasting
Very short-Term	Hours, days, weeks or up to two weeks	Optimizing, managing system operation, pumping

Source : Billings and Jones (2008)

Introduction- Demand for Water…

- **Water Demand- Forecasting…**
  - Methods
    - Simple Methods
    - Time Series Models
    - Regression Models
    - Other structural forecast models (NNM)

- Please read reference materials.
- Refer back your Numerical Methods course and Water Supply course from undergraduate .

Introduction- Demand for Water…

Water Demand- Simple Forecasting Method

- Per Capita Water Demand
- Sectoral or Per Customer Water demand forecast
- Long term water demand forecasting (one to several decades)
- Inform design and acquisition of water system capacity
- Annual time scale (q = liters per capita per day)

$$Q_t = N_t q_t$$

Q_t = Total system water use in time period t

N_t = population of the water system service area in time period t

q_t = per capita water use in time period t

- **Assignment #1**

Get any water supply project of a town in Ethiopia and summarize in maximum of 5 pages

Give due attention to per capita water demand assessment

Introduction- Demand for Water…

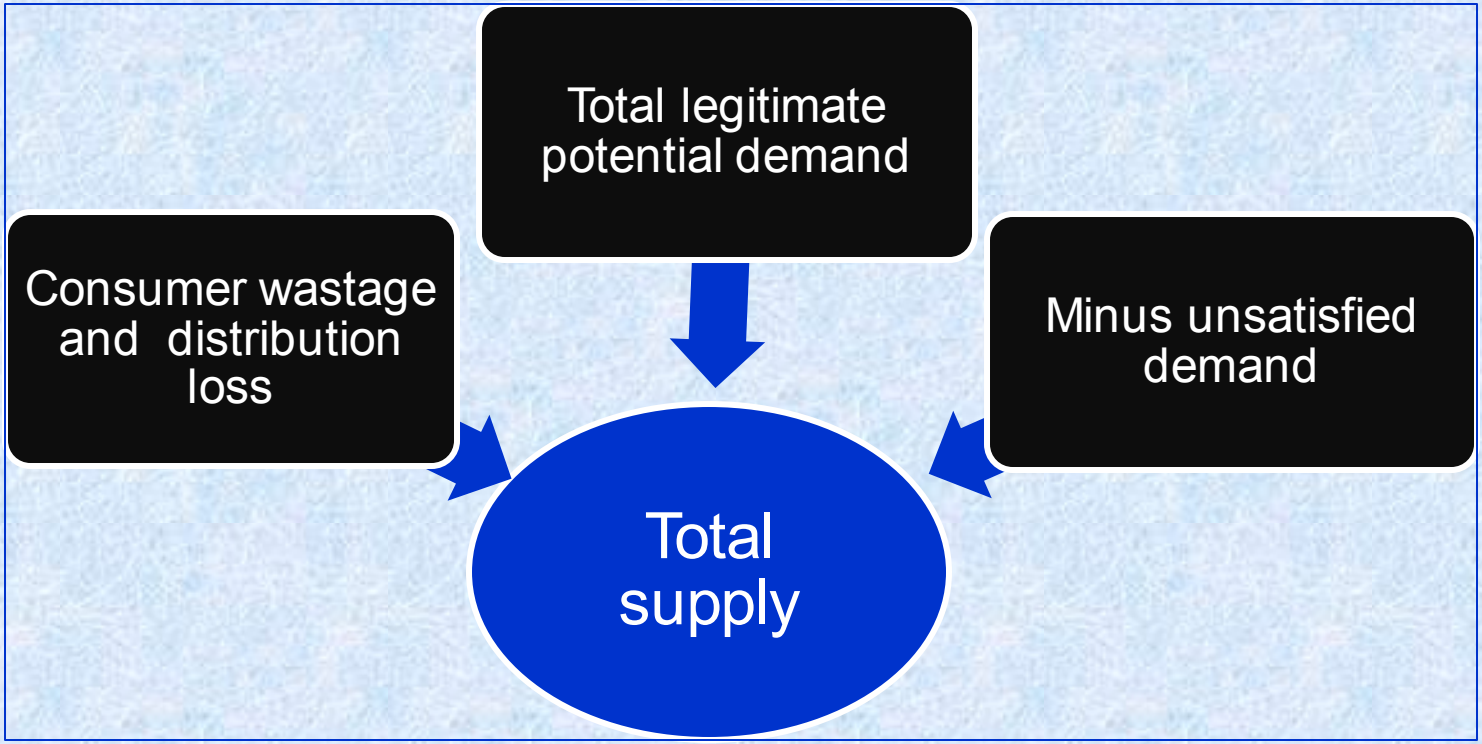
- **Water Demand- Simple Forecasting Method (Per Capita water Demand)**

Water Consumption for Various Purposes

	Types of Consumption	Normal Range (lit/capita/day)	Average	%
1	Domestic Consumption	65-300	160	35
2	Industrial and Commercial Demand	45-450	135	30
3	Public Uses including Fire Demand	20-90	45	10
4	Losses and Waste	45-150	62	25

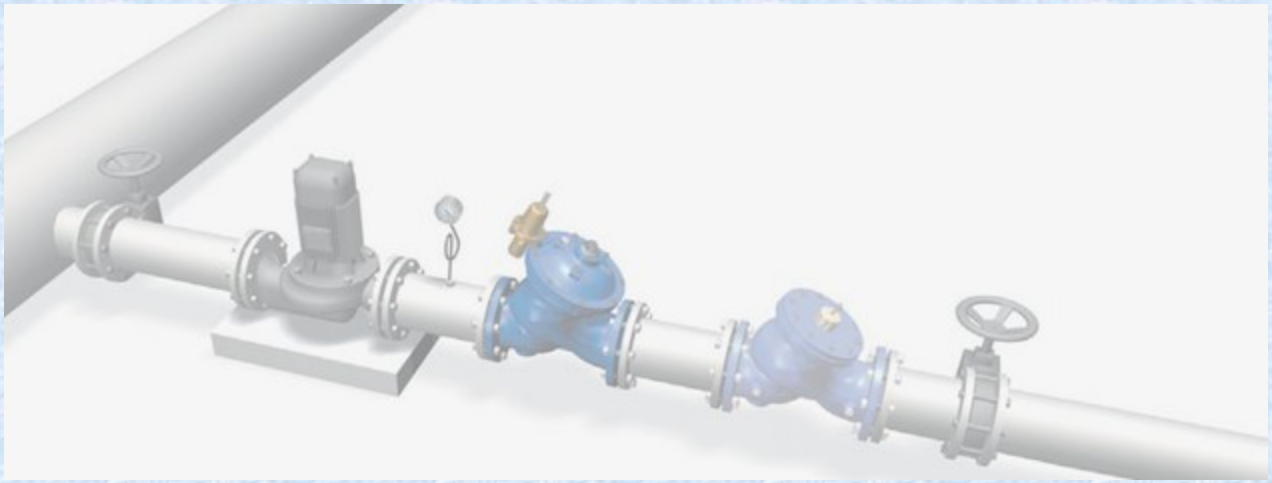
Introduction- Demand for Water…

- **Supply – Definition**



Introduction- Distribution of Water

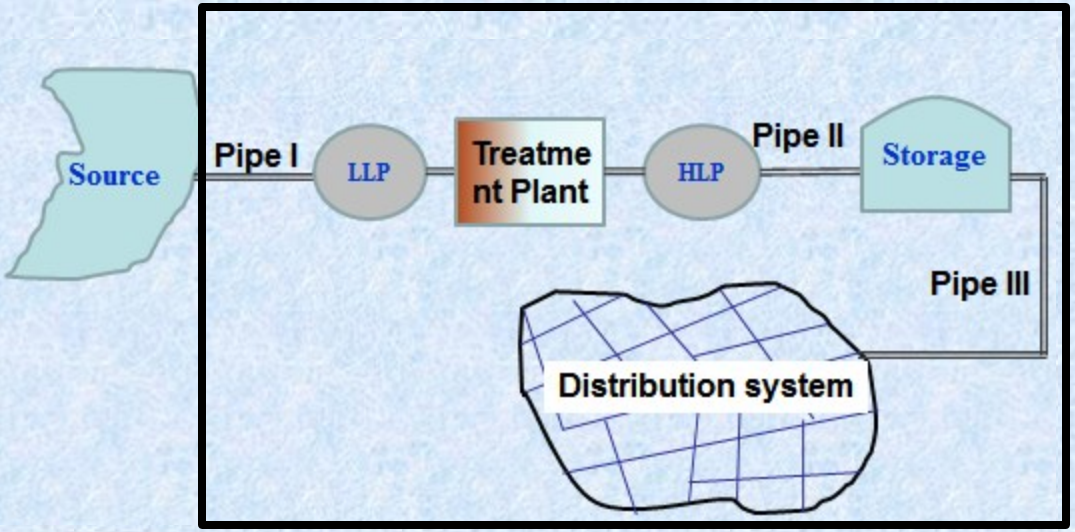
- Moving/ Transporting water from Sources to Demand Site Requires **Pipe and Appurtenant Structures**
  - Pipes
  - Pumps
  - Valves



- The transported water may also **stored in a reservoir (tanks)** to accommodate fluctuations in demand

Introduction- Distribution of Water…

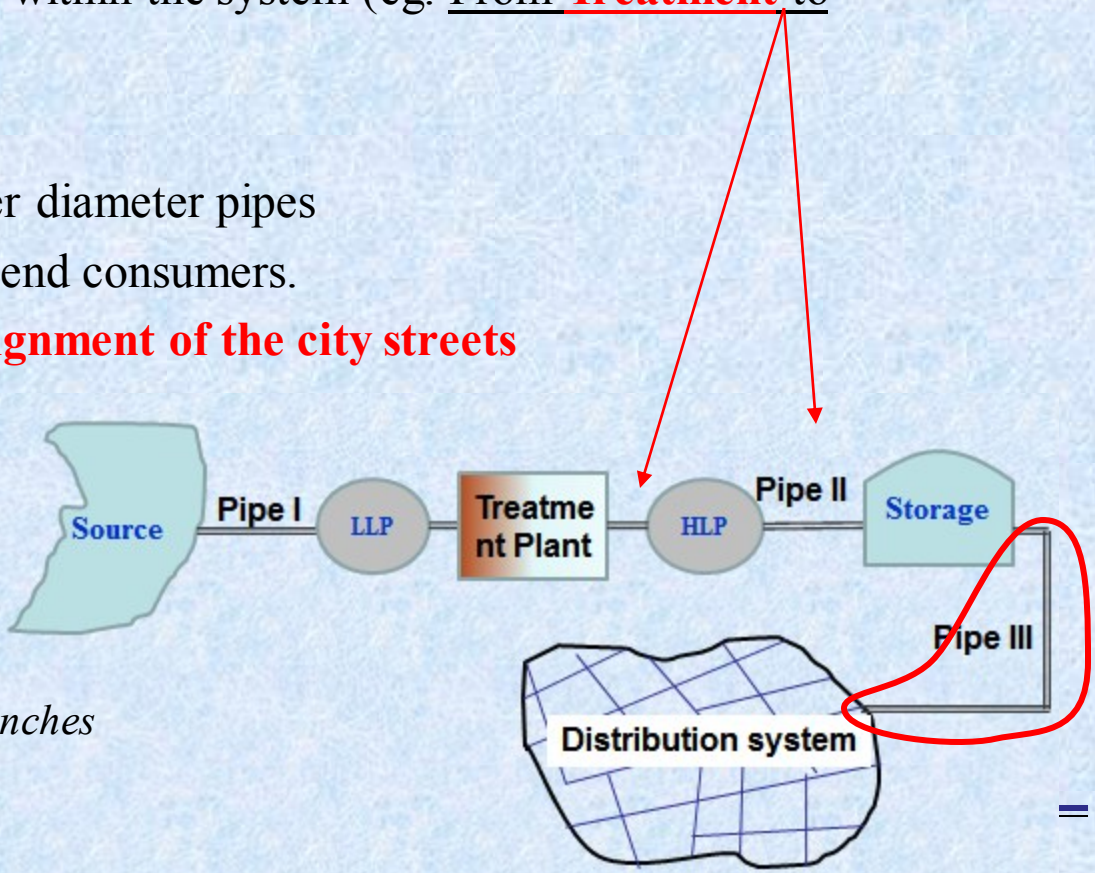
- Water Distribution System (WDS)- ***Definition***
  - **Piping, Storage and Supporting infrastructures are together referred to as water distribution system.**



- Pipes are the skeleton of any distribution system, carrying water from the source to the end user.

Introduction- Distribution of Water…

- **Piping-** can be either of the following two
  - Transmission (Trunk) Mains:
    - Designed to convey large amounts of water over longer distance between major facilities within the system (eg. From **Treatment** to **Storage**)
  - Distribution Mains:
    - Intermediate step smaller diameter pipes
    - used to deliver water to end consumers.
    - Follow topology and **alignment of the city streets**



Classes of Distribution Pipes

Primary or arterial mains
Secondary lines or Sub-mains
Small distribution mains or branches
Service Connections

Introduction- Distribution of Water…

Piping …

- In addition to the transmission and distribution mains WDS consists of
  - Service lines
  - Elbows,
  - Tees,
  - Wyes,
  - Crosses,
  - Valves (isolation, control, blow-off etc.)

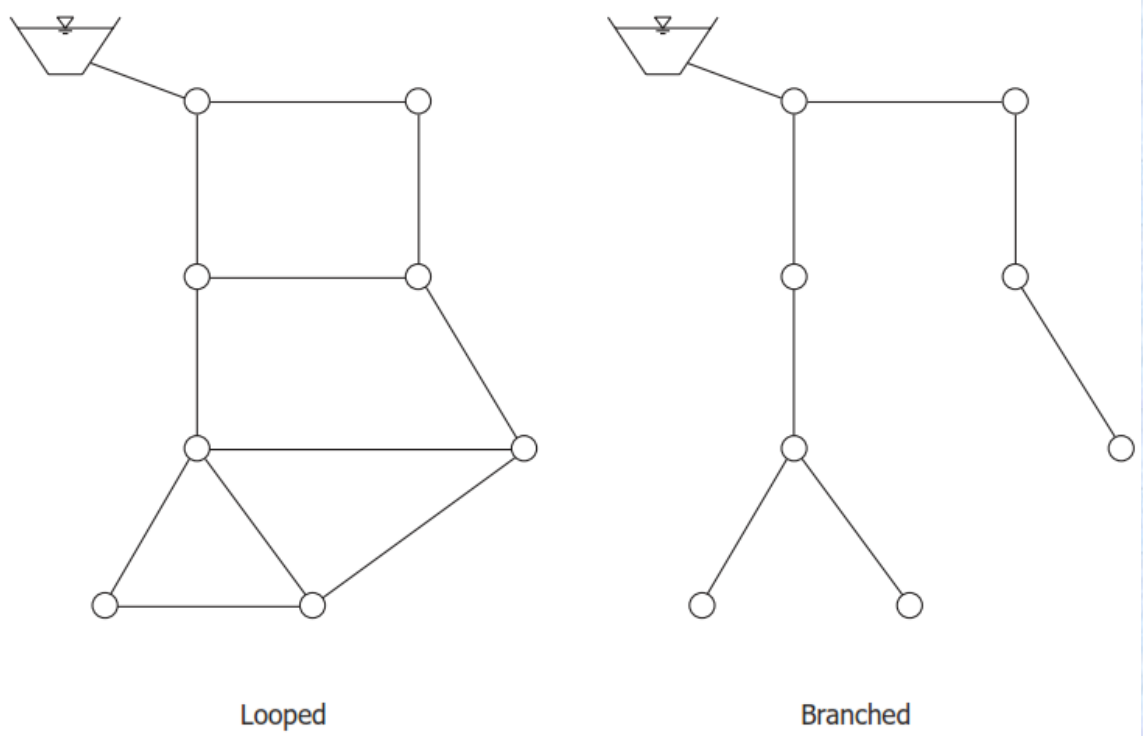
- Internal plumbing systems to transport water to sinks, washing machines and so forth are not included in WDS models unless explicitly specified.

Introduction- Distribution of Water…

Pipe System Layout

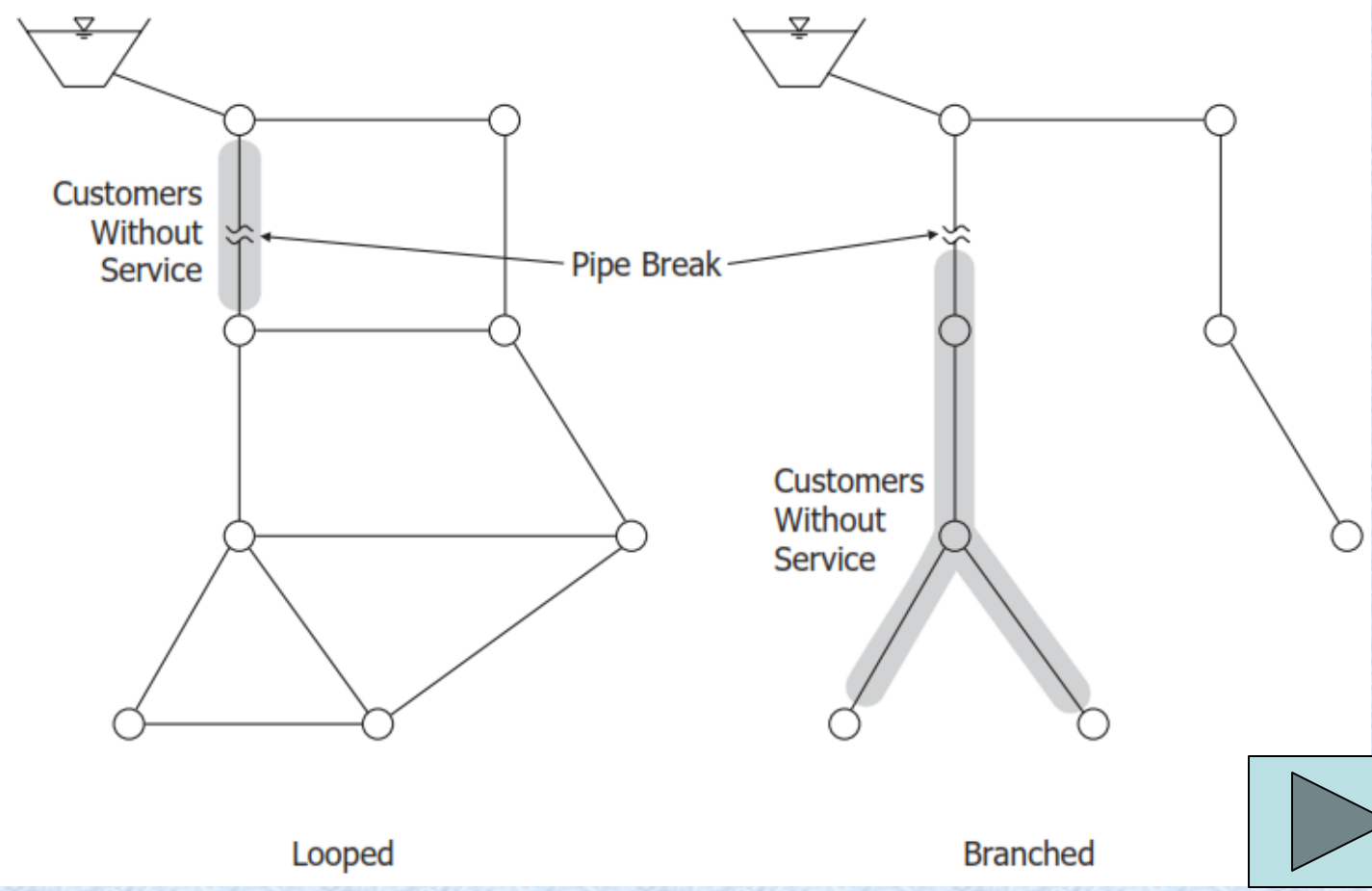
- Transmission and distribution systems
  - Looped
  - Branched

- Looped systems are more desirable than branched system



Introduction- Distribution of Water…

- **Pipe System Layout-** **Advantage and Disadvantages**



Introduction- Distribution of Water…

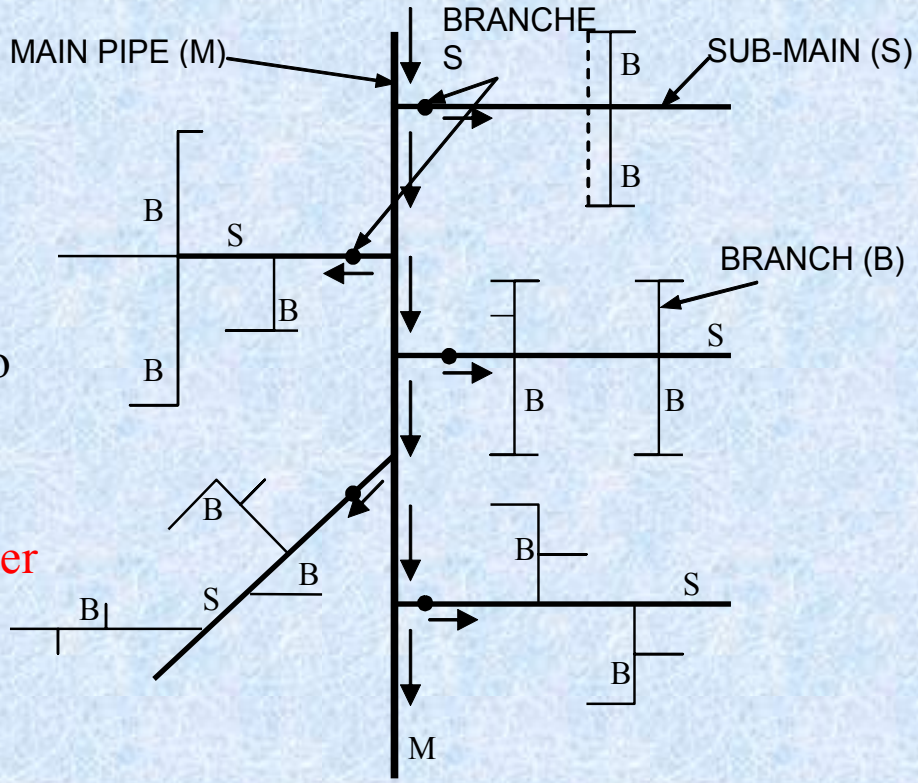
- **Layout of Distribution Systems in a pipe network:**
  - layout of distribution pipes generally follows the road pattern
  - Generally, four types of pipe network layouts –
    - ***dead end*** *system or branch system,*
    - ***gridiron*** *system,*
    - ***ring*** *system, and*
    - ***radial*** *system.*

Introduction- Distribution of Water…

- **Pipe System Layout-** Types

1. Dead end / Branched system

- solved easily
- Lesser number of shut-off valves
- Shorter pipe lengths and the are easy to lay pipes
- cheap and simple and expanded easily
- dead ends →prevent circulation of water
- Problematic if a pipe is damaged



Introduction- Distribution of Water…

- **Pipe System Layout-** Types

2. Gridiron systems

- Discharge, friction loss and pipe siz
  is less
- Not problematic if a pipe is damage
- No dead ends →allows circulation o
  water
- Good for fire fighting
- more pipelines and shut-off valves
- high cost of construction
- design is difficult and expensive

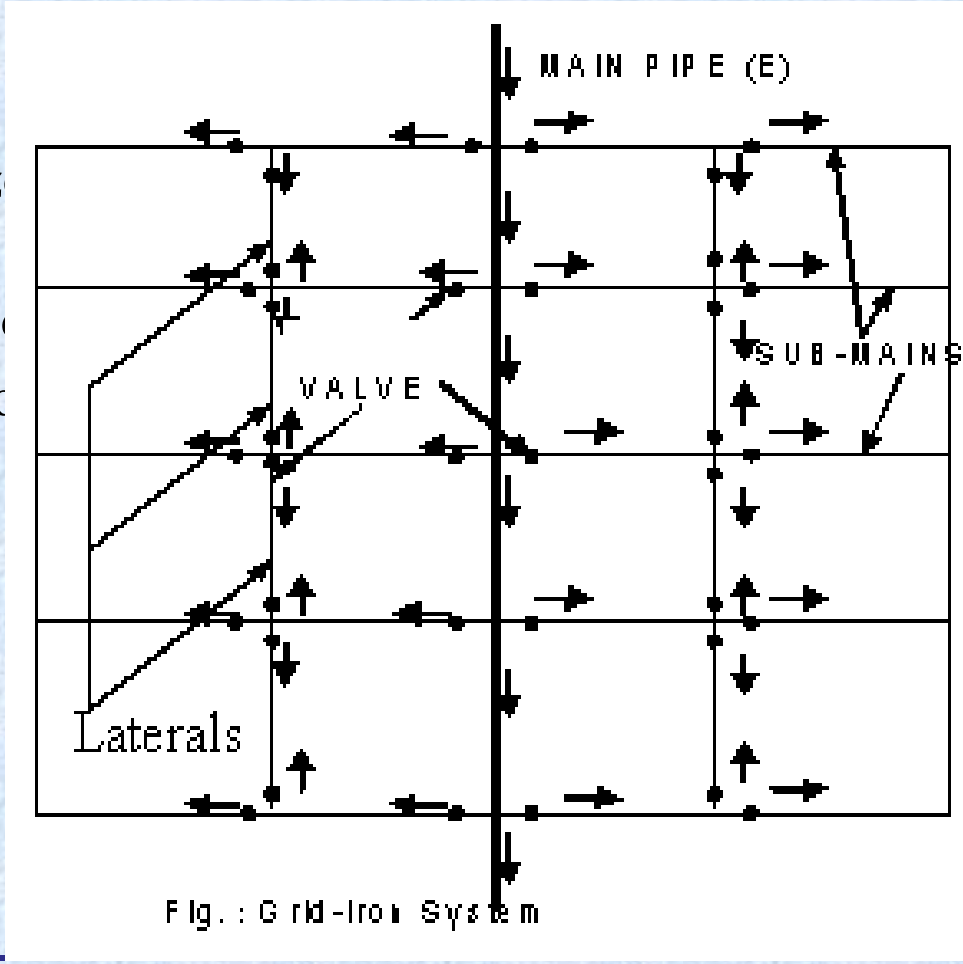


Fig. : Grid-Iron System

Introduction- Distribution of Water…

- **Pipe System Layout-** Types

3. Ring systems:

- closed ring, circular or rectangular
- suitable for well-planned towns and cities
- Generally at high demand areas
- Not problematic if a pipe is damaged
- No dead ends →allows circulation of water
- Good for fire fighting
- more pipelines and shut-off valves
- high cost of construction
- design is difficult and expensive

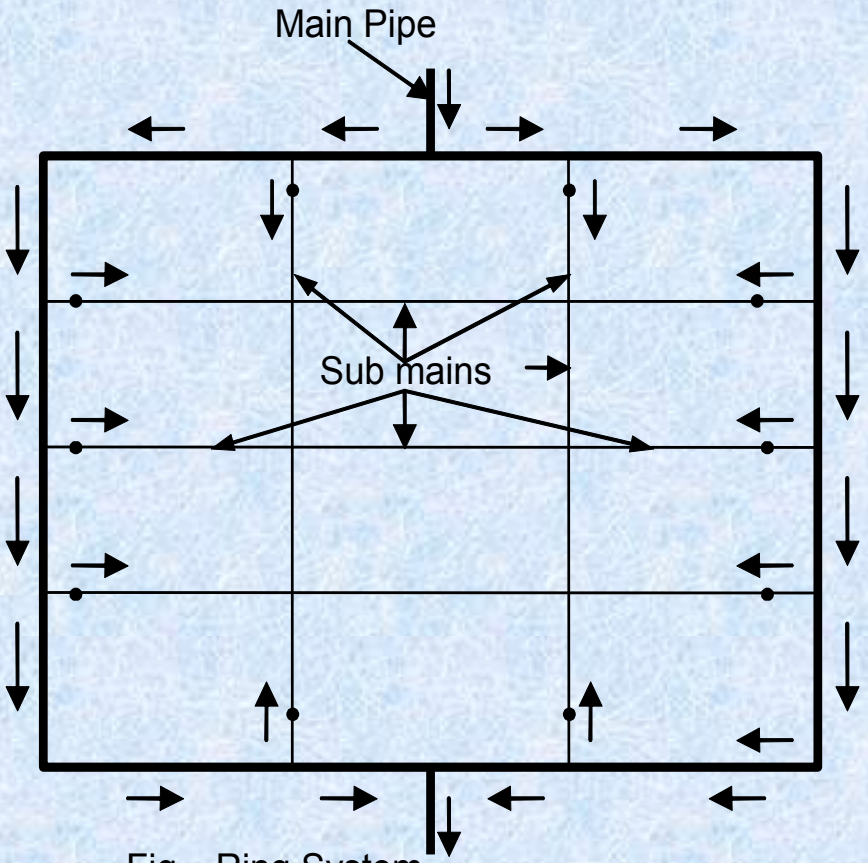


Fig. : Ring System

- **Pipe System Layout-** Types

4. *Radial systems*

- For city or a town having a system of radial roads emerging from different centers
- distribution reservoirs at these centers
- From mains → pumped into the DRs placed at different centers and then to the service areas.
- ensures high pressure and efficient water distribution

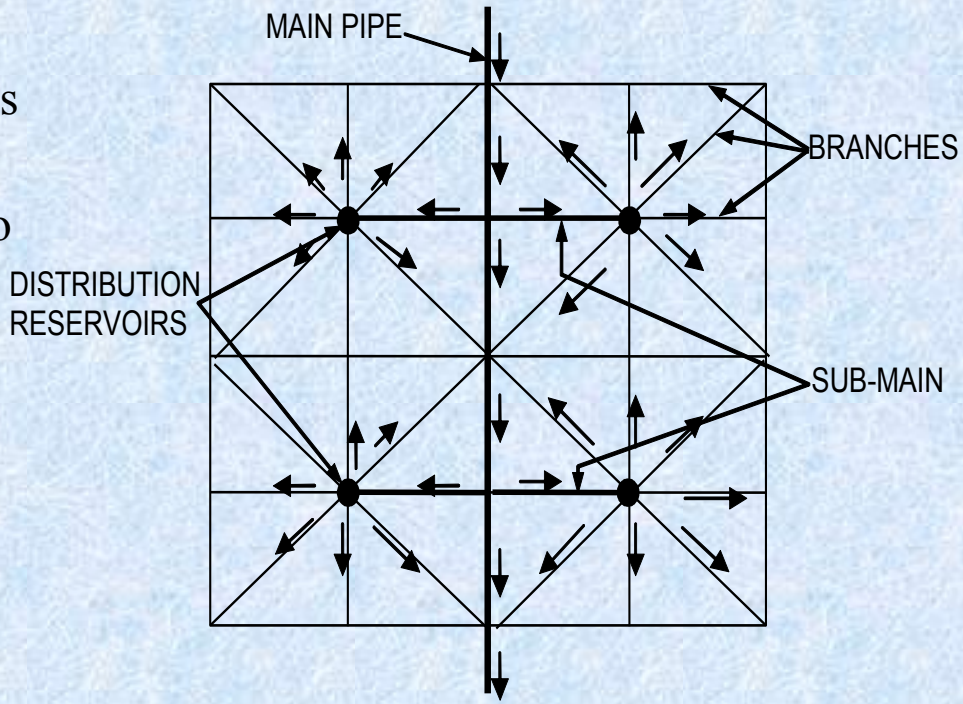


Fig. : Radial System

Summary of Chapter-1

- Regardless of its scale, a Water Supply system contains mainly the source, the collection structures, the treatment and distribution systems
- The sources are either from groundwater and surface water that need the assessment of either hydrogeologist or hydrologist respectively;
- The treatment and collection of water are mainly associated with the intake structures (dams, galleries, wells etc.) and quality which again depend on the sources;
- Distribution systems (whether branched or looped) consists all the arrangements of pipe, pumps, reservoir and others appurtenant structure;
- Demand for water depends on factors that are highly associated with socio-economic activities of end users (Example: population, climate).