WATER DISTRIBUTION NETWORKS

CE 370

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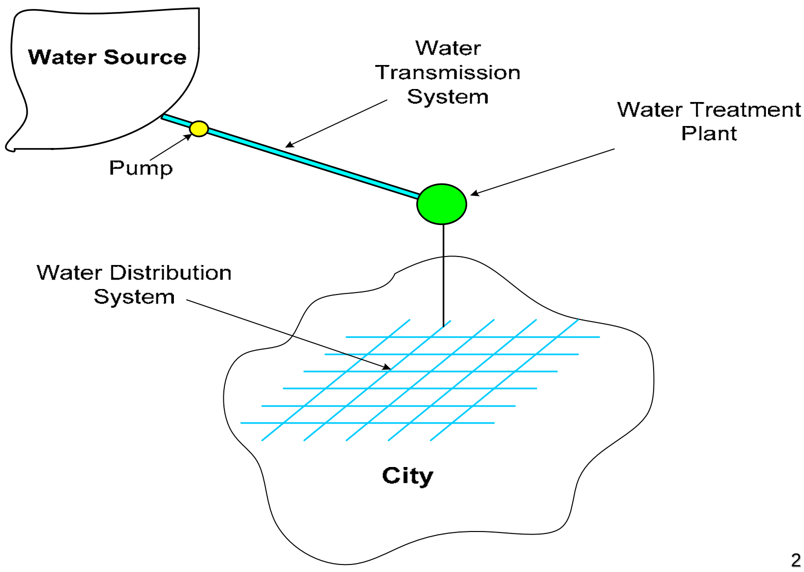
Components of Water Supply System



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Water Transportation System

Types of transportation systems:

Various types of conduits can be used for transporting water. The selection depends on factors such as: topography, head availability, construction practices, economic considerations, and water quality. The types of transportation systems include:

- Open channels.
- Pipelines
- Tunnels

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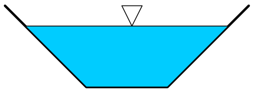
Water Transportation System

- Open channels.



- Designed to convey water under conditions of atmospheric pressure
- May be covered or open and may be of variety of shapes
- Choice of open channel depends on the topography that will permit gravity flow with minimal excavation or fill
- If the soil is pervious, the channel should be lined to prevent seepage
- The potential of pollution hazard and evaporation losses should be considered

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Open Channel

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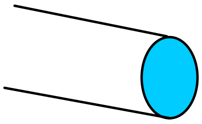
Water Transportation System

- Pipelines:



- Usually built where topographic conditions preclude the use of channels
- May be laid above or below ground or partly buried
- Pressure conduits (pipelines) are built of concrete, steel, cast iron, or plastic
- Pipelines transportation system require gate valves, check valves, air-release valves, drains, surge control equipment, expansion joints, insulation joints, manholes, and pumping stations
- The potential of pollution hazard and evaporation losses should be considered

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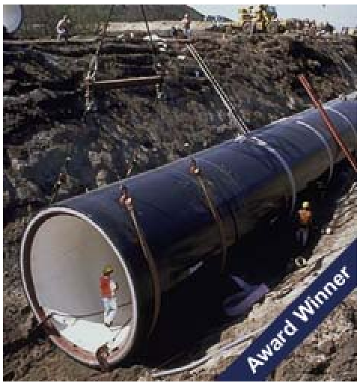
Pipeline



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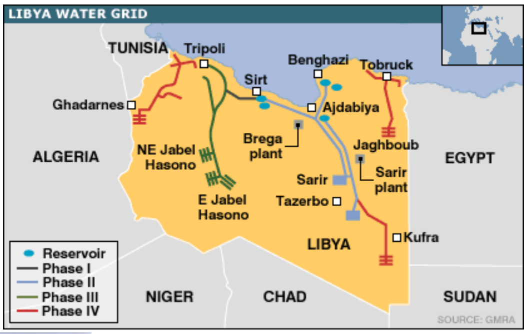
Pipeline



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Water Transportation System

- Tunnels:

  - Where it is not practicle to to lay a pipeline on the surface or provide an open channel, a tunnel is selected
  - Tunnels are well suited to mountain areas
  - They may be operated under pressure or act as an open channel

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Hydraulic considerations

- Pressure conduits:
  - The hydraulic analysis for pressure conduits is carried out using Hazen-Williams equation:

    $V = 1.318\, C\, R^{0.63}\, S^{0.54}$

Where:

V = velocity of flow, fps

C = a coefficient, which is a function of the material and age of the conduit

R = hydraulic radius (flow area divided by the wetted perimeter), ft

S = slope of energy grade line, ft/ft

The values of C for Hazen-Williams equation is given in next table.

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6.2 HYDRAULIC CONSIDERATIC

TABLE 6.1 SOME VALUES OF THE HAZEN–WILLIAMS COEFFICIENT

Pipe Material	*C*	Pipe Material	*C*
New cast iron	130	New welded steel	120
5-yr-old cast iron	120	Asbestos cement	140
20-yr-old cast iron	100	Plastic	150
Average concrete	130		

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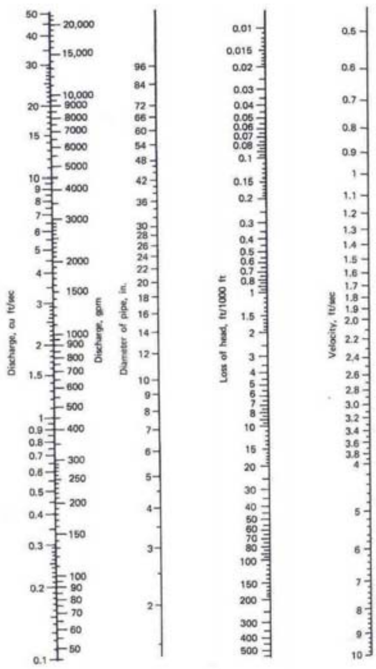
Nomograph for Hazen Williams equation



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Hydraulic considerations

- Open channel:
  - The hydraulic analysis for open channel flow is carried out using Manning equation:

$$V = \frac{1.49}{n} R^{0.66} S^{0.5}$$

Where:

V = velocity of flow, fps

n = coefficient of roughness

R = hydraulic radius (flow area divided by the wetted perimeter), ft

S = slope of energy grade line, ft/ft

The values of n for Manning equation is given in next table.

TABLE 6.2 VALUES OF MANNING'S ROUGHNESS COEFFICIENT

Material	n	Material	n
Concrete	0.013	Corrugated metal pipe	0.022
Cast-iron pipe	0.015	Bituminous concrete	0.015
Vitrified clay	0.014	Uniform, firm sodded earth	0.025
Brick	0.016		

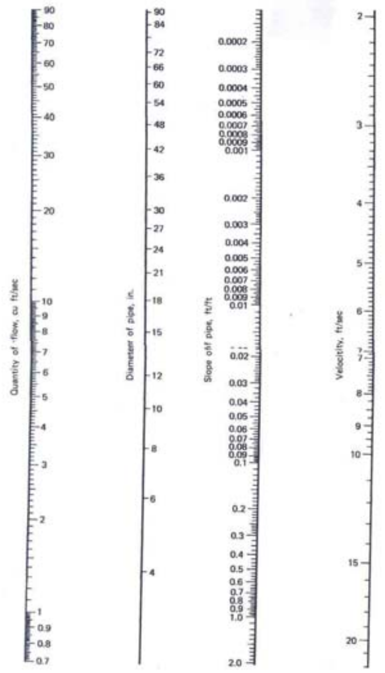

Figure 4-22 Nomograph for Manning formula, Eq. 4-19, for circular pipes flowing full based on $n = 0.013$.

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Hydraulic considerations

- **Head loss:**
  - The head loss as a result of friction can be computed using Darcy-Weisbach equation:

$$h_L = \frac{fLV^2}{2Dg}$$

Where:

h_L = head loss, ft

L = pipe length, ft

D = pipe diameter, ft

f = friction factor

V = flow velocity, fps

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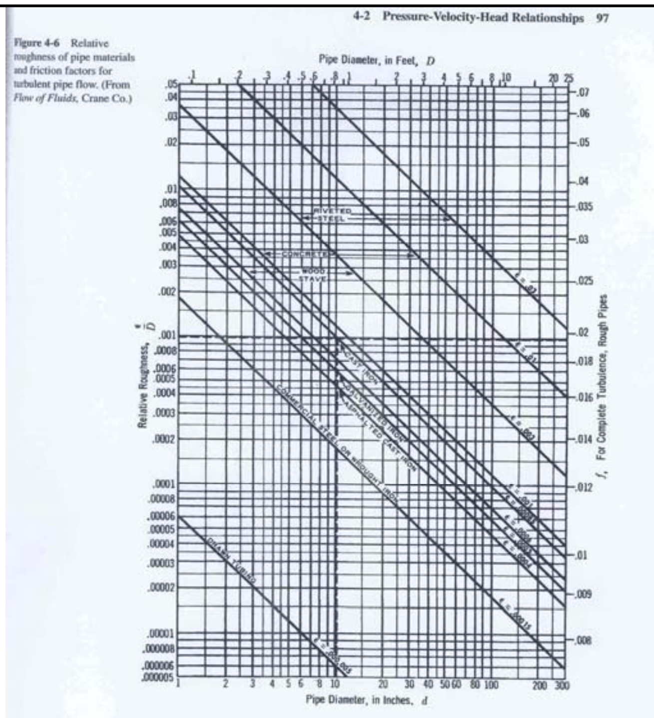

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Hydraulic considerations

- Energy equation:
  - Consider the figure below which shows the element of fluid moving from Section 1 to Section 2.
  - Energy = Pressure energy + Kinetic energy + Potential energy
  - Total energy at Section 1 = $\{p_1/\rho g\} + \{v_1^2/2g\} + z_1$
  - Total energy at Section 2 = $\{p_2/ \rho g\} + \{v_2^2/2g\} + z_2$
  - As there has been no addition or loss of energy between Sections 1 and 2,

    $\{p_1/ \rho g\} + \{v_1^2/2g\} + z_1 = \{p_2/ \rho g\} + \{v_2^2/2g\} + z_2 = E$

    This is Bernoulli's Equation.

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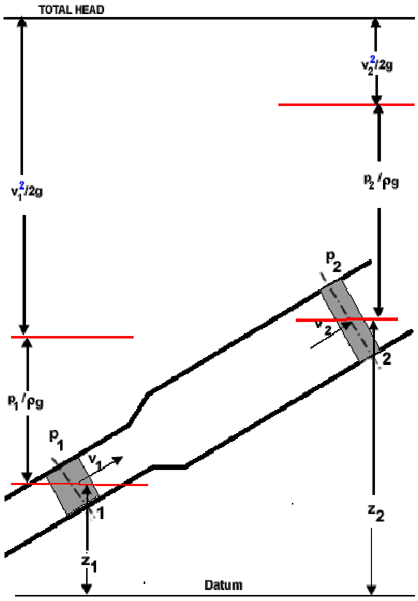

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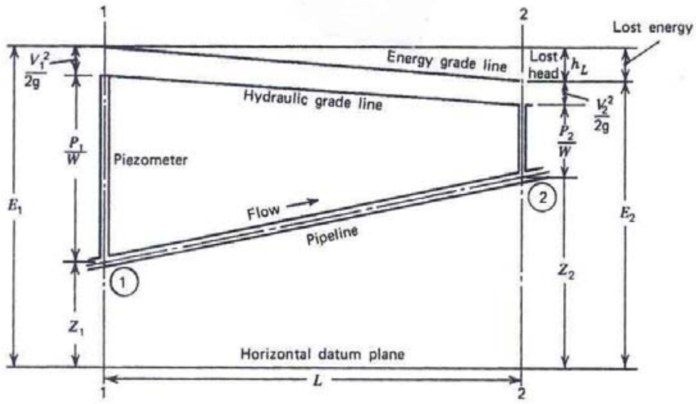
Figure 4-5 Energy equation parameters as related to water flow in a pipe.



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Design of Transportation System

The design of the transportation system involves a determination of:

- Hydraulic adequacy
- Structural adequacy
- Economic efficiency

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Design of Transportation System

➢ Locating the Aqueduct

- The location is mainly based on engineering and economic considerations
- Finding the most practical and economical route between the water source and the region to be served is a challenging issue
  - Open channel require suitable topography
  - Pressure conduits require pumping

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Design of Transportation System

- **Dimensions of Aqueduct**
  - The size will be determined on the basis of hydraulic, economic, and construction considerations.
  - Hydraulic factors that control the design are:
    - Available head
    - Limiting velocities
      - Minimum velocity is 2.5 fps (prevent silt deposition)
      - Maximum velocity between 10-20 fps (reduce pipe erosion)

EXAMPLE 6.1 ■

Consider that water is pumped 10 mi from a reservoir at elevation 100 ft to a second reservoir at elevation 230 ft. The pipeline connecting the reservoirs is 48 in. in diameter and is constructed of concrete with an absolute roughness of 0.003. If the flow is 25 mgd and the efficiency of the pumping station is 80%, what will be the monthly power bill if electricity costs 1 cent kW-h?

Solution

1. Writing the energy equation between a point on the water surface of reservoir *A* and a point on the water surface of reservoir *B*, one obtains

$$Z_A + \frac{P_A}{W} + \frac{V_A^2}{2g} + H_p = Z_B + \frac{P_B}{W} + \frac{V_B^2}{2g} + H_L$$

2. Letting $Z_A = 0$, and noting that $P_A = P_B$ is equal to the atmospheric pressure and that $V_A = V_B$ for a large reservoir, one finds that the equation reduces to

$$H_P = Z_B + H_L$$

where H_P = head developed by the pump
H_L = total head lost between *A* and *B*, including pipe friction and all minor losses

3. Using Fig. 6.1, determine the value of f as 0.0182.
4. Using Eq. 6.4, find the pipe friction head loss. Assuming that the minor losses are negligible in this problem, this is equal to H_L:

$$H_L = f\frac{L}{D}\frac{V^2}{2g}$$

V must be determined before Eq. 6.4 can be solved:

$$V = \frac{Q}{A} = \frac{25 \times 10^6 \times 1.55}{\pi \times 4 \times 10^6} = 3.09 \text{ fps}$$

$$H_L = 0.0182 \times \frac{5280 \times 10}{4} \times \frac{(3.09)^2}{64.4}$$

5. $H_p = (230 - 100) - 35.6$

   $= 130 + 35.6 = 165.6$ ft·lb/lb

   the energy imparted by the pump to the water.

6. The power requirement may be computed as

   $P = Q\gamma H_p$

   $= 25 \times 1.55 \times 62.4 \times 165.6 = 400{,}000$ ft·lb/sec

7. For 80% efficiency, the power requirement is

   $\frac{400{,}000}{0.80} = 500{,}000$ ft·lb/sec

8. $5.00 \times 10^5 \times 3.766 \times 10^{-7} = 18.8 \times 10^{-2}$ kW·h/sec

   The number of kilowatt-hours per 30-day month is then

   $18.8 \times 10^{-2} \times 30 \times 864 \times 10^2 = 485{,}000$ kW·h/month

9. The monthly power cost is therefore $485{,}000 \times 0.01 = \$4{,}850.00$.

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