CE 3372 Water Systems Design
Fall 2016

1. Figure 1 is a portion of an engineering drawing of a gravity-flow wastewater conduit.

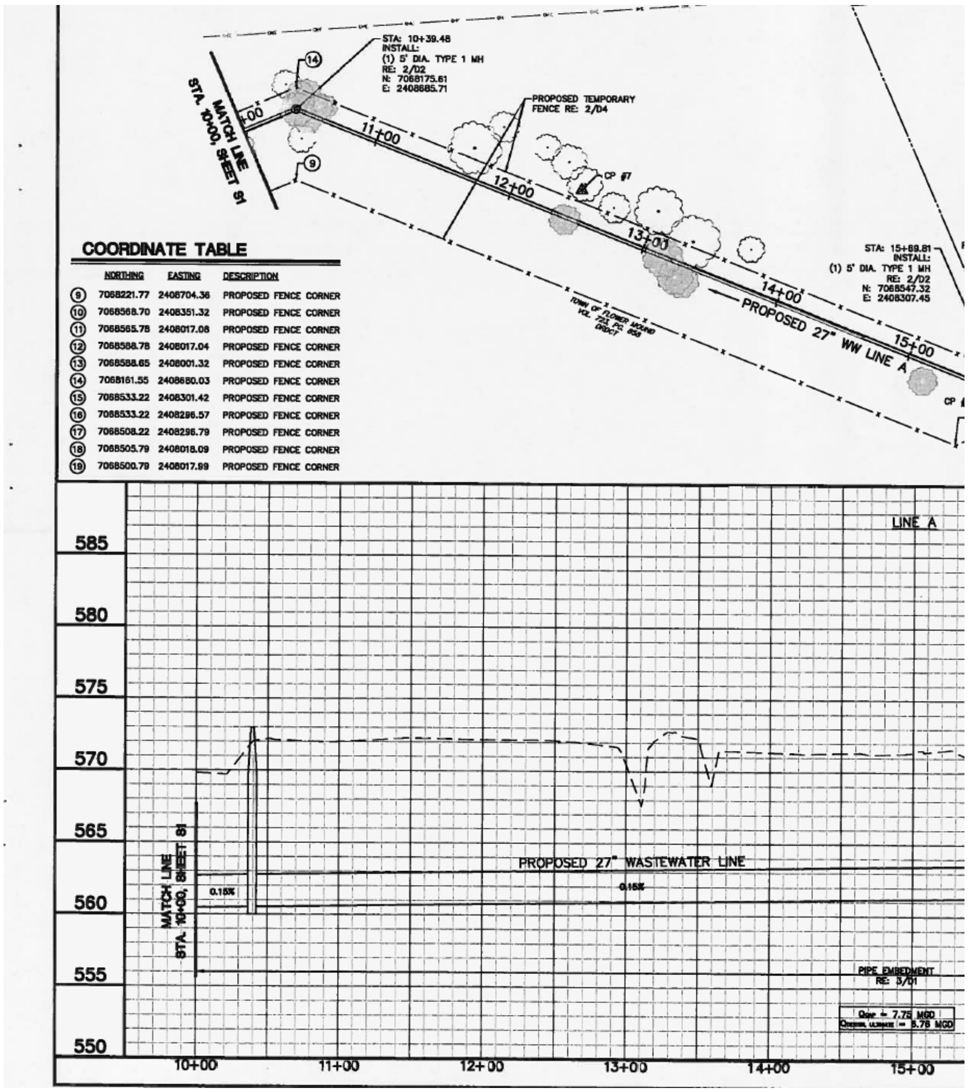

Figure 1: Engineering drawing of sanitary sewer system

(a) What object is located at station 10+38.48?

(b) What is the invert elevation of the pipe at station 13+00?

(c) What is the diameter of the pipe in inches?

(d) What direction is sewage intended to flow?

2. Equation 1 is the Hazen-Williams discharge model for U.S. Customary units.

$$Q = 1.318\ A\ C_h\ R^{0.63}\ S^{0.54} \tag{1}$$

where;

Q is the discharge in ft^3/sec;
A is the cross section area of pipe in ft^2 ($A = \frac{\pi D^2}{4}$; D is the pipe diameter.);
C_h is the Hazen-Williams friction coefficient (depends on pipe roughness);
R is the hydraulic radius in ft; and
S is the slope of the energy grade line ($\frac{h_f}{L}$); L is the length of pipe.

(a) Rearrange the equation in terms of head loss ($h_f = \dots$).

(b) Estimate the head loss in a 12,000 foot length of 6-foot diameter, enamel coated steel pipe that carries carries 60^oF water at a discharge of 295 cubic-feet per second (cfs), using the Hazen-Williams head loss model. Use a Hazen-Williams loss coefficient of $C_h = 150$.

3. Equation 2 is an explicit formula (based on the Darcy-Weisbach head loss model and the Colebrook-White frictional loss equation)for estimating discharge from head loss and material properties.

$$Q = -2.22D^{5/2} \times \sqrt{gh_f/L} \times [log_{10}(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{gh_f/L}})] \quad (2)$$

where;

Q is the discharge in L^3/T;
D is the pipe diameter;
h_f is the head loss in the pipe;
g is the gravitational acceleration constant;
L is the length of pipe;
k_s is the pipe roughness height;
ν is the kinematic viscosity of liquid in the pipe;

Water at 50^oF has kinematic viscosity of $1.45 \times 10^{-5}\ ft^2/s$. The sand roughness of ductile iron is $8.5 \times 10^{-4}\ ft$.

Determine:

(a) Depth of a column of water if the pressure at the bottom of the column is 21 psi?

(b) Estimate the discharge in the 3.2 mile long, 24-inch diameter, ductile iron pipeline connecting points A and B depicted in Figure 2. Point A is 28 feet higher in elevation than point B. The pressure at point B is 21 pounds per square-inch (psi) greater than the pressure at point A.

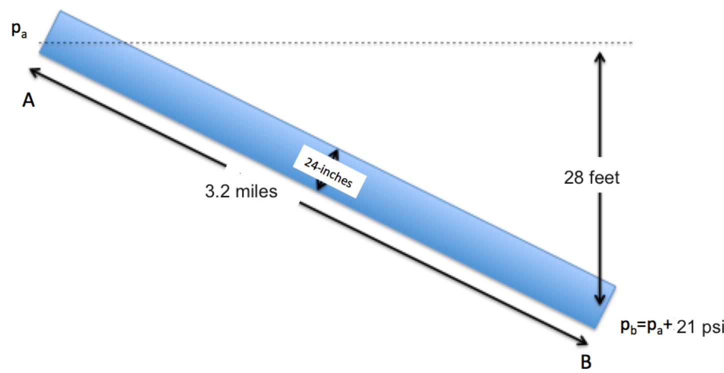

Figure 2: Pipeline Schematic

4. Figure 3 is an aerial image of a parallel pipeline system in California.

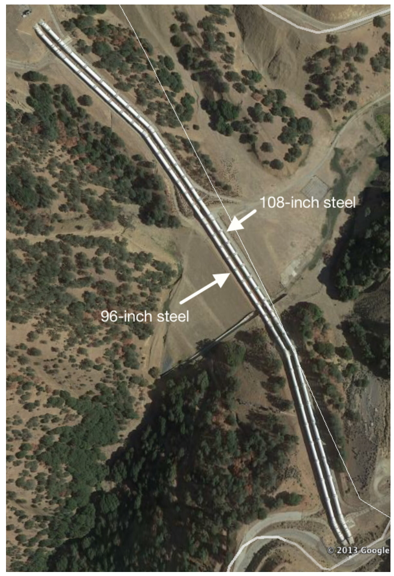

Figure 3: Parallel Pipeline System

The left pipeline is a 96-inch diameter steel pipe, whereas the right pipeline is a 108-inch diameter steel pipe. Water at 50^oF has kinematic viscosity of $1.45 \times 10^{-5}\ ft^2/s$. The sand roughness of ductile iron is $1.64 \times 10^{-4}\ ft$. If the head loss for the two one-mile long pipelines between the thrust blocks is 100 feet, determine the discharge in each pipe in cubic-feet-per-second.

Problem 3 (continued)

Figure 4 is a pipe network with the following properties:

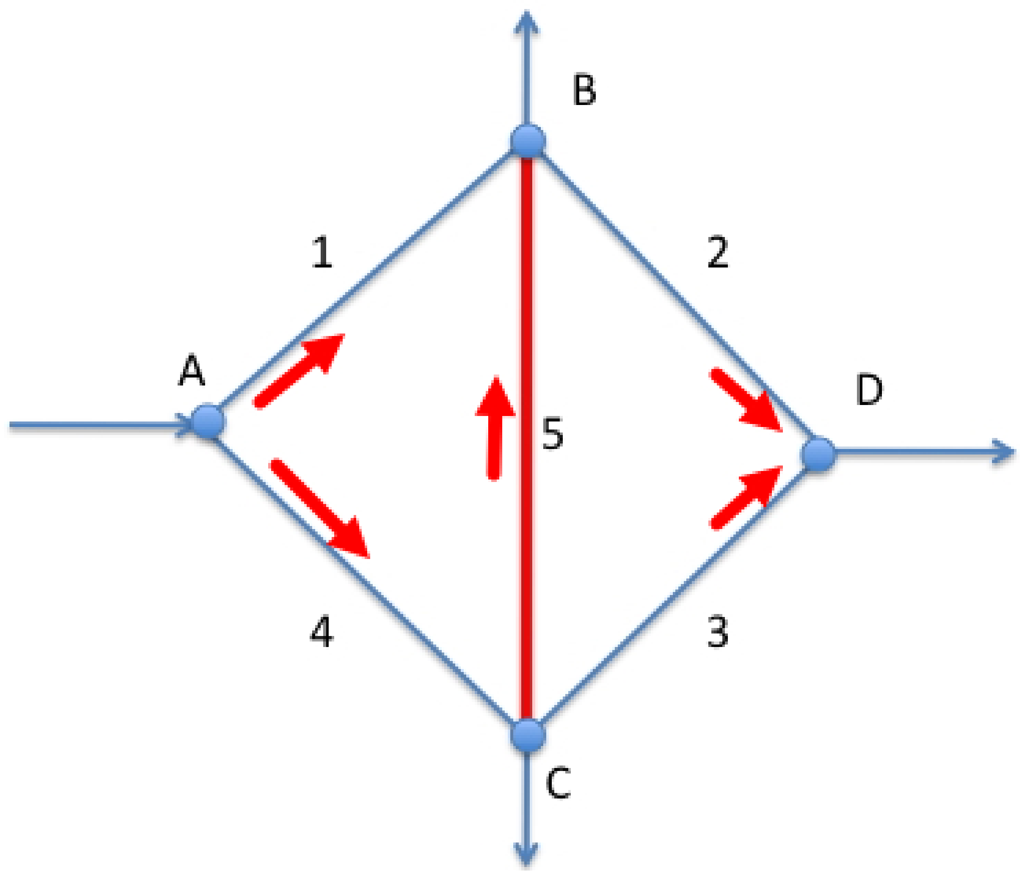

Figure 4: Pipe network

Table 1: Network properties for Figure 4

Node	Demand (cfs)	Elevation(ft)
A	-0.60	0.00
B	0.15	0.00
C	0.15	0.00
D	0.30	0.00
Pipe	**Length (ft)**	**Diameter (ft)**
1	1000	3/12
2	1000	3/12
3	1000	3/12
4	1000	3/12
5	1400	3/12

5. Referring to Figure 4, the discharge in pipe 5 is closest to
   (A) 0.00 cfs, from Node B to Node C
   (B) 0.15 cfs, from Node C to Node B
   (C) 0.66 cfs, from Node C to Node B
   (D) 0.66 cfs, from Node B to Node C
6. Referring to Figure 4, if the demands at all nodes are those in Table 1, and pipe 2 is decreased to a diameter of 2/12, the discharge in pipe 5 is closest to
   (A) 0.00 cfs, from Node C to Node B
   (B) 0.15 cfs, from Node B to Node C
   (C) 0.30 cfs, from Node C to Node B
   (D) 0.60 cfs, from Node B to Node C
7. Referring to Figure 4, assuming the average friction factor is 0.018, the head loss, in feet, from Node A to Node C (when all pipes are the same diameter) is closest to
   (A) 12 feet
   (B) 25 feet
   (C) 50 feet
   (D) 75 feet
8. Referring to Figure 4, and Table 1 the flow distribution is:
   (A) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.00] CFS
   (B) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.30] CFS
   (C) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.00,0.50] CFS
   (D) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,-0.15,-0.15,0.30,-0.60] CFS
9. An EPANET model must have which of the following components to run
   (A) A pipe, a node, and a pump
   (B) A pipe, a node, and a valve
   (C) A pipe, a tank, and a pump
   (D) A pipe, a node, and a reservoir