CE 3372 Water Systems Design
Exam 3
Spring 2016

1. Equation 1 is the Hazen-Williams head loss model.

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

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 ($h_f = \ldots$).

+4

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

$$S^{0.54} = \frac{Q}{1.318\ A C_h R^{0.63}}$$ divide both sides by 1.318A ...

$$S = \frac{h_f}{L} = \left[\frac{Q}{1.318\ A\ C_h R^{0.63}}\right]^{\frac{1}{0.54}}$$ exponentiate both sides by $\frac{1}{0.54}$

$$h_f = \left[\frac{Q}{1.318 A C_h R^{0.63}}\right]^{\frac{1}{0.54}} \cdot L$$ multiply both sides by L - desired structure

(b) Estimate the head loss in a 10,000 foot length of 5-foot diameter, enamel coated steel pipe that carries carries 60°F 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 $C_h = 150$.

+5

compute A $A = \frac{\pi D^2}{4} = \frac{\pi (5)^2}{4} = 19.635 ft^2$

compute R $R = \frac{D}{4} = \frac{5}{4} = 1.25 ft;\ R^{0.63} = (1.25)^{0.63} = 1.1509417$

exponent as a float $\frac{1}{0.54} = 1.85186$

substitute numbers & check units $h_f = \left[\frac{295 ft^3/s}{1.318 (19.365 ft^2)(150)(1.25 ft)^{0.63}}\right]^{\frac{1}{0.54}} \cdot (10{,}000 ft)$

calculate $h_f = [0.0669491 s]^{1.85186} \cdot (10{,}000 ft)$

calculate $= 0.0066904 s^{-1} (10{,}000 ft) = 69.4 ft$

10pts

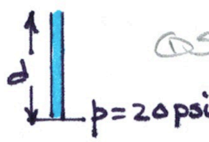
 Name: SOLUTION +1

2. 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;



① STATIC FLUID

$d = \frac{p}{\gamma} = \frac{20 psi \cdot 144 \frac{si}{ft^2}}{62.4 \frac{lbf}{ft^3}} = 46.154 ft$

PRES. HEAD

Water at 50°F 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 20 psi? +4

(b) Estimate the discharge in the 3 mile long, 24-inch diameter, ductile iron pipeline connecting points A and B depicted in Figure 1. Point A is 30 feet higher in elevation than point B. The pressure at point B is 20 pounds per square-inch (psi) greater than the pressure at point A.

$V_a = V_b$

ENERGY

$\frac{p_a}{\gamma} + \cancel{\frac{V_a^2}{2g}} + z_a = \frac{p_b}{\gamma} + \cancel{\frac{V_b^2}{2g}} + z_b + h_f$

ALGEBRA

$(\frac{p_a - p_b}{\gamma}) + (z_a - z_b) = h_f$

$(\frac{\cancel{p_a} - \cancel{p_a} - 20psi}{\gamma}) + (30ft) = h_f$

SUBSTITUTE VALUES

$30ft - \underbrace{(\frac{20psi}{\gamma})}_{46.154ft \text{ (from (a))}} = h_f$

$30ft - 46.154ft = h_f$

$-16.154ft = h_f$

∴ FLOW FROM B→A

INTERMEDIATE CONCLUSION.

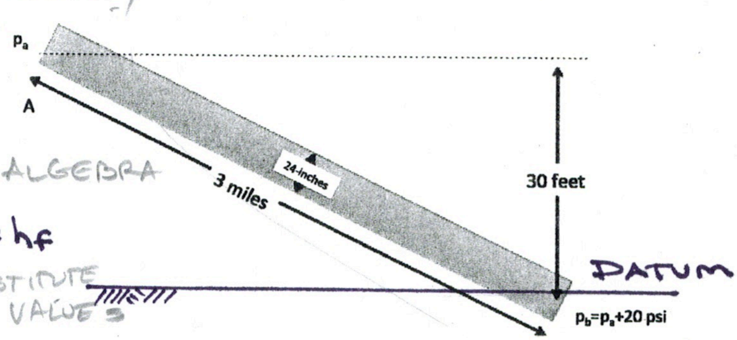


Figure 1: Pipeline Schematic

NOW JAIN EQN:

FIRST "CONSTANTS"

EVALUATE PARTS THAT DON'T CHANGE

$-2.22(2ft)^{5/2} = -12.558$

$\frac{8.5 \cdot 10^{-4} ft}{3.7(2ft)} = 1.1486 \cdot 10^{-4}$

$\frac{1.78(1.45 \cdot 10^{-5} ft^2/s)}{(2ft)^{3/2}} = 9.1252 \cdot 10^{-6}$

$\frac{(32.2 ft/s^2)(16.154 ft)}{3(5280 ft)} = 3.2838 \cdot 10^{-2}$

$(3.2838 \cdot 10^{-2})^{1/2} = 1.8121 \cdot 10^{-1}$

THEN: $Q = -12.558(1.8121 \cdot 10^{-1}) \times \log_{10}[1.1486 \cdot 10^{-4} + \frac{9.1252 \cdot 10^{-6}}{1.8121 \cdot 10^{-1}}]$

ARITHMETIC

$= 8.606 ft^3/s$

RESULT

+5

REVISION A

10PTS

3. Figure 2 is an aerial image of a parallel pipeline system in California.

Use "EQUATION" PRIOR PROBLEM
NEED CONSTANTS FOR EASIER CALCULATE

LEFT

96in = 8ft

$D^{5/2} = (8)^{5/2} = 181.02$

$D^{3/2} = (8)^{3/2} = 22.62$

$\frac{k_s}{3.7D} = \frac{1.64 \cdot 10^{-4} ft}{3.7(8ft)} = 5.5405 \cdot 10^{-6}$

$\frac{1.78\nu}{D^{3/2}} = \frac{1.78(1.45 \cdot 10^{-5} ft^2/s)}{22.62} = 1.141 \cdot 10^{-6}$

$\frac{gh_f}{L} = \frac{(32.2 ft/s^2)(100ft)}{5280ft} = 0.6098$

$\sqrt{0.6098} = 0.7809$

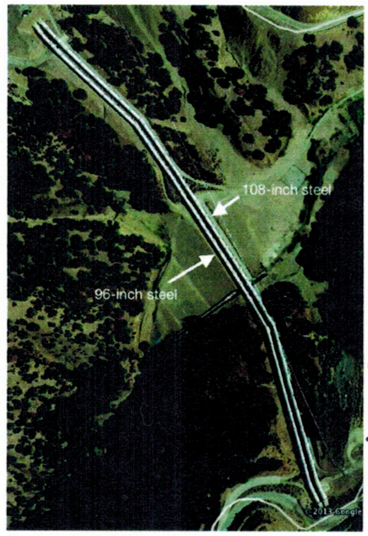


Figure 2: Parallel Pipeline System

RIGHT

108in = 9ft

$D^{5/2} = (9)^{5/2} = 243$

$D^{3/2} = (9)^{3/2} = 27$

$\frac{k_s}{3.7D} = \frac{1.64 \cdot 10^{-4} ft}{3.7(9ft)} = 4.9249 \cdot 10^{-6}$

$\frac{1.78\nu}{D^{3/2}} = \frac{1.78(1.45 \cdot 10^{-5} ft^2/s)}{27} = 9.5593 \cdot 10^{-7}$

$\frac{gh_f}{L} = \frac{(32.2 ft/s^2)(100ft)}{5280} = 0.6098$

$\sqrt{0.6098} = 0.7809$

The left pipeline is a 96-inch diameter steel pipe, whereas the right pipeline is a 108-inch diameter steel pipe. Water at 50°F has kinematic viscosity of $1.45 \times 10^{-5}\ ft^2/s$. The sand roughness of ~~ductile iron~~ steel 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.

$$Q = -2.22 D^{5/2} \cdot \sqrt{\frac{gh_f}{L}} \cdot \log_{10}\left[\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{\frac{gh_f}{L}}}\right]$$ (EQN +1)

LEFT

(ARITHMETIC & CONSTANTS)

$Q_L = -2.22(181.02)(0.7809) \cdot \log_{10}\left[5.5405 \cdot 10^{-6} + \frac{1.141 \cdot 10^{-6}}{0.7809}\right]$ * +2

$= 1.6177 \cdot 10^3$

$= 1617.7$ cfs (# + UNIT) 2

RIGHT

(ARITHMETIC & CONSTANTS)

$Q_R = -2.22(243)(0.7809) \cdot \log_{10}\left[4.9249 \cdot 10^{-6} + \frac{9.5593 \cdot 10^{-7}}{0.7809}\right]$ * +2

$= 2.2108 \cdot 10^3$

$= 2210.8$ cfs (# + UNIT) +2

+10 PTS

4. A 24-inch diameter sewer pipe, with Manning's n of 0.015 is laid on slope $S_0 = 0.01$ as shown in Figure 3.

D = 2 ft

$D^2 = 4 ft^2$

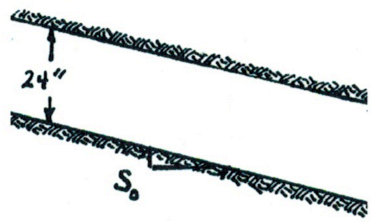


Figure 3: Sewer pipe sketch

Equation 3 is the depth-area equation and Equation 4 is the depth-perimeter equation for a circular conduit where the flow area is A, the flow depth is y, the diameter is D. and the wetted perimeter is P_w. Use Equations 3 and 4 and Manning's equation to complete Table 1.

$$A = \frac{D^2}{4}\{[cos^{-1}(1-\frac{2y}{D})] - [sin(cos^{-1}(1-\frac{2y}{D}))] \times [cos(cos^{-1}(1-\frac{2y}{D}))]\} \quad (3)$$

D. IN FT & y/D +1

$$P_w = D \times cos^{-1}(1-\frac{2y}{D}) \quad (4)$$

Table 1: Depth-Area; Perimeter, Radius, Discharge Function Values for a Circular Pipe

y (ft)	A (ft^2)	P_w (ft)	R_h (ft)	Q (ft^3/sec)
1.00	1.5708 ft^2 +1	3.14159 ft +1	0.5 ft +1	$99.33 A R^{2/3} (0.1)$ 9.82 cfs +1
2.00	3.1416 ft^2 +1	6.2831 ft +1	0.5 ft +1	$99.33 A R^{2/3} (0.1)$ 19.65 cfs +1

DON'T NEED EQUATIONS INSTEAD OBSERVE

$y=1$ $\frac{y}{D} = \frac{1}{2}$ ½ FULL! $A = \frac{\pi D^2}{4} \cdot \frac{1}{2}$; $P_w = \frac{\pi D}{2}$; $R_h = \frac{D}{4}$

$y=2$ $\frac{y}{D} = 1$ FULL! $A = \frac{\pi D^2}{4}$; $P_w = \pi D$; $R_h = \frac{D}{4}$

$\frac{\pi D^2}{4 \cdot 2} / \frac{\pi D}{2}$

MANNING'S

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

$\frac{1.49}{(0.015)} = 99.33$

$(0.01)^{1/2} = 0.1$

+10 PTS

5. Figure 4 is a sketch of a 24 inch line with Manning's n of 0.015, laid on a slope of 0.01, connecting to a 48 inch line (also at 0.01) at a junction box. The flowlines (invert elevations) match at the junction box. The downstream boundary conditions cause the flow depth in the 48 line to be 12 inches deep.

a) What is the likely flow depth in the 24 inch line (at the junction box)?

+2 12 INCHES

b) What is the discharge in the 24 inch line, assuming normal flow at the flow depth in the junction box?

+2 IF NORMAL @ 12 INCHES

$Q_{1/2} = 9.82$ cfs (PRIOR PROBLEM)

c) What is the discharge in the 24 inch line, assuming normal flow, when the pipe (24 inch) is full?

+2 IF NORMAL @ 24 INCHES

$Q_{FULL} = 19.65$ cfs (PRIOR PROBLEM)

d) What is the unused flow capacity in the 24 inch line?

+3 UNUSED: $Q_{FULL} - Q_{1/2\ FULL} = 19.65 - 9.82$

~ 9.83 cfs AVAILABLE.

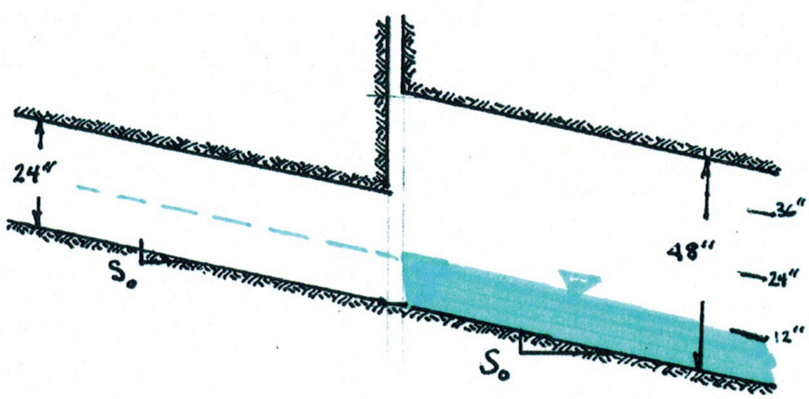


Figure 4: Sewer pipes connected at a junction box. Flowlines matched.

10 PTS

6. Figure 5 is a sketch of a 24 inch line with Manning's n of 0.015, laid on a slope of 0.01, connecting to a 48 inch line (also at 0.01) at a junction box. The soffit(crown) elevations match at the junction box. The downstream boundary conditions cause the flow depth in the 48 line to be 36 inches deep.

   a) What is the likely flow depth in the 24 inch line (at the junction box)?

   +2 12 INCHES

   b) What is the discharge in the 24 inch line, assuming normal flow at the flow depth in the junction box?

   +2 $Q_{1/2} = 9.82$ cfs (PROB 4)

   c) What is the discharge in the 24 inch line, assuming normal flow, when the pipe (24 inch) is full?

   +2 $Q_{2/2} = 19.65$ cfs (PROB 4)

   d) What is the unused flow capacity in the 24 inch line?

   +3 UNUSED = 19.65 − 9.82 = 9.83 cfs AVAILABLE

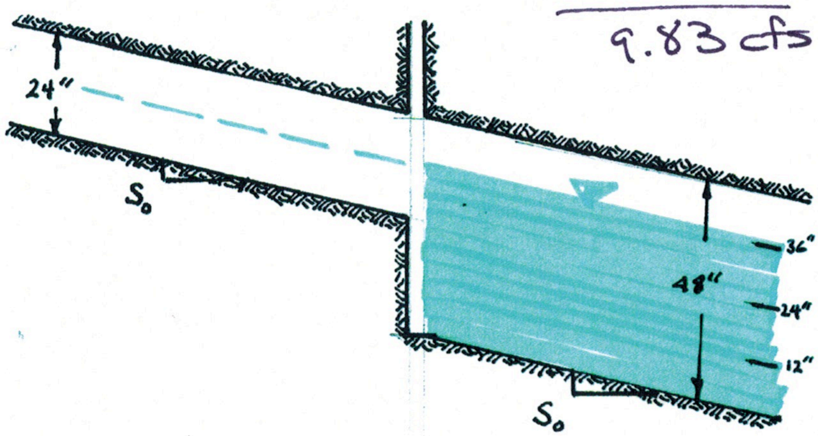


Figure 5: Sewer pipes connected at a junction box. Matching soffit elevations.

10 PTS

7. Figure 6 is a sketch of a 24 inch line with Manning's n of 0.015, laid on a slope of 0.01, connecting to a 48 inch line (also at 0.01) at a junction box. The flowlines (invert elevations) match at the junction box. The downstream boundary conditions cause the flow depth in the 48 line to be 36 inches deep.

a) What is the likely flow depth in the 24 inch line (at the junction box)?

+2 24 INCHES – PIPE IS FULL (HGL PROBABLY ABOVE SOFFIT!)

b) What is the discharge in the 24 inch line, assuming normal flow at the flow depth in the junction box?

+2 19.65 cfs (PROB 4)

c) What is the discharge in the 24 inch line, assuming normal flow, when the pipe (24 inch) is full?

+2 19.65 cfs (PROB 4)

d) What is the unused flow capacity in the 24 inch line?

+3 UNUSED = 19.65 − 19.65 = 0 cfs AVAILABLE

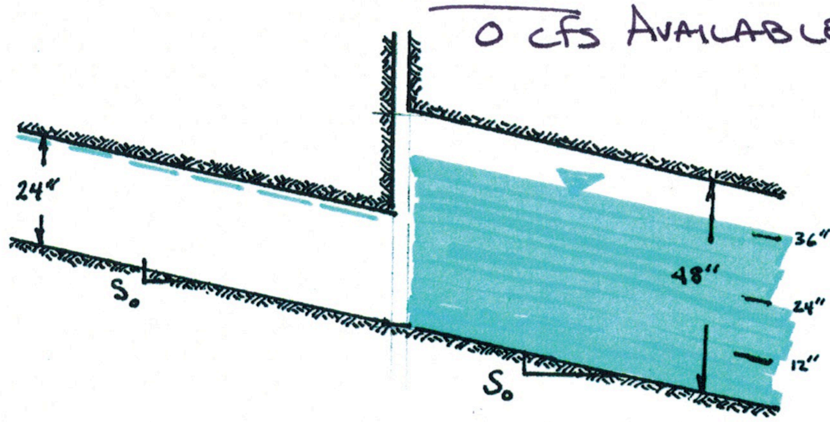


Figure 6: Sewer pipes connected at a junction box. Matching flowline elevations.

10 PTS

8. An EPA-NET simulation model for a reservoir-pump-network was constructed and operated for four (4) different operational scenarios. Figure 7 is a depiction of the network. The numbers next to the nodes are Node_ID values in the reports that follow, and the numbers next to the pipes are the Link_ID values. The network is supplied from a reservoir through a booster pump, both are depicted on Figure 7.

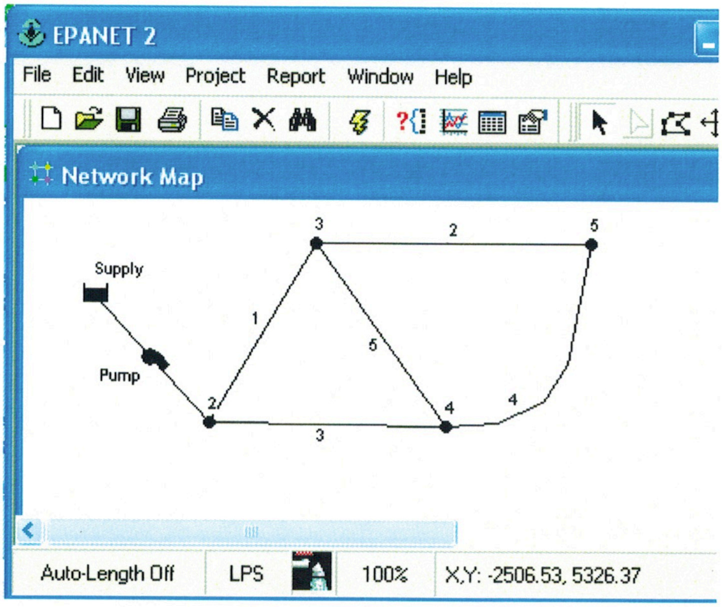


Figure 7: EPA-NET system topology.

Figure 8 is the a portion of the summary report for simulation 1. Figure 9 is the a portion of the summary report for simulation 2. Figure 10 is the a portion of the summary report for simulation 3. Figure 11 is the a portion of the summary report for simulation 4.

These four simulation represent different demand scenarios for the same system.

1 PT THIS PAGE

Interpret these reports, to answer the following questions:

(a) Complete the table below. Q_{pump} is the discharge in liters-per-second through the pump station, H_{Supply} is the head at the supply reservoir, H_{Node2} is the head at Node 2, and ΔH_{pump} is the added head supplied by the pump.

VALUES FROM

Table 2: Pump Discharge and Supplied Head

Simulation #	Q_{pump}	H_{Supply}	H_{Node2}	ΔH_{pump}	
1	0 LPS	0 m	20.0 m	20.0 m	pg 11
2	3 LPS	0 m	19.28 m	19.28 m	pg 12
3	6 LPS	0 m	17.12 m	17.12 m	pg 13
4	9 LPS	0 m	13.52 m	13.52 m	pg 14

(b) Complete the table below. Q_{pump} is the discharge in liters-per-second through the pump station, $\Delta H_{Node2-to-5}$ is head loss in the system from Node 2 to Node 5.

Table 3: System Discharge and Head Loss

Simulation #	Q_{pump}	H_{Node2}	H_{Node5}	$\Delta H_{Node2-to-5}$	VALUES FROM
1	0 LPS	20.0 m	20.0 m	0.0 m	pg 11
2	3 LPS	19.28 m	18.99 m	0.29 m	pg 12
3	6 LPS	17.12 m	16.04 m	1.08 m	pg 13
4	9 LPS	13.52 m	11.15 m	2.37 m	pg 14

16 PTS

+5

(c) If the pump performance curve has the mathematical structure: $H_{pump} = H_{shutoff} - K_{pipe} \times Q^2$, estimate the values of $H_{shutoff}$ and K_{pipe}.

+1 $20 = H_S - K_P(0)^2 \rightarrow \underline{20 = H_S}$ +1

$19.28 = H_S - K_P(3)^2$

+1 $17.12 = H_S - K_P(6)^2$

$13.52 = H_S - K_P(9)^2$

$\frac{19.28-20}{9} = -K_P = -0.08$

+1 $\frac{17.12-20}{36} = -K_P = -0.08$ $\therefore$ $\underline{K_P = 0.08}$ +1

$\frac{13.52-20}{81} = -K_P = -0.08$

PUMP CURVE

$H_P = 20 - 0.08Q^2$

(d) If the system frictional loss curve has the mathematical structure: $H_{pipe} = K_{loss} \times Q^2$, Q IN LPS estimate the value of K_{loss} USE $\Delta H_{2\rightarrow5}$

+5

$0 = K_L 0^2$

$0.29 = K_L(3)^2$ $K_L = \frac{0.29}{9} = 0.032$

$1.08 = K_L(6)^2$ $K_L = \frac{1.08}{36} = 0.03$ $\bar{K}_L = 0.03$

$2.37 = K_L(9)^2$ $K_L = \frac{2.37}{81} = 0.029$

SYSTEM CURVE

$H_P = 0.03Q^2$

Q IN LPS

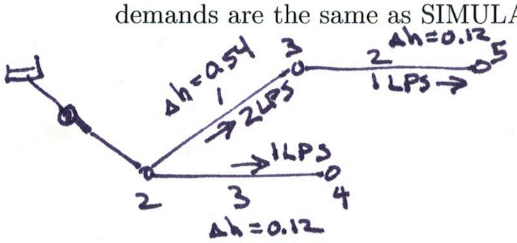
(e) What effect would removing the pipe joining nodes 3 and 4 have on the system performance? Explain your reasoning.

+2

NO CHANGE – PIPE 5 CARRIES ZERO FLOW ALL SIMULATIONS

(f) Estimate the flow distribution and head losses the the system if the the pipe joining nodes 3 and 4 are removed, and the pipe joining node 4 and 5 is removed if the nodal demands are the same as SIMULATION 2.

+5



NODE	DEMAND	HEAD
2	0.0 LPS	19.28
3	1.0	18.74
4	1.0	19.16
5	1.0	18.62

NO CALCULATIONS – USE OTHER SIMULATIONS
– FIND $\overline{\Delta H}$ IN LINKS BY AVERAGING TWO VALUES IN TABLES

LINK	FLOW	ΔH
1	2.0 LPS	0.54
2	1.0 LPS	0.12
3	1.0 LPS	0.12

18 PTS

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Page 1                                              10/4/2010 2:27:47 PM
**********************************************************************
*                            E P A N E T                             *
*                    Hydraulic and Water Quality                     *
*                    Analysis for Pipe Networks                      *
*                            Version 2.0                             *
**********************************************************************
Input File: SIMULATION #1
Link - Node Table:
----------------------------------------------------------------------
Link            Start           End                  Length  Diameter
ID              Node            Node                      m        mm
----------------------------------------------------------------------
1               2               3                      1000       124
2               3               5                      1000       124
3               2               4                      1000       124
4               4               5                      1000       124
5               3               4                      1400       124
7               6               2                      #N/A      #N/A Pump
Node Results:
----------------------------------------------------------------------
Node                  Demand       Head  Pressure   Quality
ID                       LPS          m         m
----------------------------------------------------------------------
2                       0.00      20.00     20.00      0.00
3                       0.00      20.00     20.00      0.00
4                       0.00      20.00     20.00      0.00
5                       0.00      20.00     20.00      0.00
6                       0.00       0.00      0.00      0.00 Reservoir
Link Results:
----------------------------------------------------------------------
Link                    Flow  VelocityUnit Headloss    Status
ID                       LPS       m/s       m/km
----------------------------------------------------------------------
1                       0.00      0.00       0.00      Open
2                       0.00      0.00       0.00      Open
3                       0.00      0.00       0.00      Open
4                       0.00      0.00       0.00      Open
5                       0.00      0.00       0.00      Open
7                       0.00      0.00     -20.00      Open Pump
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Figure 8: EPA-NET Summary Report, Simulation #1

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Page 1                                          10/4/2010 2:28:15 PM
**********************************************************************
*                           E P A N E T                              *
*                   Hydraulic and Water Quality                      *
*                   Analysis for Pipe Networks                       *
*                          Version 2.0                               *
**********************************************************************
Input File: SIMULATION 2
Link - Node Table:
----------------------------------------------------------------------
Link           Start          End                 Length  Diameter
ID             Node           Node                     m        mm
----------------------------------------------------------------------
1              2              3                     1000       124
2              3              5                     1000       124
3              2              4                     1000       124
4              4              5                     1000       124
5              3              4                     1400       124
7              6              2                     #N/A      #N/A Pump
Node Results:
----------------------------------------------------------------------
Node                Demand       Head  Pressure   Quality
ID                     LPS          m         m
----------------------------------------------------------------------
2                     0.00      19.28     19.28      0.00
3                     1.00      19.03     19.03      0.00
4                     1.00      19.03     19.03      0.00
5                     1.00      18.99     18.99      0.00
6                    -3.00       0.00      0.00      0.00 Reservoir
Link Results:
----------------------------------------------------------------------
Link                  Flow  VelocityUnit Headloss     Status
ID                     LPS       m/s      m/km
----------------------------------------------------------------------
1                     1.50      0.12      0.25       Open
2                     0.50      0.04      0.03       Open
3                     1.50      0.12      0.25       Open
4                     0.50      0.04      0.03       Open
5                     0.00      0.00      0.00       Open
7                     3.00      0.00    -19.28       Open Pump
```

Figure 9: EPA-NET Summary Report, Simulation #2

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 Page 1                                            10/4/2010 2:29:00 PM
**********************************************************************
*                           E P A N E T                              *
*                   Hydraulic and Water Quality                      *
*                   Analysis for Pipe Networks                       *
*                          Version 2.0                               *
**********************************************************************
 Input File: SIMULATION 4
Link - Node Table:
 ----------------------------------------------------------------------
 Link              Start           End                Length  Diameter
 ID                Node            Node                    m        mm
 ----------------------------------------------------------------------
 1                 2               3                    1000       124
 2                 3               5                    1000       124
 3                 2               4                    1000       124
 4                 4               5                    1000       124
 5                 3               4                    1400       124
 7                 6               2                    #N/A      #N/A Pump
Node Results:
 ----------------------------------------------------------------------
 Node                    Demand        Head  Pressure   Quality
 ID                         LPS           m         m
 ----------------------------------------------------------------------
 2                         0.00       17.12     17.12      0.00
 3                         2.00       16.16     16.16      0.00
 4                         2.00       16.16     16.16      0.00
 5                         2.00       16.04     16.04      0.00
 6                        -6.00        0.00      0.00      0.00 Reservoir
Link Results:
 ----------------------------------------------------------------------
 Link                      Flow  VelocityUnit Headloss    Status
 ID                         LPS         m/s      m/km
 ----------------------------------------------------------------------
 1                         3.00        0.25      0.96      Open
 2                         1.00        0.08      0.12      Open
 3                         3.00        0.25      0.96      Open
 4                         1.00        0.08      0.12      Open
 5                         0.00        0.00      0.00      Open
 7                         6.00        0.00    -17.12      Open Pump
```

Figure 10: EPA-NET Summary Report, Simulation #3

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Page 1                                          10/4/2010 2:29:46 PM
**********************************************************************
*                            E P A N E T                             *
*                    Hydraulic and Water Quality                     *
*                    Analysis for Pipe Networks                      *
*                           Version 2.0                              *
**********************************************************************
Input File: SIMULATION 3
Link - Node Table:
----------------------------------------------------------------------
Link            Start           End                  Length  Diameter
ID              Node            Node                      m        mm
----------------------------------------------------------------------
1               2               3                      1000       124
2               3               5                      1000       124
3               2               4                      1000       124
4               4               5                      1000       124
5               3               4                      1400       124
7               6               2                      #N/A      #N/A Pump
Node Results:
----------------------------------------------------------------------
Node                 Demand       Head  Pressure   Quality
ID                      LPS          m         m
----------------------------------------------------------------------
2                      0.00      13.52     13.52      0.00
3                      3.00      11.40     11.40      0.00
4                      3.00      11.40     11.40      0.00
5                      3.00      11.15     11.15      0.00
6                     -9.00       0.00      0.00      0.00 Reservoir
Link Results:
----------------------------------------------------------------------
Link                   Flow VelocityUnit Headloss    Status
ID                      LPS        m/s      m/km
----------------------------------------------------------------------
1                      4.50       0.37      2.12     Open
2                      1.50       0.12      0.25     Open
3                      4.50       0.37      2.12     Open
4                      1.50       0.12      0.25     Open
5                      0.00       0.00      0.00     Open
7                      9.00       0.00    -13.52     Open Pump
```

Figure 11: EPA-NET Summary Report, Simulation #4

9. Attached is a SWMM input file for a particular sewer system. Using the file:

   (a) Draw a plan-view sketch of system. Label nodes and links, indicate flow direction. Indicate where flow enters the system and where it exits the system.

   (b) Draw an elevation view sketch of system (indicate sewer crown, invert, and water surface elevation as indicated by the files.

   +1 (c) Which drawing below is representative of the downstream (outfall) boundary condition in the SWMM model?

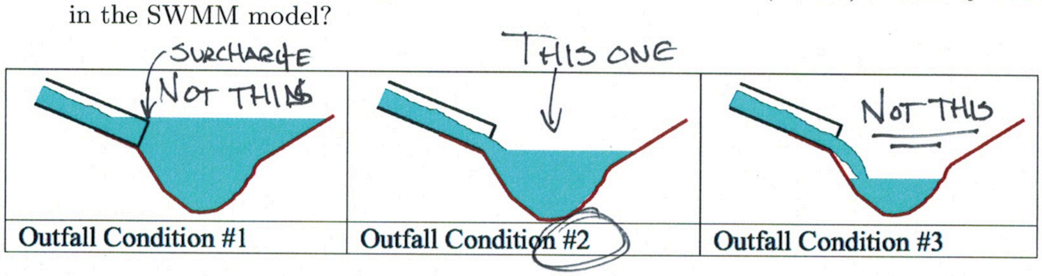
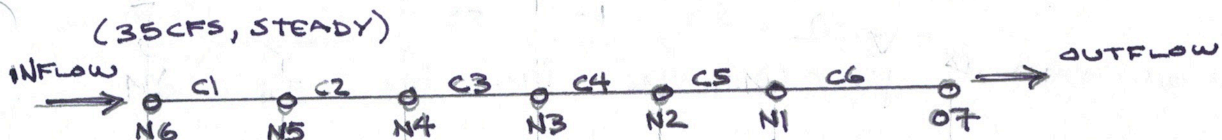


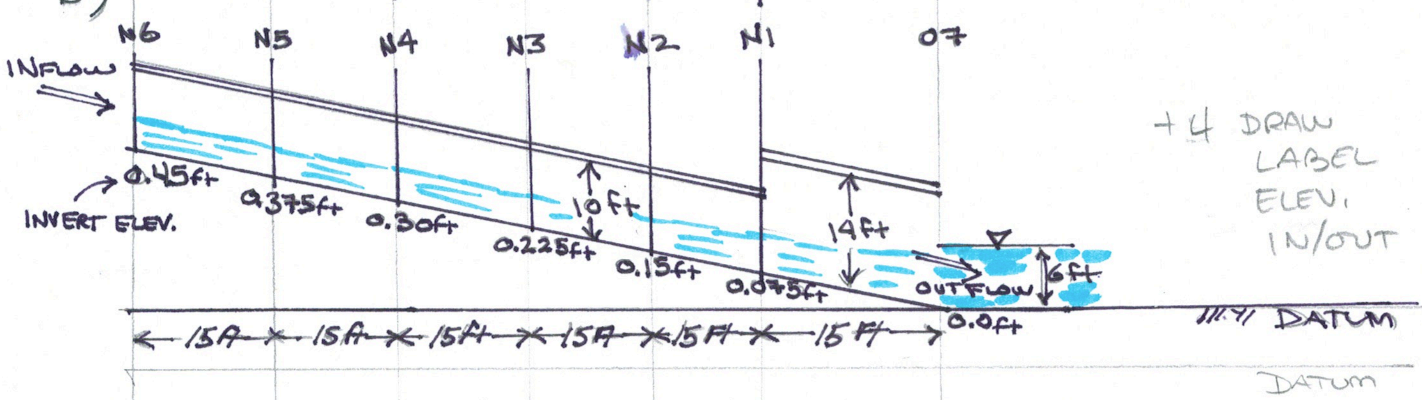
Figure 12: Conceptual downstream boundary conditions

a)



+4 DRAW LABEL IN/OUT

b)



+4 DRAW LABEL ELEV. IN/OUT

10 PTS

```
EXAM #3 SWMM INPUT FILE (.inp)
[TITLE]
[OPTIONS]
FLOW_UNITS MGD
INFILTRATION HORTON
FLOW_ROUTING DYNWAVE
START_DATE 04/08/2010
START_TIME 00:00:00
REPORT_START_DATE 04/08/2010
REPORT_START_TIME 00:00:00
END_DATE 04/09/2010
END_TIME 00:00:00
SWEEP_START 01/01
SWEEP_END 12/31
DRY_DAYS 0
REPORT_STEP 00:15:00
WET_STEP 00:15:00
DRY_STEP 01:00:00
ROUTING_STEP 0.5
ALLOW_PONDING NO
INERTIAL_DAMPING NONE
VARIABLE_STEP 0.75
LENGTHENING_STEP 0
MIN_SURFAREA 0
NORMAL_FLOW_LIMITED FROUDE
SKIP_STEADY_STATE NO
FORCE_MAIN_EQUATION H-W
LINK_OFFSETS DEPTH
MIN_SLOPE 0
[EVAPORATION]
;;Type Parameters
;;---------- ----------
CONSTANT 0.0
[JUNCTIONS]
;; Invert Max. Init. Surcharge Ponded
;;Name Elev. Depth Depth Depth Area
;;-------------- ---------- ---------- ---------- ---------- ----------
1 0.075 0 5.92 0 0
2 0.15 0 5.85 0 0
```

```
3 .225 0 5.77 0 0
4 .3 0 5.70 0 0
5 .375 0 5.62 0 0
6 .45 0 5.55 0 0
[OUTFALLS]
;; Invert Outfall Stage/Table Tide
;;Name Elev. Type Time Series Gate
;;-------------- ---------- ---------- ---------------- ----
7 0 FIXED 6 NO
[CONDUITS]
;; Inlet Outlet Manning Inlet Outlet Init. Max.
;;Name Node Node Length N Offset Offset Flow Flow
;;-------------- ---------------- ------ ---------- ---------- ---------- ---------- ---------- ----------
1 6 5 15 0.01 0 0 0 0
2 5 4 15 0.01 0 0 0 0
3 4 3 15 0.01 0 0 0 0
4 3 2 15 0.01 0 0 0 0
5 2 1 15 0.01 0 0 0 0
6 1 7 15 0.01 0 0 0 0
[XSECTIONS]
;;Link Shape Geom1 Geom2 Geom3 Geom4 Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1 RECT_CLOSED 10 14 0 0 1
2 RECT_CLOSED 10 14 0 0 1
3 RECT_CLOSED 10 14 0 0 1
4 RECT_CLOSED 10 14 0 0 1
5 RECT_CLOSED 10 14 0 0 1
6 RECT_CLOSED 14 10 0 0 1
[LOSSES]
;;Link Inlet Outlet Average Flap Gate
;;-------------- ---------- ---------- ---------- ----------
[INFLOWS]
;; Param Units Scale Baseline Baseline
;;Node Parameter Time Series Type Factor Factor Value Pattern
;;-------------- ---------------- ---------------- -------- -------- -------- -------- --------
6 FLOW "" FLOW 1.0 1.0 35.0
[REPORT]
INPUT NO
CONTROLS NO
```

```
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL
[TAGS]
[MAP]
DIMENSIONS 0.000 0.000 10000.000 10000.000
Units None
[COORDINATES]
;;Node X-Coord Y-Coord
;;-------------- ------------------ ------------------
1 -584.757 8436.268
2 466.491 8423.127
3 1741.130 8396.846
4 2897.503 8383.706
5 3843.627 8357.424
6 4618.922 8291.721
7 -1517.740 8423.127
[VERTICES]
;;Link X-Coord Y-Coord
;;-------------- ------------------ ------------------
```