CE 3372 Water Systems Design
Fall 2017

1. Consider the two networks depicted in Figure 1. Both network designs serve the same junction nodes, have same nodal demands, and draw supply from the same reservoir.

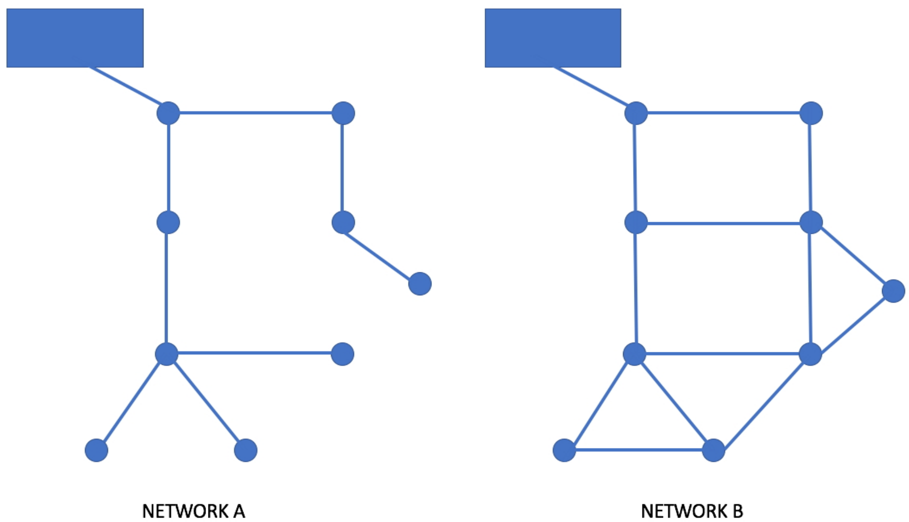

Figure 1: Two Network Designs

a) Which network design would be superior in terms of reliability? Why?

b) Which network design would cost less to build? Why?

c) Which network would be superior in terms of disinfection residual? Why?

2. Figure 2 is a screen capture of the EPANET graphical user interface. Identify the following items in the workspace, and write the item names in the empty boxes on the figure.

   a) Browser

   b) Menu Bar

   c) Network Map

   d) Property Editor

   e) Status Bar

   f) Toolbars

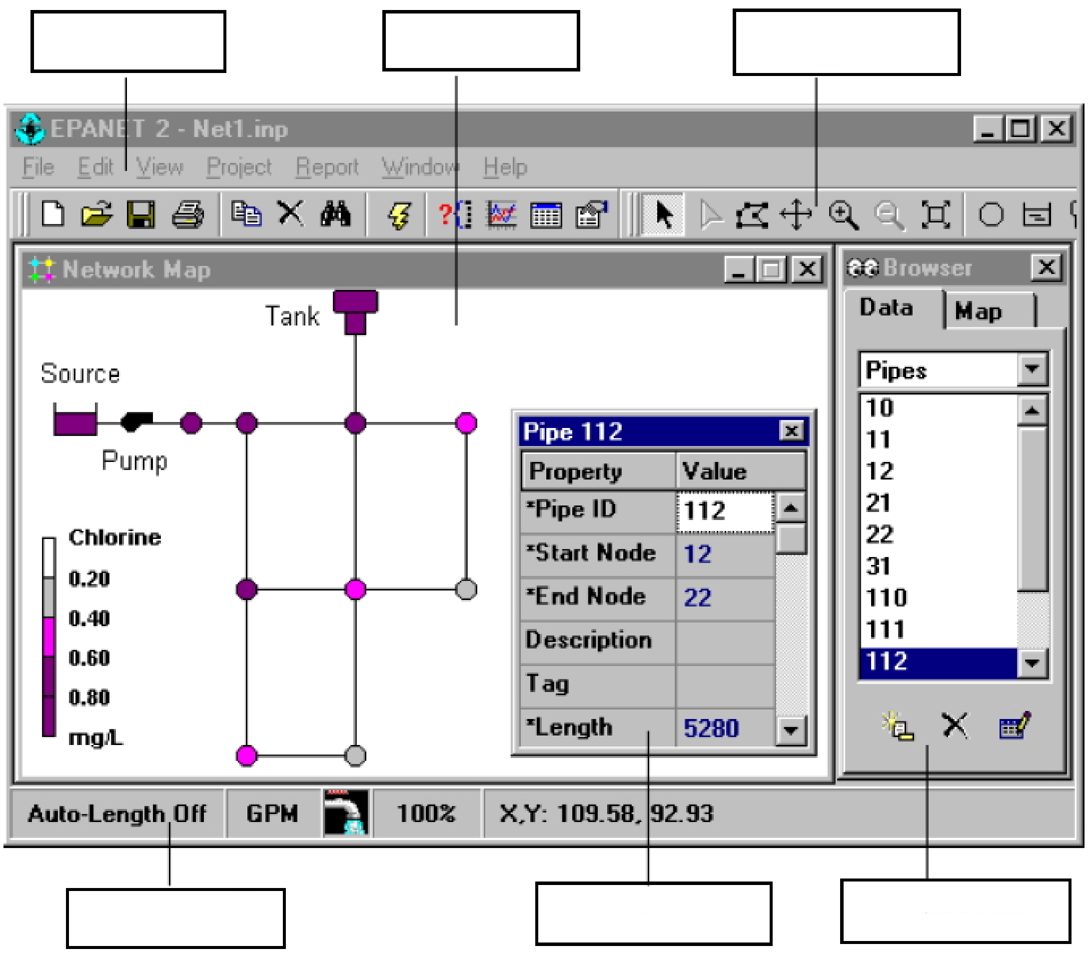

Figure 2: EPANET Workspace

3. Explain (using sketches as needed) how to model a groundwater pumping well in EPANET.

4. Explain (using sketches as needed) how to determine the maximum pressure available at a node when the demand at the node must be increased to suppress a fire.

5. 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

6. An EPA-NET simulation model for a reservoir-pump-network was constructed and operated for four (4) different operational scenarios. Figure 3 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 3.

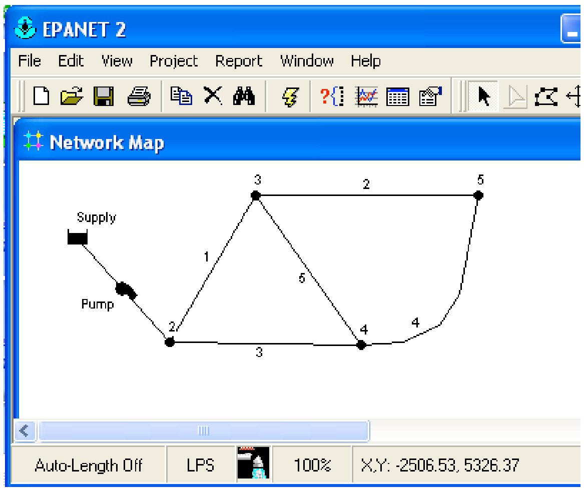

Figure 3: EPA-NET system topology.

Figure 4 is the a portion of the summary report for simulation 1. Figure 5 is the a portion of the summary report for simulation 2. Figure 6 is the a portion of the summary report for simulation 3. Figure 7 is the a portion of the summary report for simulation 4.

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

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.

Table 1: Pump Discharge and Supplied Head

Simulation #	Q_{pump}	H_{Supply}	H_{Node2}	ΔH_{pump}
1				
2				
3				
4				

(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 2: System Discharge and Head Loss

Simulation #	Q_{pump}	H_{Node2}	H_{Node5}	$\Delta H_{Node2-to-5}$
1				
2				
3				
4				

(c) If the pump performance curve has the mathematical structure:

$\Delta H_{pump} = H_{shutoff} - C_{pump} \times Q^2$, estimate the values of $H_{shutoff}$ and C_{pump}.

(d) If the system frictional loss curve has the mathematical structure:

$H_{loss-system} = K_{network} \times Q^2$, estimate the value of $K_{network}$

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

(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.

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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
```

Figure 4: 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 5: 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 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     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 6: 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 4
```

Link - Node Table:

Link ID	Start Node	End Node	Length m	Diameter 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 ID	Demand LPS	Head m	Pressure m	Quality	
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 ID	Flow LPS	Velocity m/s	Unit Headloss m/km	Status	
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 7: EPA-NET Summary Report, Simulation #4

7. The hydraulic radius in a conduit containing a flowing liquid is

   (A) the mean radius from the center of flow to the wetted side of the conduit

   (B) the ratio of the cross-sectional area of the conduit and the wetted perimeter

   (C) the ratio of the wetted perimeter and the cross-sectional area of the conduit

   (D) the ratio of the cross-sectional area of flow and the wetted perimeter

8. A circular, 60-inch diameter, reinforced concrete sewer pipe ($n = 0.013$)carries 50 MGD of wastewater to a lift station wet well. Average slope along the flow path is 1.0%.

   a) Sketch the cross section, indicate the pipe diameter.

   b) For the conditions in the problem statement, what is the flow rate in cubic feet per second?

   c) What is the diameter of the pipe, in feet?

   d) Use Manning's equation ($Q = \frac{1.49}{n} A R^{(2/3)} S^{(1/2)}$) and determine the **pipe-full** discharge in cubic feet per second.

   e) What is the pipe-full discharge (Q_f) in million gallons per day (MGD)?

f) Determine the discharge in the sewer when it is half-full, in million gallons per day (MGD).

g) Determine the discharge in the sewer when it is 90%full, in million gallons per day (MGD).

h) Determine the discharge in the sewer when it is 75%full, in million gallons per day (MGD).

i) Which of these conditions (50%,75%,90% of full) is closest to the actual flow of 50 MGD?

14. A smooth concrete channel is depicted in Figure 8. The channel's dimensionless slope in the direction of flow is 0.005. If the flow width at the surface is 2-meter, what is the flow rate in the channel?

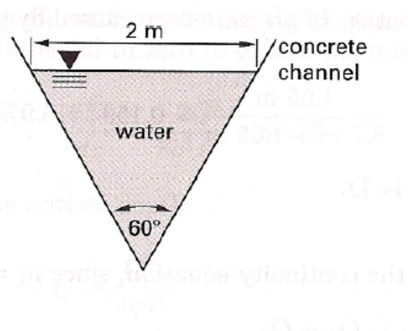

Figure 8: Triangular channel.

9. The rational runoff coefficient for a 14.81 acre parcel property is 0.35. The rainfall intensity is 4.56 inches per hour. Determine the size (diameter) of a reinforced concrete sewer pipe to convey the peak discharge, if the pipe is to be laid on a 0.5% slope, and the desired flow depth in the pipe is 1/2 full.

10. List the names of your water systems team members in the table below. Rate them in the categories indicated, from 1 to 4 with 1 being poor performance, and 4 bring excellent performance.

Table 3: Mid-term Team Mate Assessment

Team Member Name	Reliability	Availability	Work Quality	Contribution(%)
1)				
2)				
3)				
4)				
5)				

Additional Comments Below: [1]

[1] This sheet will be removed from the exam and will not be returned, the feedback is used to assess team effectiveness, but does not affect the examination score.