

CVEG 4303
WATER RESOURCES ENGINEERING
SPRING 2022

PROJECT
02

WATER DISTRIBUTION SYSTEM DESIGN

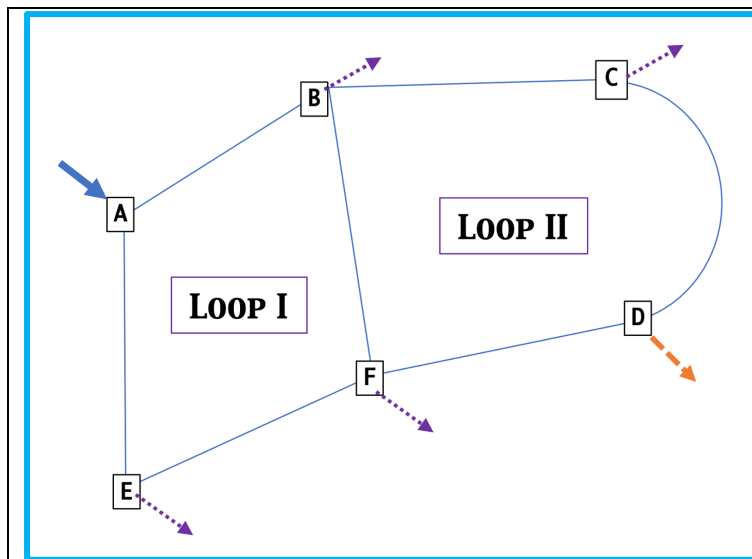
OTHER PROJECT DETAILS POSTED IN CANVAS

[ASSIGNMENT DETAILS, SPECIFIC TO EACH STUDENT, SENT VIA EMAIL]

This project involves the determination of water demand for a water distribution system, followed by the determination of network flows using the Hardy Cross method. In addition, it will require the determination of the water pressure at designated points in the system to **determine the adequacy of the system based on water pressure**. As always, students may contact the Instructor for help and for any other project details.

PROJECT OVERVIEW

WATER DISTRIBUTION SYSTEM NETWORK



At node A, water is delivered INTO the system. There are **withdrawals** at nodes, B, C, D, E, and F. The withdrawal at D includes FIRE DEMAND withdrawal (notice unique designation).

A formula for the withdrawals is provided in terms of:

TOTAL DEMAND [cfs] = **TDEM**

FIRE DEMAND [cfs] = **FDEM**

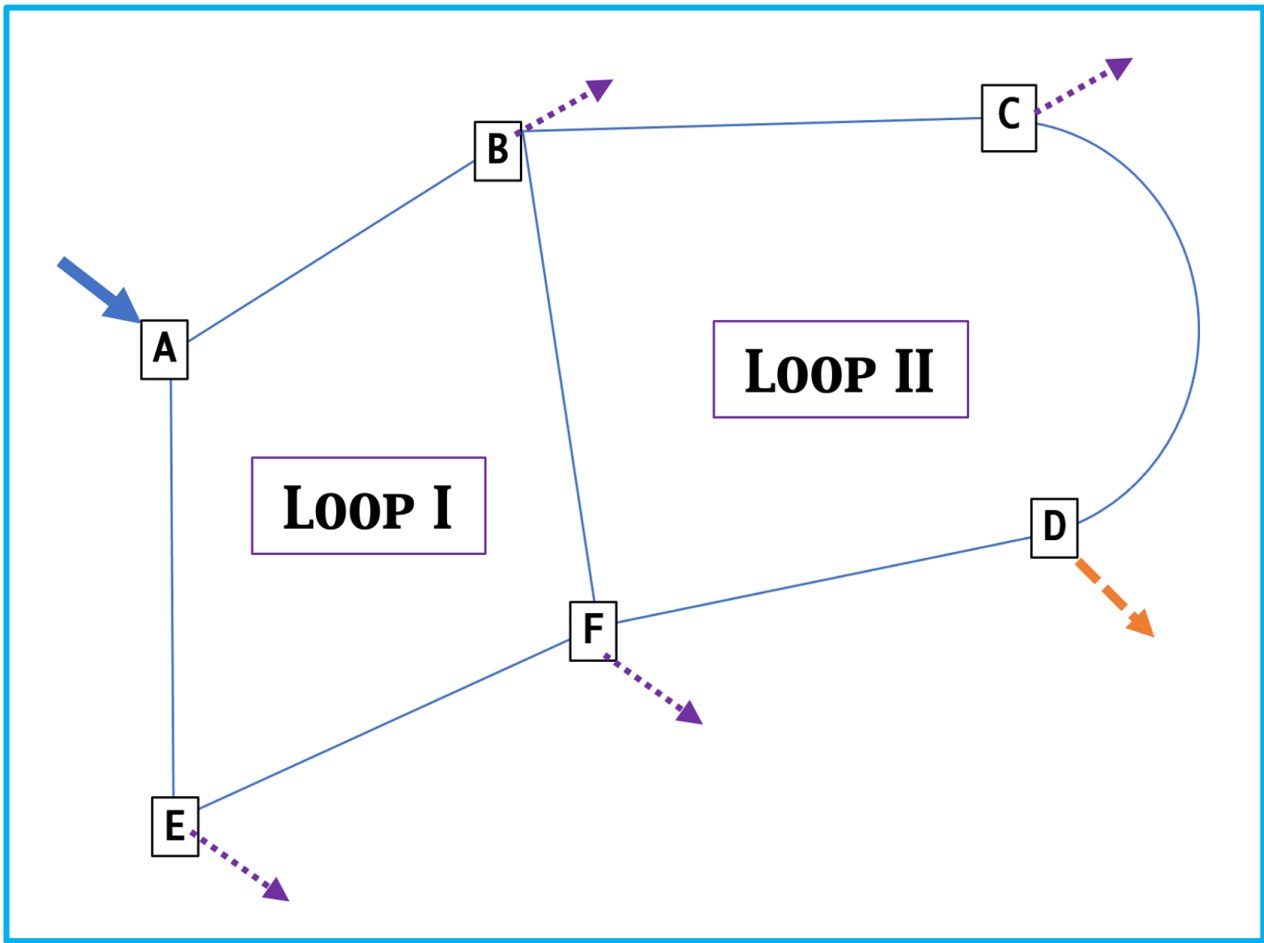
Essentially the system's water demand requirements are distributed to each of the withdrawal nodes.

Note: Ensure that **assumed flows** are determined in a manner consistent with the **balance** of flows at each node.

REQUIREMENTS

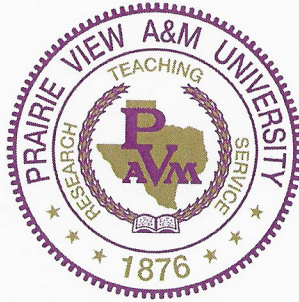
1	Provide the required information on the information sheet.
2	Determine demand flows from the information provided. The FIRE DEMAND is provided (given). <u>Tabulate your data.</u>
3	Provide the EQUIVALENT SAND ROUGHNESS [inches], EQUIVALENT SAND ROUGHNESS [feet], RELATIVE ROUGHNESS [], for EACH pipe segment. Also provide the corresponding FRICTION FACTOR for each pipe segment (assuming all flows are fully rough turbulent) using the <i>Swamee/Jain</i> equation. Provide the applicable K VALUE for each pipe. Use the EQUIVALENT SAND ROUGHNESS values given in the textbook. <u>Tabulate your data.</u>
4	Using the Hardy Cross method, determine the balanced flows [cfs] for all the pipe segments in the network. Confirm that the solution is converging (as required) by providing <u>tabulated</u> calculations for at least 3 iterations, beginning with ITERATION 1 . One Microsoft Excel workbook with adequate details must be submitted . [See the example spreadsheet provided by the Instructor.]
5	Determine the water pressures at node D and node E [psi]. <u>Detailed support calculations must be provided.</u>
6	Based on the information in #5, determine if the water distribution network, as designed, is adequate. See the information on page 666 of the textbook. Assume the area designation given in the problem statement applies.

PLEASE SUBMIT A BOUND HARDCOPY REPORT (WITH THE SYSTEM NETWORK AND FLOWS). ALSO SUBMIT AN ELECTRONIC COPY OF THE BOUND REPORT AND THE SPREADSHEET WORKBOOK. A TOTAL OF TWO (2) ELECTRONIC FILES ARE REQUIRED VIA CANVAS (1 PDF AND 1 XLS).



ABOVE
AVERAGE

Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4303: Water Resources

Section: P01

Title: Watershed Distribution System Analysis and Design

Submitted By: Allyssa Reynolds

Submitted To Dr. Nzewi

Due Date: May 5, 2022 – 5:00 PM

Prairie View A&M University
Department Of Civil & Environmental Engineering

Letter of Transmittal

Dr. Nzewi
Professor of Civil & Environmental Engineering
C.L. Wilson Engineering Building
Prairie View, Texas, 77446

May 4, 2022,

Dear Dr. Nzewi,

I submit the proposed report titled "Watershed Distribution System Analysis and Design," to fulfill the required design project for the Water Resource Engineering course.

This report aims to successfully analyze and design appropriate flows for a ~~watershed~~ ^{water} distribution system, thus providing the necessary parameters to showcase the knowledge and efficacy of the course. Components such as finding the water demand for the region based on both population and acreage, determining the appropriate flows at each node using the Hardy Cross method, and determining the adequacy of the water system based on nodal pressure, have all been observed and designed adequately. The following report reflects how the ~~watershed~~ distribution system was analyzed.

Please review my report, and provide all constructive feedback. If there are any questions, please contact me, Allyssa Reynolds, via email at areynolds18@pvamu.edu or phone at (314)-677-7306. I hope this report is sufficient in providing all of the necessary data and design.

Sincerely,

Allyssa Reynolds

Excellent work
Awesome effort!

Page 1
700
700

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1 Abstract

The objective of this project was to analyze a watershed distribution system, design the adequate flow rate within each pipe segment, and determine if the water distribution network is adequate. The client provided data such as the population, acreage, maximum daily consumption, length of each pipe, fire demand, and elevation at each node.

2 Introduction

Reynolds Consulting Firm was contracted by Dr. Nzewi of Prairie View A&M University to analyze the watershed distribution system and to determine the adequacy of the system based on the analysis. The design included the calculations for friction factor, total demand flow, head loss across each segment, and nodal elevation. Equations such as the Swamee and Jain and Bernoulli equation have been utilized.

3 Data Presentation

3.1.0 Phase 1

This project has been completed in multiple phases for ease of analysis and design. For the first phase of the project, my team had to determine the total demand for the distribution system. The following figure represents what the client provided as original raw data:

Remember: Bernoulli = Energy Eqn

I don't want to belabor this point but it is very important.

The Bernoulli eqn theoretically does not account for Headloss. It applies to inviscid flow (non-viscous)

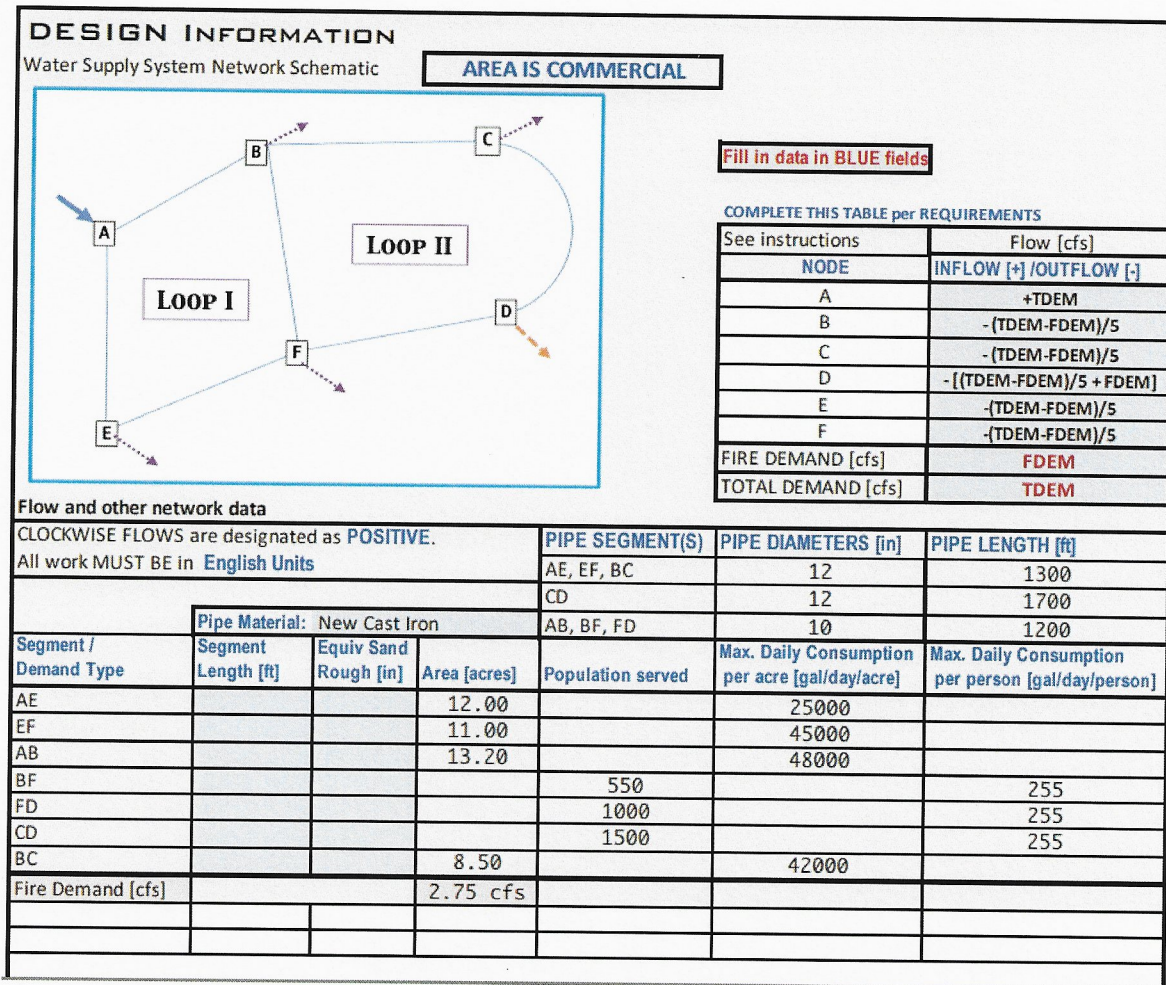


Figure 1.0: Raw Data Table

This data was used to find the total demand based on both population and acreage for each segment. The following equation reflects the calculations used to determine the total demand for each segment, and the total demand for the entire system:

$$TDEM_1 = Population * \frac{Maximum\ Daily\ Consumption}{person*day}, \text{Equation 1}$$

$$TDEM_2 = Acre * \frac{Maximum\ Daily\ Consumption}{acre*day}, \text{Equation 2}$$

$$TDEM_{1,2} = TDEM_1 + TDEM_2 + FDEM, \text{Equation 3}$$

*Where TDEM is total demand, and FDEM is the fire demand of 2.75 cfs. Fire demand value was provided by the client.

Sample calculations for these equations have been provided in **Appendix C**. The equivalent sand roughness was determined by utilizing the textbook, Hydrology and Hydraulic Systems. A chart was provided within the textbook showing the subsequent values for sand roughness and Hazen-Williams coefficient, C. The sand roughness figure-table has been provided in **Appendix**

B. All of the water demands were converted to cubic feet per second to provide uniformity and ease for calculation purposes. The sand roughness was determined to be 0.0008-ft, and the Hazen-Williams coefficient, C, was 130. The following figure represents the completed datasheet:

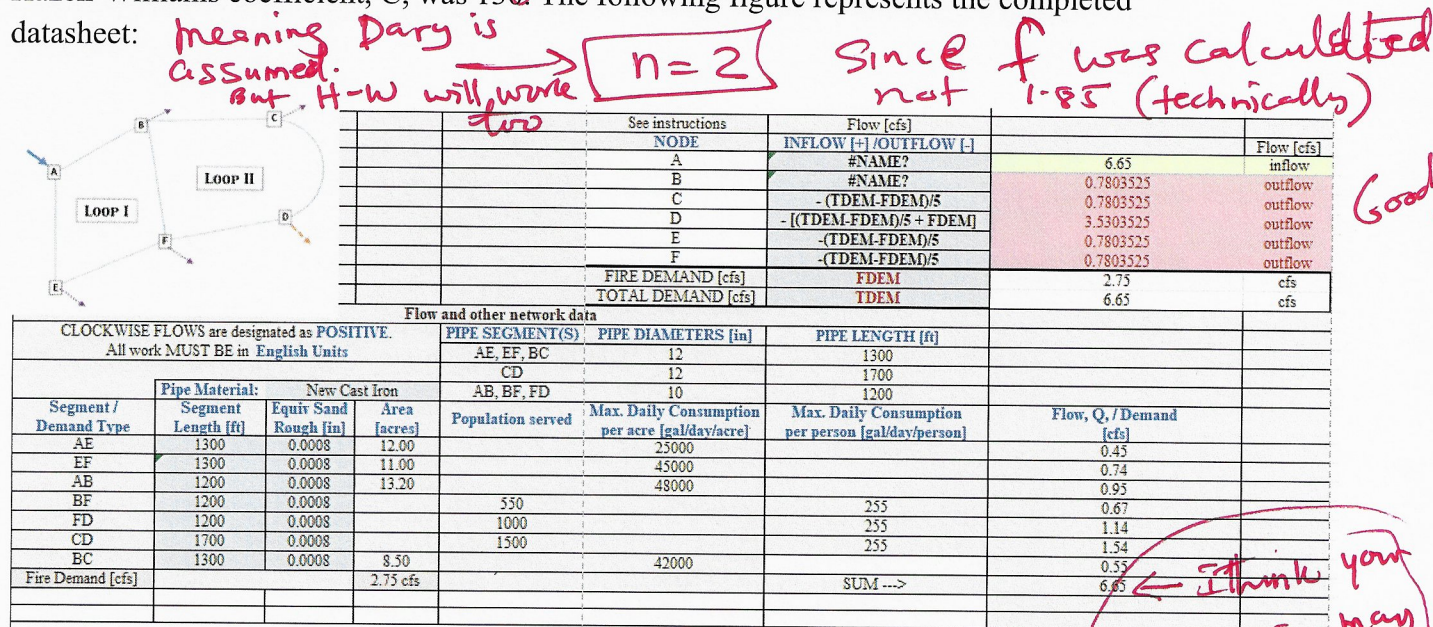


Figure 2.0: Completed Data Table

The following figure represents the flows calculated at each node:

NODE	INFLOW [+] /OUTFLOW [-]	Flow [cfs]
A	#NAME?	6.65 inflow
B	#NAME?	0.7803525 outflow
C	-(TDEM-FDEM)/5	0.7803525 outflow
D	-[(TDEM-FDEM)/5 + FDEM]	3.5303525 outflow
E	-(TDEM-FDEM)/5	0.7803525 outflow
F	-(TDEM-FDEM)/5	0.7803525 outflow

Figure 3.0: Flow at Each Node

Individual components from Figure 2.0 have been provided in Appendix B to provide greater detail.

3.1.1 Phase 2

My team had to find the most optimized flow system for the second phase. This was completed using corrections to find the correct flow output for each segment. All corrections were completed using the Hardy Cross method and Excel as the software program. The Hardy Cross Method utilizes convergence of flows by correcting the flow for each segment in different iterations. Using this method required multiple steps to be taken.

The actual/correct conversion factor is 1.54713×10^{-6}

You used 1.5×10^{-6}

The first step included finding the appropriate assumed flow, Q_a . Based on the diameter of each pipe segment, the flow was assumed to begin the correction process. This emphasis was made on each node: the flow entering the node must be equivalent to the flow exiting the node. If this was not the case, the corrections would not converge. The following figure represents the initial assumed flows developed:

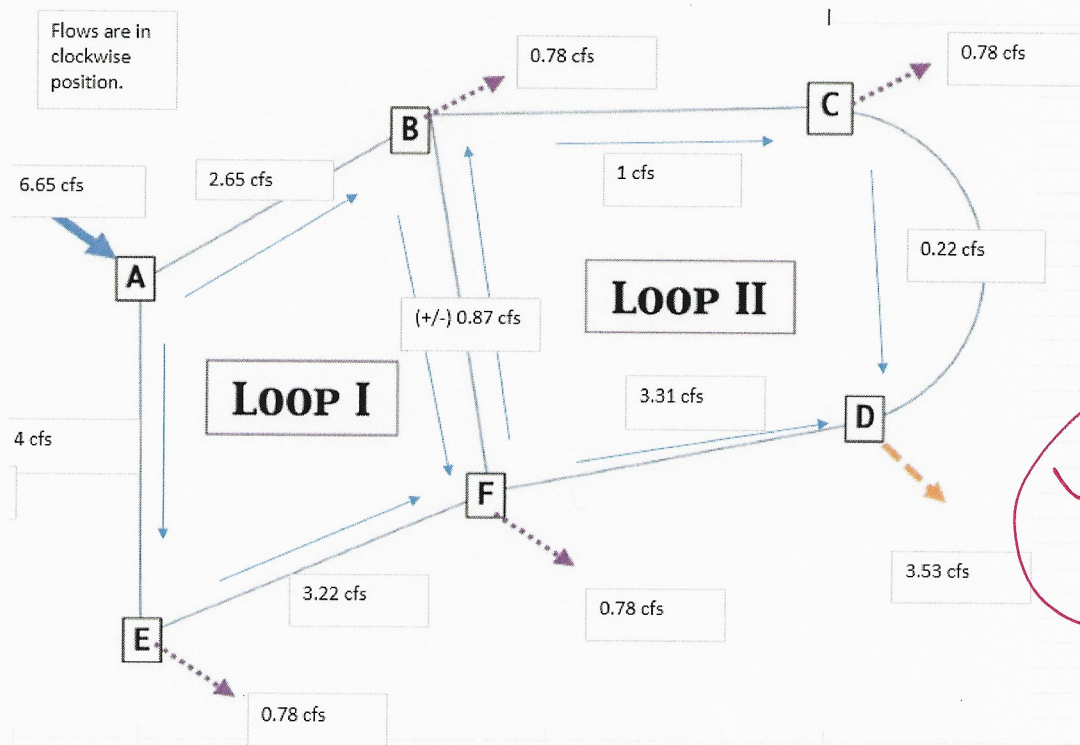


Figure 4.0: Initial Assumed Flow

To maintain zero summation of flow at each node, the assumed flows were calculated properly. An example node is Node A, where $6.65 \text{ cfs} = 4 \text{ cfs} + 2.65 \text{ cfs}$. The following table represents the first iteration developed for loops 1 and 2:

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s; headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d	
1	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.00	-7.91	-1.98	-0.21	-4.21
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.22	-5.30	-1.64	-0.21	-3.43
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.65	8.86	-3.34	-0.21	2.44
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	0.87	1.13	-1.30	1.88	2.75
Correction		d1	-0.21			Loop 2	d2	2.09			-3.22	-3.26		
$\delta = \frac{-\sum KQ_a^n}{n \sum KQ_a^{n-1}} = \frac{-\sum h_f}{n \sum \frac{h_f}{Q}}$ $\frac{0.02517d}{D}$														
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s; headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d	
1	2	BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.87	-1.13	-1.30	-1.88	-2.75
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-3.31	-13.37	4.04	2.09	-1.22
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	0.22	0.05	0.23	2.09	2.31
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	1	0.61	0.61	2.09	3.09

Table 1.0: Iteration 1 for Loops 1 and 2

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness
1	1	AE	1300	1.00	130	0.0008	0.0008
		EF	1300	1.00	130	0.0008	0.0008
		AB	1200	0.83	130	0.0008	0.00096
		BF	1200	0.83	130	0.0008	0.00096
Correction	d1	-0.21			Loop 2	d2	2.09
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness
1	2	BF	1200	0.83	130	0.0008	0.00096
		FD	1200	0.83	130	0.0008	0.00096
		CD	1700	1.00	130	0.0008	0.0008
		BC	1300	1.00	130	0.0008	0.0008

Table 1.1: Part One of Table 1.1

f	K	Qa (ft ³ /s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d
0.0186	0.61	-4.00	-7.91	-1.98	-0.21	-4.21
0.0186	0.61	-3.22	-5.30	-1.64	-0.21	-3.43
0.01943	1.46	2.65	8.86	-3.34	-0.21	2.44
0.01943	1.46	0.87	1.13	-1.30	1.88	2.75
			-3.22	-8.26		
$\delta = \frac{-\sum KQ_a^n}{n \sum KQ_a^{n-1} } = \frac{-\sum h_f}{n \sum \left \frac{hf}{Q} \right }$						
f	K	Qa (ft ³ /s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d
0.01943	1.46	-0.87	-1.13	-1.30	-1.88	-2.75
0.01943	1.46	-3.31	-13.37	4.04	2.09	-1.22
0.01943	0.83	0.22	0.05	0.23	2.09	2.31
0.0186	0.61	1	0.61	0.61	2.09	3.09

Table 1.2: Part Two of Table 1.2

The following equations were used to find the missing parameters:

Friction Factor, $f = 1.325[\ln(0.27\epsilon/D)]^{-2}$, Equation 4

*Where ϵ is the equivalent sand roughness, D is the diameter, and g , gravitational acceleration is 32.2 ft/s². This is the Swamee and Jain equation for fully turbulent flow.

Equivalent Resistance, $K = \frac{0.02517fL}{D^5}$, Equation 5

*Where D is the diameter, L is the length of the pipe, and f is the friction factor.

Head Loss, $h_f = KQ_a^{1.85}$, Equation 6

Relative Roughness = $\frac{\epsilon}{d}$, Equation 7

*Where ϵ is the equivalent sand roughness and d is the diameter.

assuming
BF

good!

good

Darcy

$$\text{Correction, } \delta = \frac{-\sum h_f}{n \sum \left| \frac{h_f}{Q} \right|}, \text{ Equation 8}$$

*Note, a correction had to be applied twice for the segment shared between each loop. Equation 10 represents this double correction.

$$\text{New } Q = Q_a + \delta, \text{ Equation 9}$$

$$\text{New } \delta = \delta_1 + (-\delta_2), \text{ Equation 10}$$

The second set of sample calculations can be found in **Appendix C**. It is important to note that the following assumptions had to be made to use the Hardy Cross Method:

1. The flow in the pipe is fully turbulent.
2. The flow entering each node is equivalent to the flow exiting the node.
3. All clockwise flows are positive.
4. Negative flow means the flow is entering the clockwise position.

The assumptions aided in completing the Hardy Cross Method accurately. The Swamee and Jain equation, found in **Equation 4**, was used to determine the friction factor. **Appendix C** also includes a sample calculation of how the friction factor was determined for one pipe segment.

After completing the first iteration, nine iterations were completed until the system converged. This means, the corrections obtained were close to or equivalent to zero. The following table reflects the ninth iteration and its subsequent correction values:

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d
9	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.47	-9.71	2.17	0.00	-4.47
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.69	-6.81	1.85	0.00	-3.69
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.18	6.17	2.83	0.00	2.18
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.89	10.39	3.60	0.00	2.89
Correction	d1	0.00									0.03	10.45		-3.10
Loop 2														
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d
9	2	BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-2.89	-10.39	3.60	0.00	-2.89
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.82	1.02	1.24	0.00	-0.82
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.71	5.25	1.94	0.00	2.71
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.49	6.14	1.76	0.00	3.49

Table 2.0: Iteration 9 for Loops 1 and 2

Excellent
Convergence

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness
9	1	AE	1300	1.00	130	0.0008	0.0008
		EF	1300	1.00	130	0.0008	0.0008
		AB	1200	0.83	130	0.0008	0.00096
		BF	1200	0.83	130	0.0008	0.00096
Correction	d1	0.00			Loop 2	d2	0.00
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness
9	2	BF	1200	0.83	130	0.0008	0.00096
		FD	1200	0.83	130	0.0008	0.00096
		CD	1700	1.00	130	0.0008	0.0008
		BC	1300	1.00	130	0.0008	0.0008

Table 2.1: Part One of Table 2.0

f	K	Qa (ft ³ /s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d
0.0186	0.61	-4.47	-9.71	2.17	0.00	-4.47
0.0186	0.61	-3.69	-6.81	1.85	0.00	-3.69
0.01943	1.46	2.18	6.17	2.83	0.00	2.18
0.01943	1.46	2.89	10.39	3.60	0.00	2.89
			0.03	10.45		-3.10
f	K	Qa (ft ³ /s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d
0.01943	1.46	-2.89	-10.39	3.60	0.00	-2.89
0.01943	1.46	-0.82	-1.02	1.24	0.00	-0.82
0.01943	0.83	2.71	5.25	1.94	0.00	2.71
0.0186	0.61	3.49	6.14	1.76	0.00	3.49

Table 2.2: Part Two of Table 2.0

*Note that the values at the end of Table 2.0 and Table 2.2 are sums of the values above its placement.

Note that the corrected flows were used at the assumed flows for each new iteration. Thus, the assumed flows for iteration 9 were the corrected flows from the eighth iteration. The following tables represent this:

New Q = Qa+d
-4.47
-3.69
2.18
2.89
-3.10
New Q = Qa+d
-2.89
-0.82
2.71
3.49

Table 3.0: Iteration 8 Corrected Flows

Q_a (ft ³ /s/he
-4.47
-3.69
2.18
2.89
Q_a (ft ³ /s/he
-2.89
-0.82
2.71
3.49

Table 4.0: Iteration 9 Assumed Flows

The corrected flows found for the ninth iterations were used for the subsequent two phases. The following figure represents the corrected flows from the ninth iteration:

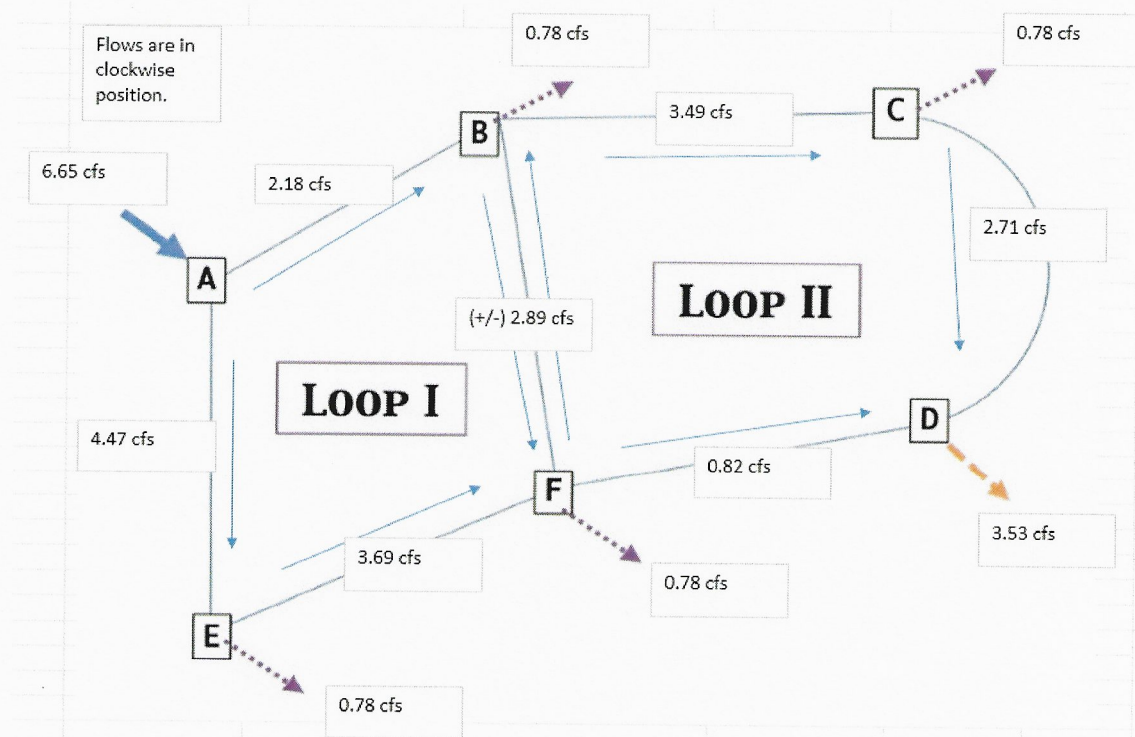


Figure 5.0: Final Corrected Flows from Ninth Iteration

3.1.2 Phase 3

For phase 3, my team was tasked with finding the pressure at nodes E and D. The following table represents the elevation and pressure data the client provided:

PRESSURE at A	77.00 psi
NODE	Elevation [ft]
A	308.0
B	302.0
C	306.0
D	305.0
E	306.0
F	306.0

Table 5.0: Pressure and Elevation

The pressure at each node was determined to by utilizing a manipulated Bernoulli equation. As the summation of flows at each node was zero, no velocity was detected. Thus, velocity was negligible and removed from Equation 11. To utilize Bernoulli equation, an assumption had to be made on the temperature of water. As a standard value, it was assumed that the water within the system held a temperature of 32°C. The following equation was used:

$$\frac{P_A}{\gamma} + Z_A = \frac{P_B}{\gamma} + Z_B + h_L, \text{ Equation 11}$$

*Where P is the pressure, γ is specific weight of water at 32°C = 62.4 lb/ft³, Z is the elevation at each node, and h_L is the head loss at the node. *good*

*Energy Eqn
See previous
Comments*

Sample calculations for the Bernoulli equation are located in **Appendix C**. The following table represents the pressure found for each node:

Segment-Pipe	Node	Elevation, ft	Pipe Diameter, ft	Headloss, hf, ft	Pressure, psi
AE	A	308	1.00	2.17	77.00
AB	B	305	1.00	1.85	79.34
BC	C	306	0.83	2.83	77.68
CD	D	305	0.83	3.60	76.55
EF	E	306	0.83	-1.02	77.43
DF	F	306	1.00	5.25	79.71
FB			1.00	6.14	

Table 4.0: Pressure at Each Node

Thus, it was determined that the pressure at nodes D and E respectively were 76.55 psi and 77.43 psi. *ok*

3.1.3 Phase 4

I
For the last phase, my team determined if the watershed distribution system was adequate for commercial areas. The appropriate pressure range for commercial areas is 60 psi to 75 psi. For residential neighborhoods, this range is 40 psi to 50 psi. The recommended pressure for commercial areas is greater than residential areas due to the demand for water being greater in these areas. As the pressure range for the watershed distribution system was 77 psi to 79.71 psi, it was determined that the system was not suitable for the commercial area. Additionally, based on the nodal analysis for both nodes D and E, the flow ranged from 76.55 psi to 77.43 psi. Since this pressure range is above the recommended range, the system was determined to be inadequate consequently. *OK*

4 Conclusion

Please note the ranges are usually lower limits. Higher pressures may have integrity concerns

The project's objective was to analyze the watershed distribution system and design an appropriate flow based on the analysis. By completing eight phases, the design was able to be developed appropriately. Flow corrections using the Hardy-Cross method were successful, with proper convergence occurring for nine iterations. These flows include - 4.47 cfs for segment AE, - 3.69 cfs for segment EF, 2.18 cfs for segment AB, 2.89 cfs for segment BF, - 2.89 cfs for segment FB, - 0.82 cfs for segment FD, 2.71 cfs for segment CD, and 3.49 cfs for segment BC. The pressure at all six nodes was determined based on the appropriate flows. Finally, the system was inadequate for a commercial area based on its pressure range of 77 psi to 79.71 psi. When focusing on the nodal analysis for both nodes D and E only, the flow ranged from 76.55 psi to 77.43 psi. Since this pressure range is above the recommended range, the system was determined to be inadequate consequently. Recommendations include developing a larger team to complete multiple analyses for the watershed. This will improve the development of the most optimized analysis and design. ✓

References

1. Gupta, Ram S. *Hydrology & Hydraulic Systems.* , 2017. Print.

Appendix A

Data Tables

PIPE SEGMENT(S)	PIPE DIAMETERS [in]	PIPE LENGTH [ft]
AE, EF, BC	12	1300
CD	12	1700
AB, BF, FD	10	1200

Table 1.0: Segment Lengths and Diameters reflect part one of the pipe characteristics provided by the client.

Segment / Demand Type	Pipe Material:	New Cast Iron	
	Segment Length [ft]	Equiv Sand Rough [in]	Area [acres]
AE	1300	0.0008	12.00
EF	1300	0.0008	11.00
AB	1200	0.0008	13.20
BF	1200	0.0008	
FD	1200	0.0008	
CD	1700	0.0008	
BC	1300	0.0008	8.50
Fire Demand [cfs]			2.75 cfs

Table 1.2: Segment Characteristics reflect part two of the pipe characteristics provided by the client.

NODE	INFLOW [+] /OUTFLOW [-]		Flow [cfs]
A	#NAME?	6.65	inflow
B	#NAME?	0.7803525	outflow
C	- (TDEM-FDEM)/5	0.7803525	outflow
D	- [(TDEM-FDEM)/5 + FDEM]	3.5303525	outflow
E	-(TDEM-FDEM)/5	0.7803525	outflow
F	-(TDEM-FDEM)/5	0.7803525	outflow
FIRE DEMAND [cfs]	FDEM	2.75	cfs
TOTAL DEMAND [cfs]	TDEM	6.65	cfs

Table 2.0: Nodal Flow reflects the inflow and outflow at each node.

Pipeline	e/D	V, ft/s	g, ft/s ²	Re	f
AE	0.0008	5.09	32.2	0.897516	0.0186
EF	0.0008	4.10	32.2	0.7225	0.0186
AB	0.00096	4.86	32.2	0.937953	0.01943
BF	0.00096	1.60	32.2	0.307932	0.01943
FD	0.00096	6.07	32.2	1.171557	0.01943
CD	0.00096	0.28	32.2	0.049363	0.01943
BC	0.0008	1.27	32.2	0.224379	0.0186

Table 3.0: Friction Factor Results reflect the friction factor obtained from the Swamee and Jain equation.

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s; headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d	
8	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.46	-9.68	2.17	-0.01	-4.47
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.68	-6.79	1.84	-0.01	-3.69
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.19	6.21	2.84	-0.01	2.18
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.89	10.40	3.60	0.00	2.89
Correction	d1	-0.01									0.14	10.45		
		Loop 2				d2	0.00							
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s; headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d	
8	2	BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-2.89	-10.40	3.60	0.00	-2.89
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.83	-1.03	1.24	0.00	-0.82
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.70	5.23	1.94	0.00	2.71
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.48	6.12	1.76	0.00	3.49

Table 4.0: Iteration 8 reflects the eighth iteration completed for the Hardy-Cross method.

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s; headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d	
9	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.47	-9.71	2.17	0.00	-4.47
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.69	-6.81	1.85	0.00	-3.69
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.18	6.17	2.83	0.00	2.18
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.89	10.39	3.60	0.00	2.89
Correction		d1	0.00			Loop 2	d2	0.00			0.03	10.45		-3.10
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s; headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d	
9	2	BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-2.89	-10.39	3.60	0.00	-2.89
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.82	-1.02	1.24	0.00	-0.82
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.71	5.25	1.94	0.00	2.71
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.49	6.14	1.76	0.00	3.49

Table 5.0: Iteration 9 reflects the ninth iteration completed for the Hardy-Cross method.

Segment-Pipe	Node	Elevation, ft	Pipe Diameter, ft	Headloss, hf, ft	Pressure, psi
AE	A	308	1.00		77.00
AB	B	305	1.00	1.85	79.34
BC	C	306	0.83	2.83	77.68
CD	D	305	0.83	3.60	76.55
EF	E	306	0.83	-1.02	77.43
DF	F	306	1.00	5.25	79.71
FB			1.00		

Table 6.0: Pressure Head reflects the pressure head determined at each node.

Appendix B

Figures Used

Table 15.1 Roughness Values for Pipes

Pipe Material	Equivalent Roughness, ϵ (ft)	Hazen-Williams Coefficient, C
PVC, plastic	Smooth	140
Brass, copper, aluminum, glass	Smooth	140
Dawn tubing	5×10^{-6}	—
Cast iron		
new	8.0×10^{-4}	130
old		100
Galvanized iron/ductile pipe	5.0×10^{-4}	120
Asphalted iron	4.0×10^{-4}	—
Wrought iron	1.5×10^{-4}	—
Commercial and welded steel	1.5×10^{-4}	120
Wood stave	20.0×10^{-4}	120
Concrete	40.0×10^{-4}	130
Riveted steel	60.0×10^{-4}	110
Brick sewer	—	100

Figure 1.0: Roughness Values for Pipes reflect the figure used to determine the sand roughness for the new cast iron pipe used for the analysis.

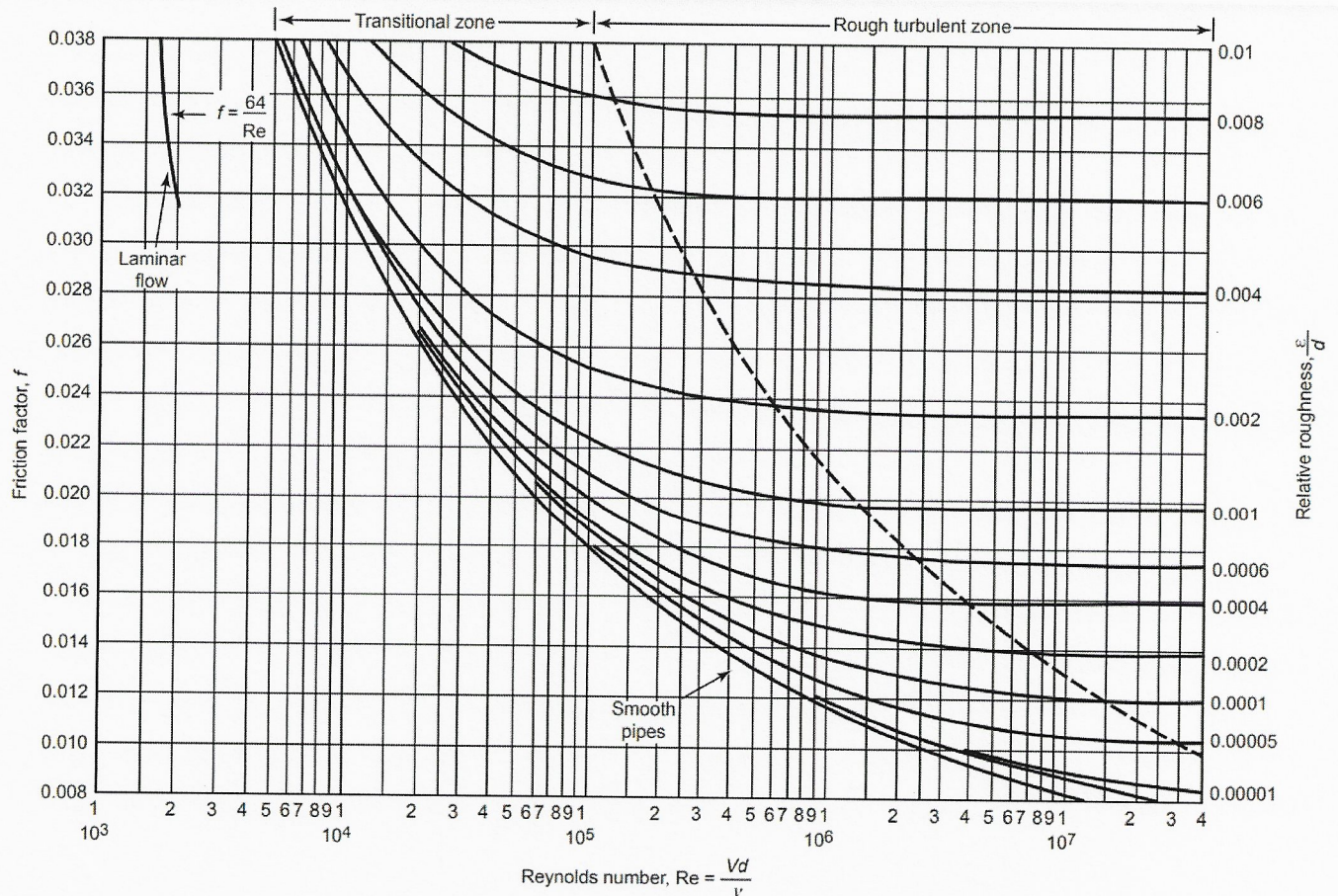


Figure 2.0: Moody Diagram reflects the alternative method of finding the friction factor for the new cast iron pipe.

Appendix C

Sample Calculations

Sample Calculations 1: Total Demand

$$TDEM_1 = Population * \frac{Maximum\ Daily\ Consumption}{person*day} = 550 * 255 = 140,250\ gal/day$$

$$TDEM_2 = Acre * \frac{Maximum\ Daily\ Consumption}{acre*day} = 12 * 25,000 = 300,000\ gal/day$$

$$TDEM_{1,2} = (140,250 + 300,000)1.55 * 10^{-6} + 2.75 = 3.43\ ft^3/s$$

Sample Calculations 2: Hardy-Cross Method

$$\text{Friction Factor, } f = 1.325[\ln(0.27e/d)]^{-2} = 1.325[\ln(0.27 * 0.008)]^{-2} = 0.0186$$

$$\text{Equivalent Resistance, } K = \frac{0.02517fL}{D^5} = \frac{0.025170*0.0186*1300}{1^5} = 0.61\ ft$$

$$\text{Head Loss, } h_f = KQ_a^{1.85} = 0.61 * -4.45^{1.85} = -9.66\ ft$$

$$\text{Relative Roughness} = \frac{\varepsilon}{d} = \frac{0.0008}{1} = 0.0008$$

$$\text{Correction, } \delta = \frac{-\Sigma h_f}{n\Sigma \left| \frac{h_f}{Q} \right|} = \frac{-(-.20)}{1.85|8.52|} = -0.0127$$

$$\text{New } Q = Q_a + \delta = -4.45 + (-0.0127) = -4.46\ cfs$$

$$\text{New } \delta = \delta_1 + (-\delta_2) = .01 + (-0.01) = 0$$

Sample Calculations 3: Bernoulli Equation

$$\frac{P_A}{\gamma} + Z_A = \frac{P_B}{\gamma} + Z_B + h_L \Rightarrow \frac{77(144)}{62.4} + 308 = \frac{P_B}{62.4} + 306 + (1.85), P_B = 79.34\ psi$$

$$\frac{P_B}{\gamma} + Z_B = \frac{P_C}{\gamma} + Z_C + h_L \Rightarrow \frac{79.34}{62.4} + 304 = \frac{79.34*144}{62.4} + 306 + 2.83, P_C = 77.68\ psi$$

$$\frac{P_C}{\gamma} + Z_C = \frac{P_D}{\gamma} + Z_D + h_L \Rightarrow \frac{77.68*144}{62.4} + 306 = \frac{P_D}{62.4} + 205 + 3.6, P_D = 76.55\ psi$$

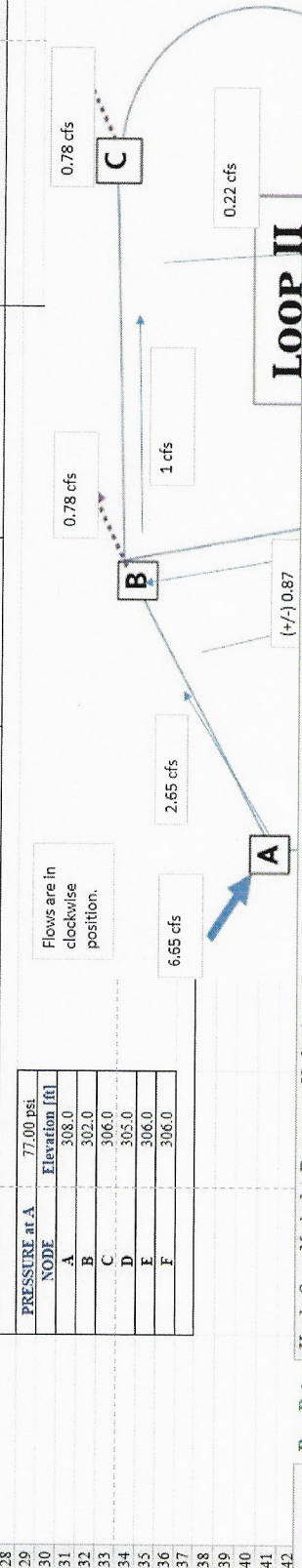
$$\frac{P_A}{\gamma} + Z_A = \frac{P_E}{\gamma} + Z_E + h_L \Rightarrow \frac{P_A}{62.4} + Z_A = \frac{77*144}{62.4} + 306 + (-1.02), P_E = 77.43\ psi$$

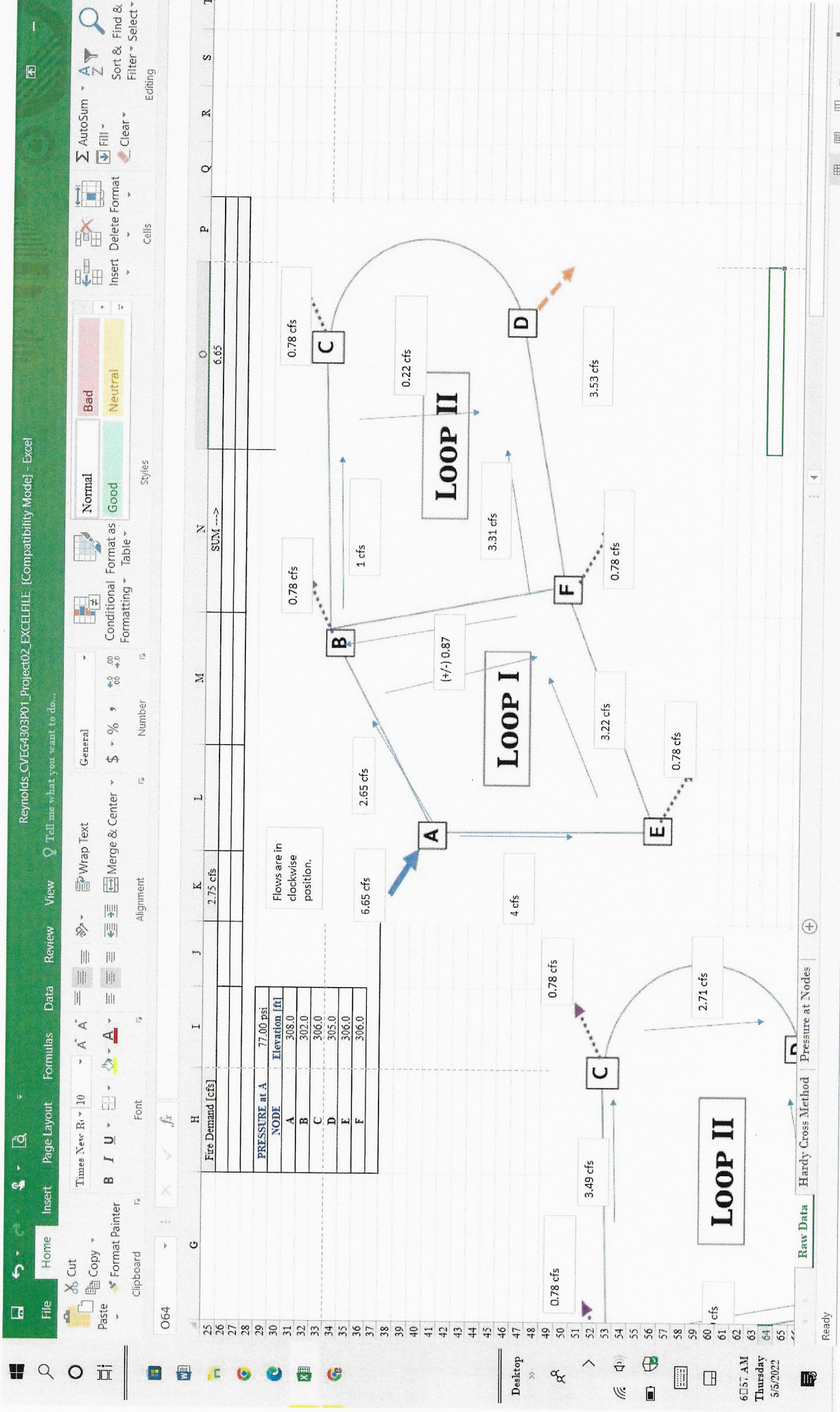
$$\frac{P_E}{\gamma} + Z_E = \frac{P_F}{\gamma} + Z_F + h_L \Rightarrow \frac{77.43*144}{62.4} + 306 = \frac{P_F}{62.4} + 306 + 5.25, P_F = 79.71\ psi$$

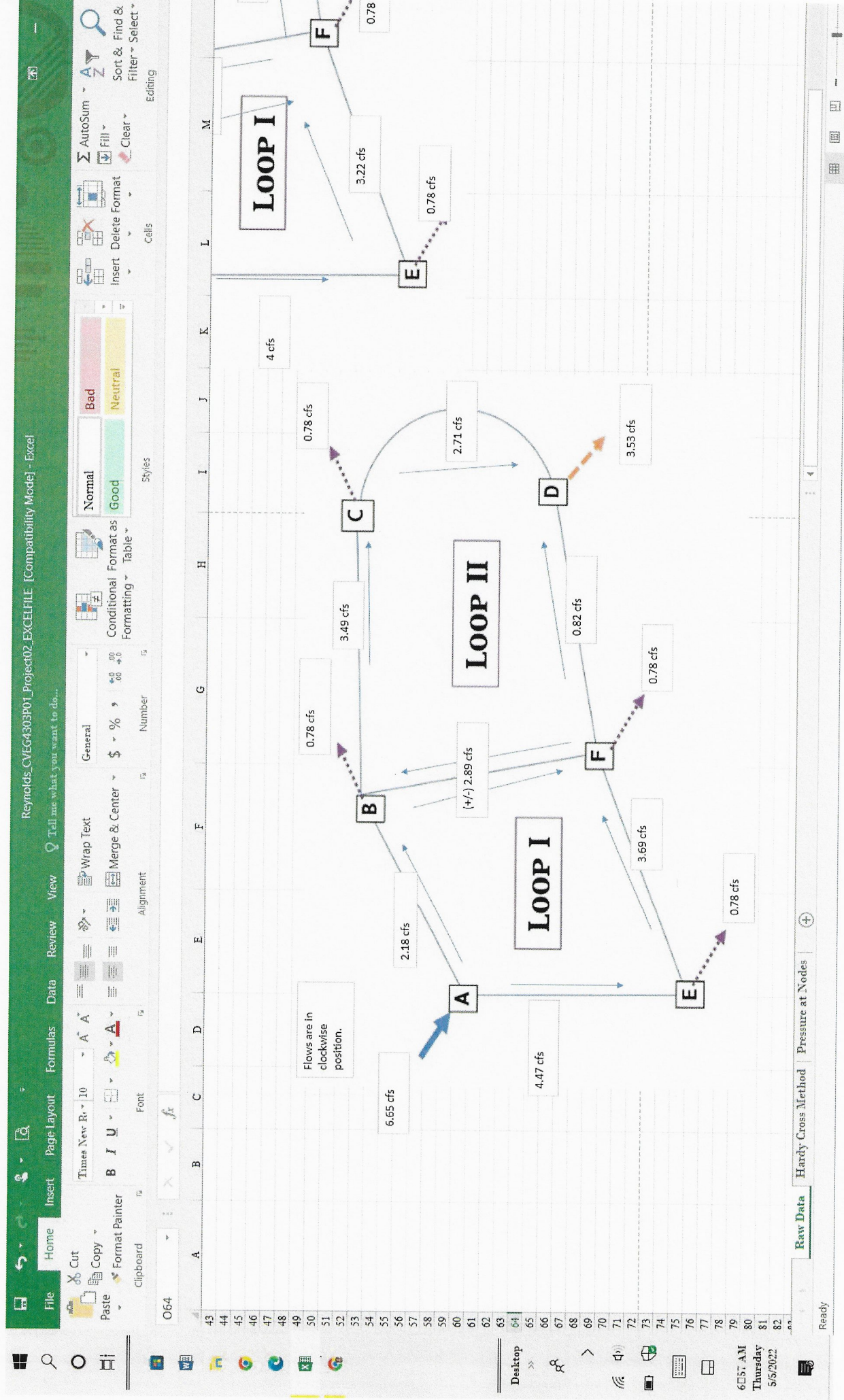
The screenshot displays the Microsoft Excel ribbon, specifically the Home tab. The ribbon is organized into several functional groups:

- Font:** Includes options for font face (Times New Roman), size (10), bold (B), italic (I), and underline (U).
- Paragraph:** Includes options for bullet points, numbering, and text alignment (left, center, right, justified).
- Styles:** Includes options for conditional formatting (Normal, Good, Bad, Neutral) and table formatting.
- Cells:** Includes options for inserting and deleting cells, rows, and columns.
- Editing:** Includes options for finding and selecting data.

The ribbon also features a search bar at the top right, which is currently empty. The background of the ribbon is a light blue color.

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Styles: Conditional Formatting, Table, Bad, Neutral, Good

Cells: Insert, Delete, Format, Clear, Filter, Sort & Find, AutoSum, Fill, Editing

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d
4	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.40	-9.42	2.14	-0.03	-4.43
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.62	-6.56	1.82	-0.03	-3.65
		AB	1200	0.83	130	0.0008	0.0006	0.01943	1.46	2.25	6.56	2.91	-0.03	2.22
		BF	1200	0.83	130	0.0008	0.0006	0.01943	1.46	2.85	10.03	3.54	0.02	2.85
Correction	d1	-0.03	Loop 2	d2	0.05	10.41								
4	2	AE	1300	0.83	130	0.0008	0.0006	0.01943	1.46	-2.83	-10.03	3.54	-0.02	-2.85
		BF	1200	0.83	130	0.0008	0.0006	0.01943	1.46	-0.95	-1.33	1.40	0.05	-0.90
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.58	4.80	1.86	0.05	2.63
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.36	5.73	1.71	0.05	3.41
Correction, d New Q = Qa+d														

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa+d	
5	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.43	-9.55	2.16	-0.02	-4.45	
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.65	-6.67	1.83	-0.02	-3.67	
		AB	1200	0.83	130	0.0008	0.0006	0.01943	1.46	2.22	6.40	2.88	-0.02	2.20	
		BE	1200	0.83	130	0.0008	0.0006	0.01943	1.46	2.85	10.17	3.56	0.01	2.87	
Correction	d1	-0.02	Loop 2	d2	0.03	0.34									10.42
5	2	AE	1300	1.00	130	0.0008	0.0008	0.01943	1.46	-2.85	-10.17	3.56	-0.01	-2.87	
		FD	1300	1.00	130	0.0008	0.0006	0.01943	1.46	-0.90	-1.20	1.33	0.03	-0.87	
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.63	4.98	1.89	0.03	2.66	
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.41	5.90	1.73	0.03	3.44	
Correction: d = -0.48, 8.51															

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qs (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa-d	
6	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.45	-9.62	2.16	0.01	-4.43	
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.67	-6.73	1.84	0.01	-3.65	
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.20	6.30	2.86	0.01	2.22	
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.87	10.25	3.58	0.03	2.90	
Correction	d1	0.01			Loop 2	d2	0.02			Qs (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa-d	
6	2	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-2.87	-10.25	3.58	-0.03	-2.90	
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.87	-1.11	1.29	0.02	-0.85	
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.87	-1.11	1.29	0.02	-0.85	
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.66	5.09	1.91	0.02	2.68	
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.44	5.93	1.74	0.02	3.46	

Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d	New Q = Qa-d
6	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.45	-9.62	2.16	0.01	-4.43
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.67	-6.73	1.84	0.01	-3.65
		AB	1200	0.83	130	0.0008	0.0006	0.01943	1.46	2.20	6.30	2.86	0.01	2.22
		BF	1200	0.83	130	0.0008	0.0006	0.01943	1.46	2.87	10.25	3.58	0.03	2.90
Correction: d1 = 0.01, Loop 2, d2 = 0.02														
6	2	AE	1300	1.00	130	0.0008	0.0008	0.01943	1.46	-2.87	-10.25	3.58	-0.03	-2.90
		EF	1300	1.00	130	0.0008	0.0006	0.01943	1.46	-0.87	-1.11	1.29	0.02	-0.85
		AB	1200	0.83	130	0.0008	0.0008	0.01943	0.83	2.65	5.09	1.91	0.02	2.68
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.44	5.93	1.74	0.02	3.46
Correction: d = -0.29, 8.52														

Hardy Cross Method

Raw Data

Pressure at Nodes

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Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d New Q = Qa+d
7	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.43	-9.56	2.16	-4.46
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.65	-5.68	1.83	-3.68
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.21	5.38	2.83	2.19
		BF	1300	0.83	130	0.0008	0.00096	0.01943	1.46	2.89	10.47	3.61	2.89
Correction	d1	0.00			Loop 2	d2	0.00				0.61	10.47	
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d New Q = Qa+d
7	2	BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-2.90	-10.47	3.61	-2.89
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.85	-1.08	1.27	-0.83
		CD	1700	1.00	130	0.0008	0.0008	0.01943	2.68	5.16	1.92	0.01	2.70
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.46	6.05	1.75	0.02
											-0.34	3.55	
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d New Q = Qa+d
8	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.46	-9.68	2.17	-4.47
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.68	-5.79	1.84	-3.69
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.19	6.21	2.84	2.18
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.89	10.40	3.60	2.89
Correction	d1	0.00			Loop 2	d2	0.00				0.14	10.45	
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d New Q = Qa+d
8	2	BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-2.89	-10.40	3.60	-2.89
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.88	-1.03	1.24	-0.82
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.70	5.23	1.94	0.00
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.48	6.12	1.76	0.00
											-0.08	3.54	
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d New Q = Qa+d
9	1	AE	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-4.47	-9.71	2.17	-4.47
		EF	1300	1.00	130	0.0008	0.0008	0.0186	0.61	-3.69	-6.81	1.85	-3.69
		AB	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.18	6.17	2.83	2.18
		BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	2.89	10.39	3.60	2.89
Correction	d1	0.00			Loop 2	d2	0.00				0.03	10.45	
Iteration	Loop	Pipeline	Length (ft)	Diameter (ft)	C	Sand Roughness	Relative Roughness	f	K	Qa (ft³/s)	headloss, hf (ft)	(hf/Q)	Correction, d New Q = Qa+d
9	2	BF	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-2.89	-10.39	3.60	-2.89
		FD	1200	0.83	130	0.0008	0.00096	0.01943	1.46	-0.82	-1.02	1.24	-0.82
		CD	1700	1.00	130	0.0008	0.0008	0.01943	0.83	2.71	5.25	1.94	0.00
		BC	1300	1.00	130	0.0008	0.0008	0.0186	0.61	3.49	6.14	1.76	0.00
											-0.02	3.53	

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62.4

77 psi to psf 11088

Segment-Pipe

Node

Elevation, ft

Pipe Diameter, ft

Headloss, hf, ft

Pressure, psi

AE

A

308

1.00

77.00

AB

B

305

1.00

1.85

79.34

BC

C

306

0.83

2.83

77.68

CD

D

305

0.83

3.60

76.55

EF

E

306

0.83

-1.02

77.43

DF

F

306

1.00

5.25

79.71

FB

1.00

Raw Data

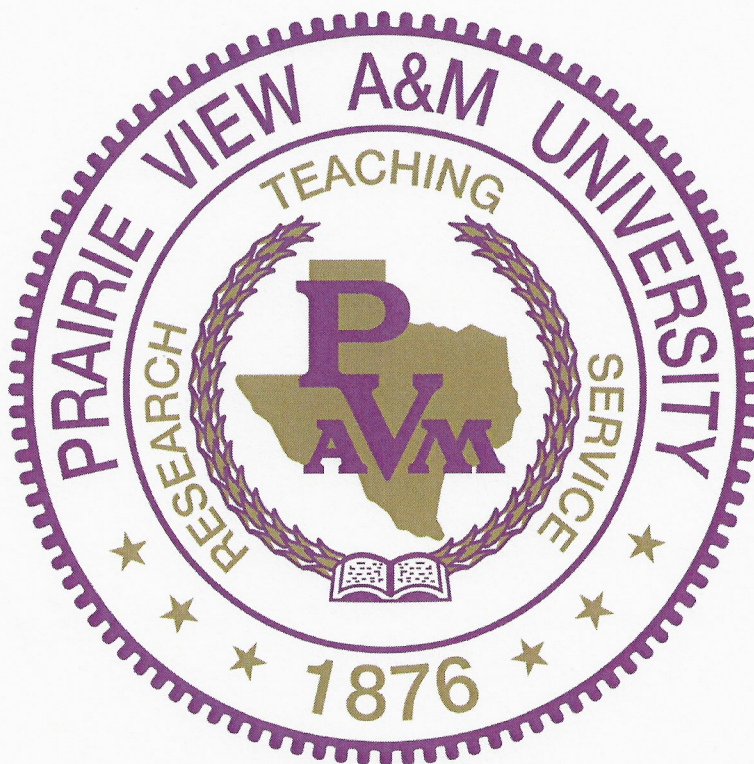
Hardy Cross Method

Pressure at Nodes

Ready

AVERAGE

**Prairie View A&M University
Roy G. Perry College of Engineering
Civil & Environmental Engineering Department**



CVEG 4303: Water Resources

Section: P01

Water Distribution System Design

Submitted By: Nathaniel Smith

Submitted To: Dr. Nzewi

Due Date: May 04, 2022

Letter of Transmittal

NS Engineering Inc.

May 04, 2022
Dear Dr. Nzewi,

The attached report contains the detailed plans of adequacy for a ~~newly constructed~~ water distribution system in Harris County, Texas. This report includes the task requirements, visual representation of the water distribution system design, and professionalism from civil engineers to design the system adequately.

NS Engineering Inc. is available to answer any questions you may have concerning this report or the project. You can contact Nathaniel Smith by email nsmith54@pvamu.edu

Sincerely,

Nathaniel Smith

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Acknowledgment

The project was prepared by Nathaniel Smith. Also, a special thanks to Dr. Nzewi for providing resources and guidance throughout the semester. Knowledge from this design course allowed for an advantage in creating a well-planned project.

Introduction

NS Engineering INC. is given the task of designing a water distribution system in Harris County, Texas. The water distribution system network contains two loops and six nodes. The goal of this project was to determine the total water demand, determine the network flows using the Hardy Cross method, and to determine the water pressure at designated points in the system in order to find out the adequacy of the system.

Total Water Demand

The total water demand (TDEM) of the system was found by multiplying the max daily consumption per acre from segments AE, EF, AB, and BC by their respective areas as well as by multiplying the max daily consumption per person from segments BF, FD, and CD by their respective populations. Then each of those individual demands are recorded and added together to get the total water demand. The calculations of each are seen below:

Segment	Area (acre)	Population	Max Daily Consumpti on per acre (gal/day/acre)	Max Daily Consumpti on per person (gal/day/person)	Area * Max Daily Consumpti on per acre (gpd)	Population * Max Daily Consumpti on per person (gpd)
AE	10		25000		250000	
EF	11		45000		495000	
AB	14		47000		658000	
BF		320		270		86400
FD		1100		270		297000
CD		1400		270		378000
BC	9		41000		369000	
					Σ of individual demands =TDEM	
					TDEM = 2533400 gpd	

$$1 \text{ ft}^3 = 7.481 \text{ gallons}$$

7.48052 Conversion

Next the water demands were converted from gpd to cfs:

Segment	Individual Water Demands (gpd)	Individual Water Demands (cfs)
AE	250000	0.375
EF	495000	0.7425
AB	658000	0.987
BF	86400	0.1296
FD	297000	0.4455
CD	378000	0.567
BC	369000	0.5535
TDEM =	2533400 gpd	3.8001 cfs

Please make a note of this

makes a difference

3.919

ADD FIRE DEMAND

Now the flow of each of the nodes were determined using the given design information where the fire demand (FDEM) is 2 cfs:

Node	Flow Formula	Flow Value (cfs)
A	+TDEM	3.8001
B	-(TDEM-FDEM)/5	-0.36002
C	-(TDEM-FDEM)/5	-0.36002
D	-[(TDEM-FDEM)/5 + FDEM]	-2.36002
E	-(TDEM-FDEM)/5	-0.36002
F	-(TDEM-FDEM)/5	-0.36002

Total DEM including Fire DEMAND = 5.92 cfs

-30

Roughness

The equivalent roughness of each of the pipes was determined to be the same value because they were all using galvanized iron:

Segment	Equivalent Roughness (in)	Equivalent Roughness (ft)
AE	0.0005	0.006
EF	0.0005	0.006
AB	0.0005	0.006
BF	0.0005	0.006
FD	0.0005	0.006
CD	0.0005	0.006
BC	0.0005	0.006

The relative roughness was then determined by dividing the equivalent roughness by each pipe's diameter:

Segment	Equivalent Roughness, ϵ (ft)	Diameter, D (ft)	Relative Roughness, ϵ/D
AE	0.006	1	0.0005
EF	0.006	1	0.0006
AB	0.006	0.833	0.0006
BF	0.006	0.833	0.0005
FD	0.006	0.833	0.0006
CD	0.006	1.25	0.0004
BC	0.006	1	0.0006

Friction Factor and Equivalent Resistance

By using the Swamee/Jain equation, derived relative roughnesses, and an assumed Reynold's number (Re) of 5000 (assuming all flows are fully turbulent), the friction factor for each pipe was determined. The values are seen below:

Segment	Relative Roughness, ϵ/D	Reynolds Number, Re	Friction factor, f $f = \frac{1.325}{(\ln(0.27 \frac{\epsilon}{D} + \frac{5.74}{Re}))^2}$
AE	0.0005	5000	0.0299
EF	0.0006	5000	0.0301
AB	0.0006	5000	0.0301
BF	0.0005	5000	0.0299
FD	0.0006	5000	0.0301
CD	0.0004	5000	0.0297
BC	0.0006	5000	0.0301

The K factors were determined by using the Manning's where the headloss, length, and diameter are in feet and the flow is in cfs. The calculations are seen below:

Segment	Friction factor, f	Length, L (ft)	Diameter, D (ft)	Equivalent Resistance, K $K = \frac{0.02517fL}{D^5}$
AE	0.0299	1200	1	0.90
EF	0.0301	1200	1	2.26
AB	0.0301	1300	0.833	2.45
BF	0.0299	1300	0.833	0.98
FD	0.0301	1300	0.833	2.45
CD	0.0297	1500	1.25	0.37
BC	0.0301	1200	1	2.26

Hardy Cross Method

The Hardy Cross method was used to determine the balanced pipe flows in all of the segments in the network. It is seen in the tables from Excel below, that the solution is converging with the headloss decreasing with each iteration. The tables are presented as followed:

Iteration	Loop	Pipeline	Length (ft)	Dia (in)	Dia (ft)	Equivalent	Equivalent	Relative	Reynolds	friction	K	Qa (gpd)	Qa (cfs)	headloss,	hf/Q	correction	Q=Qa+δ
						Sand	Sand							hf (ft)=			
						Roughness	Roughness	Roughness	Number	factor, f							
1	1	AB	1300	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.450751593	658000	0.987	2.387446	2.418892	-0.41389	0.573107
		BF	1300	12	1	0.006	0.0005	0.0005	5000	0.0299	0.9783579	-86400	-0.1296	0.016433	0.126795	-0.16866	-0.29826
		EF	1200	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.26223224	495000	0.7425	1.247183	1.679707	-0.41389	0.328607
		AE	1200	12	1	0.006	0.0005	0.0005	5000	0.0299	0.9030996	250000	0.375	0.126998	0.338662	-0.41389	-0.03889
	2	BC	1200	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.26223224	369000	0.5535	0.693063	1.252146	-0.24524	0.308263
		CD	1500	15	1.25	0.006	0.0005	0.0004	5000	0.0297	0.367435284	-378000	-0.567	0.118126	0.208336	-0.24524	-0.81224
		FD	1300	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.450751593	297000	0.4455	0.486401	1.09181	-0.24524	0.200263
		BF	1300	12	1	0.006	0.0005	0.0005	5000	0.0299	0.9783579	86400	0.1296	0.016433	0.126795	0.168656	0.298256
	Sum ->													3.77806	4.564057	61=	-0.41389
	Sum ->													1.314023	2.679086	62=	-0.24524
2	1	AB	1300	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.450751593	382071.5	0.573107	0.804954	1.404544	-0.22984	0.343269
		BF	1300	12	1	0.006	0.0005	0.0005	5000	0.0299	0.9783579	-198837	-0.29826	0.087031	0.291801	-0.04914	-0.3474
		EF	1200	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.26223224	219071.5	0.328607	0.244282	0.743386	-0.22984	0.098769
		AE	1200	12	1	0.006	0.0005	0.0005	5000	0.0299	0.9030996	-25928.5	-0.03889	0.001366	0.035124	-0.22984	-0.26873
	2	BC	1200	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.26223224	205508.6	0.308263	0.214971	0.697362	-0.1807	0.127568
		CD	1500	15	1.25	0.006	0.0005	0.0004	5000	0.0297	0.367435284	-541491	-0.81224	0.242408	0.298445	-0.1807	-0.99293
		FD	1300	10	0.833333	0.006	0.0005	0.0006	5000	0.0301	2.450751593	133508.6	0.200263	0.098288	0.490795	-0.1807	0.019568
		BF	1300	12	1	0.006	0.0005	0.0005	5000	0.0299	0.9783579	198837.1	0.298256	0.087031	0.291801	0.049143	0.347399
	Sum ->													1.137633	2.474854	61=	-0.22984
	Sum ->													0.642698	1.778402	62=	-0.1807
3	1	AB	1300	10	0.833333	0.006	0.0005	0.0006	0.0301	0.0301	2.450751593	228845.9	0.343269	0.288781	0.841267	-0.14999	0.193281
		BF	1300	12	1	0.006	0.0005	0.0005	0.0299	0.0299	0.9783579	-231599	-0.3474	0.118074	0.33988	0.098791	-0.24861
		EF	1200	10	0.833333	0.006	0.0005	0.0006	0.0301	0.0301	2.26223224	65845.86	0.098769	0.022069	0.223438	-0.14999	-0.05122
		AE	1200	12	1	0.006	0.0005	0.0005	0.0299	0.0299	0.9030996	-179154	-0.26873	0.065219	0.242691	-0.14999	-0.41872
	2	BC	1200	10	0.833333	0.006	0.0005	0.0006	0.0301	0.0301	2.26223224	85045.05	0.127568	0.036814	0.288587	-0.24878	-0.12121
		CD	1500	15	1.25	0.006	0.0005	0.0004	0.0297	0.0297	0.367435284	-661955	-0.99293	0.36226	0.364838	-0.24878	-1.24171
		FD	1300	10	0.833333	0.006	0.0005	0.0006	0.0301	0.0301	2.450751593	13045.05	0.019568	0.000938	0.047955	-0.24878	-0.22921
		BF	1300	12	1	0.006	0.0005	0.0005	0.0299	0.0299	0.9783579	231599.2	0.347399	0.118074	0.33988	-0.09879	0.248608
	Sum ->													0.494142	1.647276	61=	-0.14999
	Sum ->													0.518087	1.041261	62=	-0.24878

Should be negative
fn=2
Good!

head loss is negative when flow is negative

26
Corrections are still too high to stop

Water Pressures

Next the water pressures at nodes D and E had to be computed (detailed calculations in appendix). The pressures are tabulated below:

Node	Pressure (psi)
D	74.3
E	74.81

Based on page 666 of the textbook, the water distribution system is adequate as designed because the pressures fall in the range of 60 psi to 75 psi. That is the range for commercial areas.

Conclusion

Upon successful completion of this project, it is seen from the data collected and computed that the designed water distribution system is adequate for use.

Appendix

$$f = \frac{1.325}{\left(\ln\left(1.27 \frac{E}{D} + \frac{5.74}{Re}\right)\right)^2}$$

Assume $Re = 5000$

$$f_{AB} = \frac{1.325}{\left(\ln\left(1.27(0.0006) + \frac{5.74}{5000}\right)\right)^2} = .0301$$

$$f_{BF} = .0299$$

$$f_{EF} = .0301$$

$$f_{AE} = .0299$$

$$f_{BC} = .0301$$

$$f_{CD} = .0297$$

$$f_{FD} = .0301$$

$$f_{BF} = .0299$$

Water Pressures

$$Z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_f \quad \gamma_w = 62.4 \text{ lb/ft}^3$$

Good!

$$AE) 308 \text{ ft} + \frac{74 \text{ psi}(144)}{62.4 \text{ lb/ft}^3} = 306 \text{ ft} + \frac{P_E}{62.4 \text{ lb/ft}^3} + .13 \text{ ft}$$

$$1.97 \text{ ft} + \frac{10656 \text{ lb/ft}^2}{62.4 \text{ lb/ft}^3} = \frac{P_E}{62.4 \text{ lb/ft}^3}$$

$$172.64 \text{ ft} = \frac{P_E}{62.4 \text{ lb/ft}^3}$$

$$P_E = 172.64 \text{ ft} (62.4 \frac{\text{lb}}{\text{ft}^3}) (\frac{1 \text{ ft}^2}{144 \text{ in}^2}) = \boxed{74.81 \text{ psi} = P_E}$$

$$EF) 306 \text{ ft} + \frac{74.81 \text{ psi}(144)}{62.4 \text{ lb/ft}^3} = 306 \text{ ft} + \frac{P_F}{62.4 \text{ lb/ft}^3} + 1.25 \text{ ft}$$

$$\frac{10772.64 \text{ lb/ft}^2}{62.4 \text{ lb/ft}^3} - 1.25 \text{ ft} = \frac{P_F}{62.4 \text{ lb/ft}^3}$$

$$P_F = (172.64 \text{ ft} - 1.25 \text{ ft}) (62.4 \text{ lb/ft}^3) (\frac{1 \text{ ft}^2}{144 \text{ in}^2}) = 74.3 \text{ psi} = P_F$$

$$FD) 306 \text{ ft} + \frac{74.3 \text{ psi}(144)}{62.4 \text{ lb/ft}^3} = 305 \text{ ft} + \frac{P_D}{62.4 \text{ lb/ft}^3} + .49 \text{ ft}$$

$$.51 \text{ ft} + \frac{10699 \text{ lb/ft}^2}{62.4 \text{ lb/ft}^3} = \frac{P_D}{62.4 \text{ lb/ft}^3}$$

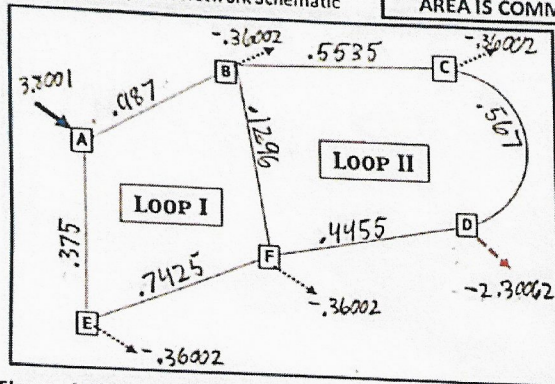
$$171.46 \text{ ft} = \frac{P_D}{62.4 \text{ lb/ft}^3}$$

$$P_D = 171.46 \text{ ft} (62.4 \frac{\text{lb}}{\text{ft}^3}) (\frac{1 \text{ ft}^2}{144 \text{ in}^2}) = \boxed{74.3 \text{ psi} = P_D}$$

DESIGN INFORMATION

Water Supply System Network Schematic

AREA IS COMMERCIAL



Fill in data in BLUE fields

COMPLETE THIS TABLE per REQUIREMENTS

See instructions	Flow [cfs]
NODE	INFLOW (+) /OUTFLOW (-)
A	+TDEM
B	-(TDEM-FDEM)/5
C	-(TDEM-FDEM)/5
D	-(TDEM-FDEM)/5 + FDEM
E	-(TDEM-FDEM)/5
F	-(TDEM-FDEM)/5
FIRE DEMAND [cfs]	FDEM
TOTAL DEMAND [cfs]	TDEM

Flow and other network data

CLOCKWISE FLOWS are designated as POSITIVE.
All work MUST BE in English Units

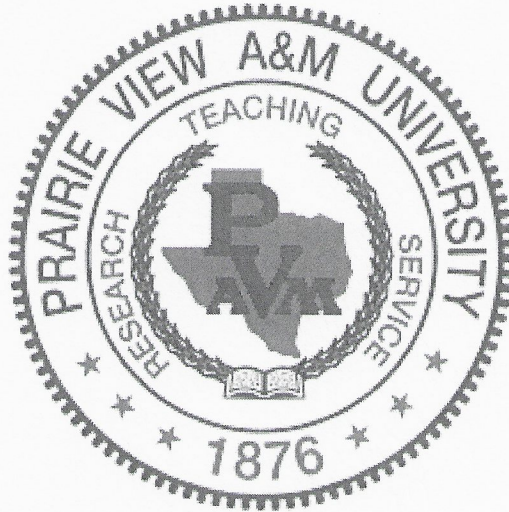
Segment / Demand Type	Pipe Material: Galvanized Iron			PIPE SEGMENT(S)	PIPE DIAMETERS [in]	PIPE LENGTH [ft]
	Segment Length [ft]	Equiv Sand Rough [in]	Area [acres]	AE, EF, BC	12	1200
AE	1200	.006	10.00	CD	15	1500
EF	1200	.006	11.00	AB, BF, FD	10	1300
AB	1300	.006	14.00			
BF	1300	.006				
FD	1300	.006				
CD	1500	.006				
BC	1200	.006	9.00			
Fire Demand [cfs]			2.00 cfs		41000	

PRESSURE at A	74.00 psi
NODE	Elevation [ft]
A	308.0
B	302.0
C	306.0
D	305.0
E	306.0
F	306.0

$$\rightarrow 74 \frac{\text{lb}}{\text{in}^2} \times \left(\frac{12 \text{ in}}{1 \text{ ft}} \right)^2 = 10,656 \text{ psf}$$

BELOW
AVERAGE

Prairie View A&M University
Roy G Perry College of Engineering
Civil & Environmental Engineering Department



CVEG 4303 P01 – Water Resources

Spring 2022

Project Report 2- Water Distribution System
Design

Submitted to:

Dr. Nzewi

Submitted by: Sydney Jones

Date Due: May 5, 2022

Letter of Transmittal

May 5, 2022

Dr. Nzewi

Civil Engineering Department

Prairie View A&M University

Dear Dr. Nzewi:

The attached technical ~~laboratory~~ ^{Project} report contains the detailed results of Water Distribution System Design in a residential area. The report contains detailed calculations, the results, and a recommendation regarding whether it is adequate for a residential region.

Please contact me at 512-586-4461 or by e-mail at sjones117@pvamu.edu if you have any questions on the report.

Sincerely,

Sydney N Jones

580
700

Abstract

Determining whether a water distribution system is adequate for the people it serves, includes a lot of calculations and assumptions. By utilizing the provided data necessary to make a calculated recommendation, students were able to decide that the provided water distribution system is not adequate for the residential area it serves due to the extremely high water pressure found at each node. This recommendation was made after calculating the inflow and outflow at each node, calculating the total flow rate in the system and using that information in a spreadsheet for the Hardy Cross method. After calculating the correct flow rate in each segment, the water pressure was calculated and compared to water pressure requirements. These steps can be found in the appendix and throughout the report.

✓
good!

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List of Equations

Task 1 : No equation utilized

Task 2 : No equation utilized

Task 3 : $K = \frac{4.73L}{C^{1.85} d^{4.87}}$

Relative Roughness $= \frac{\epsilon}{D}$

Task 4 : $h_f = KQ^n$

Correction $= \frac{-\Sigma h_f}{n \Sigma \left| \frac{h_f}{Q} \right|}$

Task 5 :

$$\frac{P_A}{\gamma} + Z_A = \frac{P_B}{\gamma} + Z_B + h_L$$

Task 6 : No equation utilized

List of Tables

Task 1: Table 1.1: Length and Maximum Consumption

Task 2: Table 2.1: Node Inflow and Outflow

Table 2.2: Inflow and Outflow

Task 3: Table 3.1: Sand Roughness, Friction factor, K and Relative Roughness

Task 4: Table 4.1: Iteration 3 from Hardy Cross Spreadsheet

Task 5: Table 5.1: Pressure at each node

Task 6: No Tables Utilized

Results and Calculations

Task 1:

For task 1, students were asked to fill in the provided table. Below, the length of each segment was found, the maximum consumption for each section (gal/day) and (cfs) and the total flow rate for the system.

Table 1.1: Length and Maximum Consumption

Segment	Length (ft)	Maximum Consumption (gal/day)	Maximum Consumption (cfs)
AE	1400	320000	0.5 ✓
EF	1400	336000	0.52 ✓
AB	1300	495000	0.77 ✓
BF	1300	80000	0.12 ✓
FD	1300	275000	0.43 ✓
CD	1500	350000	0.54 ✓
BC	1400	200000	0.31 ✓

Task 2:

For task 2, students were asked to calculate the demand flows from the information provided. This was calculated by drawing out the distribution system figure and utilizing the chart we were provided shown below in table 2.2.

Table 2.1: Node Inflow and Outflow

Node	Flow
A	+3.2 cfs
B	-0.14 cfs
C	-0.14 cfs
D	-2.64 cfs
E	-0.14 cfs
F	-0.14 cfs

in correct distribution

30
Total demand = 5.68 cfs

Table 2.2: Inflow and Outflow

See instructions	Flow [cfs]
NODE	INFLOW [+] /OUTFLOW [-]
A	+TDEM
B	-(TDEM-FDEM)/5
C	-(TDEM-FDEM)/5
D	-[(TDEM-FDEM)/5 + FDEM]
E	-(TDEM-FDEM)/5
F	-(TDEM-FDEM)/5
FIRE DEMAND [cfs]	FDEM
TOTAL DEMAND [cfs]	TDEM

Task 3:

For task 3, students were asked to provide the equivalent sand roughness in inches and feet for each segment of the water distribution system as well as the relative roughness and friction factor. Utilizing the sand roughness allowed for K to be calculated as well. The flow was categorized as fully rough turbulent which allowed for the friction factor to be assumed. The equations that were used are shown below and the results of each portion are shown in table 3.1.

$$K = \frac{4.73L}{C^{1.85} d^{4.87}}$$

$$\text{Relative Roughness} = \frac{\epsilon}{D}$$

Table 3.1: Sand Roughness, Friction factor, K and Relative Roughness

Segment	Sand Roughness (in)	Sand Roughness (ft)	Friction Factor	K value	Relative Roughness
AE	.0018	1.5e-4	5000	2.82e-3	1.2e-4
EF	.0018	1.5e-4	5000	2.82e-3	1.2e-4
AB	.0018	1.5e-4	5000	3.60e-4	1.8e-4
BF	.0018	1.5e-4	5000	3.60e-4	1.8e-4
FD	.0018	1.5e-4	5000	3.60e-4	1.8e-4
CD	.0018	1.5e-4	5000	4.20e-4	1.8e-4
BC	.0018	1.5e-4	5000	2.82e-3	1.2e-4

uses Jain/Swamee equation

↑ NO f values are not this high

Task 4:

For task 4, students were asked to utilize the Hardy Cross method in order to determine the balanced flows [cfs] for all the pipe segments in the network. Three iterations were done and the final iteration is shown below in table 4.1. More details can be found in the spreadsheet found in the appendix. Equations used can be found below.

$$h_f = KQ^n$$

$$\text{Correction} = \frac{-\sum h_f}{n \sum \left| \frac{h_f}{Q} \right|}$$

Table 4.1: Iteration 3 from Hardy Cross Spreadsheet

C	Pipe Segment	Length (FT)	Dia (in)	Dia(FT)	K	Qa (cfs)	hf	hf/Q	New Q
120	AE	1400	15	1.25	0.002817	-1.56888	-0.00648171	0.004131	-1.56888
120	EF	1400	15	1.25	0.002817	1.631116	0.006965356	0.00427	1.631116
120	AB	1300	10	0.833333	0.000363	-1.42888	-0.00070282	0.000492	-1.42888
120	BF	1300	10	0.833333	0.000363	0.761116	0.00021917	0.000288	0.761116
Loop 1									
Correction=		3.35106E-17							
120	BF	1300	10	0.833333	0.000363	1.868033	0.001153875	0.000618	1.868039
120	FD	1300	10	0.833333	0.000363	0.408033	6.91645E-05	0.00017	0.408039
120	CD	1500	10	0.833333	0.000419	1.728033	0.0011527	0.000667	1.728039
120	BC	1400	15	1.25	0.002817	-0.91197	-0.00237579	0.002605	-0.91196
Loop 2									
Correction=		6.80725E-06							

Task 5:

For task 5, students were asked to calculate the water pressure at node D and E. The equation used was Bernoulli's equation shown below. The calculations to determine the pressure at each node can be found in the appendix. Head Loss was negated in this calculation due to the lack of information on each node such as length and diameter. Table 5.1 consists for all the calculated pressures at each node.

$$\frac{P_A}{\gamma} + Z_A = \frac{P_B}{\gamma} + Z_B + h_L$$

Table 5.1: Pressure at each node

Node	Pressure (psi)
A	75 (Given)
B	77.6
C	75.8
D	76.3
E	75.8
F	75.8

30

Task 6:

For task 6, students were asked to determine if the water distribution network, as designed, is adequate based on provided information. The water distribution center I was tasked with was proposed for a residential area. Based on the provided information, a distribution center in a residential area has a recommended pressure range of 40-50 psi. Based on the calculated pressures found in task 5, this distribution center would not be deemed as adequate. The calculated pressures are significantly more than the recommended pressure range and as a result **would not** be the safest option.

Conclusion

Based on the calculations completed for the calculations completed for this residential water distribution system, this will not be an adequate design based on the water pressures. A design that allows water pressure to fall in the recommended range of 40-50 psi would be the best option.

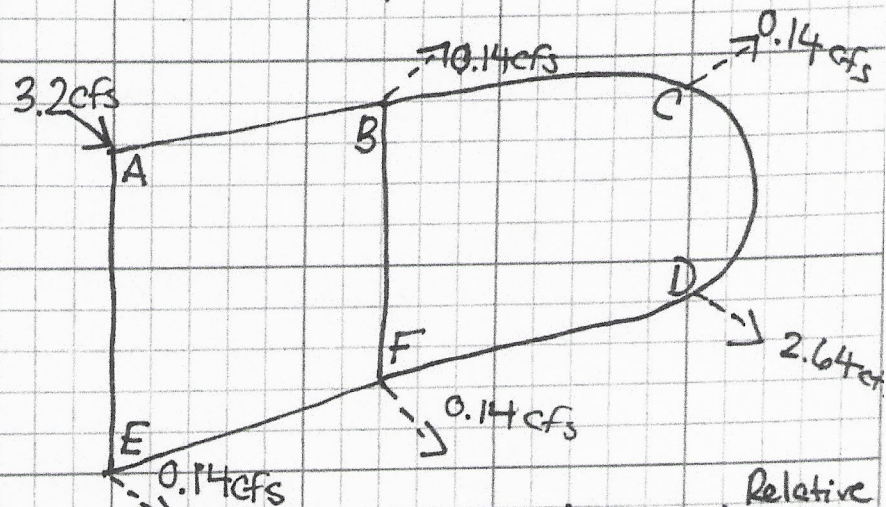
Appendix

Part 1

Segment	Length	Sand Rough	Max Consumption (gal/day)	Max Consumption (cfs)
AE	1400 ft	.0018 in	320000	0.50000
EF	1400 ft	.0018 in	336000	0.52000
AB	1300 ft	.0018 in	495000	0.77000
BF	1300 ft	.0018 in	80000	0.12
FD	1300 ft	.0018 in	275000	0.43
CD	1500 ft	.0018 in	350000	0.54
BC	1400 ft	.0018 in	200000	0.31
Σ			2056000 gal/d	3.19 cfs $\approx$ 3.2 cfs

Part 2

Node	Flow
A	+3.2 cfs
B	-.14 cfs
C	-.14 cfs
D	-2.64 cfs
E	-.14 cfs
F	-.14 cfs



Part 3

Segment	Sand Rough (in)	Sand Rough (ft)	Friction Factor	K Value	Relative roughness
AE	.0018	$1.5E-4$	5000	.00282	$1.2E-4$
EF	.0018	$1.5E-4$	5000	.00282	$1.2E-4$
AB	.0018	$1.5E-4$	5000	.000436	$1.8E-4$
BF	.0018	$1.5E-4$	5000	.000436	$1.8E-4$
FD	.0018	$1.5E-4$	5000	.000436	$1.8E-4$
CD	.0018	$1.5E-4$	5000	.00042	$1.8E-4$
BC	.0018	$1.5E-4$	5000	.00282	$1.2E-4$

$$K = \frac{4.73L}{C^{1.85} d^{4.87}}$$

$$\frac{E}{D}$$

Part 4

Please see attached excel sheet

Part 5

$$\frac{P_A}{\gamma} + z_A = \frac{P_B}{\gamma} + z_B + h_L$$

$$\frac{75(144)}{62.4} + 308 = \frac{P_B(144)}{62.4} + 302$$

$$P_B = 77.6 \text{ psi}$$

$$\frac{75(144)}{62.4} + 308 = \frac{P_C(144)}{62.4} + 306$$

$$P_C = 75.8 \text{ psi}$$

$$\frac{75(144)}{62.4} + 308 = \frac{P_D(144)}{62.4} + 305$$

$$P_D = 76.3 \text{ psi}$$

$$\frac{75(144)}{62.4} + 308 = \frac{P_E(144)}{62.4} + 306$$

$$P_E = 75.8 \text{ psi}$$

$$\frac{75(144)}{62.4} + 308 = \frac{P_F(144)}{62.4} + 306$$

$$P_F = 75.8 \text{ psi}$$

head loss?

I don't see where you included the head loss values

Part 6

Based on 15.154 in the textbook, the distribution system would not be deemed as adequate. For a residential area, the appropriate & recommended pressure range is between 40-50 psi. The calculated pressures for this system ~~are 75.8 psi~~ exceed this range.

C	Pipe Segment	Length (FT)	Dia (in)	Dia(FT)	K	Qa (cfs)	hf	hf/Q	New Q
	120 AE	1400	15	1.25	0.002817387	-1.6	-0.00672153	0.004200959	-1.568882782
	120 EF	1400	15	1.25	0.002817387	1.6	0.006721534	0.004200959	1.631117218
	120 AB	1300	10	0.833333333	0.000363159	-1.46	-0.00073139	0.000500953	-1.428882782
	120 BF	1300	10	0.833333333	0.000363159	0.73	0.000202883	0.000277921	0.761117218

Loop 1

Correction= 0.03111722

120 BF	1300	10	0.833333333	0.000363159	0.73	0.000202883	0.000277921	1.672072119
120 FD	1300	10	0.833333333	0.000363159	-0.73	-0.00020288	0.000277921	0.212072119
120 CD	1500	10	0.833333333	0.00041903	0.59	0.000157878	0.00026759	1.532072119
120 BC	1400	15	1.25	0.002817387	-2.05	-0.01063142	0.005186056	-1.107927881

Loop 2

Correction= 0.94207212

Segment	LENGTH	Diameter (in)	Diameter (Ft)	SAND ROUGH (FT)	SAND ROUGH (IN)	AREA	POPULATION	MAX DAILY CONSUMPTION/ ACRE	MAX DAILY CONSUMPTION/ CAPITA
AE	1400	15	1.25	1.50E-04	0.0018	16		20000	
EF	1400	15	1.25	1.50E-04	0.0018	8		42000	
AB	1300	10	0.833333	1.50E-04	0.0018	11		45000	
BF	1300	10	0.833333	1.50E-04	0.0018		320		250
FD	1300	10	0.833333	1.50E-04	0.0018		1100		250
CD	1500	10	0.833333	1.50E-04	0.0018		1400		250
BC	1400	15	1.25	1.50E-04	0.0018	5		40000	

NODE	FLOW
A	3.2
B	-0.14
C	-0.14
D	-2.64
E	-0.14
F	-0.14

Iteration 2	C	Pipe Segment	Length (FT)	Dia (in)	Dia(FT)	K	Qa (cfs)
		120 AE	1400	15	1.25	0.002817387	-1.568882782
		120 EF	1400	15	1.25	0.002817387	1.631117218
		120 AB	1300	10	0.833333	0.000363159	-1.428882782
		120 BF	1300	10	0.833333	0.000363159	0.761117218
Loop 1							
		Correction=	-1.404E-06				
		120 BF	1300	10	0.833333	0.000363159	1.672072119
		120 FD	1300	10	0.833333	0.000363159	0.212072119
		120 CD	1500	10	0.833333	0.00041903	1.532072119
		120 BC	1400	15	1.25	0.002817387	-1.107927881
Loop 2							
		Correction=	0.18981525				

Flow Rate (gal/day)	Flow Rate (cfs)	Friction	C	K Value	ε/D	H _F
320000	-1.6	5000	120	0.00281739	1.20E-04	0.006722
336000	-1.46	5000	120	0.00281739	1.20E-04	0.005674
495000	1.6	5000	120	0.00036316	1.80E-04	0.000866
80000	0	5000	120	0.00036316	1.80E-04	0
275000	-1.32	5000	120	0.00036316	1.80E-04	0.000607
350000	-1.32	5000	120	0.00041903	1.80E-04	0.0007
200000	-1.46	5000	120	0.00281739	1.20E-04	0.005674
2056000						

hf	hf/Q	New Q	Iteration 3	C	Pipe Segm Length (FT)	Dia (in)	Dia(FT)
-0.006481699	0.004131411	-1.568884186		120 AE	1400	15	1.25
0.006965367	0.004270304	1.6311115814		120 EF	1400	15	1.25
-0.000702815	0.000491863	-1.428884186		120 AB	1300	10	0.833333
0.000219171	0.000287959	0.7611115814		120 BF	1300	10	0.833333
				Loop 1			
				Correction=	-2.4E-15		
0.000939981	0.000562165	1.861887369		120 BF	1300	10	0.833333
2.06107E-05	9.7187E-05	0.401887369		120 FD	1300	10	0.833333
0.000922596	0.000602189	1.721887369		120 CD	1500	10	0.833333
-0.003405593	0.00307384	-0.918112631		120 BC	1400	15	1.25
				Loop 2			
				Correction=	0.006145		

K	Qa (cfs)	hf	hf/Q	New Q	Iteration 4	C	Pipe Segment	Length (FT)	Dia (in)
0.002817	-1.56888	-0.00648171	0.004131	-1.56888	Loop 1		120 AE	1400	15
0.002817	1.631116	0.006965356	0.00427	1.631116			120 EF	1400	15
0.000363	-1.42888	-0.00070282	0.000492	-1.42888			120 AB	1300	10
0.000363	0.761116	0.00021917	0.000288	0.761116			120 BF	1300	10
Correction=							3.35106E-17		
0.000363	1.861887	0.001146862	0.000616	1.868033	Loop 2		120 BF	1300	10
0.000363	0.401887	6.72497E-05	0.000167	0.408033			120 FD	1300	10
0.000419	1.721887	0.001145128	0.000665	1.728033			120 CD	1500	10
0.002817	-0.91811	-0.00240549	0.00262	-0.91197			120 BC	1400	15
Correction=							6.80725E-06		

Dia(FT)	K	Qa (cfs)	hf	hf/Q	New Q
1.25	0.002817	-1.56888	-0.00648171	0.004131	-1.56888
1.25	0.002817	1.631116	0.006965356	0.00427	1.631116
0.833333	0.000363	-1.42888	-0.00070282	0.000492	-1.42888
0.833333	0.000363	0.761116	0.00021917	0.000288	0.761116
0.833333	0.000363	1.868033	0.001153875	0.000618	1.868039
0.833333	0.000363	0.408033	6.91645E-05	0.00017	0.408039
0.833333	0.000419	1.728033	0.0011527	0.000667	1.728039
1.25	0.002817	-0.91197	-0.00237579	0.002605	-0.91196

VI.

CLASSWORK

[07]

CVEG 4303
WATER RESOURCES ENGINEERING
SPRING 2022

CLASSWORK
01

ABOVE
AVERAGE

(H)

Course: CVEG 4303P01 Name: MAALVIKA AGGARWAL DUE: Friday, Jan 28, 2022, 11:30 PM (CANVAS)
 Classwork **01** 2022Jan27A [150/150] Date: 2022Jan27A

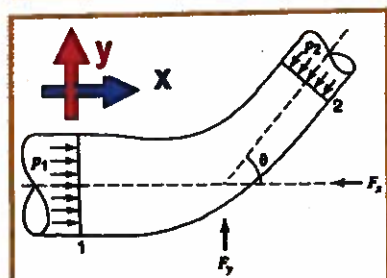
Water is flowing through a horizontal reducing bend shown, where $\theta = 60^\circ$. The initial diameter, $D_1 = 40$ cm and the final diameter, $D_2 = 25$ cm while the discharge rate is $0.60 \text{ m}^3/\text{s}$. The pressure at the upstream end is 105 kPa and headloss in the bend is negligible.

Determine the force in kN (x- and y-components) to keep the bend in place.

$$\sum F_x = \rho Q(\bar{V}_{2x} - \bar{V}_{1x})$$

$$\sum F_y = \rho Q(\bar{V}_{2y} - \bar{V}_{1y})$$

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.
 WRITE ON ONLY 1 SIDE OF PAPER. The scanned submission must be clear and EASY to read.



X-dir: $-F_x + p_1 A_1 - p_2 A_2 \cos \theta = \rho Q(V_2 \cos \theta - V_1)$
 Y-dir: $+F_y + 0 - p_2 A_2 \sin \theta = \rho Q(V_2 \sin \theta - 0.0)$

$$A_1 = \frac{\pi(0.40)^2}{4} = 0.1256 \text{ m}^2, A_2 = \frac{\pi(0.25)^2}{4} = 0.0491 \text{ m}^2$$

as $D_1 = 40 \text{ cm} = 0.4 \text{ m}$, $D_2 = 25 \text{ cm} = 0.25 \text{ m}$

$P_1 = 105 \text{ kPa}$, $Q = 0.60 \text{ m}^3/\text{s}$

$Q = V_1 A_1$, so, $V_1 = \frac{Q}{A_1} = \frac{0.60}{0.1256} = 4.77 \text{ m/s}$

Using $V_1 A_1 = V_2 A_2$, $V_2 = \frac{V_1 A_1}{A_2} = \frac{(4.77)(0.1256)}{0.0491} = 12.22 \text{ m/s}$

Now, $\frac{P_1}{\rho} + \frac{V_1^2}{2g} = \frac{P_2}{\rho} + \frac{V_2^2}{2g}$

$$P_2 = \left[\left(\frac{P_1}{\rho} + \frac{V_1^2}{2g} \right) - \frac{V_2^2}{2g} \right] \rho = \left[\left(\frac{105,000}{9810} + \frac{4.77^2}{2(9.81)} \right) - \left(\frac{12.22^2}{2(9.81)} \right) \right] 9810 = 41,696.6 \text{ Pa}$$

$P_2 = 41.69 \text{ kPa}$

Forces

X-direction: $-F_x + P_1 A_1 - P_2 A_2 \cos \theta = \rho Q(V_2 \cos \theta - V_1)$
 $F_x = P_1 A_1 - P_2 A_2 \cos \theta - \rho Q(V_2 \cos \theta - V_1) = (105,000)(0.1256) - (41,696.6)(0.0491) \cos 60 - (1000)(0.60)(12.22 \cos 60 - 4.77)$

$F_x = -11,369.16 \text{ N}$

$F_x = -11.369 \text{ kN}$

Y-direction:

$F_y = \rho Q(V_2 \sin \theta) + P_2 A_2 \sin \theta = (1000)(0.60)(12.22 \sin 60) + (41,696.6)(0.0491) \sin 60$

$F_y = 8,123.86 \text{ N}$

$F_y = 8.123 \text{ kN}$

AVERAGE

Nathaniel Smith

Course: CVEG 4303P01Name:

DUE: Friday, Jan 28, 2022, 11:30 PM (CANVAS)

Classwork01_2022Jan27A [130/150]

Date: 2022Jan27A

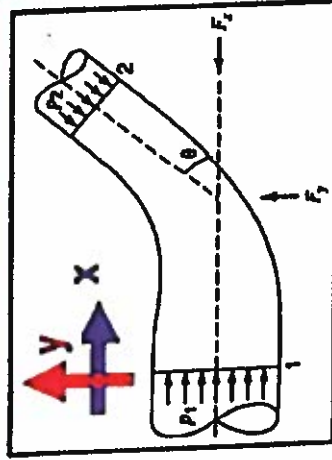
Water is flowing through a horizontal reducing bend shown, where $\theta = 60^\circ$. The initial diameter, $D_1 = 40$ cm and the final diameter, $D_2 = 25$ cm while the discharge rate is $0.60 \text{ m}^3/\text{s}$. The pressure at the upstream end is 105 kPa and headloss in the bend is negligible.

Determine the force in kN (x- and y-components) to keep the bend in place.

$$\sum F_x = \rho Q (\bar{V}_x - \bar{V}_1)$$

$$\sum F_y = \rho Q (\bar{V}_y - \bar{V}_1)$$

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.
WRITE ON ONLY 1 SIDE OF PAPER. The scanned submission must be clear and EASY to read.



$$\text{X-dir: } -F_x + p_1 A_1 - p_2 A_2 \cos \theta = \rho Q (V_2 \cos \theta - V_1)$$

$$\text{Y-dir: } +F_y + 0 - p_2 A_2 \sin \theta = \rho Q (V_2 \sin \theta - 0.0)$$

Given

$$\theta = 60^\circ$$

$$D_1 = 40 \text{ cm} = .4 \text{ m}$$

$$D_2 = 25 \text{ cm} = .25 \text{ m}$$

$$Q = .6 \text{ m}^3/\text{s}$$

$$P_1 = 105 \text{ kPa}$$

$$Q = VA \rightarrow V = \frac{Q}{A}$$

$$A = \frac{\pi D^2}{4}$$

$$A_1 = \frac{\pi (.4 \text{ m})^2}{4} = .126 \text{ m}^2, A_2 = \frac{\pi (.25 \text{ m})^2}{4} = .049 \text{ m}^2$$

$$V_1 = \frac{.6 \text{ m}^3/\text{s}}{.126 \text{ m}^2} = 4.76 \text{ m/s}, V_2 = \frac{.6 \text{ m}^3/\text{s}}{.049 \text{ m}^2} = 12.24 \text{ m/s}$$

$$z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_f$$

$$\frac{105 \text{ kPa}}{9.81 \text{ kN/m}^3} + \frac{(4.76 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)} = \frac{P_2}{9.81 \text{ kN/m}^3} + \frac{(12.24 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)}$$

$$10.70 \text{ m} + 1.15 \text{ m} = \frac{P_2}{9.81 \text{ kN/m}^3} + 7.64 \text{ m}$$

$$P_2 = 41.3 \text{ kPa}$$

$$x\text{-direction: } F_x = P_1 A_1 - P_2 A_2 \cos \theta - \rho Q (V_2 \cos \theta - V_1)$$

$$F_x = 105 \text{ kPa} (.126 \text{ m}^2) - 41.3 \text{ kPa} (.049 \text{ m}^2) \cos 60 - 1000 \text{ kg/m}^3 (.6 \text{ m}^3/\text{s}) (12.24 \cos 60 - 4.76 \text{ m/s})$$

$$F_x = 13.23 \text{ kN} - 1.01 \text{ kN} - 816 \text{ kN}$$

$$F_x = 803.78 \text{ kN} \quad \text{No}$$

looks like math error

$$y\text{-direction: } F_y = \rho Q (V_2 \sin \theta) + P_2 A_2 \sin \theta$$

$$F_y = 1000 \text{ kg/m}^3 (.6 \text{ m}^3/\text{s}) (12.24 \text{ m/s} \sin 60) + 41.3 \text{ kPa} (.049 \text{ m}^2) \sin 60$$

$$F_y = 6360.09 \text{ kN} + 1.75 \text{ kN}$$

$$F_y = 6361.84 \text{ kN} \quad \text{N}$$

Always write in same units!

BELOW
AVERAGE

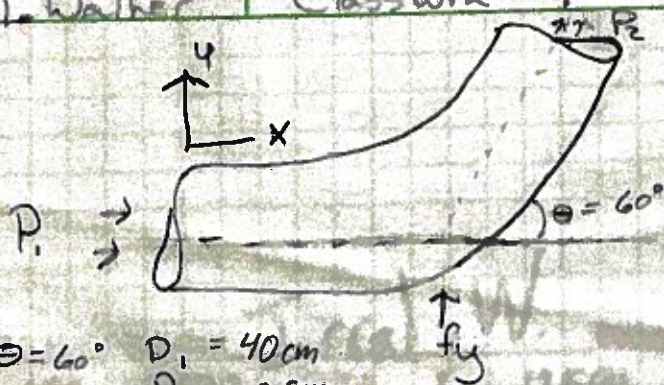
WALKER

Jermal T. Walker

Classwork - 1

90/100

Ⓛ



given: $\theta = 60^\circ$ $D_1 = 40 \text{ cm}$
 $D_2 = 25 \text{ cm}$

$Q = 0.6 \text{ m}^3/\text{s}$
 $P_1 = 150 \text{ kPa}$ hdt negligible
 $P_2 = 0$ assume at p

$\rho = 1000 \text{ kg/m}^3$

Area of Sphere = $\frac{\pi D^2}{4}$

$$A_1 = \frac{\pi (0.1)^2}{4} = 0.00785 \text{ m}^2$$

$$A_2 = \frac{\pi (0.025)^2}{4} = 0.00049 \text{ m}^2$$

Determine the force (kN)

Solution

$$V_1 = \frac{Q}{A} = \frac{0.6 \text{ m}^3/\text{s}}{0.00785} = 76.43 \text{ m/s}$$

$$V_2 = \frac{Q}{A} = \frac{0.6 \text{ m}^3/\text{s}}{0.00049} = 1224.49 \text{ m/s}$$

$$\Sigma \text{ force} = \rho Q (V_2 - V_1)$$

$$-F_x + P_1 A_1 - P_2 A_2 \cos \theta = \rho Q (V_2 \cos \theta - V_1)$$

$$-F_x + 150 \times 10^3 \times 0.00785 - 0 = 1000 \text{ kg/m}^3 \times 0.6 \text{ m}^3/\text{s} (1224.49 \text{ m/s} \cos(60^\circ) - 76.43 \text{ m/s})$$

$$-F_x + 1177.5 = -3181.2$$

$$F_x = 15568.7 \text{ N} / 1000 = 15.57 \text{ kN}$$

$$\cos(60^\circ) = 0.5$$

$$\Sigma F_y = \rho Q (V_2 - V_1)$$

$$+F_y + 0 - P_2 A_2 \sin \theta = \rho Q (V_2 \sin \theta - 0)$$

$$+F_y + 0 - 0 = 1000 \text{ kg/m}^3 \times 0.6 \text{ m}^3/\text{s} (1224.49 \text{ m/s} \sin(60^\circ) - 0)$$

$$F_y = 41460.73 / 1000 \Rightarrow F_y = 41.46 \text{ kN}$$

$P_2 = ?$

Where is the P_2 in the

Momentum Equation?

CVEG 4303
WATER RESOURCES ENGINEERING
SPRING 2022

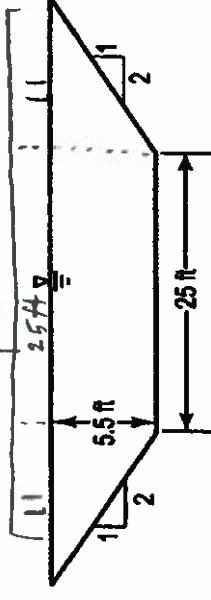
CLASSWORK
02

ABOVE
AVERAGE

Classwork02_2022Feb01A: [150/150] Date: 2022Feb01

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

Determine the following channel parameters and values for water flowing in the open channel shown. The Manning's $n = 0.015$ and the slope is $6.0 \text{ ft}/1200 \text{ ft}$. **WRITE ON ONLY 1 SIDE OF PAPER**



a) The area of flow, A [ft^2]

$$A = by + \frac{1}{2} y^2 (m_1 + m_2) = 25 \text{ ft} (5.5 \text{ ft}) + \frac{1}{2} (5.5 \text{ ft})^2 (2 + 2) = 198 \text{ ft}^2$$

b) The hydraulic radius, R [ft] and hydraulic depth, D [ft]

$$R = \frac{A}{P} = \frac{198 \text{ ft}^2}{25 \text{ ft} + 5.5 \text{ ft} (\sqrt{1+2^2} + \sqrt{1+2^2})} = 3.99 \approx 4 \text{ ft}$$

$$D = \frac{A}{B} = \frac{198 \text{ ft}^2}{47 \text{ ft}} = 4.2 \text{ ft}$$

c) The velocity, V [ft/s] and the flowrate, Q [ft^3/s] of the flow using the Manning Equation (provided).

$$V = \frac{1.486}{n} R^{2/3} \sqrt{S} = \frac{1.486}{0.015} \cdot 4^{2/3} \cdot \sqrt{\frac{6 \text{ ft}}{1200 \text{ ft}}} = 17.7 \text{ ft/s}$$

$$Q = \frac{1.486}{n} A R^{2/3} \sqrt{S} = 198 \text{ ft}^2 (17.7 \text{ ft/s}) = 3504.6 \text{ ft}^3/\text{s}$$

d) Calculate the flow Froude Number, Fr [] for the flow

$$Fr = \frac{V}{\sqrt{gD}} = \frac{17.7 \text{ ft/s}}{\sqrt{32.2 \text{ ft/s}^2 (4.2 \text{ ft})}} = 1.52$$

$$\text{Froude Number, } Fr = \frac{V}{\sqrt{gD}}$$

$$D = \text{Hydraulic Depth} = \frac{A}{T}$$

e) Is the flow sub-critical or super-critical? [CIRCLE one] WHY? $Fr > 1$

AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

Determine the following channel parameters and values for water flowing in the open channel shown. The Manning's $n = 0.015$ and the slope is $6.0 \text{ ft}/1200 \text{ ft}$. **WRITE ON ONLY 1 SIDE OF PAPER**

a) The area of flow, $A \text{ [ft}^2\text{]}$

$$A = by + \frac{1}{2} y^2 (m_1 + m_2)$$

$$= (25 \text{ ft}) (5.5 \text{ ft}) + \frac{1}{2} (5.5 \text{ ft})^2 (2 + 2)$$

$$= 198 \text{ ft}^2$$

b) The hydraulic radius, $R \text{ [ft]}$ and hydraulic depth, $D \text{ [ft]}$

$$R = \frac{A}{P} = \frac{198 \text{ ft}^2}{(25 \text{ ft}) + (5.5 \text{ ft}) \sqrt{(1+2)^2 + 1+2^2}} = 3.99 \text{ ft}$$

$$D = \frac{A}{T} = \frac{198 \text{ ft}^2}{(25 \text{ ft}) + (5.5 \text{ ft}) (2 + 2)} = 4.213 \text{ ft}$$

c) The velocity, $V \text{ [ft/s]}$ and the flowrate, $Q \text{ [ft}^3\text{/s]}$ of the flow using the Manning Equation (provided).

$$Q = \frac{1}{n} A R^{2/3} \sqrt{S} = \left(\frac{1}{0.015} \right) (198 \text{ ft}^2) (3.99 \text{ ft})^{2/3} \left(\sqrt{\frac{6 \text{ ft}}{1200 \text{ ft}}} \right) = 2348.05 \frac{\text{ft}^3}{\text{s}}$$

$$V = \left(\frac{1}{0.015} \right) (3.99)^{2/3} \left(\sqrt{\frac{6}{1200}} \right) = 11.859 \frac{\text{ft}}{\text{s}}$$

d) Calculate the flow Froude Number, $Fr \text{ []}$ for the flow

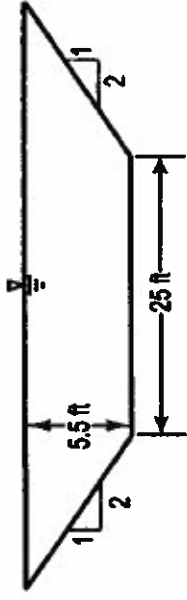
$$Fr = \frac{11.859 \frac{\text{ft}}{\text{s}}}{\sqrt{(32.2) (4.213 \text{ ft})}} = 0.874$$

Manning's Eqn
English units [1.486]
SI [1.00]

$$\sqrt{(32.2) (4.213 \text{ ft})} = 11.859$$

e) Is the flow sub-critical or super-critical? **CIRCLE one** WHY?

Subcritical because $Fr < 1$



$$\text{Froude Number, } Fr = \frac{V}{\sqrt{gD}} = \frac{11.859 \frac{\text{ft}}{\text{s}}}{\sqrt{32.2 \frac{\text{ft}}{\text{s}^2} (4.213 \text{ ft})}} = 0.874$$

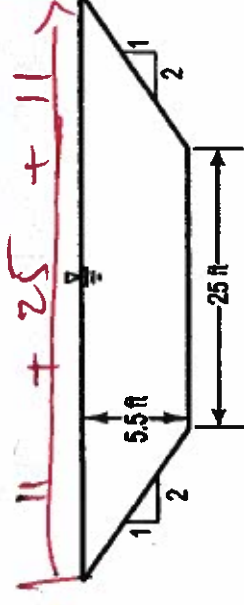
$$D = \text{Hydraulic Depth} = \frac{A}{T}$$

BELOW
AVERAGE

Classwork02_2022Feb01A: [95/150] Date: 2022Feb01

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

Determine the following channel parameters and values for water flowing in the open channel shown. The Manning's $n = 0.015$ and the slope is $6.0 \text{ ft}/1200 \text{ ft}$. **WRITE ON ONLY 1 SIDE OF PAPER**



a) The area of flow, A [ft²]

$$n = 0.015 \quad m = \frac{6}{1200} = 0.005 = \frac{1}{200}$$

$$A = by + \frac{1}{2}y^2(m_1 + m_2) = (25)(5.5) + \frac{1}{2}(5.5)^2 \left(\frac{200}{200} + \frac{200}{200} \right) = 8187.5 \text{ ft}^2 = 198$$

b) The hydraulic radius, R [ft] and hydraulic depth, D [ft]

$$R = \frac{A}{P} = \frac{8187.5}{25' + 5.5'(\sqrt{1+200^2} + \sqrt{1+200^2})} = \frac{6187.5}{2225.0275} = 2.78 \text{ ft}$$

$$D = \frac{A}{T} = \frac{8187.5}{25' + 5.5'(\sqrt{1+200^2} + \sqrt{1+200^2})} = \frac{6187.5}{2225} = 2.78 \text{ ft}$$

c) The velocity, V [ft/s] and the flowrate, Q [ft³/s] of the flow using the Manning Equation (provided).

$$V = \frac{1.486}{0.015} (2.78)^{4/3} \sqrt{0.005} = 13.85 \text{ ft/s}$$

$$Q = VA = 85695.42 \text{ ft}^3/\text{s}$$

d) Calculate the flow Froude Number, Fr [] for the flow

$$Fr = \frac{V}{\sqrt{(32.2)(2.78)}} = 1.46$$

Froude Number, $Fr = \frac{V}{\sqrt{gD}}$
 $D = \text{Hydraulic Depth} = \frac{A}{T}$

e) Is the flow sub-critical or super-critical? [CIRCLE one] WHY? $Fr > 1$ Ok

CVEG 4303
WATER RESOURCES ENGINEERING
SPRING 2022

CLASSWORK
03

ABOVE
AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

For the arrangement shown, a pump draws water (50° F) from a reservoir (1), where the water surface elevation is 520 ft, and forces the water through a 5000 ft long iron pipe (diameter = 1.0 ft). The water discharges into a reservoir with water surface elevation of 620 ft. The friction factor of the pipe (with the flow conditions is 0.010) and the head supplied by the pump 190 ft. **WRITE ONLY ON THIS SIDE OF PAPER. NOTE: BE SURE TO BRING YOUR TEXTBOOK TO CLASS for Reference values.**

a) [40] Determine pipe flow velocity [ft/s], the Reynolds Number, Relative Roughness, and Specific Weight of the water [lb/ft³]

Wrought iron $Q = VA \rightarrow V = \frac{Q}{A} = \frac{7.85 \text{ cfs}}{\frac{\pi}{4}(1\text{ft})^2} = 9.99 \approx 10 \text{ ft/s}$ $Re = \frac{Vd}{\nu} = \frac{10 \text{ ft/s}(1\text{ft})}{1.41 \times 10^{-5} \text{ ft}^2/\text{s}} = 7.1 \times 10^5$

Pipe Flow Velocity = 10 [ft/s] Reynolds Number = 7.1×10^5 []

Relative Roughness = 1.5×10^{-4} [ft/ft] Specific Weight of the water = 62.41 [lb/ft³]

b) Determine the friction headloss for the system [ft] **SHOW WORK FULLY**

$$h_f = f \left(\frac{L}{D} \right) \left(\frac{V^2}{2g} \right) = .01 \left(\frac{5000 \text{ ft}}{1 \text{ ft}} \right) \left(\frac{(10 \text{ ft/s})^2}{2(32.2 \text{ ft/s}^2)} \right) = 77.64 \text{ ft}$$

c) Determine the minor headloss for the system [ft] **SHOW WORK FULLY**

Friction Headloss = 77.64 ft

$$H_p = \Delta z + h_L \rightarrow h_L = 90 \text{ ft}$$

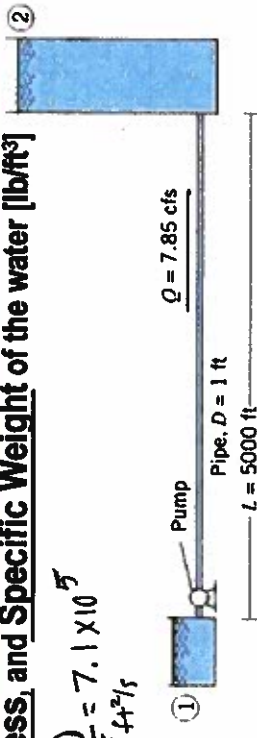
$$190 = (620 - 520) + h_L \rightarrow h_m = h_L - h_f = 90 - 77.64 = 12.36 \text{ ft}$$

d) Determine the power supplied to the pump [hp] **SHOW WORK FULLY**

$$BHP = \frac{\gamma Q H_p}{550 \eta} = \frac{62.41(7.85)(190)}{550(1)} = 169.24 \text{ hp}$$

assume 100% efficiency

POWER SUPPLY TO PUMP = 169.24 hp



AVERAGE

Course: CVEG 4303P01 Name:

Sydney Jones DUE: [IN CLASS]

Classwork03: 2022Feb10A [160 /200]

Date: 2022Feb10

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

For the arrangement shown, a pump draws water (50° F) from a reservoir (1), where the water surface elevation is 520 ft, and forces the water through a 5000 ft long iron pipe (diameter = 1.0 ft). The water discharges into a reservoir with water surface elevation of 620 ft. The friction factor of the pipe (with the flow conditions is 0.010) and the head supplied by the pump 190 ft. **WRITE ONLY ON THIS SIDE OF PAPER. NOTE: BE SURE TO BRING YOUR TEXTBOOK TO CLASS for Reference values.**

a) [40] Determine pipe flow velocity [ft/s], the Reynolds Number, Relative Roughness, and Specific Weight of the water [lb/ft³]

$$V = \frac{Q}{A} = \frac{7.85 \text{ cfs}}{\frac{\pi}{4} (1)^2}$$

$$Re = \frac{VD}{\nu} = \frac{10 \cdot 1}{1.41 \times 10^{-5}} = 709219.86$$

$$\frac{E}{D} = \frac{1.5 \times 10^{-4}}{1}$$

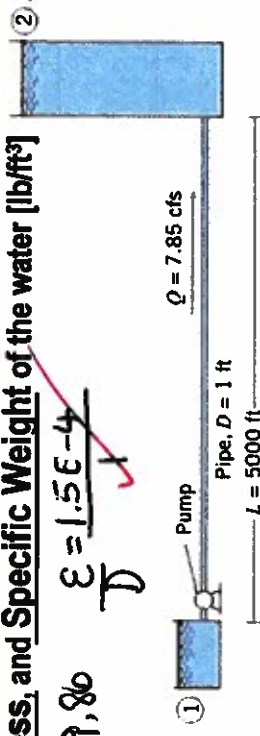
Pipe Flow Velocity = 9.99 ft/s Reynolds Number = 709219.86

Relative Roughness = 1.5×10^{-4} [ft/ft] Specific Weight of the water = 62.4 [lb/ft³]

b) Determine the friction headloss for the system [ft] **SHOW WORK FULLY**

$$h_L = \frac{fLV^2}{2gD} = \frac{(0.01)(5000)(10^2)}{2(32.2)(1)} = 1.41 \times 10^5$$

$$h_f = \frac{fLV^2}{2gD}$$



Friction Headloss = 77.6 ft

Kinematic Viscosity = 1.41×10^{-5} ft²/s

c) Determine the minor headloss for the system [ft] **SHOW WORK FULLY**

$$\frac{P_1}{\rho g} + \alpha_1 \frac{V_1^2}{2g} + z_1 + h_p = \frac{P_2}{\rho g} + \alpha_2 \frac{V_2^2}{2g} + z_2 + h_f + h_{minor}$$

d) Determine the power supplied to the pump [hp] **SHOW WORK FULLY**

$$BHP = \frac{\gamma Q H_F}{\eta} = \frac{(62.4)(7.85 \text{ cfs})(190)}{100(550)}$$

POWER SUPPLY TO PUMP = 12.36 hp

BELOW
AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

For the arrangement shown, a pump draws water (50° F) from a reservoir (1), where the water surface elevation is 520 ft, and forces the water through a 5000 ft long iron pipe (diameter = 1.0 ft). The water discharges into a reservoir with water surface elevation of 620 ft. The friction factor of the pipe (with the flow conditions is 0.010) and the head supplied by the pump 190 ft. **WRITE ONLY ON THIS SIDE OF PAPER. NOTE: BE SURE TO BRING YOUR TEXTBOOK TO CLASS for Reference values.**

a) [40] Determine pipe flow velocity [ft/s], the Reynolds Number, Relative Roughness, and Specific Weight of the water [lb/ft³]

$$Q = 7.85 \text{ ft}^3/\text{s} \quad A = \frac{\pi D^2}{4} = 0.785 \quad Q = VA \quad V = \frac{Q}{A} = \frac{7.85}{0.785} = 9.99 = 10 \text{ ft/s}$$

$$Re = \frac{VD}{\nu} = \frac{10 \times 1}{1.41 \times 10^{-4}} = 709219.8582$$

Pipe Flow Velocity = 10 [ft/s]

Reynolds Number = 709219.86



Relative Roughness = $\frac{e}{D} = \frac{0.00015}{1} = 1.5 \times 10^{-4}$ [ft/ft] Specific Weight of the water = 62.4 [lb/ft³]

b) Determine the friction headloss for the system [ft] **SHOW WORK FULLY**

$$h_f = f \frac{L}{D} \frac{V^2}{2g} = 0.01 \left(\frac{5000}{1} \right) \left(\frac{10^2}{2(32.2)} \right) = 77.16$$

Kinematic Viscosity = 1.41×10^{-4} ft²/s

c) Determine the minor headloss for the system [ft] **SHOW WORK FULLY**

$$h_m = \sum K_m \frac{V^2}{2g} = 0.5 \frac{10^2}{2(32.2)} = 0.78$$

d) Determine the power supplied to the pump [hp] **SHOW WORK FULLY**

$$h_{loss} = h_f + h_m = 77.16 + 0.78 = 77.94$$

POWER SUPPLY TO PUMP = 77.94 hp

CVEG 4303
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SPRING 2022

CLASSWORK
04

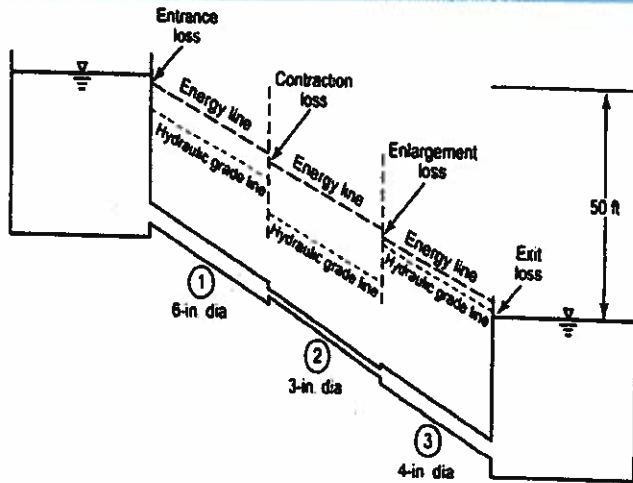
ABOVE
AVERAGE

Course: CVEG 4303P01 Name: Nathaniel Smith DUE [In Class]

Classwork 2022Feb15A: [100/100] Date: 2022Feb15

Brass pipes ($C=140$), 1 (12-inch, 1500 ft), 2 (6-inch, 600 ft), and 3 Concrete (8-inch, 2000 ft) for a difference in head of 70 ft, determine the discharge at 50°F.

(H)



$$Q = 0.432 C D^{2.63} S^{0.54} \quad \text{English}$$

$$Q = 0.278 C D^{2.63} S^{0.54} \quad \text{SI}$$

$$h_L = \frac{4.731 L}{C^{1.85} D^{4.87}} Q^{1.85} \quad (\text{for English Units})$$

$$h_L = \frac{10.704 L}{C^{1.85} D^{4.87}} Q^{1.85} \quad (\text{for SI Units})$$

Allowable Headloss, $H = 70$ ft

Determine Q for the system

$$S = \frac{h_L}{L} = \frac{4.731}{C^{1.85} D^{4.87}} Q^{1.85}$$

1	2	3	4	5	6	7	8
Pipe	C	Size [in]	Size [ft]	Assumed Q_a [cfs]	Friction Slope, S []	Length, L [ft]	Headloss, $h_L = S \cdot L$ [ft]
1	##	12	1.00	0.800	.000335	1500	.5025
2	##	6	0.50	0.800	.00980	600	5.88
3	##	8	0.67	0.800	.00541	2000	4.92
PIPE EQV	##	6	0.50	0.800	.00980	1143.16	11.203

←-sum $h_L = H$

$$L_E = \frac{H}{S}$$

The length of an equivalent 6-in pipe ($C = 140$) to replace the 3 pipes, $L_E =$

1143.16 ft

Given headloss, $h = 70.0$ ft

C	D [in]	D [ft]	Flow [cfs]	$S = h/L_E$	L_E [ft]	h
EQV ##	6	0.5	2.16	.0612	1143.16	70ft

$$Q = 0.432 C D^{2.63} S^{0.54}$$

AVERAGE

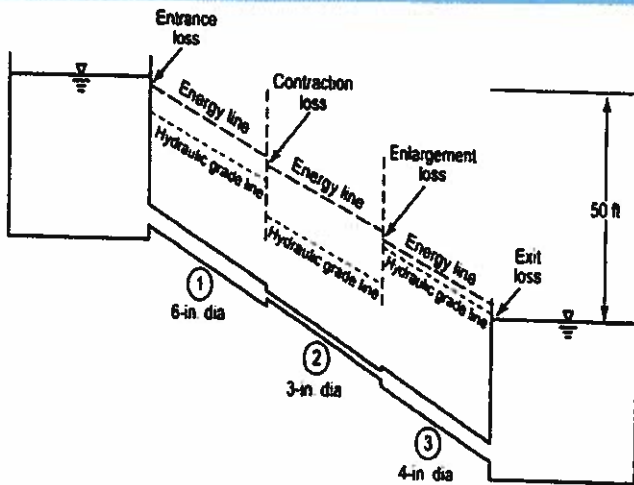
Course: CUEG 4303P01 Name: Daniel Grant

DUE [In Class]

Classwork 01 2022Feb15A: [80/100] Date: 2022Feb15

Brass pipes ($C=140$), 1 (12-inch, 1500 ft), 2 (6-inch, 600 ft), and 3 Concrete (8-inch, 2000 ft) For a difference in head of 70 ft, determine the discharge at 50°F.

(M)



$$Q = 0.432 C D^{2.63} S^{0.54} \quad \text{English}$$

$$Q = 0.278 C D^{2.63} S^{0.54} \quad \text{SI}$$

$$h_L = \frac{4.731 L}{C^{1.85} D^{4.87}} Q^{1.85} \quad \text{[for English Units]}$$

$$h_L = \frac{10.704 L}{C^{1.85} D^{4.87}} Q^{1.85} \quad \text{[for SI Units]}$$

Allowable Headloss, H : 70 ft

Determine Q for the system

$$S = \frac{h_L}{L} = \frac{4.731}{C^{1.85} D^{4.87}} Q^{1.85}$$

1	2	3	4	5	6	7	8
Pipe	C	Size [in]	Size [ft]	Assumed Q_a [cfs]	Friction Slope, S []	Length, L [ft]	Headloss, $h_L = S \cdot L$ [ft]
1	##	12	1.00	0.800	0.000335	1500	0.503
2	##	6	0.50	0.800	0.00096	600	5.98
3	##	8	0.67	0.800	0.00036	2000	4.72
PIPE EQV	##	6	0.50	0.800	0.0094	1132.96	11.103

← sum $h_L = H$

$$L_E = \frac{H}{S}$$

The length of an equivalent 6-in pipe ($C = 140$) to replace the 3 pipes, $L_E =$

1132.96 ft

Given headloss, $h = 70.0$ ft

GIVEN

C	D [in]	D [ft]	Flow [cfs]	$S = h/L_E$	L_E [ft]	h
EQV	##	6	0.8034	0.0094	1132.96	20

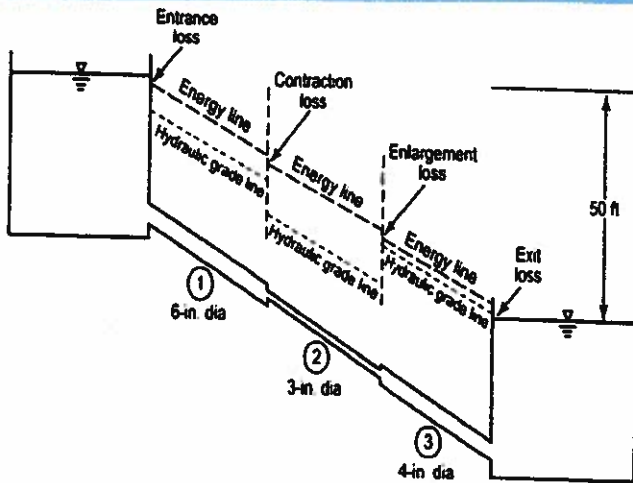
$$Q = 0.432 C D^{2.63} S^{0.54}$$

20
70

BELOW
AVERAGE

Course: CVEG 4303P01 Name: Sydney Jones DUE [In Class]
 Classwork 03/2022Feb15A: [60/100] Date: 2022Feb15

Brass pipes ($C=140$), 1 (12-inch, 1500 ft), 2 (6-inch, 600 ft), and 3 Concrete (8-inch, 2000 ft)
 For a difference in head of 70 ft, determine the discharge at 50°F.



$$Q = 0.432 C D^{2.63} S^{0.54} \quad \text{English}$$

$$Q = 0.278 C D^{2.63} S^{0.54} \quad \text{SI}$$

$$h_L = \frac{4.731 L}{C^{1.85} D^{4.87}} Q^{1.85} \quad \text{[for English Units]}$$

$$h_L = \frac{10.704 L}{C^{1.85} D^{4.87}} Q^{1.85} \quad \text{[for SI Units]}$$

Allowable Headloss, $H = 70$ ft

Determine Q for the system

$$S = \frac{h_L}{L} = \frac{4.731}{C^{1.85} D^{4.87}} Q^{1.85}$$

1	2	3	4	5	6	7	8
Pipe C	Size	Size	Assumed Q_a	Friction Slope, S	Length, L	Headloss, h_L = S*L	
	[in]	[ft]	[cfs]	[]	[ft]	[ft]	
1 ##	12	1.00	0.800	8.05E-9	1500	2.79E-6	
2 ##	6	0.50	0.800	6.44E-8	600	3.27E-5	
3 ##	8	0.67	0.800	1.24E-7	2000	2.68E-5	
EQV ##	6	0.50	0.800	6.97E-8	893.8	6.23E-5	

← sum $h_L = H$

$$L_E = \frac{H}{S}$$

too small

The length of an equivalent 6-in pipe ($C = 140$) to replace the 3 pipes, $L_E =$

893.8

Given headloss, $h = 70.0$ ft

C	D [in]	D [ft]	Flow [cfs]	$S = h/L_E$	L_E [ft]	h
EQV ##	6	0.5	2.46	0.078	893.8	70.0

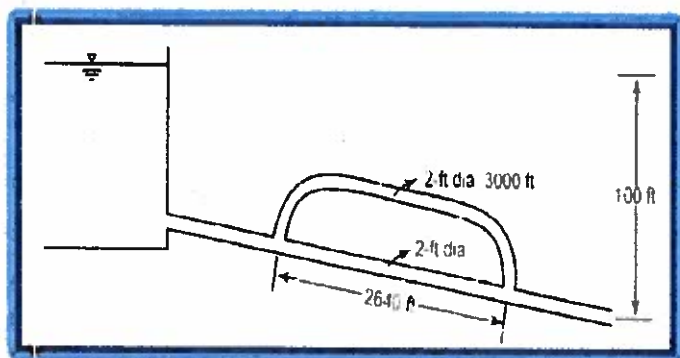
given

$$Q = 0.432 C D^{2.63} S^{0.54}$$

**CVEG 4303
WATER RESOURCES ENGINEERING
SPRING 2022**

**CLASSWORK
05**

ABOVE
AVERAGE



$$h_L = \frac{4.731L}{C^{1.85}D^{4.87}} Q^{1.85} \text{ [for English Units]}$$

$$h_L = \frac{10.704L}{C^{1.85}D^{4.87}} Q^{1.85} \text{ [for SI Units]}$$

$$Q = 0.0278 CD^{2.63} S^{0.54} \text{ SI}$$

$$Q = 0.432 CD^{2.63} S^{0.54} \text{ English}$$

$$Q = 0.432 CD^{2.63} S^{0.54}$$

NEW(Allowable Headloss) = 90 ft

Determine Q [cfs] for the system

OLD Cast Iron pipe, C = 100

1	2	3	4	5	6	7	8
Pipe	C	Size [in]	Size [ft]	Assumed Headloss, h_L [ft]	Pipe Length, L [ft]	Slope, h_L/L [ft/ft]	Calculated Q [cfs]
1	100	24	2.00	40.00	2640.00	.0152	27.89
2	100	18	1.50	40.00	3000.00	.0133	12.18
PIPE EQV	100	24	2.00	40.000	1342.28	.0298	40.07 <== Total Q

$$L_E = \frac{h_L}{S}$$

$$S = \frac{h_L}{L} = \frac{4.731}{C^{1.85}D^{4.87}} Q^{1.85}$$

$$Q = 0.432 CD^{2.63} S^{0.54}$$

Total Eqv. Pipe length, $L_E = 2640.0 + 1342.28 = 3982.28$

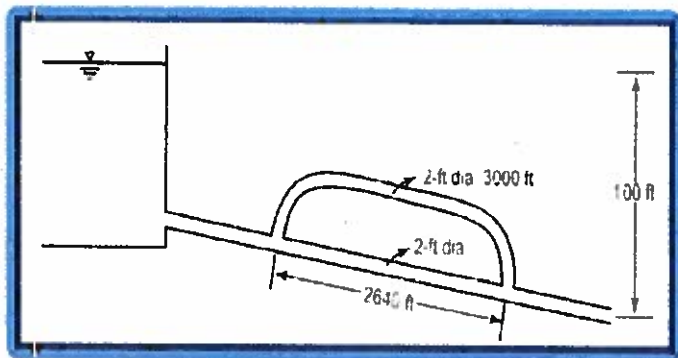
OLD Cast Iron pipe, C = 100

	C	D [in]	D [ft]	headloss, H [ft]	S = H/ L_E	Total Eqv. Length, L_E	Q [cfs]
PIPE EQV	100	24	2.00	90	.0226	3982.28	34.55

Therefore the flow in the system is = 34.55 cfs

AVERAGE

Course: CUEG 4303P01 Name: Layla Ogletree DUE [In Class]
 Classwork 04_2022Feb15B: [80/100] Date: 2022Feb15



$$h_L = \frac{4.731L}{C^{1.85}D^{4.87}} Q^{1.85} \text{ (for English Units)}$$

$$h_L = \frac{10.704L}{C^{1.85}D^{4.87}} Q^{1.85} \text{ (for SI Units)}$$

$$Q = 0.278 CD^{2.63} S^{0.54} \text{ SI}$$

$$Q = 0.432 CD^{2.63} S^{0.54} \text{ English}$$

$$Q = 0.432 CD^{2.63} S^{0.54}$$

NEW(Allowable Headloss) = 90 ft
 Determine Q [cfs] for the system

OLD Cast Iron pipe, C = 100

1	2	3	4	5	6	7	8
Pipe	C	Size [in]	Size [ft]	Assumed Headloss, h_L [ft]	Pipe Length, L [ft]	Slope, h_L/L [ft/ft]	Calculated Q [cfs]
1	100	24	2.00	40.00	2640.00	0.015	27.83
2	100	18	1.50	40.00	3000.00	0.13	12.19
PIPE EQV	100	24	2.00	40.000	5640	0.02848	40.029
							39.41 <== Total Q

$$L_E = \frac{h_L}{S}$$

$$S = \frac{h_L}{L} = \frac{4.731}{C^{1.85}D^{4.87}} Q^{1.85}$$

Total Eqv. Pipe length, $L_E = 2640.0 + 5640 = 8280$

$$Q = 0.432 CD^{2.63} S^{0.54}$$

OLD Cast Iron pipe, C = 100

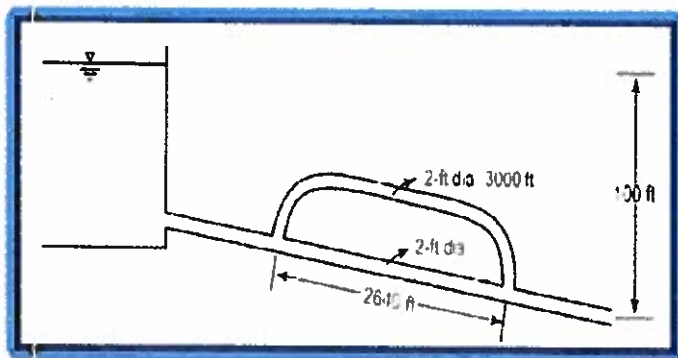
	C	D [in]	D [ft]	headloss, H [ft]	S = H/ L_E	Total Eqv. Length, L_E	Q [cfs]
PIPE EQV	100	24	2.00	90	0.0108	8280	23.429

Therefore the flow in the system is =

23.429

BELOW
AVERAGE

L



$$h_L = \frac{4.731L}{C^{1.85}D^{4.87}} Q^{1.85} \text{ [for English Units]}$$

$$h_L = \frac{10.704L}{C^{1.85}D^{4.87}} Q^{1.85} \text{ [for SI Units]}$$

$$Q = 0.278 CD^{2.63} S^{0.54} \text{ SI}$$

$$Q = 0.432 CD^{2.63} S^{0.54} \text{ English}$$

$$Q = 0.432 CD^{2.63} S^{0.54}$$

NEW(Allowable Headloss) = **90 ft**
 Determine Q [cfs] for the system

OLD Cast Iron pipe, C = 100

	1	2	3	4	5	6	7	8
	Pipe	C	Size [in]	Size [ft]	Assumed Headloss, h_L [ft]	Pipe Length, L [ft]	Slope, h_L/L [ft/ft]	Calculated Q [cfs]
	1	100	24	2.00	40.00	2640.00	0.015	27.69
	2	100	18	1.50	40.00	3000.00	0.01333	12.17
PIPE EQV	100	24	2.00	40.000	1413.43	0.0283	39.86	← Total Q

$$L_E = \frac{h_L}{S}$$

$$S = \frac{h_L}{L} = \frac{4.731}{C^{1.85} D^{4.87}} Q^{1.85}$$

$$Q = 0.432 CD^{2.63} S^{0.54}$$

Total Eqv. Pipe length, $L_E = 2640.0 +$

OLD Cast Iron pipe, C = 100

	C	D [in]	D [ft]	headloss, H [ft]	Total Eqv. Length, L_E	Q [cfs]
PIPE EQV	100	24	2.00	90	 	

Therefore the flow in the system is =

Incomplete

30

**CVEG 4303
WATER RESOURCES ENGINEERING
SPRING 2022**

**CLASSWORK
06**

ABOVE
AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

(H)

In the figure, pipe #1 [500-m, 50 cm diameter pipe] and pipe #2 [800-m, 25 cm diameter] are configured as shown in a looped piping system. Assume that the friction factor in pipe #1 and pipe #2 are 0.025 and 0.015, respectively. $Q = 1.0 \text{ m}^3/\text{s}$ flows into and out the system. Minor losses are negligible.

Determine:

- The velocity [m/s] in Pipe #1
- The velocity [m/s] in Pipe #2
- The discharge [m³/s] in Pipe #1

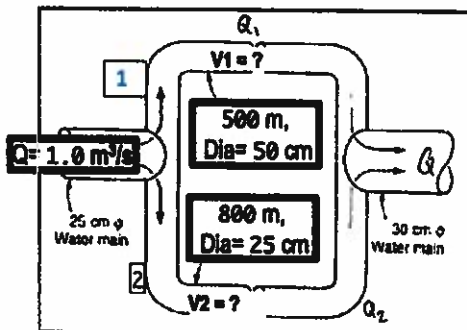
Governing Equations

[1] $Q_1 + Q_2 = Q$

$\frac{1}{4}\pi(D_1^2 V_1 + D_2^2 V_2) = Q$

[2] $\frac{f_1 L_1 V_1^2}{2D_1 g} = \frac{f_2 L_2 V_2^2}{2D_2 g}$ OR $\frac{f_1 L_1 V_1^2}{2D_1} = \frac{f_2 L_2 V_2^2}{2D_2}$

$$Q = VA \Rightarrow V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$



Excellent!

$$a) \frac{0.025(500\text{ m})V_1^2}{2(0.50\text{ m})} = \frac{0.015(800\text{ m})V_2^2}{2(0.25\text{ m})}$$

$$12.5 V_1^2 = 24 V_2^2$$

$$V_2 = \sqrt{0.521 V_1^2}$$

$$1\text{ m}^3/\text{s} = \frac{1}{4}\pi((0.5\text{ m})^2 V_1 + (0.25\text{ m})^2 (\sqrt{0.521 V_1^2}))$$

$$1\text{ m}^3/\text{s} = 0.196 V_1 + 0.035 V_1$$

$$V_1 = 4.33 \text{ m/s}$$

$$c) Q_1 = V_1 A_1 = 4.33 \text{ m/s} \left(\frac{\pi}{4} (0.5\text{ m})^2 \right)$$

$$Q_1 = 0.85 \text{ m}^3/\text{s}$$

$$b) V_2 = \sqrt{0.521 (4.33 \text{ m/s})^2}$$

$$V_2 = 3.12 \text{ m/s}$$

AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

In the figure, pipe #1 [500-m, 50 cm diameter pipe] and pipe #2 [800-m, 25 cm diameter] are configured as shown in a looped piping system. Assume that the friction factor in pipe #1 and pipe #2 are 0.025 and 0.015, respectively. $Q = 1.0 \text{ m}^3/\text{s}$ flows into and out the system. Minor losses are negligible.

Determine:

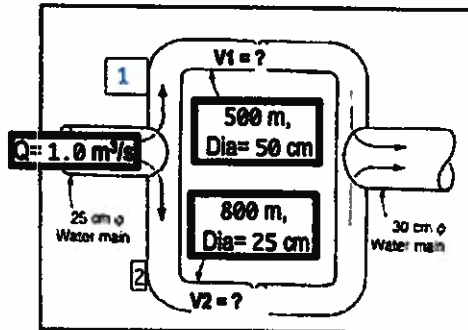
- The velocity [m/s] in Pipe #1
- The velocity [m/s] in Pipe #2
- The discharge [m³/s] in Pipe #1

Governing Equations

$$[1] Q_1 + Q_2 = Q$$

$$\frac{1}{4}\pi(D_1^2 V_1 + D_2^2 V_2) = Q$$

$$[2] \frac{f_1 L_1 V_1^2}{2D_1 g} = \frac{f_2 L_2 V_2^2}{2D_2 g} \quad \text{OR} \quad \frac{f_1 L_1 V_1^2}{2D_1} = \frac{f_2 L_2 V_2^2}{2D_2}$$



Pipe 1 $d_1 = 0.50 \text{ m}, L = 500 \text{ m}, f_1 = 0.025$

Pipe 2 $d_2 = 0.25 \text{ m}, L = 800 \text{ m}, f_2 = 0.015$

$$Q = 1 \text{ m}^3/\text{s}$$

$$A_1 = \frac{\pi d_1^2}{4} = 0.196$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{3.14(0.25)^2}{4} = 0.049$$

$$\text{So, } \frac{f_1 L_1 V_1^2}{2D_1 g} = \frac{f_2 L_2 V_2^2}{2D_2 g}$$

$$\frac{(0.025)(500)V_1^2}{(19.62)(0.50)} = \frac{(0.015)(800)V_2^2}{(19.62)(0.25)}$$

$$1.274 V_1^2 = 2.44 V_2^2$$

$$V_1 = \sqrt{\frac{2.44 V_2^2}{1.274}}$$

$$V_1 = 1.92 V_2$$

$$Q_1 = V_1 A_1$$

$$= (4.508)(0.196)$$

$$= 0.883 \text{ m}^3/\text{s}$$

$$V_1^2 = 1.92 V_2^2$$

$$V_1 = 1.386 V_2$$

ERROR

$$4.51 \times 0.2$$

more error

$$\text{So, } \frac{1}{4}\pi(D_1^2 V_1 + D_2^2 V_2) = Q$$

$$1 = \frac{1}{4}(3.14)(0.5^2(1.92 V_2) + 0.25^2(V_2))$$

$$1 = 0.785(0.48 V_2 + 0.062 V_2)$$

$$1 = 0.425 V_2$$

$$V_2 = 2.34$$

$$\text{So, } V_1 = 1.92(2.34) = 4.508 \text{ m/s}$$

BELOW
AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.

(L)

In the figure, pipe #1 [500-m, 50 cm diameter pipe] and pipe #2 [800-m, 25 cm diameter] are configured as shown in a looped piping system. Assume that the friction factor in pipe #1 and pipe #2 are 0.025 and 0.015, respectively. $Q = 1.0 \text{ m}^3/\text{s}$ flows into and out the system. Minor losses are negligible.

Determine:

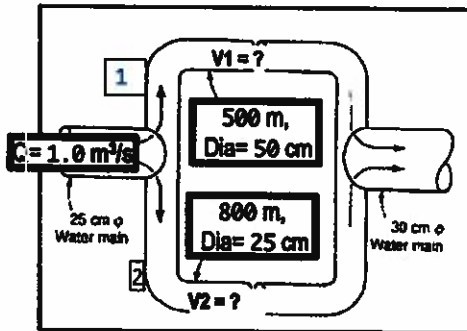
- The velocity [m/s] in Pipe #1
- The velocity [m/s] in Pipe #2
- The discharge [m³/s] in Pipe #1

Governing Equations

$$[1] Q_1 + Q_2 = Q$$

$$\frac{1}{4} \pi (D_1^2 V_1 + D_2^2 V_2) = Q$$

$$[2] \frac{f_1 L_1 V_1^2}{2 D_1 g} = \frac{f_2 L_2 V_2^2}{2 D_2 g} \quad \text{OR} \quad \frac{f_1 L_1 V_1^2}{2 D_1} = \frac{f_2 L_2 V_2^2}{2 D_2}$$



Does not matter here but take note

$$\frac{f_1 L_1 V_1^2}{2 D_1 g} = \frac{f_2 L_2 V_2^2}{2 D_2 g}$$

$$\Rightarrow \frac{(0.025)(500)(V_1^2)}{2(0.5)} = \frac{(0.015)(800)(V_2^2)}{2(0.25)}$$

9.81 m/s

$$Q = \frac{1}{4} \pi (50^2 \cdot 5.09 + 25^2 \cdot 20.4)$$

$$Q = 2.00 \text{ m}^3/\text{s}$$

Total = 1.0 V = Q/A = 1.0 m³/s

$$.38 V_1^2 = .75 V_2^2$$

$$A = \frac{\pi}{4} (.5)^2$$

So it cannot be greater

$$V_1 = 5.09 \text{ m/s}$$

Velocity for pipe #1 = 5.09 m/s

Velocity for pipe #2 = 20.4 m/s

$$V = \frac{Q}{A} = \frac{1.0 \text{ m}^3/\text{s}}{.049}$$

$$V_2 = 20.4$$

$$A = \frac{\pi}{4} (.25)^2$$

$$V_1 > V_2$$

$$\frac{(0.025)(500) V_1^2}{2(0.5)} = \frac{0.015(800) V_2^2}{2(0.25)}$$

This leads to $12.5 V_1^2$

$$= 24 V_2^2$$

$$\therefore V_1 = \sqrt{\frac{24}{12.5}} V_2$$

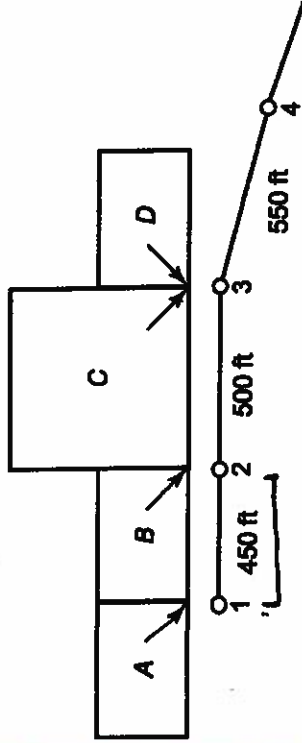
$$V_2 = 1.386 V_1$$

**CVEG 4303
WATER RESOURCES ENGINEERING
SPRING 2022**

**CLASSWORK
08**

ABOVE
AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.



$$D = t_c$$

If L is expressed in feet [English units], then t_c [minutes] is given by:

$$t_c = \frac{0.0078 L^{0.77}}{S^{0.385}}$$

For a 25-year design storm, using the IDF curves (equations) provided for Region 1 of Louisiana (see behind), determine the peak runoff [cfs] that will be required to design the sewer segments BETWEEN manholes 1, 2, 3 and 4. The minimum time of concentration is 12 minutes.

Data for the Sections

SECTION	C Value	Length [ft]	Slope [%]	Sewer Length [ft]	Area [ac]
A	0.5	1000	3	---	100
B	0.7	1200	5	450	130
C	0.8	2500	4	500	250
D	0.3	1000	2	(3-→4) 550 (4-→ detention) 1200	580

For 25 yrs assume $V = 3.5 \text{ ft}^3/\text{s}$

$$a = 4.611, b = 0.346, c = -0.798$$

100

$$t_{cA} = \frac{0.0078(1000)^{0.77}}{(0.03)^{0.385}} = 6.14$$

$$t_{cB} = \frac{0.0078(1200)^{0.77}}{(0.05)^{0.385}} = 5.81$$

$$t_{cC} = \frac{0.0078(2500)^{0.77}}{(0.04)^{0.385}} = 11.14 \text{ (max)}$$

$$t_{cD} = \frac{0.0078(1000)^{0.77}}{(0.02)^{0.385}} = 7.18$$

$$t_c = 11.14 = D = \frac{11.14}{60} = 0.185 = 0.19 \text{ hrs}$$

$$I = a(D + b)^c = 4.611(0.19 + 0.346)^{-0.798} = 7.63 \text{ in/hr}$$

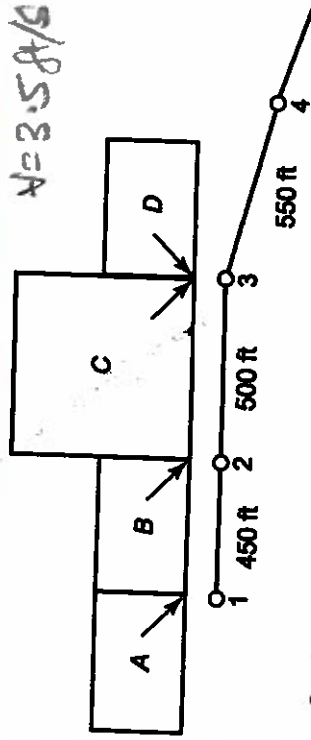
$$C = \frac{367}{580} = 0.63$$

$$Q = C$$

A	6.5 · 100 = 50
B	0.7 · 120 = 84
C	0.8 · 250 = 200
D	0.3 · 110 = 33
	367

AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.



$$V = 3.58 \text{ ft/s}$$

$$t_c = \frac{0.0078 L^{0.77}}{5^{0.385}}$$

If L is expressed in feet [English units], then t_c [minutes] is given by:

For a 25-year design storm, using the IDF curves (equations) provided for Region I of Louisiana (see behind), determine the peak runoff [cfs] that will be required to design the sewer segments BELOW manholes 1, 2, 3 and 4. The minimum time of concentration is 12 minutes.

Data for the Sections

SECTION	C Value	Length [ft]	Slope [%]	Sewer Length [ft]	Area [ac]	t_c	$a \times C$
A	0.5	1000	3	---	100	6.112	50
B	0.7	1200	5	450	120	3.244	84
C	0.8	2500	4	500	250	13.513	200
D	0.3	1000	2	(3-4) 550	110	8.801	33
TOTAL	2.3			(4-4) detention 1200	580	3.67	367

$$a = 4.611, b = 0.346, \text{ and } C = 0.998 \quad [25 \text{ yr storm}]$$

Travel time

$$B = (450/3.5)/60 = 2.142$$

$$C = (500/3.5)/60 = 2.381$$

$$D = (550/3.5)/60 = 2.619$$

$$\text{So, for 1 } \Rightarrow Q = \left(\frac{50}{100}\right)(7.208)(100) = 354 \text{ cfs}$$

$$0, t_c = 13.517 \text{ min} = 0.225 \text{ hr} = D$$

$$= a(D+b)^C = 4.611(0.225+0.346)^{0.998}$$

$$C = 7.208 \text{ cu/hr}$$

$$RA \quad a \times C = (100)(0.5) = 50$$

$$\text{for 2 } \Rightarrow Q = \left(\frac{50+84}{220}\right)(7.208)(120) = 605.47 \text{ cfs}$$

$$\text{for 3 } \Rightarrow Q = \left(\frac{50+84+200}{470}\right)(7.208)(250) = 1280.57 \text{ cfs}$$

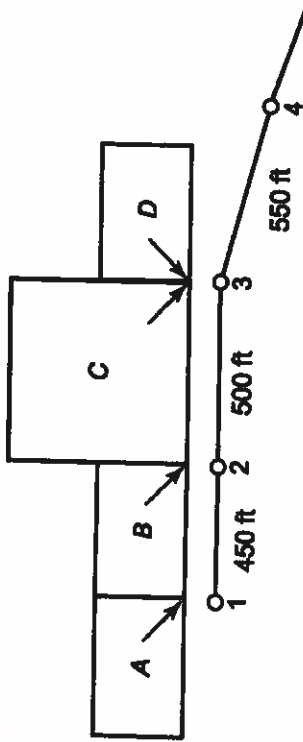
$$\text{for 4 } \Rightarrow Q = \left(\frac{50+84+200+33}{580}\right)(7.208)(110) = 501.702 \text{ cfs}$$

$$t_c = t_c + \text{travel time}$$

$$\text{runoff } C = \sum a \times C / \sum a$$

BELOW
AVERAGE

You must provide enough details and description of the solution method to demonstrate your knowledge of the solution method.



Data for the Sections

SECTION	C Value	Length [ft]	Slope [%]	Sewer Length [ft]	Area [ac]
A	0.5	1000	3	---	100
B	0.7	1200	5	450	120
C	0.8	2500	4	500	250
D	0.3	1000	2	(3-→4) 550 (4-→ detention) 1200	110

Rainfall intensity, i (in/hr) = $a(D+b)^c$ where $D = T_c$

For Louisiana (Region I), the IDF parameters for a 25-year storm are

$$A: T_c = \frac{0.0078 \times 1000^{0.77}}{3^{0.385}} = 1.04 \text{ mm}$$

$$B: T_c = \frac{0.0078 \times 1200^{0.77}}{5^{0.385}} = 0.986 \text{ mm}$$

$$C: T_c = \frac{0.0078 \times 2500^{0.77}}{4^{0.385}} = 1.89 \text{ mm}$$

$$D: T_c = \frac{0.0078 \times 1200^{0.77}}{2^{0.385}} = 1.22 \text{ mm}$$

$$\text{longest } T_c = 1.89 \text{ mm} / 60 = 0.0315 \text{ hr}$$

Area Number	Drainage size	Rainfall coeff. C
i	a	a x C
100		
120		
250		
...		

If L is expressed in feet [English units], then t_c [minutes] is given by:

$$t_c = \frac{0.0078 L^{0.77}}{S^{0.385}}$$

$$V = 3.5 \text{ ft/s}$$

For a 25-year design storm, using the IDF curves (equations) provided for Region I of Louisiana (see behind), determine the **peak runoff** [cfs] that will be required to design the sewer segments **BELOW** manholes 1, 2, 3 and 4. The minimum time of concentration is 12 minutes.

$$D = T_c$$

$$Q = C I A$$

$$A = \frac{100 + 120 + 250 + 110}{4} = 141 \text{ a}$$

$$I =$$