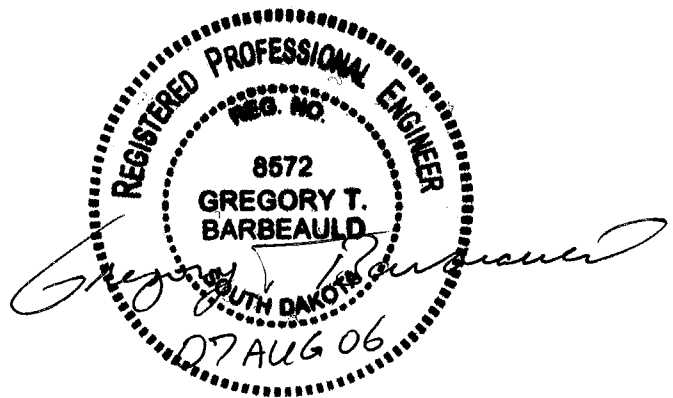


Engineer's Certification

I certify that the attached water pressure calculations for the Red Rock Meadows Phase 2 project were performed by me or under my direct supervision.

Gregory T. Barbeauld, P.E., S.D. Reg No. 8572



## Red Rock Meadows Phase 2 Water Pressure Analysis

### **Objective**

Staff has requested that we provide an analysis to substantiate that there is sufficient water pressure to support the proposed Red Rock Meadows Phase 2 development. The attached calculations were performed to demonstrate that the water system can deliver the required flows at or above the required minimum pressure.

### **Domestic Demand**

It is estimated that the 16-inch water main that provides potable water for the Red Rock area serves approximately 300 dwelling units in the Red Rock Estates area, and approximately 150 dwelling units in the Red Rock Meadows area (this includes the units proposed with Phase 2.) Based on an assumed water consumption of 300 gpd/edu, this equates to a peak domestic demand of 375 gpm (using a peak factor of 4.0.)

### **Pressure Calculations**

Enclosed is the result from a current hydrant flow test on the 16-inch water main. Assuming a flow rate of 1,875 gpm (the 375 gpm peak domestic flow plus 1,500 gpm fire flow), we calculated a pressure at the residual hydrant of 22.3-psi. At this flow rate, the pressure at the location of the proposed 8-inch connection for the Phase 2 development is 36.8-psi.

The construction of the proposed 8-inch water main pipe at Red Rock Meadows Phase 2 will effectively complete or close a loop in the water main system. Therefore, the flows to any particular point in the loop will be balanced or adjusted to equalize the pipe head loss. For this specific situation, the head loss calculated through the proposed 1,120-ft of 8-inch water main is based on a flow rate in the pipe of 868 gpm. This flow rate was determined using a Hardy Cross loop analysis to identify the flow distribution through the 3-pipe loop that is shown on the enclosed map. The calculated pressure at the end of the proposed 1,120-ft 8-inch water main is 20.5-psi when 1,625 gpm (125 gpm domestic flow and 1,500 gpm fire flow) is being delivered to that point in the loop.

### **Conclusion**

Based on our assumptions and calculations, we believe that there is sufficient water pressure in the Red Rock water delivery system to accommodate the Red Rock Meadows Phase 2 development. The domestic water demands and a 1,500 gpm fire flow can be provided while still maintaining a minimum system pressure in excess of 20-psi. In fact, it could be argued that the proposed water main will actually provide a benefit to at least portions of the existing Phase 1 area by introducing another loop into the water main system.

Finally, it should be noted that there is a water supply reservoir slated to be constructed in the Red Rock area by the Fall of 2007. The reservoir is to be built at an elevation of between 4000 and 4025-ft. This future reservoir should eliminate any problems or concerns with water pressure throughout the Red Rock development. Questions about the scope and status of the reservoir project should be directed to Public Works.

ADDRESS	0 Red Rocks	
DESCRIPTION	Flow Test	
Flow Hydrant Location	2nd Hyd West of were 10" Main Turns to 16" Main	elev 3844 ft
Date	8/1/2006	
Time	3:30:00 PM	
Hydrant Manufacturer	WATEROUS	
Year Manufactured	2001	
Residual Street		
Residual hydrant location	1st Hyd. West of were 10" Main Turns to 16" Main	elev 3880 ft
Outlet Diameter	2.5	
Outlet Coefficient	0.9	
Pitot Pressure	35	
Static Pressure	45	
Residual Pressure	38	
Discharge	992.68	
Q20	1973.99	
Q0	2711.39	

Michelle Dream Design

$$Q = 29.83 cd^2 \sqrt{p} = 992.68$$

find residual pressure when flowing 1,875 gpm

$$Q_R = Q_F \times \left(\frac{h_n}{h_f}\right)^{0.54} = 1875 = 993 \times \left(\frac{45-x}{7}\right)^{0.54} \text{ where}$$

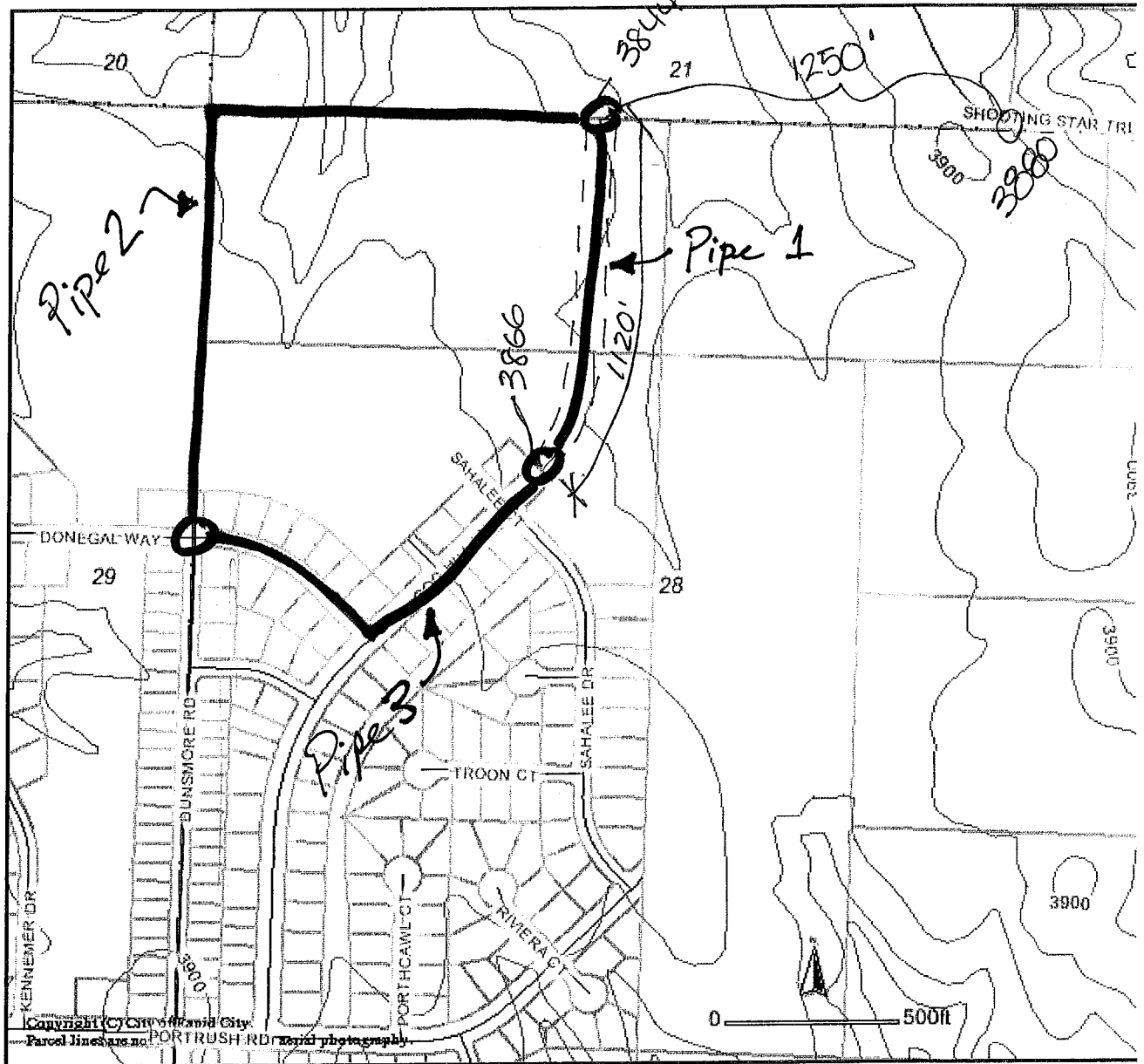
x = residual pressure (at elev 3880)

$$\text{Residual Pressure} = 22.3 \text{ psi}$$

# Loop Diagram for Hardy-Cross Analysis

Pennington County - Rapid City GIS

Print Close



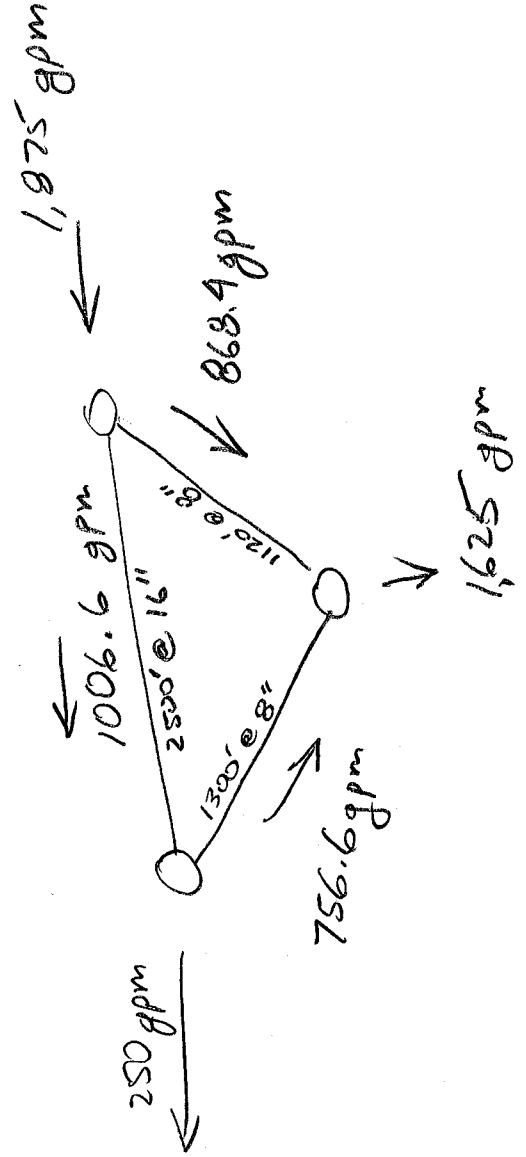
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# Hardy Cross Loop Analysis

Project: Red Rock Meadows Phase 2

$$h_L = h_f = (10.44)(L_{(eq)}) \frac{(gpm)^{1.85}}{C^{1.85} d^{4.8655}} \quad (\text{inches})$$

Loop No.	Pipe No.	Hazen-Williams "C"	Diameter (inches)	Length L <sub>(eq)</sub> (ft)	Initial Flow Q (gpm)	h <sub>L</sub>	1.85h <sub>L</sub> /Q	ΔQ	Adjusted Flow #1 Q (gpm)	h <sub>L</sub>	1.85h <sub>L</sub> /Q	ΔQ	Adjusted Flow #2 Q (gpm)	h <sub>L</sub>
1	1	130	8	1120	475.0	5.188	0.0202		863.3	15.668	0.0336		868.4	15.841
1	2	130	16	2500	-1400.0	-2.935	0.0039		-1011.7	-1.609	0.0029		-1006.6	-1.594
1	3	130	8	1300	-1150.0	-30.914	0.0497		-761.7	-14.428	0.0350		-756.6	-14.248
1	1				0.000	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
1	1				0.000	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
1	1				0.000	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
1 & 2					0.000	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
1 & 2					0.000	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
1 & 3					0.000	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
1 & 3					0.000	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
						-28.660	0.0738	388.27		-0.369	0.0716	5.16		



1.85h <sub>L</sub> /Q	ΔQ	Adjusted Flow #3 Q (gpm)	h <sub>L</sub>	1.85h <sub>L</sub> /Q	ΔQ	Adjusted Flow #4 Q (gpm)	h <sub>L</sub>	1.85h <sub>L</sub> /Q	ΔQ	Adjusted Flow #5 Q (gpm)	h <sub>L</sub>	1.85h <sub>L</sub> /Q	ΔQ	Adjusted Flow #6 Q (gpm)	h <sub>L</sub>
0.0337		868.4	15.841	0.0337		868.4	15.841	0.0337		868.4	15.841	0.0337		868.4	15.841
0.0029		-1006.6	-1.594	0.0029		-1006.6	-1.594	0.0029		-1006.6	-1.594	0.0029		-1006.6	-1.594
0.0348		-756.6	-14.248	0.0348		-756.6	-14.248	0.0348		-756.6	-14.248	0.0348		-756.6	-14.248
0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000	0.0000		0.0	0.000
0.0715	0.00		0.000	0.0715	0.00		0.000	0.0715	0.00		0.000	0.0715	0.00		0.000

Red Rock Meadows Phase 2

1.85h <sub>L</sub> /Q	ΔQ	Adjusted Flow #7 Q (gpm)	h <sub>L</sub>	1.85h <sub>L</sub> /Q	Pressure Loss (psi)	Pipe No.	Hazen-Williams "C"	Diameter (inches)	Length L(eq) (ft)
0.0337		868.4	15.841	0.0337	6.86	1	130	8	1120
0.0029		-1006.6	-1.594	0.0029	0.69	2	130	16	2500
0.0348		-756.6	-14.248	0.0348	6.17	3	130	8	1300
0.0000		0.0	0.000	0.0000	0.00				
0.0000		0.0	0.000	0.0000	0.00				
0.0000		0.0	0.000	0.0000	0.00				
0.0000		0.0	0.000	0.0000	0.00				
0.0000		0.0	0.000	0.0000	0.00				
0.0000		0.0	0.000	0.0000	0.00				
0.0000		0.0	0.000	0.0000	0.00				
0.0000		0.0	0.000	0.0000	0.00				
0.0715	0.00		0.000	0.0715					

16-inch Pipe, Pressure at PH2 Connection  
Worksheet for Pressure Pipe

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Project Description	
Project File	x:\366-399\0390\excel\fireflow.fm2
Worksheet	16-inch pipe
Flow Element	Pressure Pipe
Method	Hazen-Williams Formula
Solve For	Pressure at 2

---



---

Input Data	
Pressure at 1	22.30 psi
Elevation at 1	3,880.00 ft
Elevation at 2	3,844.00 ft
Length	1,250.00 ft
C Coefficient	130.0
Diameter	16.00 in
Discharge	1,875.0 gal/min

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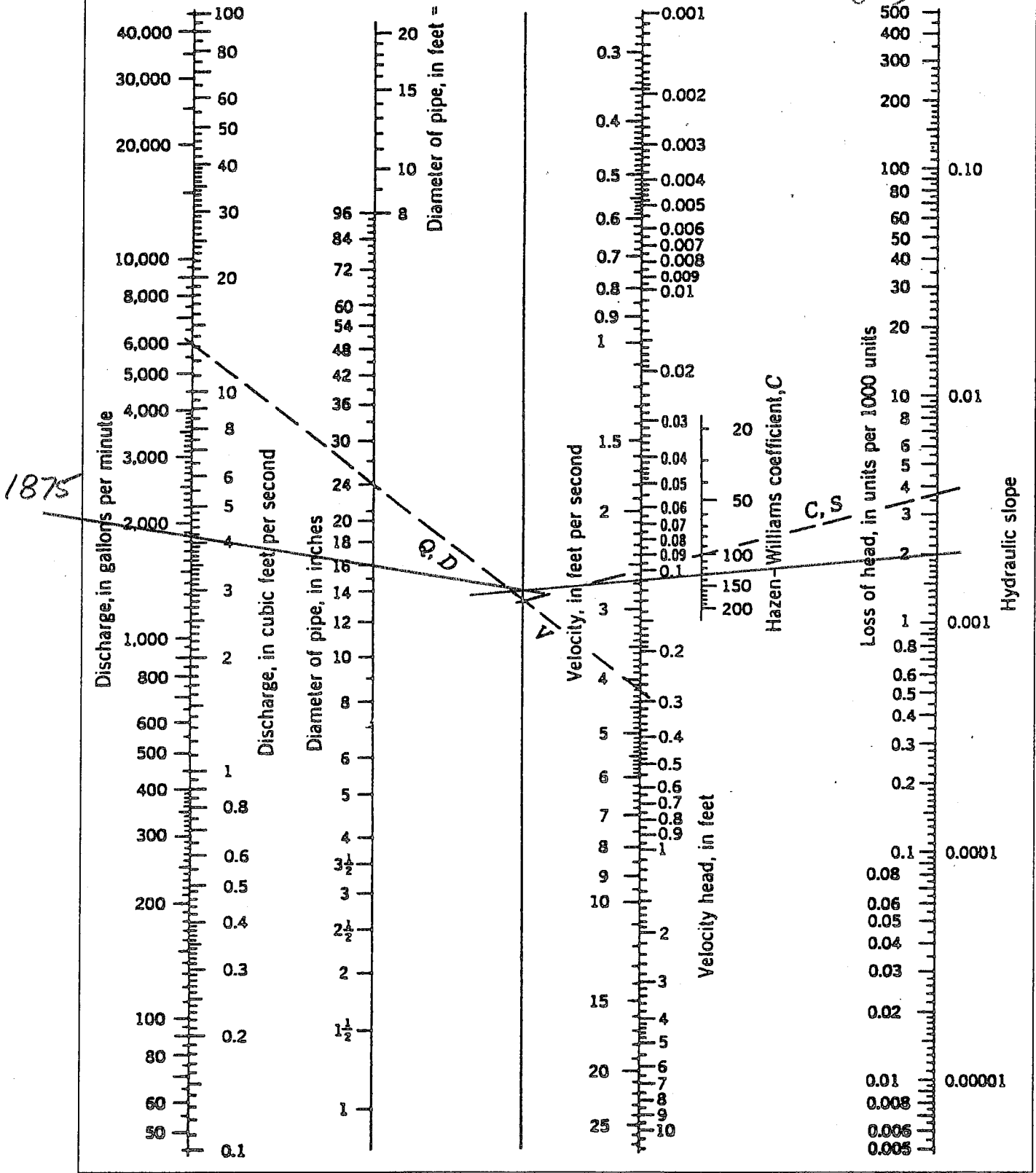
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Results		
Pressure at 2	36.82	psi
Headloss	2.50	ft
Energy Grade at 1	3,931.58	ft
Energy Grade at 2	3,929.07	ft
Hydraulic Grade at 1	3,931.44	ft
Hydraulic Grade at 2	3,928.94	ft
Flow Area	1.40	ft <sup>2</sup>
Wetted Perimeter	4.19	ft
Velocity	2.99	ft/s
Velocity Head	0.14	ft
Friction Slope	0.002001	ft/ft

---



16-inch (1250-ft long)



Hazen-Williams nomograph.

$$2 \times 1.25 / 2.307 = 1.08 \text{ psi}$$

$$3844 - 3880 = -36 \text{ ft} \quad -36 / 2.307 = -15.6 \text{ psi}$$

$$\text{gain} = 14.5 \text{ psi}$$

$$22.3 + 14.5 = 36.8 \text{ psi}$$

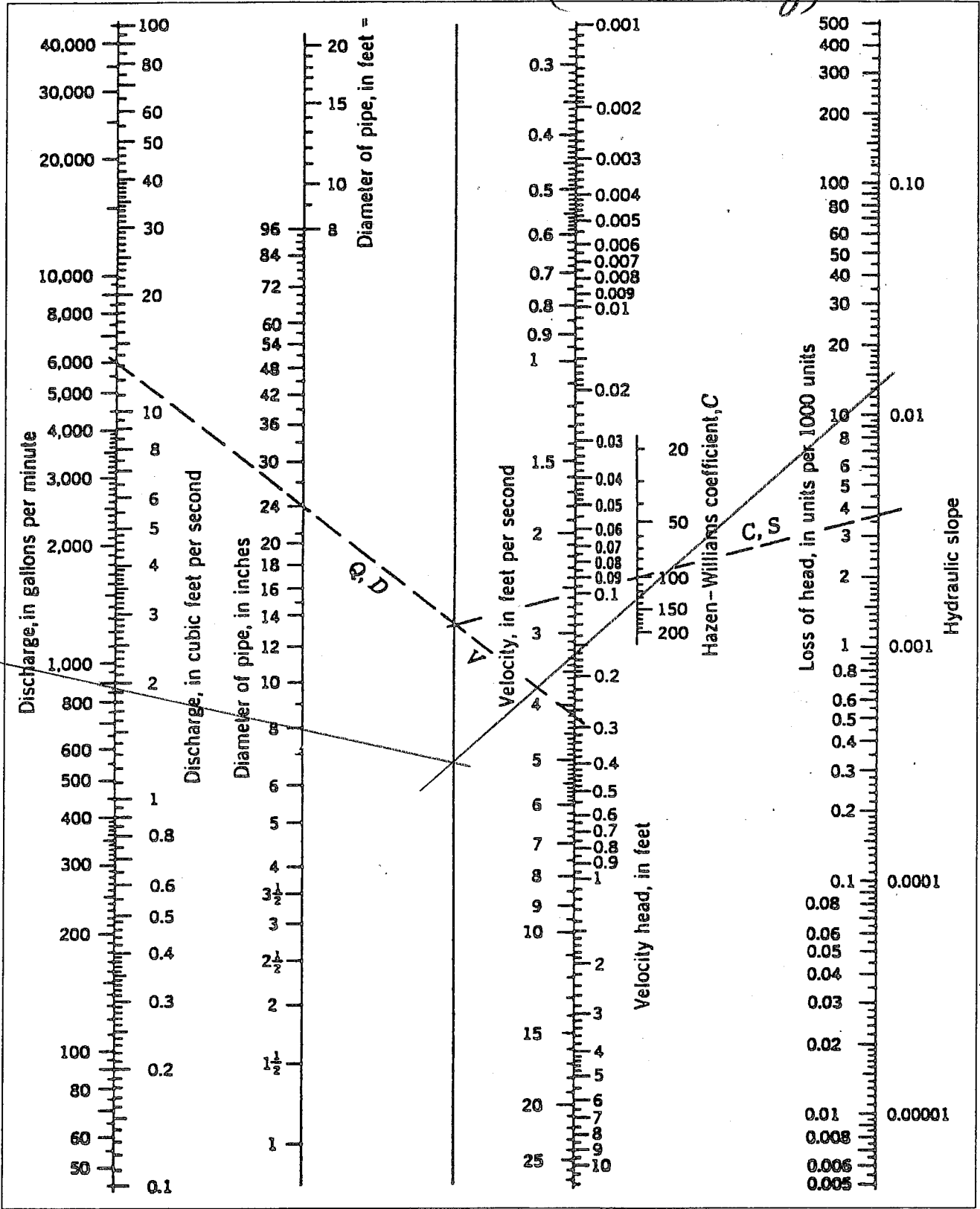
Pressure in RR Meadows Phase 2 8-inch WM  
Worksheet for Pressure Pipe

Project Description	
Project File	x:\366-399\0390\excel\fireflow.fm2
Worksheet	8-inch Pipe
Flow Element	Pressure Pipe
Method	Hazen-Williams Formula
Solve For	Pressure at 2

Input Data	
Pressure at 1	36.82 psi
Elevation at 1	3,844.00 ft
Elevation at 2	3,866.00 ft
Length	1,120.00 ft
C Coefficient	130.0
Diameter	8.00 in
Discharge	868.0 gal/min

Results		
Pressure at 2	20.46	psi
Headloss	15.75	ft
Energy Grade at 1	3,929.41	ft
Energy Grade at 2	3,913.66	ft
Hydraulic Grade at 1	3,928.93	ft
Hydraulic Grade at 2	3,913.18	ft
Flow Area	0.35	ft <sup>2</sup>
Wetted Perimeter	2.09	ft
Velocity	5.54	ft/s
Velocity Head	0.48	ft
Friction Slope	0.014060	ft/ft

8-inch (1120 ft long)



Hazen-Williams nomograph.

$$13 \times 1.12 / 2.307 = 6.31 \text{ psi}$$