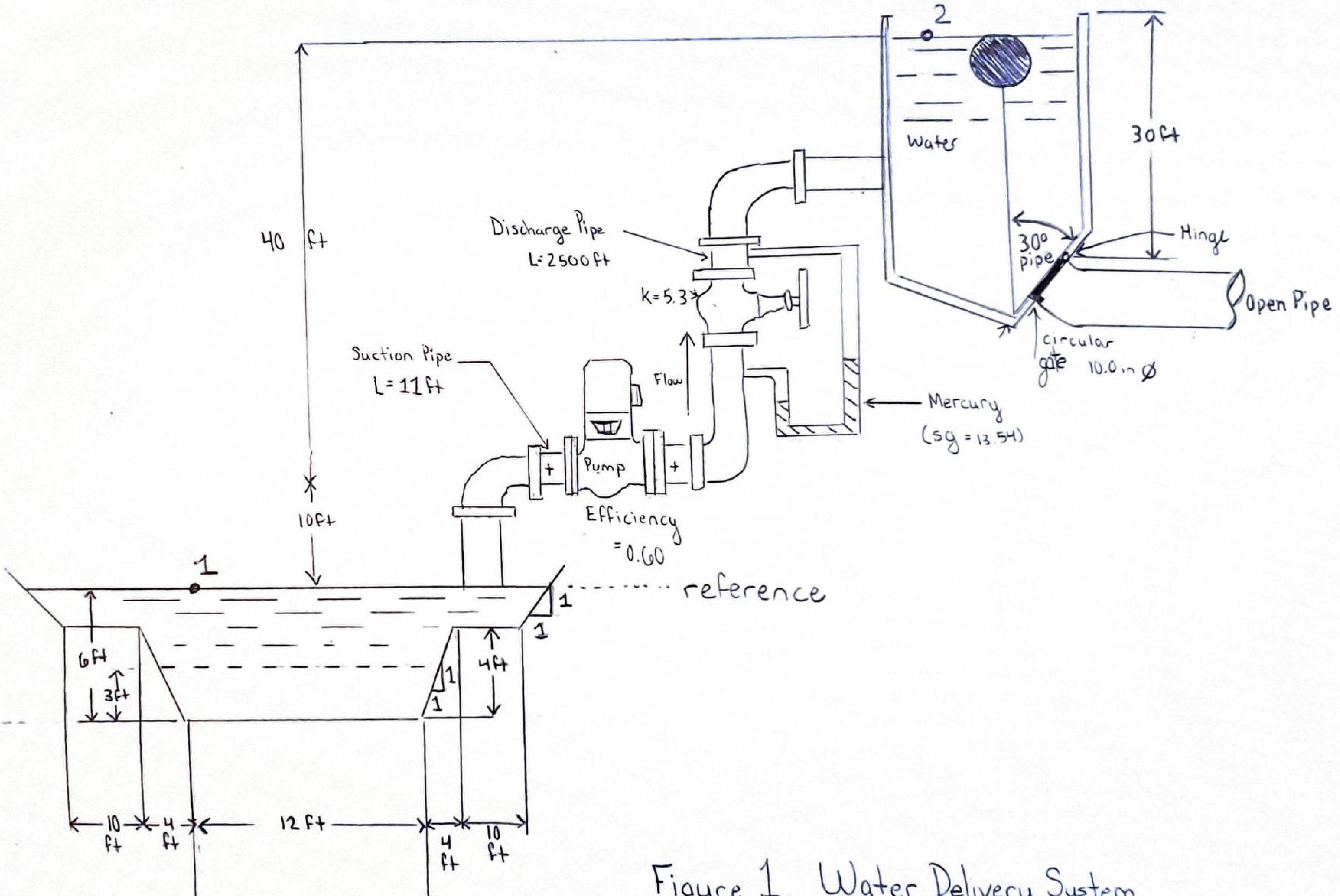


Figure 1. Water Delivery System

Chris Betton

Note:
- Drawing not to scale

Part a | Chris Betton

Procedure

- We will select an appropriate pipe diameter for required Vel, fluid flow.
- We will use Bernoulli's Equation with energy losses & pump head
- Energy losses will be solved for in the piping and valve.
- Finally, solve for power of pump.

Materials

- Pump, 8" NPS piping sched. 40, two elbows, globe valve for pump discharge

Company Requirements — Assumptions / Data from Tables

$Q = 3.387 \frac{ft^3}{s}$, $V = 3 \frac{m}{s} = 9.8425 \frac{ft}{s}$

$K_{valve} = 5.3$

Pump Eff. = 60%

$\gamma_w = 62.43 \frac{lb}{ft^3}$

$D_{pipe} = 0.6651\ ft$, 8" NPS, $A_{flow} = 0.3472\ ft^2$

$\varepsilon_{steel} = 1.50 \times 10^{-4}\ ft$

$\eta_{water @ 60°F} = 2.50 \times 10^{-5}\ \frac{lb\text{-}s}{ft^2}$

Calculations

- $Q = VA$, $A = \frac{\pi}{4} \cdot D^2$ $\therefore d = \sqrt{\frac{Q4}{V \cdot \pi}} = \sqrt{\frac{3.387\ ft^3}{s} \cdot \frac{4}{} \cdot \frac{s}{9.8425\ ft} \cdot \frac{}{\pi}} = 0.6619\ ft \approx 0.6651\ ft$

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

P_1 & P_2 can be negated due to open channel
V_1 & V_2 can be negated due to large surface Area.

$\therefore h_A = z_2 - z_1 + h_L$

$h_L = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$ where $f = \frac{0.25}{\left[\log\left(\frac{1}{3.7(\frac{D}{\varepsilon})} + \frac{5.74}{N_R^{0.9}}\right)\right]^2}$

Note: friction factor calculated using excel

$\left(\frac{D}{\varepsilon}\right) = \frac{0.6651\ ft}{1.50 \times 10^{-4}\ ft}$

$f = 0.01415873$

$\therefore h_L = (0.014) \cdot \frac{2511}{0.6651} \cdot \frac{(9.8425)^2}{2 \cdot 32.2}$

$\left(\frac{ft}{s}\right)\left|\frac{ft}{ft}\right|\frac{s^2}{ft}$

$h_{L\,major} = 79.508$

$h_{L\,minor} = K_{valve} \cdot \frac{V^2}{2g} = \frac{5.3 \cdot 9.8425^2}{2 \cdot 32.2} = 7.9726 \approx 10\%$ so must consider

h_{elbow} = negligible because < 1%

$h_A = 50\ ft + 79.508 + 7.9726 = 137.4806\ ft$

$P_A = \gamma \cdot Q \cdot h_A = \frac{62.43\ lb}{ft^3} \cdot \frac{3.387\ ft^3}{s} \cdot \frac{137.4806\ ft}{} \cdot \frac{1\ HP \cdot s}{550\ ft \cdot lb}$

$P_A = 52.8297\ HP$

$P_M = \frac{52.8297\ HP}{.60} = \boxed{88.04\ HP}$

Analysis

- The pumps power is proportional to head & flow rate.
- The elevation of the tanks in which the pump is transferring fluid directly effects its power.

Part B | Chris Betton

Procedure

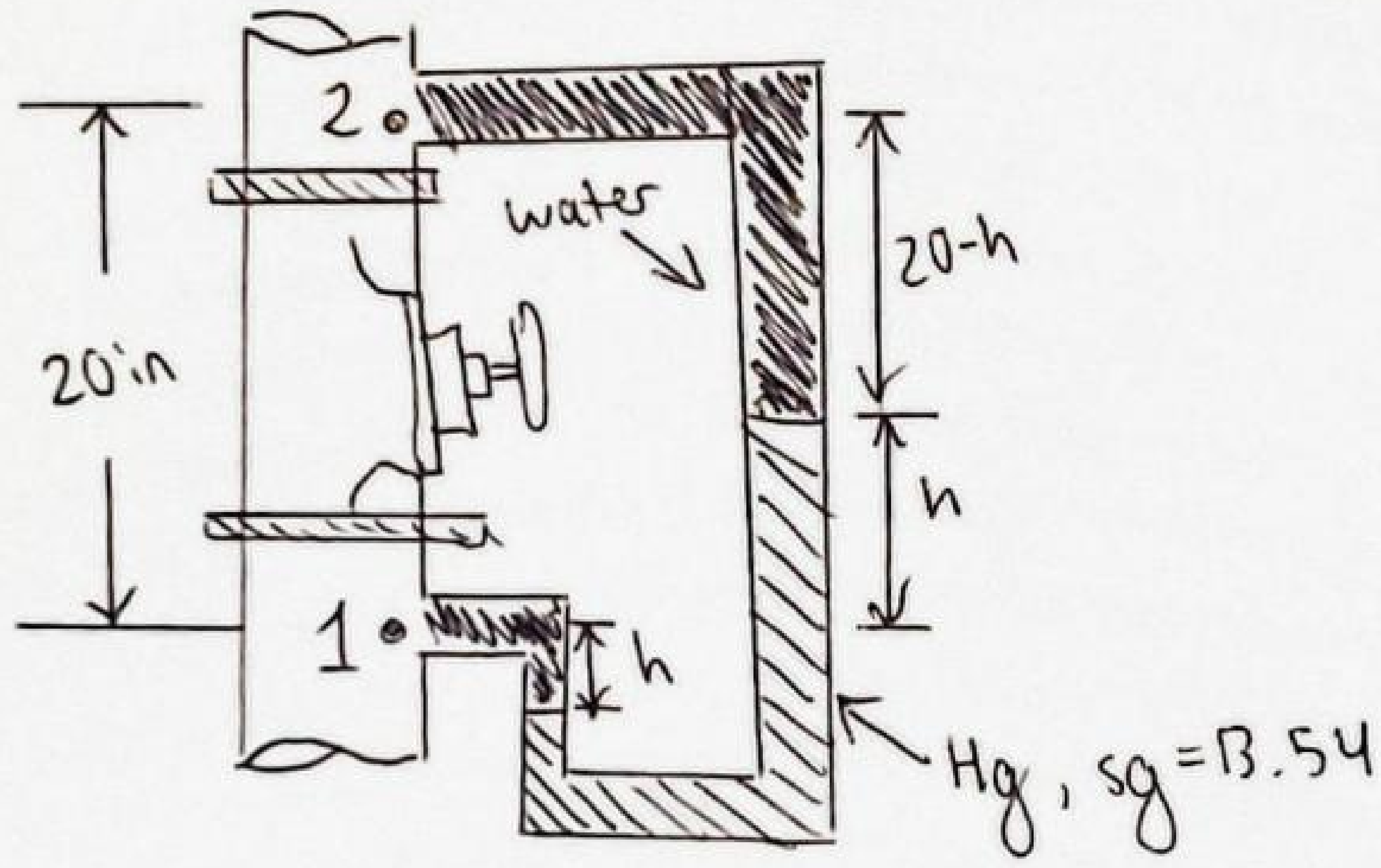
- First the change in pressure between point 1 & 2 was calculated.
- Then a manometric relation was formed based on the elevations of water & mercury (Hg) in the U-tube manometer.

Materials

- U-tube manometer, water, mercury

Diagram:

$20 in \cdot \frac{1 ft}{12 in} = 1.\overline{66} ft$



Calculations

$v = 9.8425 \frac{ft}{s}$ (see part a), $\gamma_w = 62.43 \frac{lb}{ft^3}$, $K = 5.3$, $g = 32.2 \frac{ft}{s^2}$

- $\frac{\Delta P}{\gamma_w} = K \cdot \frac{v^2}{2g} \therefore \Delta P = \gamma\left(K \cdot \frac{v^2}{2g}\right)$

$$\Delta P = 62.43\left(5.3 \frac{9.8425^2}{2(32.2)}\right)$$

- $P_1 - P_2 = \gamma_{Hg}(2h) + \gamma_w(1.\overline{66}) - \gamma_w(h) - \gamma_w(h)$ ⟶ Equation for excel

$$h = \frac{\Delta P - \gamma_w(20)}{2\gamma_{Hg} - 2\gamma_w}$$

$$\Delta P = 13.54(62.43)(2h) + 62.43(20) - 62.43(h) - 62.43(h)$$

$$\Delta P = 1690.6044(h) + 104.0695 - 124.86(h)$$

$$497.49 - 1565.744(h) + 124.86$$

$$h = 0.25128 ft \cdot \frac{12 in}{1 ft} = \boxed{3.017 inHg}$$

Analysis

- The water-mercury contact point drops a distance of "h" which results in a raise of mercury surface level in the same amount.
- The U-tube manometer is an effective tool for measuring differential pressure across the discharge valve. This pressure is directly related to the valve's performance

Data for Calculati			
Volume Flow - Q (ft^3/s)	**Average flow velocity - v (ft/s)**	**Valve resistance coefficient - k**	**Pump Efficiency**
3.387	9.8425	5.3	0.6

Calculated Data	
Calculated diameter (ft)	0.661926771
Major System losses (ft)	80.40960178
Minor System losses (ft)	7.972616042
Total losses - h_L (ft)	88.38221782
Energy addition - (ft) (Derived from Bernoulli's eq.)	138.3822178
Pump power (HP)	53.20177581
Power output from motor (HP)	88.66962635

Friction Factor Calculati	
Relative Roughness (D/ε)	**Reynolds Number N_R**
4434	16347287.38

ons			
Δz (ft)	Length of piping (ft)	Gravity (ft/s^2)	γ water (lb/ft^3)
50	2511	32.2	62.43

ion	Data From Tables		
Friction Factor	**Reference Location**	**Variable**	**Value**
0.014158693	**Appendix D**	Dynamic Viscosity water (60°F) (η)	0.000025
	Table 8.2	Pipe Roughness - ε (slug/ft*s)	0.00015
	Table F.1	Diameter (ft)	0.6651
	Table F.1	Flow area (ft^2)	0.3472
	Table F.1	NPS (in)	8