

**BIE 5110/6110  
Sprinkle & Trickle Irrigation  
Fall Semester, 2004**

**Assignment #10 (100 pts)  
Trickle Manifold Pipe Sizing  
Due: 13 Dec 04**

**Given:**

- A trickle irrigation system with a manifold inflow rate of 5.00 lps.
- An allowable subunit pressure head variation of  $\Delta H_s = 4.2$  m.
- A lateral pressure variation of  $\Delta H_l = 2.3$  m.
- A uniform ground slope of 1.04% in the manifold direction.
- A total manifold length of 200 m.
- A lateral spacing of 2.0 m.
  
- The following PVC pipe sizes are available:

Size (inches)	I.D.	
	(inches)	(mm)
0.5	0.622	15.8
0.75	0.824	20.9
1	1.049	26.6
1.25	1.380	35.1
1.5	1.610	40.9
2	2.067	52.5
2.5	2.469	62.7
3	3.068	77.9
4	4.000	101.6
6	6.000	152.4
8	8.000	203.2
10	10.000	254.0

**Required:**

1. Design the manifold, using up to four different pipe diameters.
2. Use the Darcy-Weisbach and Blasius equations for friction loss.
3. Do not use any pipe diameter which is less than  $\frac{1}{2}$  the largest diameter.
4. Determine appropriate manifold pipe sizes and lengths.
5. Use either the semi-graphical method, or develop a computer program.

**Solution:**

- Assume a water temperature of 10°C, giving a kinematic viscosity of:

$$\nu = 1.306(10)^{-6} \text{ m}^2/\text{s}.$$

- Then, the Reynolds number is:

$$N_R = \frac{4Q}{\nu\pi D} = 9.75(10)^5 \left( \frac{Q}{D} \right)$$

- Plugging the above into the Blasius equation:

$$f = 0.0102 \left( \frac{Q}{D} \right)^{-0.25}$$

- Darcy-Weisbach:

$$h_f = 0.169 \left( \frac{Q^{1.75}}{D^{4.75}} \right)$$

for  $L = 200 \text{ m}$ ;  $h_f$  in  $\text{m}$ ;  $Q$  in  $\text{m}^3/\text{s}$ ; and  $D$  in  $\text{m}$ .

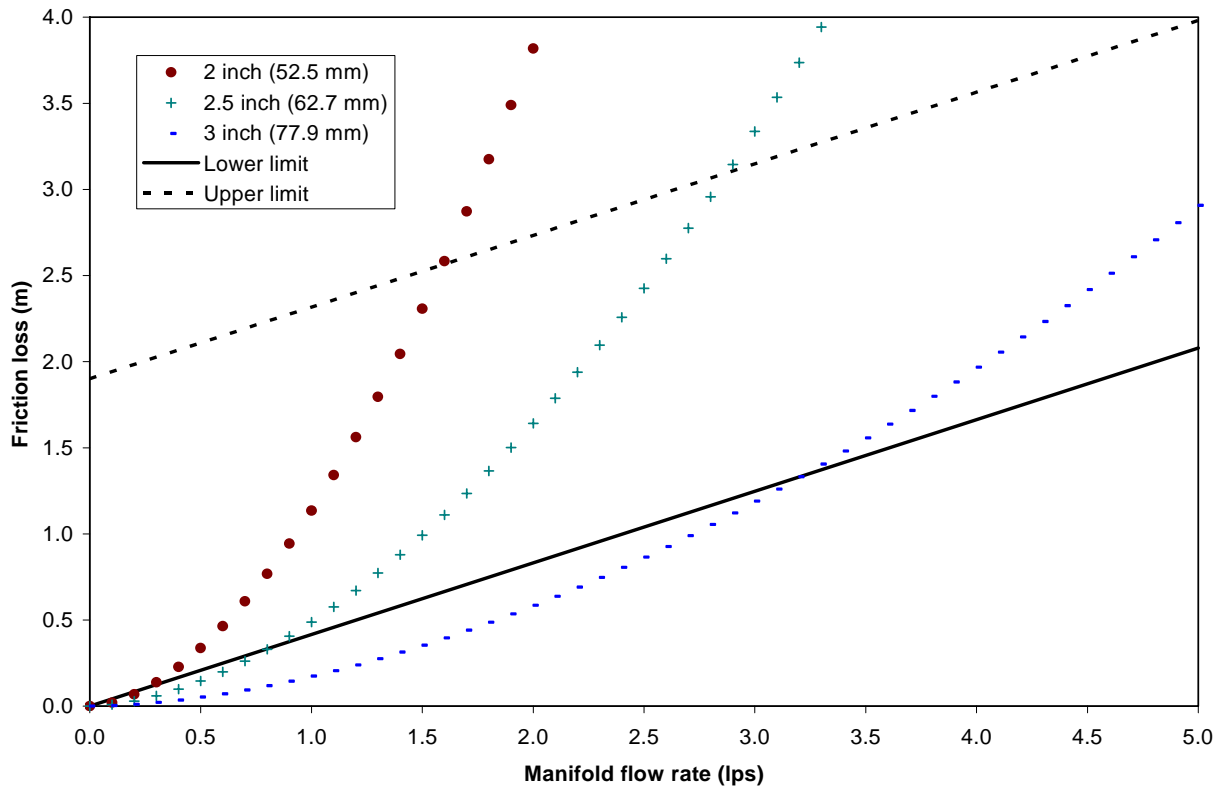
- Elevation change over 200-m manifold length:

$$\Delta h_e = (200)(0.0104) = 2.08 \text{ m}$$

- Allowable manifold pressure head variation:

$$(\Delta h_m)_a = \Delta H_s - \Delta h_l = 4.2 - 2.3 = 1.9 \text{ m}$$

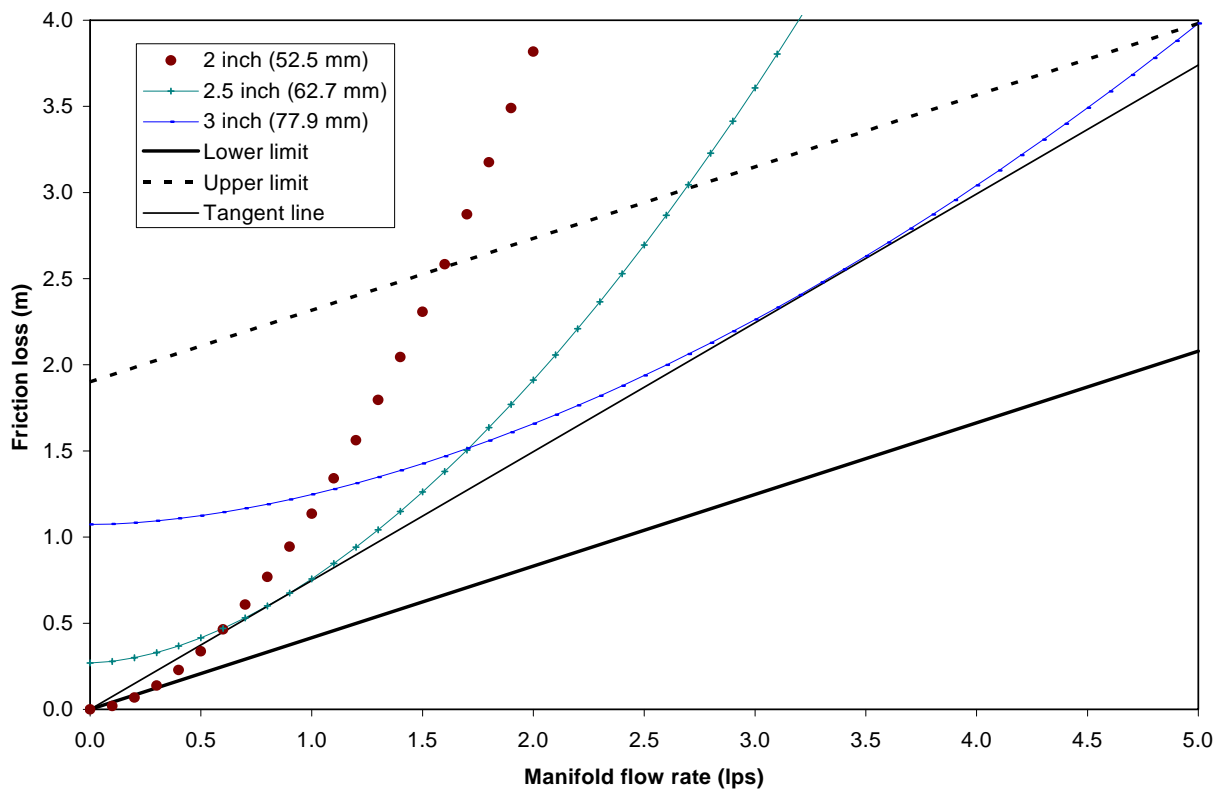
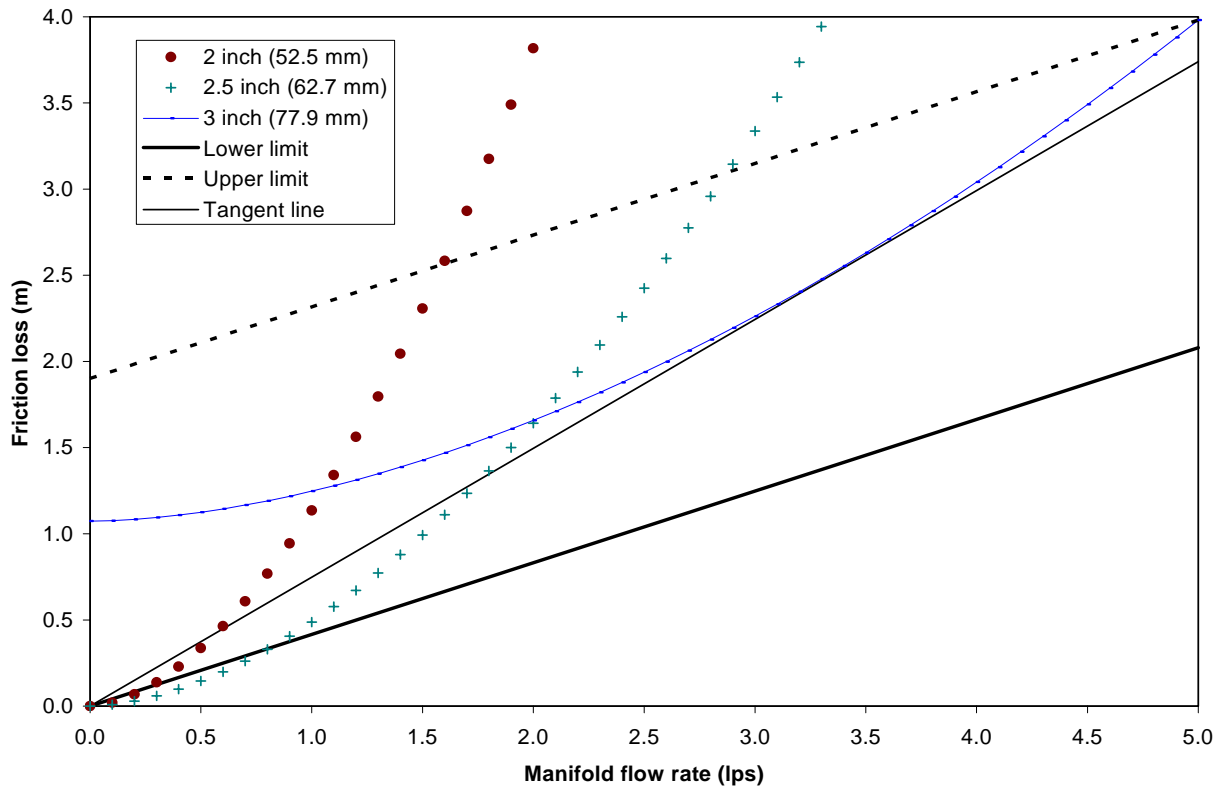
- In a spreadsheet, make a graph of  $h_f$  versus  $Q$  (0 to 5 lps) with a separate curve for each of the available pipe sizes (diameters).
- It is seen that the smallest five pipe sizes (1.5 inches and lower) have curves which are obviously too steep for the range  $0 < h_f < (2.08 + 1.9)$ , so these are omitted from the graph.
- Plot straight lines which define the limits of the allowable manifold pressure head variation. The lower line begins at the origin (0,0) and goes to (5,2.08). The upper line goes from (0,1.9) to (5,2.08+1.9) = (5,3.98).
- Now it is seen that the largest four pipe sizes have head loss curves which are too flat. These are eliminated from the graph. The graph has three pipe diameters:

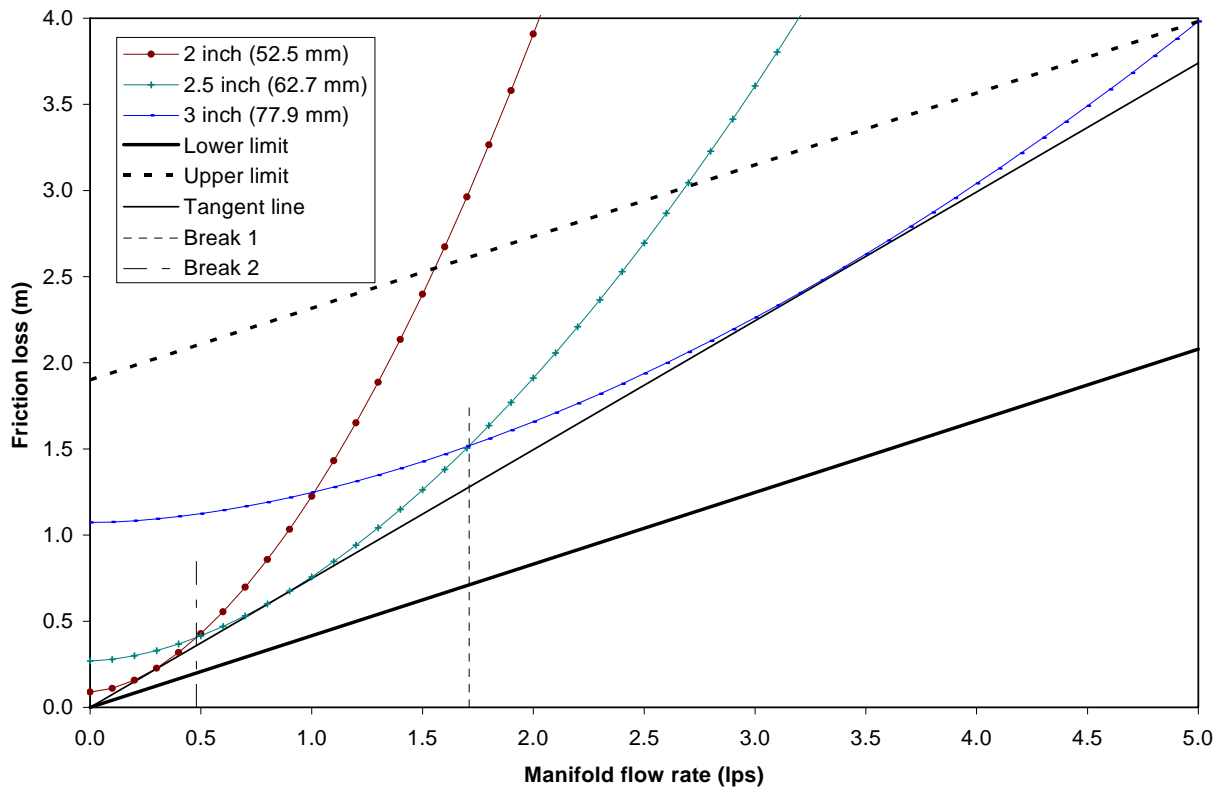
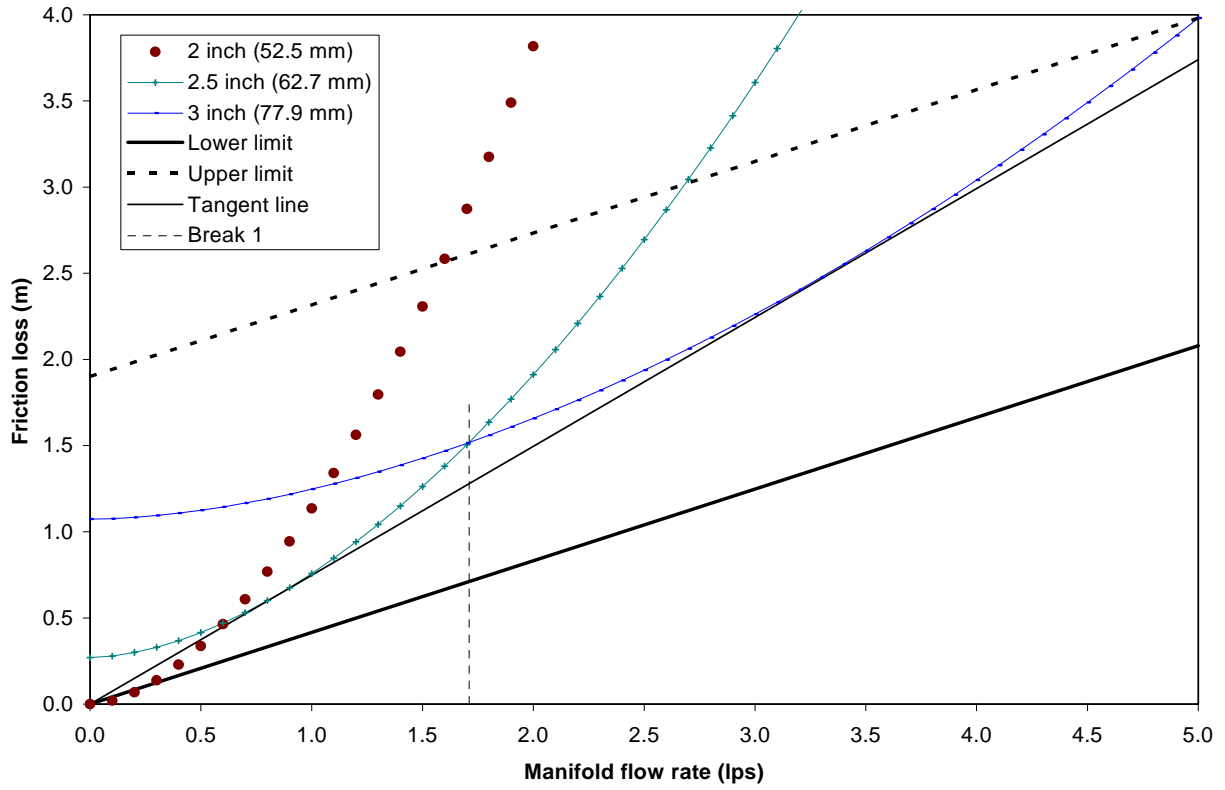


- Make the head loss curve for the largest of the three diameters (3 inch) pass through the point (5,3.98). Do this by observing that at 5 lps, the head loss from the 3-inch curve is 2.907 m. Add  $3.98 - 2.907 = 1.073$  m to all points on the curve for the 3-inch pipe size, thereby shifting it vertically as needed, then draw a straight line through the origin, tangent to this shifted curve (see the figure below).
- Next, vertically shift the curve for the 2.5-inch pipe so that it is tangent to the tangent line, as shown in the second figure on the next page.
- Draw a vertical line at the intersection between these two curves, defining the length of the 3-inch pipe size. The break point is at 1.71 lps. This gives the following length for the 3-inch pipe size (assuming a linear change in flow rate along the manifold):

$$L_{3''} = 200 \left( \frac{1.71 - 5.00}{-5.00} \right) \approx 132 \text{ m}$$

- Finally, make the 2-inch curve tangent to the tangent line (by vertical shifting), then draw a vertical line at the intersection of this curve with the 2.5-inch curve. See the final graph below.





- The break point between the 2.5 and 2.0 curves is at 0.48 lps. This gives the following length for the 2.5-inch pipe size:

$$L_{2"} = 200 \left( \frac{0.48}{5.00} \right) \approx 19 \text{ m}$$

- Then, the 2.5-inch pipe size would have a length of  $200 - 19 - 132 = 49 \text{ m}$ .
- In summary:

Size (inches)	Length (m)	$V_{\max}$ (m/s)
3	132	1.05
2.5	49	0.55
2	19	0.22
<b>Total:</b>	<b>200</b>	

- Note that the design would also be acceptable (within allowable limits) if only two sizes were used: 3-inch and 2.5-inch. This would also simplify installation and would not increase the cost significantly.
- Note also that the maximum average velocity in each of the pipe sizes is well within acceptable limits.
- Finally, observe that the smallest pipe diameter (2 inches) is greater than  $\frac{1}{2}$  the largest pipe diameter (3 inches), as desired for the manifold design.
- Note that if a different kinematic viscosity is applied, a different pipe sizing solution might be obtained.