Example 4A-10_4: Pressure Flow Problem 1

Determine if the existing storm sewer pipe can be used in the new storm sewer design.

Given:

Discharge, Q = 40 ft^3/s.

Pipe dimensions:

L = 300 ft.

Diameter = 24 inches.

Slope = 1.0%.

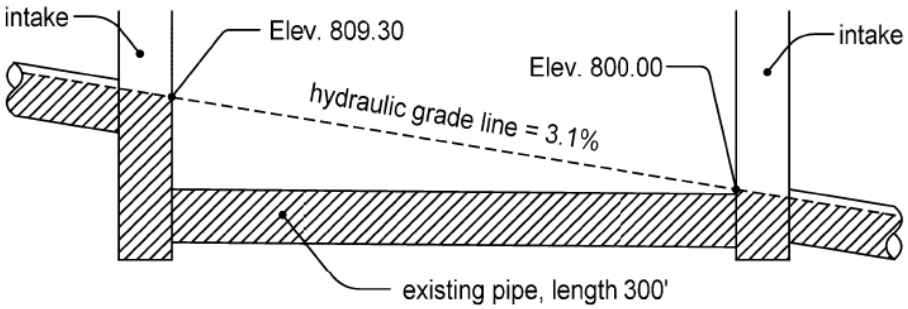

Figure 1: Existing storm sewer pipe.

Solution:

1. Check the velocity assuming no pressure in the existing pipe:

$$V = \left(\frac{K_c}{n}\right)\left(\frac{D}{4}\right)^{0.67}\sqrt{S} = \left(\frac{1.49}{0.013}\right)\left(\frac{2}{4}\right)^{0.67}\sqrt{0.01} = 7.20 \text{ ft/s.}$$

   The velocity is acceptable.

2. Check the capacity:

$$Q = VA = V \times \left[\pi\frac{D^2}{4}\right] = 7.20 \times \left[\pi\frac{2^2}{4}\right] = 22.6 \text{ ft}^3/\text{s.}$$

   The capacity of 22.6 ft^3/s is below the new storm sewer design discharge of 40 ft^3/s. Check the capacity under pressure flow.

3. Use the required capacity (Q = 40 ft^3/s) to determine the needed hydraulic gradient:

$$40 = V \times \left[\pi\frac{2^2}{4}\right], \text{ so } V = \frac{40 \times 4}{\pi \times 2^2} = 12.73 \text{ ft/s, which is less than the 15 ft/s maximum.}$$

$$12.73 = \left(\frac{1.49}{0.013}\right)\left(\frac{2}{4}\right)^{0.67}\sqrt{S}\text{, so } S = \left(\left(\frac{12.73 \times 0.013}{1.49}\right)^{1.5}\left(\frac{4}{2}\right)^{.67}\right)^2 = 3.1\%$$

4. Calculate the elevation required to create the needed hydraulic gradient:
   a. From Figure 1 above, the elevation in the downstream intake will be below the top of the existing pipe. Use 800.00 ft. as the downstream elevation.
   b. Determine the upstream elevation required to carry 40 ft^3/s:

      rise = length of existing pipe × hydraulic gradient = 300 × 0.031 = 9.30 ft.

      upstream elevation = downstream elevation + rise = 800.00 + 9.30 = 809.30 ft.

   If the elevation is above the form grade, the existing pipe will not work and will need to be replaced.