

Example Problem 4A-7_2, Open Throat Curb Intake in a Sag.

Given:

Primary Highway, posted speed ≥ 45 mph. The gutter is 3 feet wide, so the maximum allowable spread = 6 ft (gutter width plus maximum allowable encroachment onto roadway pavement of 3 ft).

Total gutter flow: $Q = 0.91$ ft³/s approaching from the north side.

Total gutter flow: $Q = 0.80$ ft³/s approaching from the south side.

Cross slope: $S_x = 0.03$ ft/ft.

Longitudinal slope $S_L = 0.005$ ft/ft.

Minimum longitudinal slope at sag intake: $S_L = 0.003$ ft/ft.

Empirical Coefficient: $K_u = 0.56$.

Manning's coefficient: $n = 0.016$; new pavement.

Weir Coefficient, $C_w = 2.3$

The well for the intake is located outside of the pavement.

Upstream intakes are located 60 ft from the sag intake.

Solution:

- Using the process for triangular gutter sections, calculate the spread coming from each direction to the sag intake ([Equation 4A-6_4](#)):

North side:

$$T = \left[\frac{nQ}{K_u S_x^{1.67} \sqrt{S_L}} \right]^{0.375} = \left[\frac{0.016 \times 0.91}{0.56 \times 0.03^{1.67} \sqrt{0.003}} \right]^{0.375} = 6.80 \text{ ft.}$$

South side:

$$T = \left[\frac{nQ}{K_u S_x^{1.67} \sqrt{S_L}} \right]^{0.375} = \left[\frac{0.016 \times 0.8}{0.56 \times 0.03^{1.67} \sqrt{0.003}} \right]^{0.375} = 6.48 \text{ ft.}$$

Since 6.80 ft and 6.48 ft are both greater than the maximum allowable spread of 6 ft., the upstream intakes need to be resized or relocated (to reduce bypass flow).

- For this example, assume the upstream intakes are resized such that flow is reduced to 0.41 ft³/s from the north side and 0.35 ft³/s from the south side. Recalculate spread (T) for both sides:

North side:

$$T = \left[\frac{nQ}{K_u S_x^{1.67} \sqrt{S_L}} \right]^{0.375} = \left[\frac{0.016 \times 0.41}{0.56 \times 0.03^{1.67} \sqrt{0.003}} \right]^{0.375} = 5.04 \text{ ft.}$$

South side:

$$T = \left[\frac{nQ}{K_u S_x^{1.67} \sqrt{S_L}} \right]^{0.375} = \left[\frac{0.016 \times 0.35}{0.56 \times 0.03^{1.67} \sqrt{0.003}} \right]^{0.375} = 4.75 \text{ ft.}$$

Since 5.04 ft and 4.75 ft are both less than 6 ft, they are within allowable spread limits.

3. Calculate the depth of ponding (d) using [Equation 4A-7.7](#) (assume weir flow):

$$d = \left[\frac{Q}{C_w \times (L + 1.8W)} \right]^{0.67}$$

where:

Total flow from both sides, $Q = 0.41 + 0.35 = 0.76 \text{ ft}^3/\text{s}$.

For the SW-509 and SW-510, the throat opening length is 8 ft.

Width of gutter depression, $W = 2 \text{ ft}$.

$$d = \left[\frac{Q}{C_w \times (L + 1.8W)} \right]^{0.67} = \left[\frac{0.76}{2.3 \times (8 + 1.8 \times 2)} \right]^{0.67} = 0.092 \text{ ft.}$$

$d = 0.092 \text{ ft.} < 0.75 \text{ ft}$, so the assumption the intake is operating as a weir is correct.

4. Check spread (T) at the intake:

$$T = \frac{d}{S_x} = \frac{0.092}{0.03} = 3.07 \text{ ft.}$$

This is less than the 6 ft allowable spread.

Discussion:

Flanking Intakes should already be located on the Concept Plan per Sections 4A-4 and 4A-7; however, they should be ignored when evaluating spread and inlet capacity at the sag.

The above procedure will generally be required for each side of the roadway since the opposite side will generally not have the same overland and bypass flow contributions.