# SECTION 4 – INLETS

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# SECTION 4 - INLETS

## 4.1.0 GENERAL

The primary purpose of storm drain inlets is to intercept excess surface runoff and deposit it in a drainage system, thus reducing the possibility of surface flooding.

The most common location for inlets is in streets which collect and channelize surface flow, making it convenient to intercept. Because the primary purpose of streets is to carry vehicular traffic, inlets must be designed so as not to conflict with that purpose.

The following guidelines shall be used in the design of inlets to be located in streets:

A. Grated curb inlets are discouraged from use due to their increased tendency to clog and problems with replacement. In all instances where a curb inlet can be used in lieu of a grated curb inlet, it shall be required unless approval is given from the City Engineer.

B. Minimum transition for recessed inlets shall be ten (10) feet, in accordance with the Engineering & Development Services Department standard detail for recessed inlets (standard No. 508-5).

C. All curb inlets (whether in a sump or on grade) incorporate a standard five (5) inch depression. Unless otherwise approved in writing by City Engineer, all curb inlets shall be a minimum of ten (10) feet in length.

D. When recessed inlets are used, they shall not decrease the width of the sidewalk. Also, it should be noted that the use of recessed inlets must be approved by the City Engineer for all streets.

E. Design and location of inlets shall take into consideration pedestrian and bicycle traffic. In particular, grate inlets shall be designed to assure safe passage of bicycles.

F. Inlet design and location must be compatible with the criteria established in Section 3 of this Manual.

G. The use of slotted drains is discouraged except in instances where there is no alternative. If used, the manufacturer's design guidelines should be followed.

## 4.2.0 INLET CLASSIFICATIONS

Inlets are classified into two (2) major groups: (1) inlets in sumps where flow contributes from two (2) or more sides (Type S); and (2) inlets on grade (Type G). The following list references the various inlet types. (See Figures 4-1 through 4-7 in Appendix B of this Manual).

| Inlets in Sumps | |
|---|---|
| (1) Curb Opening | Type S-1 |
| (2) Grate* | Type S-2 |
| (3) Combination (Grate and Curb Opening)* | Type S-3 |
| (4) Area Without Grate | Type S-4 |

| Inlets on Grade | |
|---|---|
| (1) Curb Opening | Type G-1 |
| (2) Grate* | Type G-2 |
| (3) Combination (Grate and Curb Opening)* | Type G-3 |

Recessed inlets are identified by the suffix (R), i.e.: S-1(R).

* For the flow capacity through the grate inlets, the Engineer should check appropriate vendor catalog.

## 4.3.0 STORM INLET HYDRAULICS

### 4.3.1 Inlets In Sumps

Inlets in sumps are inlets at low points with gutter flow contributing from two (2) or more sides. The capacity of inlets in sumps must be known in order to determine the depth and width of ponding for a given discharge. Sump inlets should be designed using Figure 4-8 in Appendix B of this Manual for an unsubmerged inlet or Figure 4-9 in Appendix B of this Manual for submerged conditions, regardless of what depth of depression exists at the inlet.

A. **Curb Opening Inlets (Type S-1) and Area Inlet Without Grate (Type S-4).**

Unsubmerged curb opening inlets (Type S-1) and area inlets without grates (Type S-4) in a sump function as rectangular weirs with a coefficient of discharge of 3.0. Their capacity shall be based on the following equation:

$$Q = 3.0h^{1.5}L \quad \text{(Eq. 4-1)}$$

where,

Q = Capacity of curb opening inlet or of area inlet, cfs

h = Head at the inlet, feet, = a + $Y_0$

L = Length of opening through which water enters the inlet, feet

Figure 4-8 in Appendix B of this Manual provides for direct solution of the above equation.

Curb opening inlets and drop inlets in sumps have a tendency to collect debris at their entrances. For this reason, the calculated inlet capacity shall be reduced by ten (10) percent to allow for clogging.

B. **Grate Inlets (Type S-2).**

An area inlet with a grate (Type S-2) in a sump functions as an orifice with a coefficient of discharge of 0.60. Therefore, the orifice equation becomes:

$$Q = 4.82Ah^{0.5} \qquad \text{(Eq. 4-2)}$$

where,

- Q = Capacity, cfs
- h = Depth of flow at inlet, feet
- A = Area of grate opening, square feet

The curves shown in Figure 4-9 in Appendix B of this Manual provide for direct solution of the above equation.

Area inlets with grates in sumps have a tendency to clog from debris which becomes trapped by the inlet. For this reason, the calculated inlet capacity of a grate inlet shall be reduced by fifty (50) percent to allow for clogging. Since the clogging problems require maintenance, grate inlets in sumps are discouraged.

C. **Combination Inlets (Type S-3).**

The capacity of a combination inlet Type S-3 consisting of a grate and curb opening in a sump shall be considered to be the sum of the capacities obtained from Figures 4-8 and 4-9 in Appendix B of this Manual. When the capacity of the gutter is not exceeded, the grate inlet accepts the major portion of the flow.

Combination inlets in sumps have a tendency to clog and collect debris at their entrances. For this reason, the calculated inlet capacities shall be reduced by their respective percentages indicated previously (which are ten (10) percent for a curb opening and fifty (50) percent for grate inlets).

D. **Recessed Inlets in Sumps. (Type S-1(R), Type S-3(R))**

Recessed inlets can be either curb opening or combination types. The clogging factors shall remain the same for recessed or non-recessed inlets.

### 4.3.2 Inlets On Grade With Gutter Depression

A. **Curb Opening Inlets on Grade (Type G-1).**

The capacity of a depressed curb inlet should be determined by use of Figures 4-10 and 4-11 in Appendix B of this Manual. Because the inlet is on a slope and there is no grate to catch debris, the majority of the debris will be carried downstream; therefore, no reduction for clogging is necessary.

B. **Grate Inlets on Grade (Type G-2).**

The depression of the gutter at a grate inlet decreases the flow past the outside of the grate. The effect is the same as that caused by the depression of a curb inlet.

The bar arrangements for grate inlets greatly affect the efficiency of the inlet. In order to determine the capacity of a grate inlet on grade, the appropriate vendor catalog should be checked (see Bibliography, Item 4-3 of this Manual).

Grate inlets have a tendency to trap debris such as leaves and paper being carried by the gutter flows. This causes traffic problems from ponding water and requires maintenance. A reduction factor of thirty (30) percent to allow for clogging should be applied.

C. **Combination Inlets on Grade (Type G-3).**

Combination inlets (curb opening plus grate) have greater hydraulic capacity than curb opening inlets or grate inlets of the same length. Generally speaking, combination inlets are the most efficient of the three (3) types of inlets on grade presented in this manual. The basic difference between a combination inlet and a grate inlet is that the curb opening receives the carry-over flow that passes between the curb and the grate. The reduction factor for clogging of this type of inlet shall be zero (0) percent for the curb opening and thirty five (35) percent for the grate inlet.

D. **Recessed Inlets on Grade (Type G-1R, G-3R).**

Capacities for recessed inlets on grade shall be calculated as 0.75 times the capacity for non-recessed inlets. The clogging factors shall remain the same for the various types of inlets.

### 4.3.3 Example 4-1

Given: Parabolic crown street width = thirty (30) feet
Cross Slope = zero (0) ft/ft
Street Grade = five (5) 0 percent
$Q_a$ in one gutter = twelve (12) cfs

Find: Capacity of a ten (10) foot curb inlet on grade (Type G-1) with a five (5) inch gutter depression.

Step 1. From Equation 3-3 (Section 3 of this Manual) depth of flow in gutter is $y_0$ = 0.43 feet, of 5.1 inches.

Step 2. Enter Fig. 4-10 with $y_0$= 0.43 feet and a = 5 inches and find corresponding $Q_a/L_a$= 0.90

Step 3. Compute $L_a$= 12/0.90 = 13.33.

Step 4. Compute $L/L_a$= 10/13.33 = 0.75.

Step 5. Enter Figure 4-11 (in Appendix B of this Manual) with $L/L_a$0.75 and $a/y$ = 0.98 and find corresponding $Q/Q_a$= 0.84.

Step 6. Determine Q from $Q/Q_a$.
Q = 0.84 (12) = 10.1 cfs

Step 7. Determine $Q_{pass}$.
$Q_{pass}$= 12 - 10.1 = 1.9 cfs

Step 8. The by-pass flow is 1.90 cubic feet per second.

## 4.4.0 INLET SYSTEM LAYOUT

The following is intended to provide a general step by step procedure for the layout of an inlet system utilizing the information that has been provided in Chapters 3 and 4 of this Manual. This information is in no way a requirement for design and is provided solely for the benefit of the Engineer or designer.

### 4.4.1 Preliminary Design Considerations

A. Prepare a drainage map of the entire area to be drained by proposed improvements. Contour maps serve as excellent drainage area maps when supplemented by field observation.

B. Outline the drainage area for each inlet in accordance with present and future street development. Show all existing underground utilities.

C. Make a tentative layout of the proposed storm drainage system, locating all inlets, manholes, mains, laterals, ditches, culverts, etc.

D. Establish the design rainfall frequency.

E. Establish the minimum inlet time of concentration.

F. Establish the typical cross section of each street.

G. Establish the permissible spread of water on all streets within the drainage area.

H. Indicate each drainage area, the size of area, the direction of surface runoff by small arrows and the coefficient of runoff for the area.

### 4.4.2 Inlet System Design

Determining the size and location of inlets is largely a trial and error procedure. Based on criteria outlined in Sections 2, 3 and 4 of this Manual, the following steps will serve as a guide to the procedure to be used.

**Step 1.** Beginning at the upstream end of the project drainage basin, outline a trial subarea and calculate the runoff from it.

**Step 2.** Compare the calculated runoff to allowable street capacity. If the calculated runoff is greater than the allowable street capacity, reduce the size of the trial subarea. If the calculated runoff is less than street capacity, increase the size of the trial subarea. Repeat this procedure until the calculated runoff equals the allowable street capacity. This is the first point at which a portion of the flow must be removed from the street. The percentage of flow to be removed will depend on street capacities versus runoff entering the street downstream.

**Step 3**. Record the drainage area, time of concentration, runoff coefficient and calculated runoff for the subarea. This information shall be recorded on the plans or in tabular form similar to that shown in Table 4-1 convenient for review.

**Step 4.** If an inlet is to be used to remove water from the street, determine and record the inlet size, amount of intercepted flow and amount of flow carried over (bypassing the inlet).

**Step 5.** Continue the above procedure for other subareas until a complete system of inlets has been established. Remember to account for carry-over from one inlet to the next.

**Step 6.** After a complete system of inlets has been established, modification should be made to accommodate special situations such as point sources of large quantities of runoff, and variation of street alignments and grades.

**Step 7.** Record information as in Steps 3 and 4 above for all inlets.

**Step 8.** After the inlets have been located and sized the inlet pipes can be designed (see Section 5 of this Manual).

### 4.4.3 Inlet Flow Calculation Table

An example of a calculation table for inlet flow design is shown in Table 4-1 of this Manual.

The following is an explanation of each column in Table 4-1:

**Column 1.** Inlet number. All inlets are classified with a designated number.

**Column 2.** Drainage area number. List all numbers of the drainage areas which drain stormwater into inlet number in Column 1.

**Column 3.** The corresponding discharge from the drainage areas in Column 2.

**Column 4.** The carry-over flow ($Q_{pass}$) in this column is the quantity of water which has passed by the last preceding inlet to the inlet under consideration.

**Column 5.** The total run-off, $Q_a$, is the run-off from Column 3 plus the carry-over from preceding drainage areas.

**Column 6.** The slope, S, expressed in percentage, is obtained from established grade lines as shown on the plan-profile sheets, or from specified data.

**Column 7.** Gutter depression.

**Column 8.** The water depth, $Y_0$, in the gutter is expressed in feet. " $Y_0$ " can be determined from Equation 3-1 or Figure 3-1 (in Appendix B of this Manual) for the straight crown streets and determined from Equations 3-3, 3-4 or 3-5 for the parabolic crown streets.

**Column 9.** The value of the ponded width is the product of the water depth (in Column 7) and the reciprocal of the cross slope (z) in the Equation 3-2. The ponding width must be kept within the maximum permissible ponded limit of the streets.

**Column 10.** The reduction factor for each inlet as specified in Section 4.3.0 of this Manual.

**Column 11.** $Q_a/L_a$ is read from Figure 4-10 in Appendix B of this Manual by the gutter depression and gutter flow depth.

**Column 12.** $L_a$ is calculated from $Q_a$ divided by the value in Column 11. $L_a$ represents the length of an inlet for one hundred percent (100) percent interception.

**Column 13.** Length of the inlet L.

**Column 14.** The ratio of $L/L_a$.

**Column 15.** The ratio of gutter depression (in feet) to water depth in the gutter (in feet).

**Column 16.** The ratio of $Q/Q_a$. The value is read from Figure 4-11 in Appendix B of this Manual.

**Column 17.** Q is the flow intercepted by the inlet of length L.

**Column 18.** The carry-over flow ($Q_{pass}$) is the result of $Q_a$-Q.

**Column 19.** This column is used to specify the inlet information.

## Table 4-1 Inlet Flow Calculation Table

INLET FLOW CALCULATION TABLE

| INLET NUMBER | DRAINAGE AREA NO. | Q (CFS) | Q PASS (CFS) | Q TOTAL (Qa) (CFS) | SLOPE (%) | a (IN) | $y_o$ (FT) | PONDED WIDTH (FT.) | R.F. (%) | Qa/La | La (FT) | LENGTH (FT) | L/La | $a/y_o$ | Q/Qa | Q (CFS) | Q pass (CFS) | REMARK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
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**Source: City of Austin Drainage Criteria Manual**