

8.0 Introduction

Presented in this chapter are the criteria and methodology for design and evaluation of storm sewer inlets located in Douglas County. The review of all planning submittals will be based on the criteria presented herein.

8.1 General

8.1.1 Function of Inlets. The primary purpose of storm drain inlets is to intercept excess surface runoff and convey it into a storm drainage system, thereby reducing or eliminating surface flooding. Roadway geometry often dictates the location of street inlets located along the curb and gutter. In general, inlets are placed at all low points (sumps), along continuous grade curb and gutter, median breaks, intersections, and crosswalks. The spacing of inlets along a continuous grade segment of roadway is governed by the allowable spread of flow. See further details of allowable spread of flow in Chapter 7, Street Drainage, of these *Criteria*.

8.1.2 Types of Inlets. There are two major types of inlets approved for use within the County Right-of-Way, curb opening and grate. Inlets are further classified as being on a “continuous grade” or in a “sump”. The term “continuous grade” refers to an inlet placed in curb and gutter such that the grade of the street has a continuous slope past the inlet and, therefore, water ponding does not occur at the inlet. The sump condition exists whenever an inlet is located at a low point and the result is ponding water.

8.1.3 General Design Guidelines. The following guidelines shall be used when designing inlets along a street section:

1. Design and location of inlets shall take into consideration pedestrian and bicycle traffic. All inlet grates shall be pedestrian and bicycle-safe.
2. Design and location of inlets shall be in accordance with the criteria established in Chapter 7, Street Drainage, of these *Criteria*.
3. Maintenance of inlets shall be considered when determining inlet locations. The slope of the street, the potential for debris and ice accumulations, the distance between inlets and/or manholes etc., shall be considered. Maintenance access shall be provided to all inlets.
4. To avoid potential damage from large vehicles driving over the curb return, inlets shall not be placed in the curb return radii.
5. Selection of the appropriate inlet grate shall be based on a number of factors, including, but not limited to, the adjacent land use and potential for pedestrian or bicycle traffic, the potential for debris accumulation, visibility, expected loading from vehicles, and hydraulic capacity.
6. Consideration should be given to flanking inlets on each side of the low point when the depressed area has no outlet except through the system. The purpose is to provide relief if the inlet at the low point becomes clogged. Consult HEC-22 for additional information regarding this concept.

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7. In many cases, inlets are necessary at grade breaks, where street or ditch grades change from steep to relative flat because of the reduced conveyance capacities. In addition, it is common for icing or sediment deposition to occur with nuisance flows in reaches where the grades are relatively mild.

8.1.4 Inlet Capacity. The procedures used to define the capacity of standard inlets under continuous grade or sump flow conditions are described in the following sections. Unless otherwise noted, all storm sewer inlet criteria shall be in accordance with Section 3.0 of the Streets/Inlets/Storm Sewers Chapter in Volume 1 of the *UDFCD Manual*. In general, the procedure for calculating inlet capacity consists of defining the quantity and depth of flow in the gutter and determining the theoretical flow interception by the inlet.

8.2 Standard County Inlets

8.2.1 Applicable Settings for Various Inlet Types. Table ST-5 from Section 3.0 of the Streets/Inlets/Storm Sewers Chapter in Volume 1 of the *UDFCD Manual* provides information on the appropriate application of the different types of inlets along with advantages and disadvantages of each. The information provided in this table should be taken into consideration when determining the inlet of choice for a given site condition.

8.2.2 Standard Inlets Accepted for Use in the County. Table 8-1 provides the standard inlets permitted for use in the County:

**TABLE 8-1
STANDARD COUNTY INLETS**

Inlet Type	Standard Detail	Permitted Use
Curb-Opening Inlet – Type R	SD-1	All street types with 6-inch vertical curb and gutter and 4-inch mountable curb and gutter, with appropriate transitions
Grate Inlet – Type C	SD-2	Roadside or median grass swales; Landscaped area drains; generally non-pedestrian accessible areas; Used in sump condition
Grate Inlet – Type D	SD-2A	Roadside or median grass swales; Landscaped area drains; generally non-pedestrian accessible areas; Used in sump condition

Along with the inlets mentioned in the above table, there are a large number of additional inlets which are used in the Denver Metro Area. Some of these inlets include the Denver Type 13 Inlet, Vane Grate Inlet, and the Denver No. 16 Inlet. The inlets provided in Table 8-1 are accepted for use in the County. For retrofit situations or when special circumstances exist, other inlets may be used but will

be evaluated by the County on a case-by-case basis. UD-Inlet must be used for hydraulic analysis of these non-standard inlets.

8.3 Inlets on Continuous Grade

8.3.1 Inlet Capacity Factors. The capacity of an inlet located on a continuous grade is dependent upon a variety of factors including gutter slope, depth and velocity of flow in the gutter, height and length of the curb opening, street cross slope, and the amount of depression at the inlet. Inlets placed on continuous grades rarely intercept all of the flow in the gutter during the minor storm. This results in flow continuing downstream of the inlet and is typically referred to as “carryover”. The amount of carryover must be accounted for in the drainage system evaluation as well as in the design of the downstream inlet.

8.3.2 Curb Opening Inlet (Type R). The capture efficiency of a curb-opening inlet is dependent on the length of the opening, the depth of flow at the curb, the street cross slope, and the longitudinal gutter slope. If the curb opening is long, the flow rate is low, and the longitudinal gutter slope is small, all of the flow will be captured by the inlet. During the minor storm event, a portion of the stormwater often bypasses the inlet as indicated by the inlet efficiency. See Section 3.3.2 of the Streets/Inlets/Storm Sewers chapter in Volume 1 of the *UDFCD Manual* for additional information on the efficiency and design of curb opening inlets on continuous grades.

8.4 Hydraulic Evaluation of Inlets on Continuous Grade

8.4.1 Preliminary Versus Final Design of Inlets on Continuous Grade. Capacity charts for Type R inlets on continuous grades along standard County street sections have been completed for the minor and major storm events, based on the maximum allowable flow in the street section. Further discussion on the use of the charts can be found in Sections 8.4.3 and 8.4.4, respectively. It is recommended that these charts be used for preliminary design phases and rough inlet placement. For final design, the design engineer can use these charts if the street is at maximum allowable flow. When flow in the gutter is less than maximum flow, the UD-Inlet spreadsheets shall be used to determine the interception by the proposed inlet. Further discussion on the use of UD-Inlet for less than maximum allowable flow can be found in Section 8.4.5.

8.4.2 Inlet Analysis Spreadsheets. The Streets/Inlets/Storm Sewers chapter of the *UDFCD Manual* provides detailed instruction on the appropriate analysis of inlet capacities including equations, coefficients, and examples. The worksheets are the most accurate means of determining inlet capture rates and capacity calculations. The UD-Inlet Spreadsheets may be downloaded from the UDFCD web site at www.udfcd.org.

8.4.3 Minor Event Curb Opening Inlet Capacity Charts for Standard Street Sections at Maximum Capacity. The County requires Type R curb opening inlets to be used in the County. Minor event inlet capacity charts for curb

opening inlets on continuous grades along standard County street sections have been generated and can be found at the end of this chapter (Figures 8-2 through 8-11). These inlet capacity charts were calculated based on the maximum flow allowed in the street gutter for the minor design storm. These charts also incorporate clogging factors as discussed in Section 3.3.6 in the Streets/Inlets/Storm Sewers chapter in Volume 1 of the *UDFCD Manual*. Chapter 7, Street Drainage, provides additional information on the maximum street flow allowed for the minor storm event.

8.4.4 Major Event Curb Opening Inlet Capacity Charts for Standard Street Sections at Maximum Capacity. Major event inlet capacity charts for curb opening inlets on continuous grades along standard County street sections have also been generated and can be found at the end of this chapter (Figures 8-2 through 8-11). These inlet capacity charts were calculated based on the maximum flow allowed in the street gutter for the major design storm. Chapter 7, Street Drainage, provides additional information on the maximum street flow allowed for the major storm event. The major storm inlet capacity charts contain two curves which correspond to the street capacity charts generated in Chapter 7 Street Drainage. The two curves represent both 6-inches and 12-inches of depth at the gutter flowline. Both curves are provided to assist the design engineer in calculating the inlet capacity based upon the gutter flow depth that meets the County street flow criteria. Due to the large scale of the major storm inlet capacity chart, the minor storm inlet capacity chart may be used to determine a more accurate interception rate for the gutter-full condition. These inlet capacity charts also incorporate clogging factors as discussed in Section 3.3.6 in the Streets/Inlets/Storm Sewers chapter in Volume 1 of the *UDFCD Manual*.

8.4.5 Procedure for Street Flows Less than Maximum Allowable. For final design, if the quantity of flow in the street is less than the maximum allowable flow (minor or major event) as determined per Chapter 7 Street Drainage of these *Criteria*, then the design engineer must determine the interception rate of the Type R inlet using UD-Inlet based on the actual flow in the gutter.

8.4.6 Non-Standard Street Sections and Other Types of Inlets. There are two additional cases when the design engineer must use the UD-Inlet worksheets in the *UDFCD Manual* to determine the minor and major storm allowable inlet capacity. The first case occurs when a non-standard street section is analyzed. The second case is when the inlet being analyzed is not a Type R curb opening inlet. The appropriate worksheets from the UD-Inlet spreadsheet should be used for calculating the capacity of an inlet when either of these aforementioned cases occur.

8.5 Inlets in Sump Conditions

8.5.1 Capacity Calculation Factors and Inlet Selection. Inlets located in sumps (low points) must be sized to intercept all of the design storm flows at a predetermined reasonable depth of ponding. The capacity of an inlet in a sump is dependent upon the depth of ponding above the inlet and the amount of debris

clogging the inlet. Ponded water is a nuisance and can be a hazard to the public; therefore curb opening and combination inlets (where approved for use) are highly recommended for sump conditions due to their reduced clogging potential versus grate inlets acting alone.

- 8.5.2 Hydraulic Capacity Calculations.** Capacity charts for Type C and Type R inlets in a sump condition are located at the end of this chapter, Figures 8-12 and 8-13, respectively. These charts are based upon the depth of ponding above the inlet. The depth of ponded water shall not exceed the maximum allowable water depth for the given street classification as summarized in Chapter 7, Street Drainage. All calculations for inlets located in a sump shall conform to the procedures, variables, and coefficients provided in Section 3.3.5 and Table ST-7 in the Streets/Inlets/Storm Sewers chapter in Volume 1 of the *UDFCD Manual*.
- 8.5.3 Emergency Overflow Path with Drainage Tract.** A surface flow path shall be provided at all sump inlets to provide for emergency overflows if the inlet becomes clogged. The emergency overflow shall be designed to convey the major storm discharge. The depth of ponding shall not exceed the maximum allowable water depth for the given street classification as summarized in Chapter 7, Street Drainage.
- 8.5.4 Type C and D Inlets.** To determine the capacity of a Type D inlet in a sump, the capacity curve for a two Grate Type C inlet shall be used. The capacity curves provided at the end of this chapter include a 50% reduction factor for a standard grate and a 75% reduction factor for a close mesh grate. If a Type C or D inlet is placed in an area with pedestrian traffic, a close mesh grate shall be used.

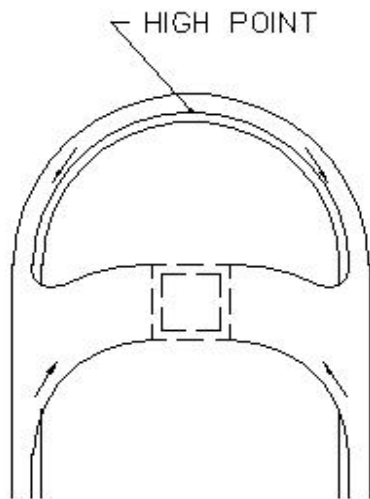
8.6 Inlet Location and Spacing

- 8.6.1 Inlet Location and Spacing.** The location and spacing of inlets is based upon street design considerations, topography (sumps), maintenance requirements, and the allowable spread of flow within the street. A significant amount of cost savings can be realized if inlets are placed in locations where their efficiency is maximized. The greater the efficiency of an inlet, the smaller the carryover flow, which may result in a smaller number of inlets downstream. Inlets are most efficient in a sump condition or along mild continuous street grades.
- 8.6.2 Inlet Placement on a Continuous Grade Based on Flow Spread.** As the flow increases in the gutter on a long, continuous grade segment of roadway, so does the spread. Since the spread (encroachment) is not allowed to exceed the maximum spread specified in Chapter 7 Street Drainage, inlets need to be strategically placed to remove flow from the gutter. A properly designed storm sewer system makes efficient use of the conveyance capacity of the street gutters by positioning inlets at the point where the allowable spread is about to be exceeded for the design storm. Section 3.4 of the Streets/Inlets/Storm Sewers chapter in Volume 1 of the *UDFCD Manual* provides a detailed discussion on inlet placement on continuous grades.

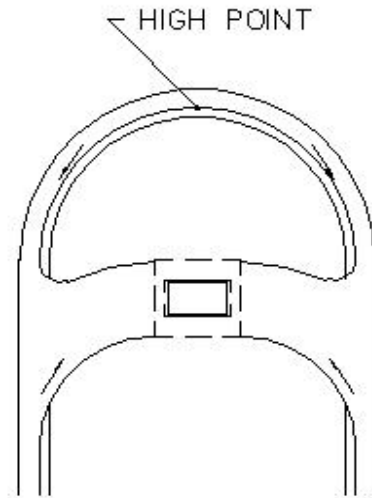
8.7 Other Design Considerations

- 8.7.1 Curb Chase Drain (Sidewalk Chase).** Curb chase drains shall NOT be used in place of a standard inlet to remove runoff from a street section. Curb chase drains have limited efficiency and have poor long-term performance.
- 8.7.2 Median Inlets.** For all streets constructed with asphalt, the median shall be constructed with a “catch” curb and gutter. Inlets are required along the median to reduce ponding at curb and gutter low points and to eliminate concentrated flow crossing over the lanes of traffic at the nose of the median. Figure 8-1, Special Median Inlet Details, presents conceptual representations of options available for placing median nose inlets. The final design and construction drawings must address inlet sizing, dimensions, and required curb and gutter transitions. If a street is constructed with concrete, it is acceptable for the median curb and gutter to be constructed as a “spill” section.
- 8.7.3 Maximum Inlet Length.** Inlets shall be designed to blend in with the streetscape, and not present a dramatic structural departure from the general surroundings. The use of extremely long inlets is discouraged, as they are generally not aesthetic, require increased maintenance, and are viewed as a hazard by the public. The maximum length of an inlet in a specific location shall not exceed the length of a triple unit (i.e., 15-feet. for a Type R inlet).

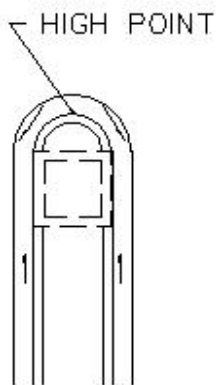
**FIGURE 8-1
SPECIAL MEDIAN INLET DETAILS**



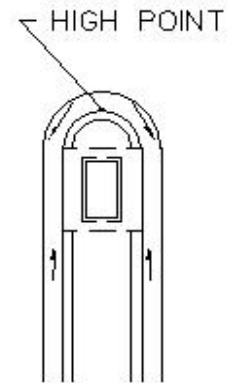
16' Median w/
Type C Inlet



16' Median w/
Grated Inlet Type 13



4' Median w/
Type C Inlet

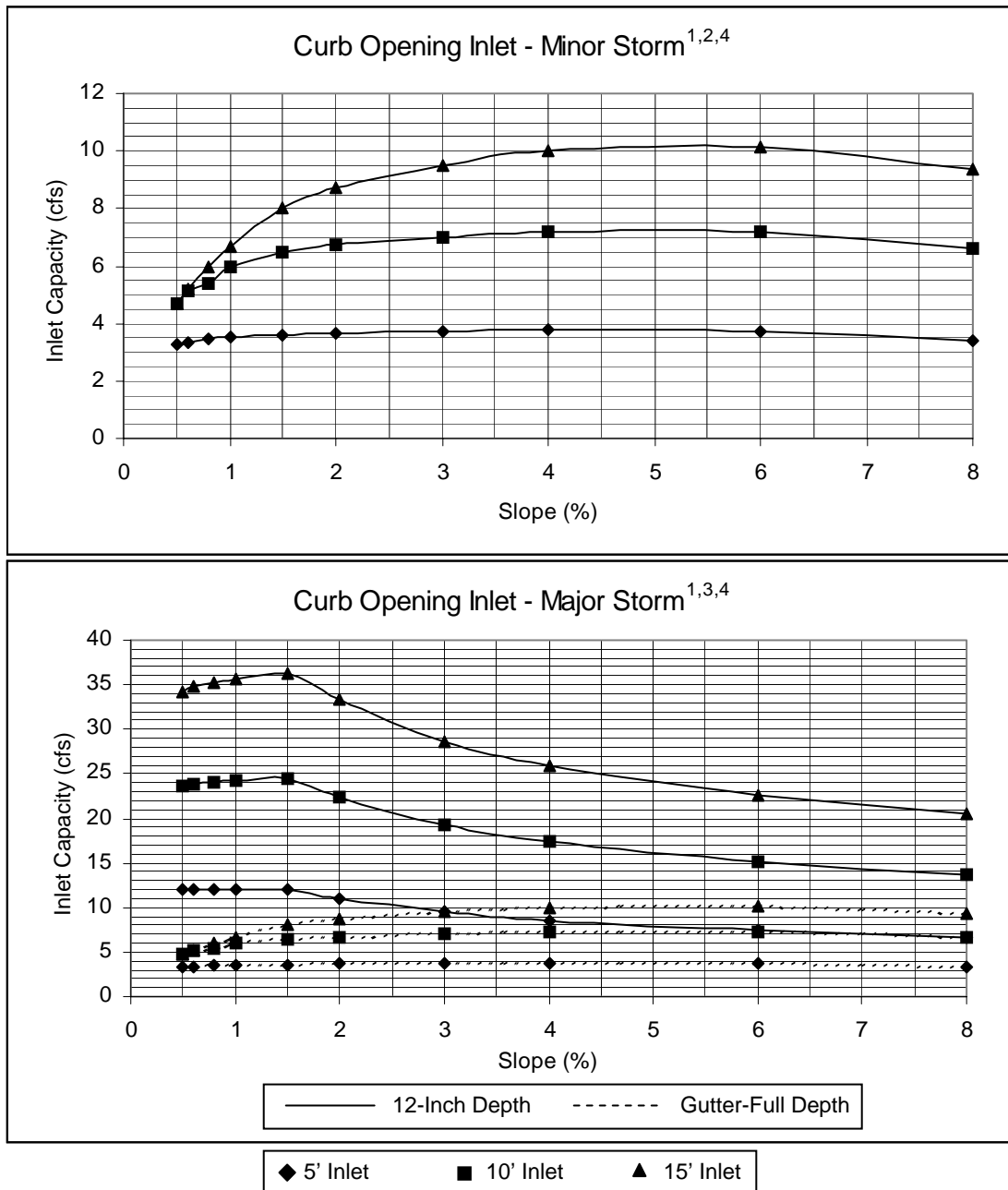


4' Median w/
Grated Inlet Type
13

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FIGURE 8-2, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
 URBAN LOCAL TYPE I (SINGLE FAMILY)
 CUL-DE-SAC (SINGLE FAMILY)

Street Section Data: Street Width Flowline to Flowline = 36'
 Type of Curb and Gutter = 4" combination
 Minor Storm Maximum Spread = 13.9'

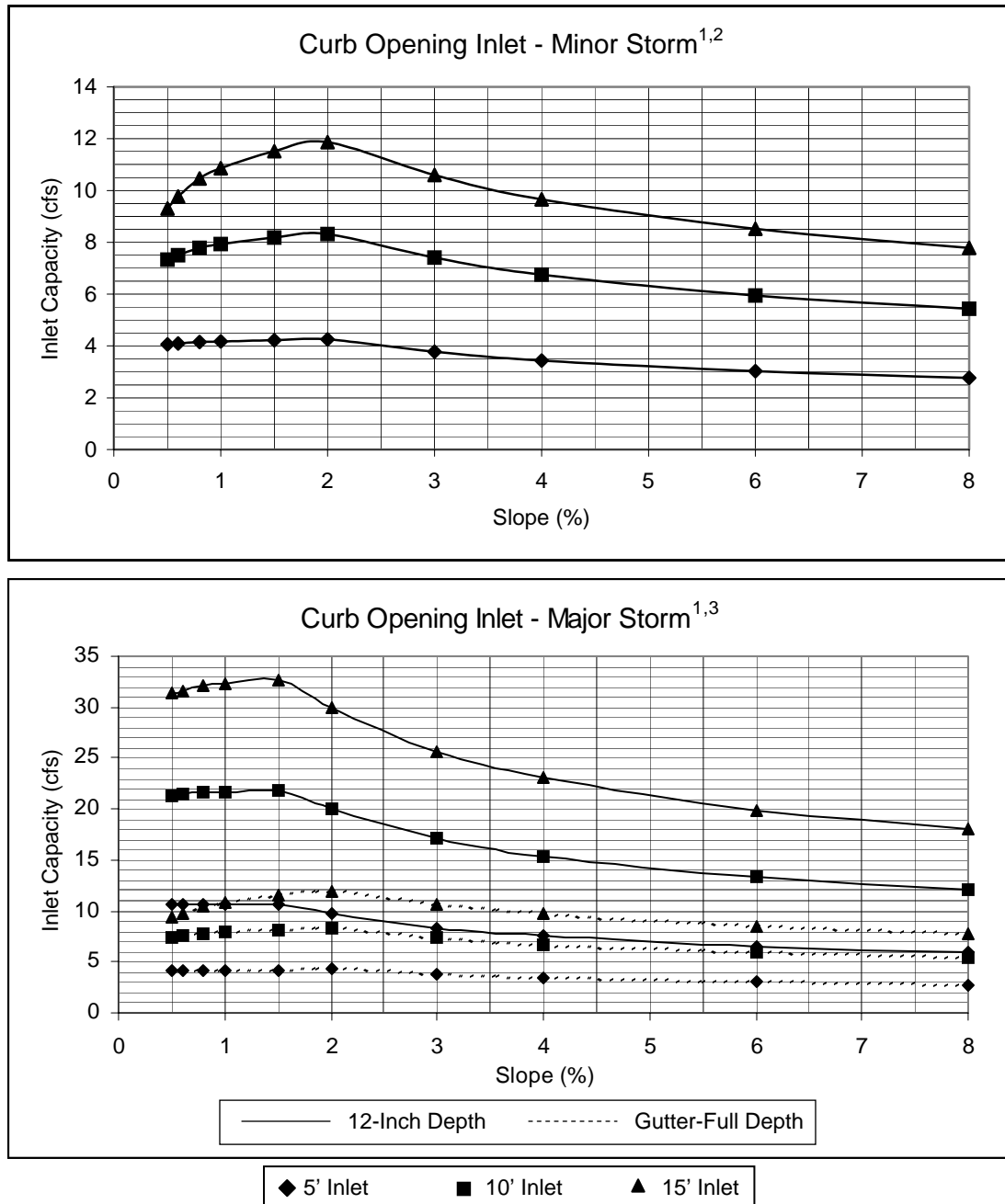


¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).
²The maximum spread width is limited by the curb height based on no curb overtopping allowable during a minor storm.
³Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.
⁴The capacity shown assumes gutter-full depth of 4.9" to the back of the attached sidewalk. If a 4" curb without an attached sidewalk is used, the street capacity shall be calculated using the UDFCD spreadsheets.

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FIGURE 8-3, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
 URBAN LOCAL TYPE I (MULTI-FAMILY)
 CUL-DE-SAC (MULTI-FAMILY)

Street Section Data: Street Width Flowline to Flowline = 44'
 Type of Curb and Gutter = 6" vertical
 Minor Storm Maximum Spread = 18.7'



¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

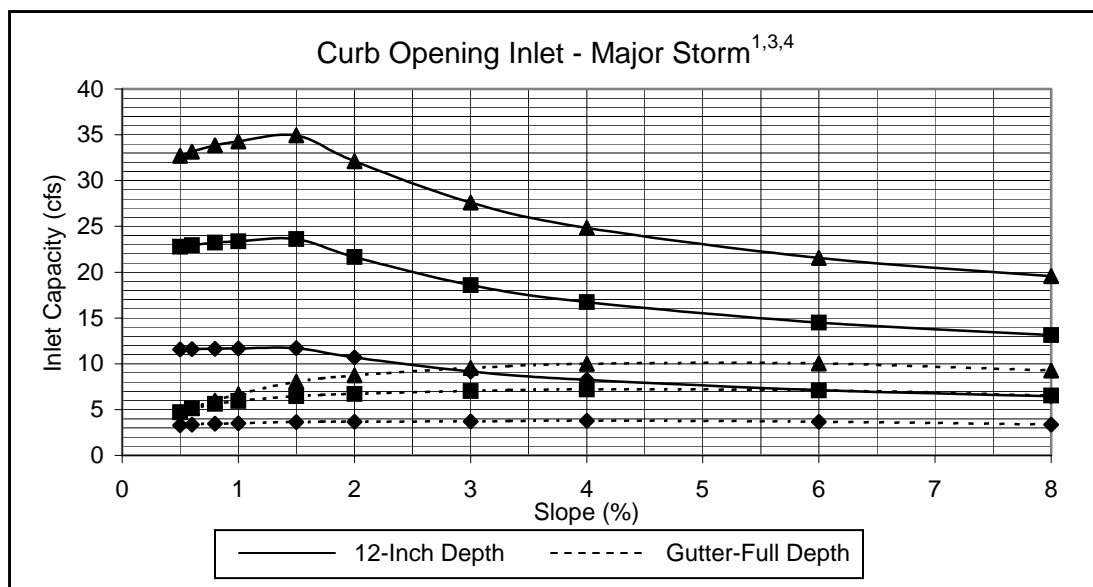
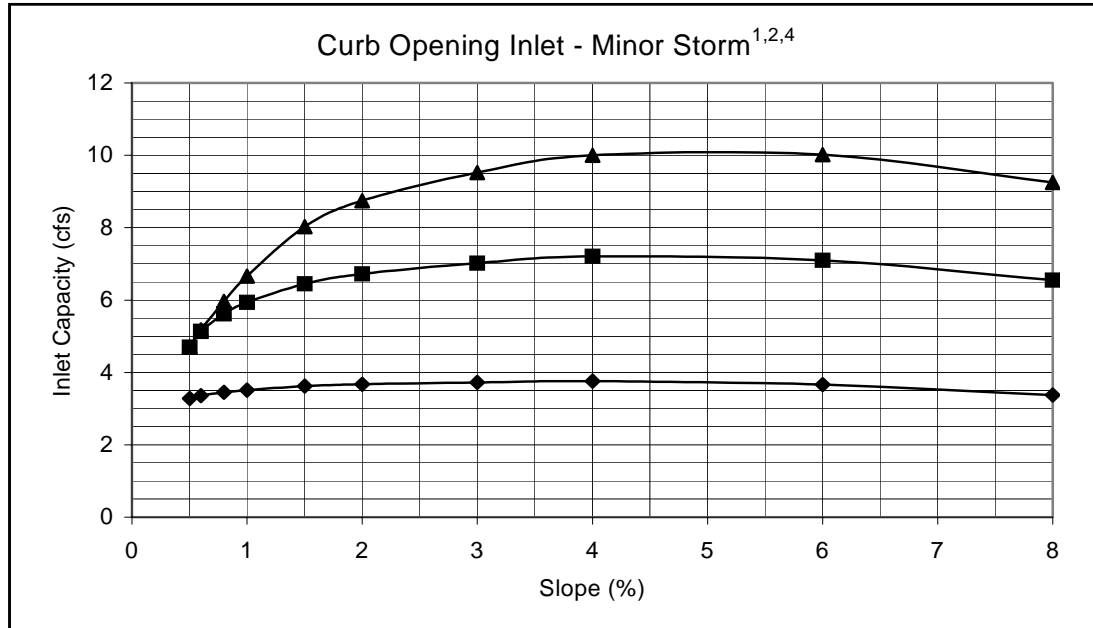
²The maximum spread width is limited by the curb height based on no curb overtopping allowable during a minor storm.

³Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

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**FIGURE 8-4, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
URBAN LOCAL TYPE II**

Street Section Data: Street Width Flowline to Flowline = 28'
Type of Curb and Gutter = 4" combination
Minor Storm Maximum Spread = 13.9'



◆ 5' Inlet ■ 10' Inlet ▲ 15' Inlet

¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

²The maximum spread width is limited by the curb height based on no curb overtopping allowable during a minor storm.

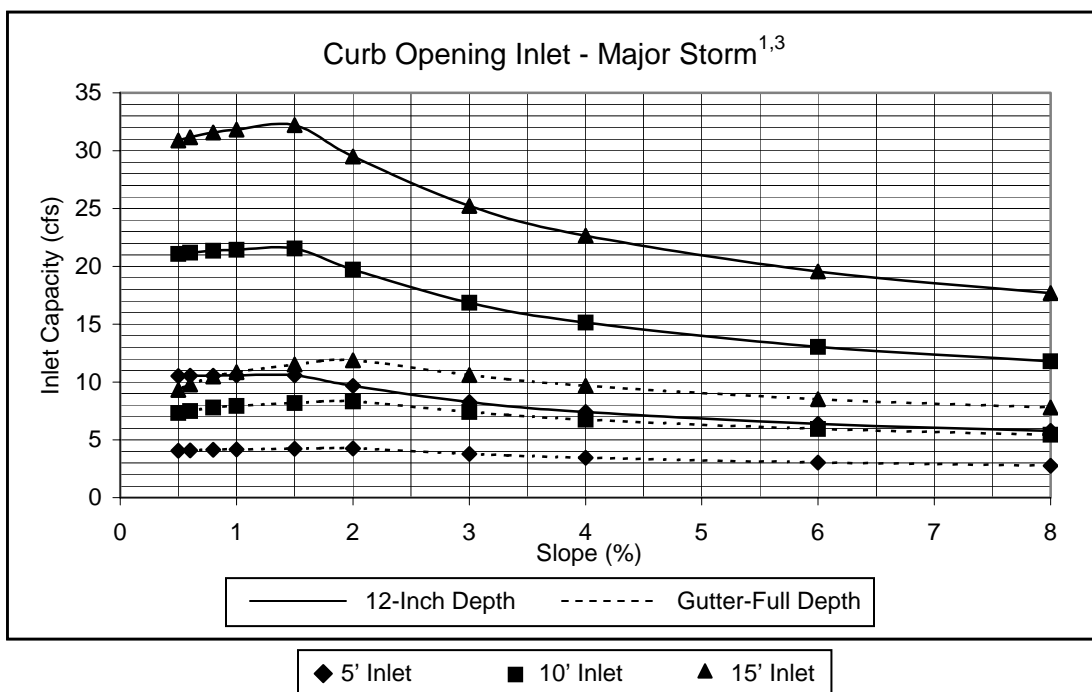
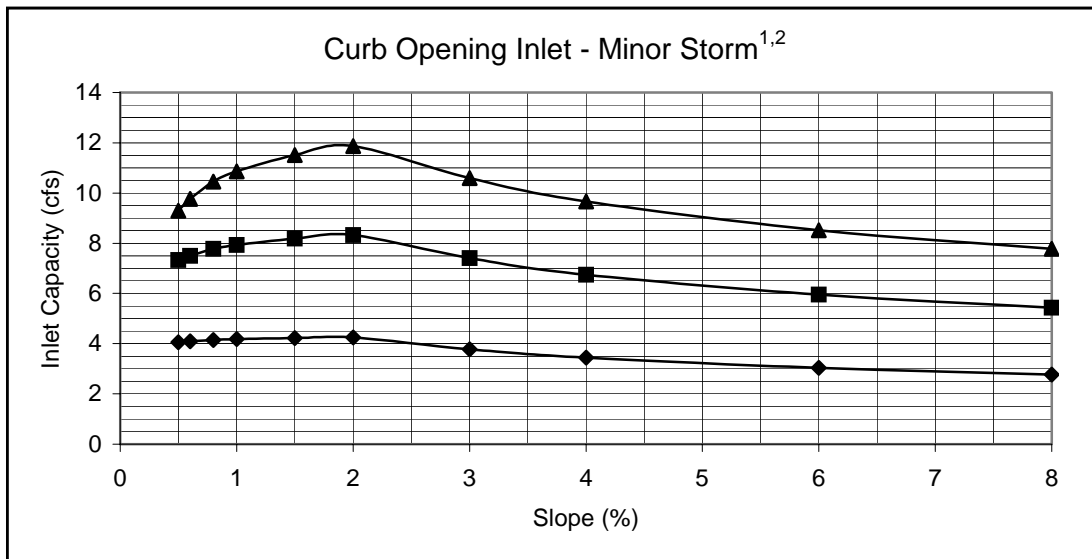
³Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

⁴The capacity shown assumes gutter-full depth of 4.9" to the back of the attached sidewalk. If a 4" curb without an attached sidewalk is used, the street capacity shall be calculated using the UDFCD spreadsheets.

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FIGURE 8-5, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
 ENTRY STREET
 SCHOOL ACCESS STREET
 COMMERCIAL & INDUSTRIAL

Street Section Data: Street Width Flowline to Flowline = 40'
 Type of Curb and Gutter = 6" vertical
 Minor Storm Maximum Spread = 18.7'



¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

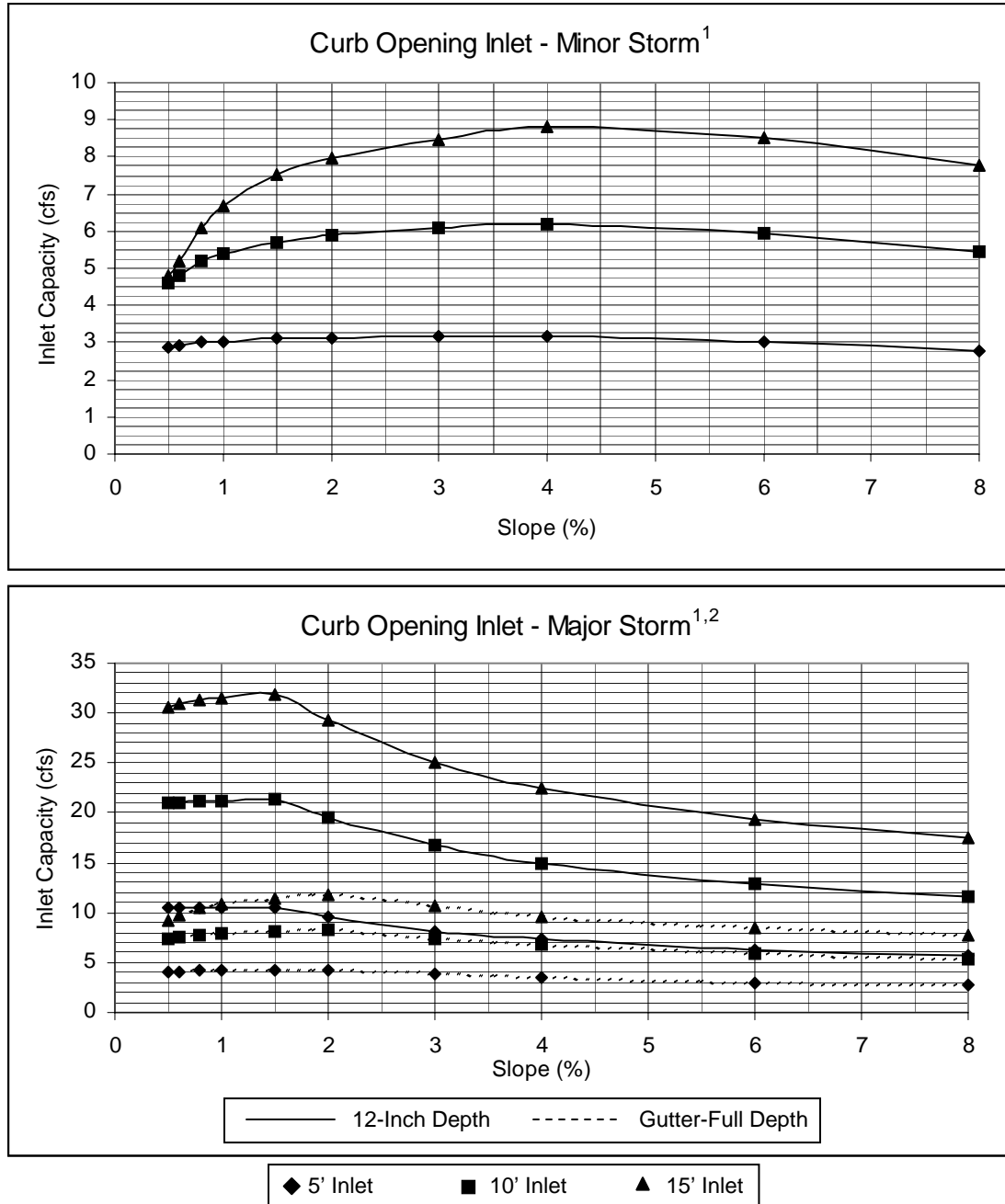
²The maximum spread width is limited by the curb height based on no curb overtopping allowable during a minor storm.

³Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

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**FIGURE 8-6, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
MINOR URBAN COLLECTOR**

Street Section Data: Street Width Flowline to Flowline = 38'
Type of Curb and Gutter = 6" vertical
Minor Storm Maximum Spread = 14'



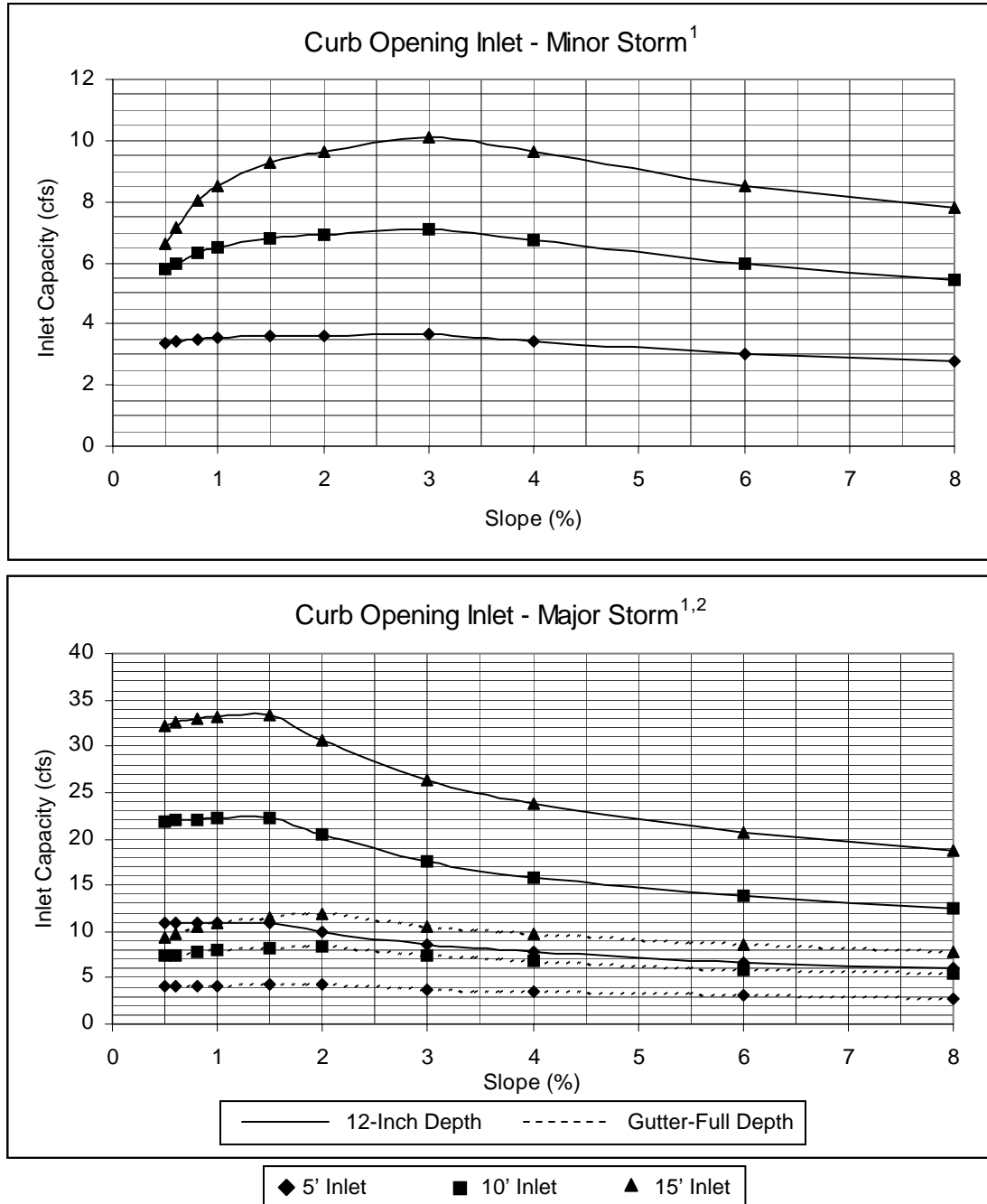
¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

²Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

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**FIGURE 8-7, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
MAJOR URBAN COLLECTOR**

Street Section Data: Street Width Flowline to Flowline = 70'
Type of Curb and Gutter = 6" vertical
Minor Storm Maximum Spread = 16'



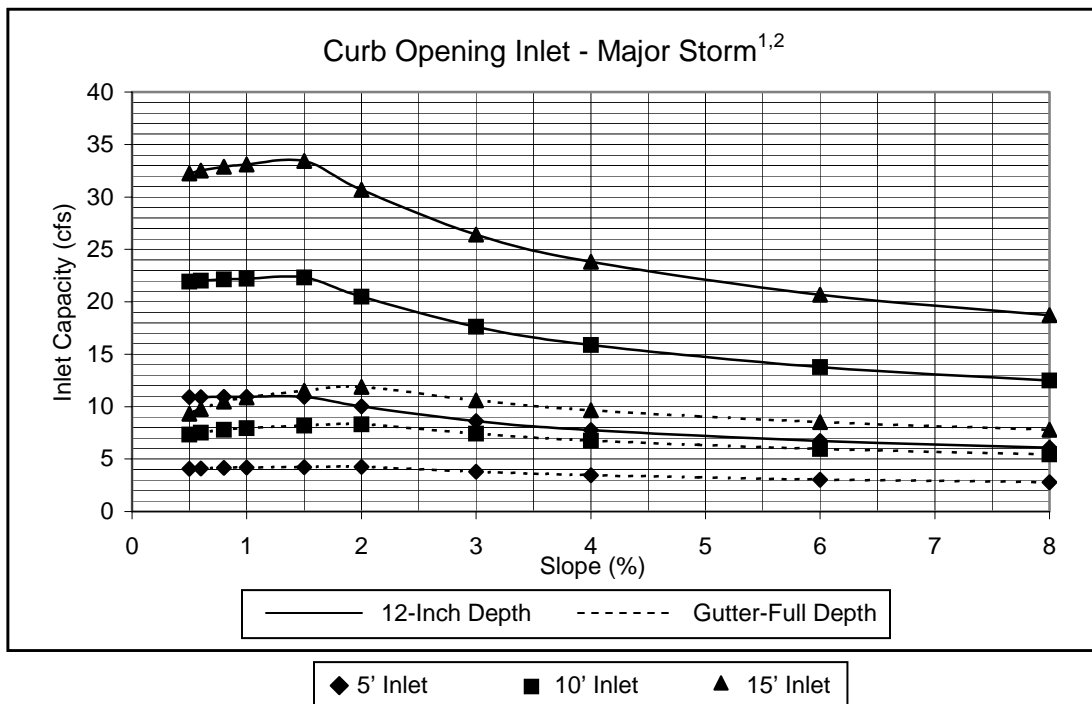
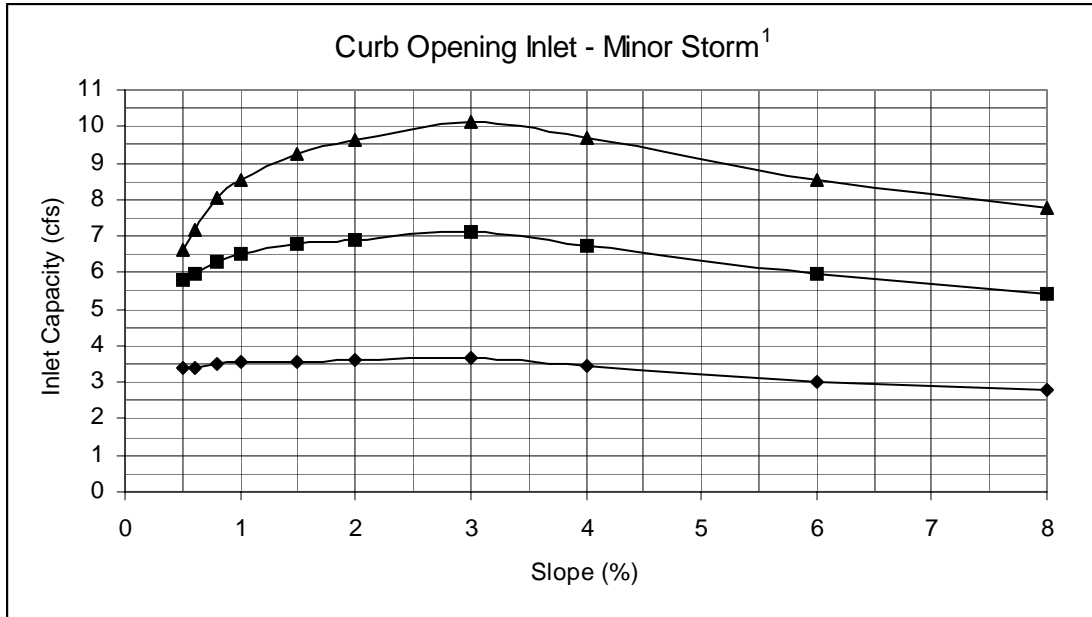
¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

²Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

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**FIGURE 8-8, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
MINOR ARTERIAL**

Street Section Data: Street Width Flowline to Flowline = 70'
Type of Curb and Gutter = 6" vertical
Minor Storm Maximum Spread = 16'



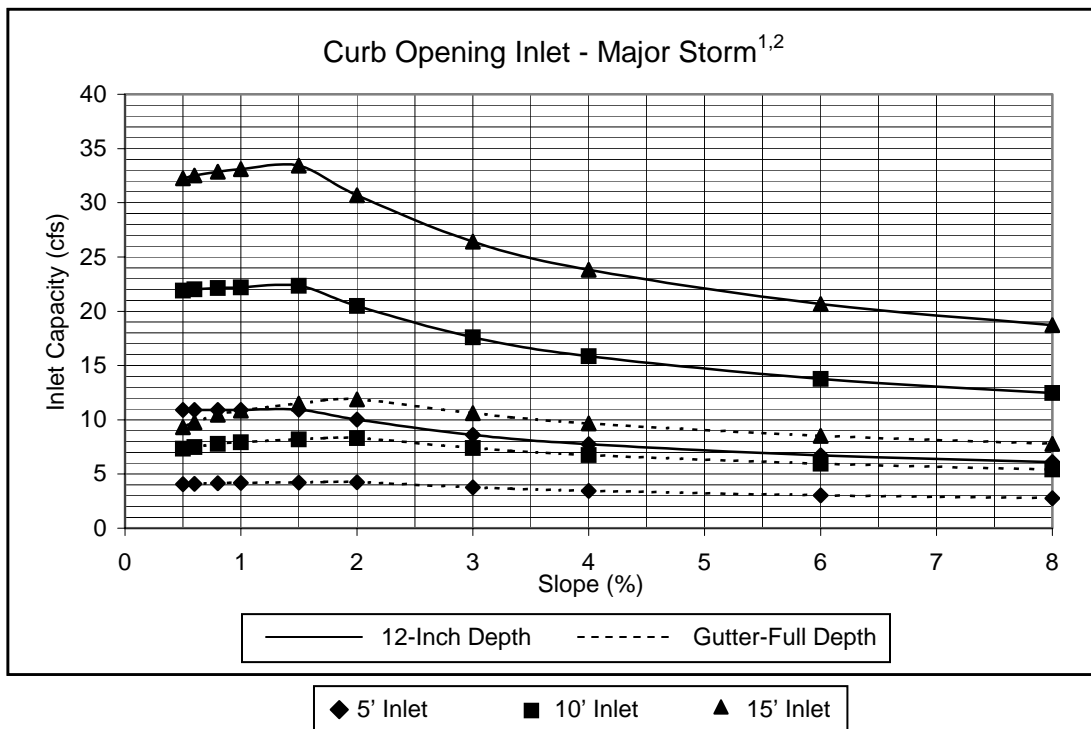
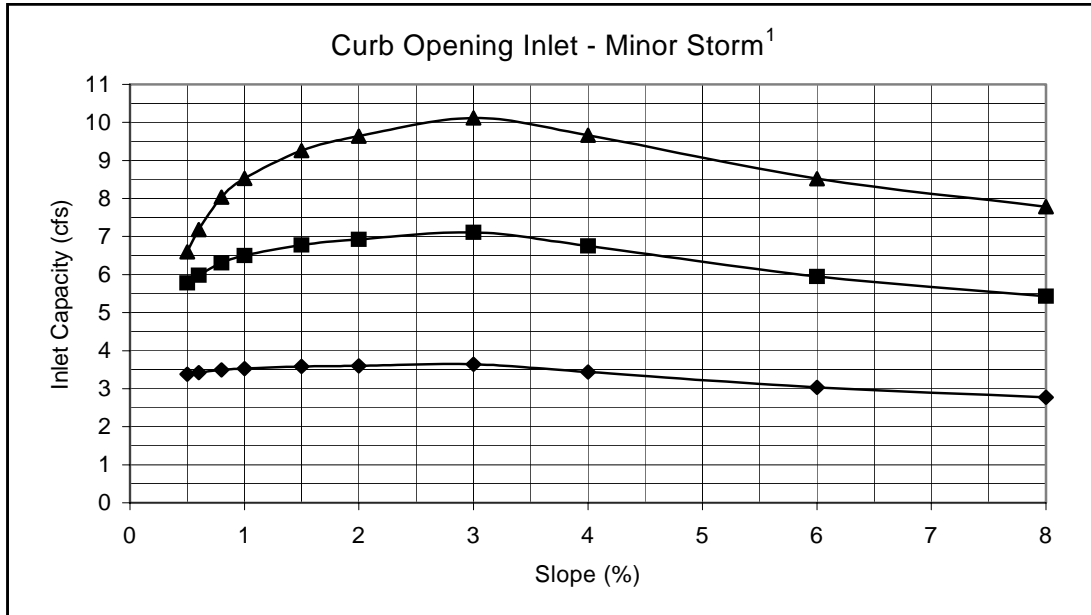
¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

²Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

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FIGURE 8-9, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
4 LANE PRINCIPAL ARTERIAL

Street Section Data: Street Width Flowline to Flowline = 70'
Type of Curb and Gutter = 6" vertical
Minor Storm Maximum Spread = 16'



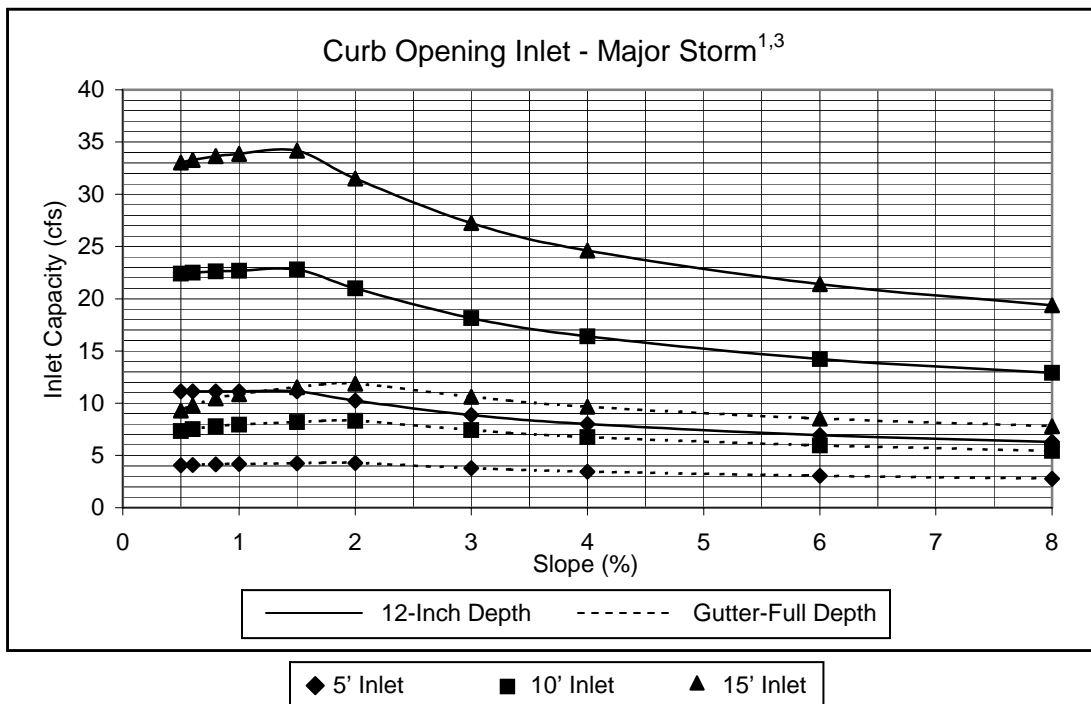
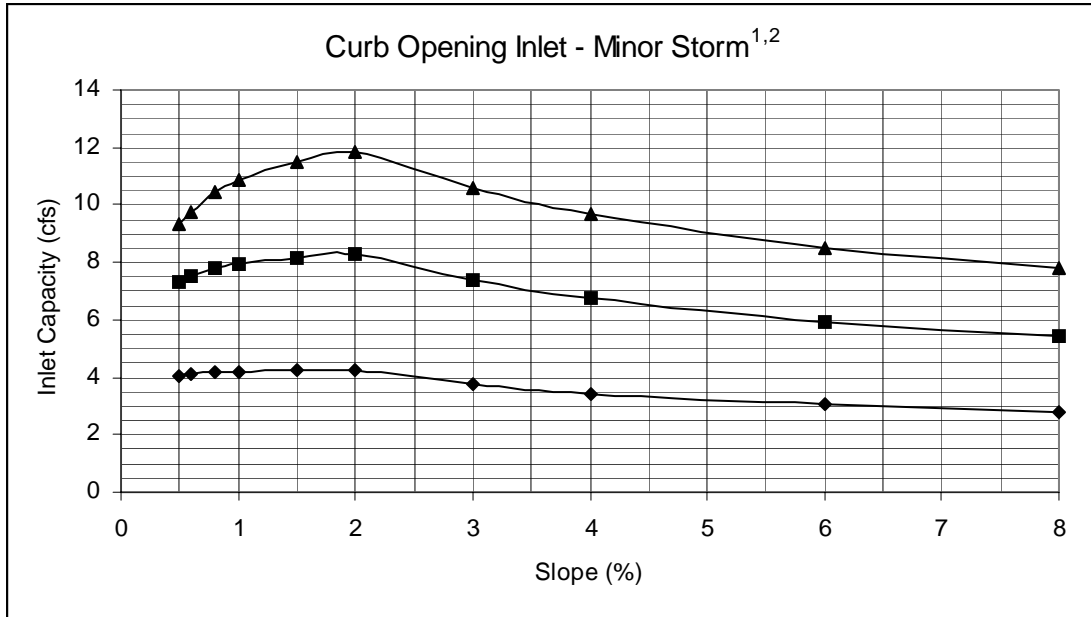
¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

²Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

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**FIGURE 8-10, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
6 LANE PRINCIPAL ARTERIAL**

Street Section Data: Street Width Flowline to Flowline = 94'
Type of Curb and Gutter = 6" vertical
Minor Storm Maximum Spread = 18.7'



¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

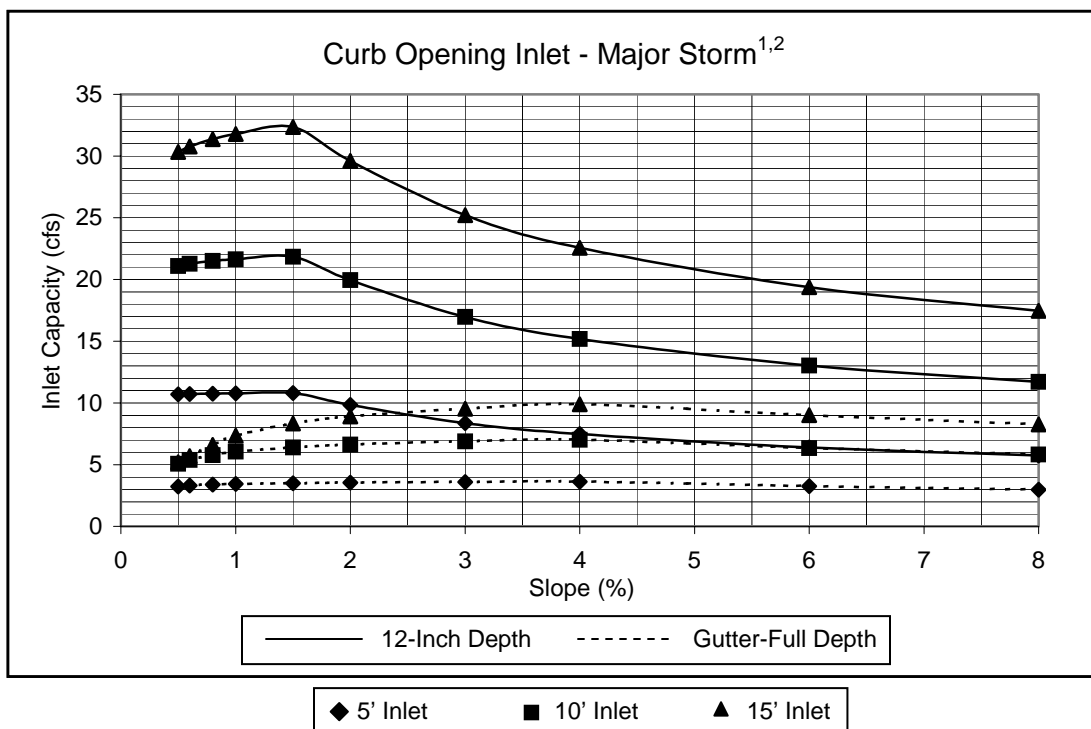
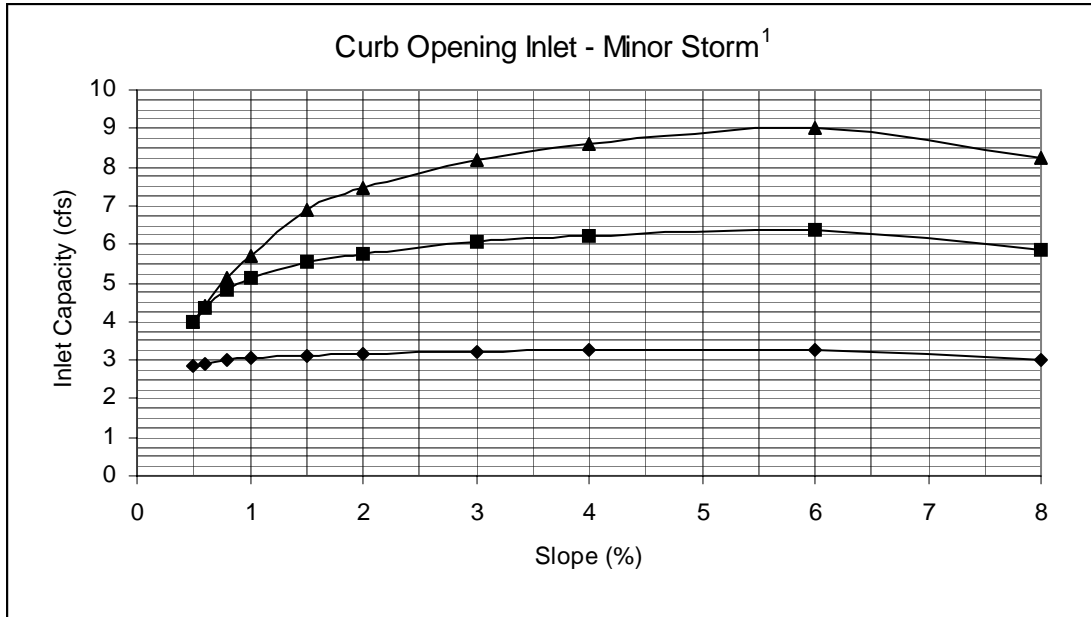
²The maximum spread width is limited by the curb height based on no curb overtopping allowable during a minor storm.

³Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

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**FIGURE 8-11, INLET CAPACITY CHART CURB OPENING (TYPE R) INLET
RURAL LOCAL TYPE II**

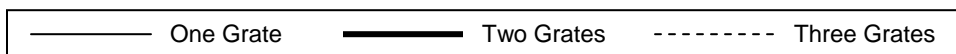
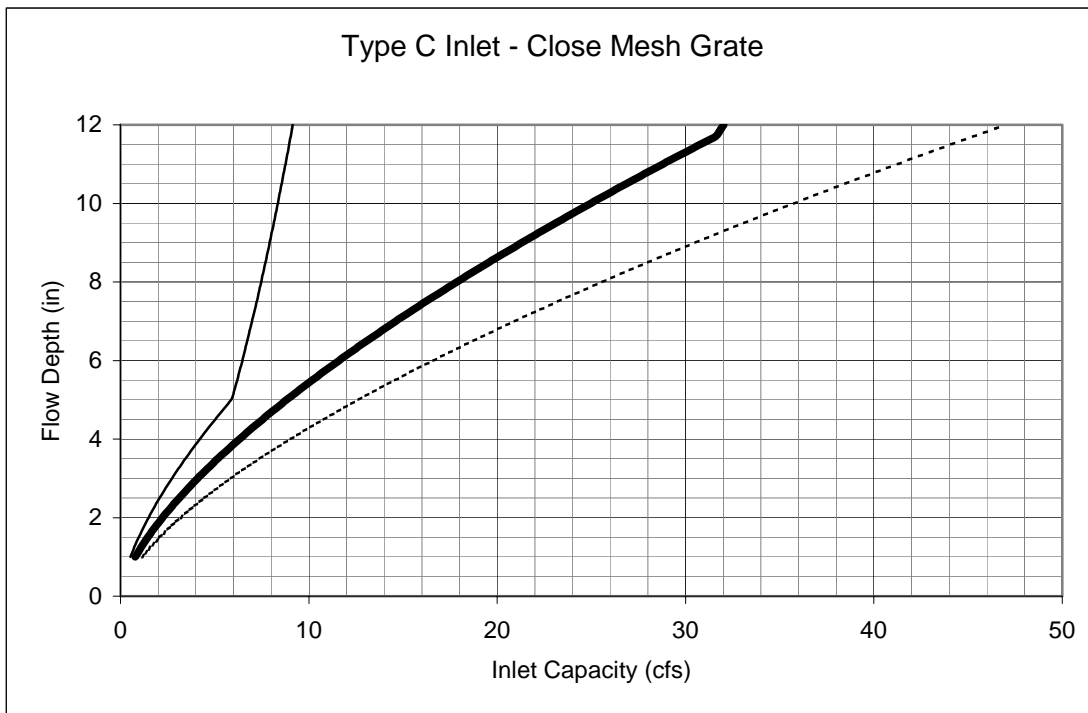
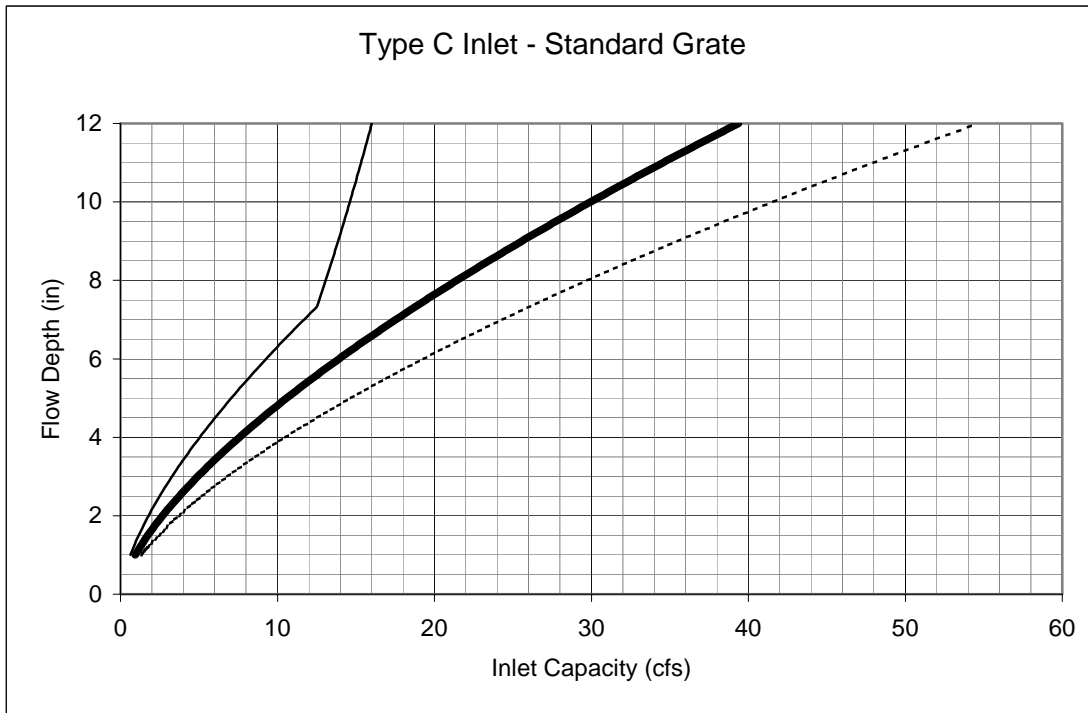
Street Section Data: Street Width Flowline to Flowline = 26'
Type of Curb and Gutter = 5" mountable
Minor Storm Maximum Spread = 13'



¹The Douglas County standard street section parameters must apply to use these charts. For non-standard sections, the inlet capacity shall be calculated using the UDFCD spreadsheets (see Section 8.4).

²Calculations for the 12-inch depth curve assume a vertical wall behind the top of curb. For the gutter-full depth case, the Minor Storm Capacity Chart may be used.

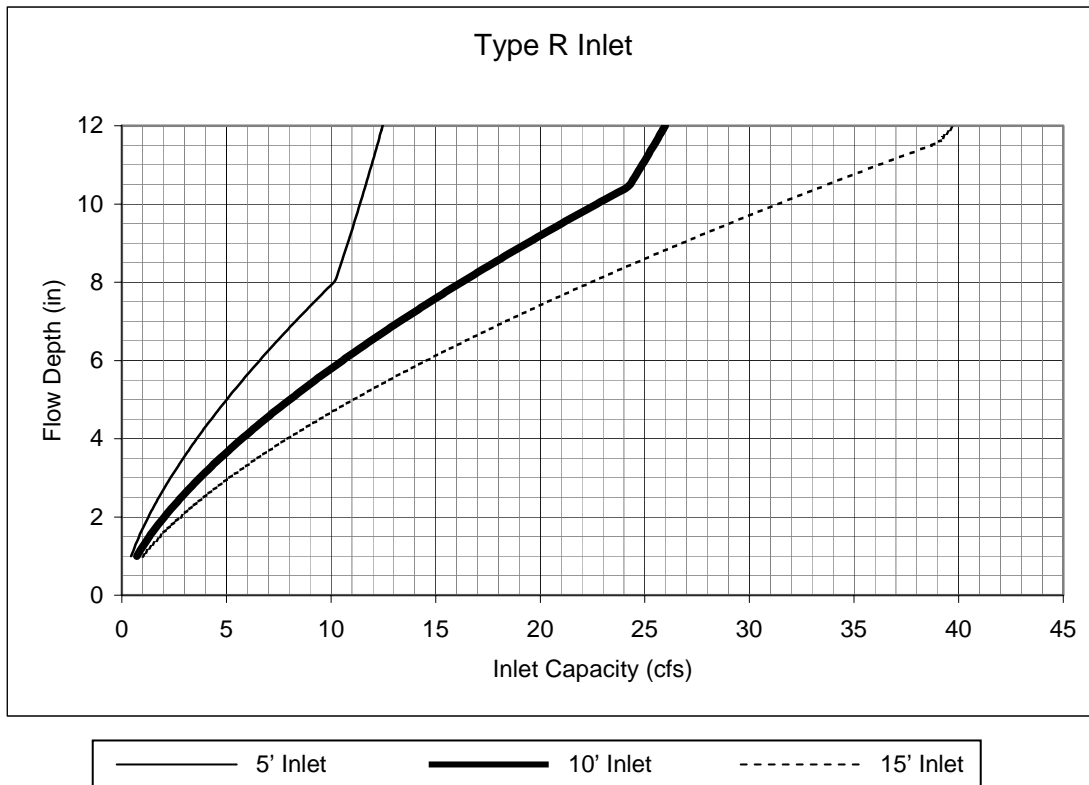
FIGURE 8-12, INLET CAPACITY CHART SUMP CONDITIONS
 AREA (TYPE C) INLET



Notes:

1. The Douglas County standard inlet parameters must apply to use these charts.

FIGURE 8-13, INLET CAPACITY CHART SUMP CONDITIONS
CURB OPENING (TYPE R) INLET



Notes:

1. The Douglas County standard inlet parameters must apply to use this chart.