SECTION 7 – INLETS
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SECTION 7 INLETS

7.1 INTRODUCTION

There are three types of inlets: curb opening, grated, and combination inlets. Inlets are further classified as being on a "continuous grade" or in a sump condition. The term continuous grade refers to an inlet located so that the grade of the street has a continuous slope past the inlet and, therefore, ponding does not occur at the inlet. The sump condition exists whenever water ponds because the inlet is located at a low point. A sump condition can occur at a change in grade of the street from negative to positive, or at an intersection due to the crown slope of a cross street.

Presented in this section is the criteria and methodology for design and evaluation of stormwater inlets in the City. Except as modified herein, all stormwater inlet criteria shall be in accordance with the USDCM.

7.2 STANDARD INLETS

The standard inlets permitted for use in the City are in the following table:

TABLE 7.2 – STANDARD INLETS

Inlet Type	Detail	Permitted Use
Curb Opening Inlet, Type R	Detail 7-1	Arterial and Collector Streets; Commercial and Industrial Areas; Discouraged on rollover curb and Residential Streets (See note below)
Grated Inlet, Type C	Detail 7-2	Streets with road-side ditches or median ditches
Grated Inlet, Type 13	Detail 7-3	All Street types w/o curbs; Alleys; parking lots; or private drives with a valley pan
Combination Inlet, Type 3	Detail 7-4	All street types w/ curbs; Recommended for Residential Areas

Note: In areas where vertical curbs are installed, particularly where there is no on-street parking, Type R inlets may be acceptable. In areas where large storm flows need to be captured by inlets, particularly with flat street grades; it may be desirable to install Type R inlets. These situations shall be reviewed on a case by case basis.

Other types of combination inlets may be requested as a variance and used only with City Approval.

Inlets and inlet transitions are prohibited in curb transitions.

7.3 INLET HYDRAULICS

The procedures and basic data used to define the capacities of the standard inlets under various flow conditions were obtained from the USDCM, Volume 1, Chapter on "Street/Inlets/Storm Sewers", for curb opening inlets. The procedure consists of defining the amount and depth of flow in the gutter and determining the theoretical flow interception by the inlet. To account for effects which decrease the capacity of the various types of inlets, such as debris plugging, pavement overlaying, and variations in design assumptions, the theoretical capacity calculated for the inlets is reduced to the allowed capacity by the factors presented below for the standard inlets.

TABLE 7.3 – ALLOWABLE INLET CAPACITY

ALLOWABLE INLET CAPACITY		
Condition	Inlet Type	Percentage of Theoretical Capacity Allowed
Sump or Continuous Grade	Type R 5' Length 10' Length 15' Length	 88 92 95
Sump or Continuous Grade	Grated Type 13	50
Continuous Grade	Combination Type 3	66
Sump	Grated Type C	50
Sump	Combination Type 3	65

Allowable standard inlet capacities for the initial storm have been developed and are presented in Figures 7-5, 7-6, and 7-7 for continuous grade and Figure 7-8 for sump conditions. **These figures include the reduction factors in the above table.** (Depths greater than initial storm shall be calculated.) The allowable inlet capacity is compatible with the allowable street capacity (see Section 8). The values shown were calculated on the basis of the maximum flow allowed in the street gutter (or roadside ditch for Type C). For the gutter flow amounts less than the maximum, the allowable inlet capacity must be proportionately reduced.

7.3.1 CONTINUOUS GRADE CONDITION

For the continuous grade condition, the capacity of the inlet is dependent upon many factors including gutter slope, depth of flow in the gutter, height and length of curb opening, street cross slope, and the amount of depression at the inlet. In addition, not all of the gutter flow will be intercepted and some flow will continue past the inlet area (called "carryover"). The amount of carryover must be included in the drainage facility evaluation as well as in the design of the inlet.

DESIGN EXAMPLE – Design of Type R Curb Opening Inlets (Initial Storm)

GIVEN:

Street type = Arterial, 6 lane; S = 1.0 percent
Maximum flow depth = 0.5 feet (refer to Section 8)
Maximum allowable gutter capacity = 11.0 cfs
Starting gutter flow (Q_t) = 8.0 cfs

FIND: Interception and carryover amounts for the inlets and flow conditions illustrated on Figure 7-9.

SOLUTION: From Figure 7-9 we can see that inlets 1 and 2 are in a continuous grade condition and inlet 3 is in a sump condition. The first step is to calculate the interception ratio R, for the continuous grade inlets. This ratio is then applied to the actual gutter flow (local runoff plus carryover flow) to determine amount intercepted by the inlet and the carryover flow. The final step is to calculate the size of the inlet required for the sump condition, as discussed in the following section.

STEP 1: From Figure 7-6 for an allowable depth of 0.50 feet and a 15-foot inlet, read the value 8.6 cfs. Note that even though the gutter flow is less than maximum allowable, the maximum depth is used for Figure 7-6. The effect of the lower depth on the inlet capacity shall be accounted for in the following steps.

STEP 2: Compute the interception ratio R

$$R = \frac{\text{Allowable inlet capacity}}{\text{Allowable street capacity}} = \frac{8.6}{11.0}$$

R = 0.78

STEP 3: Compute the interception amount Q_1

Q_1 = R x Q street
= 0.78 x 8.0
= 6.2 cfs intercepted by inlet

STEP 4: Compute the carryover amount Q_{co}

Q_{co} = Q street - Q_1
= 8.0 - 6.2
= 1.8 cfs

STEP 5: Compute the total flow at the next inlet, which is the sum of the carryover (Q_{co}) from inlet #1 plus the local to inlet #2

Q_T (inlet #2) = Q_{co} (inlet #1) + Q_L (inlet #2)
= 1.8 cfs + 4 cfs
= 5.8 cfs

STEP 6: Compute the interception ratio, intercepted amount, and carryover flow for inlet #2 using the procedure described in Steps 1 through 4.

Allowable inlet capacity = 7.2 cfs {Figure 7-**6**}

R = (7.2 cfs)/(11.0 cfs) = 0.65
Q_1 (inlet #2) = (0.65)(5.8 cfs) = 3.8 cfs
Q_{co} (inlet #2) = 5.8 cfs - 3.8 cfs = 2.0 cfs

STEP 7: Compute the total flow at inlet #3 using the procedures described in Step 5

Q_T (inlet #3) = 8 cfs + 2.0 cfs = 10.0 cfs

STEP 8: Size the inlet in the sump condition using the procedures described in the following section for a sump condition. For this example, with an allowable maximum depth of flow of 0.5 ft, a 10-foot Type R inlet shall intercept more than the total gutter flow and is therefore acceptable.

7.3.2 SUMP CONDITION

The capacity of the inlet in a sump condition is dependent on the depth of ponding above the inlet. Typically, the problem consists of estimating the amount of inlets or depth of flow required to intercept a given flow amount.

<u>DESIGN EXAMPLE</u>: Allowable capacity for Type 3 Inlet in a Sump (Initial Storm)

<u>GIVEN:</u>

Flow = 8.0 cfs
Maximum allowable street depth = 0.50
Type 3 combination double inlet

<u>FIND:</u> Depth of ponding

SOLUTION:

STEP 1: From Figure 7-8 read the depth of ponding for a double Type 3 combination inlet as D = 0.28' at the gutter flow of 8.0 cfs (inlet capacity).

STEP 2: Compare computed to allowable depth. Since the computed depth is less than the allowable depth, the inlet is acceptable, otherwise the amount of inlets or the type of inlet would be changed and the procedure repeated.

7.4 INLET SPACING

The optimum spacing of storm inlets is dependent upon several factors including traffic requirements, contributing land use, street slope, and distance to the nearest outfall system. The suggested sizing and spacing of the inlets is based upon the interception rate of 70 to 80 percent. This spacing has been found to be more efficient than a spacing using 100 percent interception rate. Using the suggested spacing only, the most downstream inlet in a development would be designed to intercept 100 percent of the flow. Also, considerable improvements in overall inlet system efficiency can be achieved if the inlets are located in the sumps created by street intersections. The following example illustrates how inlet sizing and interception capacity may be analyzed:

DESIGN EXAMPLE: Inlet Spacing

GIVEN:

Maximum allowable street flow depth = 0.50 ft.
Street slope = 1.0 percent
Maximum allowable gutter flow = 11.0 cfs
Gutter flow = 11.0 cfs

FIND: Size and type of inlet for 75 percent interception

SOLUTION:

STEP 1: Compute desired capacity

Q = 0.75 (11.0 cfs) = 8.3 cfs

STEP 2: Read the allowable inlet capacities from Figures 7-5 and 7-6 for various inlets. The following values were obtained:

Inlet Type	Capacity	% Interception
Triple Type 3	5.5 cfs	50
Triple Type R	8.6 cfs	78

Therefore, a curb opening inlet Type R, L = 15 feet is required and shall intercept 8.6 cfs. The remaining 2.4 cfs shall continue downstream and contribute to the next inlet. Spacing between such inlets shall depend on the local runoff, and the amount of flow bypassed at the upstream inlet. In situations where local runoff is not the governing factor, inlets placed on a continuous grade must be spaced at least 50 feet apart in order to pick up carry over flow as indicated by allowable inlet capacity as shown by Figures 7-5, 7-6, and 7-7.

A comparison of the inlet capacity with the allowable street capacity (refer to Section 8) shall show that the percent of street flow interception by the inlets varies from less than 50 percent to as much as 95 percent of the allowable street capacity. Therefore, the optimum inlet spacing cannot be achieved in all instances, and the Design Engineer should analyze the spacing requirements.

7.5 CHECKLIST

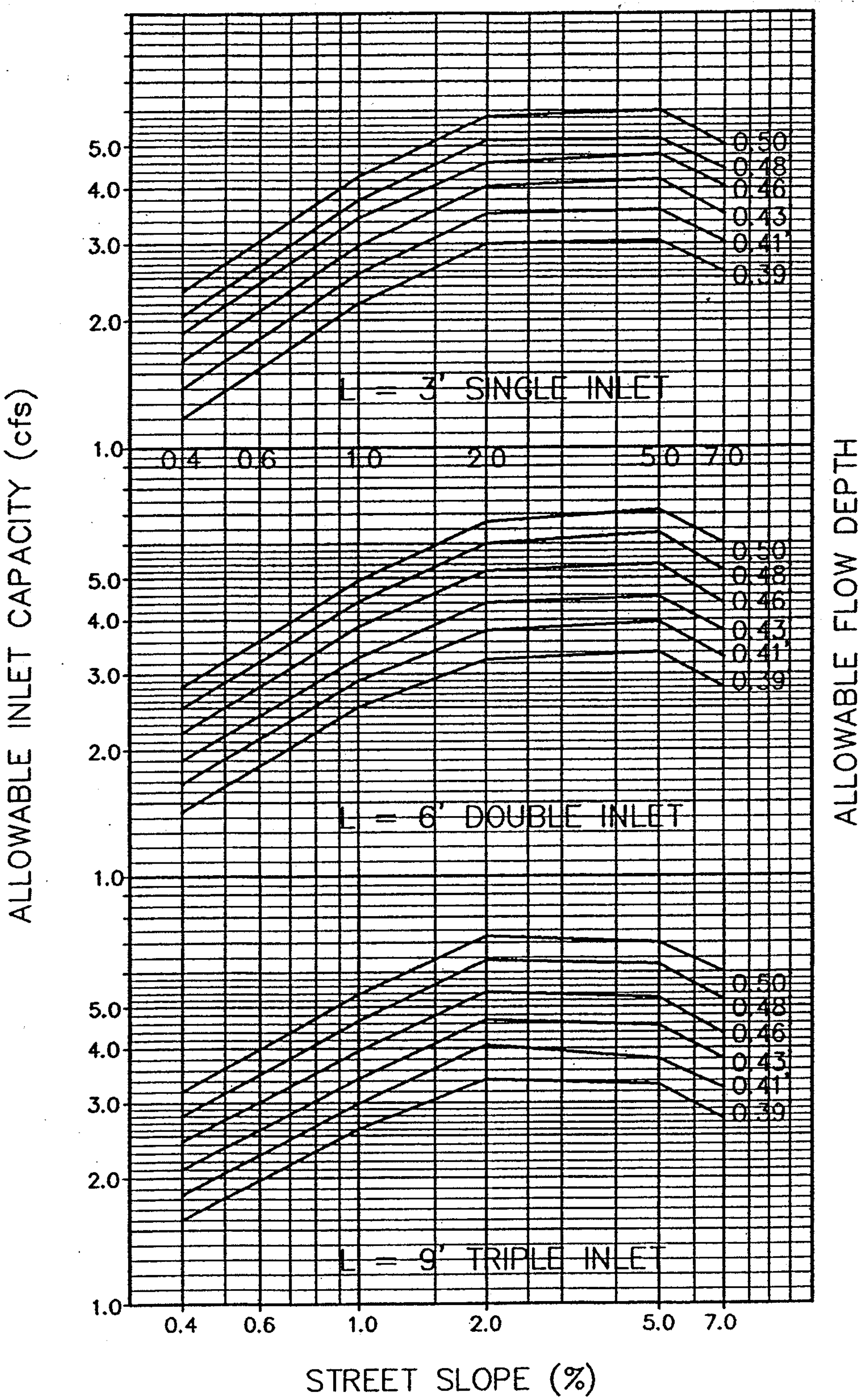
To aid the Designer and Reviewer, the following checklist has been prepared:

Check the inlet capacity to determine the carryover flow, and account for this flow plus the local runoff in the sizing of the downstream inlet.

Place inlets at the flattest grade or in sump conditions where possible to increase capacity.

Space inlets based upon the interception rate of 70 to 80% of the gutter flow to optimize inlet capacity.

Inlet structures shall not be constructed until the curb and gutter has been installed. The City may allow the inlet structures to be constructed if the curb and gutter has been staked and the stakes can be used to set the inlet structures for line and grade 100 feet in each direction.



NOTES:
1. ALLOWABLE CAPACITY = 66% THEORETICAL CAPACITY
2. MAXIMUM INLET CAPACITY AT MAXIMUM ALLOWABLE FLOW DEPTH. PROPORTIONALLY REDUCE FOR OTHER DEPTHS.

ALLOWABLE INLET CAPACITY TYPE 3 COMBINATION ON A CONTINUOUS GRADE

FIGURE 7-5

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Great. From the Ground Up.

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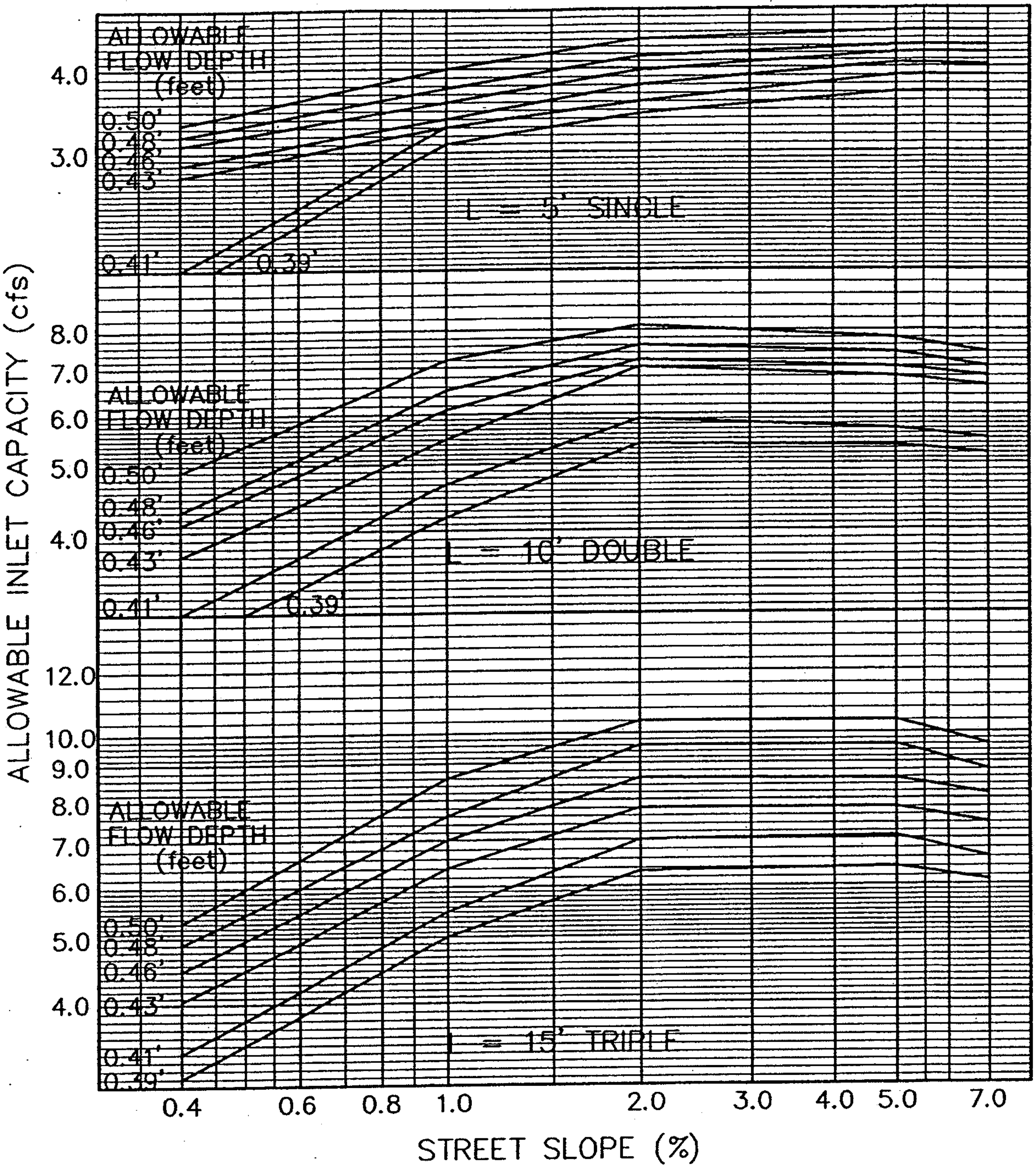
SCALE: NTS
REVISED OCT 1997



NOTES:

1. MAXIMUM INLET CAPACITY AT MAXIMUM ALLOWABLE FLOW DEPTH. PROPORTIONALLY REDUCE FOR OTHER DEPTHS.
2. ALLOWABLE CAPACITY =
   88% (L = 5')
   92% (L = 10') OF THEORETICAL CAPACITY
   95% (L = 15')
3. INTERPOLATE FOR OTHER INLET LENGTHS.

ALLOWABLE INLET CAPACITY TYPE R CURB OPENING ON A CONTINUOUS GRADE

FIGURE 7-6

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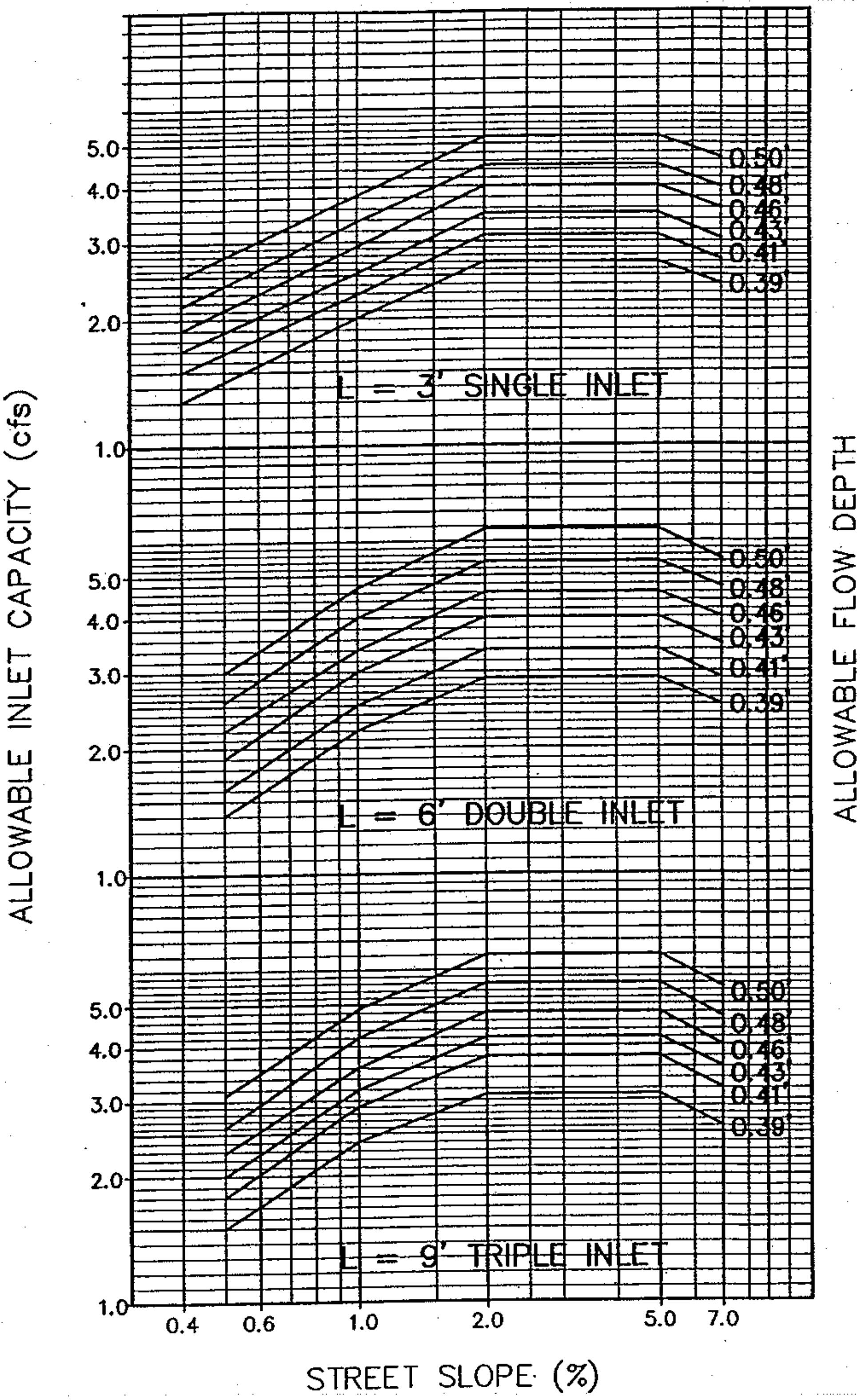

NOTES:
1. ALLOWABLE CAPACITY = 60% THEORETICAL CAPACITY
2. MAXIMUM INLET CAPACITY AT MAXIMUM ALLOWABLE FLOW DEPTH. PROPORTIONALLY REDUCE FOR OTHER DEPTHS.

ALLOWABLE INLET CAPACITY TYPE 13 GRATED INLET ON A CONTINUOUS GRADE

FIGURE 7-7

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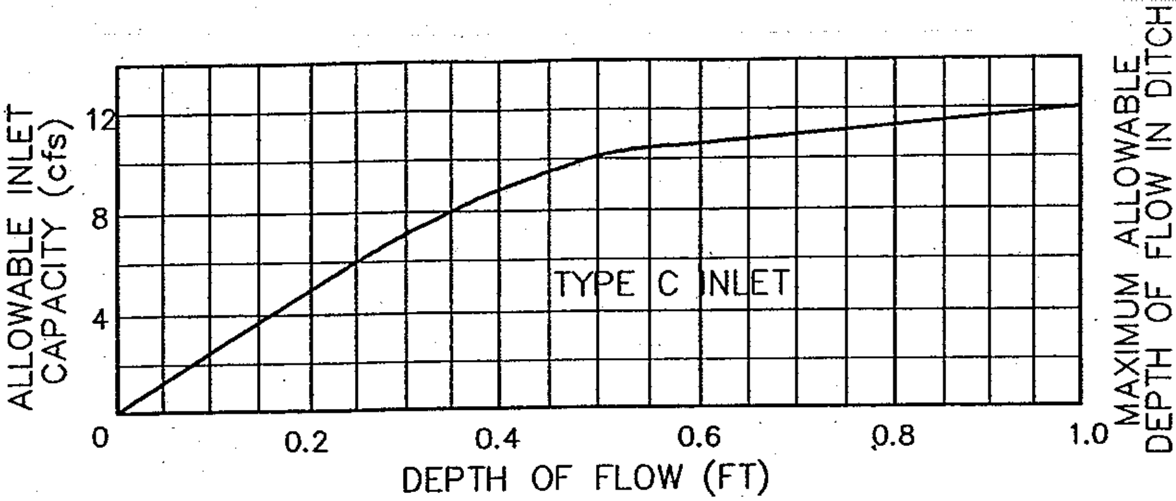

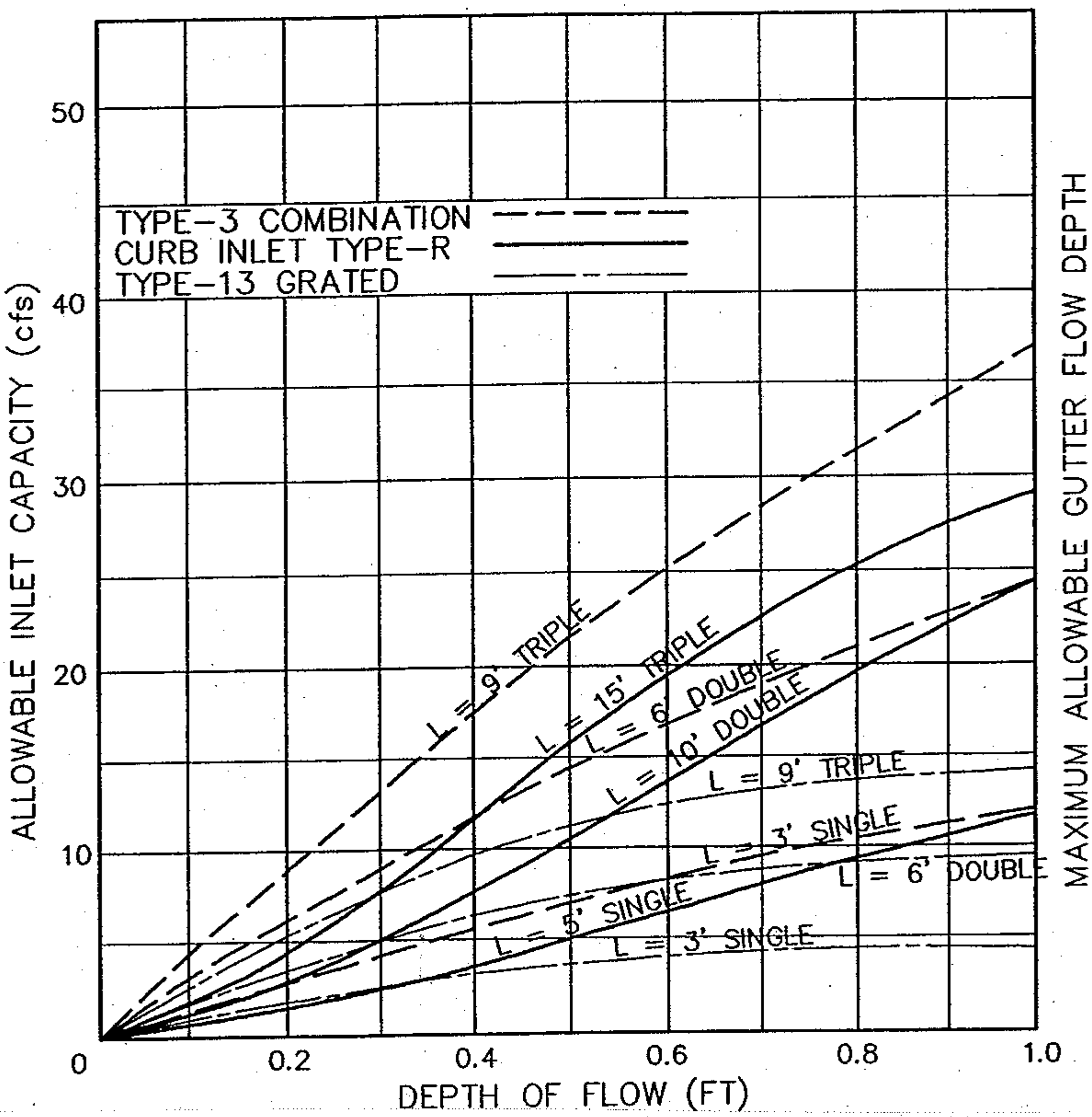

ALLOWABLE INLET CAPACITY SUMP CONDITIONS - ALL INLETS

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FIGURE 7-8

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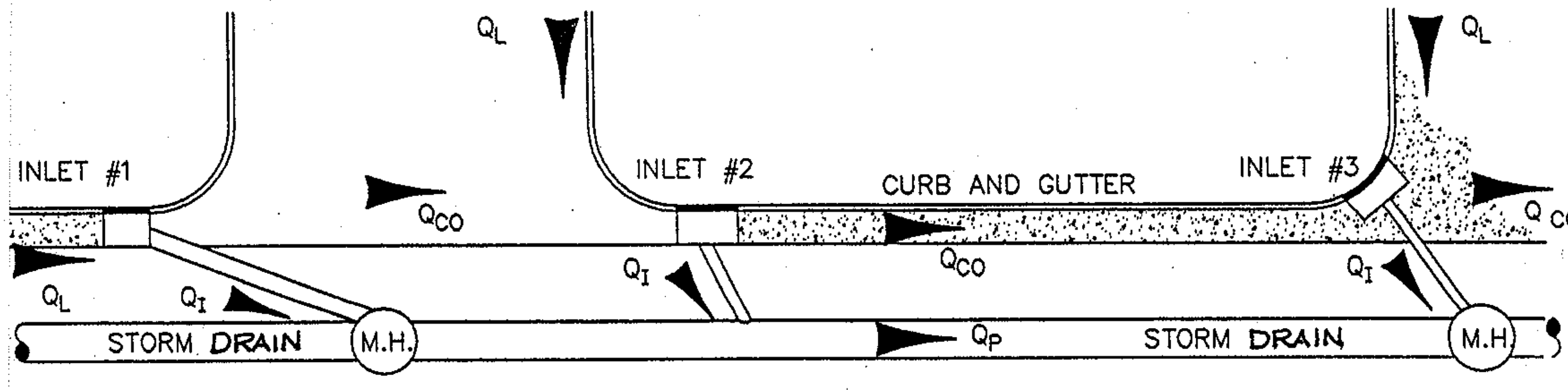

LEGEND

- Q_L = LOCAL RUNOFF FOR DESIGN STORM TRIBUTARY TO DESIGNATED INLET (cfs)
- Q_I = RUNOFF INTERCEPTED BY INLET (cfs)
- Q_{CO} = CARRY OVER RUNOFF PAST INLET (cfs)
- Q_T = TOTAL RUNOFF AT INLET = $Q_L + Q_{CO}$
- Q_P = RUNOFF IN PIPE

SUMMARY OF FLOWS
FOR DESIGN EXAMPLE 3

INLET	Q^* ALLOW	Q_L	Q_{CO}	Q_T	Q_I	Q_{CO}	Q_P DRAIN	COMMENTS
NO. 1, 15' TYPE R	8.6	8	0	8	6.2	1.8	6.2	INLET ON GRADE
NO. 2, 10' TYPE R	7.2	4	1.8	5.8	3.8	2.0	10.0	INLET ON GRADE
NO. 3, 10' TYPE R	10.4	8	2.0	10.0	10.0	0	20.0	INLET IN SUMP CONDITION

* MAXIMUM ALLOWABLE INLET CAPACITY AT MAXIMUM ALLOWABLE GUTTER CAPACITY, FROM FIGURES – 7–6 AND 7–8

INLET DESIGN EXAMPLES - INITIAL STORM

FIGURE 7-9

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