# CHAPTER 7

# STORM SEWER INLETS

## CHAPTER 7 STORM SEWER 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. the term "continuous grade" refers to an inlet so located 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 is restricted or 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 chapter is the criteria and methodology for design and evaluation of storm sewer inlets in the Town. Except as modified herein, all storm sewer inlet criteria shall be in accordance with the Urban Storm drainage Criteria Manual.

### 7.2 STANDARD INLETS

The standard inlets permitted for use in the Town are:

| INLET TYPE | STANDARD DETAIL | PERMITTED USE |
|---|---|---|
| Curb Opening Inlet Type R | SD-1 | All street types |
| Grated Inlet Type C | SD-2 | Special Approval Only |
| Grated Inlet Type 13 | SD-3 | Special Approval Only |
| Combination Inlet Type 13 | SD-4 | Special Approval Only |

## 7.3 INLET HYDRAULICS

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.

ALLOWABLE INLET CAPACITY

| CONDITION | INLET TYPE | PERCENTAGE OF THEORETICAL CAPACITY ALLOWED |
|---|---|---|
| Sump or Continuous Grade | CDOH type R (SD-1) | |
| | 5' length | 88 |
| | 10' length | 92 |
| | 15' length | 95 |
| Sump or Continuous Grade | Grated Type 13 (SD-3) | 50 |
| Continuous Grade | Combination Type 13 (SD-4) | 66 |
| Sump | Grated Type C (SD-2) | 50 |
| Sump | Combination Type 13 (SD-4) | 65 |

Allowable inlet capacities for the standard inlets have been developed and are presented in Figures 701, 702, and 703 for "continuous grade" and Figure 704 for sump conditions. These figures include the reduction factors in the above table. The allowable inlet capacity is compatible with the allowable street capacity. 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.

Type R inlets are allowed in 1 foot increments from 5 feet (minimum) to 15 feet (maximum). The capacity of these incremental inlets shall be obtained by linear interpolation between the inlet capacities presented on Figure 702.

### 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, all of the gutter flow will not be intercepted and some flow will continue past the inlet area ("inlet carryover"). The amount of carryover must be included in the drainage facility evaluation as well as in the design of the inlet.

The use of Figures 702 and 704 is illustrated by the following examples:

Example 2: Design of Type R Curb Opening Inlets

Given: Street Type = Minor Arterial – Type C, S = 1.0 percent
Maximum flow depth = 0.5 feet (refer to Chapter 10)
Maximum allowable gutter capacity = 11.0 C.F.S. (refer to Chapter 10)
Starting gutter flow ($Q_L$) = 8.0 C.F.S.

Find: Interception and carryover amounts for the inlets and flow conditions illustrated on Figure 705.

Solution: From Figure 705, 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, discussed in Example #3 in the following section.

Step 1: From Figure 702, for an allowable depth of 0.50 feet and a 15' inlet, read the value 8.6 C.F.S. Note that even though the gutter flow is less than maximum allowable, the maximum depth is used for Figure 702. The effect of the lower depth on the inlet capacity will 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 $Q_I$

$Q_I$ = R X Q street

= 0.78 x 8.0

$Q_I$ = 6.2 C.F.S. amount intercepted by inlet

Step 4: Compute the carryover amount $Q_{co}$

$Q_{co}$ = Q Street – $Q_I$

= 8.0 – 6.2

$Q_{co}$ = 1.8 C.F.S.

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 runoff to inlet #2

$Q_T$ (inlet #2) = $Q_{co}$ (inlet #1) + $Q_L$ (inlet #2)

= 1.8 C.F.S. + 4 C.F.S.

$Q_T$ (inlet #2) = 5.8 C.F.S.

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 C.F.S. Figure 702

$$R = \frac{7.2\ \text{C.F.S.}}{11.0\ \text{C.F.S.}} = 0.65$$

$Q_I$ (inlet #2) = 0.65 x 5.8 C.F.S. = 3.8 C.F.S.

$Q_{co}$ (inlet #2) = 5.8 C.F.S. – 3.8 C.F.S. = 2.0 C.F.S.

Step 7: Compute the inlet #2 using the procedure described in step 5

$Q_T$ (inlet #3) = 8 C.F.S. + 2.0 C.F.S. = 10.0 C.F.S.

Step 8: Size the inlet in the sump condition using the procedures described in Example #3, Section 7.3.2, and Figure 704. For this example, with an allowable maximum depth of flow of 0.5 C.F.S., a 10 foot Type R inlet will 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 number of inlets or depth of flow required to intercept a given flow amount. The use of Figure 704 is illustrated by the following example:

Example 3: Allowable Capacity for Combination Type 13 Inlet in a Sump

Given: Flow in gutter = 8.0 C.F.S.
Maximum allowable street depth = 0.50 feet
Type 13 double inlet

Find: Depth of ponding

Solution:

Step 1: From Figure 704, read the "Depth of Ponding" for a double Type 13 inlet as D = 0.28' at the gutter flow of 8.0 C.F.S. (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%. This spacing has been found to be more efficient than a spacing using 100% interception rate. Using the suggested spacing only, the most downstream inlet in a development would be designed to intercept 100% 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:

Example 4: Inlet Spacing

Given: Maximum Allowable street flow depth = 0.50 ft.
Street slope = 1.0 percent
Maximum allowable gutter flow = 11.0 C.F.S.
Gutter flow = 11.0 C.F.S.

Find: Size and type of inlet for 75 percent interception

Solution:

Step 1: Compute desired capacity

$Q = .75 \times 11.0$ C.F.S. $= 8.3$ C.F.S.

Step 2: Read the allowable inlet capacities from Figures 701 and 702 for various inlets. The following values were obtained:

| INLET TYPE | CAPACITY | % INTERCEPTION |
|---|---|---|
| Triple Type 13 | 4.7 C.F.S. | 43 |
| Double Type R | 6.5 C.F.S. | 59 |
| Triple Type R | 7.7 C.F.S. | 70 |

Therefore, a curb opening inlet Type R, L = 15 feet is required and will intercept 7.7 C.F.S. The remaining 13.3 C.F.S. will continue downstream and contribute to the next inlet. Spacing between such inlets will depend on the local runoff, and the amount of flow bypassed at the upstream inlet.

A comparison of the inlet capacity with the allowable street capacity (refer to Chapter 10) will 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 spacing requirements should be analyzed by the design engineer.

## 7.5 CHECKLIST

To aid the designer and reviewer, the following checklist has been prepared:

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

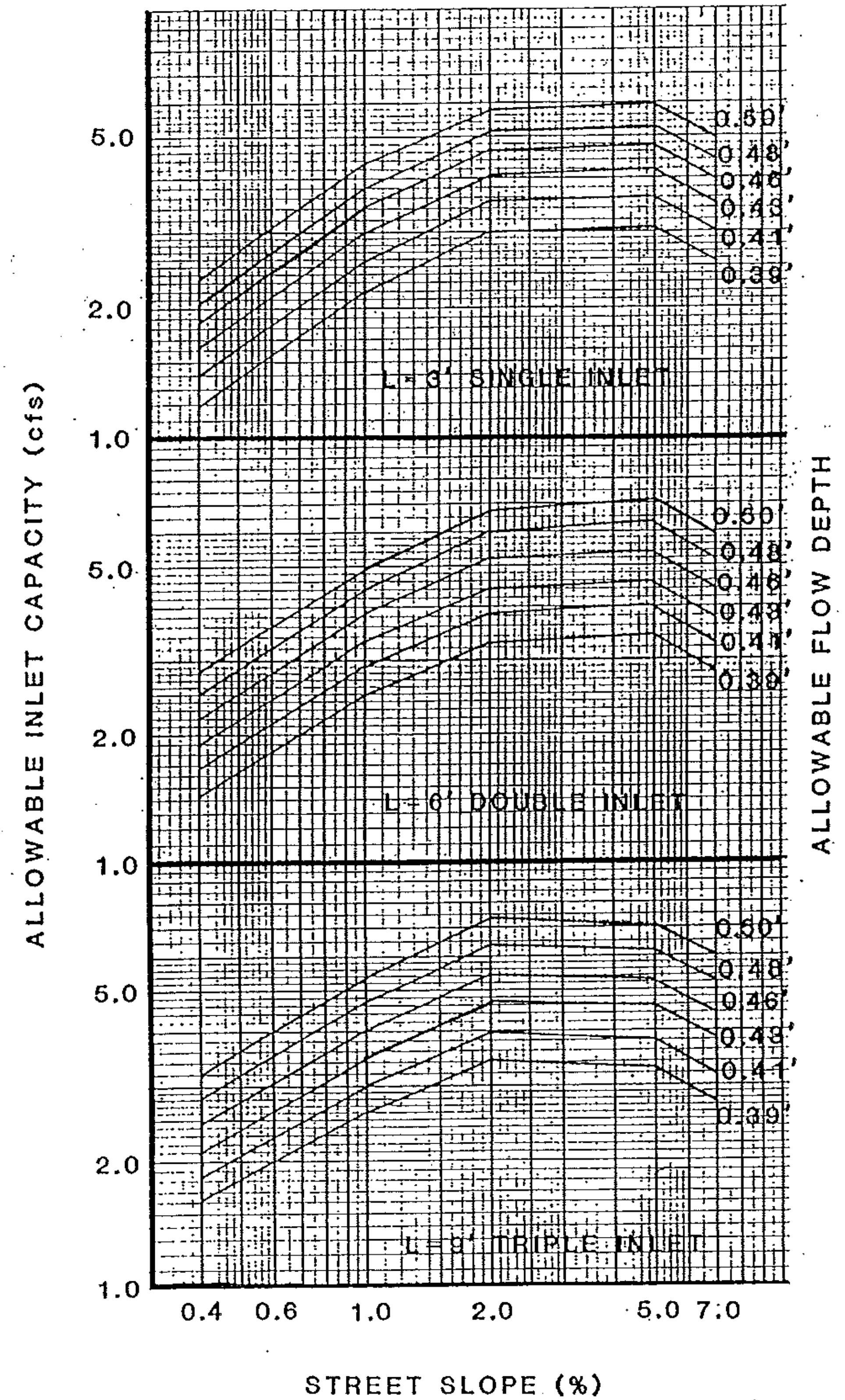
(2) Place inlets at the flattest grade or in sump conditions where possible to increase capacity.

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

# DESIGN TABLES & FIGURES

# ALLOWABLE INLET CAPACITY

## TYPE 13 COMBINATION ON A CONTINUOUS GRADE

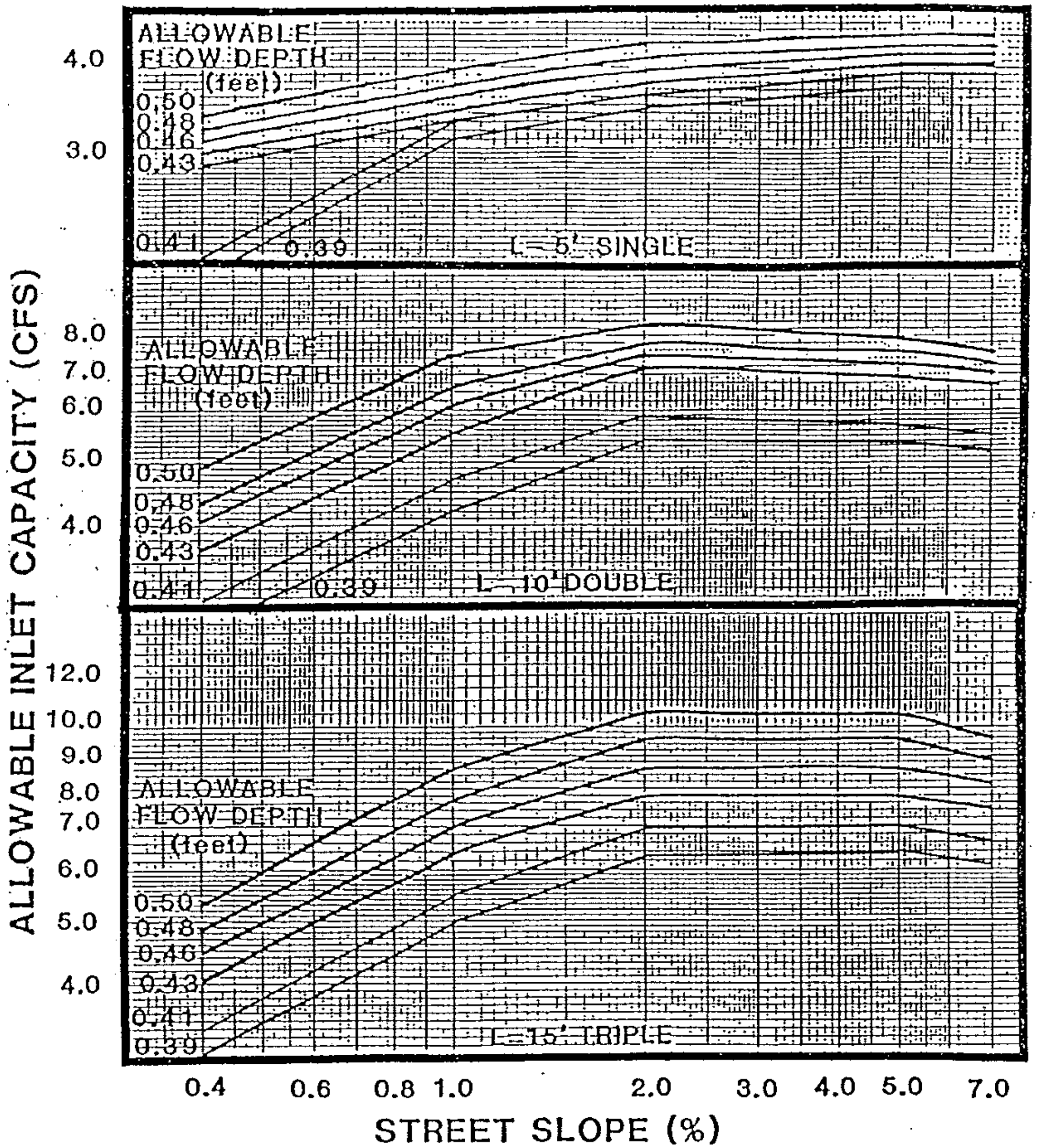



NOTES:
1. Allowable capacity = 66% theoretical capacity
2. Maximum inlet capacity at maximum allowable flow depth. Proportionally reduce for other depths.

| DATE: REV: | REFERENCE: |
|---|---|

# ALLOWABLE INLET CAPACITY

## TYPE - R CURB OPENING ON A CONTINUOUS GRADE




NOTES:

1. Maximum inlet capacity at maximum allowable flow depth. Proportionally reduce for other depths.
2. Allowable Capacity =
   88% (L = 5')
   92% (L = 10')
   95% (L = 15')
   of Theoretical Capacity
3. Interpolate for other inlet lengths.

| | |
|---|---|
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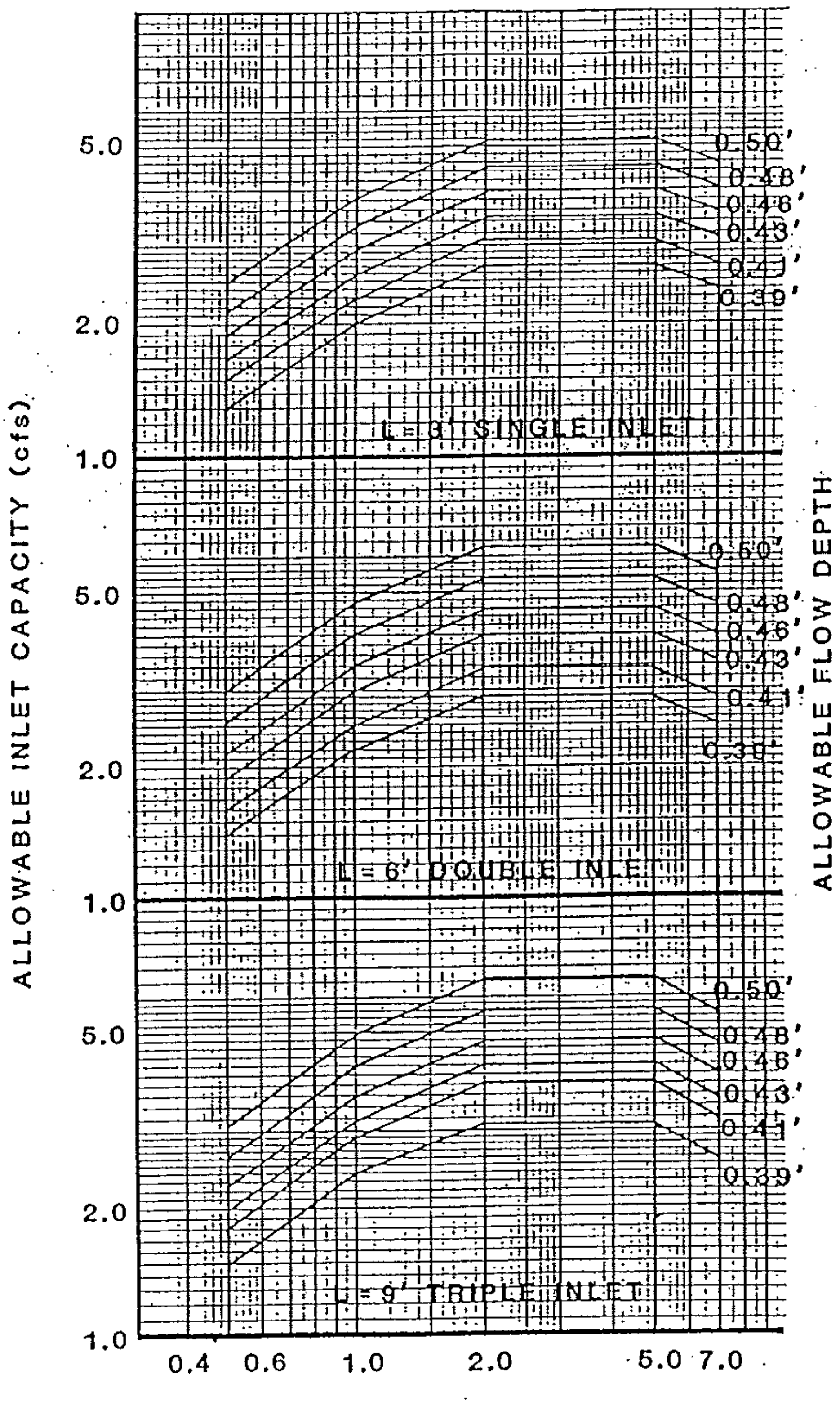
# ALLOWABLE INLET CAPACITY

## TYPE 13 GRATED ON A CONTINUOUS GRADE




NOTES:
1. Allowable capacity = 60 % theoretical capacity
2. Maximum inlet capacity at maximum allowable flow depth. Proportionally reduce for other depths.

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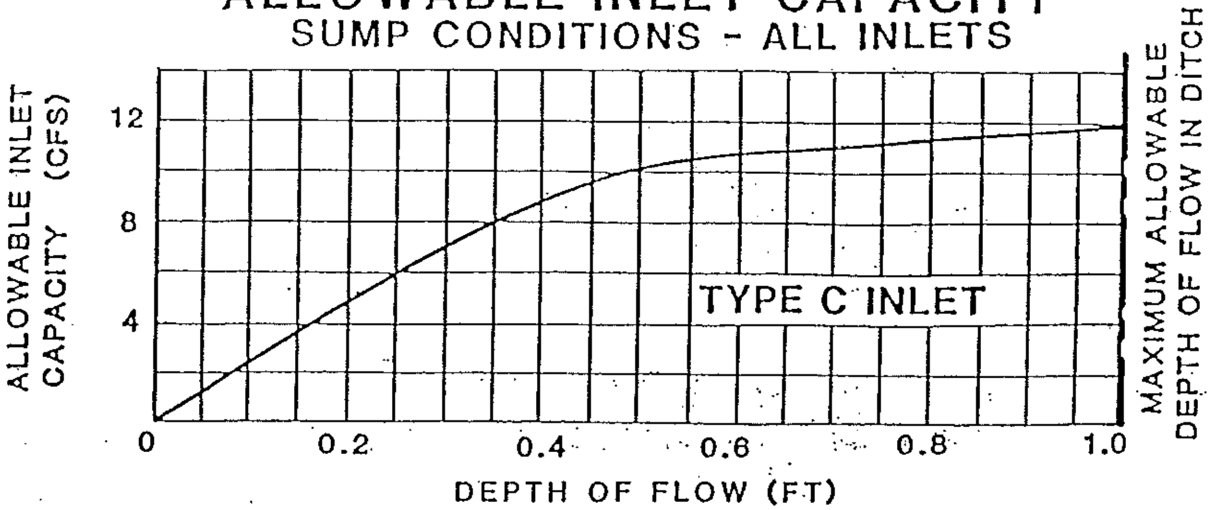
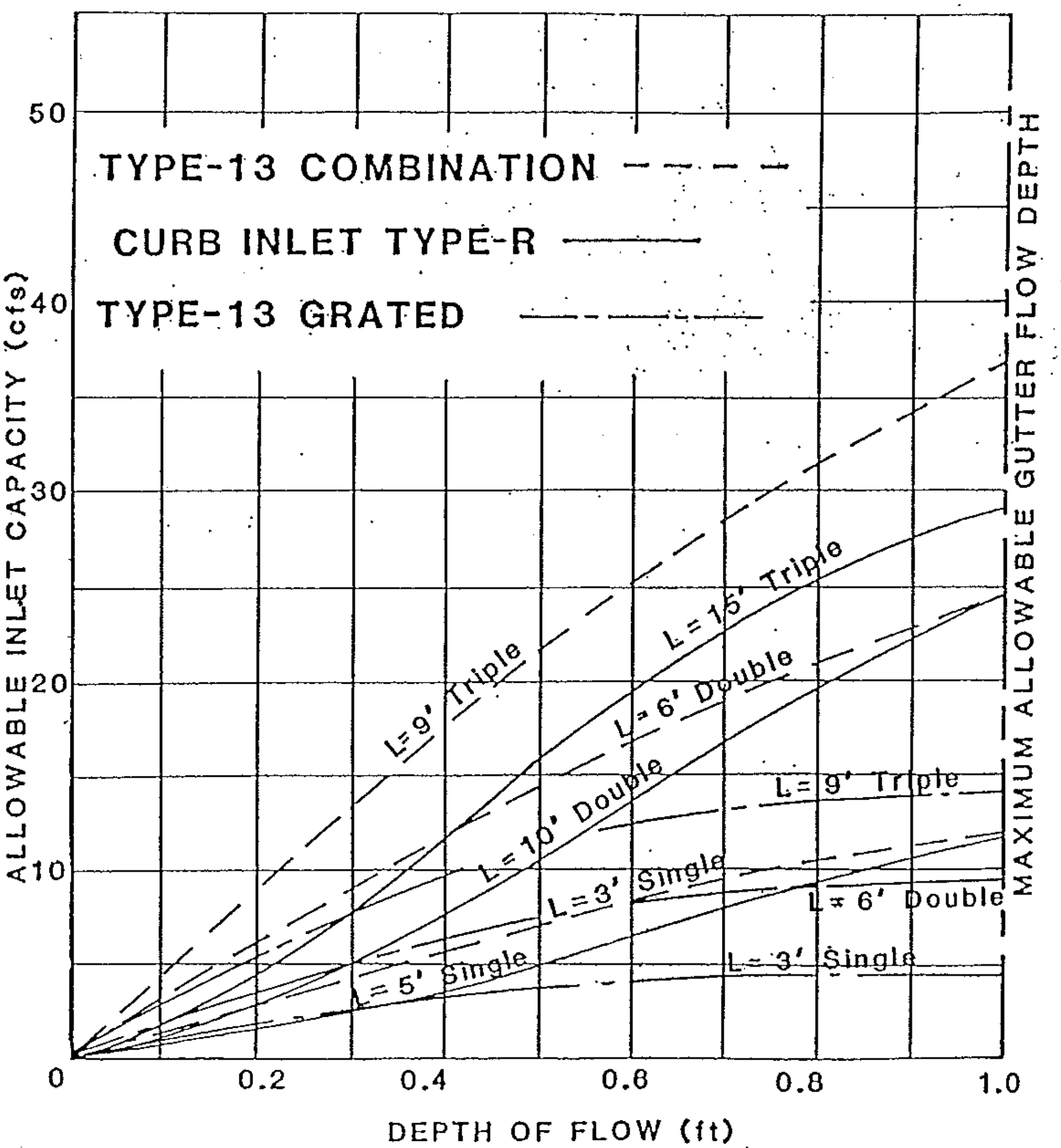
# ALLOWABLE INLET CAPACITY
## SUMP CONDITIONS - ALL INLETS

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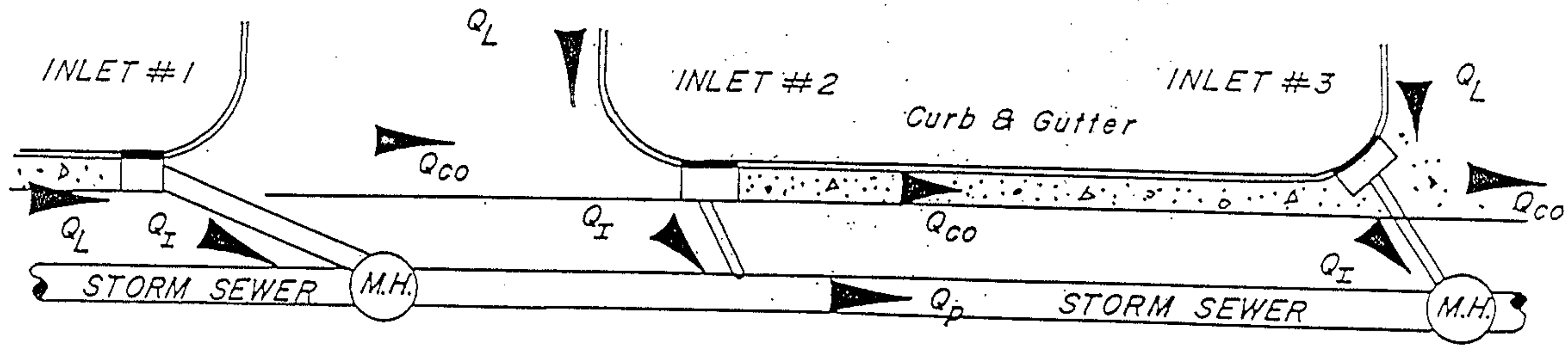


LEGEND
$Q_L$ = Local runoff for design storm tributary to designated inlet (cfs)
$Q_I$ = Runoff intercepted by inlet (cfs)
$Q_{CO}$ = Carry over runoff past inlet (cfs)
$Q_T$ = Total runoff at inlet = $Q_L + Q_{CO}$
$Q_p$ = Runoff in Pipe

SUMMARY OF FLOWS
FOR DESIGN EXAMPLE 3

| INLET | $Q^*$ ALLOW | $Q_L$ | $Q_{CO}$ | $Q_T$ | $Q_I$ | $Q_{CO}$ | $Q_p$ SEWER | 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-902 and -904

# INLET DESIGN EXAMPLES - MINOR STORM

DATE:
REV:
REFERENCE: