SECTION 4
STORM DRAIN INLETS

4.01 GENERAL

The primary purpose of storm drain inlets is to intercept excess runoff and deposit it in a drainage system, therby 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:

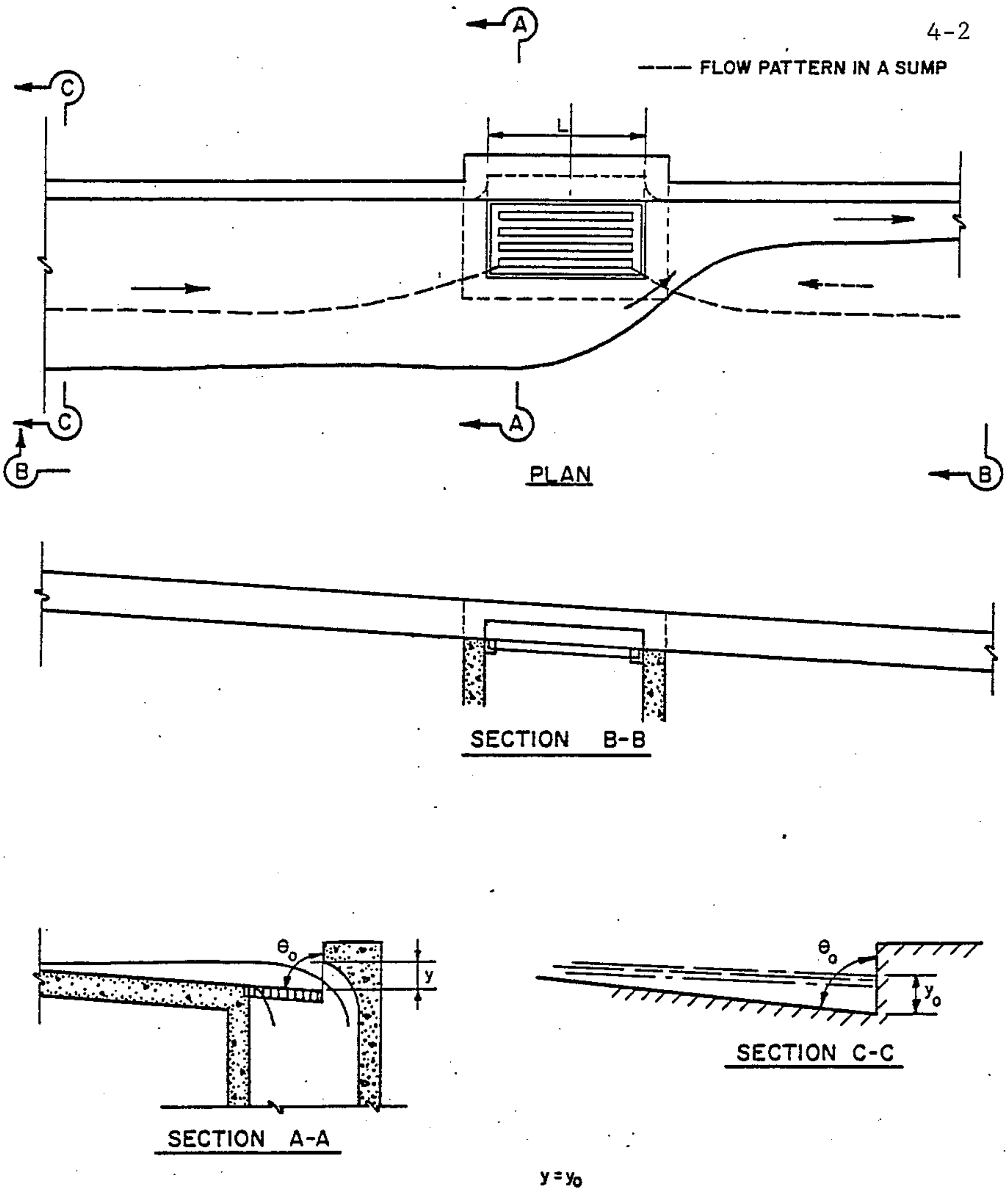
1. Minimum transition for depressed inlets shall be 10 feet.
2. The use of inlets with a 5 inch depression is discouraged on collector, industrial and arterial streets unless the inlet is recessed.
3. When recessed inlets are used, they shall not interfere with the intended use of the sidewalk.
4. The capacity of a recessed inlet on grade shall be calculated as 0.75 of the capacity of similar unrecessed inlet.
5. Design and location of inlets shall take into consideration pedestrian and bicycle traffic.
6. Inlet design and location must be compatible with the criteria established in Section 3 of this manual.

4.02 CLASSIFICATION

Inlets are classified into three major groups, namely: inlets in sumps (Type A), inlets on grade without gutter depression (Type B), and inlets on grade with gutter depression (Type C). Each of the three major calsses includes several varieties. The following are presented herein and are likely to find reasonably wide use. (See Figs. 4-1 through 4-7).

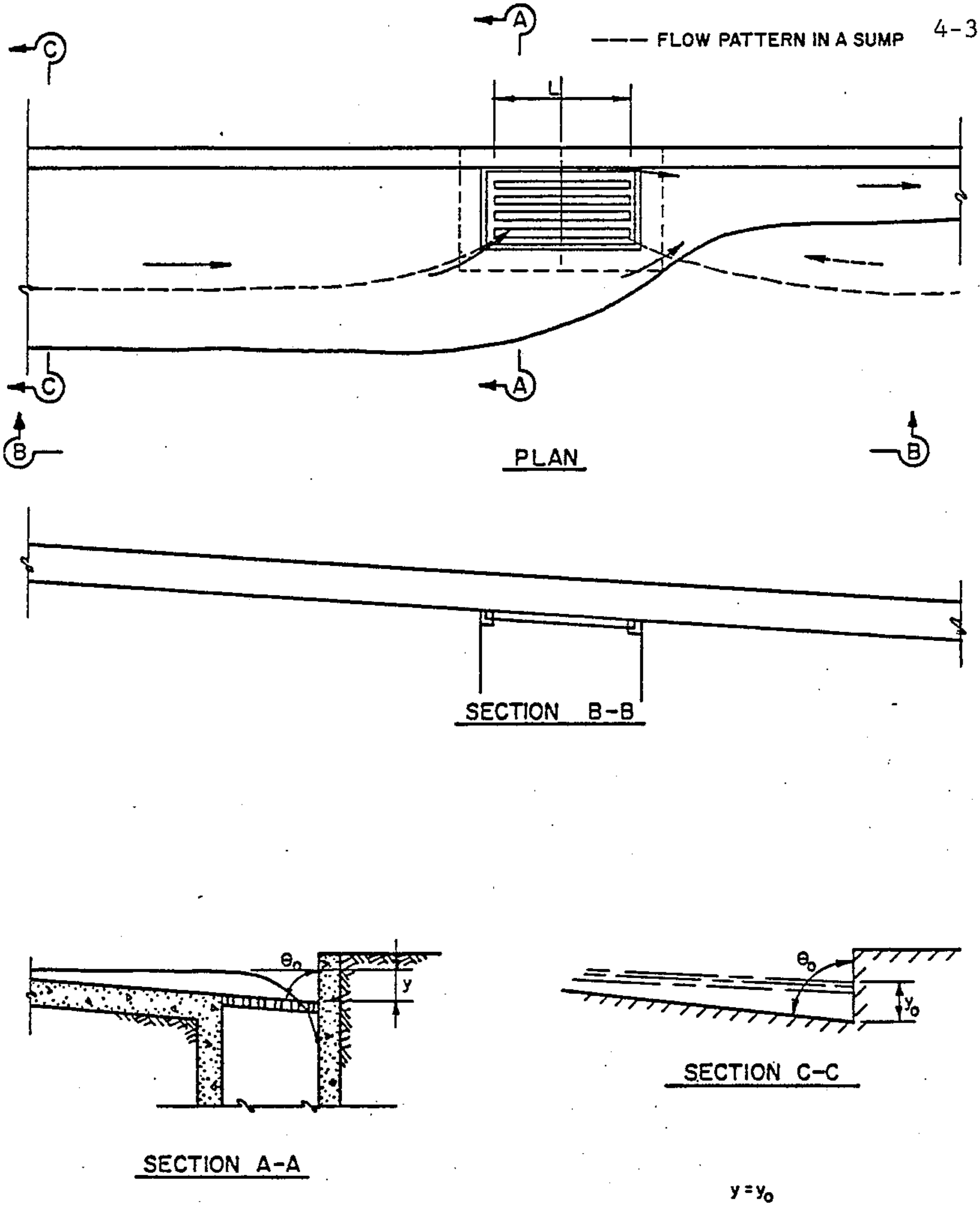
Inlets in Sumps

(1)	Curb Opening	Type A-1
(2)	Grate	Type A-2
(3)	Combination (Grate and Curb Opening)	Type A-3
(4)	Drop	Type A-4
(5)	Drop (Grate Covering)	Type A-5



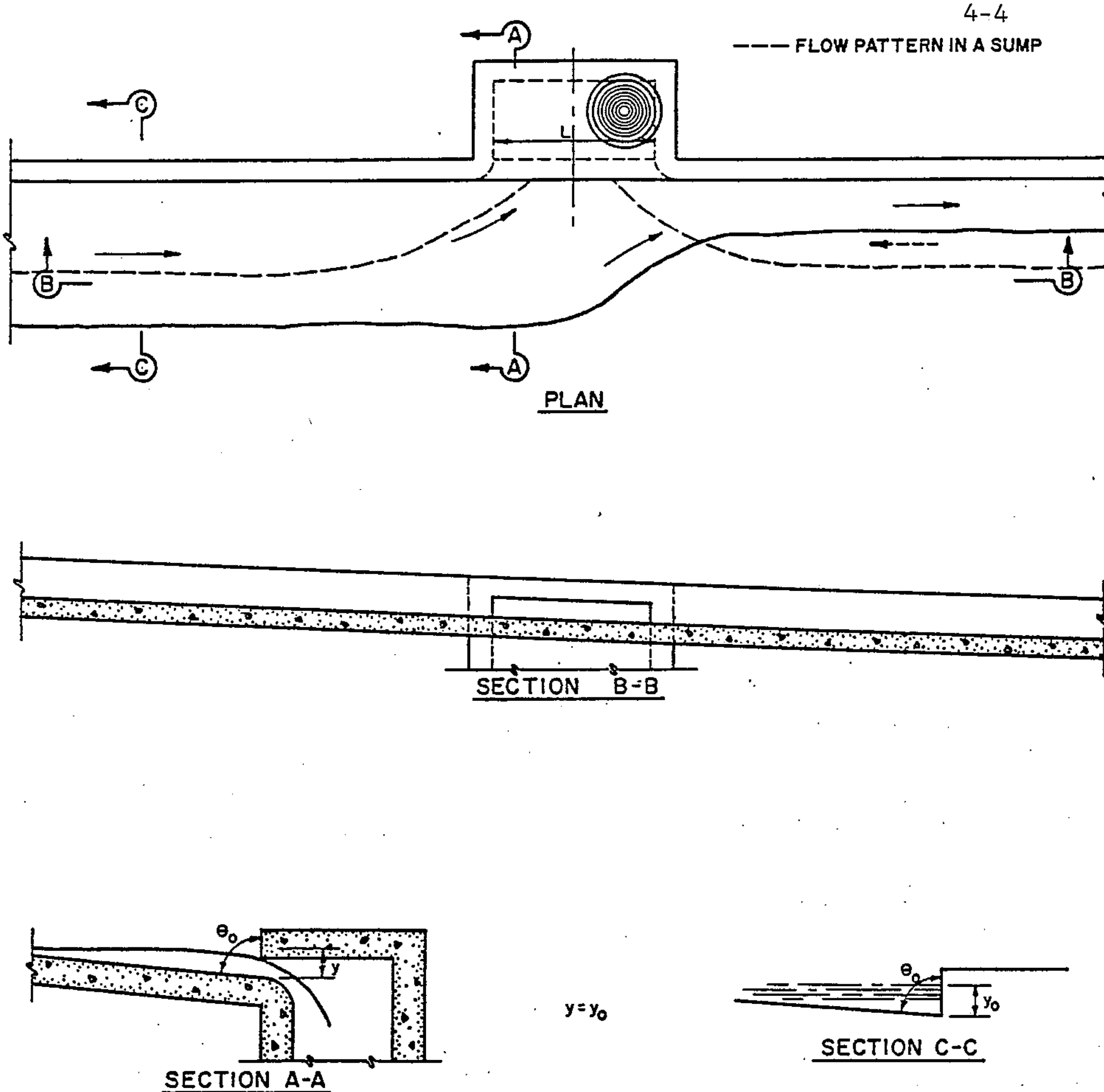
UNDEPRESSED COMBINATION
INLET TYPE A-3 & B-3 (RECESSED)

Figure 4-1



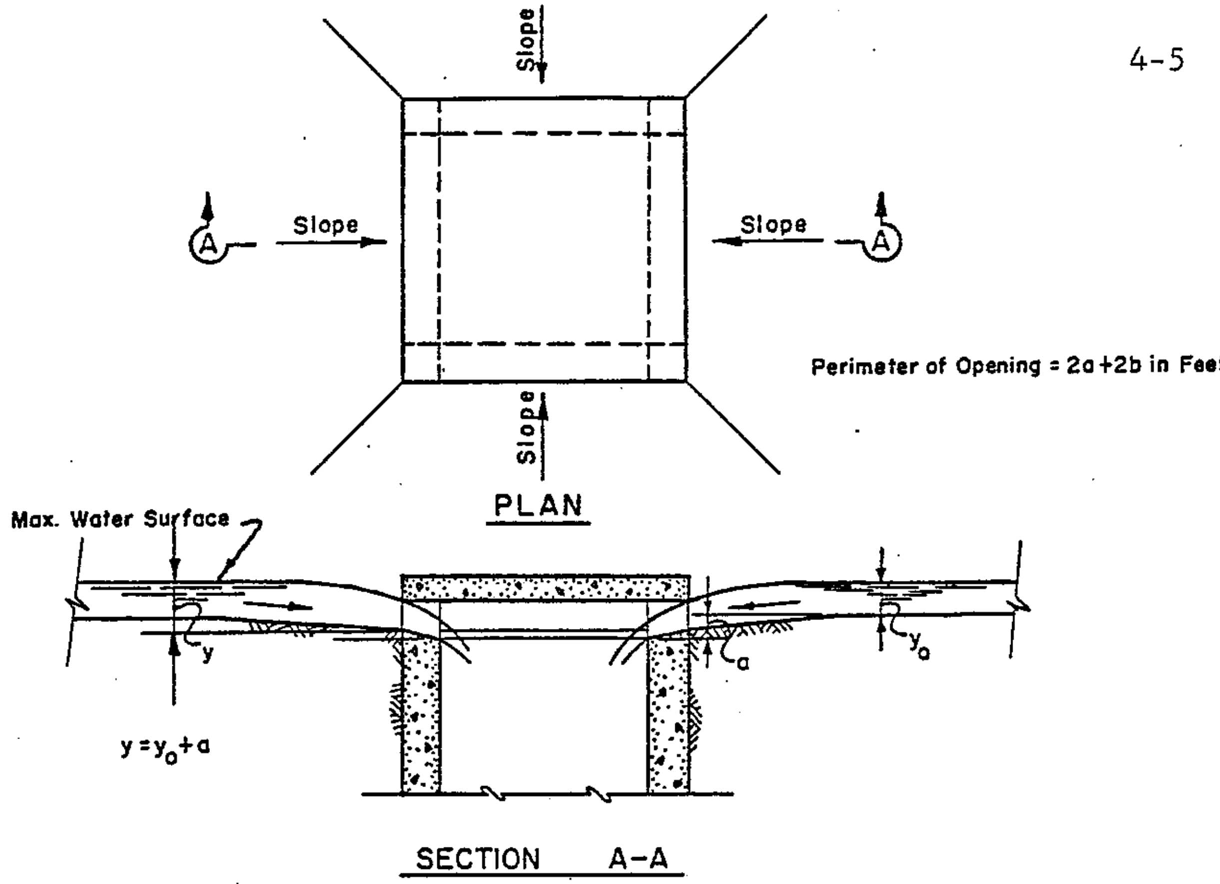
UNDEPRESSED GRATE INLET
TYPE A-2 & B-2

Figure 4-2

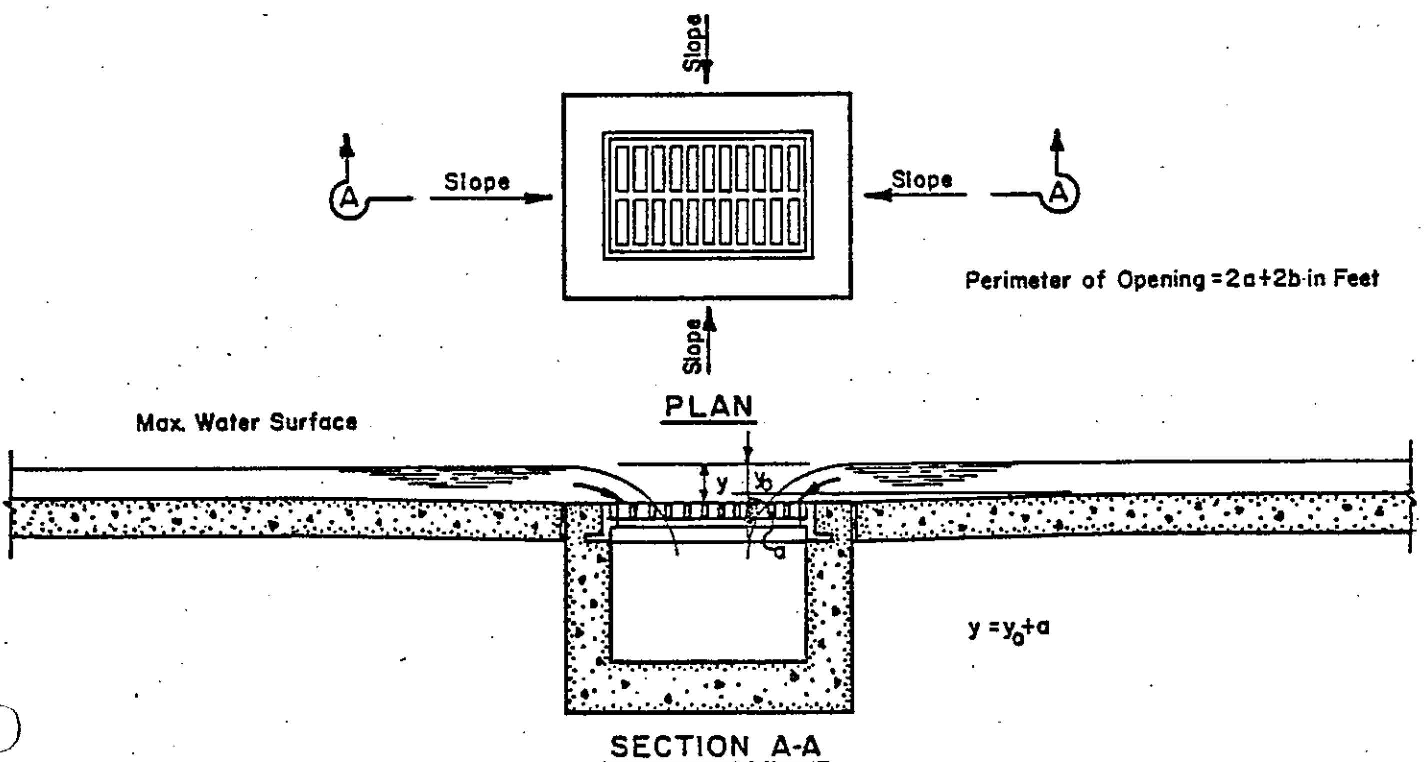


UNDEPRESSED CURB-OPENING
INLET TYPE A-1 & B-1 (RECESSED)

Figure 4-3

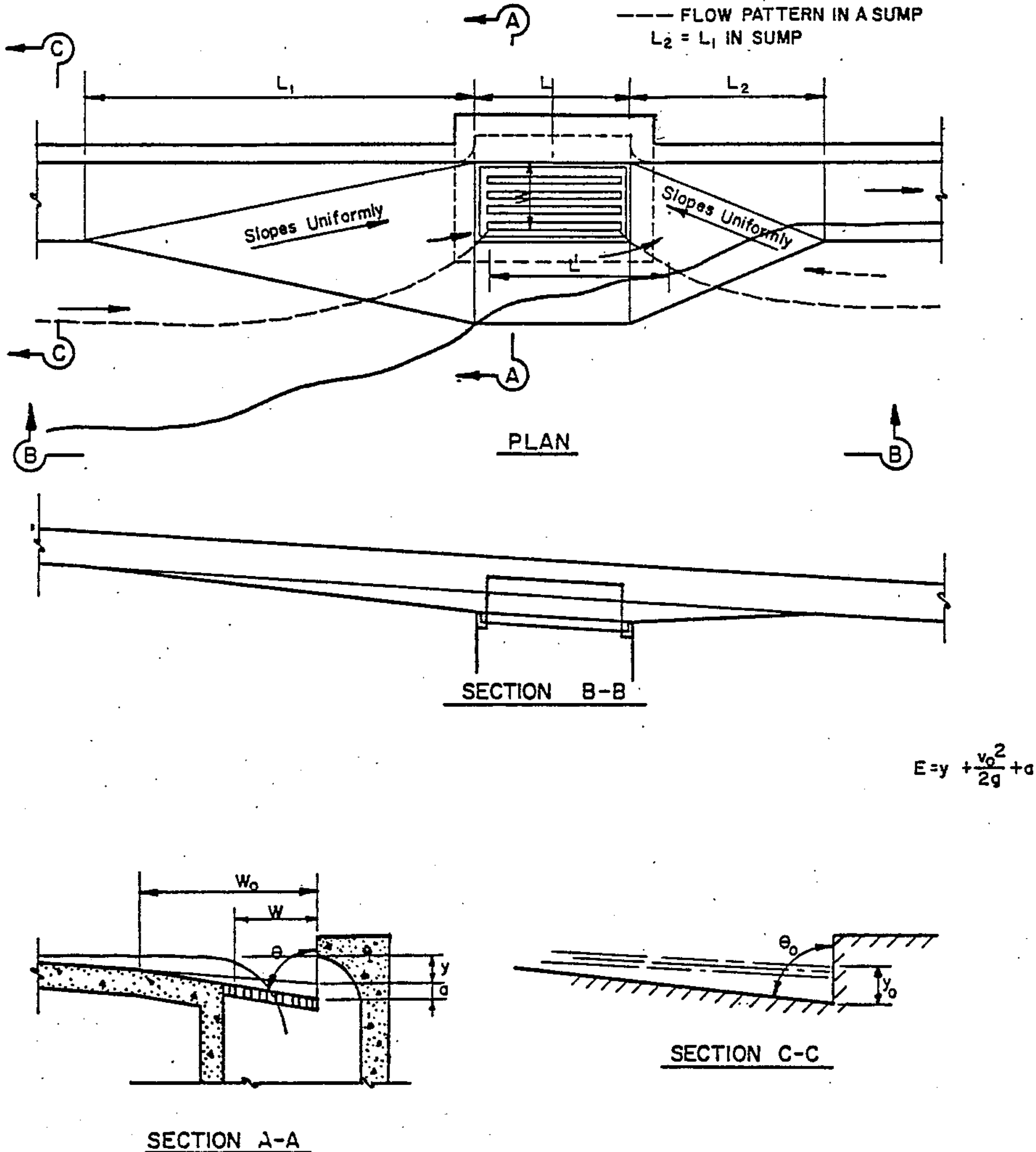


DROP INLET
TYPE A-4



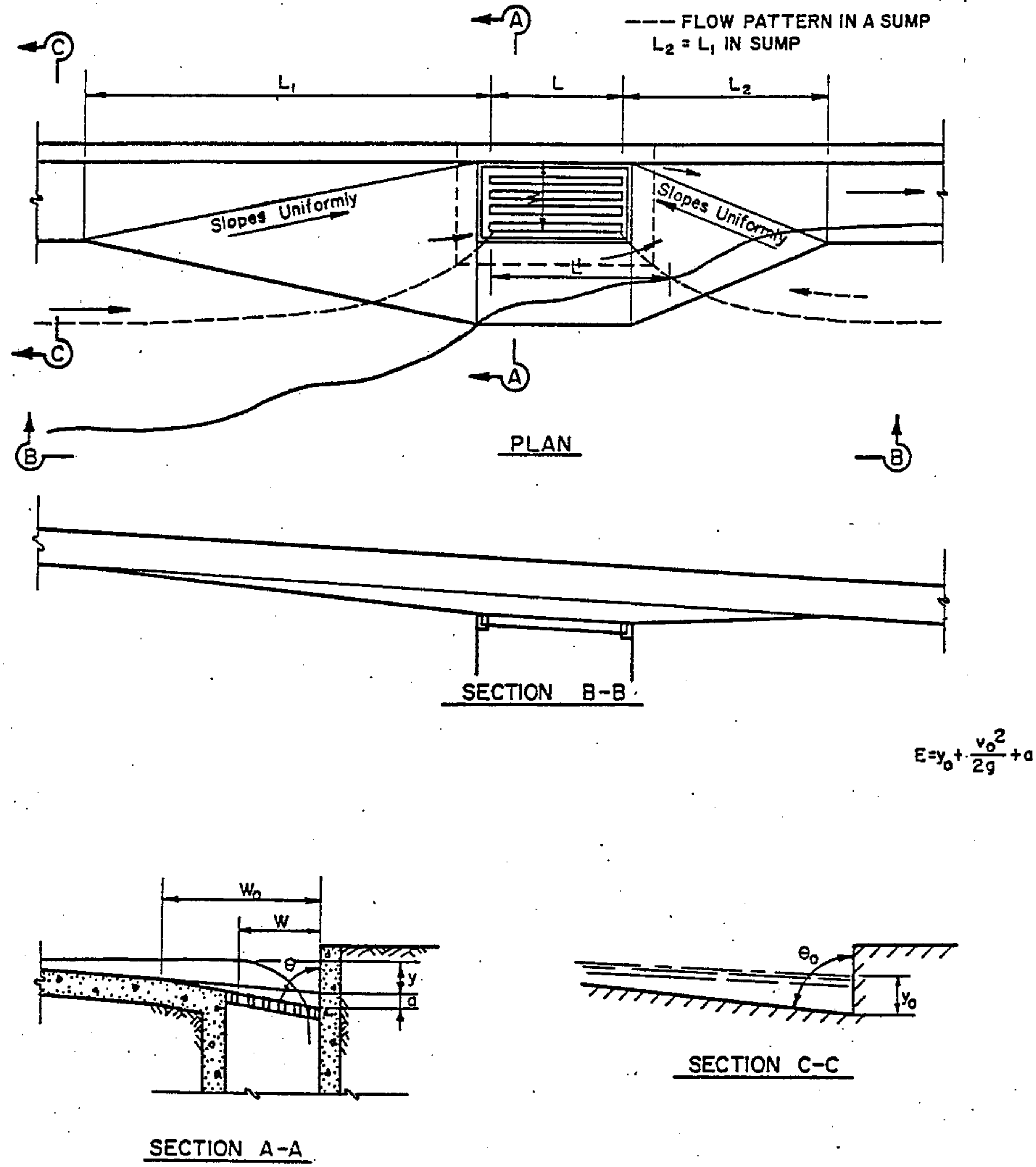
DROP INLET
(Grate covering)
TYPE A-5

Figure 4-4



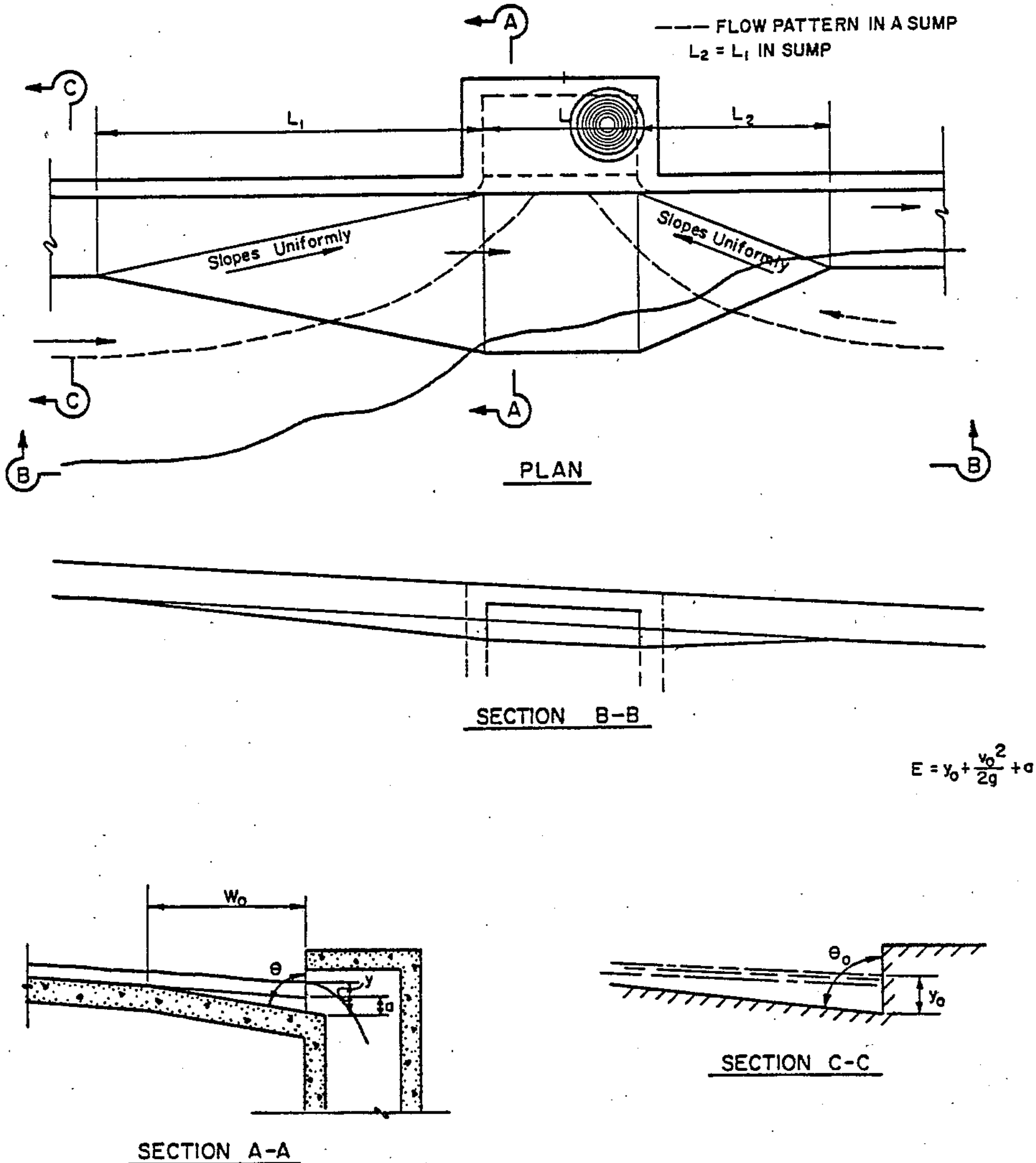
DEPRESSED COMBINATION INLET
TYPE A-3 & C-3

Figure 4-5



DEPRESSED GRATE INLET
TYPE A-2 & C-2

Figure 4-6



DEPRESSED CURB-OPENING INLET
TYPE A-1 & C-1

Figure 4-7

Inlets on Grade without Gutter Depression

(1) Curb Opening Type B-1
(2) Grate Type B-2
(3) Combination (Grate and Curb Opening) Type B-3

Inlets on Grade with Gutter Depression

(1) Curb Opening Type C-1
(2) Grate Type C-2
(3) Combination (Grate and Curb Opening) Type C-3

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

Engineering Department review of proposed drainage plans shall include an examination of the supporting computations. Computations must be submitted either as a part of the plans or on separate tabulation sheets convenient for review and permanent record.

4.03 INLETS IN SUMPS

Inlets in sumps are inlets in low points of surface drainage to relieve ponding. Inlets with a five inch depression located in streets of less than one percent (1.0%) grade, shall be considered inlets in sumps. The capacity of inlets in sumps must be known in order to determine the depth and width of ponding for a given discharge. The charts in this section may be used in the design of any inlet in a sump, regardless of its depth of depression.

A. Curb Opening Inlets and Drop Inlets

General. Unsubmerged curb opening inlets (Type A-1) and drop inlets (Type A-4) in a sump or low point are considered to function as rectangular weirs with a coefficient of discharge of 3.0. Their capacity shall be based on the following equation:

$$Q = 4.82\ A_g y^{1/2}\ ;$$

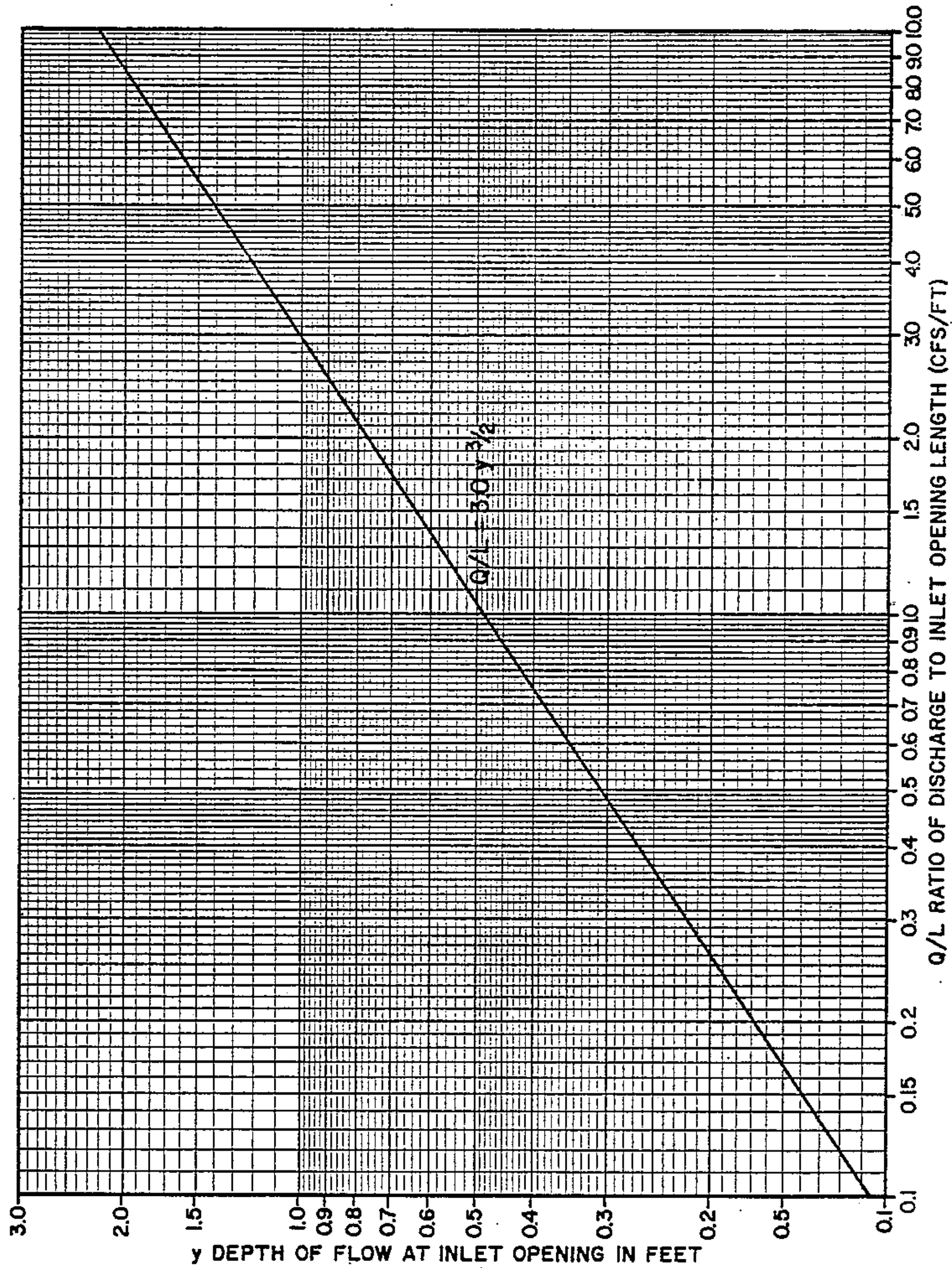
Q = Capacity in cfs

A_g = Area of Clear opening in sq. ft.

y = Depth of flow at inlet or head at sump in feet.

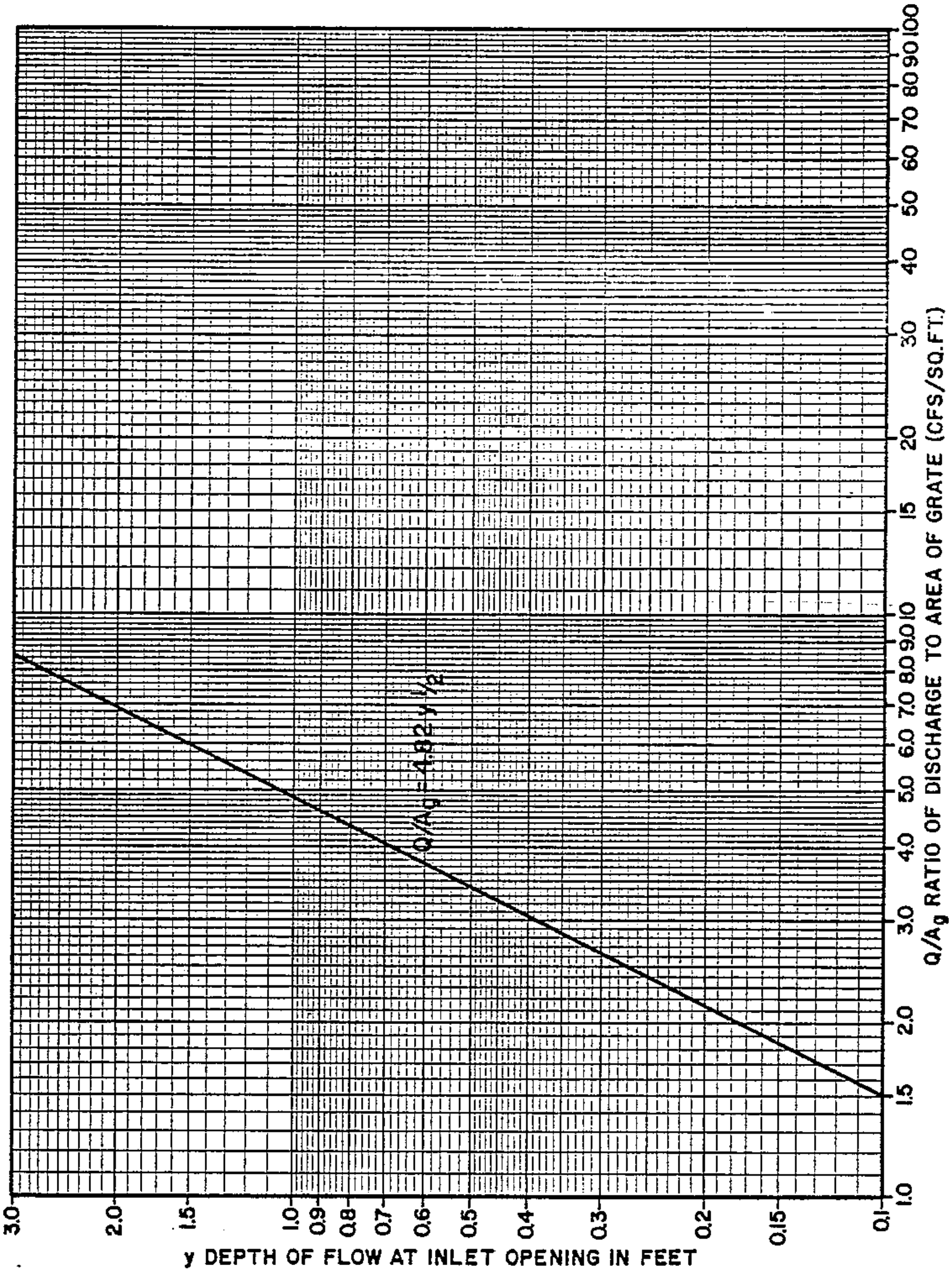
The curves shown in Figure 4-9 provides for direct solution of the above equation.

Grate inlets in sumps have a tendency to clog when flows carry debris such as leaves and papers. For this reason, the calculated inlet capacity of a grate inlet shall be reduced by 25 percent to allow for clogging.



INLET CAPACITY TYPE A-1 & A-4

Figure 4-8



INLET CAPACITY TYPE A-2 & A-5

Figure 4-9

C. Combination Inlets (Type A-3)

The capacity of a combination inlet Type A-3 consisting of a grate and curb opening inlet in a sump shall be considered to be the sum of the capacities obtained from figs. 4-8 and 4-9. When the capacity of the gutter is not exceeded, the grate inlet accepts the major portion of the flow. Under severe flooding conditions, however, the curb inlet will accept most of the flow since its capacity varies with $y^{1.5}$ whereas the capacity of the grate inlet varies as $y^{0.5}$.

Combination inlets in sumps have a tendency to clog and collect debris at their entrances. For this reason, the calculated inlet capacity shall be reduced by 20 percent to allow for this clogging.

4.04 INLETS ON GRADE WITHOUT GUTTER DEPRESSION

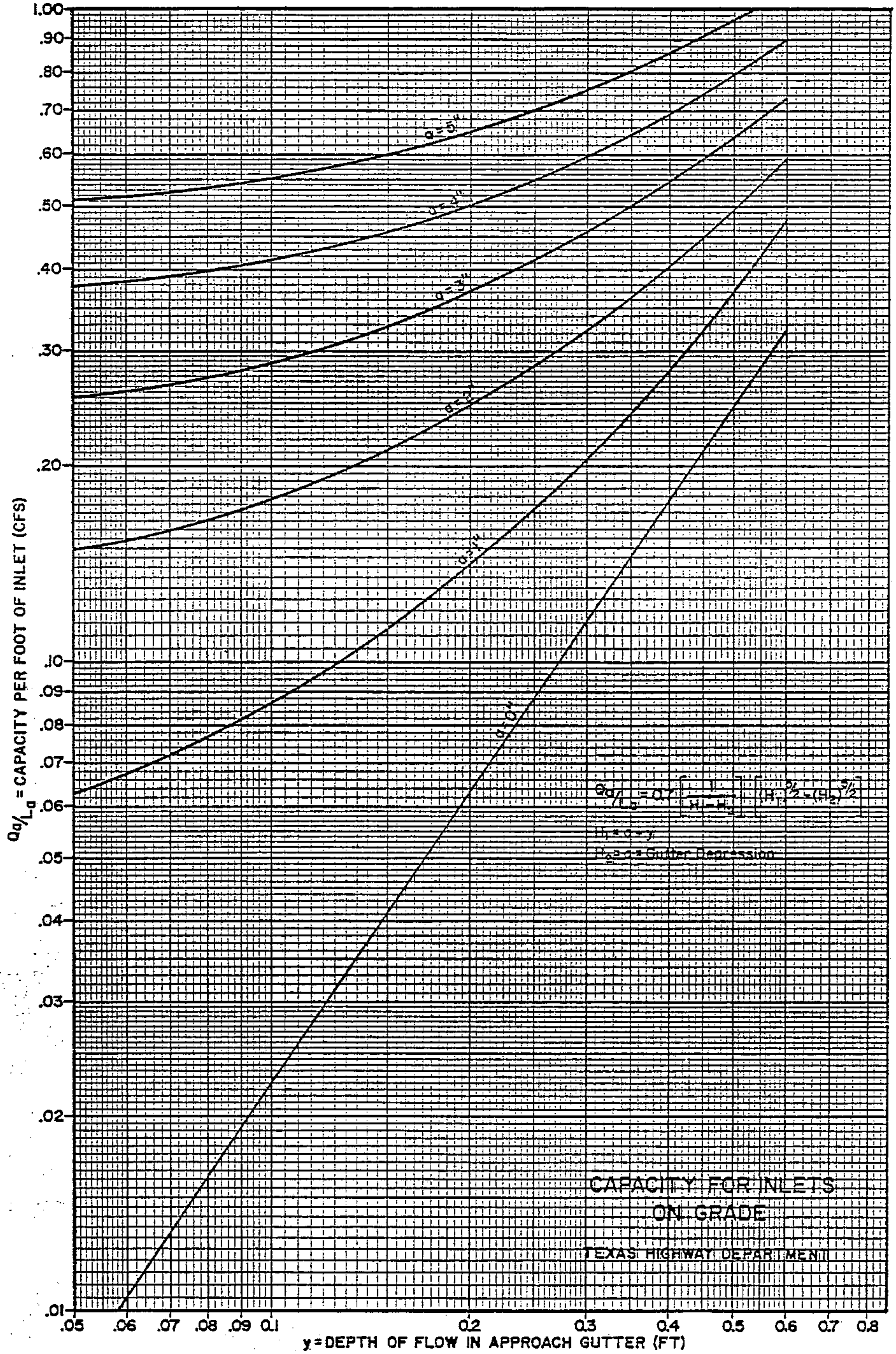
A. Curb Opening Inlets (Undepressed; Type B-1)

General. The capacity of a curb inlet, like any weir, depends upon the head and length of overfall. In the case of an undepressed curb opening inlet, the head at the upstream end of the opening is the depth of flow in the gutter. In streets where grades are greater than one percent the velocities are high and the depths of flow are usually small as there is little time to develop cross flow into the curb openings; therefore, undepressed inlets are inefficient when used in streets of appreciable slope, but may be used satisfactorily where the grade is low and the crown slope high or the gutter channelized. Undepressed inlets do not interfere with traffic and usually are not susceptible to clogging. Inlets on grade should be designed and spaced so that 5 to 15 percent of gutter flow reaching each inlet will carry over to the next inlet downstream, provided the carry over is not objectionable to pedestrian or vehicular traffic.

The capacity of an undepressed inlet shall be determined by use of figs. 4-10 and 4-11. An example of the use of figs. 4-10 and 4-11 is included at the end of this section.

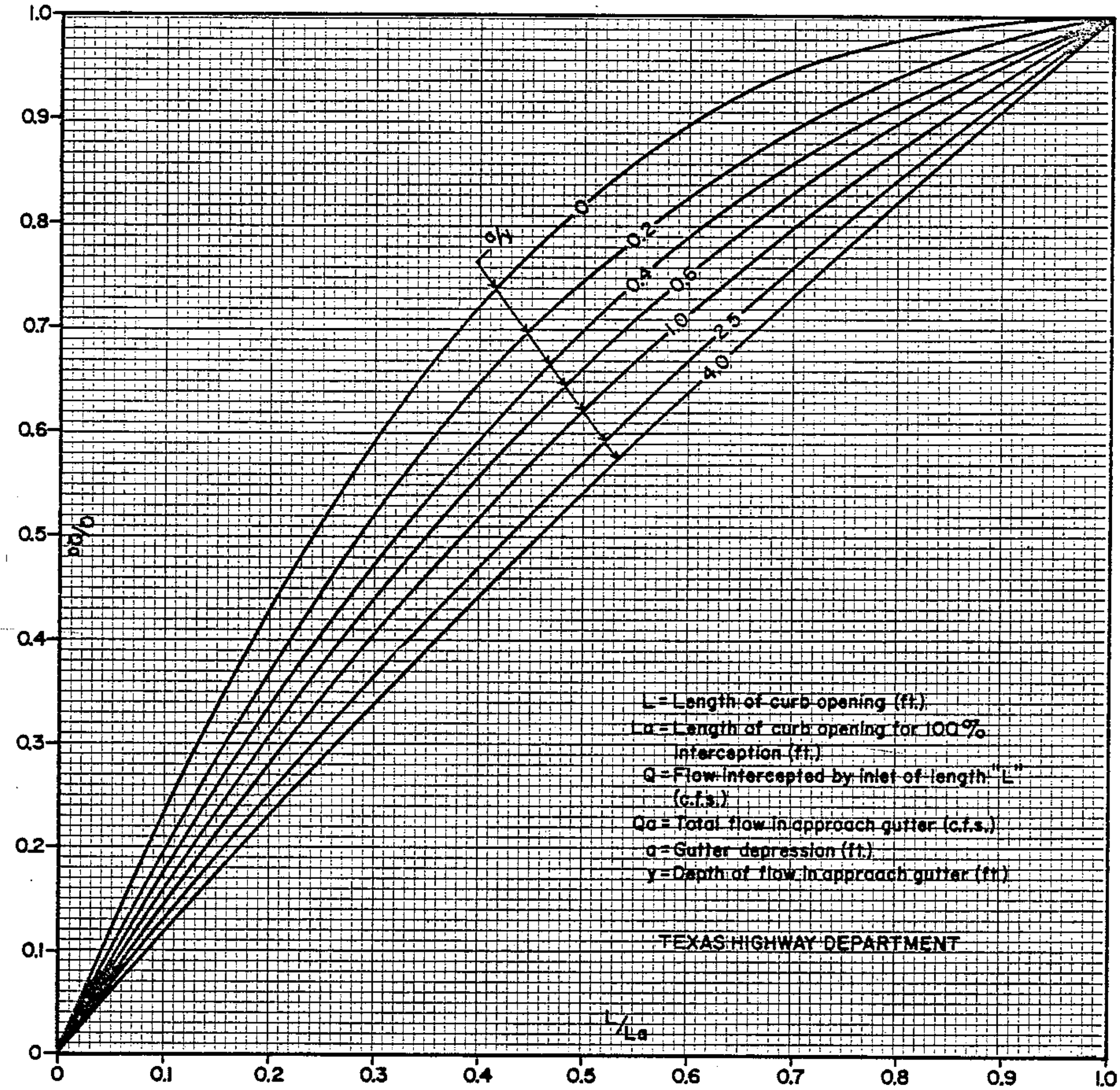
B. Grate Inlets on Grade (Undepressed; Type B-2)

General. Undepressed grate inlets on grade have a greater hydraulic capacity than curb inlets of the same length so long as they remain unclogged. Undepressed grate inlets on grade are inefficient in comparison to grate inlets in sumps. Their capacity shall be the capacity determined from figure 4-9 reduced by 15 percent. Grate inlets should be so designed and



1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
Qa/La = CAPACITY PER FOOT OF INLET (CFS)
.05
.06
.07
.08
.09
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
y = DEPTH OF FLOW IN APPROACH GUTTER (FT)
a = 5"
a = 4"
a = 3"
a = 2"
a = 1"
a = 0"
Qa/La = 0.7 [1/(H1 - H2)] [(H1)5/2 - (H2)5/2]
H1 = a + y
H2 = a = Gutter Depression
CAPACITY FOR INLETS ON GRADE
TEXAS HIGHWAY DEPARTMENT

Figure 4-10



RATIO OF INTERCEPTED TO TOTAL FLOW FOR INLETS ON GRADE

Figure 4-11

spaced so that 5 to 15 percent of the gutter flow reaching each inlet will carry over to the next downstream inlet, provided the carry over is not objectionable to pedestrian or vehicular traffic.

Grates with bars parallel to the curb should always be used for the above described installations because transverse framing bars create splash which causes the water to jump or ride over the grate. Grates used shall be certified by the manufacturer as bicycle-sage. For flows on streets with grades less than one percent, little or no splashing occurs regardless of the direction of bars.

The calculated capacity for a grate inlet shall be reduced by 25 percent to allow for clogging.

C. Combination Inlets on Grade (Undepressed; Type B-3)

General. Undepressed combination (curb opening and grate) inlets on grade have greater hydraulic capacity than curb inlets or grate inlets of the same length. Generally speaking, combination inlets are the most efficient of the three types of undepressed inlets presented in this manual. Grates with bars parallel to the curb should always be used. The basic difference between a combination inlet and a grate inlet is that the curb opening receives the carry-over flow that falls between the curb and the grate.

The capacity of a Type B-3 inlet shall be considered to be 90 percent of the sum of the capacities as determined for a Type B-1 inlet and a Type B-2 inlet (allowing for reduction due to clogging).

4.05 INLETS ON GRADE WITH GUTTER DEPRESSION

A. Curb Opening Inlets on Grade (Depressed; Type C-1)

General. The depression of the gutter at a curb opening inlet below the normal level of the gutter increases the cross-flow toward the opening, thereby increasing the inlet capacity. Also, the downstream transition out of the depression causes backwater which further increases the amount of water captured. Depressed inlets should be used on continuous grades that exceed one percent except that their use in traffic lanes shall conform with requirements of Section 3 of this manual.

The depression depth, width, length and shape all have significant effects on the capacity of an inlet. Reference to Section 3 of this manual must be made for permissible gutter depressions.

The capacity of a depressed curb inlet will be determined by use of Figures 4-10 and 4-11.

B. Grate Inlets on Grade (Depressed; Type C-2)

General. The depression of the gutter at a grate inlet decreases the flow past the outside of a grate. The effect is the same as that when a curb inlet is depressed, namely the cross slope of the street directs the outer portion flow toward the grate.

The bar arrangements for depressed grate inlets on streets with grades greater than one percent greatly effect the efficiency of the inlet. Grates with longitudinal bars eliminate splash which causes the water to jump and ride over the cross bar grates, and it is recommended that grates have a minimum of transverse or crossbars for strength and spacing only.

For low flows or for streets with grades less than one percent, little or no splashing occurs regardless of the direction of bars. However, as the flow or street grade increases, the grate with longitudinal bars becomes progressively more superior to the cross bar grate. A few small rounded cross bars, installed at the bottom of the longitudinal bars as stiffeners or a safety stop for bicycle wheels, do not materially affect the hydraulic capacity of longitudinal bar grates.

The capacity of a Type C-2 inlet on grades less than one percent shall be the capacity determined from Fig. 4-9. The capacity of C-2 inlets on grades greater than one percent shall be 90 percent of the capacity determined from Fig. 4-9.

Grate inlets in depressions have a tendency to clog when gutter flows carry debris such as leaves and papers. For this reason the calculated inlet capacity of a grate inlet shall be reduced by 25 percent to allow for clogging.

C. Combination Inlets on Grade (Depressed; Type C-3)

General. Depressed 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 types of depressed inlets presented in this manual. Grates with bars parallel to the curb should always be used for maximum efficiency. 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 depression depth, width, length and shape all have significant effect on the capacity of any inlet. Reference to Section 3 of this manual must be made for permissible gutter depressions.

The capacity of a C-3 inlet shall be considered to be 90 percent of the sum of the capacity of a C-1 inlet and a C-2 inlet (allowing for reduction due to clogging).

4.06 USE OF FIGURE 4-10 AND 4-11

Example 1.

Given:
Street Width = 30 ft
Cross Slope = 0 ft
Street Grade = 1.0%
Q_a in one gutter = 8 cfs

Determine: Capacity of 10 ft curb inlet with 2.5 in depression.

Step 1. From Figure 3-5 (Section 3) depth of flow in gutter is y = 6.2 in or 0.51 ft.

Step 2. Enter Figure 4-10 with y = 0.51 ft and a = 2.5 in and find corresponding $\frac{Q_a}{L_a} = 0.56$.

Step 3. Compute L_a ; $L_a = \frac{8}{0.56} = 14.3$.

Step 4. Compute $\frac{L}{L_a} = \frac{10}{14.3} = 0.70$.

Step 5. Enter Figure 4-11 with $\frac{L}{L_a} = 0.70$ and $\frac{a}{y} = 0.41$ and find corresponding $\frac{Q}{Q_a} = 0.86$.

Step 6. Determine Q from $\frac{Q}{Q_a} = 0.86$.

$Q = 0.86\ (8) = 6.9$ cfs

Example 2.

Given:
Street Width = 44 ft
Cross Slope = 0.4 ft
Street Grade = 0.6%
Q_a in low gutter = 8 cfs

Determine: Length of undepressed curb inlet required to intercept 80% of gutter flow (Q = 6.4).

Step 1. From Figure 3-23 (Section 3) depth of flow in gutter y = 6.75 in or 0.56 ft.

Step 2. Entering Figure 4-10 with 6 = 0.56, and a = 0 and find corresponding $\frac{Q_a}{L_a} = 0.28$.

Step 3. Determine L_a ; $L_a = \frac{8}{0.28} = 28$.

Step 4. Entering Figure 4-11 with $\frac{Q}{Q_a} = 0.8$ and $\frac{a}{y} = 0$ and find corresponding $\frac{L}{L_a} = 0.48$.

Step 5. Compute L from $\frac{L}{L_a} = 0.48$, L = 28.6 (0.48) = 13.7 ft. Use L = 15 ft.

Step 6. Compute $\frac{L}{L_a} = \frac{15}{28} = 0.54$.

Step 7. Entering Figure 4-11 with $\frac{L}{L_a} = 0.54$ and $\frac{a}{y} = 0$ and find corresponding $\frac{Q}{Q_a} = 0.85$.

Step 8. Compute Q from $\frac{Q}{Q_a} = 0.85$.
Q = 8 (0.85) = 6.8 cfs