TABLE OF DETAILS

STORM DRAINAGE DESIGN

STORM DRAINAGE DESIGN REQUIREMENTS

In order that the Engineering Department may adequately review preliminary plats, construction plans and stormwater management plans, the following items should be indicated or accounted for on all plans submitted for approval:

D-1 All storm drainage facilities shall comply with the requirements as stated in the Stormwater Management Program for the City of Greenville and the North Carolina Division of Water Quality Stormwater Best Management Practices Manual.

D-2 Storm drainage pipes to be designed for a 10-year storm (post development), catch basins to be designed for a 2-year storm (post development).

D-3 Minimum storm drainage pipe size is 15 inches.

D-4 Double Basins are permitted.

D-5 Minimum allowable velocity is 2.5 feet per second. Maximum velocity is 10 feet per second within a system. Exiting velocities shall be in conformance with the Sedimentation and Erosion Control Ordinance of the City of Greenville or the latest version thereof.

D-6 Drainage pipes which are located parallel or near parallel to public streets shall be contained within street rights-of-way. If this is not possible, dedicated storm drainage easements shall be required as defined on std detail 681.01.

D-7 In cases where two ditches intersect at perpendicular or obtuse angles, erosion control measures must be indicated.

D-8 Headwalls or flared end pipe will be required at the influent and effluent of all pipe systems.

D-9 Indicate all ditch sections with centerline elevations at least every 50' and cross sections if there is a significant change in the profile.

D-10 Indicate topography, ditches, pipes, swales, and drainage easements which are adjacent to the proposed project.

D-11 Catch basins shall be placed such that the maximum depth of flow in the curb and gutter for all streets shall not exceed 6" for standard curb and gutter and 4" for roll type curb and gutter.

D-12 With all storm drainage designs, the following design data must be submitted for each run of pipe.

a. Area drained

b. Design storm intensity adjusted for duration

c. Design flow

d. Coefficient of runoff

e. Grade of pipe

f. Type of pipe

g. Size of pipe

h. Velocity of flow

i. Maximum capacity

j. Hydraulic grade lines

D-13 Not more than one acre may drain in the street at a single concentrated point.

D-14 The minimum grade for any storm drainage pipe shall be 0.3%. In the event that this requirement cannot be met, the City Engineer may approve an alternate provided the minimum velocity of 2.5 ft/sec is met.

D-15 Any storm drainage system to be city-maintained shall have “Record Drawings” submitted and approved prior to scheduling a pre-final street acceptance inspection. All “Record Drawings' for storm drainage infrastructure shall include, but is not necessarily limited to, the information as identified in the *Street and Storm Drainage “Record Drawings” Submittal Requirements.*

D-16 Maximum distance between manholes/boxes shall be 300'.

REQUIREMENTS FOR INSTALLATION OF REINFORCED CONCRETE PIPE

1. Reinforced Concrete pipe shall meet the requirements of AASHTO M 170 (latest revision). All pipe installed within the street right-of-way shall be Class III or higher. Minimum and Maximum fill heights shall be in accordance to manufacturers recommendations.
2. A flexible plastic joint material shall be applied on the spigot end of the pipe. Joints shall be pushed together until the pipe is completely homed. Joints shall be wrapped with a non-woven geotextile fabric, extending a minimum of 12” beyond either side of the connection.
3. A manning's roughness coefficient of 0.013 (“n” factor) shall be used in the design of reinforced concrete drainage systems
4. Backfill shall be a NCDOT Class II or better
5. In areas where high groundwater exists, joints shall meet ASTM C443
6. All pipes shall be designed to meet a minimum H-20 load condition.

REQUIREMENTS FOR INSTALLATION OF CORRUGATED ALUMINUM PIPE

1. Corrugated Aluminum pipe shall meet the requirements of AASHTO M196 (latest revision) Coupling bands shall be used at all joints and shall be of a size specified by the manufacturer in accordance with the pipe design. Bands shall conform to AASHTO Designation M196. Bands to be of Hugger-Type or approved equal.
2. Pipe installation shall be per NCDOT recommended practices and meet the manufacturers recommended minimum and maximum fill heights.
3. A manning's roughness coefficient of 0.024 (“n” factor) shall be used in the design of corrugated metal pipe drainage systems.
4. In areas where high groundwater exists, joints shall meet performance expectations found in ASTM C443.
5. All pipes shall be designed to meet a minimum H-20 load condition.

REQUIREMENTS FOR INSTALLATION OF CORRUGATED HIGH DENSITY POLYETHYLENE PIPE

1. Corrugated High Density Polyethylene pipe shall meet the requirements of AASHTO M294.
2. Joints shall be bell and spigot with a rubber gasket meeting ASTM F477.
3. A manning's roughness coefficient of 0.012 (“n” factor) shall be used in the design of corrugated High Density Polyethylene pipe.
4. Pipes installation shall be per NCDOT recommended practices and meet the manufacturers recommended minimum and maximum fill heights.
5. In areas where high groundwater exists, joints shall meet or exceed leakage rate found in ASTM C443.
6. All pipes shall be designed to meet a minimum H-20 load condition.

REQUIREMENTS FOR INSTALLATION OF POLYPROPYLENE PIPE

1. Polypropylene pipe shall meet the requirements of ASTM F2736 OR ASTM F2764.
2. Joints shall be bell and spigot with a gasket meeting the requirements of ASTM F477.
3. A manning's roughness coefficient of 0.012 (“n”) shall be used in the design of Polypropylene pipe.
4. Pipe installation shall be in accordance with the manufacturer's recommendations, but shall not be backfilled with materials less than an NCDOT Class II or better unless compaction is field verified, and backfill meets manufacturer's standards.
5. In areas where high ground water exists, joints shall meet or exceed leakage rate found in ASTM C443.
6. All pipes shall be designed to meet a minimum H-20 load condition.

COMPACTION AND BACKFILL

Backfill type and Compaction for reinforced concrete, corrugated high density polyethylene, and corrugated aluminum pipe shall be in accordance with NCDOT Standard Specifications for Road and Structures.

STORM WATER DESIGN CALCULATIONS

RUNOFF DETERMINATION

There are two acceptable methods: (1) Rational Method (good for areas less than 20 acres and minor design systems) and (2) Soil Conservation Service Method using Curve Numbers.

DETERMINATION OF DISCHARGE:

The most widely used method for determining discharge in storm drainage is the Rational Method and shall be the method used for the purpose of this manual. It should be noted, however, that this method should be used with caution since it does not adequately recognize all of the complications of the runoff process. The basic formula may be reduced to “Q=CIA”, where:

Q = Discharge, in cubic feet per second.

C = “Runoff” coefficient, unitless

I = Intensity of rainfall, inches per hour

A = Drainage basin area, acres

These factors are explained in detail in the following paragraphs.

C.....RUNOFF COEFFICIENT

The runoff coefficient is the proportion of the total rainfall which runs off the basin area into the drainage system. The runoff coefficients to be used for the Greenville area are listed on Std. detail No. 682.03.

I.....INTENSITY

Values for the rainfall intensity for the Greenville area may be derived from Std. detail No. 682.01 and 682.02. The design procedures for runoff for the City of Greenville shall be based on a 10-year rainfall and the time of concentration (Tc).

$$T_C = [(L^3/H)^{0.385}]/128$$

L = Maximum length of travel time of water (feet)

H = Difference in elevation between the most remote point on the basin and the outlet (feet)

NOTES: Overland flow, grass, multiply Tc by 2.
Overland flow, concrete or asphalt, multiply Tc by 0.4
Concrete channel, multiply Tc by 0.2

A.....DRAINAGE BASIN AREA

The drainage basin area can be calculated with the use of topographic maps by marking the basin ridgeline and planimetering the designated areas. When marking the basin ridgeline, it should be remembered that water runoff flows perpendicular to contour lines.

Q.....DISCHARGE

After determining the coefficient of runoff, rainfall intensity, and drainage basin area; the discharge can be computed by the use of rational formula “Q=CIA”.

CATCH BASIN DESIGN

DESIGN PROCEDURE:

The following procedure for the location and design of catch basins for the City of Greenville is based on the actual hydraulic characteristics of the standard catch basin for the City as depicted in Std. detail No. 682.04. Catch basin design shall be based on a 2-year storm. Double basins are permitted. The catch basin data sheets, Std. detail No. 682.05 or approved equivalent shall be completed and submitted with each pan.

1 - DETERMINE DRAINAGE LIMITS:

The drainage limits should be calculated by the use of topographic maps by marking the basin ridge line. It should be noted that the centerline of the streets will usually represent a ridge line on a normal crown.

2 - DETERMINE DEPTH OF FLOW:

The depth of flow allowed is the depth of the water in the gutter line which will be tolerated in flooding conditions.

3 - DETERMINE LONGITUDINAL SLOPE (S_L) OF THE STREET:

Determine the slope of the street in percent.

4 - DETERMINE TRANSVERSE SLOPE (S_T) OF THE STREET:

This can be determined from the typical section of the street and will usually consist of the vertical distance from the gutter line to the crown of the street divided by the horizontal distance from the gutter line to the crown of the street.

5 - DETERMINE CAPACITY OF THE BASIN:

The capacity of the basin can be determined by the chart on Std. detail No. 682.04. Enter the bottom of the chart with the transverse slope and draw a vertical line to the longitudinal slope. Then, using this as a turning point, draw a horizontal line to intersect the "K" factor. Then use the equation.

$Q = KD^{1.67}$, where:

Q = the capacity of the basin in cubic feet per second

K = a dimensionless factor determined from said chart

D = the depth of flow in the gutter line in feet

With this information, complete columns 1, 2, 3 and 4 of the catch basin design data sheet (Std. detail 682.05).

6 - DETERMINE AREA SERVED BY THE BASIN:

STEP NO. 1: Assume a trial coefficient and a trial intensity for the design area and place these figures in columns 5 and 6 of the data sheet. At this point, an approximate area served by the catch basin may be determined by dividing the catch basin capacity by the trial coefficient of runoff and the trial intensity (column 5 x column 6). This derived area should be placed in column 7 in the design data sheet. This gives an approximate area served by the catch basin. With this area and topographic lines, a trial location of the proposed basin should be made.

STEP NO. 2: To ensure that the location as derived in Step No. 1 is appropriate and that the trial coefficient of runoff and trial intensity are in order, the runoff for the area determined by the proposed location of the basin should be calculated. This is accomplished by calculating the runoff as established in the RUNOFF DETERMINATIONS listed in the previous section and completing columns 8 through 13. If column 13 varies by more than 10% from the column 7, this would indicate that the trial coefficient and/or trial intensity were not in line with the actual coefficient and intensity, and therefore, the basin is not properly located. The procedure in Step No.1 should then be repeated and then adjust the trial coefficient of runoff (col. 5) and trial intensity (col.6) accordingly. Once all the basins have been property located, the pipe design associated with the basins may be completed according to the PIPE SYSTEM DESIGN PROCEDURES listed in this chapter.

CULVERT DESIGN

DESIGN PROCEDURE:

There are two steps in storm drainage design. The first step is to determine the amount of water discharged at the point of design. This can be accomplished by using the RUNOFF DETERMINATION section of this manual. The second step is the actual selection of a size for the structure, based on the calculated discharge.

DETERMINE OF STRUCTURE SIZE:

There are essentially two types of control which must be considered in every culvert design situation: inlet control and outlet control. Both types of control must be considered separately in the design of culverts.

INLET CONTROL:

Inlet control exists in cases where the culvert is not flowing full. The inlet control charts (Std. details No. 683.01 through 683.11) have headwater depth as the controlling criteria. Headwater depth is the depth of the water on the upstream side of the culvert, expressed in diameters of the pipe under study.

The maximum allowable headwater is limited by either the controlling flood elevation or existing or proposed development. However, the maximum headwater depth should not exceed 1.2 times the open height of the culvert for a 10-year storm.

OUTLET CONTROL:

Outlet control exists in cases where the culvert is flowing full. Before using the outlet control charts (Std. details No. 683.07 through 683.11), it is necessary to determine the coefficient of entrance loss “Ke”. These valves are found in the coefficient of entrance loss table on Std. detail No. 682.07.

A controlling criteria for outlet control is tailwater depth, which is represented in the tables by the amount of “head”. Head is the difference in elevation of the water surface on the upstream side of the culvert and the downstream water surface. The tailwater elevation is determined by downstream conditions and may be calculated if these conditions are known. In any case, the tailwater elevation will not be below the design year flood elevation at the outlet. If flood data is not available, the assumption may be made that the tailwater elevation is the crown of the culvert.

PIPE SYSTEM DESIGN

Once all the catch basins have been located according to the CATCH BASIN DESIGN PROCEDURES, the next step is to design the pipe systems to serve the basins. For the purpose of this manual and for the City of Greenville, pipes within the system shall be designed to carry a 10-year storm (post development). The sizing of these pipes shall be based on the Manning Equation. It should be noted that the velocities for the pipes shall be maintained between 2.5 feet per second and 10 feet per second. In addition, points of discharge should be treated in such a manner to conform with the State and local ordinances on velocity controls. This design is based on the sum of the individual areas served by the catch basins and not the sum of the capacities of each basin. The Storm Drainage Design Data Sheet, Std. detail No. 682.06, or an approved equivalent, should be completed and submitted with each plan.

GENERAL NOTES:

1. FOR OPEN CHANNELS THE MINIMUM EASEMENT MUST CONTAIN THE WIDTH OF THE CHANNEL FROM TOP OF BANK TO TOP BANK PLUS (+) 10' ON EACH SIDE OF CHANNEL.
2. WIDER EASEMENT WIDTHS MAY BE REQUIRED FOR PIPE DEPTHS GREATER THAN EIGHT FEET.
3. PIPE SYSTEMS AND OPEN CHANNELS ON PRIVATE PROPERTY CONVEYING STORMWATER FROM MULTIPLE PROPERTIES SHALL BE PLACED IN A STORM DRAINAGE EASEMENT.

Easement Requirements for Storm Drain Pipe

Pipe Size	Easement Requirement
15"	15'
18"	15'
24"	15'
30"	20'
36"	20'
42"	25'
48"	25'
54"+	30' MIN. (VARIES)

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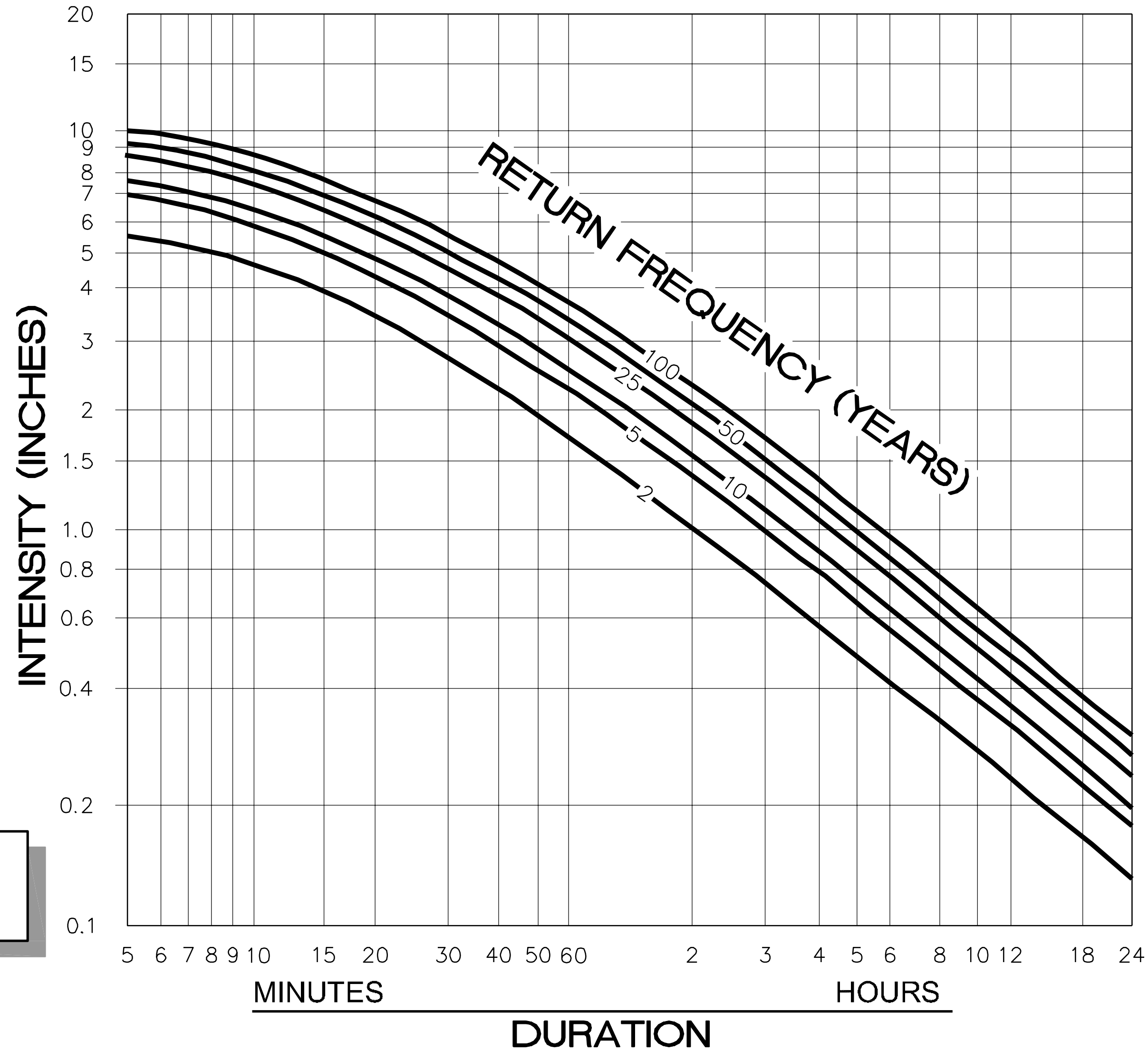
1	9/16/11	APPROVAL

DRAINAGE ESM'T REQMTS FOR STORM DRAIN PIPES & OPEN CHANNELS

Scale: not to scale | Sheet #: 1 of 1 | Detail # 681.01



NOTE: ASSUME TIME OF CONCENTRATION EQUALS DURATION

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RAINFALL INTENSITY VS. DURATION

Scale:	Sheet #:	Detail #
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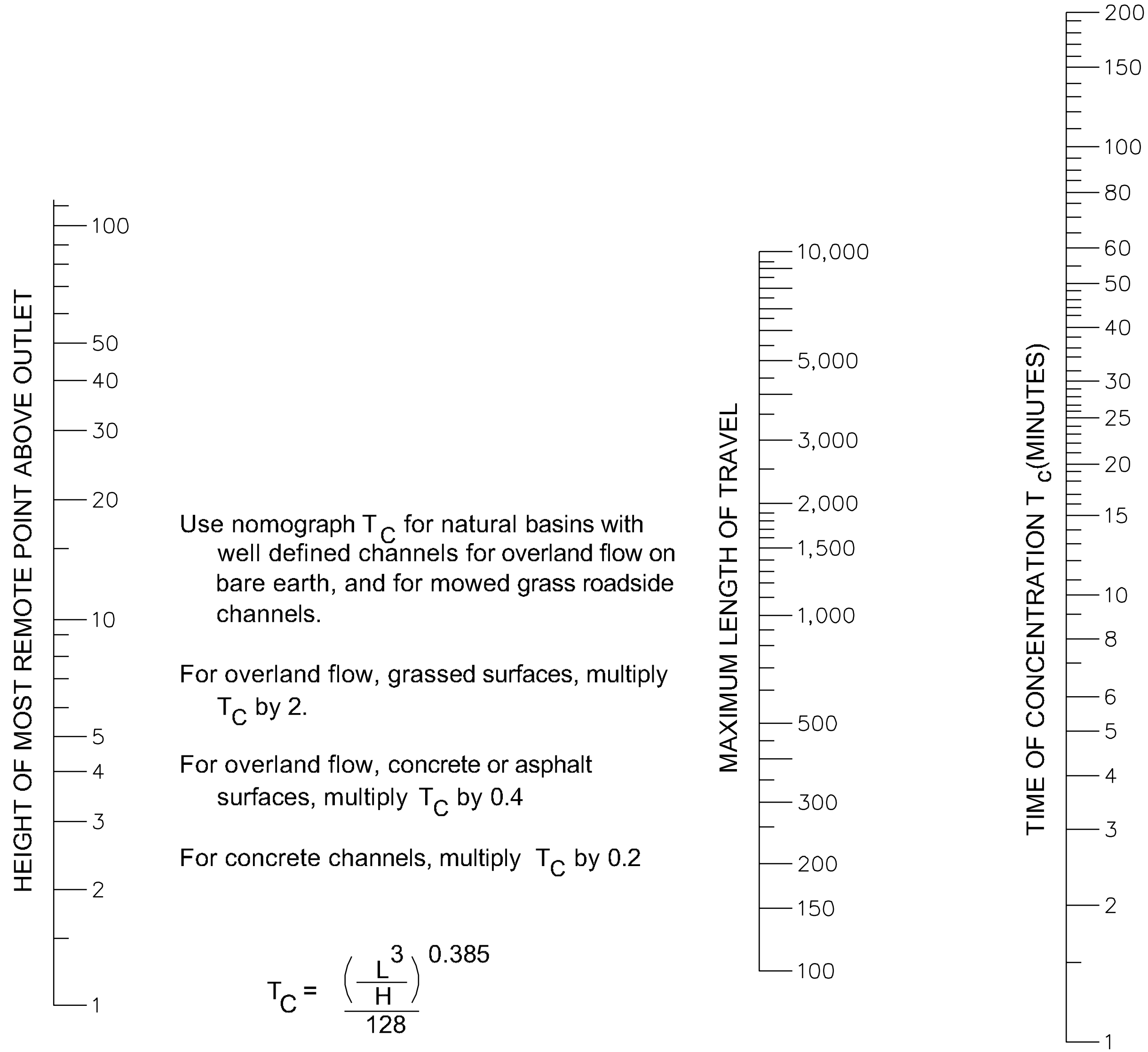

Use nomograph T_C for natural basins with well defined channels for overland flow on bare earth, and for mowed grass roadside channels.

For overland flow, grassed surfaces, multiply T_C by 2.

For overland flow, concrete or asphalt surfaces, multiply T_C by 0.4

For concrete channels, multiply T_C by 0.2

$$T_C = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128}$$

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TIME OF CONCENTRATION

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RUNOFF COEFFICIENTS

LAWNS:	(1) SANDY SOILS	FLAT	<2%	0.10
		AVERAGE	2% - 7%	0.15
		STEEP	>7%	0.20
	(2) HEAVY SOILS	FLAT	<2%	0.15
		AVERAGE	2% - 7%	0.20
		STEEP	>7%	0.30
WOODS, CEMETERIES, PARKS:				0.20
UNIMPROVED AREAS (PASTURE, CROP, ETC.):				0.25
PLAYGROUNDS:				0.30
RESIDENTIAL:	(1) APARTMENTS AND TOWNHOUSES			0.70
	(2) LOT SIZE <1/4 ACRE (R-6, R-9)			0.60
	(3) LOT SIZE <1/3 ACRE (R-15)			0.55
	(4) LOT SIZE <1/2 ACRE (R-20)			0.50
	(5) LOT SIZE <1.0 ACRE			0.40
	(6) LOT SIZE >1.0 ACRE			0.35
INDUSTRIAL:	(1) LIGHT			0.70
	(2) HEAVY			0.80
COMMERCIAL:	(1) DOWNTOWN, STRIP, MALL, PAVEMENT AREAS			0.95
	(2) CENTER			0.90
	(3) NEIGHBORHOOD			0.85
ROOF:				0.95
PAVEMENT:	(1) ASPHALT OR CONCRETE			0.90
	(2) BRICK			0.80
GRAVEL:				0.30

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RUNOFF COEFFICIENTS

Scale: not to scale | Sheet #: 1 of 1 | Detail # 682.03

CAPACITY OF BASIN =

$$Q = K D^{5/3}$$

WHERE:
- Q= C.F.S.
- D= DEPTH OF GUTTER FLOW IN FEET

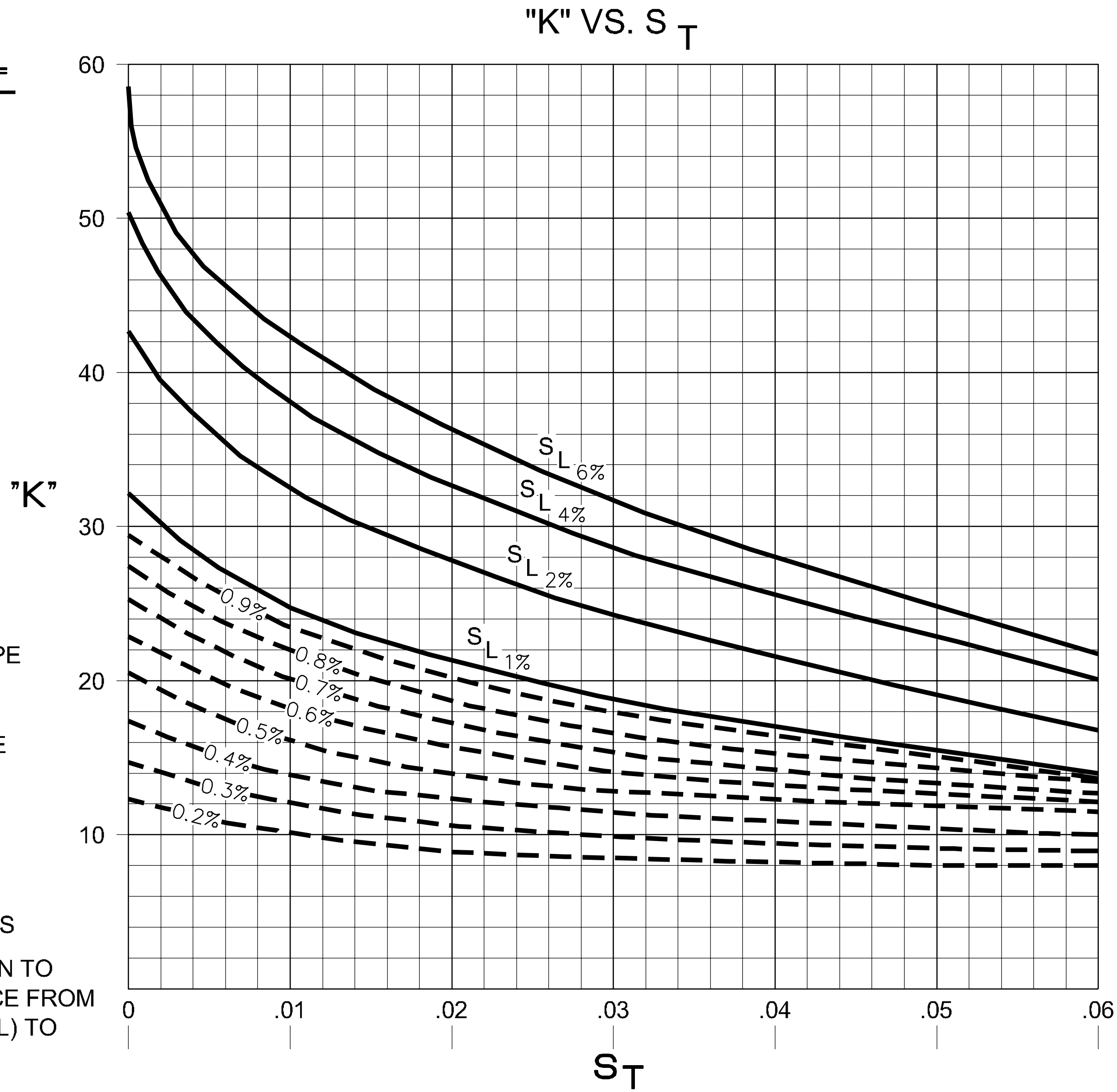
S_L = LONGITUDINAL GUTTER SLOPE

S_T = TRANSVERSE GUTTER SLOPE

K = GRATE INLET COEFFICIENT

— — — INDICATES INTERPOLATED VALUES

S_T = VERTICAL DISTANCE FROM CROWN TO GUTTER LINE DIVIDED BY DISTANCE FROM CREST OF ROADWAY (USUALLY C/L) TO GUTTER LINE.



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STANDARD CATCH BASIN INLET CAPACITY

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CATCH BASIN DESIGN DATA SHEET

PROJECT ____________________________ COMPUTED BY_______________________ DATE___________,20____

LOCATION ___________________________ CHECKED BY ________________________ DATE___________,20____

STORM FREQUENCY _________ YEARS

CATCH BASIN NO.	1 LONGITUDINAL STREET GRADE (S_L)%	2 TRANSVERSE STREET GRADE (S_T)	3 MAX. DEPTH OF OF FLOW IN GUTTER (FT.)	4 CAPACITY OF BASIN (C.F.S.) $Q=KD^{5/3}$	5 TRIAL COEF. OF RUNOFF	6 TRIAL INTENSITY (in.)	7 DERIVED AREA $= \frac{4}{5 \times 6}$	8 LENGTH OF DRAINAGE AREA	9 HEIGHT ABOVE MOST REMOTE POINT	10 COEF. OF RUNOFF	11 TIME OF CONCENTRATION (T_C)	12 ACTUAL INTENSITY (in.)	13 MAX. ALLOWABLE DRAINAGE AREA $= \frac{4}{10 \times 12}$	REMARKS (COLUMN 13 MUST BE W/N 10% OF COLUMN 7)

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CATCH BASIN DESIGN DATA SHEET

Scale: not to scale | Sheet #: 1 of 1 | Detail # **682.05**

STORM DRAINAGE DESIGN DATA SHEET

PROJECT ___________________________ DESIGNED BY________________________ DATE___________,20____

LOCATION ___________________________ CHECKED BY ________________________ SHEET _____ OF _____

STORM FREQUENCY _________ YEARS

LOCATION		AREA (ACRE)		C	INTENSITY			Q=CIA (C.F.S. REQ'D)	PIPE DATA							HGL	REMARKS
FROM	TO	SUB TOTAL	TOTAL		H	L	I		TYPE	N	S%	LENGTH	SIZE	VEL. (OF Q REQ'D)	Q AVAIL.		

C = RUNOFF COEFFICIENT
H = HEIGHT ABOVE INLET OF MOST REMOTE POINT
L = LENGTH OF DRAINAGE AREA
I = INTENSITY OF STORM (INCHES)
N = COEFFICIENT OF FRICTION
S = SLOPE (%)
Q = FLOW (C.F.S.)

NOTE: DESIGN BASED ON THE SUM OF AREAS AND NOT THE SUM OF THE DISCHARGES.

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STORM DRAINAGE DESIGN DATA SHEET

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COEFFICIENT OF ENTRANCE LOSS, "ke"

TYPE OF STRUCTURE AND DESIGN OF ENTRANCE	COEFFICIENT Ke:
PIPE, CONCRETE	
Projecting from fill	0.5
Headwall or headwall and wingwalls	0.5
Mitered to conform to fillslope	0.7
PIPE OR PIPE-ARCH, CORRUGATED METAL	
Projecting (no headwall)	0.9
Headwall or headwall and wingwalls	0.5
Mitered to conform to fillslope	0.7
BOX REINFORCED CONCRETE	
Headwall	0.5
Wingwall at 30 degrees to 75 degrees to barrel	0.4
Wingwalls at 10 degrees to 25 degrees to barrel	0.5

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No.	Date	Description
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COEFFICIENT OF ENTRANCE LOSS, "ke"

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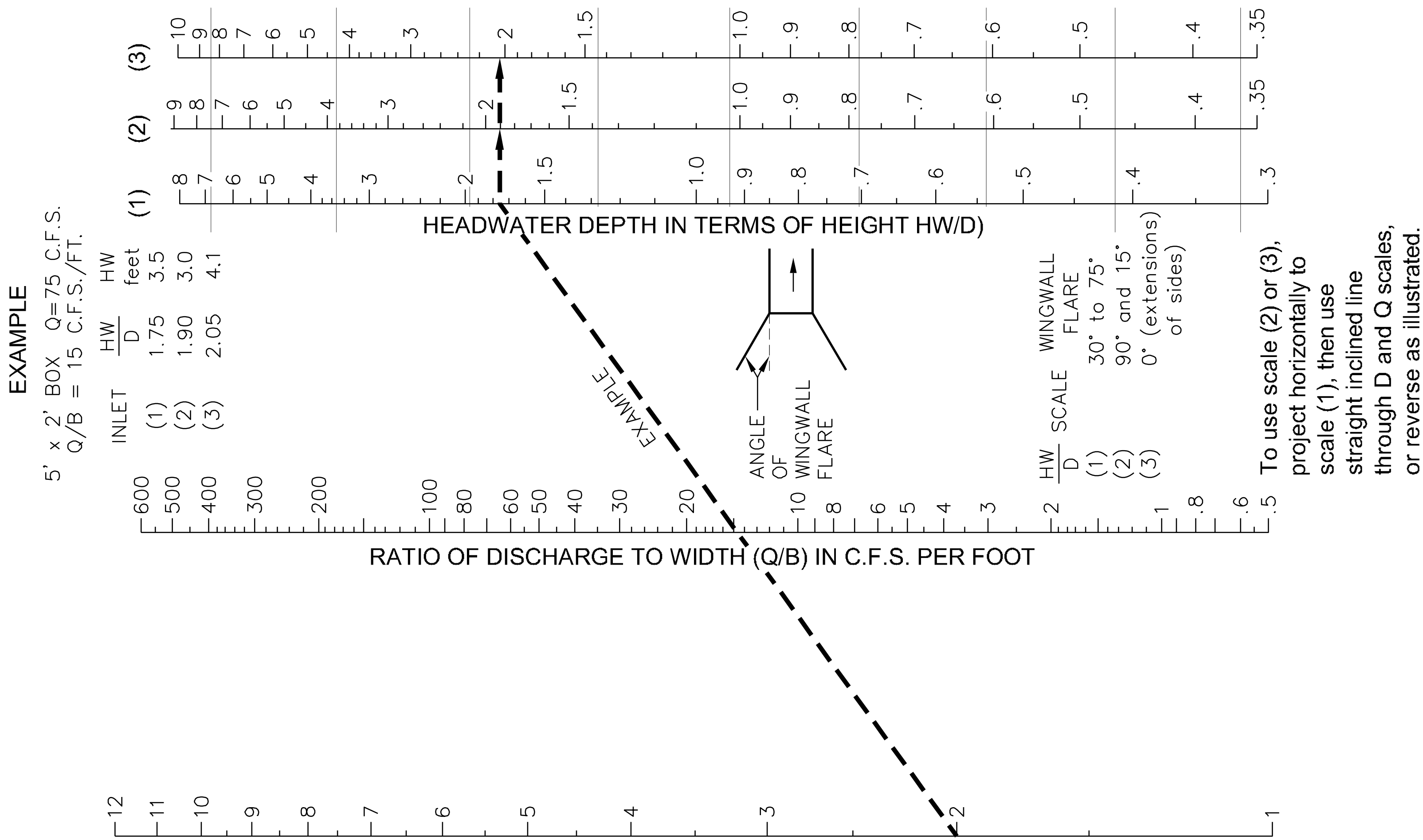
Detail # **682.07**



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

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No.	Date	Description
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BOX CULVERT DESIGN - INLET CONTROL

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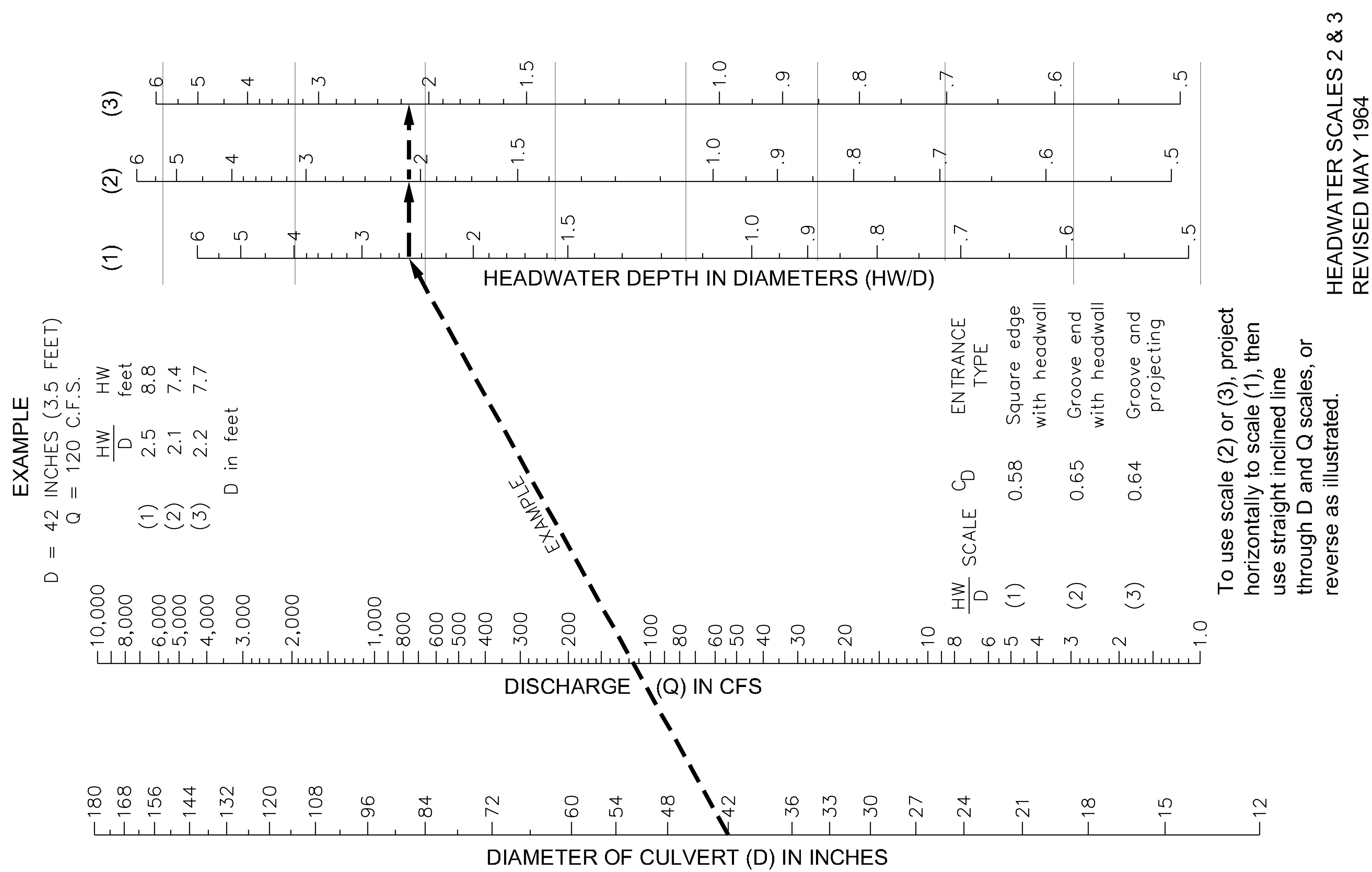

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

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CONCRETE PIPE CULVERTS - INLET CONTROL

Scale:	Sheet #:	Detail #
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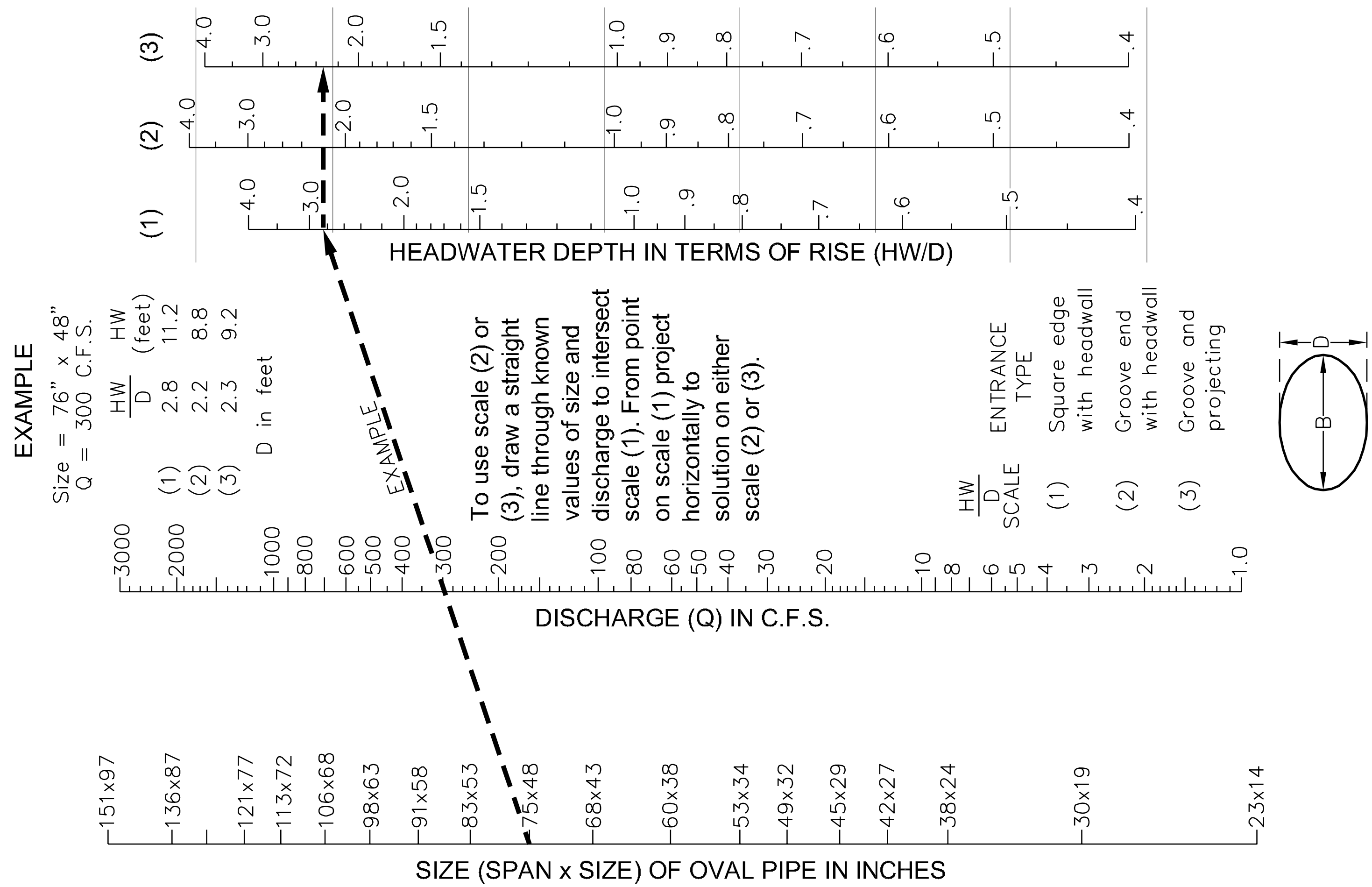

HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL WITH INLET CONTROL

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ELLIPTICAL CONCRETE PIPE CULVERTS - INLET CONTROL

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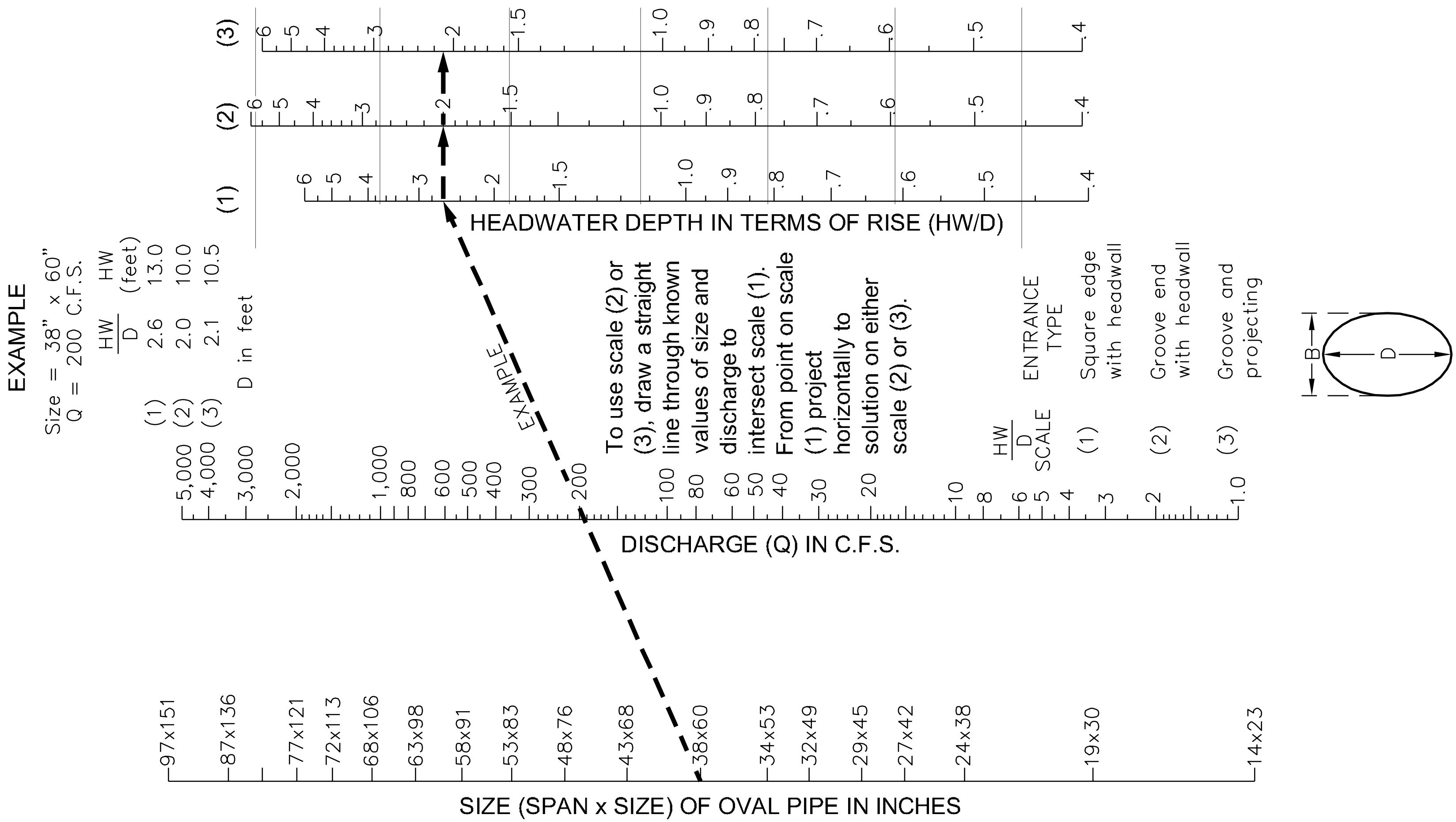

HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS VERTICAL WITH INLET CONTROL

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ELLIPTICAL CONCRETE PIPE CULVERTS - INLET CONTROL

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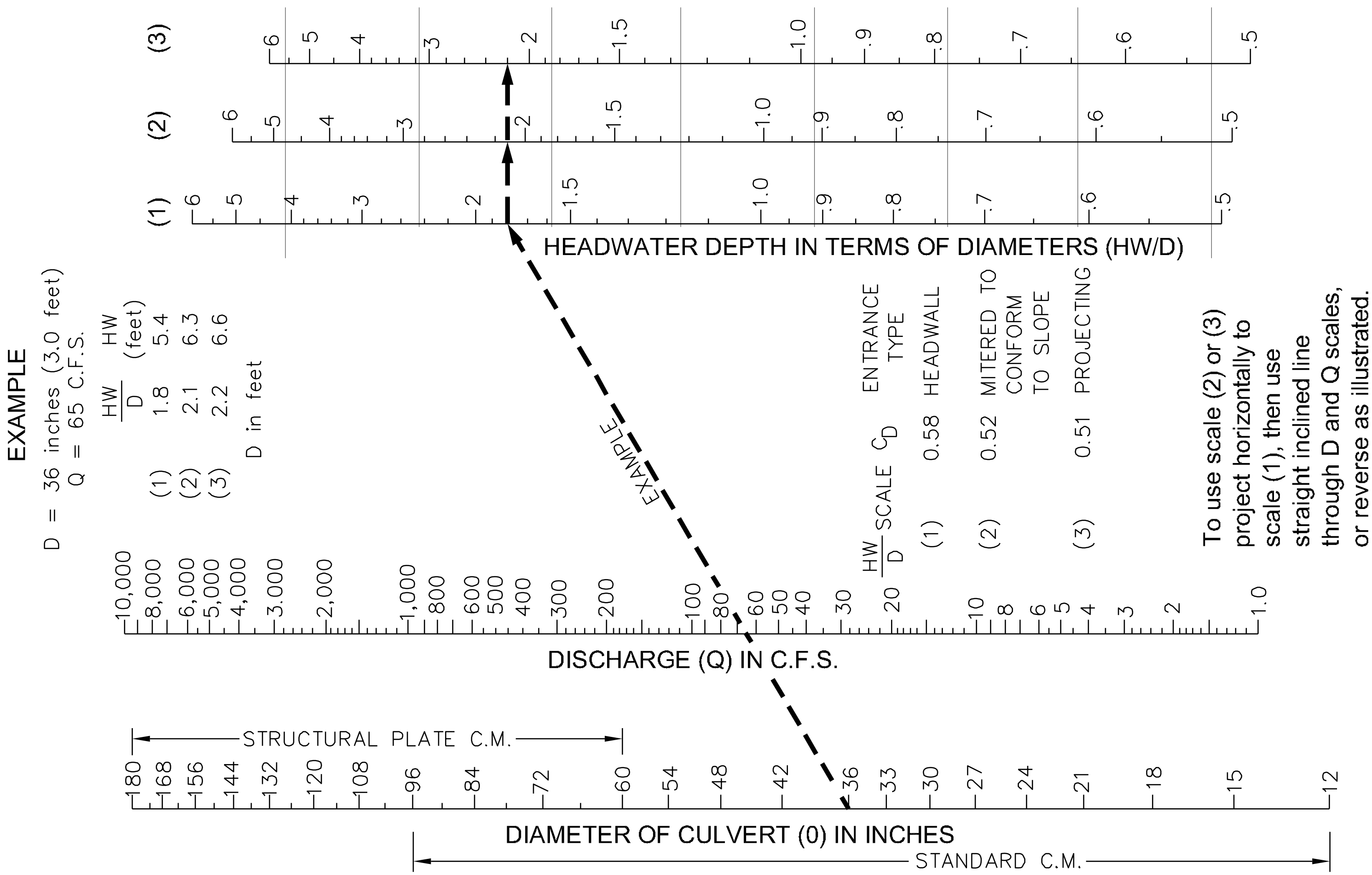

HEADWATER DEPTH FOR C.M. PIPE CULVERTS WITH INLET CONTROL

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No.	Date	Description
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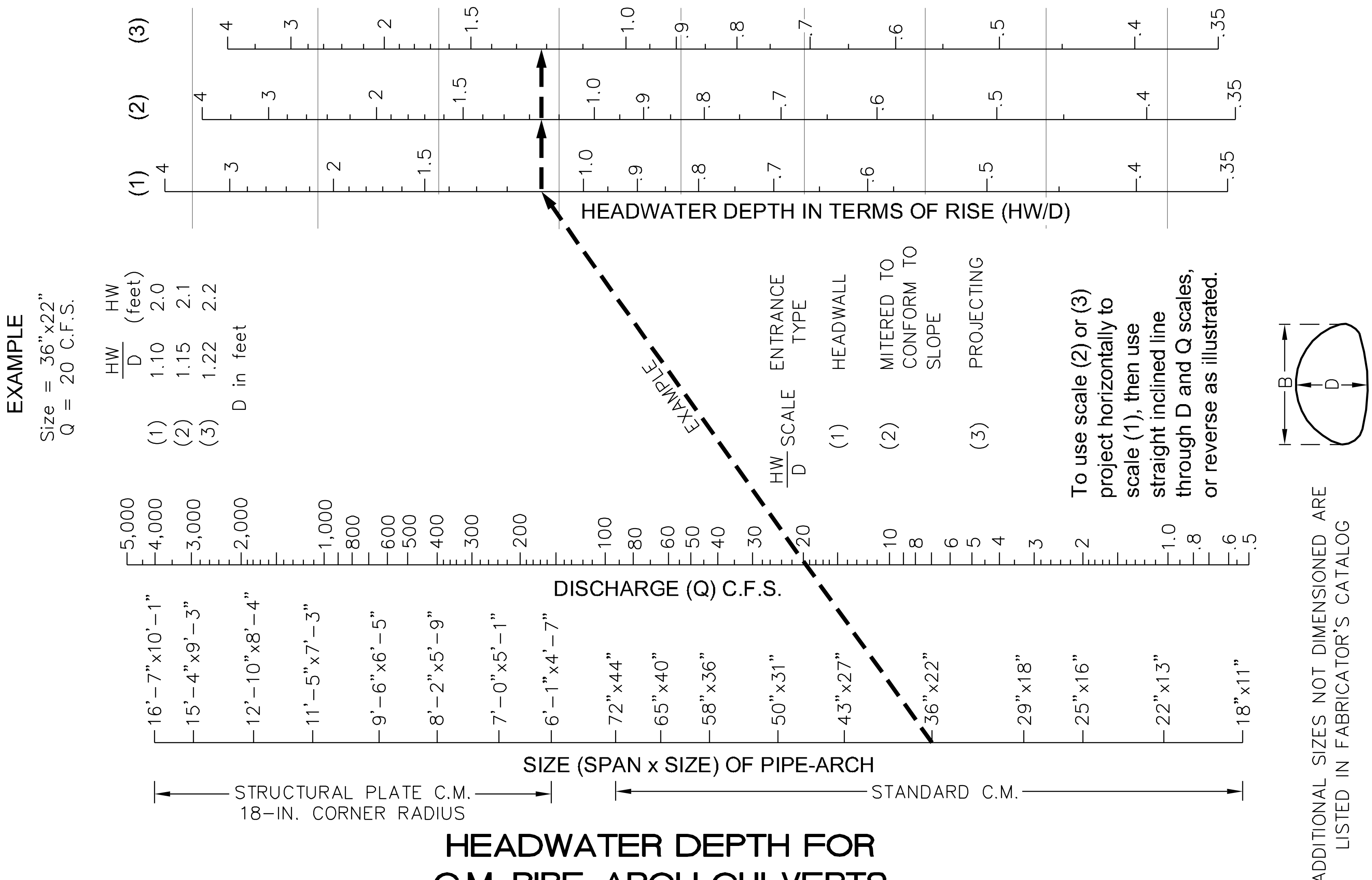
C.M. PIPE CULVERTS - INLET CONTROL

Scale:	Sheet #:	Detail #
not to scale	1 of 1	683.05



HEADWATER DEPTH FOR C.M. PIPE-ARCH CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS - JAN. 1963

PUBLIC WORKS DEPARTMENT
1500 Beatty Street
Greenville, North Carolina 27834

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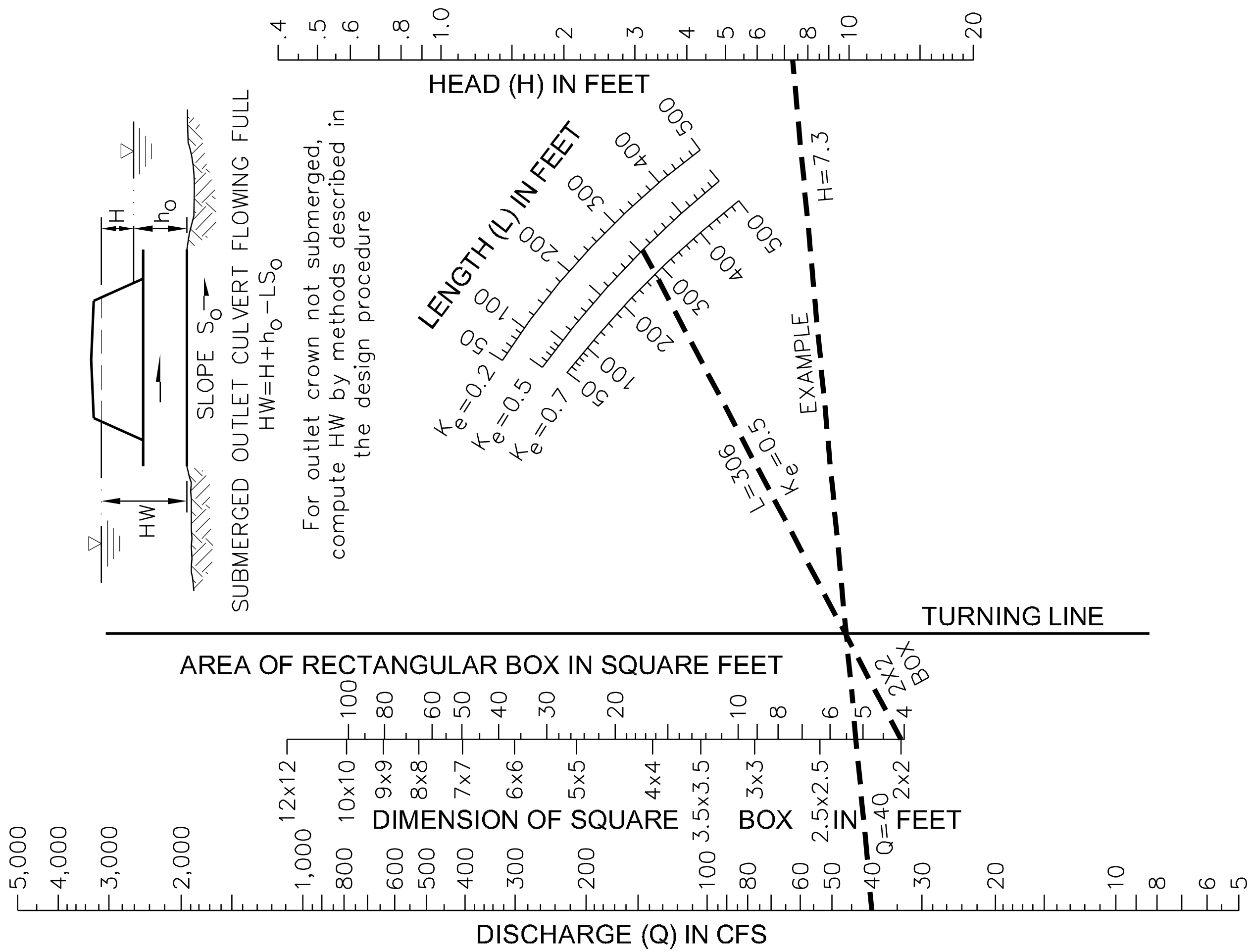
1	9/16/11	APPROVAL

C.M. PIPE ARCH CULVERTS - INLET CONTROL

Scale:	Sheet #:	Detail #
not to scale	1 of 1	683.06



HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL

n=0.013

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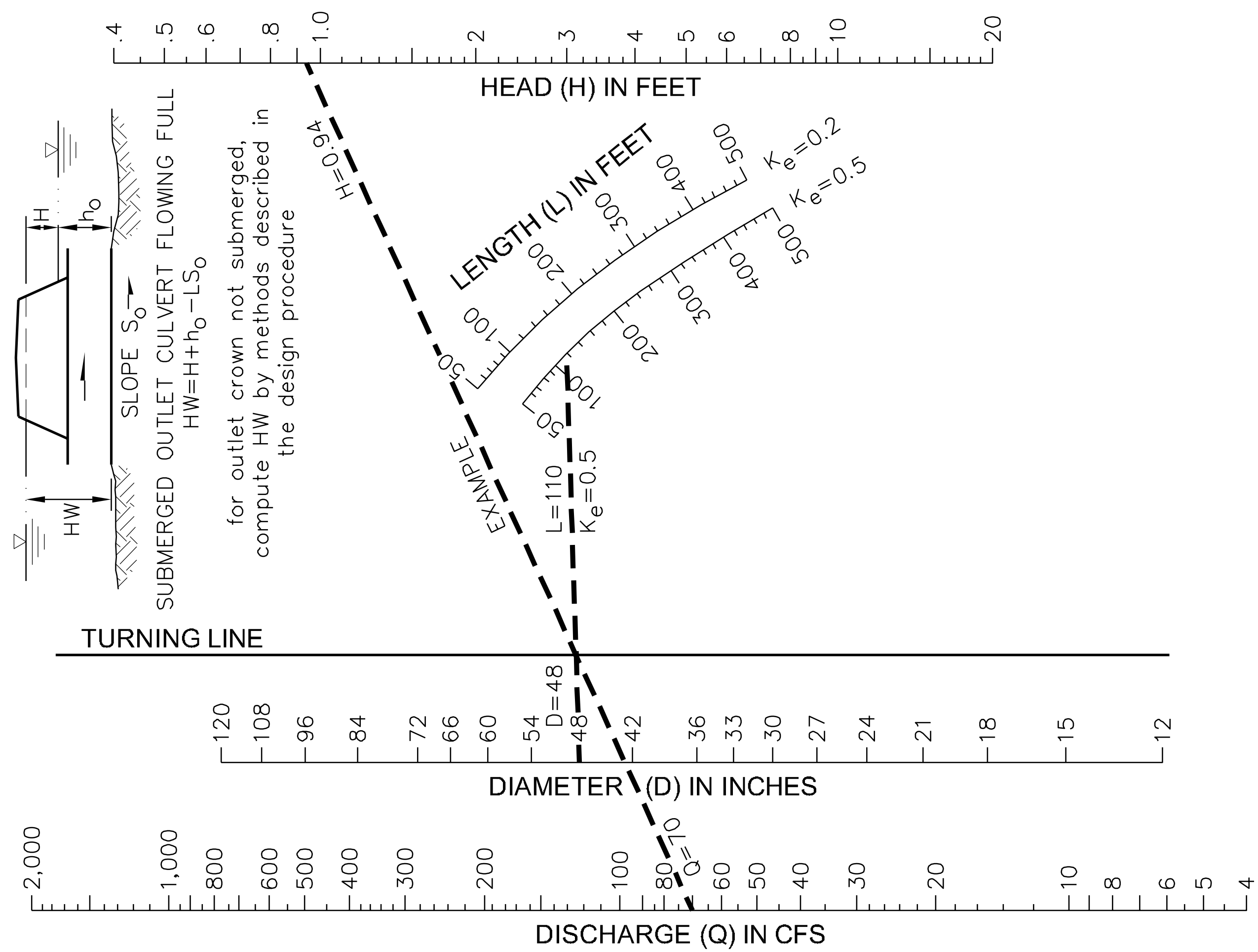
CONCRETE BOX CULVERTS - OUTLET CONTROL

Scale:	Sheet #:	Detail #
not to scale	1 of 1	683.07



HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL

n=0.013

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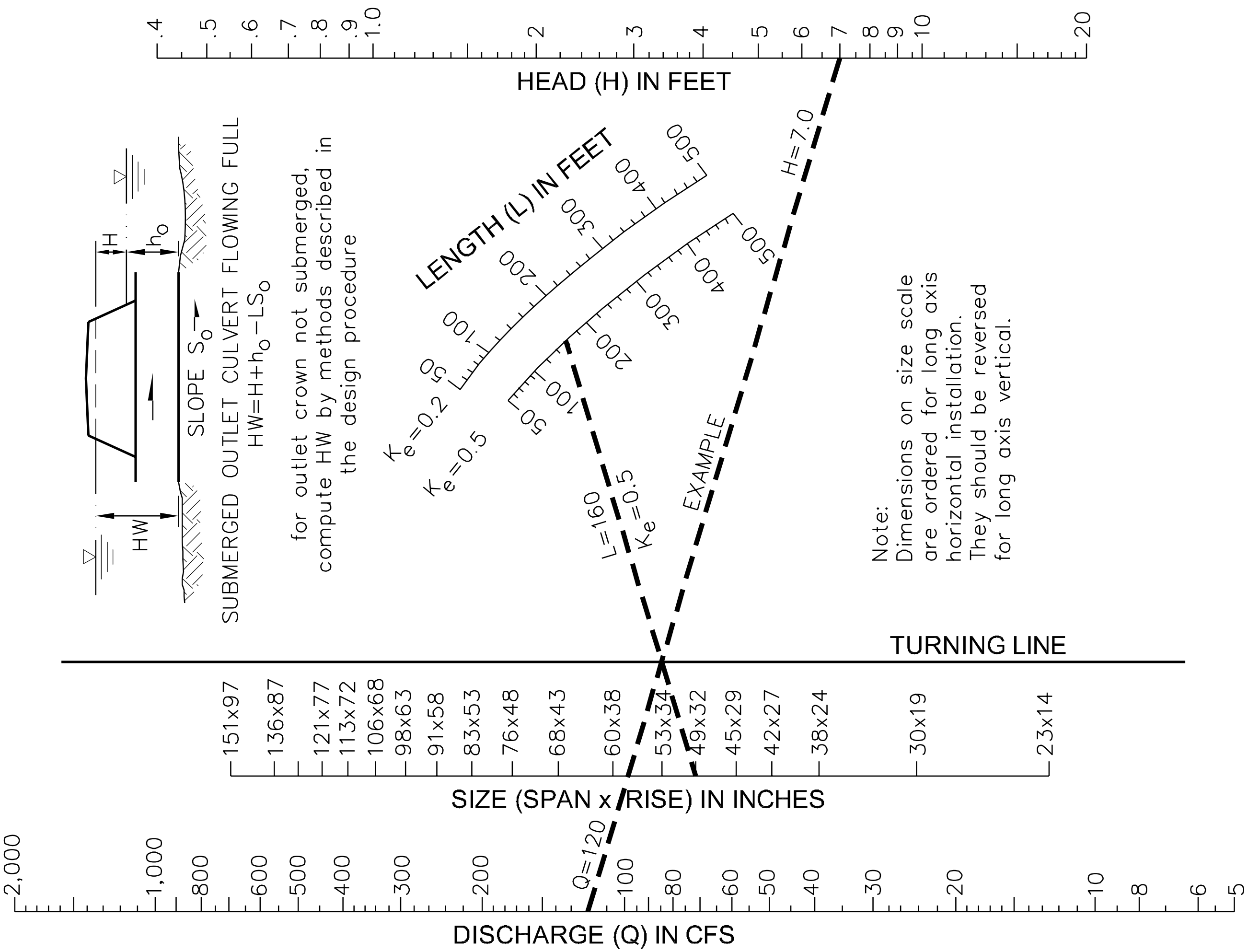
CONCRETE PIPE CULVERTS - OUTLET CONTROL

Scale:	Sheet #:	Detail #
not to scale	1 of 1	683.08



HEAD FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL OR VERTICAL FLOWING FULL

$n=0.013$

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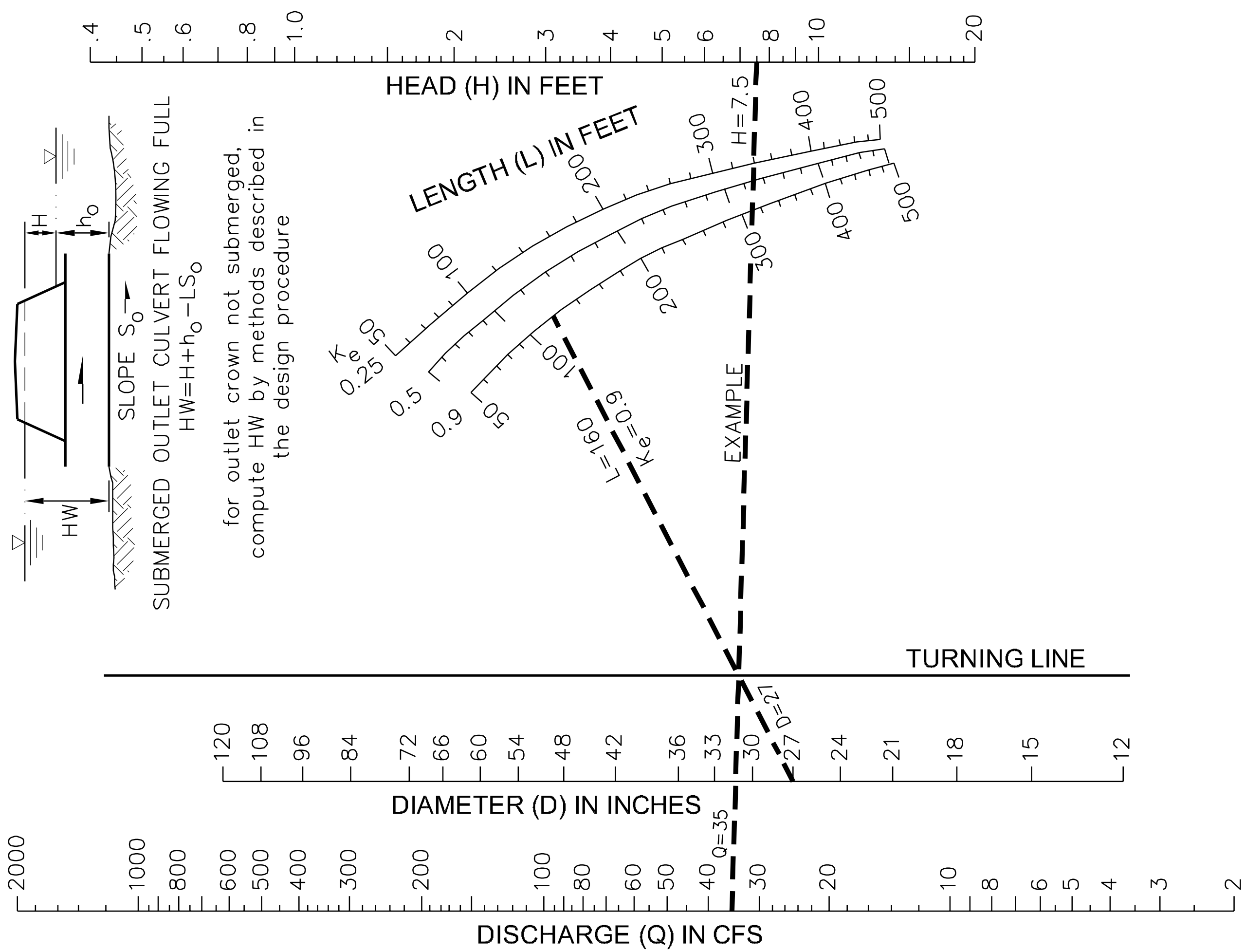
ELLIPTICAL CONCRETE PIPE CULVERTS - OUTLET CONTROL

Scale:	Sheet #:	Detail #
not to scale	1 of 1	683.09



HEAD FOR STANDARD C.M. PIPE CULVERTS FLOWING FULL

n=0.024

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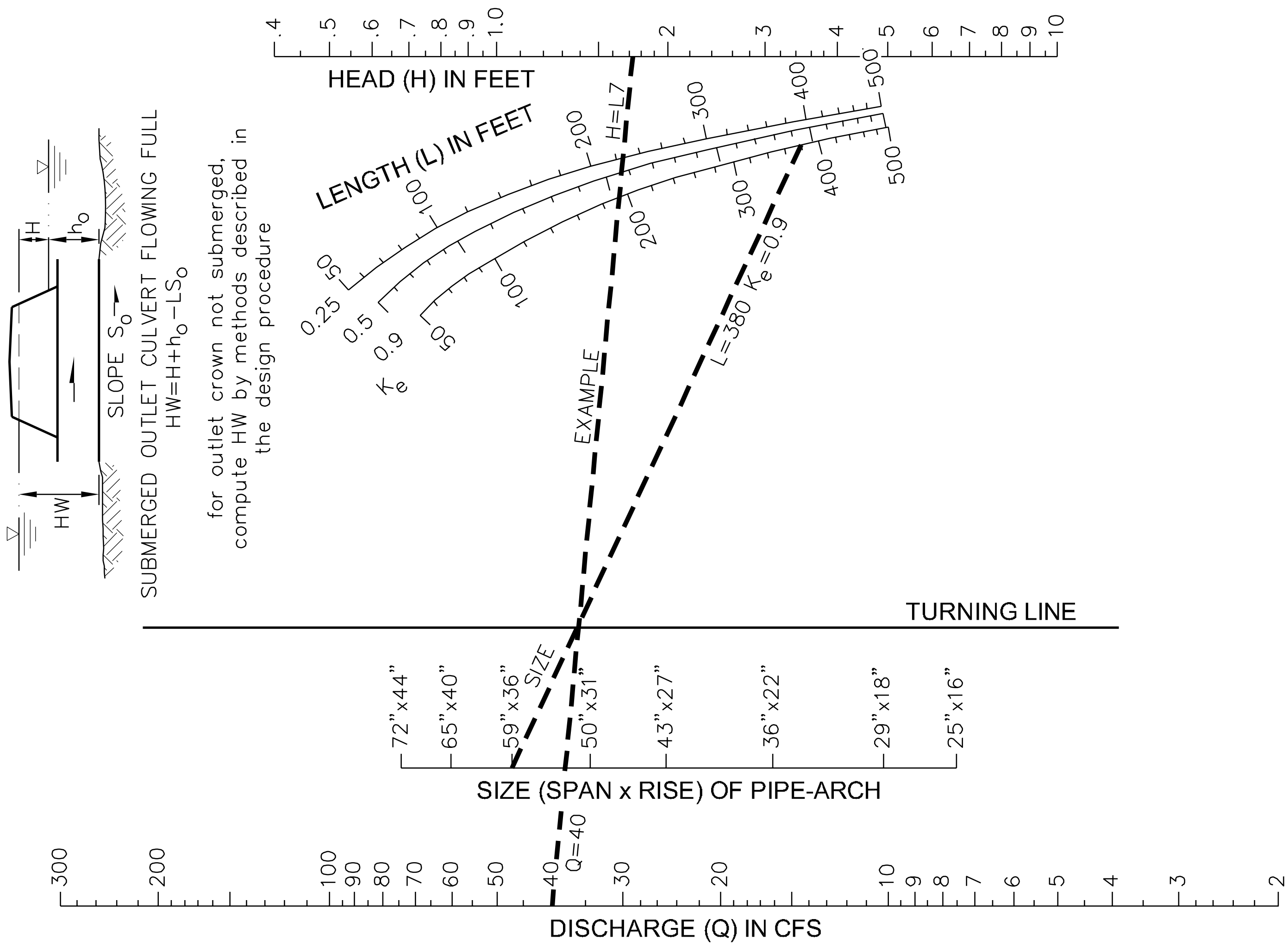
1	9/16/11	APPROVAL

C.M. PIPE CULVERTS - OUTLET CONTROL

Scale: not to scale | Sheet #: 1 of 1 | Detail # 683.10



HEAD FOR STANDARD C.M. PIPE-ARCH CULVERTS FLOWING FULL

n=0.024

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C.M. PIPE ARCH CULVERTS - OUTLET CONTROL

Scale:	Sheet #:	Detail #
not to scale	1 of 1	683.11