CHAPTER 11
APPENDIX

TABLES AND FIGURES

Tables

Table 11.1
Runoff Coefficients for Rational Method

Land Use or Surface Characteristics	Percent Impervious	Storm Frequency, years 5	10	100
Business:				
Commercial Areas	95	.88	.90	.93
Neighborhood Areas	65	.65	.70	.80
Residential:				
Single-Family	40	.45	.50	.70
Multi-Unit (detached)	50	.55	.60	.75
Multi-Unit (attached)	70	.70	.70	.80
1/2 Acre Lot or Larger	30	.40	.45	.65
Apartments	70	.70	.70	.80
Industrial:				
Light Areas	80	.80	.80	.85
Heavy Areas	90	.80	.85	.90
Parks, Cemeteries:	7	.25	.35	.60
Playgrounds:	13	.30	.40	.70
Schools:	50	.55	.60	.75
Railroad Yard Areas:	40	.45	.50	.70
Undeveloped Areas:				
Historic Flow Analysis Greenbelts, Agricultural	2	.20	.30	.60
Offsite Flow Analysis (when land use not defined)	45	.50	.55	.72
Streets:				
Paved	100	.88	.90	.93
Gravel	7	.25	.35	.65
Drives and Walks:	96	.87	.90	.92
Roofs:	90	.85	.90	.90
Lawns, Sandy Soil:	0	.10	.20	.50
Lawns, Clay Soil:	0	.20	.30	.60

NOTE: These Rational Formula coefficients do not apply for larger basins where the time-of-concentration exceeds 60 minutes.

REFERENCE: Urban Drainage and Flood Control District Rational Formula Procedure, Hydrology Research Program, August 1979.

Table 11.2

Roughness Coefficients (Manning's n) for Sheet Flow

Surface Description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).

[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Table 11.3
Reduction Factors to Apply to Inlets

Condition	Inlet Type	% of Theoretical Capacity Allowed
Sump	Grated	50%
Sump	Combination	65%
Continuous Grade	Deflector	75%
Continuous Grade	Longitudinal Bar Grate incorporating recessed transverse bars	60%
Continuous Grade	Combination	110% of that listed for type of grate utilized
Sump or Continuous Grade	Curb Opening	
	L = 3'	80%
	L = 6'	88%
	L = 8'	90%
	L = 10'	92%
	L = 15'	95%

TABLE 11.4
BMP Pollutant Removal Ranges for Stormwater Runoff and Most Probable Range for BMPs

Type of BMP	(1)	TSS	TP	TN	TZ	TPb	BOD	Bacteria
Grass Buffer	LRR:	10–50	0–30	0–10	0–10	N/A	N/A	N/A
	EPR	10–20	0–10	0–10	0–10	N/A	N/A	N/A
Grass Swale	LRR:	20–60	0–40	0–30	0–40	N/A	N/A	N/A
	EPR	20–40	0–15	0–15	0–20	N/A	N/A	N/A
Modular Block Porous Pavement	LRR:	80–95	65	75–85	98	80	80	N/A
	EPR	70–90	40–55	10–20	40–80	60–70	N/A	N/A
Porous Pavement Detention	LRR:	8–96	5–92	-130–85	10–98	60–80	60–80	N/A
	EPR	70–90	40–55	10–20	40–80	60–70	N/A	N/A
Porous Landscape Detention	LRR:	8–96	5–82	-100–85	10–98	60–90	60–80	N/A
	EPR	70–90	40–55	20–55	50–80	60–80	N/A	N/A
Extended Detention Basin	LRR:	50–70	10–20	10–20	30–60	75–90	N/A	50–90
	EPR	55–75	45–55	10–20	30–60	55–80	N/A	N/A
Constructed Wetland Basin	LRR:	40–94	-4–90	21	-29–82	27–94	18	N/A
	EPR	50–60	40–80	20–50	30–60	40–80	N/A	N/A
Retention Pond	LRR:	70–91	0–79	0–80	0–71	9–95	0–69	N/A
	EPR	80–90	45–70	20–60	20–60	60–80	N/A	N/A
Sand Filter Extended Detention	LRR:	8–96	5–92	-129–84	10–98	6D–80	60–80	N/A
	EPR	80–90	45–55	35–55	50–80	60–80	60–80	N/A
Constructed Wetland Channel*	LRR:	20–60	0–40	0–30	0–40	N/A	N/A	N/A
	EPR	30–50	20–40	10–30	20–40	20–40	N/A	N/A

(1) LRR Literature reported range, **EPR**-expected probable range of annual performance by BMPs.
N/A Insufficient data to make an assessment.

* The **EPR** rates for a Constructed Wetland Channel assume the wetland surface area is equal or greater than 0.5% of the tributary total impervious area.

TABLE 11.5
Irrigated Grass Buffer Strip Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn Mowing	Maintain a dense grass cover at a recommended length of 2 to 4 inches. Collect and dispose of cuttings offsite or use a mulching mower.	Routine—as needed or recommended by inspection
Lawn care	Use the minimum amounts of biodegradable, nontoxic fertilizers and herbicides needed to maintain dense grass cover, free of weeds. Reseed and patch damaged areas	Routine—as needed.
Irrigation	Adjust the timing sequence and water cover to maintain the required minimum soil moisture for dense grass growth. Do not overwater	As needed.
Litter removal	Remove litter and debris to prevent gully development, enhance aesthetics, and prevent floatables from being washed offsite.	Routine—as needed by inspection.
Inspections	Inspect irrigation, turf grass density, flow distribution, gully development, and traces of pedestrian or vehicular traffic and request repairs as needed.	Annually and after each major storm (that is, larger than 0.75 inch in precipitation).
Turf replacement	To lower the turf below the surface of the adjacent pavement, use a level flow spreader so that sheet flow is not blocked and will not cause water to back up onto the upstream pavement.	As needed when water ponding becomes too high or too frequent a problem. The need for turf replacement will be higher if the pavement is sanded in winter to improve tire traction on ice. Otherwise, expect replacement once every 5 to 15 years.

TABLE 11.6
Grass-Lined Swale Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn Mowing and Lawn Care	Maintain irrigated grass at 2 to 4 inches tall and nonirrigated native grass at 6 to 8 inches tall. Collect cuttings and dispose of them offsite or use a mulching mower.	Routine—as needed.
Debris and Litter Removal	Keep the area clean for aesthetic reasons, which also reduces floatables being flushed downstream.	Routine—as needed by inspection, but no less than two times per year.
Sediment Removal	Remove accumulated sediment near culverts and in channels to maintain flow capacity. Replace the grass areas damaged in the process	Routine—as needed by inspection. Estimate the need to remove sediment from 3 to 10 percent of total length per year, as determined by annual inspection.
Grass Reseeding and Mulching	Maintain a healthy dense grass in channel and side slope.	Nonroutine—as needed by annual inspection.
Inspections	Check the grass for uniformity of cover, sediment accumulation in the swale, and near culverts.	Routine—annual inspection is suggested.

TABLE 11.7
Porous Landscape Detention Maintenance Considerations

Required Action	Maintenance Objectives	Frequency
Lawn mowing and vegetative care	Occasional mowing of grasses and weed removal to limit unwanted vegetation. Maintain irrigated turf grass as 2 to 4 inches. tall and nonirrigated native turf grasses at 4 to 6 inches.	Routine—depending on aesthetic requirements.
Debris and litter removal	Remove debris and litter from detention area to minimize clogging of the sand media.	Routine—depending on aesthetic requirements
Landscaping removal and replacement	The sandy loam turf and landscaping layer will clog with time. This layer will need to be removed and replaced, along with all turf and other vegetation growing on the surface, to rehabilitate infiltration rates.	Every 5 to 10 years; depending on infiltration rates needed to drain the WQCV in 12 hours or less. May need to do it more frequently if exfiltration rates are too low to achieve this goal.
Inspections	Inspect detention area to determine if the sand media is allowing acceptable infiltration	Routine—biannual inspection of hydraulic performance

TABLE 11.8
Extended Detention Basin Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and lawn care	Occasional mowing to limit unwanted vegetation. Maintain irrigated turf grass as 2 to 4 inches tall and nonirrigated native turf grasses at 4 to 6 inches.	Routine—depending on aesthetic requirements.
Debris and litter removal	Remove debris and litter from the entire pond to minimize outlet clogging and improve aesthetics.	Routine—including just before annual storm seasons (that is, April and May) and following significant rainfall events.
Erosion and sediment control	Repair and revegetate eroded areas in the basin and channels.	Nonroutine—periodic and repair as necessary based on inspection.
Structural	Repair pond inlets, outlets, forebays, low flow channel liners, and energy dissipators whenever damage is discovered.	Nonroutine—repair as needed based on regular inspections.
Inspections	Inspect basins to insure that the basin continues to function as initially intended. Examine the outlet for clogging, erosion, slumping, excessive sedimentation levels, overgrowth, embankment and spillway integrity, and damage to any structural element.	Routine—annual inspection of hydraulic and structural facilities. Also check for obvious problems during routine maintenance visits, especially for plugging of outlets.
Nuisance control	Address odor, insects, and overgrowth issues associated with stagnant or standing water in the bottom zone.	Nonroutine—handle as necessary per inspection or local complaints.
Sediment removal	Remove accumulated sediment from the forebay, micro-pool, and the bottom of the basin.	Nonroutine—performed when sediment accumulation occupies 20 percent of the WQCV. This may vary considerably, but expect to do this every 10 to 20 years, as necessary per inspection if no construction activities take place in the tributary watershed. More often if they do. The forebay and the micro-pool will require more frequent cleanout than other areas of the basin, say every 1 or 2 years.

TABLE 11.9
Sand Filter Detention Basin Maintenance Considerations

Required Action	Maintenance Objectives	Frequency
Debris and litter removal	Remove debris and litter from detention area to minimize clogging of the sand media.	Routine—depending on aesthetic requirements
Landscaping removal and replacement	If the sand filter is covered with rock mulch, bluegrass, or other landscaping covers, the cover must be removed to allow access to the sand media. Replace landscaping cover after maintenance of sand media is complete.	Every 2 to 5 years
Scarify filter surface	Scarify top 3 to 5 inches by raking the filter's surface.	Once per year or when needed to promote drainage.
Sand filter removal	Remove the top 3 inches of sand from the sand filter. After a third removal, backfill with 9 inches of new sand to return the sand depth to 18 inches. Minimum sand depth is 12 inches.	If no construction activities take place in the tributary watershed, every 2 to 5 years, depending on observed drain times, namely when it takes more than 24 hours to empty a 3-foot deep pool. Otherwise more often. Expect to clean out forebay every 1 to 5 years.
Inspections	Inspect detention area to determine if the sand media is allowing acceptable infiltration.	Routine—biannual inspection of hydraulic performance, one after a significant rainfall.

TABLE 11.10
Wetland Pool Area Distribution

Components	Percent of Permanent Pool Surface Area	Water Design Depth
Forebay, outlet and free water surface areas	30% to 50%	2 to 4 feet deep
Wetland zones with emergent vegetation	56% to 70%	6 to 12 inches deep*

*One-third to one-half of this zone should be 6 inches deep.

TABLE 11.11
Constructed Wetlands Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and lawn care	Mow occasionally to limit unwanted vegetation. Maintain irrigated turf grass at 2 to 4 inches tall and nonirrigated native turf grasses at 4 to 6 inches.	Routine—depending on aesthetic requirements.
Debris and litter removal	Remove debris and litter from entire pond to minimize outlet clogging and aesthetics. Include removal of floatable material from the pond's surface.	Routine —including just before annual storm seasons (that is, in April and May) and following significant rainfall events.
Sediment removal	Remove accumulated sediment and muck along with much of the wetland growth. Reestablish growth zone depths and spatial distribution. Revegetate with original wetland species.	Nonroutine—every 10 to 20 years as needed by inspection if no construction activities take place in the tributary watershed. More often if they do. Expect to clean out forebay every 1 to 5 years.
Aquatic plant harvesting	Cut and remove plants growing in wetland (such as cattails and reeds) to remove nutrients permanently with manual work or specialized machinery.	Nonroutine until further evidence indicates such action would provide significant nutrient removal. In the meantime, perform this task once every 5 years or less frequently as needed to clean the wetland zone out.
Inspections	Observe inlet and outlet works for operability. Verify the structural integrity of all structural elements, slopes, and embankments.	Routine—at least once a year, preferably once during one rainfall event resulting in runoff.

TABLE 11.12
Recommended Tree and Shrub Spacing

	Tree Spacing (feet)	Shrub Spacing (feet)	Total Density (stems/acre)
Maximum	19	12	400
Average	12	8	1,000
Minimum	11	7	1,250

Source: Prince George's County, 1993.

TABLE 11.13A

Standardized WQCV Outlet Design Using Circular Openings (2" diameter maximum). Minimum Width ($W_{conc.}$) of Concrete Opening for a Well-Screen-Type Trash Rack. Requires minimum water depth below lowest perforation of 2' 4". See Figure 11.50b for Explanation of Terms.

Maximum Dia. of Circular Opening (in.)	Width of Trash Rack Opening ($W_{conc.}$) Per Column of Holes as a Function of Water Depth H					
	H=2.0'	H=3.0'	H=4.0'	H=5.0'	H=6.0'	Maximum Number of Columns
≤ 0.25	3 in.	3 in.	3 in.	3 in.	3 in.	14
≤ 0.50	3 in.	3 in.	3 in.	3 in.	3 in.	14
≤ 0.75	3 in.	6 in.	6 in.	6 in.	6 in.	7
≤ 1.00	6 in.	9 in.	9 in.	9 in.	9 in.	4
≤ 1.25	9 in.	12 in.	12 in.	12 in.	15 in.	2
≤ 1.50	12 in.	15 in.	18 in.	18 in.	18 in.	2
≤ 1.75	18 in.	21 in.	21 in.	24 in.	24 in.	1
≤ 2.00	21 in.	24 in.	27 in.	30 in.	30 in.	1

TABLE 11.13B

Standardized WQCV Outlet Design Using 2" Diameter Circular Openings. US Filter™ Stainless Steel Well-Screen* (or equal) Trash Rack Design Specification.

Max. Width of Opening	Screen #93 VEE Wire Slot Opening	Support Rod Type	Support Rod, On-Center Spacing	Total Screen Thickness	Carbon Steel Frame Type
9"	0.139	#156 VEE	3/4"	0.31"	3/8" × 1.0" flat bar
18"	0.139	TE .074" × .50"	1"	0.655"	3/4" × 1.0 angle
24"	0.139	TE .074" ×.75"	1"	1.03"	1.0" × 1½" angle
27"	0.139	TE .074" × .75"	1"	1.03"	1.0" x 1½" angle
30"	0.139	TE .074" × 1.0"	1"	1.155"	1¼" x ½" angle
36"	0.139	TE .074" × 1.0"	1"	1.155"	1¼" x 1½" angle
42"	0.139	TE .105" × 1.0"	1"	1.155"	1¼" x 1½" angle

*US Filter, St. Paul, Minnesota, USA

DESIGN EXAMPLE:

Given: A WQCV outlet with an orifice plate consisting of three columns of 5/8 in. (0.625 in) diameter openings. Water Depth H above the lowest orifice plate opening of 3.5 ft.

Solution: The dimensions within the mounting frame for a well screen trash rack are determined as follows.

Trash Rack Width: Given an orifice plate with 0.75 in. openings (i.e., rounded up from 5/8 in. actual diameter of the opening) and the Water Depth H = 4 ft (i.e., rounded up from 3.5 ft), Table 11.13a shows the minimum width for each column of openings is 6 in. Thus, the total trash rack width, W_{conc}, equals 3 columns × 6 in. = 18 in.

Trash Rack Height: Total trash rack height is the sum of the Water Depth H plus 2' (the height of the trash rack below the water depth; see Section A-A of Figure 11.50b). Thus, trash rack height equals 3'6" + 2' 0" = 66 in.

Dimensions Note: These trash rack dimensions are the minimum dimensions within the mounting frame. The trash rack mounting frame must be properly sized by a structural engineer taking into account the minimum trash rack dimensions, the intended method of fabrication, and the method of connection to the outlet structure.

Ordering Specifications: From Table 11.13b, select ordering specifications for an 18", or less, wide opening trash rack using US Filter (or equal) stainless steel well-screen with #93 VEE wire, 0.139" openings between wires, TE 0.074" × .50" support rods on 1.0" on-center spacing, total screen thickness of 0.655", with ¾ × 1.0" welded carbon steel frame.

TABLE 11.14A

Standardized WQCV Outlet Design Using 2" Height Rectangular Openings. Minimum Width ($W_{opening}$) of Opening for an Aluminum Bar Grate Trash Rack

Maximum Width W of 2" Height Rectangular Opening (inches)	Minimum Width of Trash Rack Opening as a Function of Water Depth H					
	H=2.0 ft	H=3.0 ft	H=4.0 ft	H=5.0 ft	H=6.0 ft	Spacing of Bearing Bars, Cross Rods
< 2.0	2.0 ft	2.5 ft	2.5 ft	2.5 ft	3.0 ft	1-3/16", 2"
< 2.5	2.5 ft	3.0 ft	3.0 ft	3.5 ft	3.5 ft	1-3/16", 2"
< 3.0	3.0 ft	3.5 ft	3.5 ft	4.0 ft	4.0 ft	1-3/16", 2"
< 3.5	3.5 ft	4.0 ft	4.5 ft	4.5 ft	5.0 ft	1-3/16", 2"
< 4.0	3.5 ft	4.5 ft	5.0 ft	5.0 ft	5.5 ft	1-3/16", 2"
< 4.5	4.0 ft	4.5 ft	5.0 ft	5.5 ft	5.5 ft	1-3/16", 4"
< 5.0	4.0 ft	5.0 ft	5.5 ft	6.0 ft	6.0 ft	1-3/16", 4"
< 5.5	4.5 ft	5.5 ft	6.0 ft	6.5 ft	7.0 ft	1-3/16", 4"
< 6.0	5.0 ft	6.0 ft	6.5 ft	7.0 ft	7.5 ft	1-3/16", 4"
< 6.5	5.5 ft	6.5 ft	7.0 ft	7.5 ft	8.0 ft	1-3/16", 4"
< 7.0	6.0 ft	7.0 ft	7.5 ft	8.5 ft	8.5 ft	1-3/16", 4"
< 7.5	6.0 ft	7.5 ft	8.5 ft	9.0 ft	9.5 ft	1-3/16", 4"
< 8.0	6.5 ft	8.0 ft	9.0 ft	9.5 ft	10.0 ft	1-3/16", 4"
< 8.5	7.0 ft	8.5 ft	9.5 ft	10.0 ft	N/A	1-3/16", 4"
< 9.0	7.5 ft	9.0 ft	10.0 ft	N/A	N/A	1-3/16", 4"
< 9.5	8.0 ft	9.5 ft	N/A	N/A	N/A	1-3/16", 4"
< 10.0	8.5 ft	10.0 ft	N/A	N/A	N/A	1-3/16", 4"
< 10.5	8.5 ft	N/A	N/A	N/A	N/A	1-3/16", 4"
< 11.0	9.0 ft	N/A	N/A	N/A	N/A	1-3/16", 4"
< 11.5	9.5 ft	N/A	N/A	N/A	N/A	1-3/16", 4"
< 12.0	10.0 ft	N/A	N/A	N/A	N/A	1-3/16", 4"

TABLE 11.14B
Standardized WQCV Outlet Design Using 2" Height Rectangular Openings. Klemp™ KRP Series Aluminum Bar Grate* (or equal) Trash Rack Design Specifications

Water Depth Above Lowest Opening, H	Minimum Bearing Bar Size, Bearing Bars Aligned Vertically
2.0 ft	1" × 3/16"
3.0 ft	1¼" × 3/16"
4.0 ft	1¾" × 3/16"
5.0 ft	2" × 3/16"
6.0 ft	2¼" × 3/16"

*Klemp Corporation, Orem, Utah, USA

DESIGN EXAMPLE:

Given: A WQCV outlet with an orifice plate consisting of 2" high by 6.5" wide openings with Water Depth H = 4.5 feet above the lowest orifice plate opening.

Solution: The dimensions of the concrete structure and the dimensions within the mounting frame for an aluminum bar grate trash rack are determined as follows.

Trash Rack and Structure Widths: There are three widths shown in Section B-B of Figure 11.50a: W = the width of the rectangular openings in the orifice plate, W_{conc} = the width of the concrete opening where the orifice plate attaches, and $W_{opening}$ = the width of the concrete opening where the trash rack attaches.

$W_{conc.}$ = W + 12" (from Figure 11.53) = 6.5" + 12" = 18.5".

$W_{opening}$: Given an orifice plate with rectangular openings 6.5" wide and Water Depth H = 5 feet (i.e., rounded up from 4.5 feet), Table 11-14a shows the minimum trash rack width, $W_{opening}$, is 7.5 feet.

Trash Rack Height: The total trash rack height is the sum of the Water Depth H plus 2' (the height of the trash rack below the water depth, as shown in Section A-A of Figure 11.50a). Thus, the trash rack height equals 4.5' + 2' = 6.5'.

Dimensions Note: These trash rack dimensions are the minimum dimensions within the mounting frame. The trash rack mounting frame must be properly sized by a structural engineer taking into account the minimum trash rack dimensions, the intended method of fabrication, and the method of connection to the outlet structure.

Ordering Specifications: From Tables 11.14a and 11.14b, the ordering specifications for H=5.0 feet or less is a Klemp Corporation aluminum bar grate (or equal) with 2" by 3/16" bearing bars spaced at 1-3/16" on-center, with cross rods spaced at 4" on-center. **Bearing bars are to be aligned vertically.**

Figures

RAINFALL INTENSITY, in / hr

Tc	5 YEAR	100 YEAR	2 YEAR	10 YEAR	25 YEAR	50 YEAR
15	4.39	7.43	3.53	5.04	6.00	6.72
16	4.27	7.23	3.42	4.9	5.83	6.54
17	4.15	7.05	3.32	4.77	5.68	6.37
18	4.04	6.87	3.23	4.65	5.54	6.21
19	3.93	6.71	3.13	4.53	5.4	6.06
20	3.83	6.55	3.05	4.42	5.27	5.91
21	3.74	6.40	2.97	4.31	5.14	5.78
22	3.65	6.25	2.89	4.21	5.02	5.64
23	3.57	6.11	2.82	4.12	4.91	5.52
24	3.49	5.98	2.75	4.03	4.80	5.40
25	3.41	5.86	2.68	3.94	4.70	5.28
26	3.34	5.74	2.62	3.86	4.60	5.17
27	3.27	5.62	2.55	3.78	4.50	5.07
28	3.2	5.51	2.5	3.71	4.41	4.97
29	3.14	5.40	2.44	3.63	4.33	4.87
30	3.08	5.30	2.39	3.57	4.24	4.77
31	3.02	5.20	2.34	3.50	4.16	4.68
32	2.96	5.11	2.29	3.44	4.08	4.60
33	2.91	5.02	2.24	3.37	4.01	4.51
34	2.86	4.93	2.20	3.32	3.94	4.43
35	2.81	4.84	2.15	3.26	3.87	4.36
36	2.76	4.76	2.11	3.20	3.80	4.28
37	2.72	4.68	2.07	3.15	3.74	4.21
38	2.67	4.61	2.03	3.10	3.68	4.14
39	2.63	4.53	2.00	3.05	3.61	4.07
40	2.59	4.46	1.96	3.01	3.56	4.01
41	2.55	4.39	1.93	2.96	3.50	3.94
42	2.51	4.32	1.89	2.91	3.45	3.88
43	2.47	4.26	1.86	2.87	3.39	3.82
44	2.43	4.20	1.83	2.83	3.34	3.76
45	2.40	4.13	1.80	2.79	3.29	3.71
46	2.36	4.08	1.77	2.75	3.24	3.65
47	2.33	4.02	1.74	2.71	3.20	3.60
48	2.30	3.96	1.71	2.68	3.15	3.55
49	2.27	3.91	1.69	2.64	3.11	3.50
50	2.24	3.85	1.66	2.61	3.06	3.45
51	2.21	3.80	1.64	2.57	3.02	3.41
52	2.18	3.75	1.61	2.54	2.98	3.36
53	2.15	3.70	1.59	2.51	2.94	3.32
54	2.13	3.66	1.56	2.48	2.90	3.27
55	2.10	3.61	1.54	2.45	2.87	3.23
56	2.07	3.56	1.52	2.42	2.83	3.19
57	2.05	3.52	1.50	2.39	2.80	3.15
58	2.03	3.48	1.48	2.36	2.76	3.11
59	2.00	3.44	1.46	2.33	2.73	3.07
60	1.98	3.39	1.44	2.31	2.69	3.04

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CHECKED BY: J.D.

APPROVED BY:

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Sources: FHA Circular No. 12, Drainage of Highway Pavements
Sources: U.S. Weather Bureau, Technical Paper No. 40, 1963.
NOAA Central Weather Service, Technical Memorandum NWS HYDRO-35, 1977.

SIOUX FALLS
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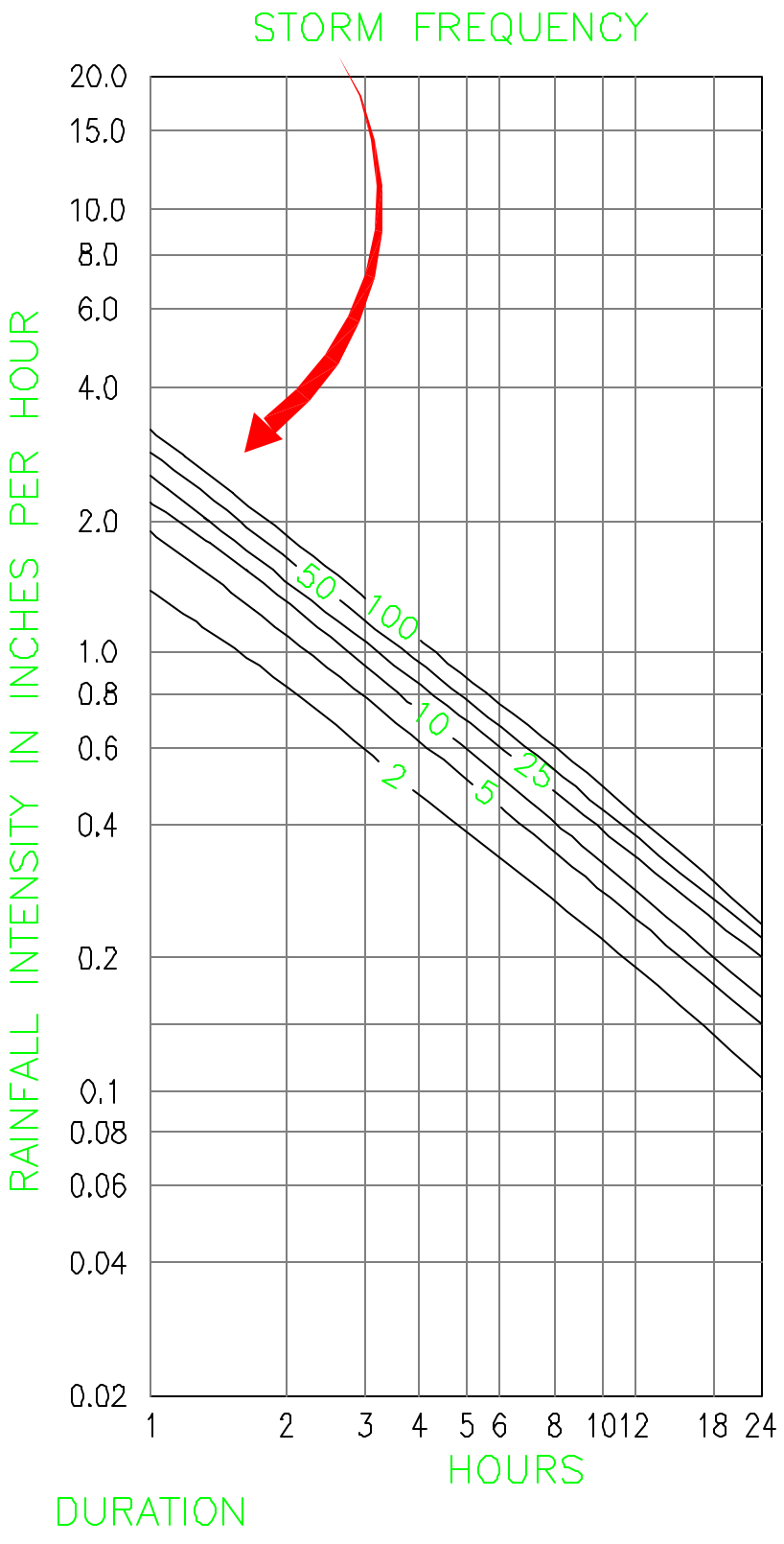
INTENSITY-DURATION-FREQUENCY CHART

ISSUED: MAY 03

REVISED:

FIGURE NO. 11.1A

04/14/17



Sources; U.S. Weather Bureau, Technical Paper No. 40, 1963.
NOAA Central Weather Service, Technical Memorandum NWS HYDRO-35, 1977.

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INTENSITY-DURATION-FREQUENCY

ISSUED: JULY 9, 1999
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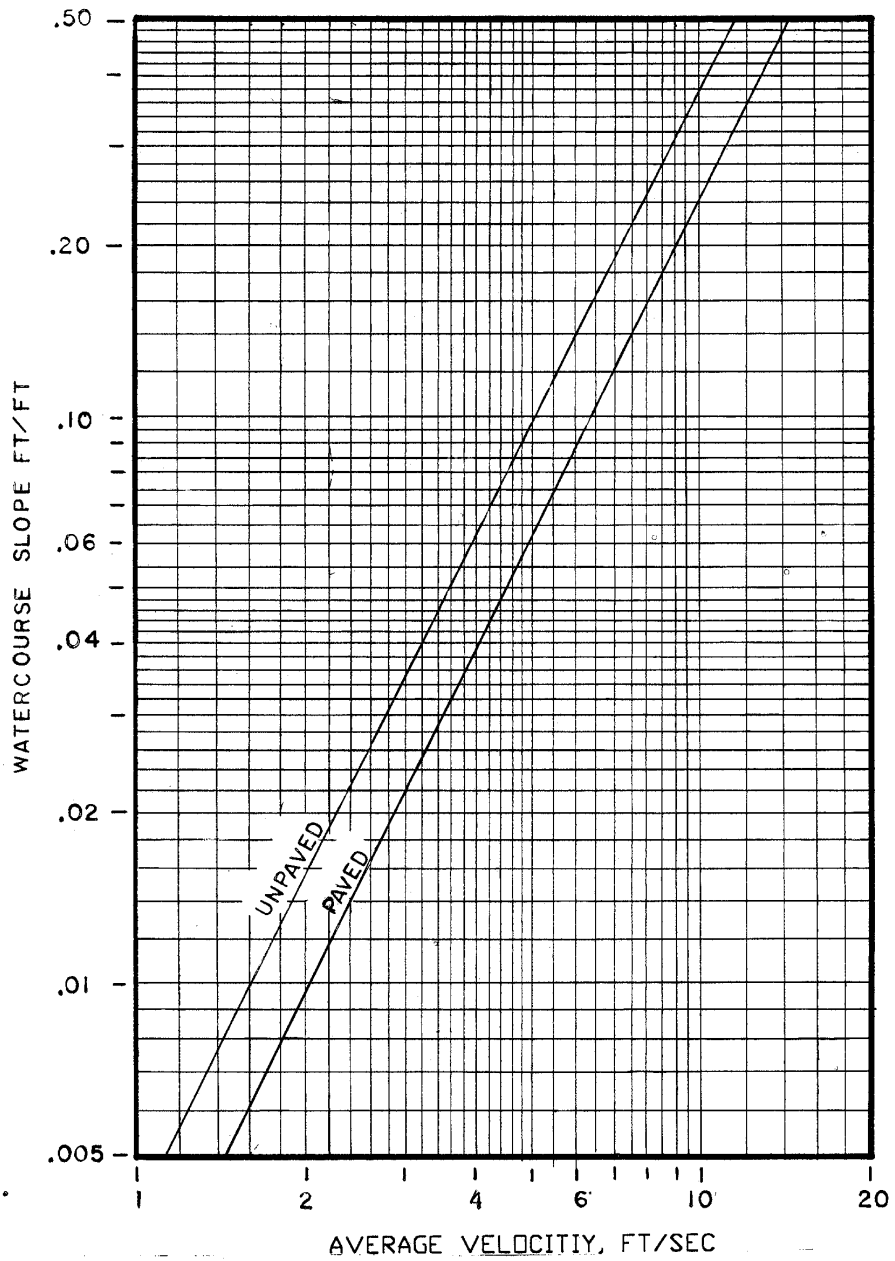
FIGURE NO.
11.1B

04/14/17



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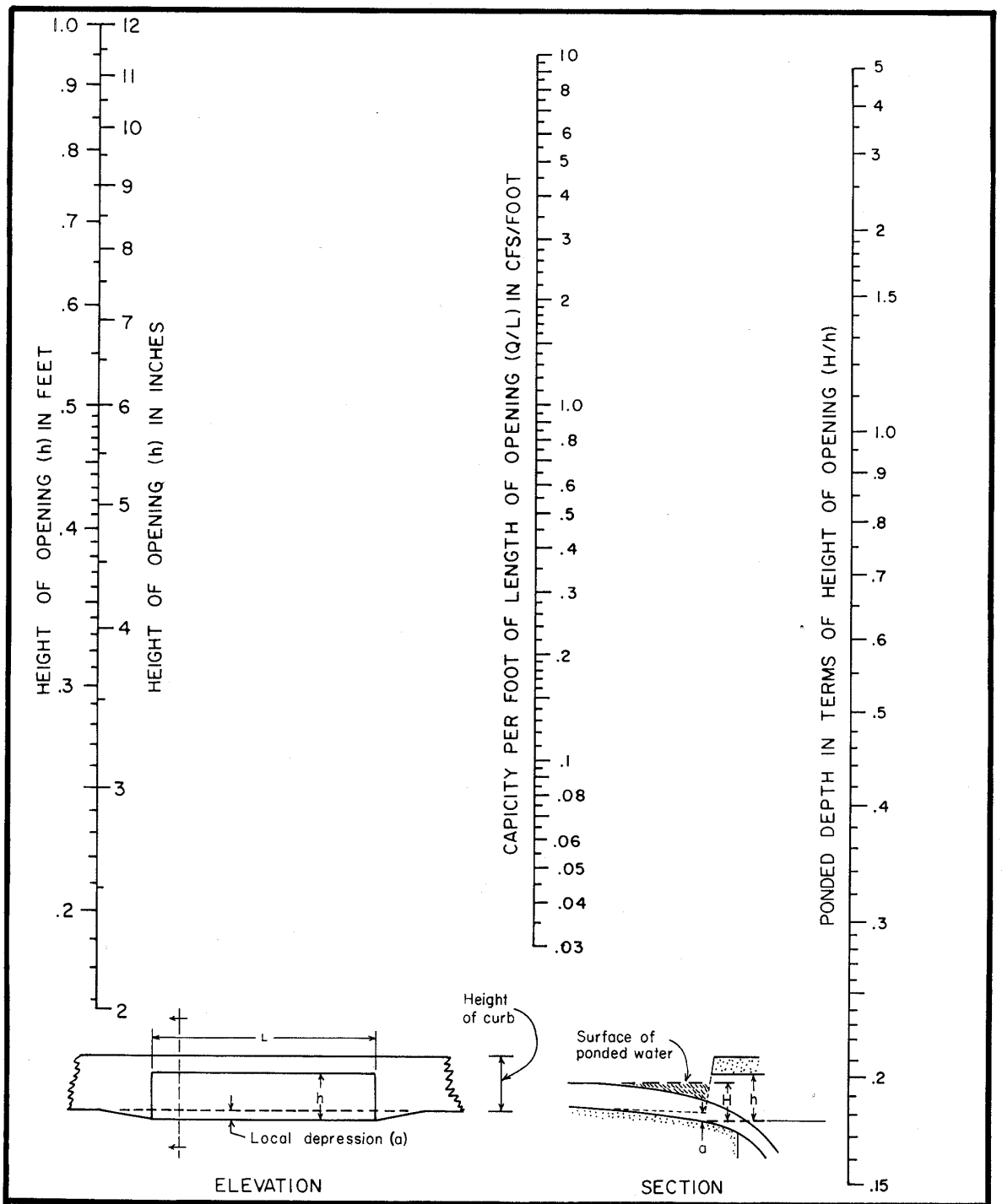
AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR SHALLOW CONCENTRATED FLOW

ISSUED: JULY 9, 1999
REVISED:

FIGURE NO. 11.2



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CAPACITY OF CURB OPENING INLET AT LOW POINT IN GRADE

ISSUED: JULY 9, 1999

REVISED:

FIGURE NO. 11.3

EQUATION: $Q = 0.56\left(\frac{Z}{n}\right) S^{1/2} Y^{8/3}$

n is roughness coefficient in manning formula appropriate to material in bottom of channel.

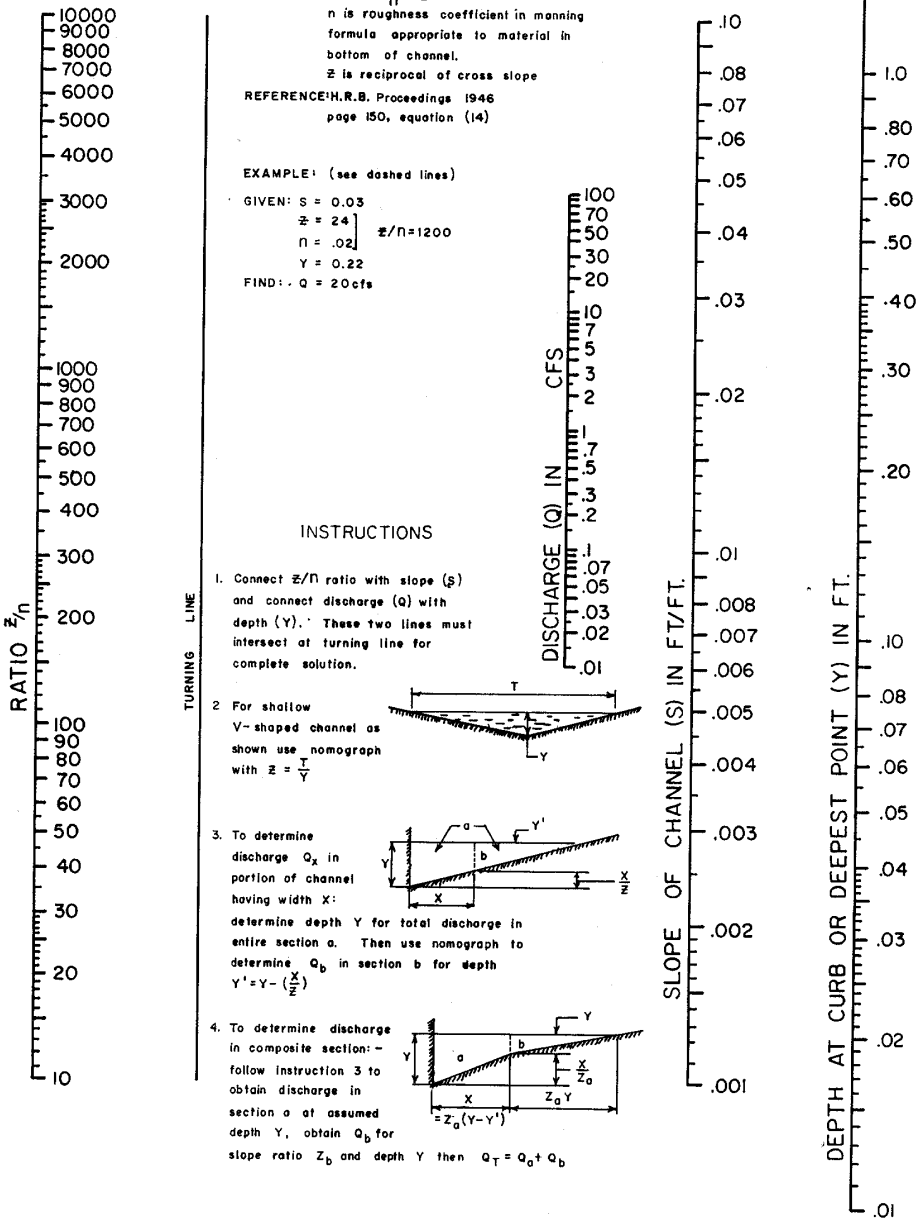
Z is reciprocal of cross slope

REFERENCE: H.R.B. Proceedings 1946 page 150, equation (14)

EXAMPLE: (see dashed lines)

GIVEN: S = 0.03
Z = 24
n = .02
Z/n = 1200
Y = 0.22

FIND: Q = 20 cfs



INSTRUCTIONS

1. Connect Z/n ratio with slope (S) and connect discharge (Q) with depth (Y). These two lines must intersect at turning line for complete solution.

2. For shallow V-shaped channel as shown use nomograph with $Z = \frac{T}{Y}$

3. To determine discharge Q_x in portion of channel having width X: determine depth Y for total discharge in entire section a. Then use nomograph to determine Q_b in section b for depth $Y' = Y - \left(\frac{X}{Z}\right)$

4. To determine discharge in composite section: - follow instruction 3 to obtain discharge in section a at assumed depth Y, obtain Q_b for slope ratio Z_b and depth Y then $Q_T = Q_a + Q_b$

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NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS

ISSUED: JULY 9, 1999
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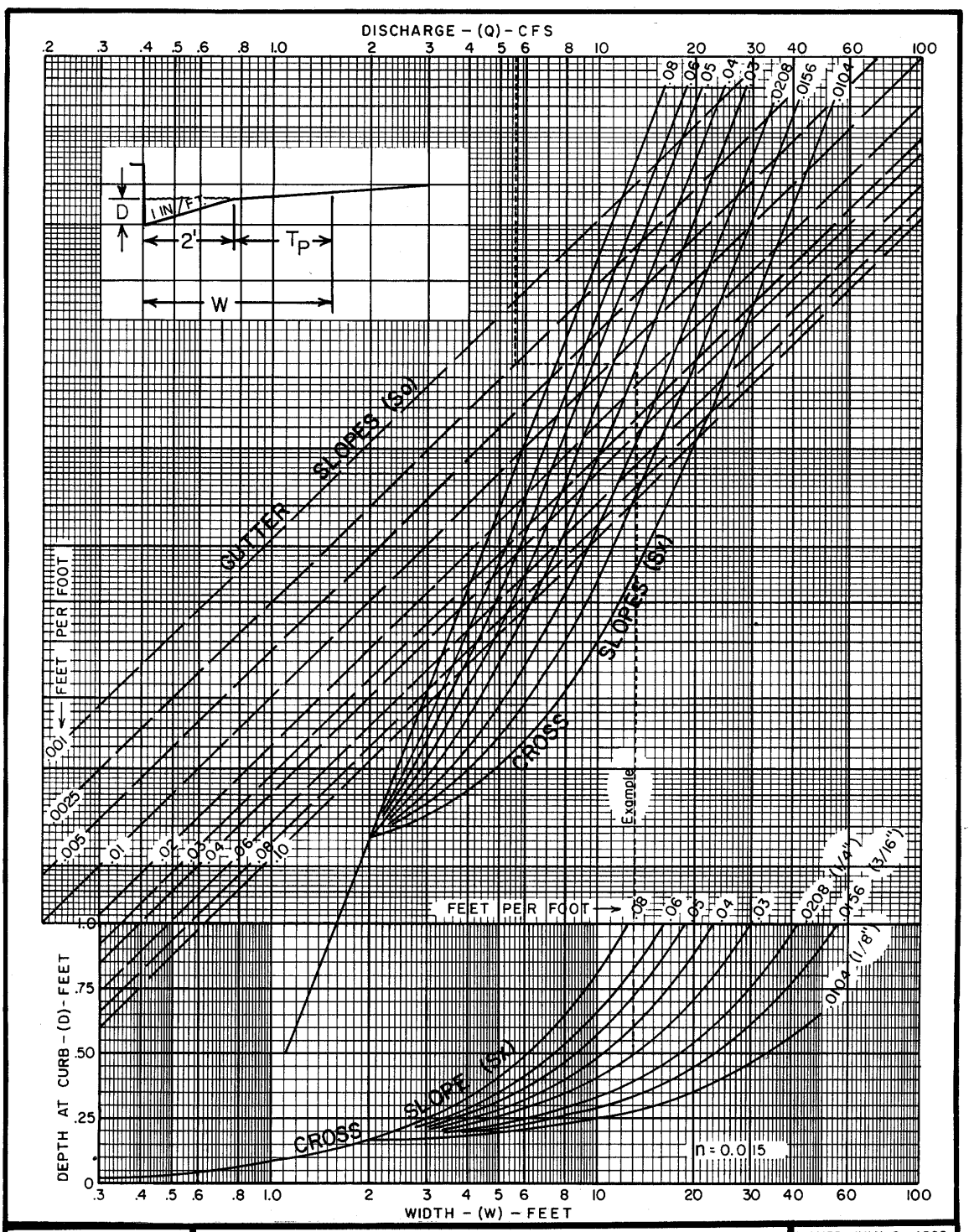
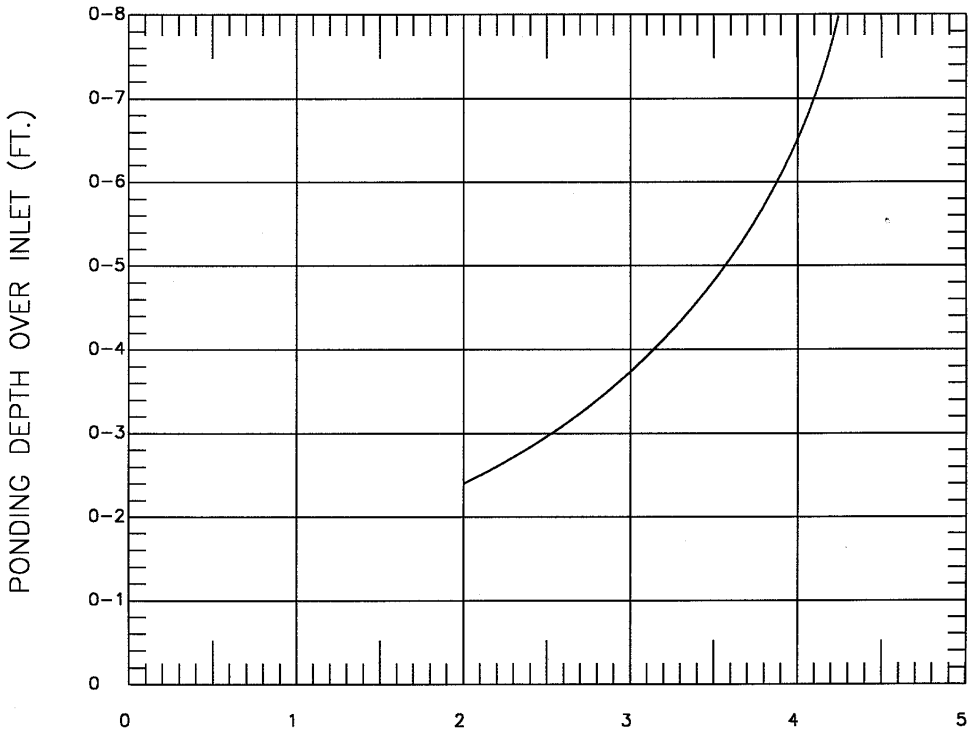
FIGURE NO. 11.4



DRAWN BY: RLN CHECKED BY: APPROVED BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048 FLOW CHARACTERISTIC CURVES	ISSUED: JULY 9, 1999 REVISED: FIGURE NO. 11.5



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CAPACITY OF A GRATED INLET IN SUMP

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FIGURE NO. 11.6

DESIGN CRITERIA	RESIDENTIAL LATERAL WITH PIPE	NON-RESIDENTIAL LATERAL / CONCRETE CHANNEL	MAJOR DRAINWAY
GRASS SIDE SLOPES	4:1 OR FLATTER	4:1 OR FLATTER	4:1 OR FLATTER
FREE BOARD (100 YEAR STORM)	0.5 FOOT	0.5 FOOT	$H = 0.5+V^2/2g$ MIN. 1 FOOT
BOTTOM WIDTH MINIMUM	4 FOOT	6 FOOT	6 X DEPTH OF 100 Yr. FLOW
DEPTH (100 YEAR STORM)	MAX. 2 FOOT	MAX. 2 FOOT	PER MASTER DRAINAGE PLAN
SLOPE MINIMUM	1%	0.5%	0.2% - 0.6% (NATURAL)
LOW FLOW PIPE / CHANNEL	18" MIN. RESIDENTIAL & COMMERCIAL 2 YEAR INDUSTRIAL	2 YEAR CAPACITY CROSS-SLOPE 1/4" PER FOOT	N/A
RADIUS	N/A	N/A	2 X TOP WIDTH AND > 100 FEET CENTERLINE
VELOCITY	N/A	MIN. 2 FOOT/SEC. 5 YEAR	MIN. 2 FOOT/SEC. 5 YEAR

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CHANNEL DESIGN CRITERIA

ISSUED: JULY 1999

REVISED: 12-17-03

FIGURE NO. 11.7A

04/14/17

MANNINGS 'n' VALUE FOR DEPTH RANGES

LINING TYPE	DEPTH		
	0 - 0.5 FEET	0.5 - 2.0 FEET	> 2.0 FEET
WOVEN PAPER NET	0.016	0.015	0.015
JUTE NET	0.028	0.022	0.019
FIBERGLASS ROVING	0.028	0.021	0.019
STRAW WITH NET	0.065	0.033	0.025
CURLED WOOD MAT	0.066	0.035	0.028
SYNTHETIC MAT	0.036	0.025	0.021
GRAVEL RIPRAP (1" D50)	0.044	0.033	0.030
GRAVEL RIPRAP (2" D50)	0.066	0.041	0.034
GRAVEL RIPRAP (6" D50)	0.104	0.069	0.035
GRAVEL RIPRAP (12" D50)	N/A	0.078	0.040

Adapted From: FHWA, HEC-15, APRIL 1988, page 37

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MANNINGS 'n' VALUES FOR CHANNEL PROTECTION CRITERIA

ISSUED: 12-17-03

REVISED:

FIGURE NO. 11.7B

04/14/17

ALLOWABLE SHEAR STRESSES FOR CHANNEL LININGS

LINING TYPE	COMMENTS	SHEAR STRESS, Td (Lbs/Square Foot)
WOVEN PAPER NET	SUBMITTED BY DESIGN ENGINEER	0.15
JUTE NET	SUBMITTED BY DESIGN ENGINEER	0.45
FIBERGLASS ROVING	SUBMITTED BY DESIGN ENGINEER, SINGLE	0.60
FIBERGLASS ROVING	SUBMITTED BY DESIGN ENGINEER, DOUBLE	0.85
STRAW WITH NET	SUBMITTED BY DESIGN ENGINEER	1.45
CURLED WOOD MAT	SUBMITTED BY DESIGN ENGINEER	1.55
SYNTHETIC MAT	SUBMITTED BY DESIGN ENGINEER	2.00
VEGETATIVE, CLASS A	WEEPING LOVEGRASS, YELLOW BLUESTEM	3.70
VEGETATIVE, CLASS B	BERMUDA, BLUE GRAMA, NATIVE GRASS MIXTURES	2.10
VEGETATIVE, CLASS C	BERMUDA, KENTUCKY BLUE, CENTIPEDE	1.00
VEGETATIVE, CLASS D	BERMUDA, BUFFALO, GRASS LEGUME	0.60
VEGETATIVE, CLASS E	BERMUDA	0.35
GRAVEL RIPRAP	D50 STONE SIZE = 1 INCH	0.33
GRAVEL RIPRAP	D50 STONE SIZE = 2 INCH	0.67
ROCK RIPRAP	D50 STONE SIZE = 6 INCH	2.00
ROCK RIPRAP	D50 STONE SIZE = 12 INCH	4.00

Adapted From: FHWA, HEC-15, APRIL 1988, pages 33 and 36

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ALLOWABLE SHEAR STRESSES FOR CHANNEL LINERS

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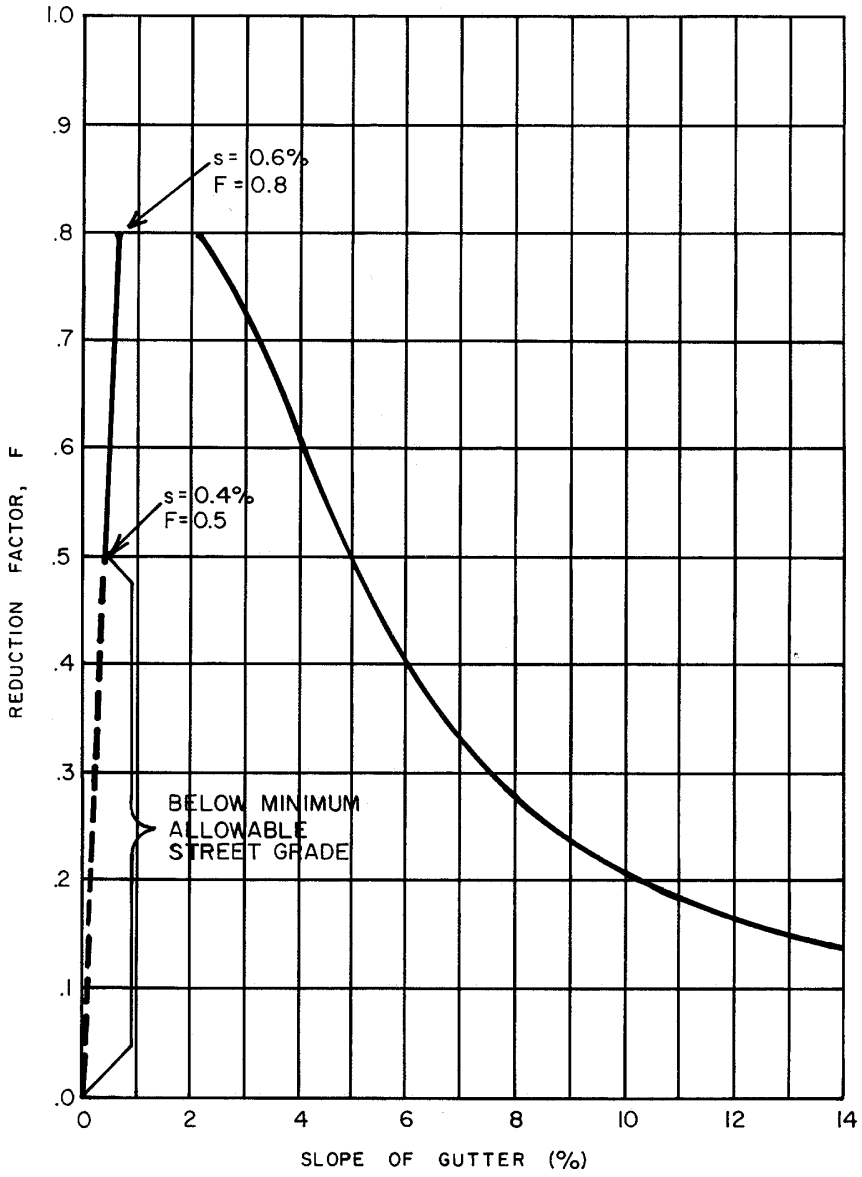
FIGURE NO. 11.7C

04/14/17

Figure 11.7D—Allowable Shear Stresses for Outlet Protection

Lining Type	Comments	Shear Stress, Td (lbs/square foot)
Rock Riprap	Class A	4.00
Rock Riprap	Class B	5.00
Rock Riprap	Class C	7.80



Apply reduction factor for applicable slope to the theoretical gutter capacity to obtain allowable gutter capacity.

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REDUCTION FACTOR FOR ALLOWABLE GUTTER CAPACITY

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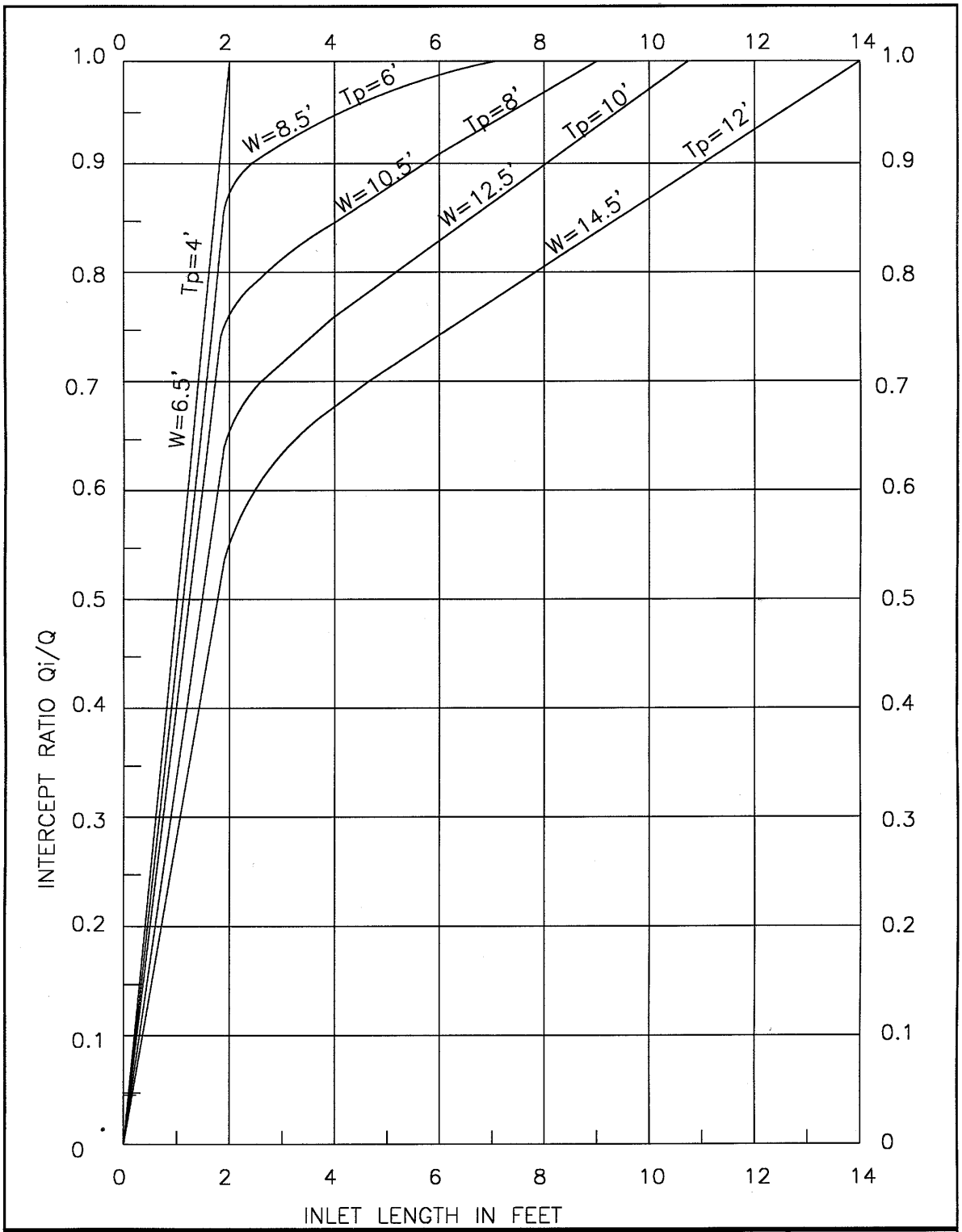
FIGURE NO. 11.8



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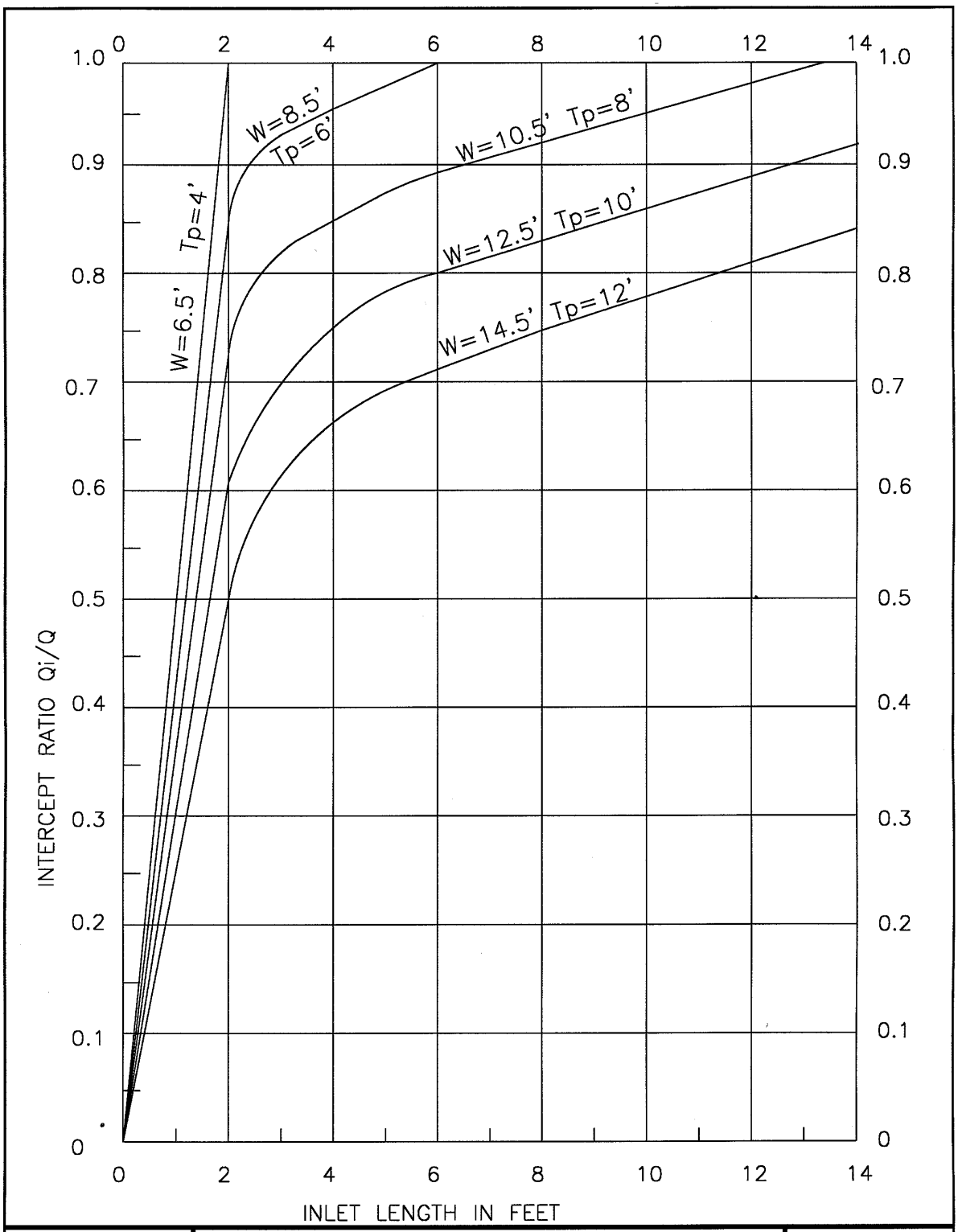
INLET CAPACITY TYPE I

So= 0.002, Sx=3/16"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.9



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INLET CAPACITY TYPE I

So= 0.004, Sx=3/16"/ft.

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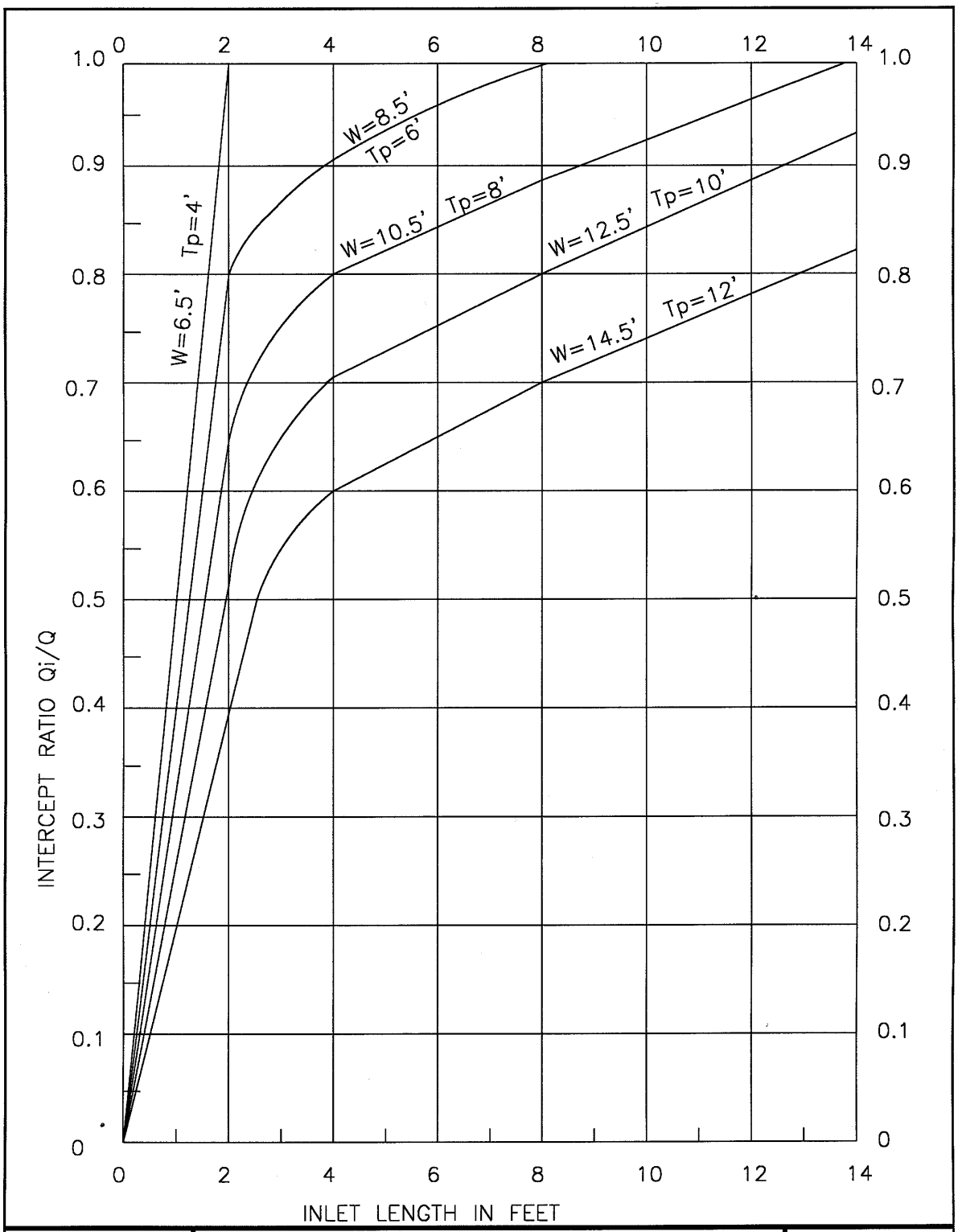
FIGURE NO. 11.10



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INLET CAPACITY TYPE I

So= 0.006, Sx=3/16"/ft.

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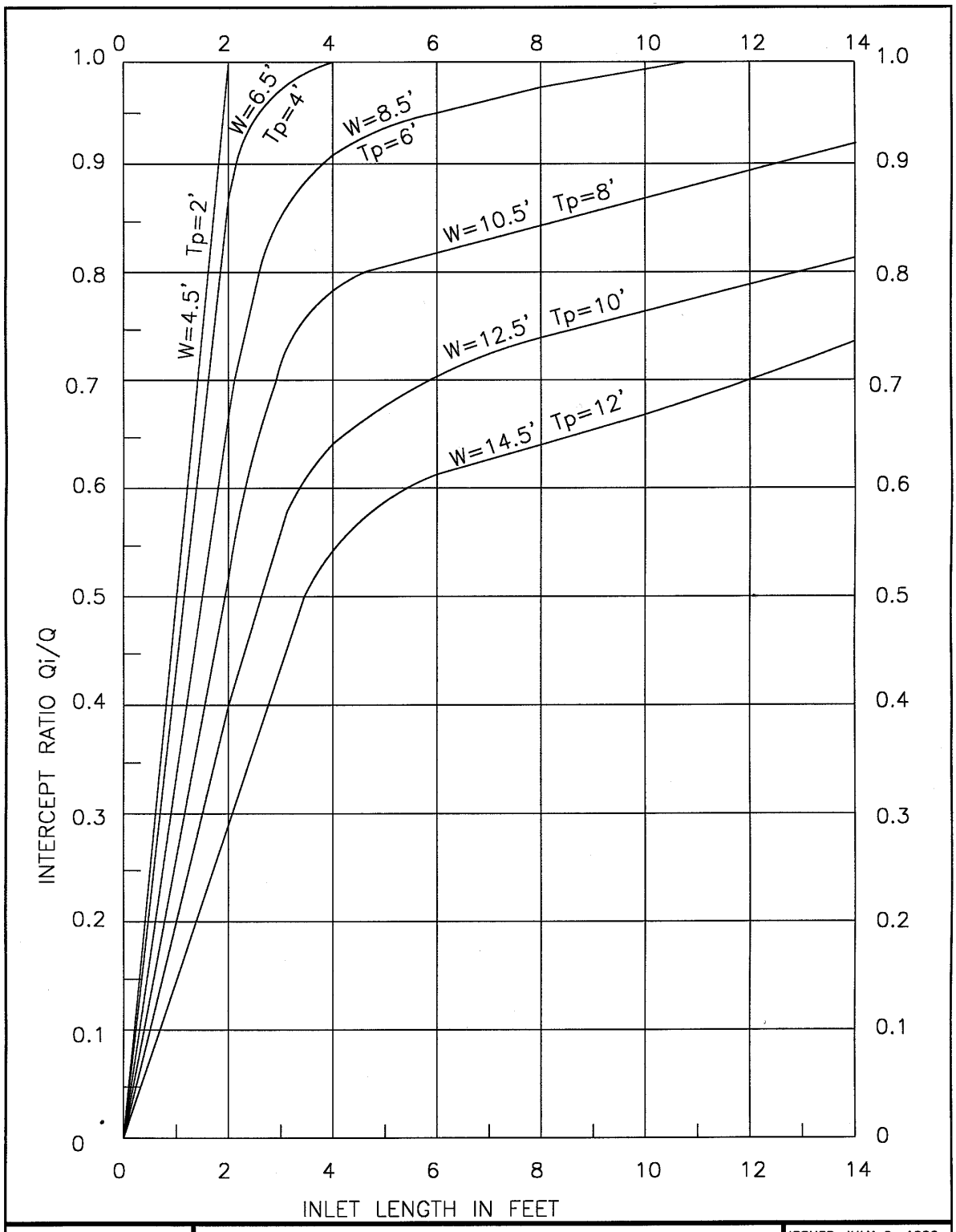
FIGURE NO. 11.11



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INLET CAPACITY TYPE I

So= 0.008, Sx=3/16"/ft.

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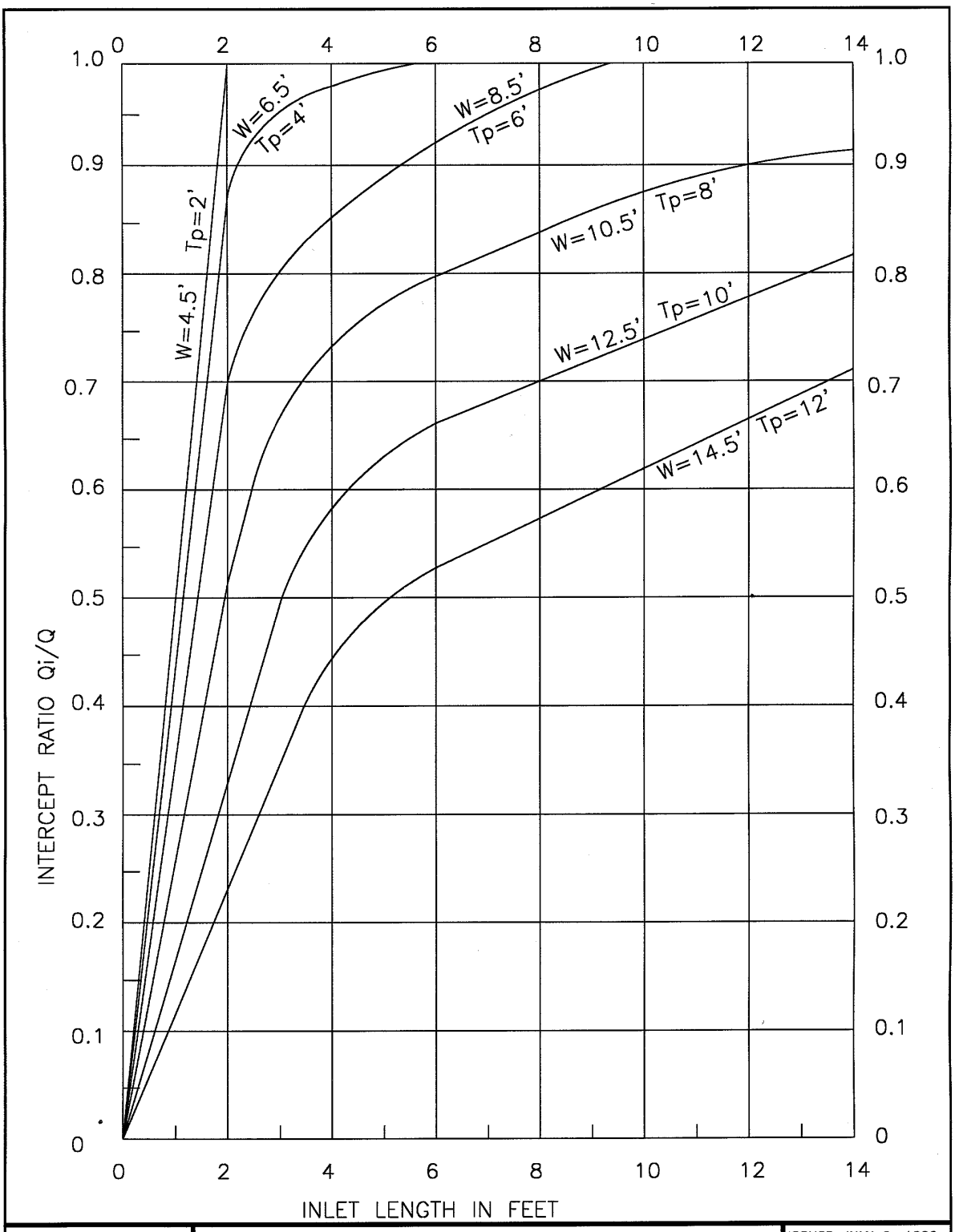
FIGURE NO. 11.12



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INLET CAPACITY TYPE I

So= 0.01, Sx=3/16"/ft.

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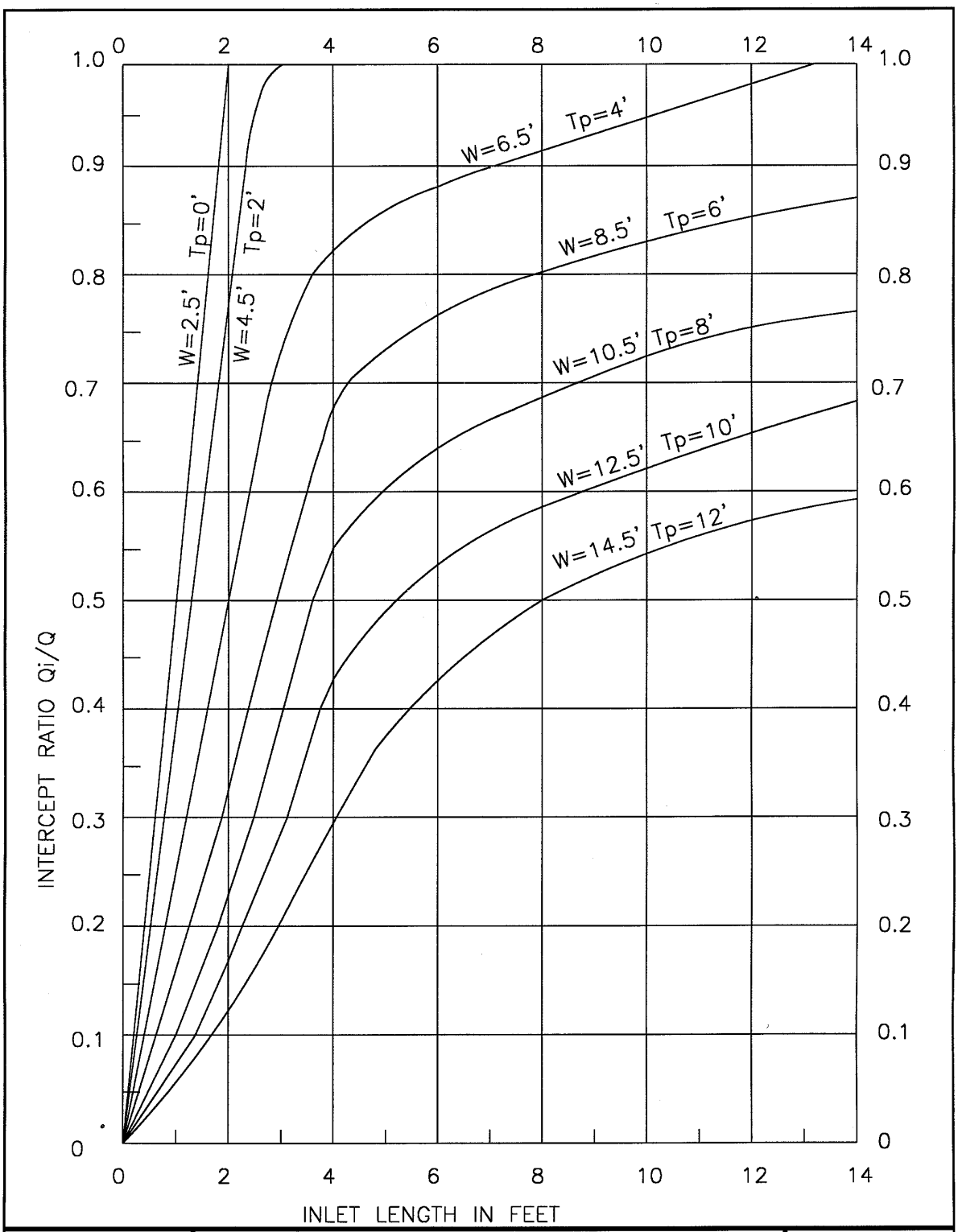
FIGURE NO. 11.13



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INLET CAPACITY TYPE I

So= 0.02, Sx=3/16"/ft.

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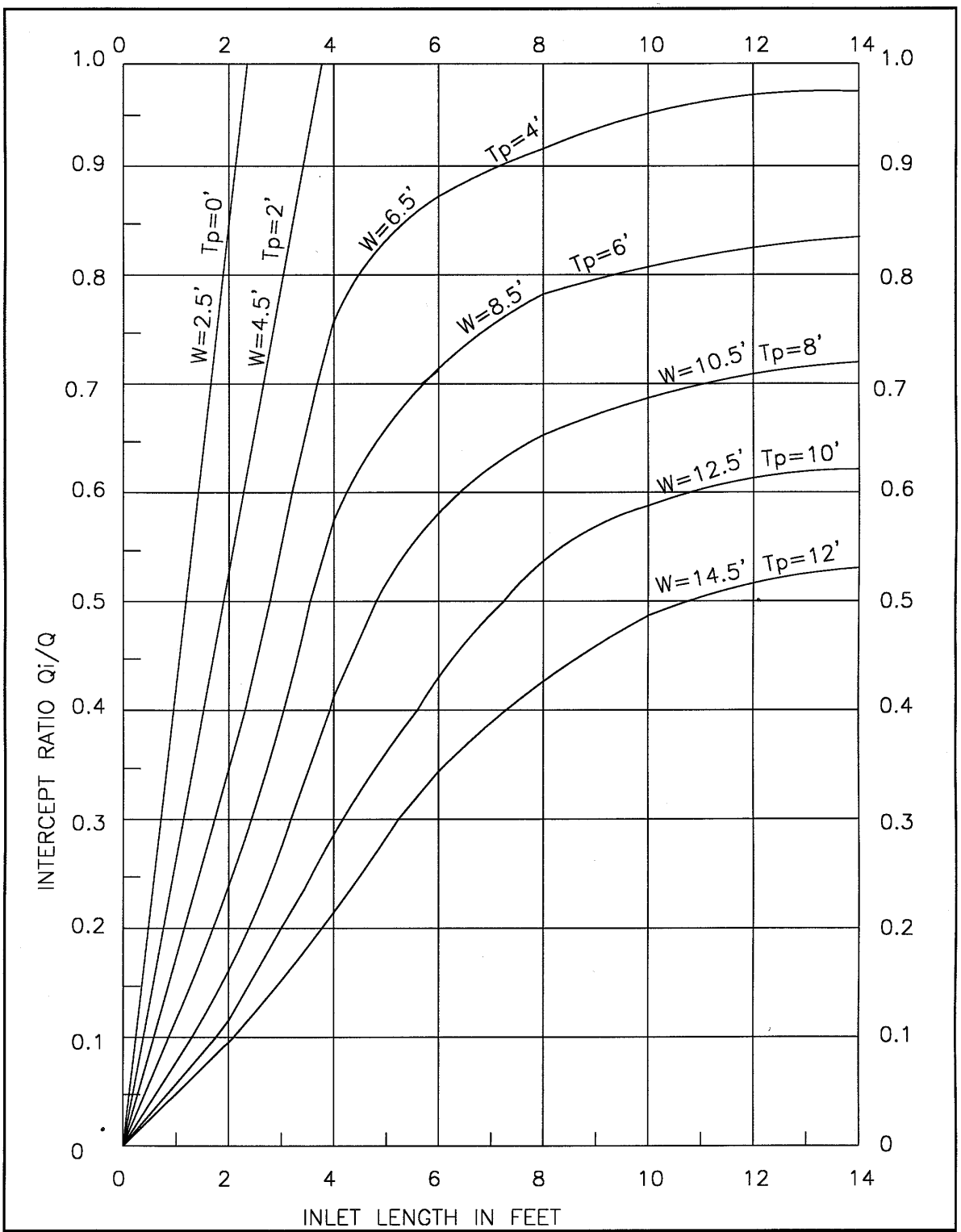
FIGURE NO. 11.14



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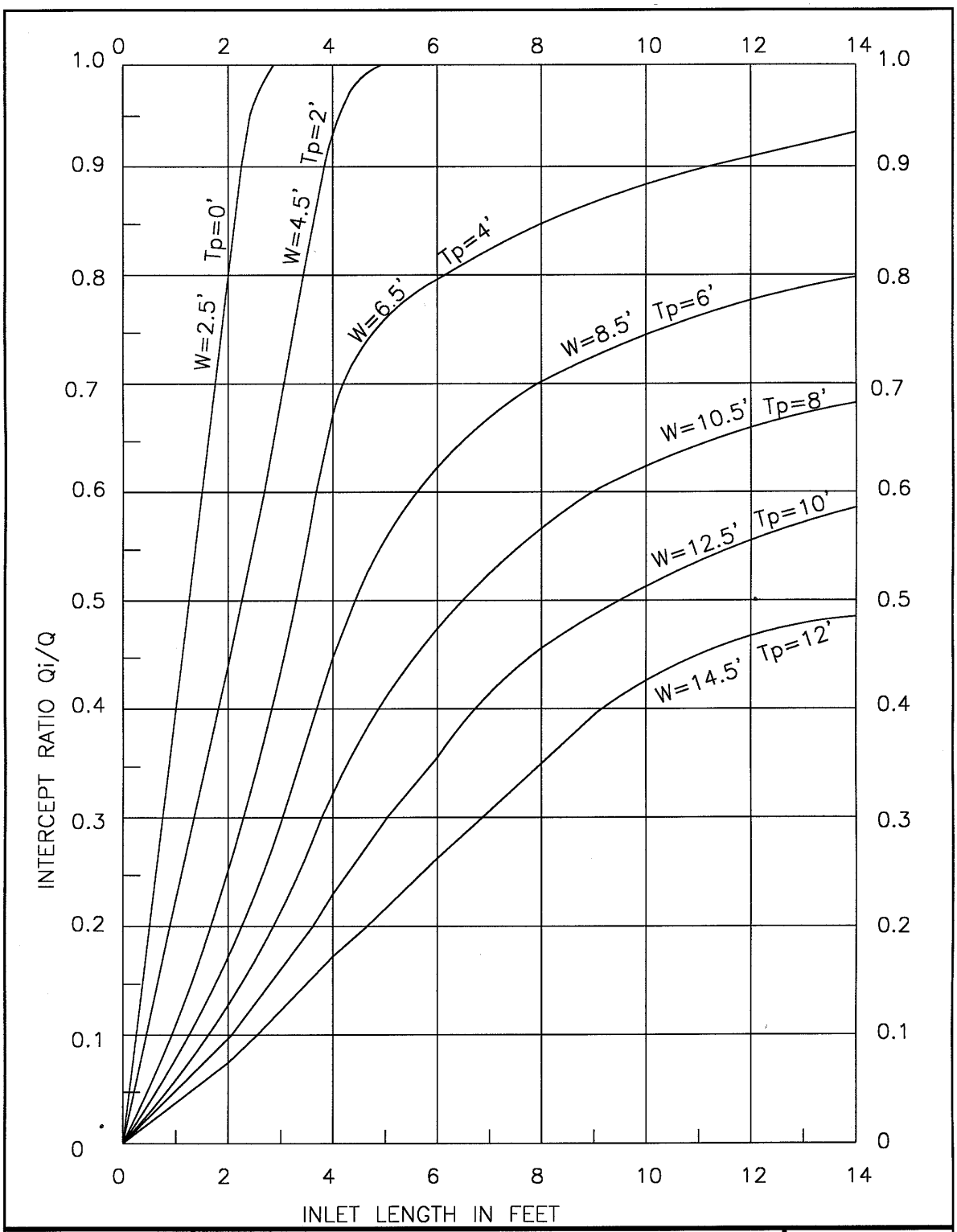
INLET CAPACITY TYPE I

So= 0.03, Sx=3/16"/ft.

ISSUED: JULY 9, 1999

REVISED:

FIGURE NO. 11.15



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INLET CAPACITY TYPE I

So= 0.04, Sx=3/16"/ft.

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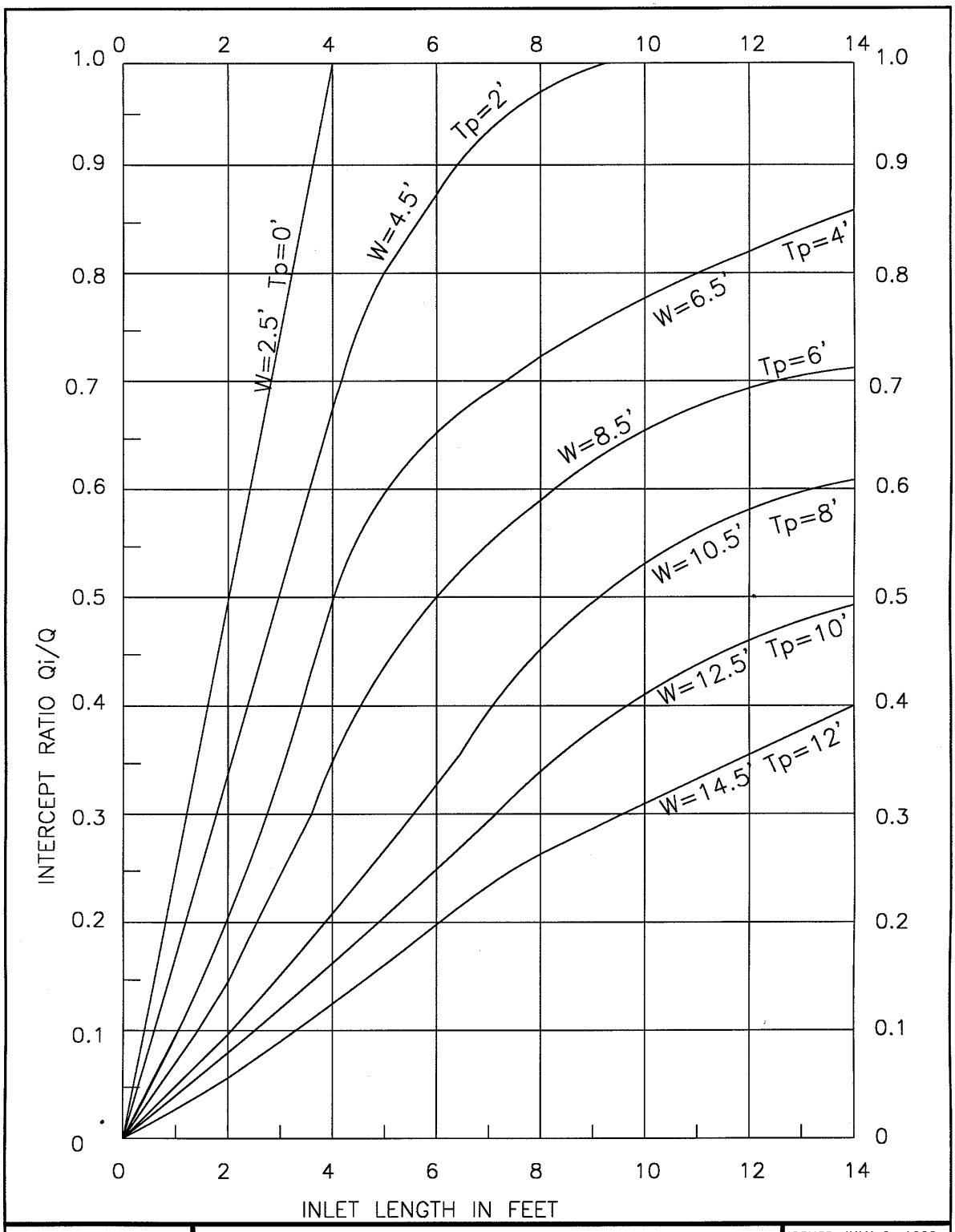
FIGURE NO. 11.16



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INLET CAPACITY TYPE I

So= 0.06, Sx=3/16"/ft.

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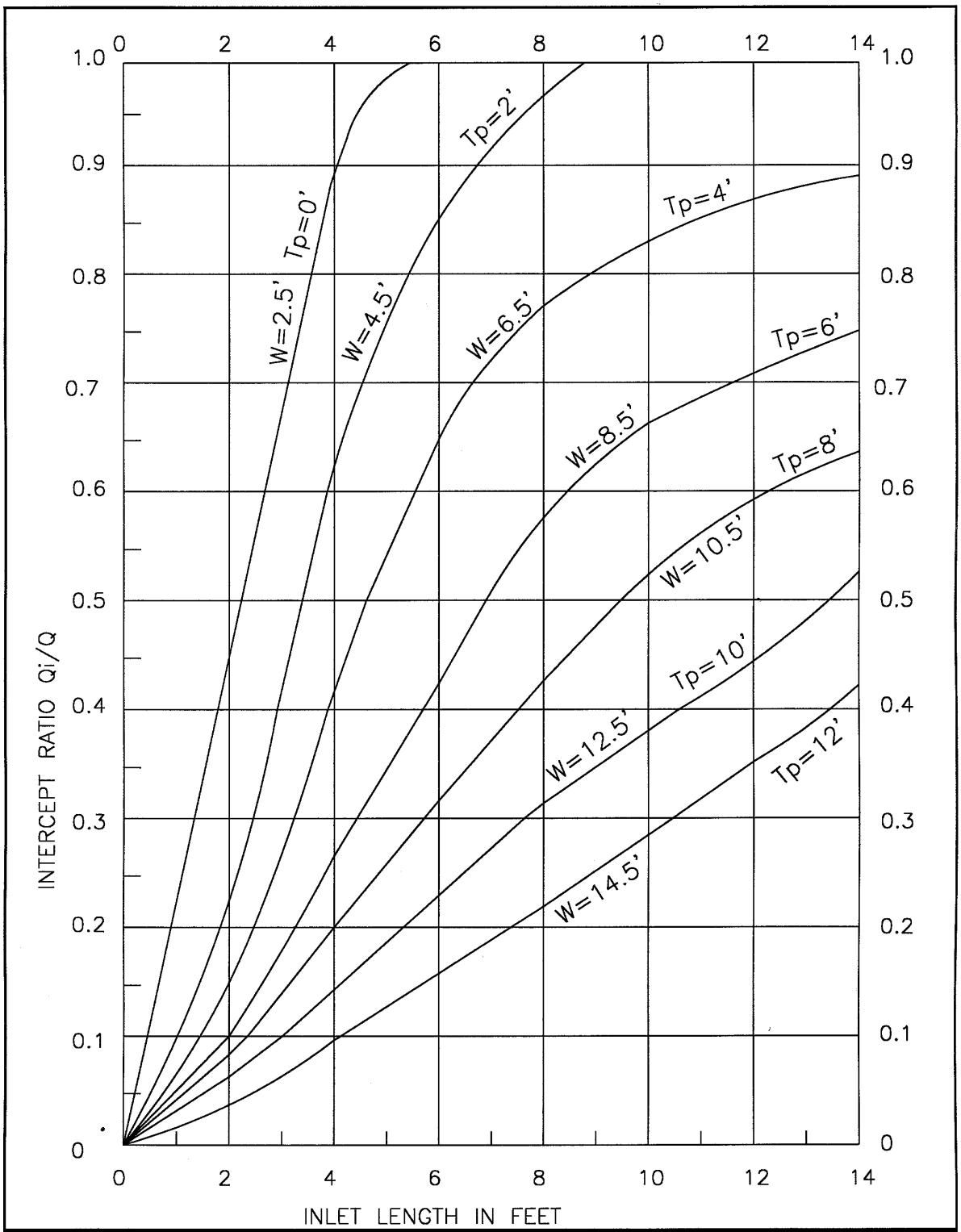
FIGURE NO. 11.17



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INLET CAPACITY TYPE I

So= 0.08, Sx=3/16"/ft.

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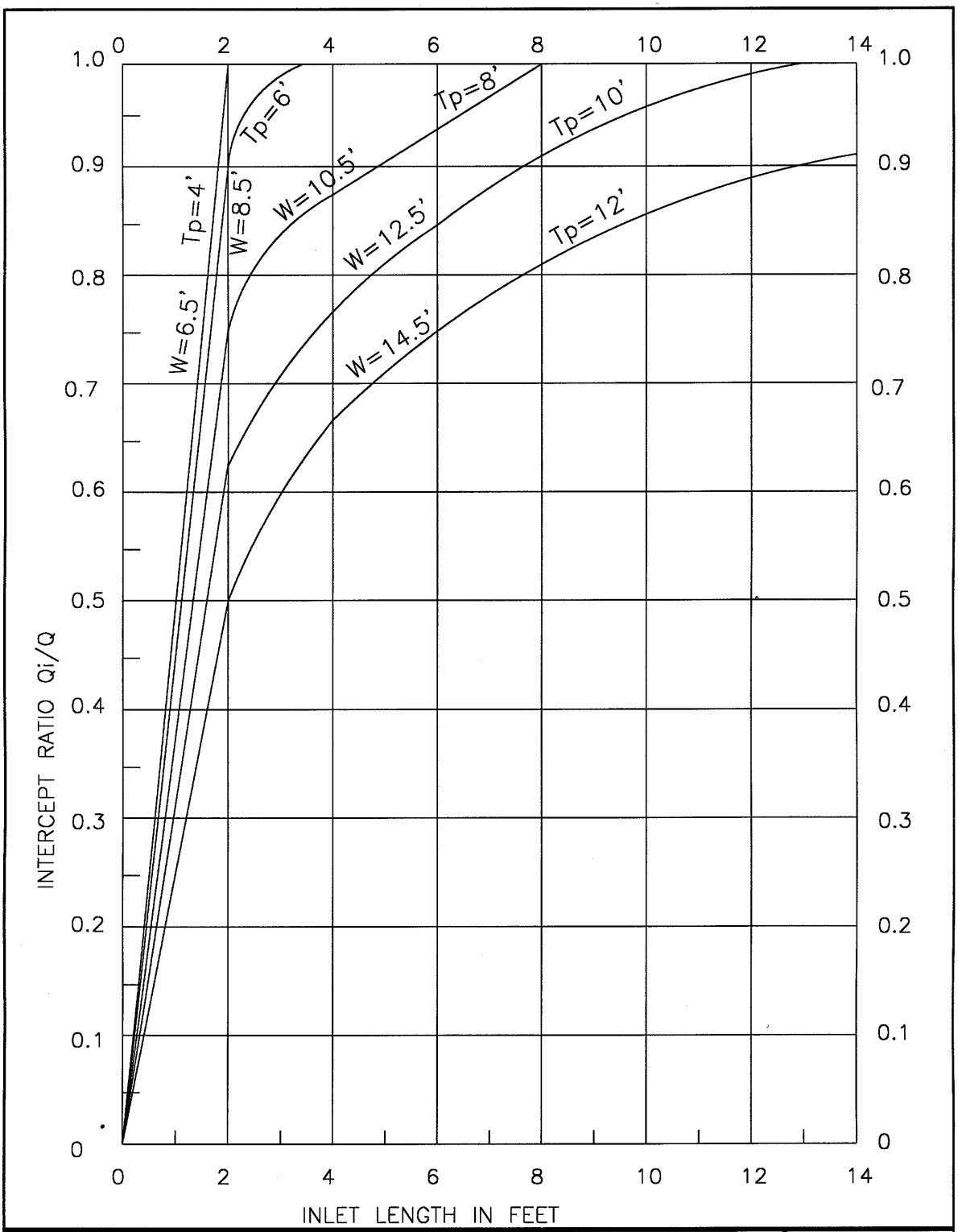
FIGURE NO. 11.18



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INLET CAPACITY TYPE I

So= 0.002, Sx=1/4"/ft.

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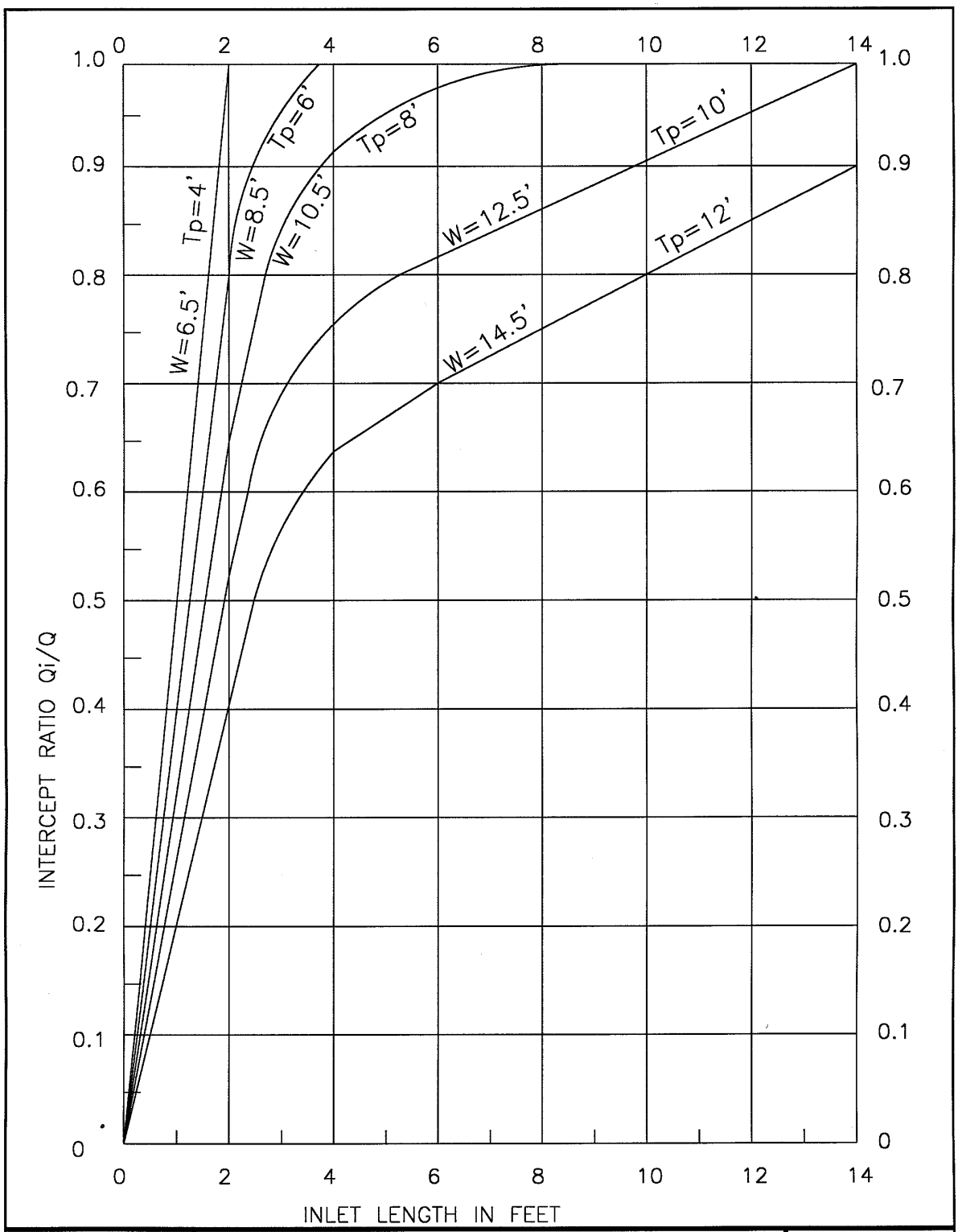
FIGURE NO. 11.19



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INLET CAPACITY TYPE I

So= 0.004, Sx=1/4"/ft.

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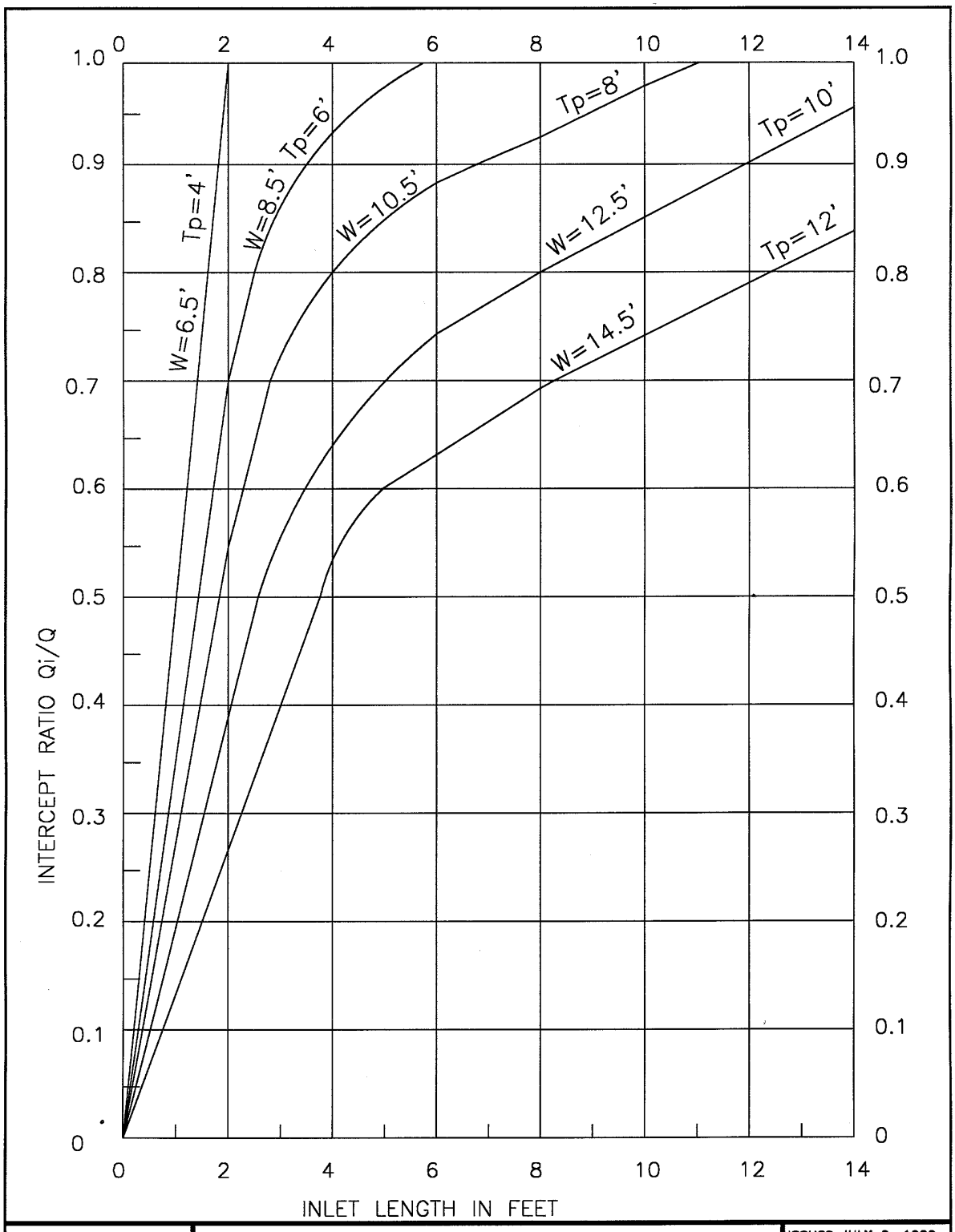
FIGURE NO. 11.20



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INLET CAPACITY TYPE I

So= 0.006, Sx=1/4"/ft.

ISSUED: JULY 9, 1999

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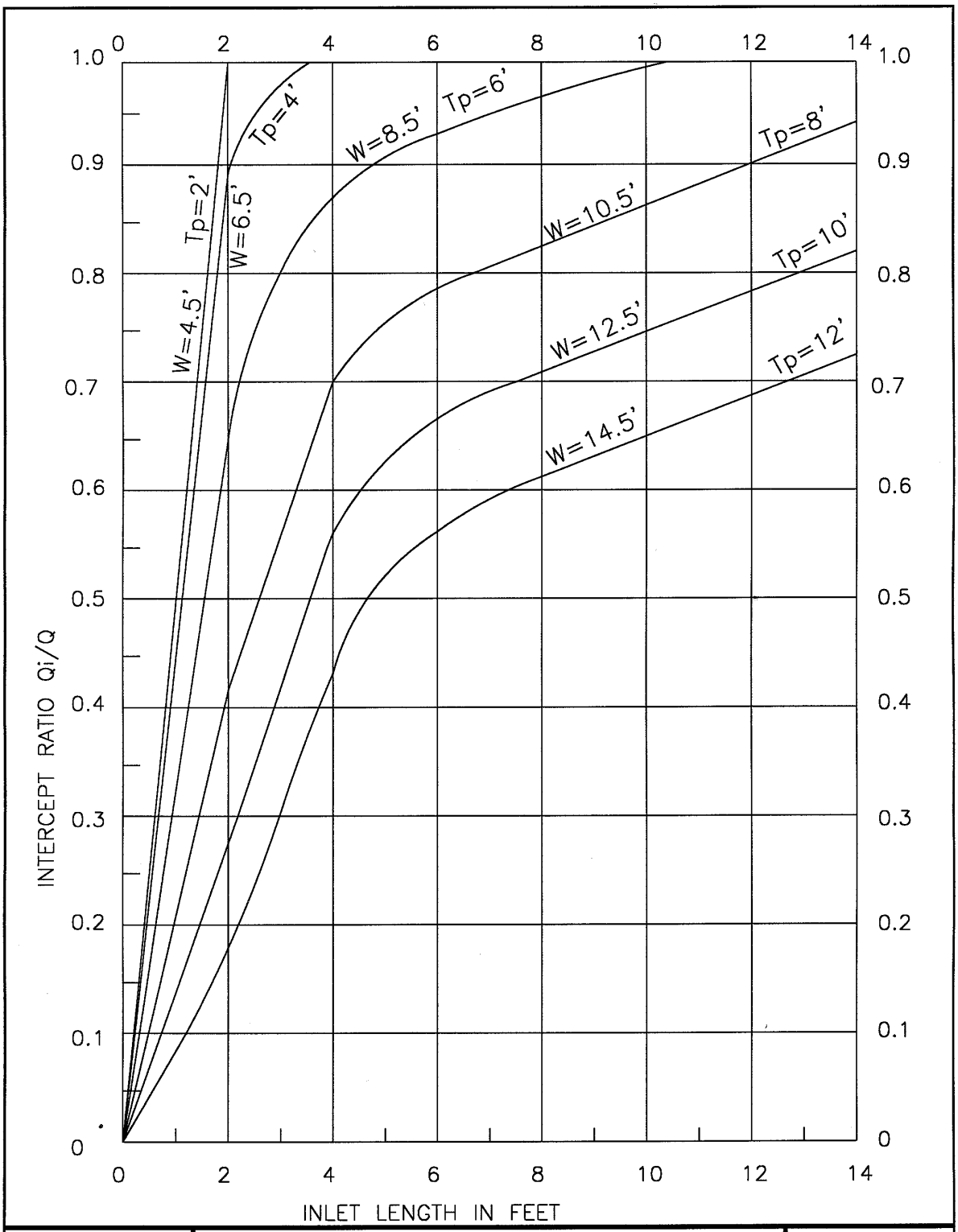
FIGURE NO. 11.21



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INLET CAPACITY TYPE I

So= 0.008, Sx=1/4"/ft.

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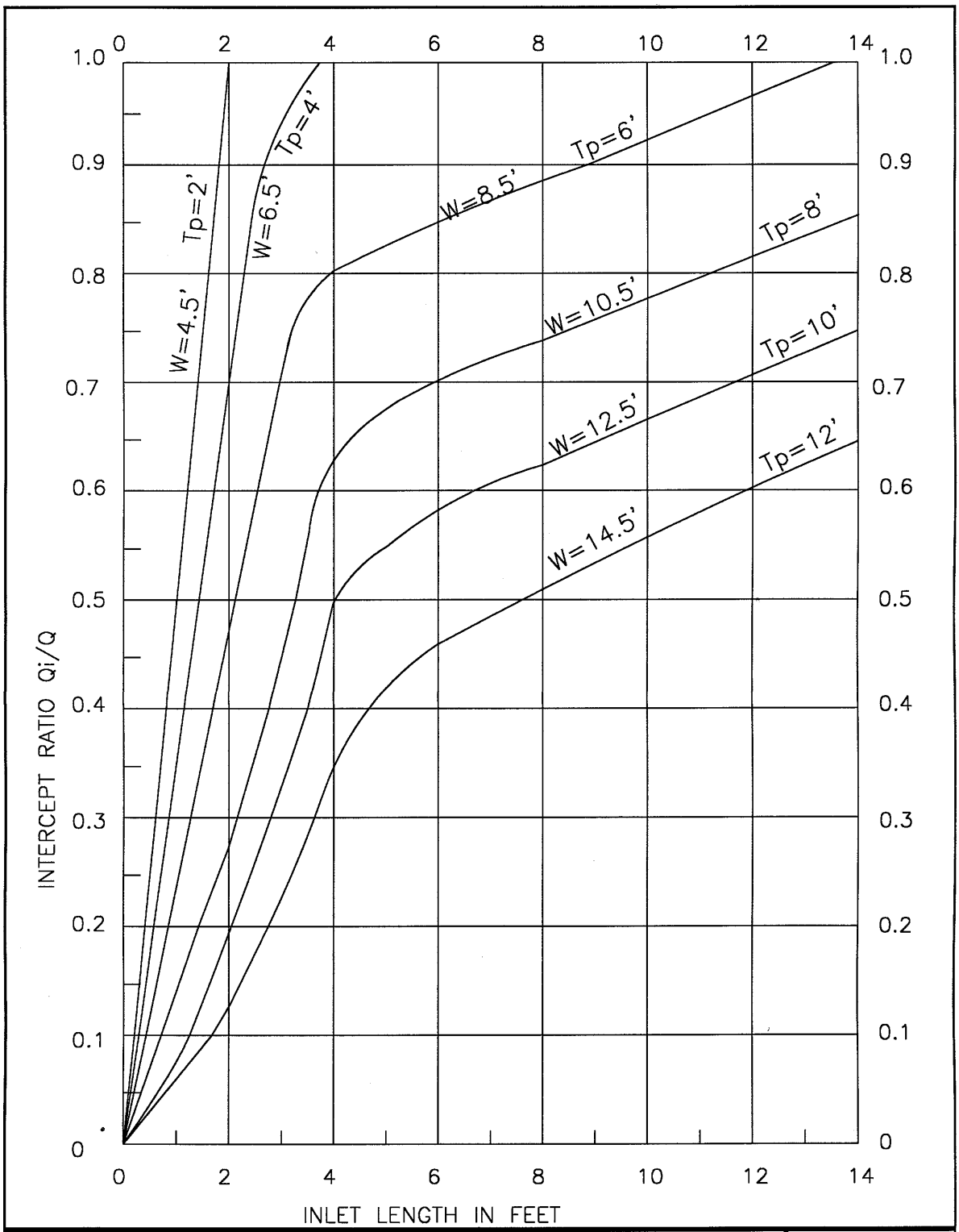
FIGURE NO. 11.22



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INLET CAPACITY TYPE I

So= 0.01, Sx=1/4"/ft.

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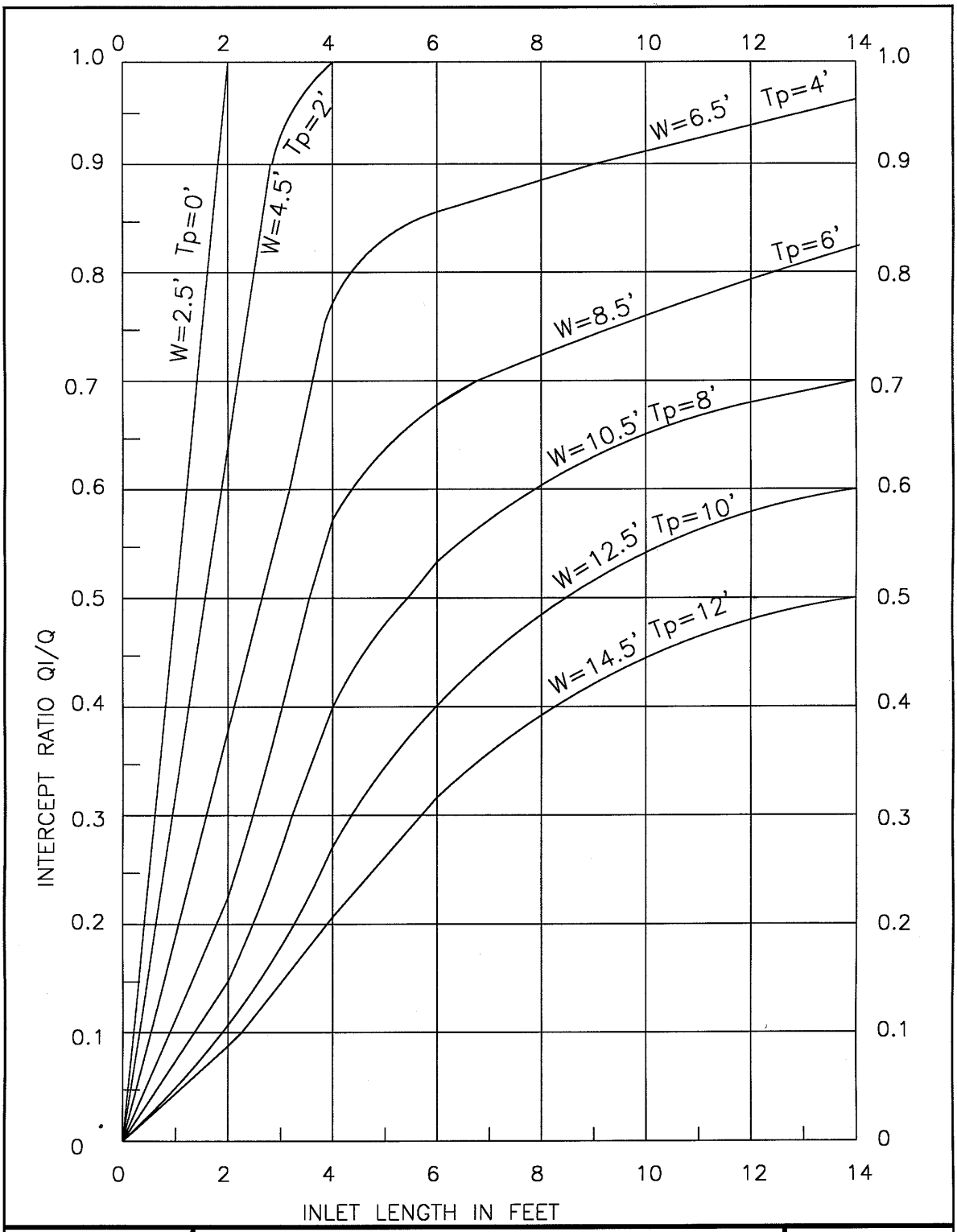
FIGURE NO. 11.23



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INLET CAPACITY TYPE I

So= 0.02, Sx=1/4"/ft.

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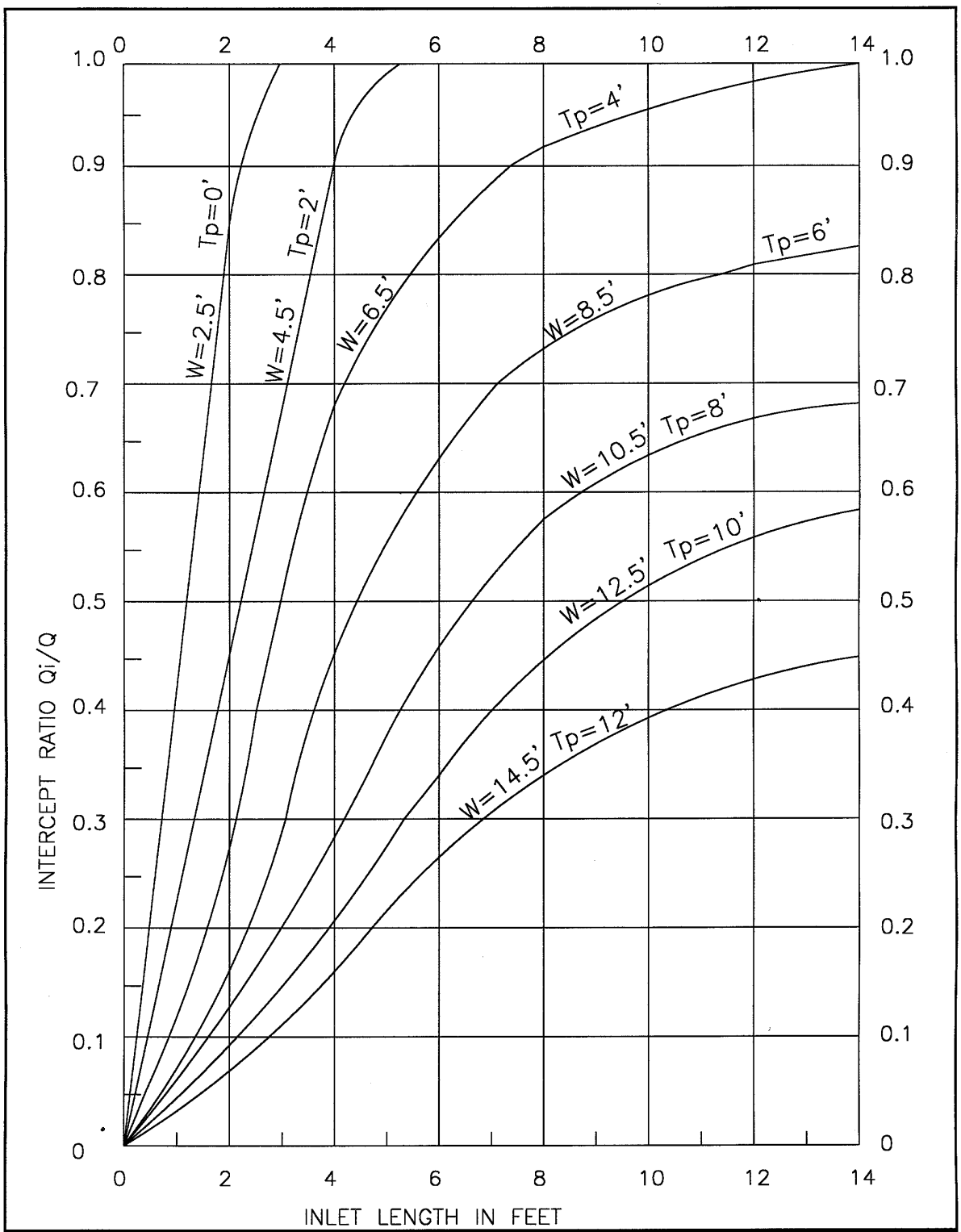
FIGURE NO. 11.24



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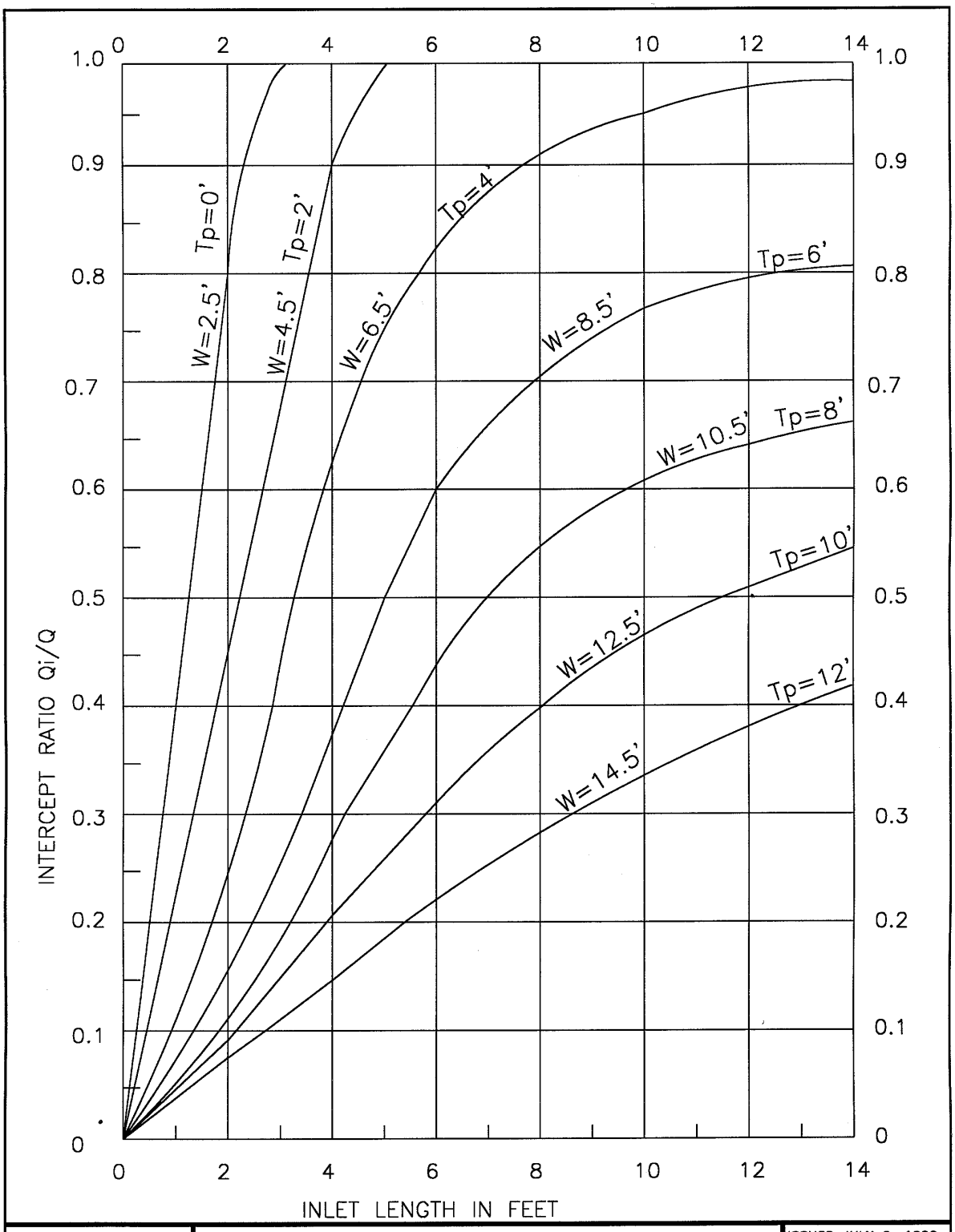
INLET CAPACITY TYPE I

So= 0.03, Sx=1/4"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.25



DRAWN BY: RRH

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APPROVED BY: J.O.

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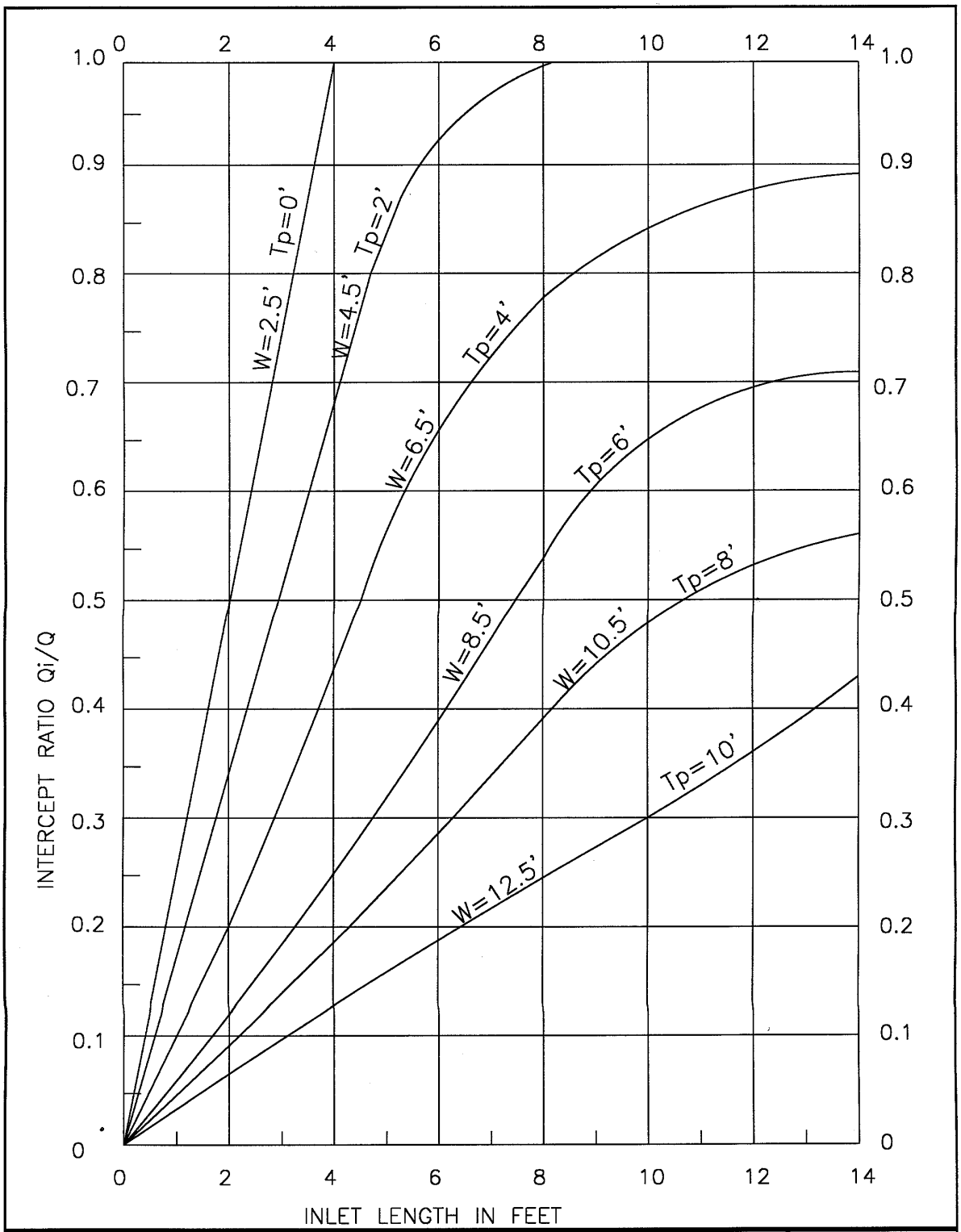
INLET CAPACITY TYPE I

So= 0.04, Sx=1/4"/ft.

ISSUED: JULY 9, 1999
REVISED: _____

FIGURE NO. 11.26



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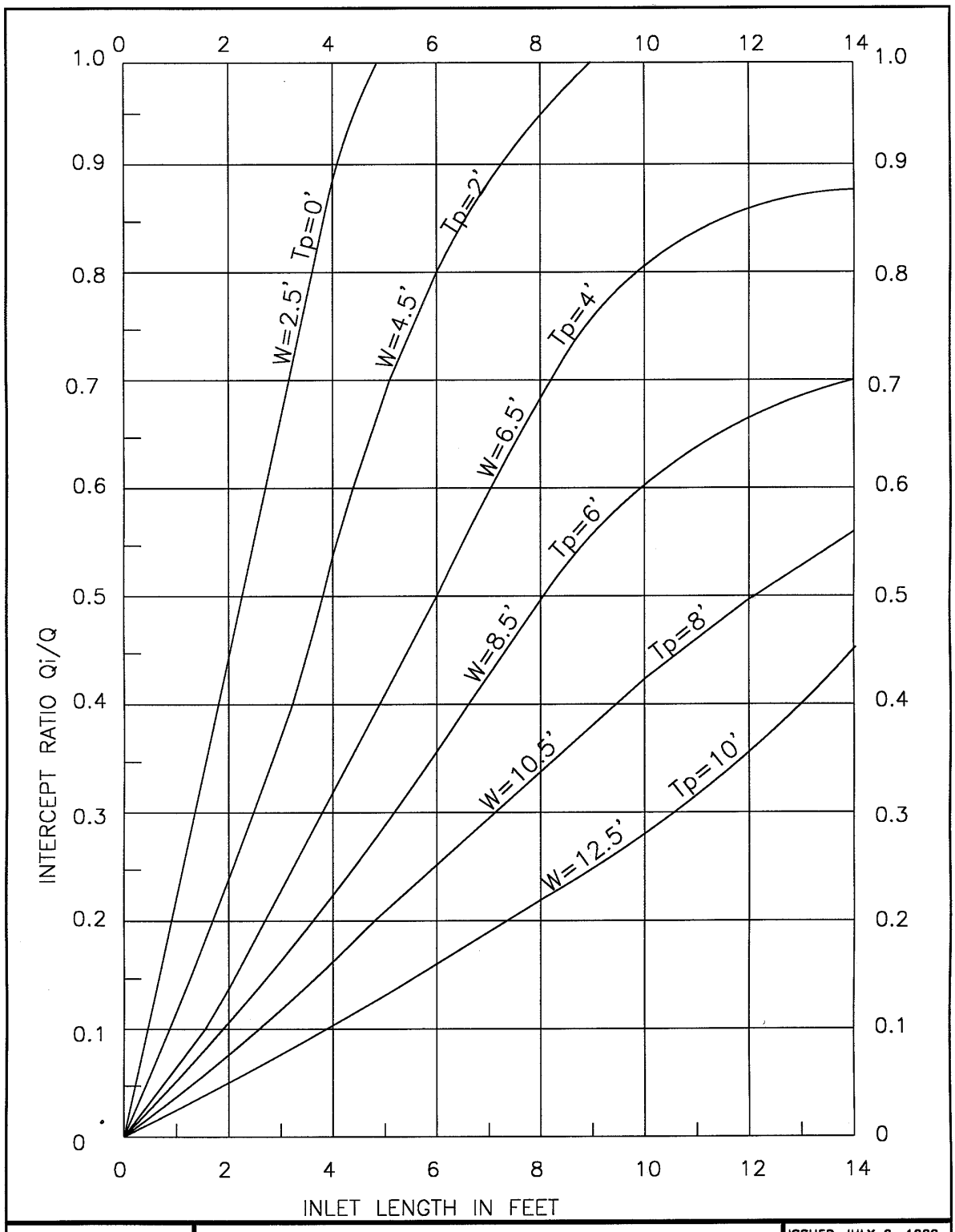
INLET CAPACITY TYPE I

So= 0.06, Sx=1/4"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.27



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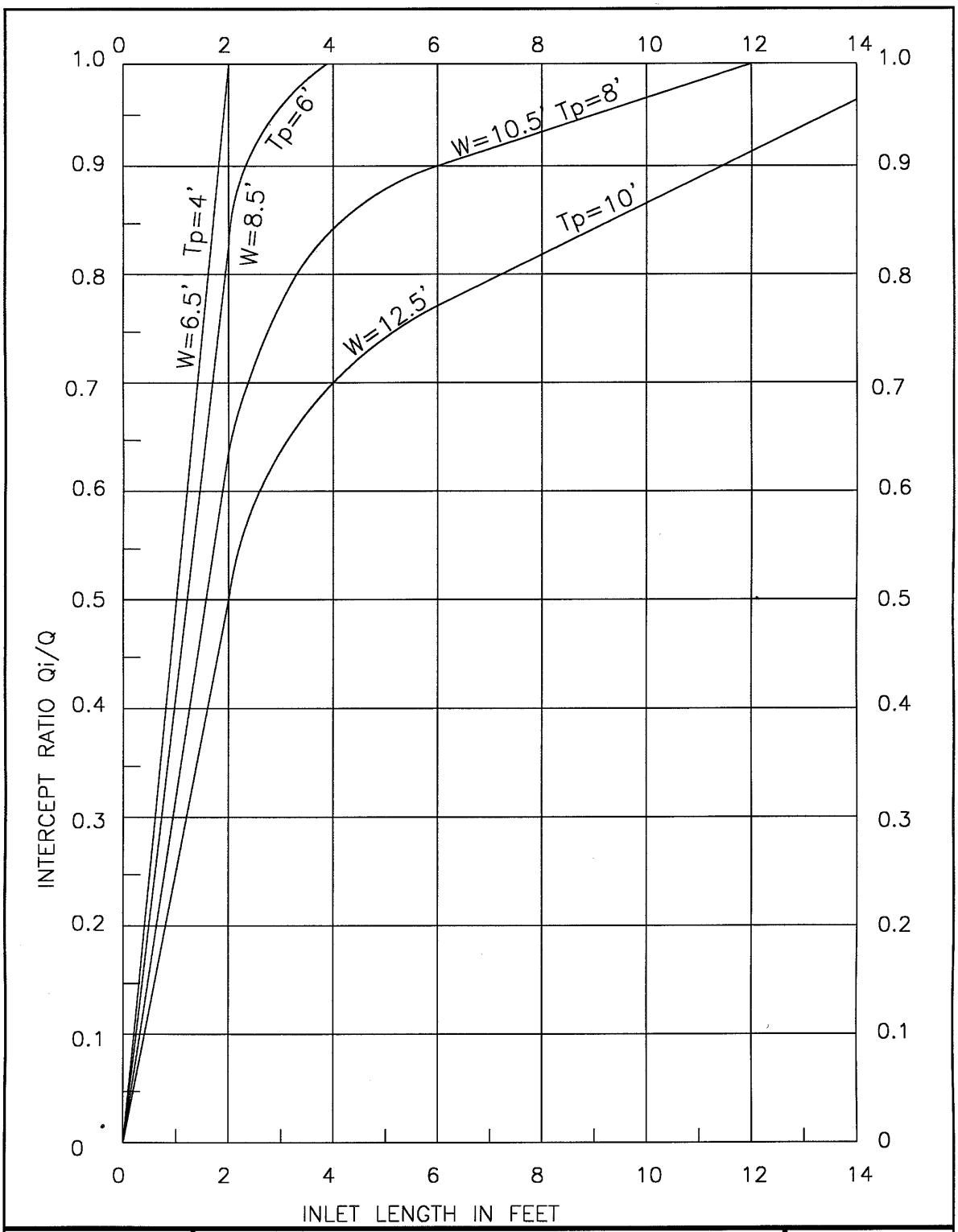
INLET CAPACITY TYPE I

So= 0.08, Sx=1/4"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.28



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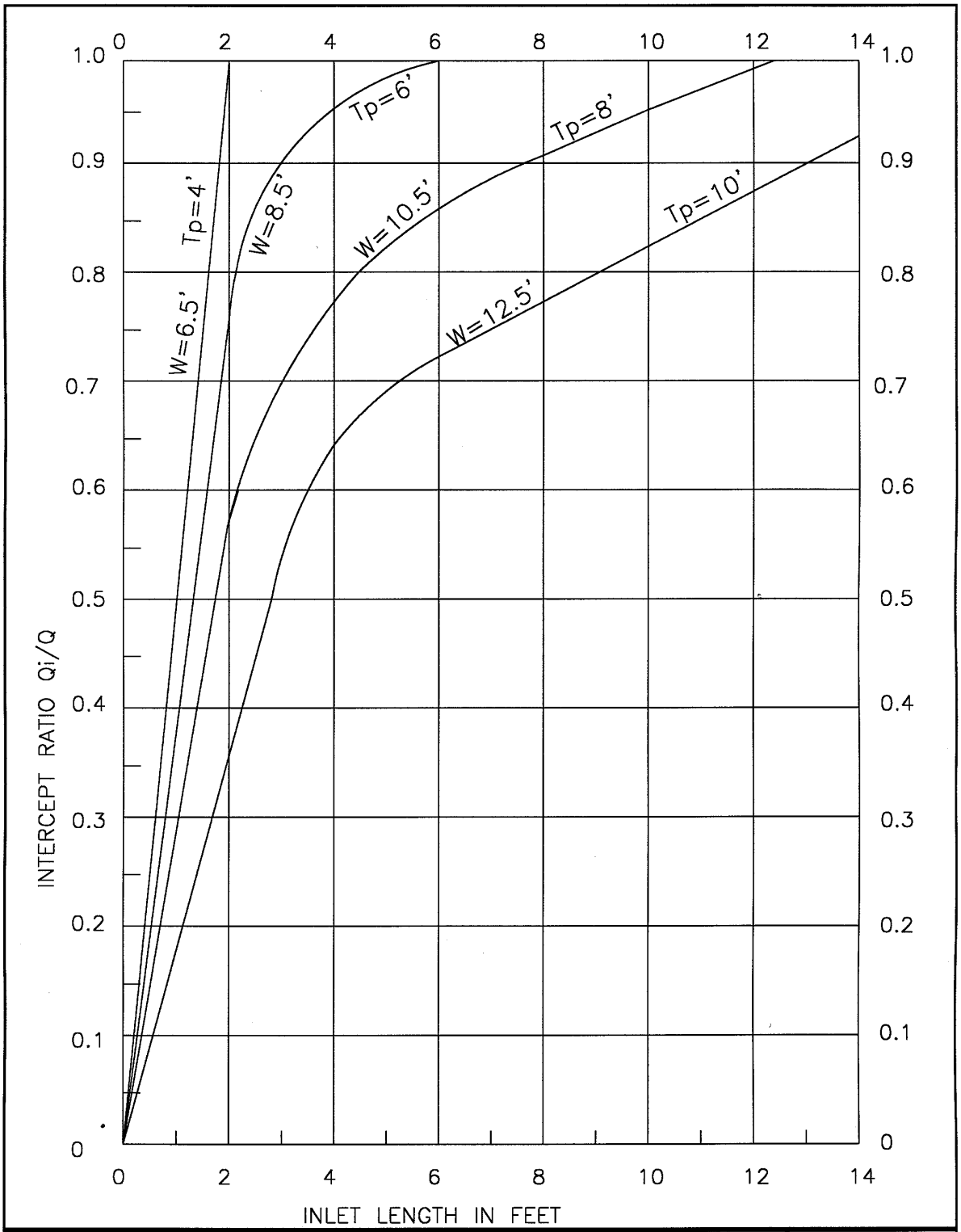
INLET CAPACITY TYPE I

So= 0.002, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.29



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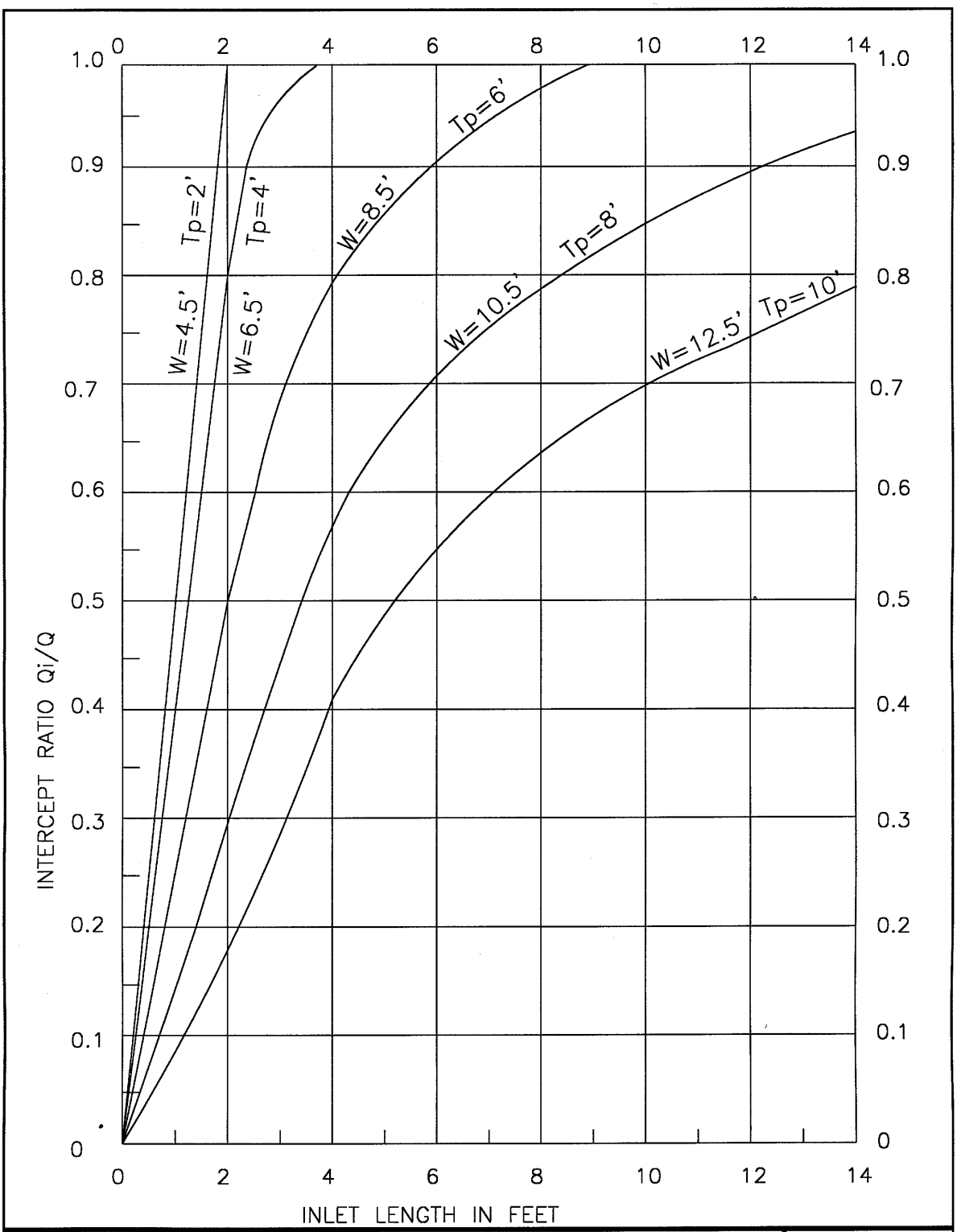
INLET CAPACITY TYPE I

So= 0.004, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.30



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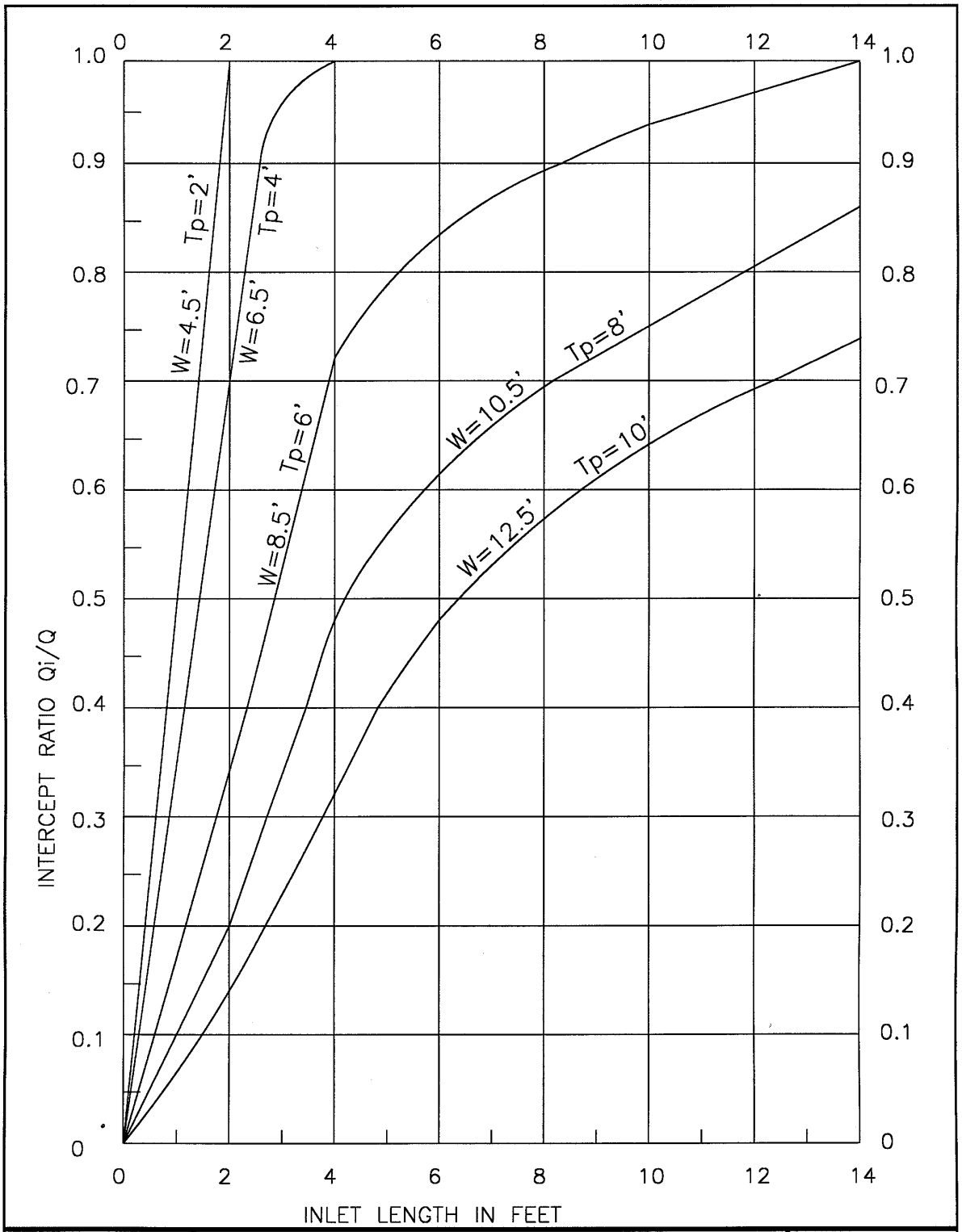
INLET CAPACITY TYPE I

So= 0.006, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.31



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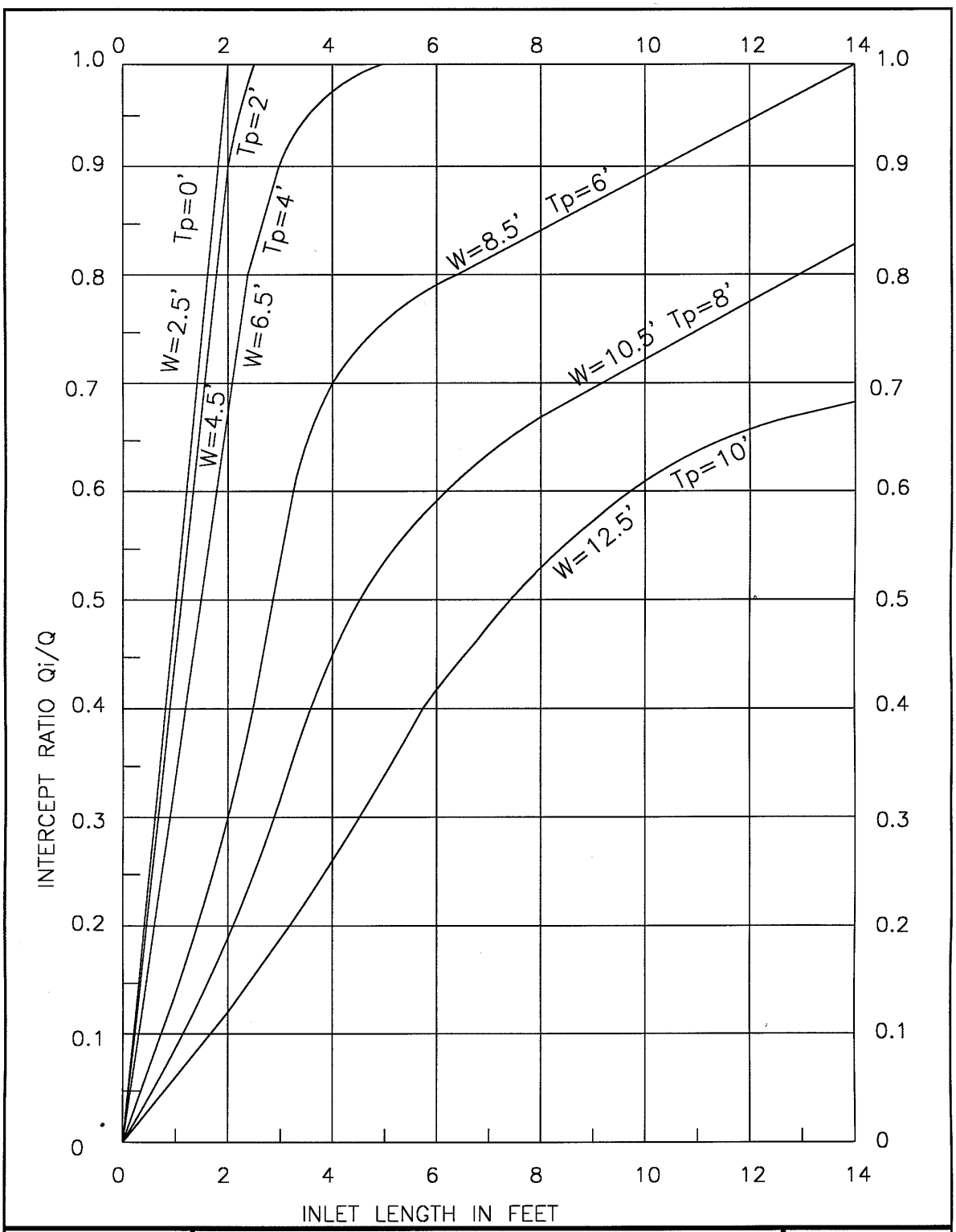
INLET CAPACITY TYPE I

So= 0.008, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.32



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APPROVED BY: J.O.

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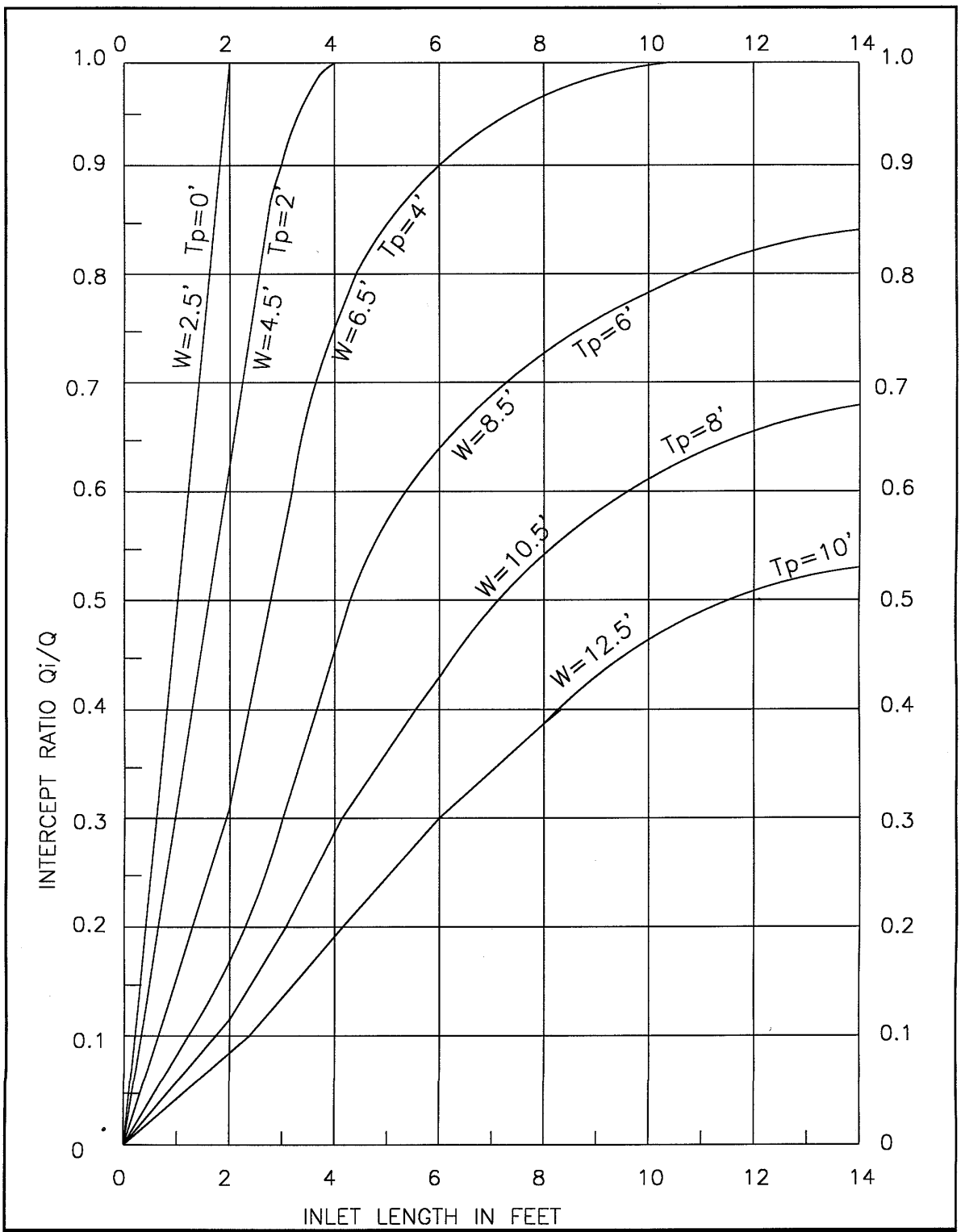
INLET CAPACITY TYPE I

So= 0.01, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.33



DRAWN BY: RRH

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APPROVED BY: J.O.

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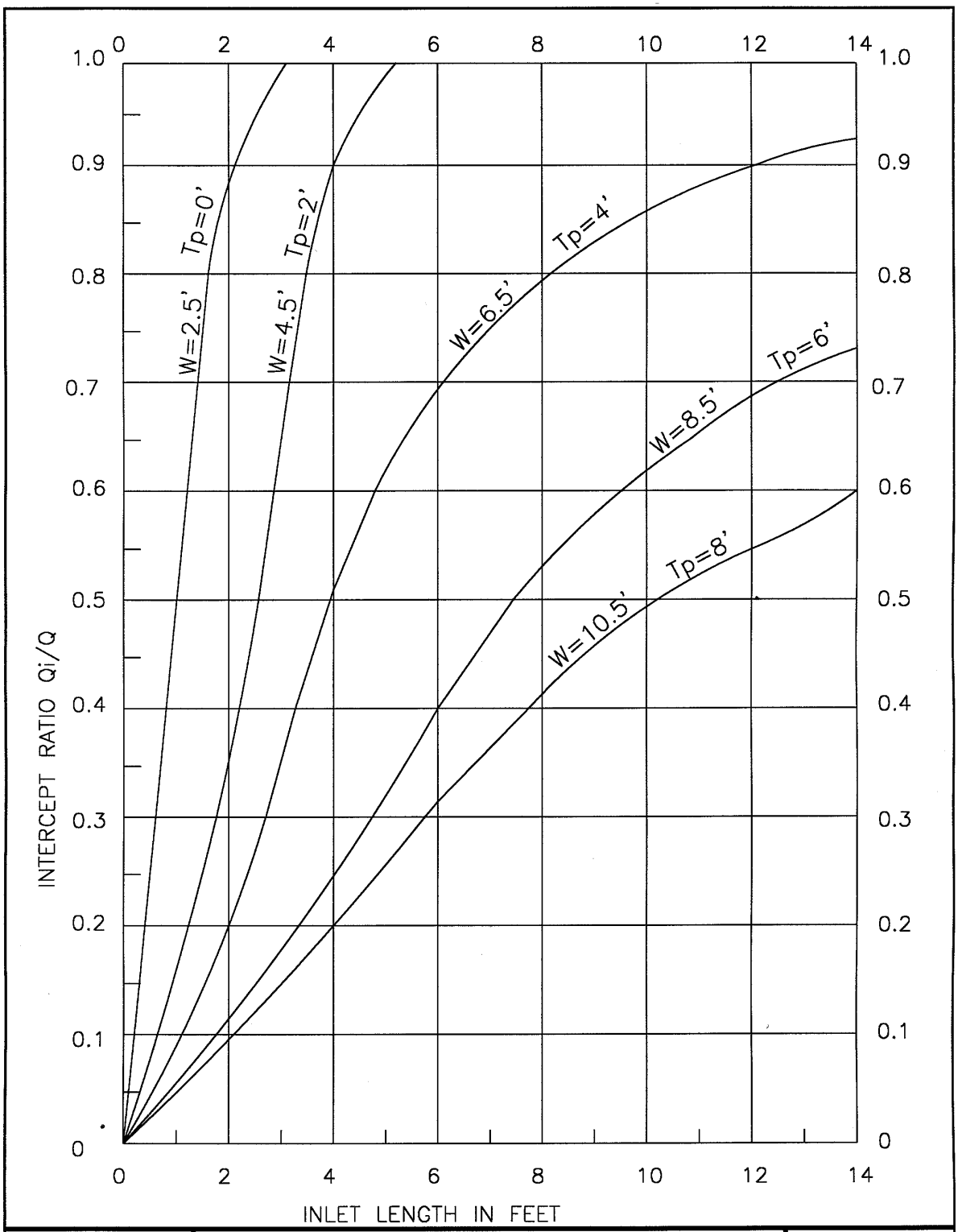
INLET CAPACITY TYPE I

So= 0.02, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED:

FIGURE NO. 11.34



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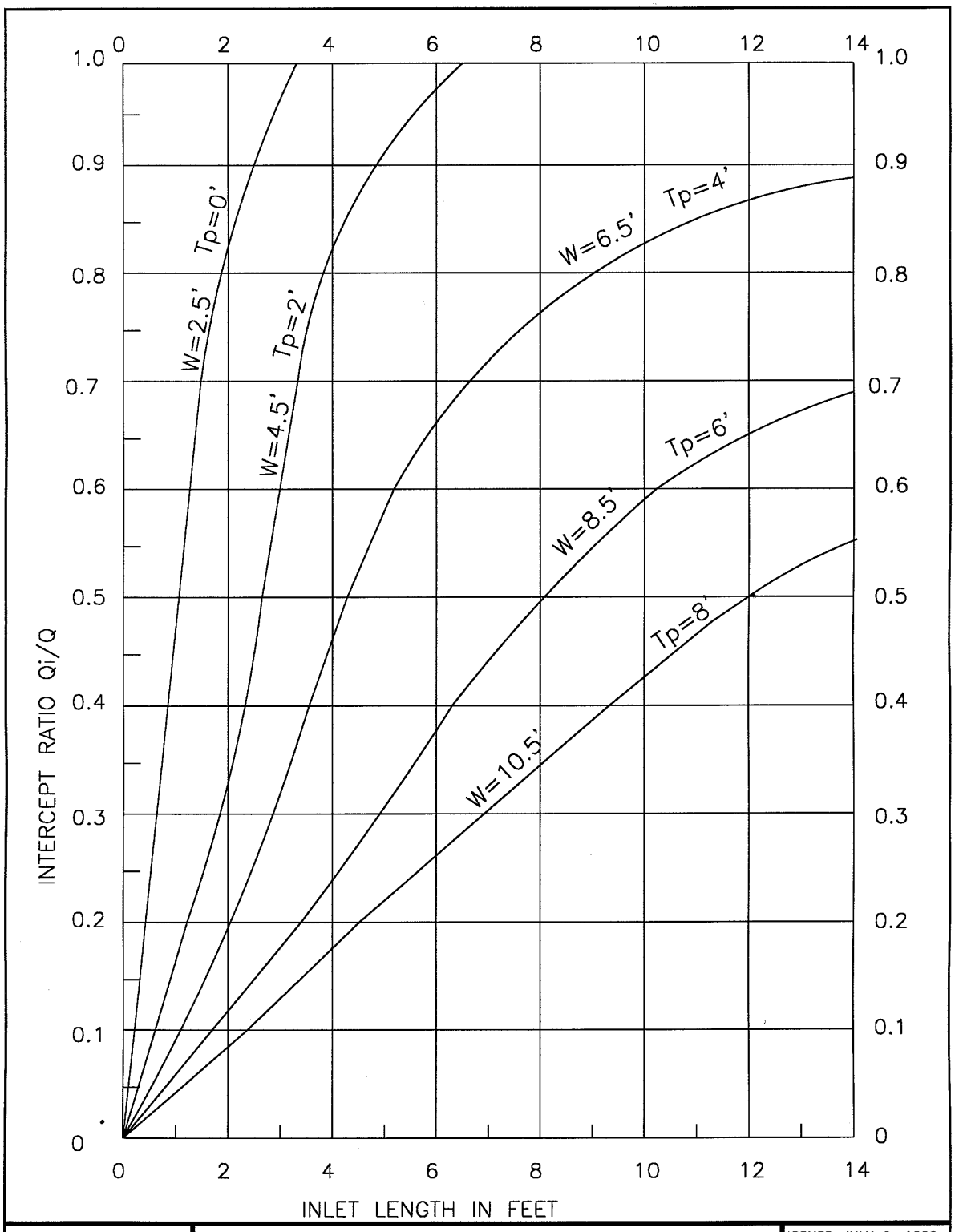
INLET CAPACITY TYPE I

So= 0.03, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.35



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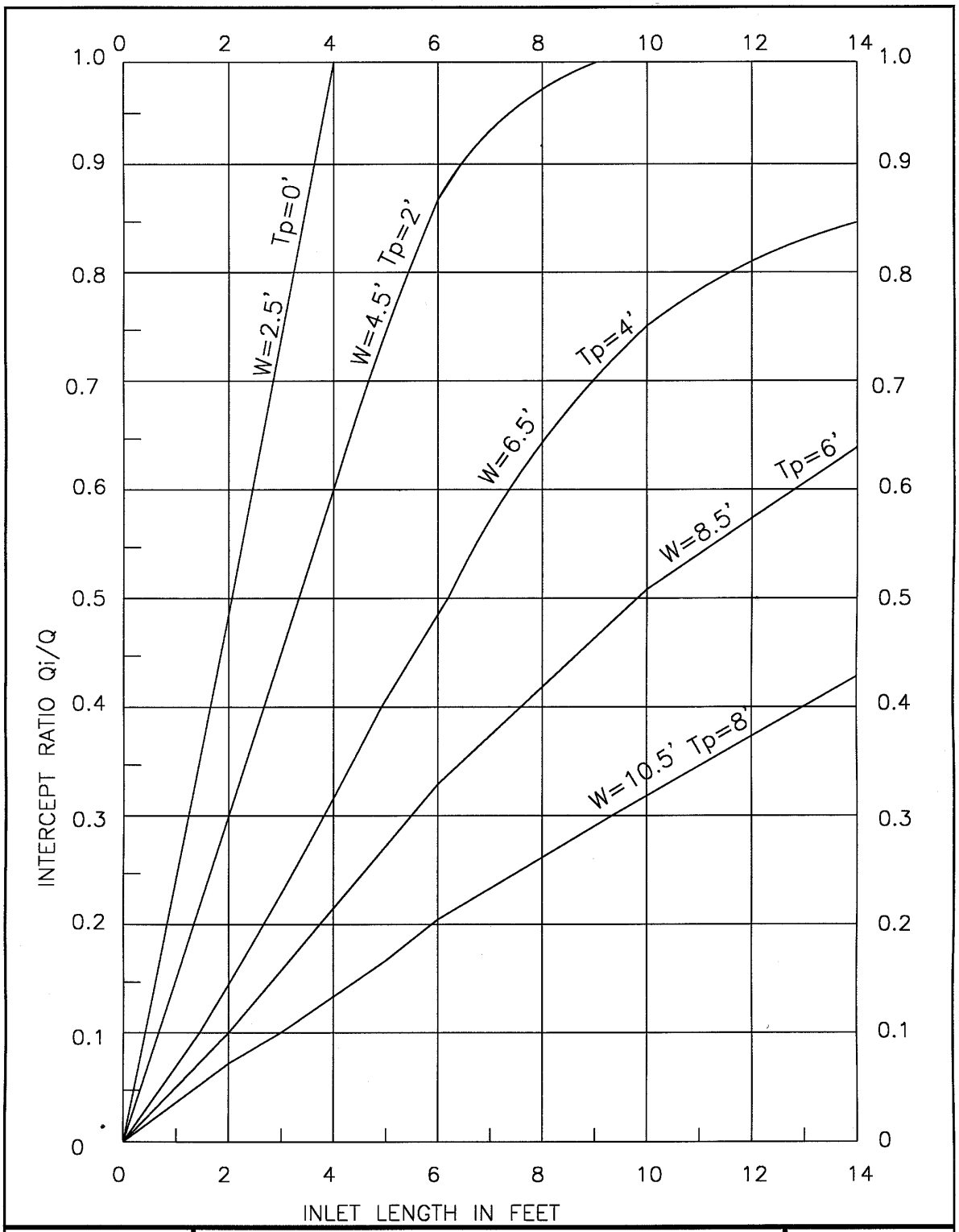
INLET CAPACITY TYPE I

So= 0.04, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.36



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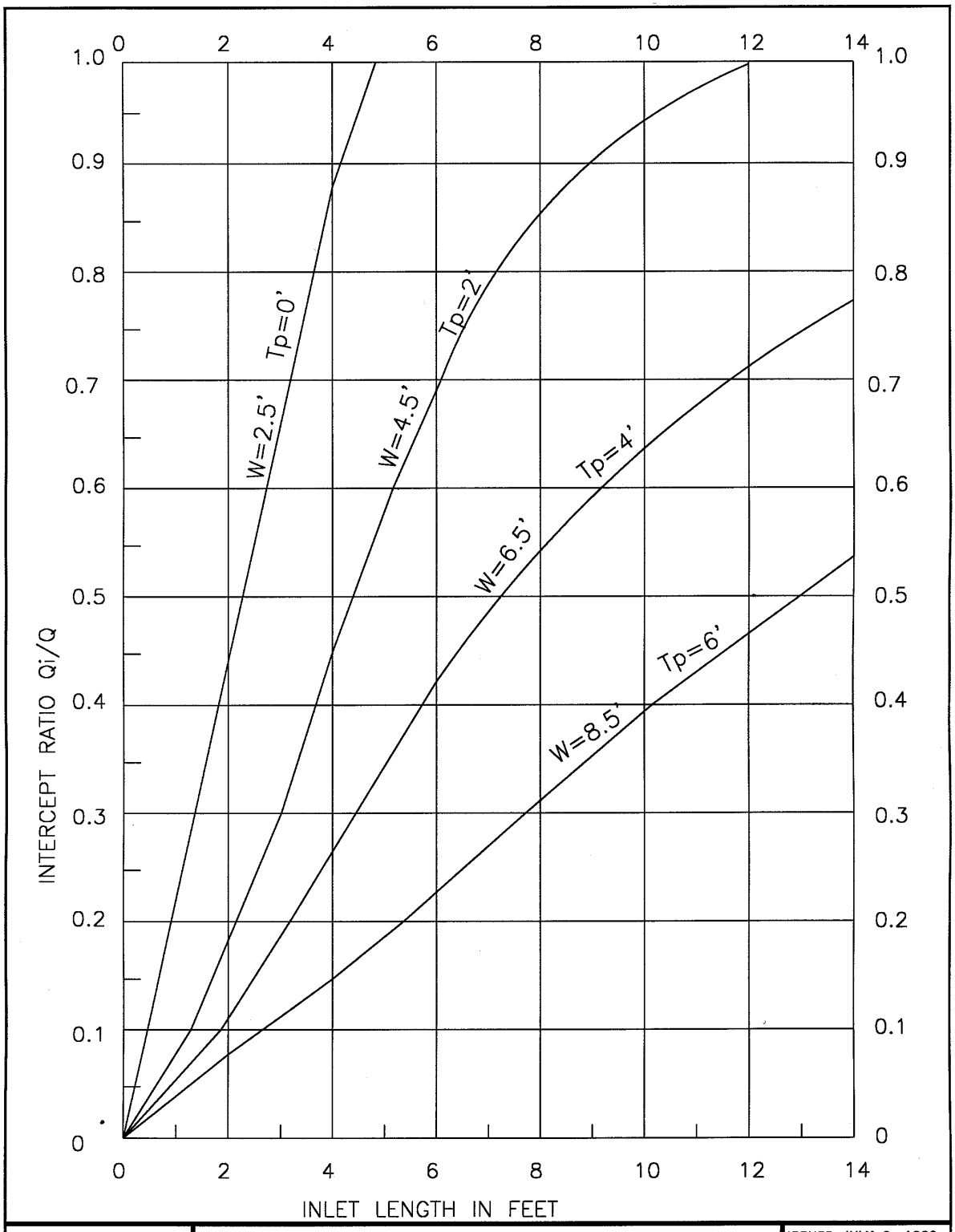
INLET CAPACITY TYPE I

So= 0.06, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.37



DRAWN BY: RRH

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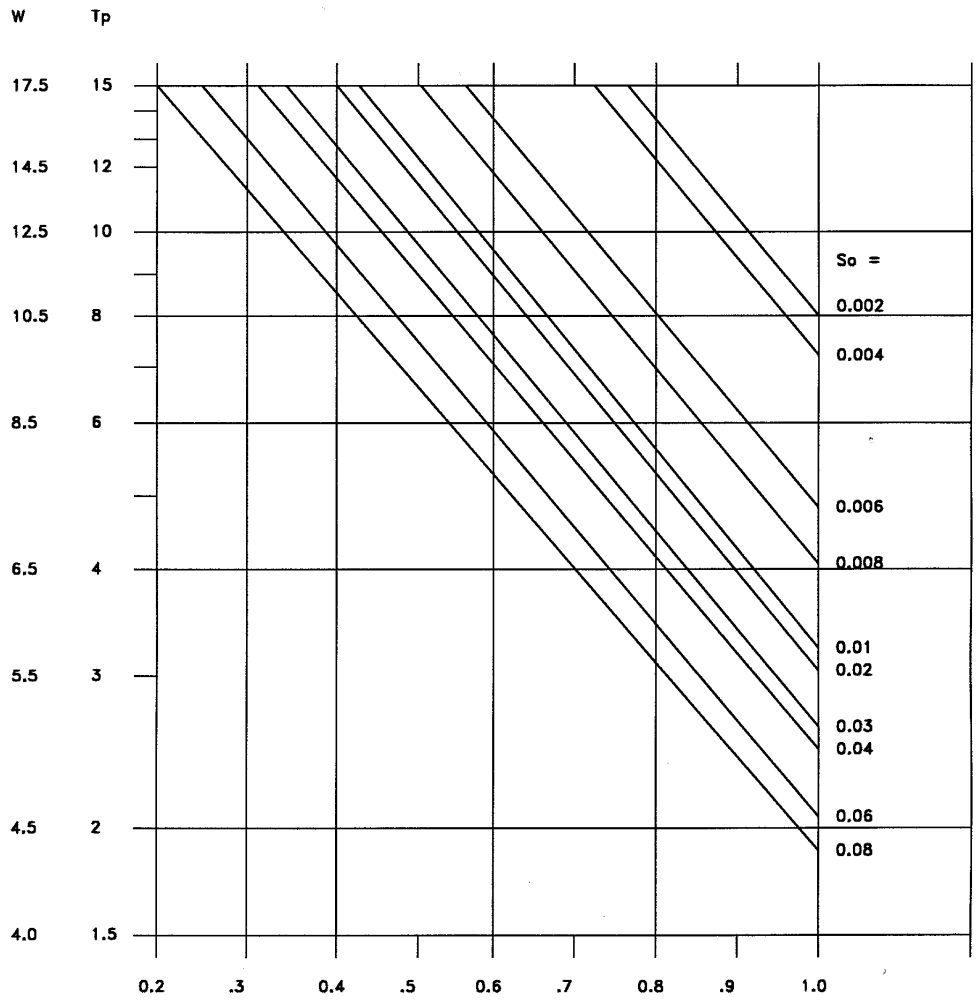
INLET CAPACITY TYPE I

So= 0.08, Sx=3/8"/ft.

ISSUED: JULY 9, 1999

REVISED: _____

FIGURE NO. 11.38



Sx = 1:64 or 3/16"/ft

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APPROVED BY: J.O.

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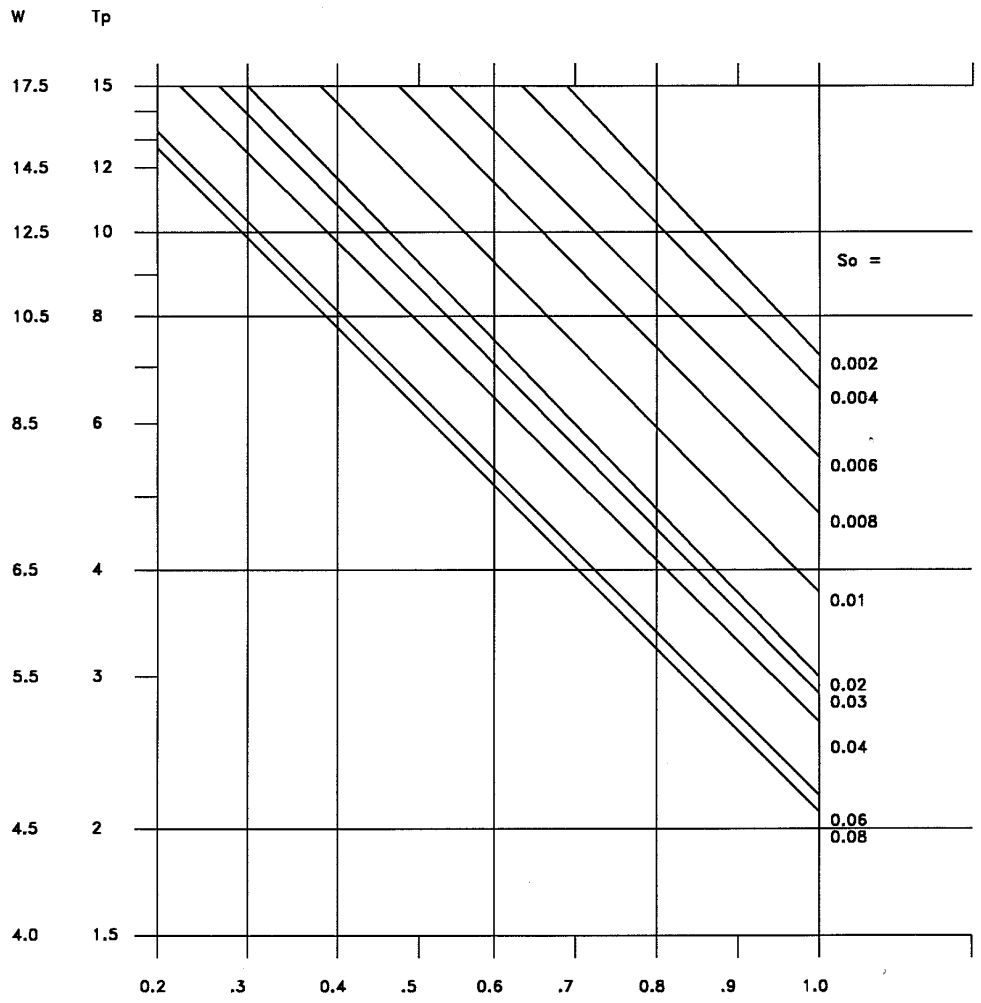
INLET CAPACITY TYPE II

ISSUED: JULY 9, 1999
REVISED:

FIGURE NO. 11.39



Sx = 1:48 or 1/4"/ft

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APPROVED BY: J.O.

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INLET CAPACITY TYPE II

ISSUED: JULY 9, 1999

REVISED:

FIGURE NO. 11.40

STORM SEWER DESIGN DATA
SIOUX FALLS ENGINEERING DEPARTMENT

SIOUX FALLS
OFFICE OF THE CITY ENGINEER
224 WEST 9TH STREET
SIOUX FALLS, S.D. 57102
(605) 367-7048

Project ______________ From ______________ To ______________

Computed by ______________ Checked by ______________ Date ______________ Sheet ______ of ______

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Inlet or Manhole No.	LOCATION	Drainage Area (Acres) A	Runoff Coefficient C	Equivalent Area C*A	Accumulative Equivalent Area	Time of Concentration (min.) T	Rainfall Rate (in. per hr.) i	Total Runoff (cfs) Q	Length of Sewer (ft)	Sewer Size (in.)	Slope Required (%)	Slope Provided (%)	Velocity Flowing Full (fps)	Capacity Flowing Full (fps)	Time of Flow in Section (min.)	Total Time (min.)	Type of Pipe	Remarks and/or Flowline Elevations

DRAWN BY: RRH
CHECKED BY: ______
APPROVED BY: J.O.

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STORM SEWER DESIGN DATA

ISSUED: JULY 9, 1999
REVISED: ______
FIGURE NO. 11.41

U30011.doc

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CHECKED BY:
APPROVED BY: J.O.

STORM SEWER INLET DESIGN DATA
SIOUX FALLS ENGINEERING DEPARTMENT

SIOUX FALLS
OFFICE OF THE CITY ENGINEER
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SIOUX FALLS, S.D. 57102
(605) 367-7048

Project _____ From _____ To _____

Computed by _____ Checked by _____ Date _____ Sheet _____ of _____

Sketch of Drainage Pattern & Inlet Location

DR. AREA		INLET		HYDROLOGY						$Q_R = CiA$		GUTTER FLOW & INLET INTERCEPTION						
No.	Acres	No.	Location	S	L	T	C	i	A	Q_R	Q_G	Gutter slope	Pav t Slope	W	D	Q_{in}	Bypass	Inlet Type

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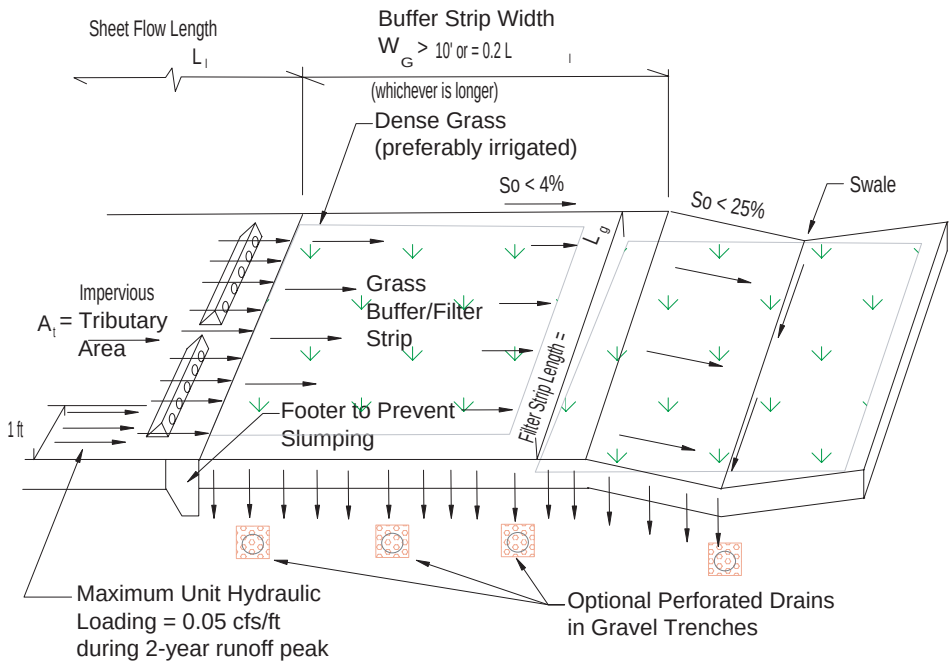
STORM SEWER INLET DESIGN DATA

ISSUED: JULY 9, 1999
REVISED: _____

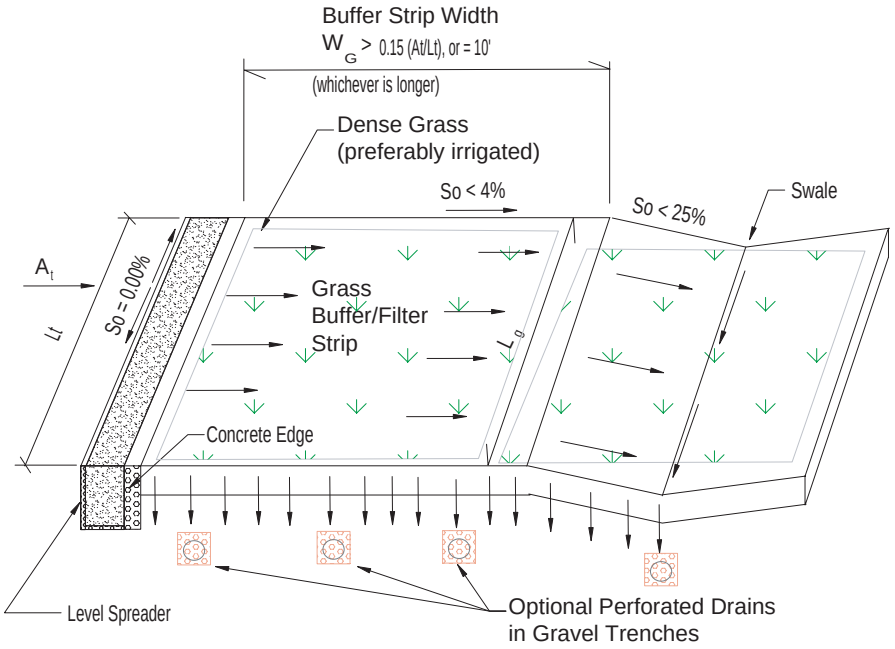
FIGURE NO. 11.42

04/14/17



SHEET FLOW CONTROL

Not To Scale



CONCENTRATED FLOW CONTROL

Not To Scale

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CHECKED BY:	APPLICATIONS OF GRASS BUFFERS	FIGURE NO. 11.43
APPROVED BY:		

Design Procedure Form: Grass Buffer (GB)

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. 2-Year Design Discharge (Total)	Q_2 = 5.0 cfs
2. Tributary Catchment Flow A) Design Length (Normal to runoff flow path): $L_G = Q_2 / 0.05$ B) Tributary Area in Square Feet (A_t)	 L_G = 100 feet A_t= 10,000 square feet
3. Design Width Along Direction of Flow (Use A **or** B) A) Sheet Flow Control Upstream i) Length of Flow Path Over Upstream Impervious Surface ii) Design Width of Buffer: $W_G = 0.2 * L_l$ (10' minimum) B) Concentrated (Non-Sheet) Flow Control Upstream (requires a level spreader in step 5 below) i) Length of Upstream Flow Level Spreader ii) Design Width of Buffer: $W_G = 0.15 * A_t / L_t$ (10' minimum)	 L_l = feet W_G = feet L_t = 80 feet W_G = 18.8 feet
4. Design Slope (not to exceed 4%)	S = 4.00 %
5. Flow Distribution (Check the type used or describe "Other") Note: If Method B was Used In Step 3, Level Spreader Must Be Checked Here	___ Slotted Curbing ___ Modular Block Porous Pavement X Level Spreader ___ Other: _____
6. Vegetation (Check the type used or describe "Other")	___ Irrigated Turf Grass X Non-Irrigated Turf Grass ___ Other: _____
7. Outflow Collection (Check the type used or describe "Other")	X Grass Lined Swale ___ Street Gutter ___ Storm Sewer Inlet X Underdrain Used ___ Other: _____

Notes: _____

DRAWN BY: _____

CHECKED BY: _____

APPROVED BY: _____

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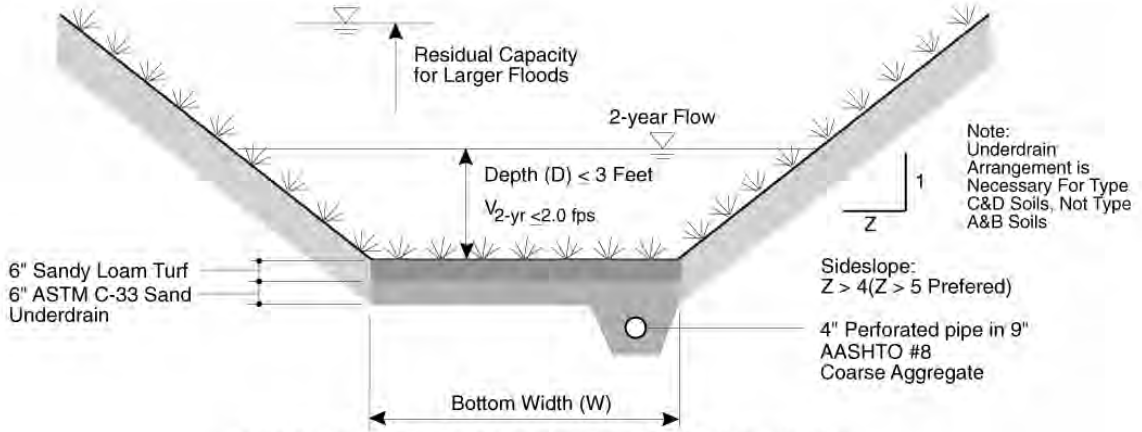
DESIGN PROCEDURE FORM: GRASS BUFFER

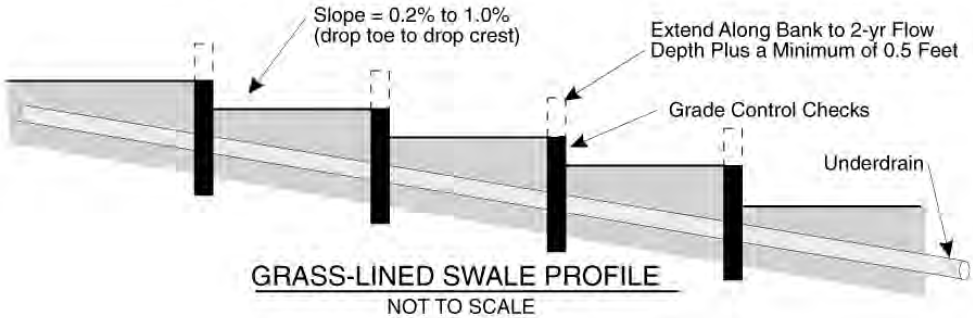
ISSUED: _____
REVISED: _____

FIGURE NO. 11.44



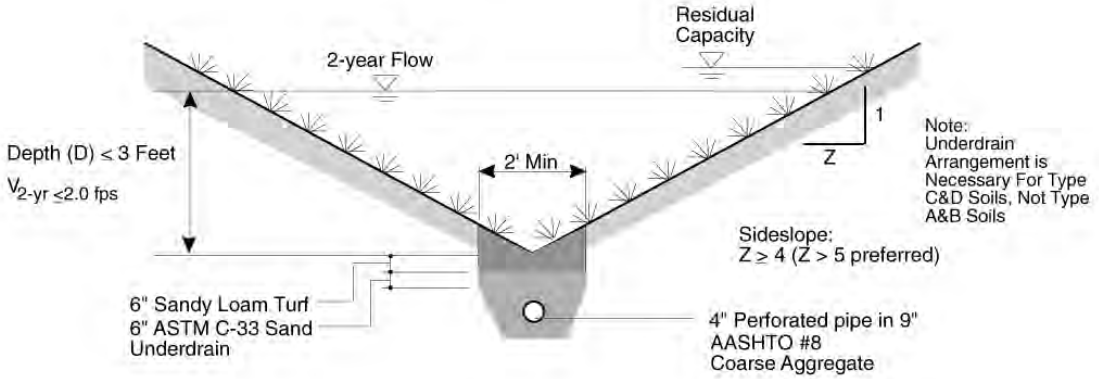
TRAPEZOIDAL GRASS-LINED SWALE SECTION

NOT TO SCALE



GRASS-LINED SWALE PROFILE

NOT TO SCALE



TRIANGULAR GRASS-LINED SWALE SECTION

NOT TO SCALE

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CHECKED BY:	PROFILE AND SECTIONS OF A GRASS SWALE	FIGURE NO. 11.45
APPROVED BY:		

Design Procedure Form: Grass Swale (GS) Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. 2-Year Design Discharge (Total)	Q_2 = 10.0 cfs
2-Year Design Flow Velocity (V_2, 1.5 fps Maximum)	V_2 = 1.30 fps
2. Swale Geometry	
A) Channel Side Slopes (Z, horizontal distance per unit vertical)	Z = 4.00 (horizontal/vertical)
B) 2-Year Design Flow Depth (D_2, 2 feet maximum)	D_2 = 1.4 feet
C) Bottom Width of Channel (B)	B = 0.0 feet
3. Longitudinal Slope	
A) Froude Number (F, 0.50 maximum, reduce V_2 until F ≤ 0.50)	F = 0.28
A) Design Slope (S, Based on Manning's n = 0.05, 0.01 Maximum)	S = 0.0032 feet/feet
B) Number of grade control structures required	5 (number)
4. Vegetation (Check the type used or describe "Other")	X Dryland Grass Irrigated Turf Grass Other:
5. Outlet (Check the type used or describe "Other")	X Infiltration Trench w/ Underdrain Grated Inlet Other:

Notes: _____

DRAWN BY: _____

CHECKED BY: _____

APPROVED BY: _____

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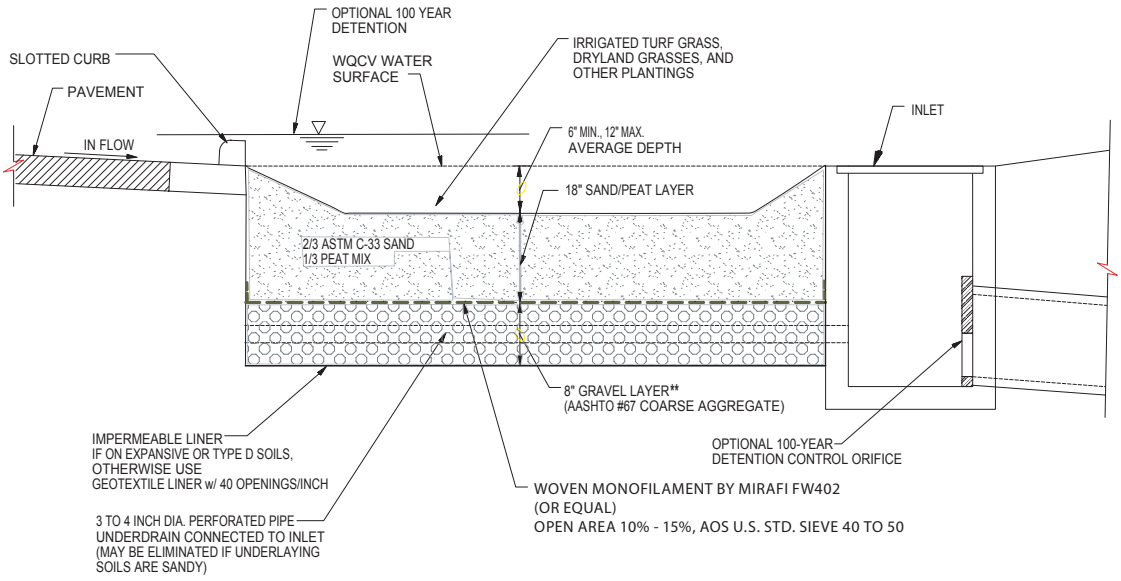
DESIGN PROCEDURE FORM: GRASS SWALE SEDIMENTATION FACILITY

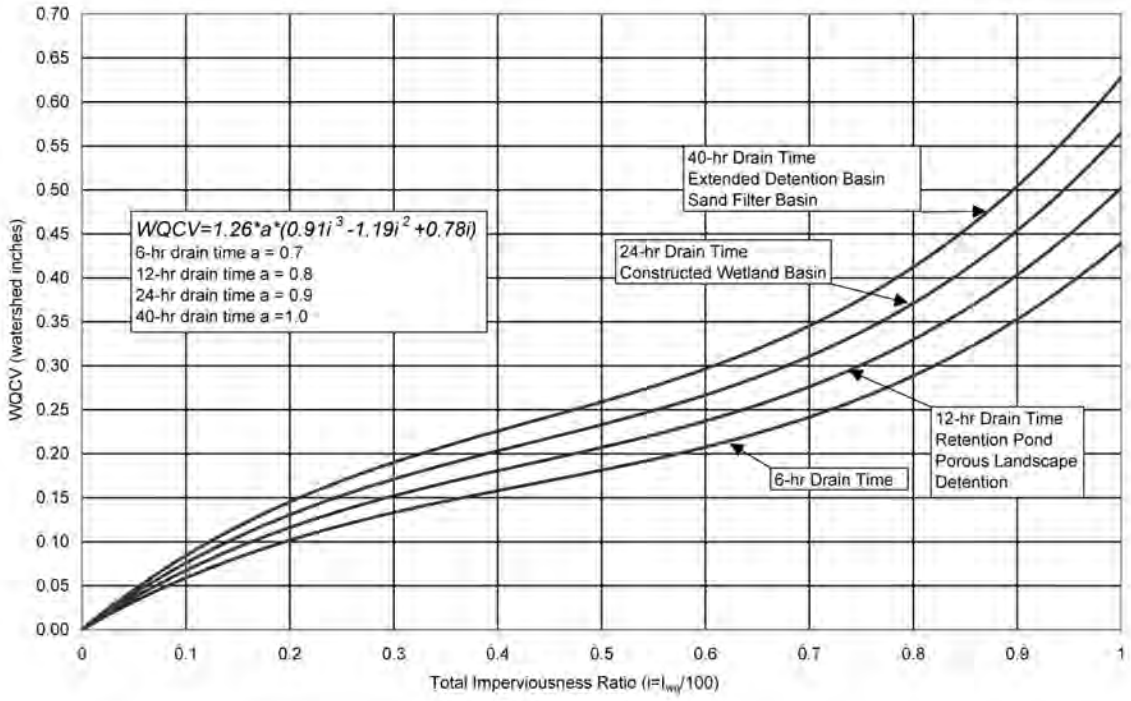
ISSUED: _____
REVISED: _____

FIGURE NO. 11.46



**** SUBSTITUTE AN 18" LAYER OF SAND/PEAT MIX FOR THE 8" GRAVEL LAYER WHEN NO UNDERDRAIN IS USED IN NRCS TYPE D SOILS OR IN EXPANSIVE SOILS. USE IMPERMEABLE LINER UNDER AND ON SIDES OF BASIN.**

DRAWN BY: _____ CHECKED BY: _____ APPROVED BY: _____	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	POROUS LANDSCAPE DETENTION	ISSUED: _____ REVISED: 10/04/12 FIGURE NO. 11.47



NOTE: WQCV adjusted to Sioux Falls based upon Urban Drainage and Flood Control District Volume 3 procedure page SQ-23

DRAWN BY: _____ CHECKED BY: _____ APPROVED BY: _____	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	WATER QUALITY CAPTURE VOLUME (WQCV), 80th PERCENTILE RUNOFF EVENT	ISSUED: _____ REVISED: _____ FIGURE NO. 11.48

Design Procedure Form: Porous Landscape Detention (PLD)

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. Basin Storage Volume (I_a = 100% if all paved and roofed areas u/s of PLD) A) Tributary Area's Imperviousness Ratio (i = I_a / 100) B) Contributing Watershed Area Including the PLD (Area) C) Water Quality Capture Volume (WQCV) (WQCV = 1.26 * 0.8 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I)) D) Design Volume: Vol_{PLD} = (WQCV / 12) * Area	I_a = 100.00 % i = 1.00 Area = 10,000 square feet WQCV = 0.50 watershed inches Vol = 420.0 cubic feet
2. PLD Surface Area (A_{PLD}) and Average Depth (d_{av}) (d_{av}: = (Vol / A_{PLD}), Min=0.5', Max=1.0')	A_{PLD} = 450 square feet d_{av} = 0.93 feet
3. Sand/Peat Mix and Gravel Subbase (See Figure 11.47) A) 67% Sand / 33% Peat Mix with 8" ASSHTO #67 Coarse Aggregate subbase B) 67% Sand / 33% Peat Mix with **no** aggregate subbase C) Other	X 18" minimum depth sand/peat mix with underdrain unless in sandy soils (no underdrain req.) _____ 36" minimum depth sand/peat mix for NRCS Type D soils where underdrain is not possible _____ Other: _____
4. Draining of PLD (Check A, **or** B, **or** C, **answer** D) Based on answers to 4A through 4D, check the appropriate method A) Check box if subgrade is heavy or expansive clay B) Check box if subgrade is silty or clayey sands C) Check box if subgrade is well-draining soils: X D) Does tributary catchment contain land uses that may have petroleum products, greases, or other chemicals present, such as gas station, hardware store, restaurant, etc.? yes: _____ no: X	X Infiltration to Subgrade with Permeable Membrane: 4(C) checked **and** 4(D) = no _____ Underdrain with Impermeable Membrane: 4(A) checked **or** 4(D) = yes _____ Underdrain with Permeable Membrane: 4(B) checked **and** 4(D) = no _____ No Underdrain with Impermeable Membrane: 3(B) checked - Evapotranspiration only _____ Other: _____

Notes: _____

DRAWN BY: _____

CHECKED BY: _____

APPROVED BY: _____

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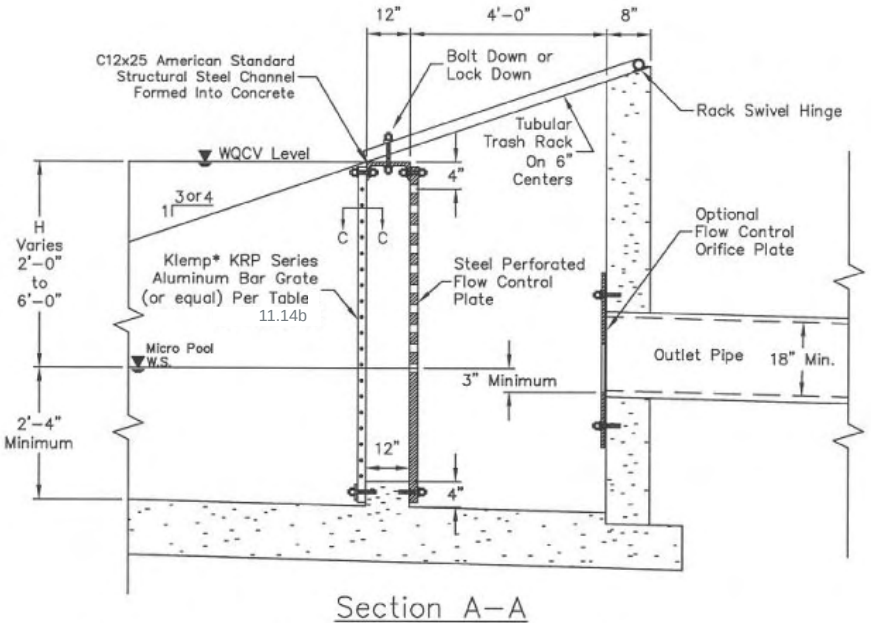
DESIGN PROCEDURE FORM: POROUS LANDSCAPE DETENTION

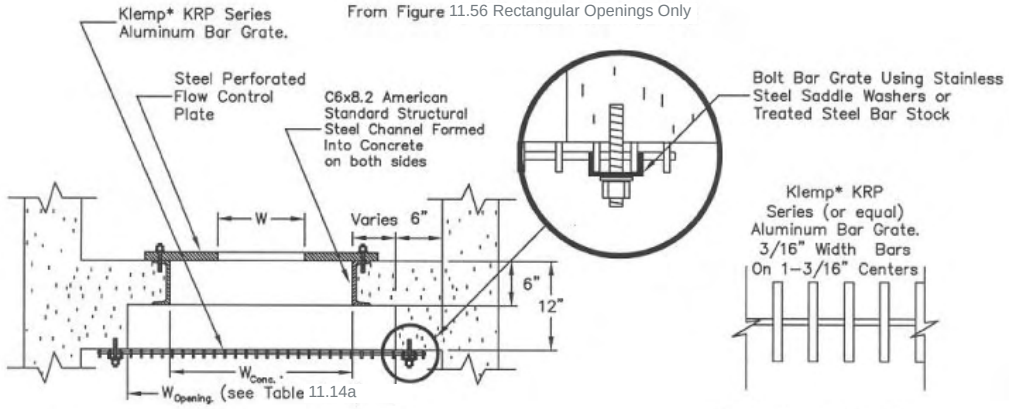
ISSUED: _____
REVISED: _____

FIGURE NO. 11.49



Section A–A

From Figure 11.56 Rectangular Openings Only



Section B–B – Plan View

From Figure 11.56 Rectangular Openings Only

Section C–C

From Figure 11.56 Rectangular Openings Only

Limits for this Standardized Design:

1. All outlet plate openings are rectangular.
2. Height of all rectangular openings = 2 inches.
3. For trash rack opening width ($W_{Opening}$), see Table 11.14a
4. Concrete opening for outlet plate ($W_{Conc.}$) = W + 12 inches

*Klemp Corporation, Orem, Utah, USA

R Value = (net open area)/(gross rack area)
= 0.71 for cross rods on 2" centers
= 0.77 for cross rods on 4" centers

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APPROVED BY: _____

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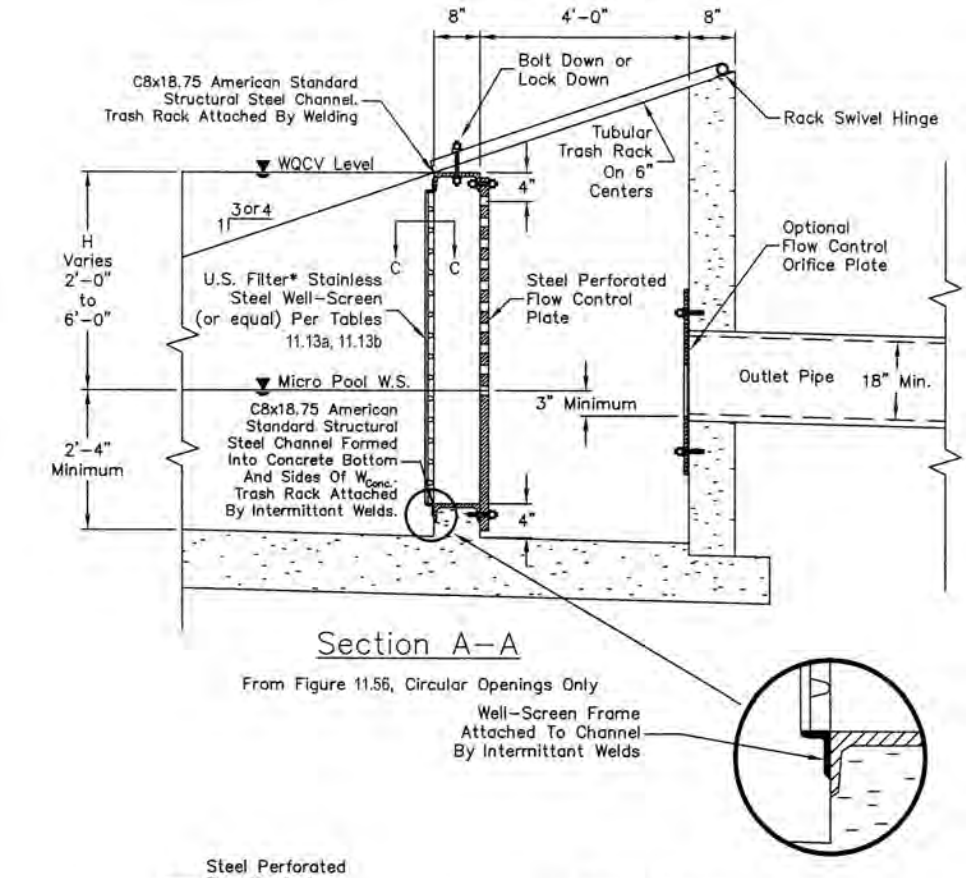
SUGGESTED STANDARDIZED TRASH RACK AND OUTLET DESIGN FOR WQCV OUTLETS WITH RECTANGULAR OPENINGS

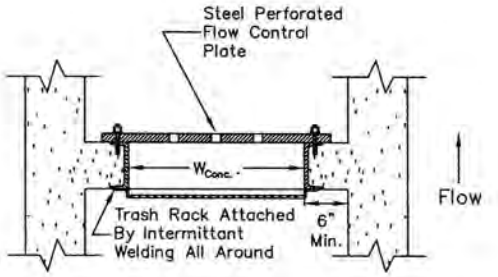
ISSUED: _____
REVISED: _____

FIGURE NO. 11.50a



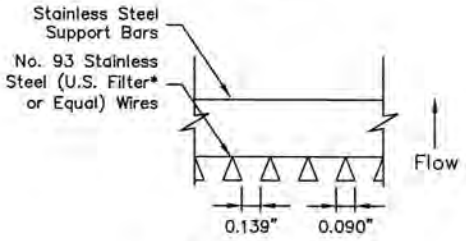
Section A–A

From Figure 11.56, Circular Openings Only



Section B–B – Plan View

From Figure 11.56, Circular Openings Only



Section C–C

From Figure 11.56, Circular Openings Only

R Value = (net open area)/(gross rack area) = 0.60

Limits for this Standardized Design:

1. All outlet plate openings are circular.
2. Maximum diameter of opening = 2 inches.

*U.S. Filter, St. Paul, Minnesota, USA

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Typical Outlet Structure Notes:

1. The details shown are intended to show design concepts. Preparation of final design plans, addressing details of structural adequacy, excavation, foundation preparation, concrete work, reinforcing steel, backfill, metalwork, and appurtenances, including preparation of technical specifications, are the responsibility of the design engineer.

2. Alternate designs to the typical outlet structures shown may be considered; however, alternate designs must address the hydraulic and trash handling functional elements of the structures shown.

3. Wingwalls shown are intended to enable the structure to be backfilled to be flush with the side slopes of the basin, which is the recommended geometry. Other geometries may be considered if their designs related to public safety, aesthetics, maintainability, and function are equal to or better than the designs shown.

4. Permanent Water Surface shown refers to micro-pool for Extended Detention Basin or permanent pool for Constructed Wetland Basin or Retention Pond.

5. An orifice plate is shown as the outflow control; however, an upturned pipe, with orifices may also be used. See Figure 11.53 for orifice design information.

6. A Vertical Trash Rack option is generally shown; however, an Adverse-Slope Trash Rack may also be used. Continuous-Slope Trash Racks for use with WQCV outlets are not recommended. See Figure 11.56 for trash rack design information.

7. References are made to 2- or 10-year detention above the WQCV; however, detention above the WQCV may be sized for any storm event.

8. The underdrain, including a shutoff valve, from the perimeter of the pond is required for a Wetland Basin and a Retention Pond. An underdrain, without a shutoff valve, is optional for the micro-pool and may be used to help dry the micro-pool during dry-weather periods.

9. When outlet designs differ from those shown herein:

   a) Provide needed orifices that are distributed over the vertical height of the WQCV, with the lowest orifice located at 2'-6" or more above the bottom of the micro-pool.

   b) Provide full hydraulic calculations demonstrating that the outlet will provide no less than the minimum required drain time of the Water Quality Capture Volume for the BMP type being designed.

   c) All outlet openings (i.e., orifices) shall be protected by a trash rack sized to provide a minimum net opening area called for by Figure 11.57, and all trash rack opening dimensions shall be smaller than the smallest dimension of the outlet orifices.

   d) Trash racks shall be manufactured from stainless steel or aluminum alloy structurally designed to not fail under a full hydrostatic load on the upstream side.

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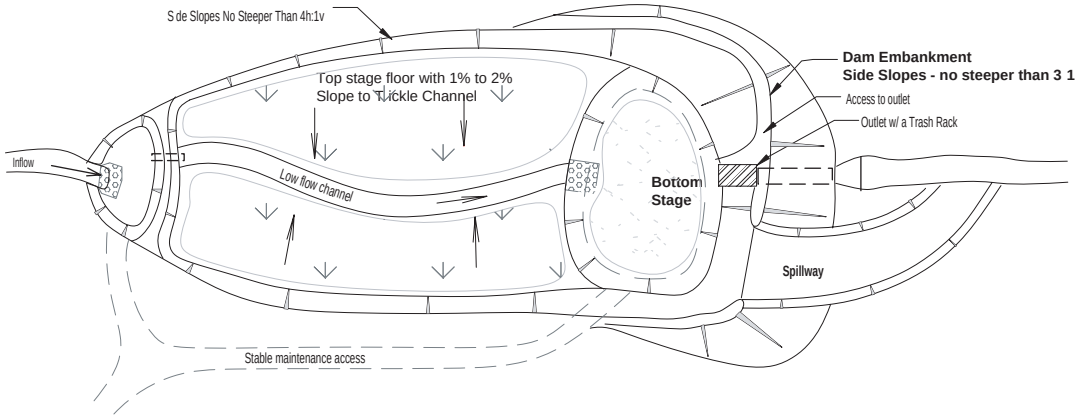
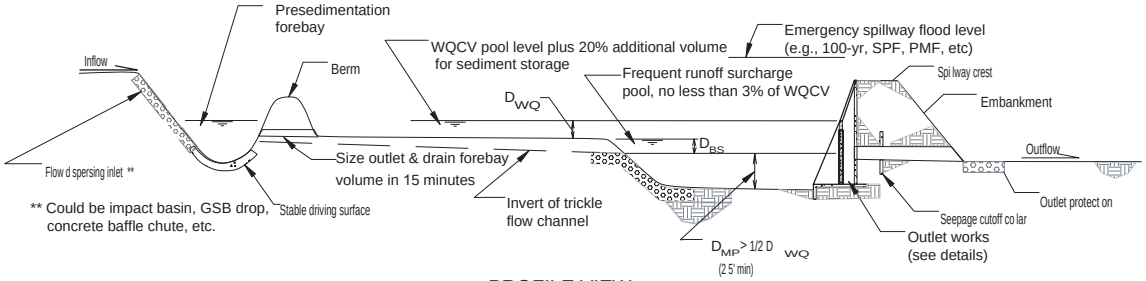
ISSUED: _____ REVISED: _____	FIGURE NO. 11.50c	



PLAN VIEW
Not to Scale



PROFILE VIEW
Not to Scale

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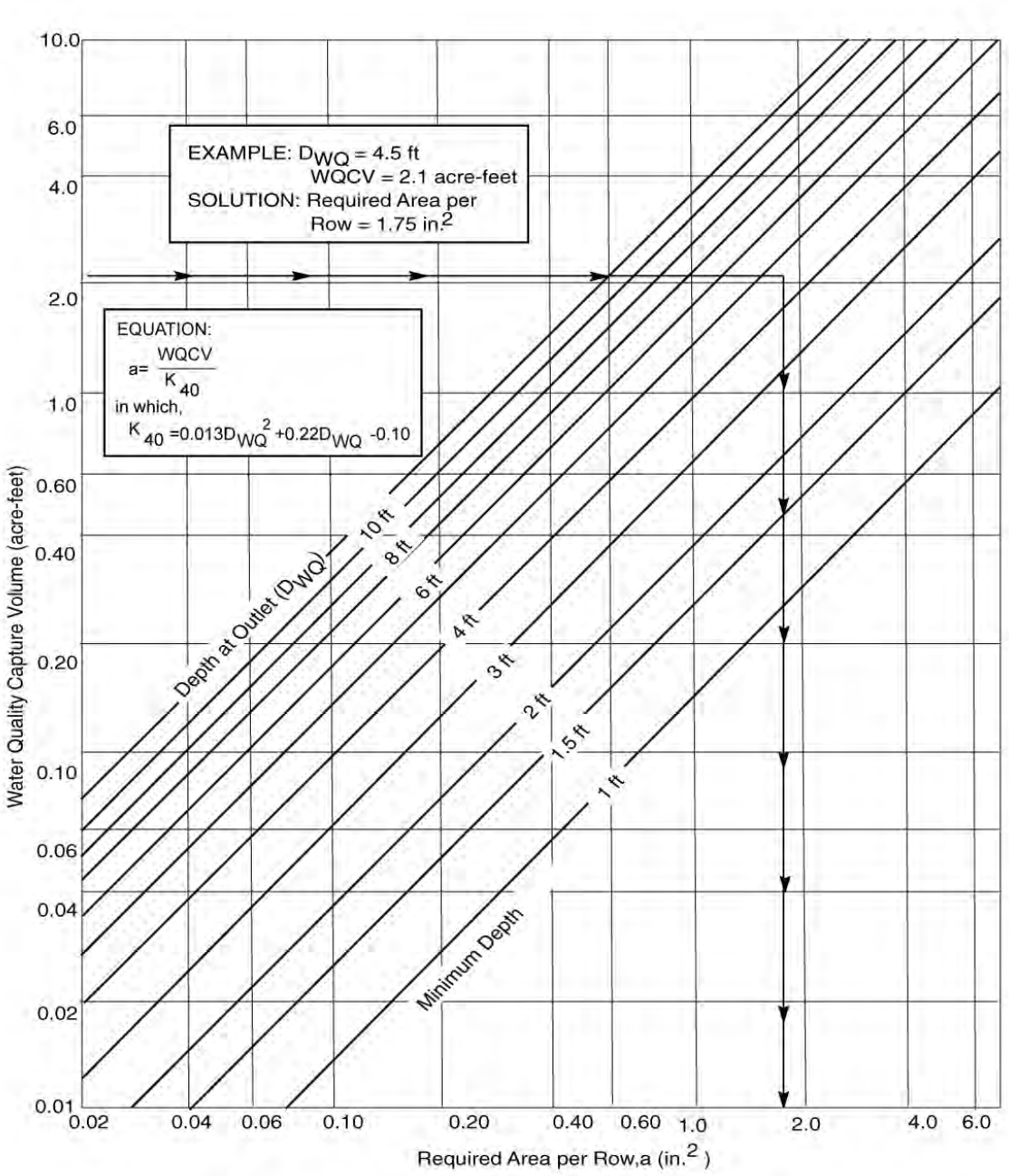
PLAN AND PROFILE OF AN EXTENDED DETENTION BASIN SEDIMENTATION FACILITY

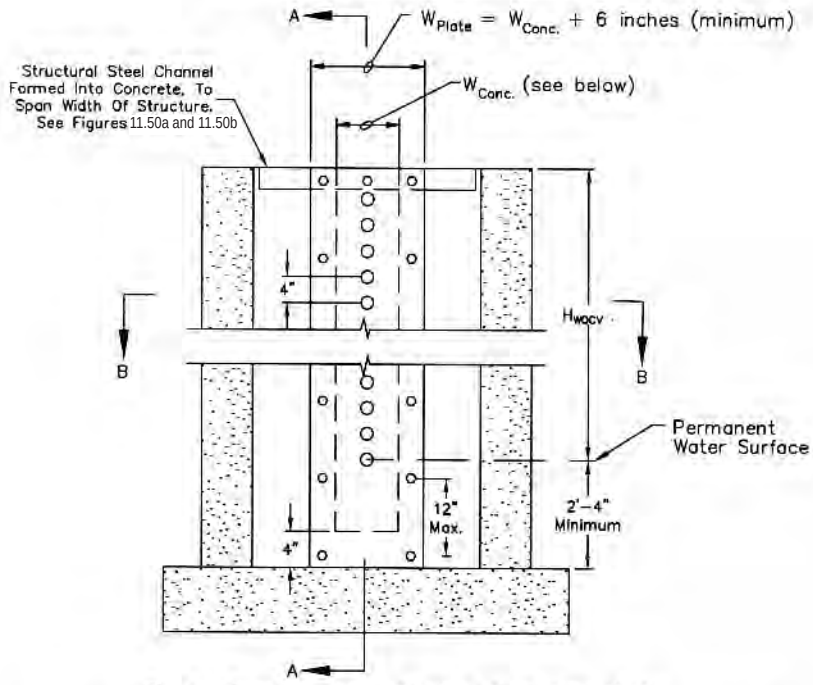
ISSUED: _____
REVISED: _____

FIGURE NO. 11.51



DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	WATER QUALITY OUTLET SIZING: DRY EXTENDED DETENTION BASIN, SAND FILTER BASIN WITH A 40-HOUR DRAIN TIME OF THE CAPTURE VOLUME	ISSUED: REVISED:
CHECKED BY:			FIGURE NO. 11.52
APPROVED BY:			

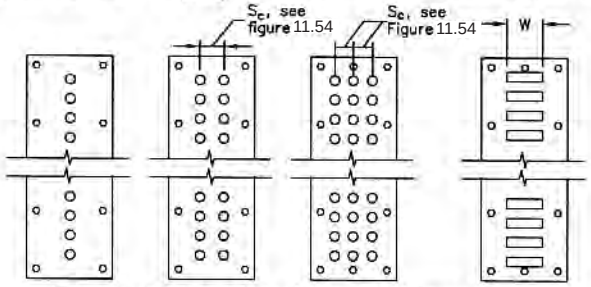
Orifice Perforation Details



Circular Openings: $W_{Conc.}$ Obtained From Table 11.13a

Rectangular Openings: $W_{Conc.}$ = (Width of Rectangular Perforation W) + 12"

Rectangular Openings: $W_{Opening}$ (see Figure 11.50a) Obtained From Table 11.14a



Example Perforation Patterns

Note: The goal in designing the outlet is to minimize the number of columns of perforations that will drain the WQCV in the desired time. Do not, however, increase the diameter of circular perforations or the height of the rectangular perforations beyond 2 inches. Use the allowed perforation shapes and configurations shown above along with Figure 11.54 to determine the pattern that provides an area per row closest to that required without exceeding it.

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Orifice Plate Perforation Sizing

Circular Perforation Sizing

Chart may be applied to orifice plate or vertical pipe outlet.

Hole Dia (in) *	Hole Dia (in)	Min. Sc (in)	Area per Row (sq in)		
			n=1	n=2	n=3
1/4	0.250	1	0.05	0.10	0.15
5/16	0.313	2	0.08	0.15	0.23
3/8	0.375	2	0.11	0.22	0.33
7/16	0.438	2	0.15	0.30	0.45
1/2	0.500	2	0.20	0.39	0.59
9/16	0.563	3	0.25	0.50	0.76
5/8	0.625	3	0.31	0.61	0.92
11/16	0.688	3	0.37	0.74	1.11
3/4	0.750	3	0.44	0.88	1.33
13/16	0.813	3	0.52	1.04	1.56
7/8	0.875	3	0.60	1.20	1.80
15/16	0.938	3	0.69	1.38	2.07
1	1.000	4	0.79	1.57	2.36
1 1/16	1.063	4	0.89	1.77	2.66
1 1/8	1.125	4	0.99	1.99	2.98
1 3/16	1.188	4	1.11	2.22	3.32
1 1/4	1.250	4	1.23	2.45	3.68
1 5/16	1.313	4	1.35	2.71	4.06
1 3/8	1.375	4	1.48	2.97	4.45
1 7/16	1.438	4	1.62	3.25	4.87
1 1/2	1.500	4	1.77	3.53	5.30
1 9/16	1.563	4	1.92	3.83	5.75
1 5/8	1.625	4	2.07	4.15	6.22
1 11/16	1.688	4	2.24	4.47	6.71
1 3/4	1.750	4	2.41	4.81	7.22
1 13/16	1.813	4	2.58	5.16	7.74
1 7/8	1.875	4	2.76	5.52	8.28
1 15/16	1.938	4	2.95	5.90	8.84
2	2.000	4	3.14	6.28	9.42
n = Number of columns of perforations					
Minimum steel plate thickness			1/4 "	5/16 "	3/8 "

* Designer may interpolate to the nearest 32nd inch to better match the required area, if desired.

Rectangular Perforation Sizing

Only one column of rectangular perforations allowed.

Rectangular Height = 2 inches

$$\text{Rectangular Width (inches)} = \frac{\text{Required Area per Row (sq in)}}{2"}$$

Rectangular Hole Width	Min. Steel Thickness
5"	1/4 "
6"	1/4 "
7"	5/32 "
8"	5/16 "
9"	11/32 "
10"	3/8 "
>10"	1/2 "

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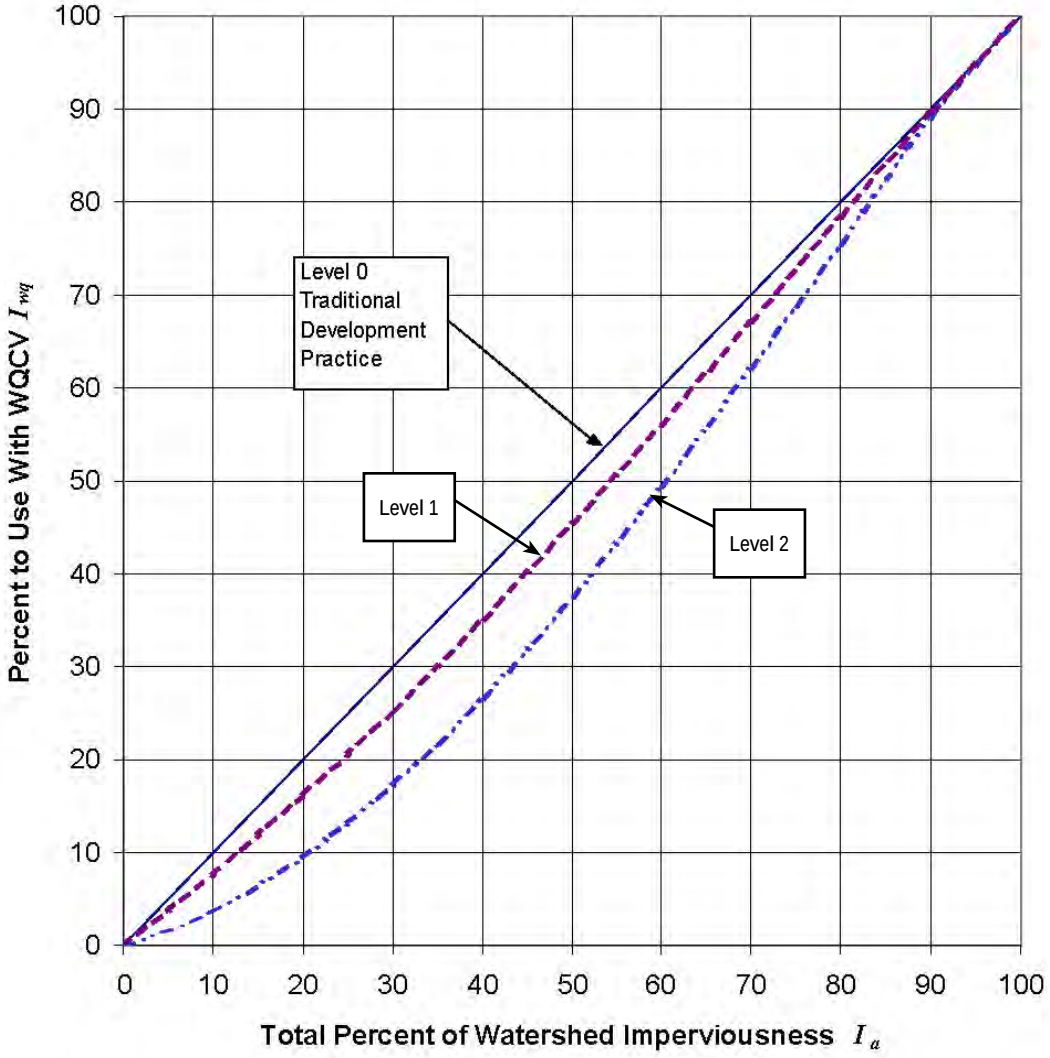
WQCV OUTLET ORIFICE PERFORATION SIZING

ISSUED: _____

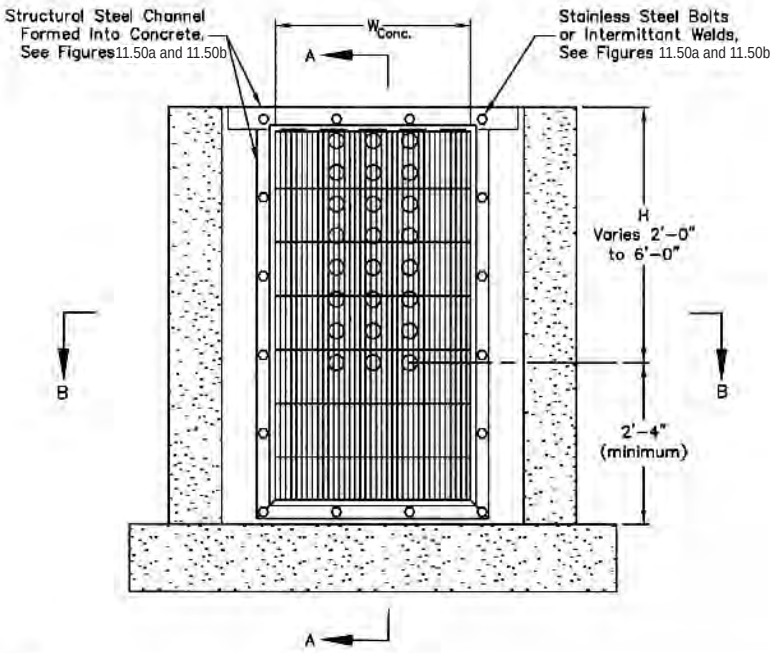
REVISED: _____

FIGURE NO. 11.54



DRAWN BY: _____ CHECKED BY: _____ APPROVED BY: _____	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	IMPERVIOUSNESS TO USE WITH WATER QUALITY CAPTURE VOLUME (WQCV)	ISSUED: _____ REVISED: _____ FIGURE NO. 11.55

Note: Vertical WQCV Trash Racks are shown in Figures 11.50a, 11.50b and 11.56 for suggested standardized outlet design. Adverse–Slope Trash Rack design may be used for non–standardized designs, but must meet minimum design criteria.



Elevation

WQCV Trash Racks:

1. Well–screen trash racks shall be stainless steel and shall be attached by intermittant welds along the edge of the mounting frame.
2. Bar grate trash racks shall be aluminum and shall be bolted using stainless steel hardware.
3. Trash Rack widths are for specified trash rack material. Finer well–screen or mesh size than specified is acceptable, however, trash rack dimensions need to be adjusted for materials having a different open area/gross area ratio (R value)
4. Structural design of trash rack shall be based on full hydrostatic head with zero head downstream of the rack.

Overflow Trash Racks:

1. All trash racks shall be mounted using stainless steel hardware and provided with hinged and lockable or boltable access panels.
2. Trash racks shall be stainless steel, aluminum, or steel. Steel trash racks shall be hot dip galvanized and may be hot powder painted after galvanizing.
3. Trash Racks shall be designed such that the diagonal dimension of each opening is smaller than the diameter of the outlet pipe.
4. Structural design of trash rack shall be based on full hydrostatic head with zero head downstream of the rack.

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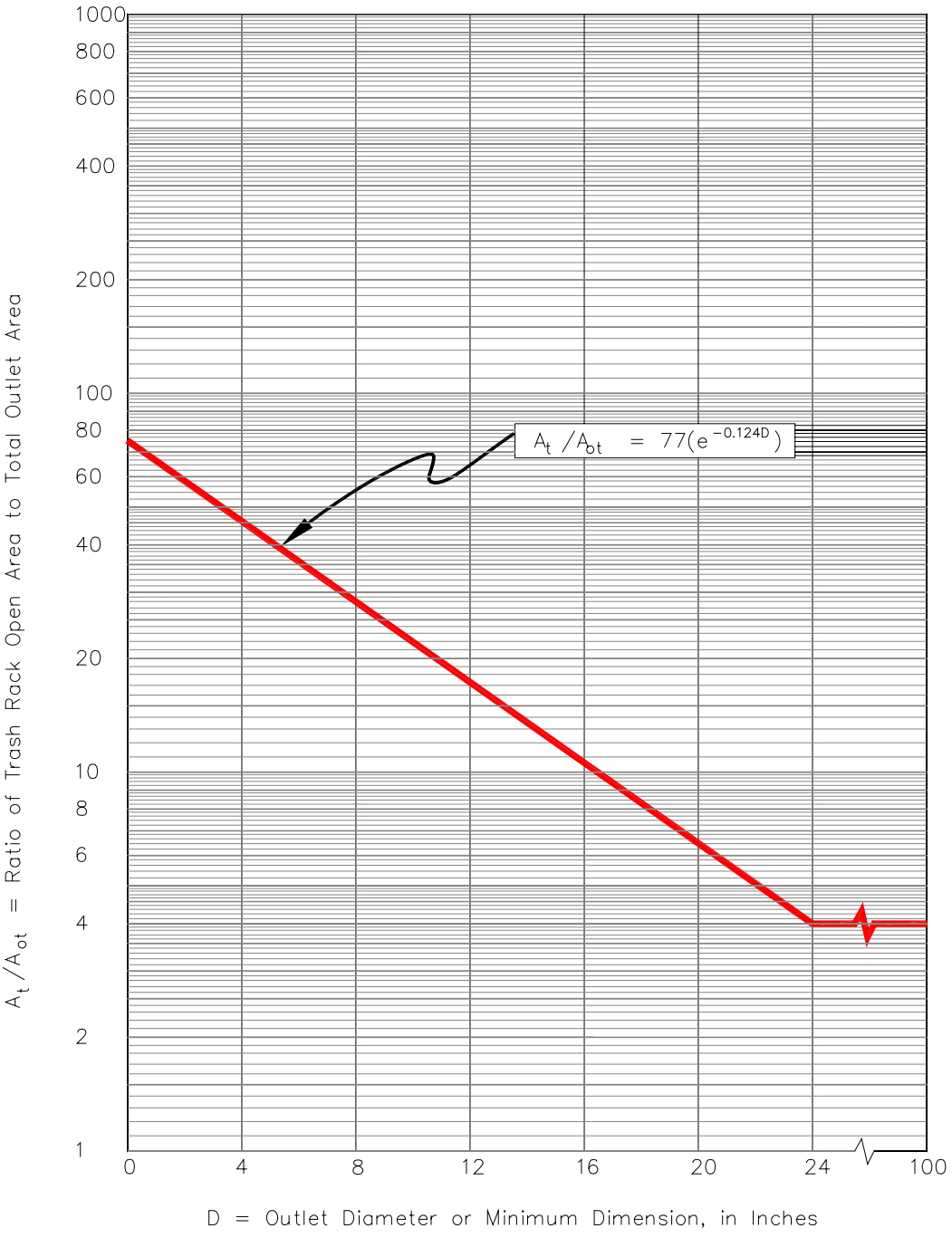

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(605) 367-7048

MINIMUM TRASH RACK OPEN AREA - EXTENDED RANGE

ISSUED: _____
REVISED: _____

FIGURE NO. 11.57

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. Basin Storage Volume	
A) Tributary Area's Imperviousness Ratio (i = I_a / 100)	I_a = 50.00 % i = 0.50
B) Contributing Watershed Area (Area)	Area = 100.00 acres
C) Water Quality Capture Volume (WQCV) (WQCV = 1.26 * 1.0 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I))	WQCV = 0.26 watershed inches
D) Design Volume: Vol = (WQCV / 12) * Area * 1.2	Vol = 2.599 acre-feet
2. Outlet Works	
A) Outlet Type (Check One)	X Orifice Plate _____ Perforated Riser Pipe _____ Other: _____
B) Depth at Outlet Above Lowest Perforation (H)	H = 4.00 feet
C) Required Maximum Outlet Area per Row, (A_o)	A_o = 2.19 square inches
D) Perforation Dimensions **(enter one only)**: i) Circular Perforation Diameter **OR** ii) 2" Height Rectangular Perforation Width	 D = 1.125 inches, **OR** W = _____ inches
E) Number of Columns (nc, See Table 11.13a For Maximum)	nc = 2 number
F) Actual Design Outlet Area per Row (A_o)	A_o = 1.99 square inches
G) Number of Rows (nr)	nr = 12 number
H) Total Outlet Area (A_{ot})	A_{ot} = 23.86 square inches
3. Trash Rack	
A) Needed Open Area: A_t = 0.5 * (Figure 11.57 Value) * A_{ot}	A_t = 799 square inches
B) Type of Outlet Opening (Check One)	X ≤ 2" Diameter **Round** _____ 2" High **Rectangular** _____ Other: _____
C) For 2", or Smaller, **Round Opening** (Ref.: Figure 11.50b):	
i) Width of Trash Rack and Concrete Opening (W_{conc}) from Table 11.13a	W_{conc} = 24 inches
ii) Height of Trash Rack Screen (H_{TR}) H	$_{TR}$ = 78 inches

DRAWN BY: _____

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DESIGN PROCEDURE FORM: EXTENDED DETENTION BASIN SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.58

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

iii) Type of Screen (Based on Depth H), Describe if "Other"	X S.S. #93 VEE Wire (US Filter) Other: _____
iv) Screen Opening Slot Dimension, Describe if "Other"	X 0.139" (US Filter) Other: _____
v) Spacing of Support Rod (O.C.) Type and Size of Support Rod (Ref.: Table 11.13b)	1.00 inches **TE 0.074 in. x 0.75 in.**
vi) Type and Size of Holding Frame (Ref.: Table 11.13b)	**1.00 in. x 1.50 in. angle**
D) For 2" High **Rectangular Opening** (Refer to Figure 11.50a):	
I) Width of Rectangular Opening (W)	W = _____ inches
ii) Width of Perforated Plate Opening (W_{conc} = W + 12")	W_{conc} = _____ inches
iii) Width of Trashrack Opening ($W_{opening}$) from Table 11.14a	$W_{opening}$ = _____ inches
iv) Height of Trash Rack Screen (H_{TR}) H	$_{TR}$ = _____ inches
v) Type of Screen (based on depth H) (Describe if "Other")	_____ Klemp™ KPP Series Aluminum Other: _____
vi) Cross-bar Spacing (Based on Table 11.14a, Klemp™ KPP Grating). Describe if "Other"	_____ inches Other: _____
vii) Minimum Bearing Bar Size (Klemp™ Series, Table 11.14b) (Based on depth of WQCV surcharge)	
4. Detention Basin length to width ratio	2.00 (L/W)
5 Pre-sedimentation Forebay Basin - Enter design values	
A) Volume (no less than 5% of Design Volume from 1D)	0.200 acre-feet
B) Surface Area	0.069 acres
C) Connector Pipe Diameter (Size to drain this volume in 15-minutes under inlet control)	6 inches
D) Paved/Hard Bottom and Sides	**yes** yes/no

DRAWN BY: _____

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APPROVED BY: _____

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DESIGN PROCEDURE FORM: EXTENDED DETENTION BASIN SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.58

Design Procedure Form: Extended Detention Basin (EDB) - Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

6. Two-Stage Design - See Figure 11.51	
A) Top Stage (Depth D_{WQ} = 2' Minimum)	D_{WQ} = 2.00 feet Storage= 2.250 acre-feet
B) Bottom Stage Depth (D_{BS} = 1.0' Minimum, 2.0' Maximum) Bottom Stage Storage (no less than 3% of Design Volume (0.0779625 acre-feet.)	D_{BS} = 2.00 feet Storage= 0.250 acre-feet Surf. Area= 0.125 acres
C) Micro Pool (Minimum Depth = the Larger of 0.5 * Top Stage Depth (1 ') or 2.5 '	Depth= 2.50 feet Storage= 0.020 acre-feet Surf. Area= 0.008 acres
D) Total Volume: Vol_{tot} = Storage from 5A + 6A + 6B (Must be > Design Volume in 1D, or 2.59875 acre-feet.)	Vol_{tot} = 2.700 acre-feet
7. Basin Side Slopes (Z, horizontal distance per unit vertical) Minimum Z = 4, Flatter Preferred	Z = 5.00 (horizontal/vertical)
8. Dam Embankment Side Slopes (Z, horizontal distance) per unit vertical) Minimum Z = 3, Flatter Preferred	Z = 4.00 (horizontal/vertical)
9. Vegetation (Check the method or describe "Other")	X Native Grass _____ Irrigated Turf Grass _____ Other: _____

Notes: _____

DRAWN BY: _____

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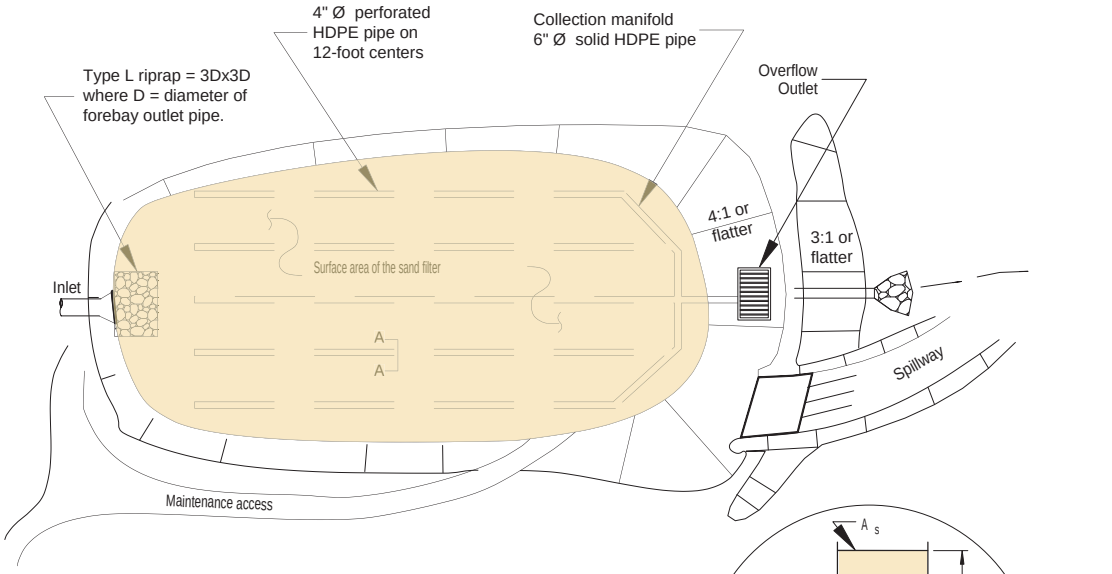
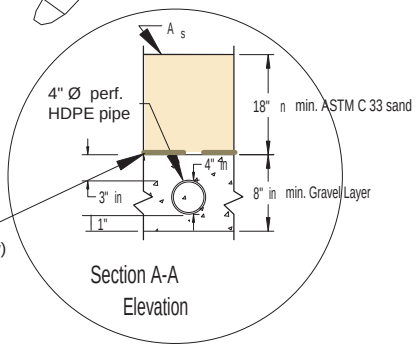
DESIGN PROCEDURE FORM: EXTENDED DETENTION BASIN SEDIMENTATION FACILITY

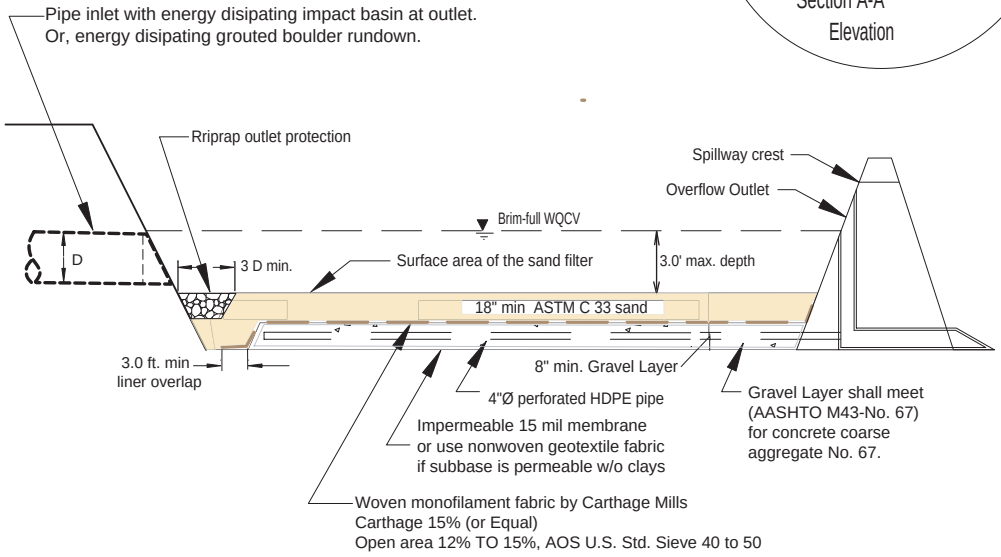
ISSUED: _____
REVISED: _____

FIGURE NO. 11.58



Plan





Profile

DRAWN BY: _____

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PLAN AND PROFILE OF A SAND FILTER EXTENDED DETENTION BASIN

ISSUED: _____
REVISED: _____

FIGURE NO. 11.59

Design Procedure Form: Sand Filter Basin (SFB)

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. Basin Storage Volume	
A) Tributary Area's Imperviousness Ratio (i = I_a / 100)	I_a = 50.00 % i = 0.50
B) Contributing Watershed Area (Area)	Area = 40.00 acres
C) Water Quality Capture Volume (WQCV) (WQCV = 1.26 * 1.0 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I))	WQCV = 0.26 watershed inches
D) Design Volume: Vol = (WQCV / 12) * Area	Vol = 0.866 acre-feet
2. Minimum Filter Surface Area: A_s = (Vol / 3) * 43,560	A_s = 12,578 square feet
Filter Surface Elevation	5478.50 feet
Average Side Slope of the Filter Basin (4:1 or flatter)	Z = 4.0
3. Estimate of Basin Depth (D), based on filter area A_s	D = 2.6 feet
4. Outlet Works	
A) Sand (ASTM C-33) Layer Thickness (18" min.)	18 inches
B) Woven Monofilament Fabric Between Sand & Gravel - Carthage Mill, Carthage 15% (or equal)	X Carthage Mill, Carthage 15% _____ Other: _____
C) Gravel (AASHTO No. 67) Layer Thickness (8" min.)	8 inches
D) Overflow Elevation At Top of Design Volume (Filter Surface Elev. + Estimate of Basin Depth (D))	5481.10 feet
5. Draining of porous pavement (Check A, **or** B, **or** C, **answer** D) Based on answers to 5A through 5D, check the appropriate method	_____ Infiltration to Subgrade with Permeable Membrane: 5(C) checked **and** 5(D) = no
A) Check box if subgrade is heavy or expansive clay [ ] B) Check box if subgrade is silty or clayey sands [ ] C) Check box if subgrade is well-draining soils [X]	X Underdrain with Impermeable Membrane: 5(A) checked **or** 5(D) = yes
	_____ Underdrain with Permeable Membrane: 5(B) checked **and** 5(D) = no
D) Does tributary catchment contain land uses that may have petroleum products, greases, or other chemicals present, such as gas station, hardware store, restaurant, etc.? yes [X] no [ ]	_____ Other: _____
6. Describe Provisions for Maintenance _____	

Notes: _____

DRAWN BY: _____

CHECKED BY: _____

APPROVED BY: _____

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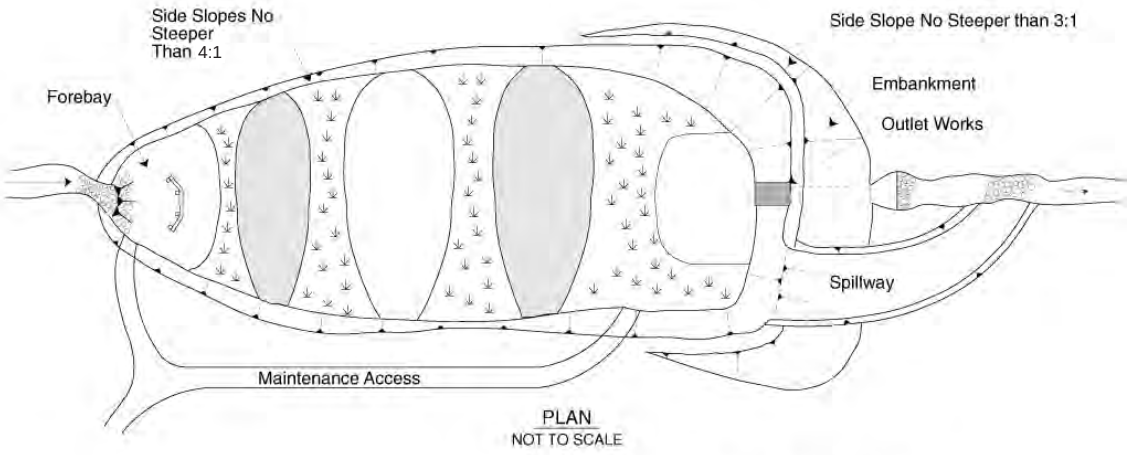
DESIGN PROCEDURE FORM: SAND FILTER BASIN

ISSUED: _____
REVISED: _____

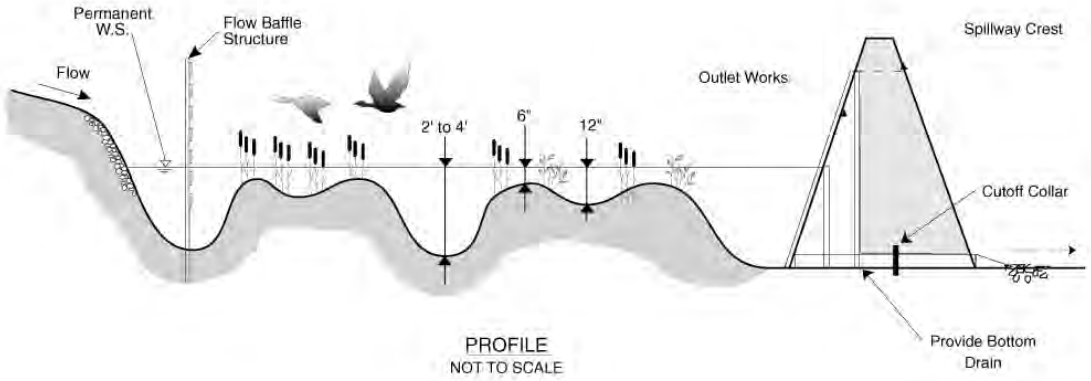
FIGURE NO. 11.60



PLAN
NOT TO SCALE

Depth Variation Legend

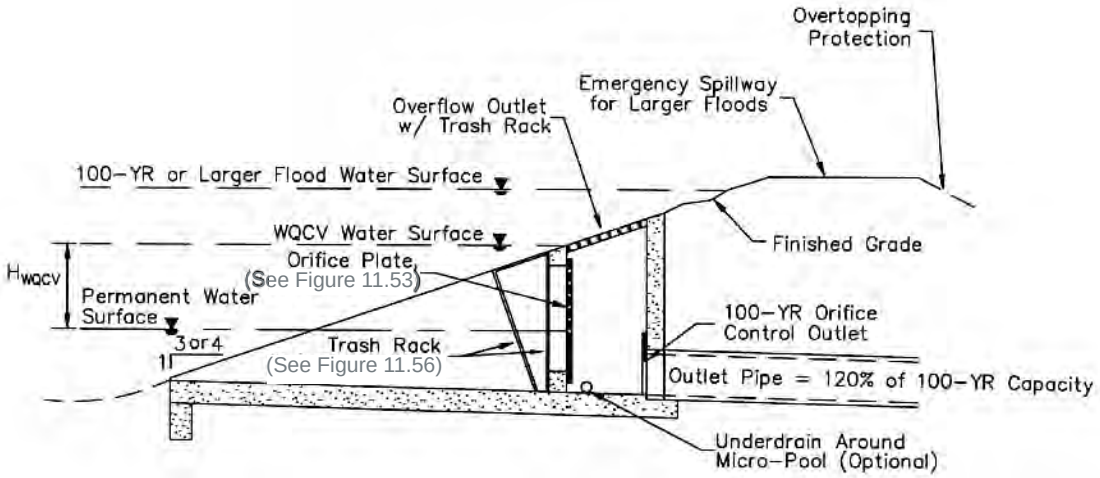
- Innundated 6" below permanent pool
- Innundated to 12" below permanent pool
- Inundated 2' to 4' below permanent pool



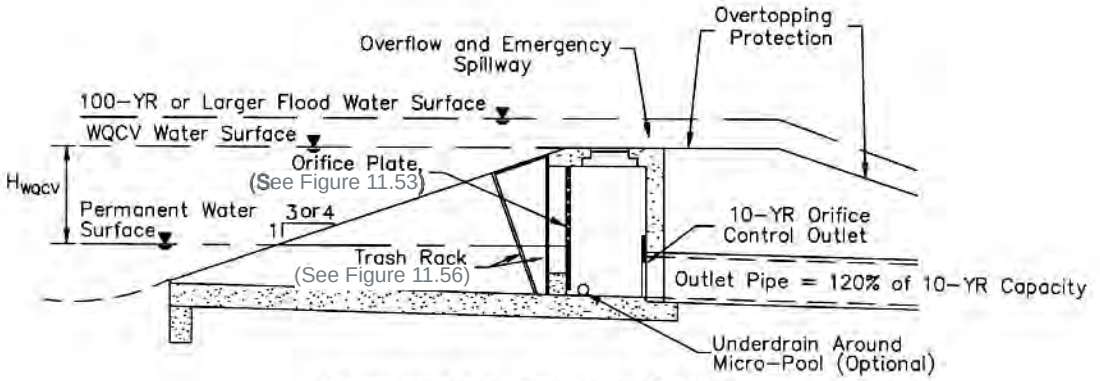
PROFILE
NOT TO SCALE

DRAWN BY: _____ CHECKED BY: _____ APPROVED BY: _____	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	PLAN AND PROFILE OF A CONSTRUCTED WETLAND BASIN SEDIMENTATION FACILITY	ISSUED: _____ REVISED: _____ FIGURE NO. 11.61

Note: Size 2- through 100-year overflow trash racks with the aid of figure 11.57

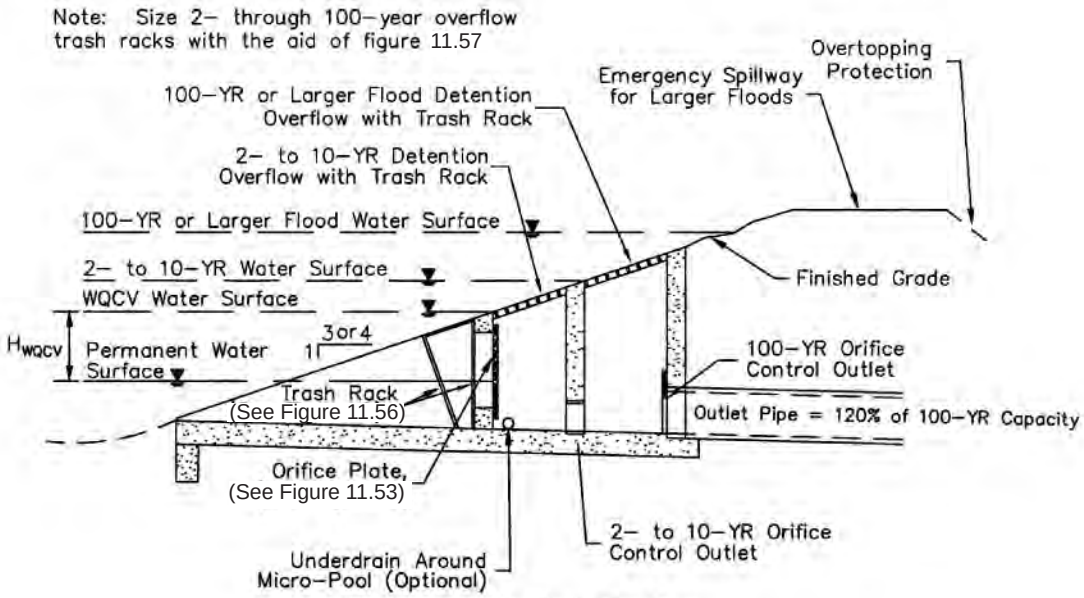


Drop Box Outlet Option

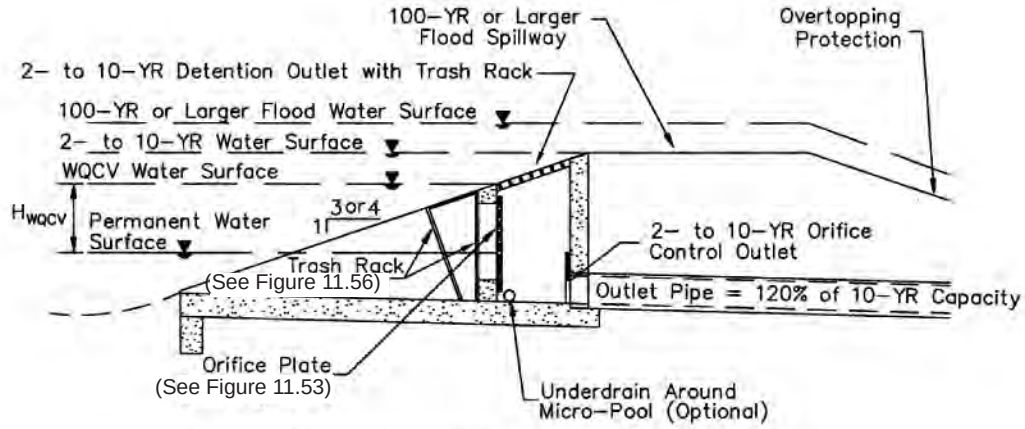


Overtopping Spillway Option

DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	TYPICAL WQCV OUTLET STRUCTURE PROFILES INCLUDING 100 YEAR DETENTION	ISSUED: REVISED:
CHECKED BY:			FIGURE NO. 11.62
APPROVED BY:			

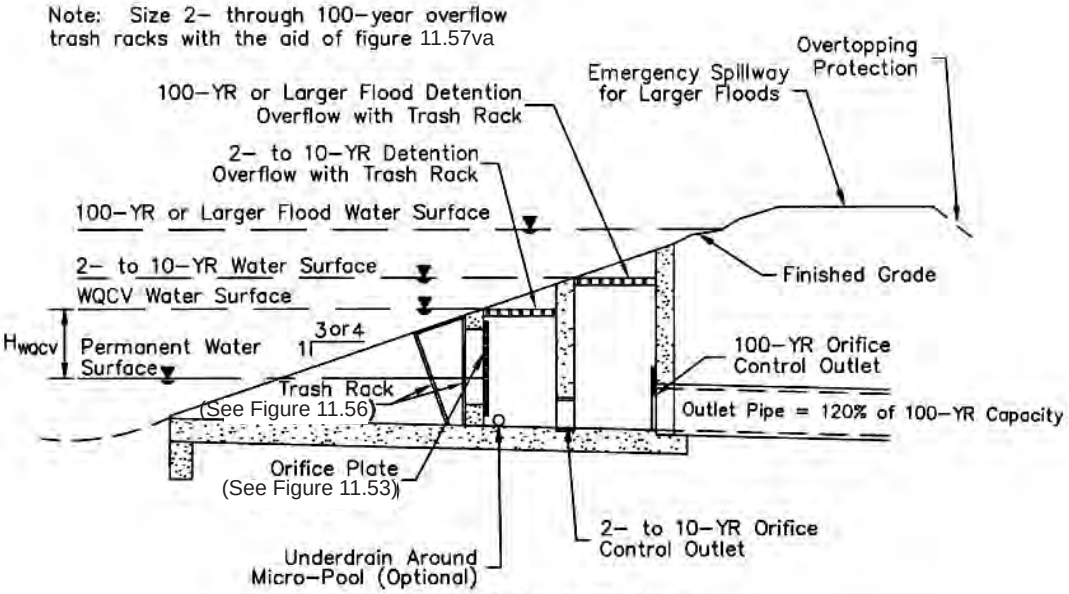


Drop Box Outlet Option

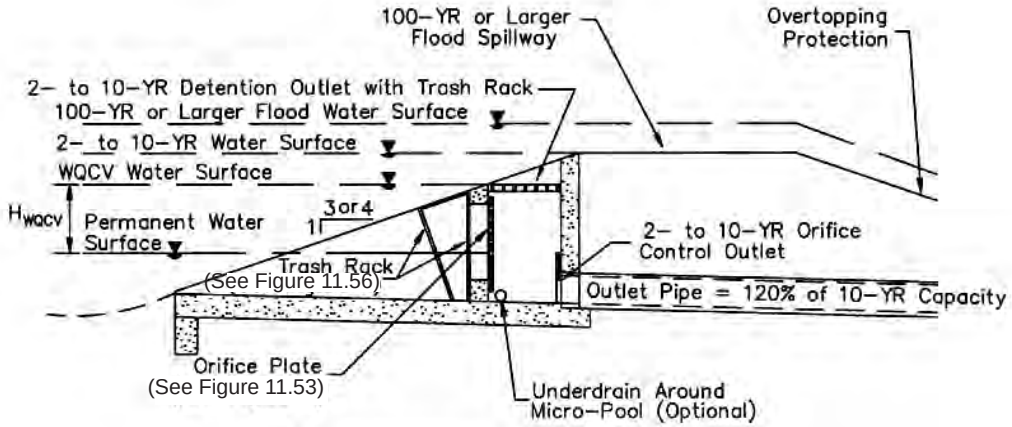


Overtopping Spillway Option

DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	TYPICAL WQCV OUTLET STRUCTURE PROFILES INCLUDING 2 TO 10 YEAR AND 100 YEAR DETENTION	ISSUED: REVISED:
CHECKED BY:			FIGURE NO. 11.63
APPROVED BY:			

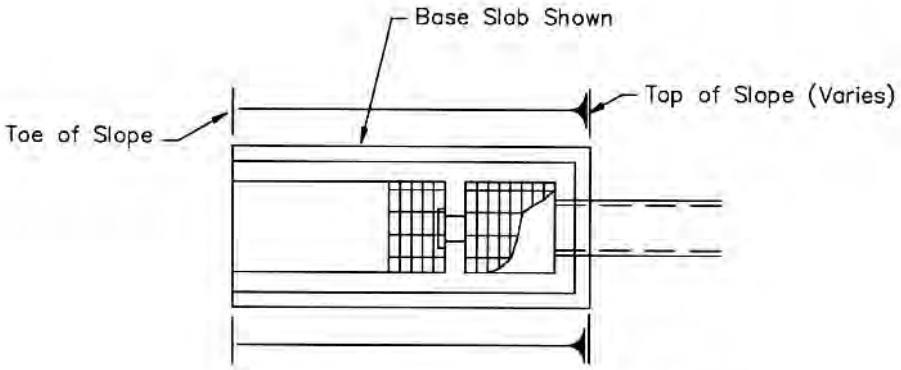


Drop Box Outlet Option

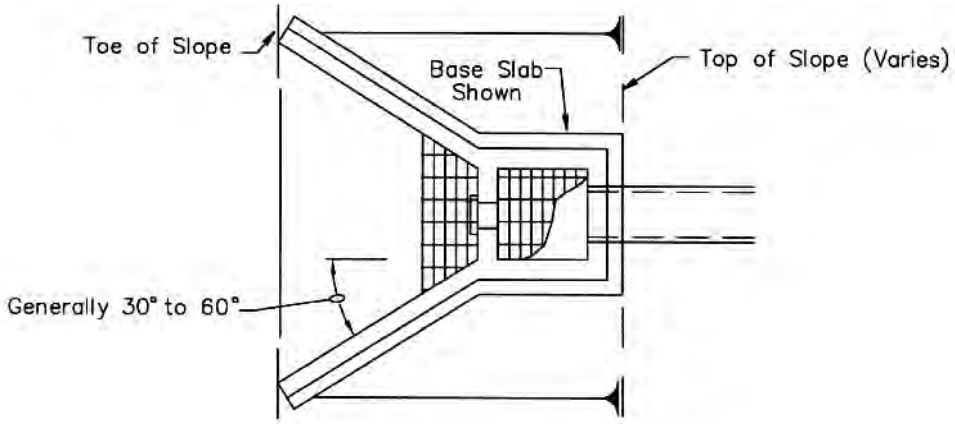


Overtopping Spillway Option

DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	TYPICAL WQCV OUTLET STRUCTURE PROFILES INCLUDING 2 TO 10 YEAR AND 100 YEAR DETENTION	ISSUED: REVISED:
CHECKED BY:			FIGURE NO. 11.64
APPROVED BY:			



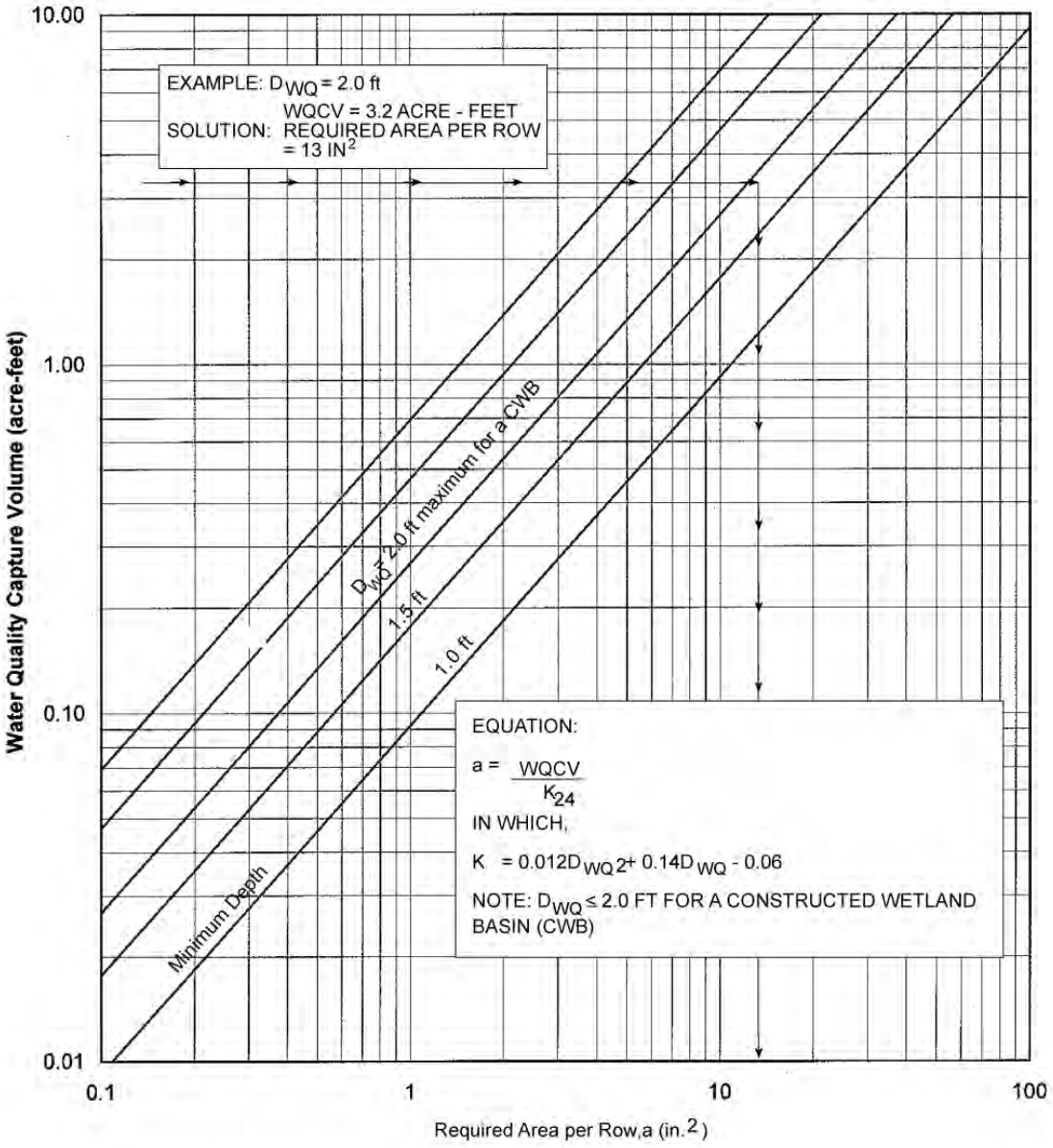
Plan View–Straight Wingwall Option



For either a Vertical or Adverse–Slope Trash Rack a handrail may be required.

Plan View–Flared Wingwall Option

DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	TYPICAL WQCV OUTLET STRUCTURE WINGWALL CONFIGURATIONS	ISSUED: REVISED:
CHECKED BY:			FIGURE NO. 11.65
APPROVED BY:			



Source: Douglas County Storm Drainage and Technical Criteria, 1986.

DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	WATER QUALITY OUTLET SIZING: CONSTRUCTED WETLAND BASIN WITH A 24 HOUR DRAIN TIME OF THE CAPTURE VOLUME	ISSUED: REVISED:
CHECKED BY:			FIGURE NO. 11.66
APPROVED BY:			

Design Procedure Form: Constructed Wetland Basin (CWB) - Sedimentation Facility

Designer: _____
Company: _____
Date: _____
Project: _____
Location: _____

1. Basin Storage Volume			
A) Tributary Area's Imperviousness Ratio (i = I_a / 100)	I_a =	50.00	%
	i =	0.50	
B) Contributing Watershed Area (Area)	Area =	50.00	acres
C) Water Quality Capture Volume (WQCV) (WQCV = 1.26 * 0.9 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I))	WQCV =	0.23	watershed inches
D) Design Volume: Vol = (WQCV / 12) * Area	Vol =	0.9745	acre-feet
2. Wetland Pond Volume, Depth, and Water Surface Area			
A) Minimum Calculated Permanent Pool: $Vol_{Pool} \geq 0.75 * Vol$	Calculated Required Minimums:		
	$Vol_{Pool} \geq$	0.7309	acre-feet
	WS Area =	0.4873	acres, estimated
	Enter the Actual Design Values:		
	$Vol_{Pool} \geq$	0.8000	acre-feet, final design
	WS Area =	0.5000	acres, final design
B) Forebay (Volume > 5% of Vol in 1D, or 0.0487 acre-feet) Depth minimum = 2.5', maximum = 4.0'	Volume=	0.0500	acre-feet
	Depth=	3.50	feet
	Area=	0.0143	acres, % = 2.86%
C) Outlet Pool (minimum depth = 2.5', maximum = 4.0') Outlet Pool Area, 6% of Design WS Area, or 0.03 acres, minimum	Depth=	3.00	feet
	Area=	0.0300	acres, % = 6.00%
D) Wetland Zones with Emergent Vegetation (0.50' to 1.0' deep) (Area = 50% to 70% of Design WS Area, or 0.25 to 0.35 acres.)	Depth=	0.75	feet
	Area=	0.3000	acres, % = 60.00%
E) Free Water Surface Areas (2' to 4' deep) (Area = 30% to 50% of Design WS Area, or 0.15 to 0.25 acres.)	Depth=	3.50	feet
	Area=	0.1557	acres, % = 31.14%
			100.00%
3 Average Side Slope Above Water Surface (4:1 or flatter)	Z =	4.00	
A) Depth of WQCV Surcharge (above permanent pool, 2' max.)		1.8	feet
4. Outlet Works			
A) Outlet Type (Check One)	X	Orifice Plate	
		Perforated Riser Pipe	
		Other:	
B) Depth at Outlet Above Lowest Perforation (H, 2' max.)	H =	1.80	feet
C) Required Maximum Outlet Area per Row, (A_o) A	$_o$ =	4.22	square inches
D) Perforation Dimensions (Refer to Figure 11.54): **(Enter one only)**:			
i) Circular Perforation Diameter **OR**	D =		inches, **OR**
ii) 2" Height Rectangular Perforation Width	W =	1.88	inches

DRAWN BY: _____
CHECKED BY: _____
APPROVED BY: _____

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(605) 367-7048

DESIGN PROCEDURE FORM: CONSTRUCTED WETLAND BASIN SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.67

Design Procedure Form: Constructed Wetland Basin (CWB) - Sedimentation Facility

Designer: _____
Company: _____
Date: _____
Project: _____
Location: _____

E) Number of Columns (nc)	nc = 1 Number
F) Actual Design Outlet Area per Row (A_o) A	$_o$ = 3.75 square inches
G) Number of Rows (nr)	nr = 5 Number
H) Total Outlet Area (A_{ot}) A	$_{ot}$ = 20.25 square inches

5. Trash Rack

A) Needed Open Area: A_t = 0.5 * (Figure 11.57 Value) * A_{ot} — A_t = 608.39 square inches

B) Type of Outlet Opening (Check One)
- ____ ≤ 2" Diameter **Round**
- X 2" High **Rectangular**
- ____ Other: _____

C) For 2", or Smaller, **Round Opening** (Ref.: Figure 11.50b):

i) Width of Trash Rack and Concrete Opening (W_{conc}) from Table 11.13a — W_{conc} = _____ inches

ii) Height of Trash Rack Screen (H_{TR}) H — $_{TR}$ = _____ inches

iii) Type of Screen (Based on Depth H), Describe if "Other"
- ____ S.S. #93 VEE Wire (US Filter)
- ____ Other: _____

iv) Screen Opening Slot Dimension, Describe if "Other"
- ____ 0.139" (US Filter)
- ____ Other: _____

v) Spacing of Support Rod (O.C.) Type and Size of Support Rod (Ref.: Table 11.13b) — ____ inches

vi) Type and Size of Holding Frame (Ref.: Table 11.13b)

D) For 2" High **Rectangular Opening** (Refer to Figure 11.50a):

I) Width of Rectangular Opening (W) — W = 1.875 inches

ii) Width of Perforated Plate Opening (W_{conc} = W + 12") — W_{conc} = 13.88 inches

iii) Width of Trashrack Opening ($W_{opening}$) from Table 11.14a — $W_{opening}$ = 24.0 inches

iv) Height of Trash Rack Screen (H_{TR}) H — $_{TR}$ = 46 inches

v) Type of Screen (based on depth H) (Describe if "Other")
- X Klemp™ KPP Series Aluminum
- ____ Other: _____

vi) Cross-bar Spacing (Based on Table 11.14a, Klemp™ KPP Grating). Describe if "Other"
- 2 inches
- ____ Other: _____

DRAWN BY: _____
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APPROVED BY: _____

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DESIGN PROCEDURE FORM: CONSTRUCTED WETLAND BASIN SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.67

Design Procedure Form: Constructed Wetland Basin (CWB) - Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

vii) Minimum Bearing Bar Size (Klemp™ Series, Table 11.14b) (Based on depth of WQCV surcharge)	**1.00 in. x 3/16 in.**
6. Basin Use for Quantity Controls (Check one or describe if "Other")	X Detention within the facility _____ Detention upstream of the facility _____ Other: _____
7. Basin length to width ratio	3.00 (L/W)
8. Basin Side Slopes (Z, horizontal distance per unit vertical)	4.00 (horizontal/vertical)
9 Annual/Seasonal Water Balance (Q_{net} has to be positive)	Q_{inflow} 362.00 acre-feet/year Q_{evap} 1.40 acre-feet/year $Q_{seepage}$ 2.80 acre-feet/year $Q_{E.T.}$ 1.50 acre-feet/year Q_{net} 356.30 acre-feet/year
10 Vegetation (Check the method being applied or describe)	_____ Native Grass X Irrigated Turf Grass Side Slopes _____ Wetland Species in Pool* _____ Other: _____ *Describe Species Density and Mixl.

Notes: _____

DRAWN BY: _____

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APPROVED BY: _____

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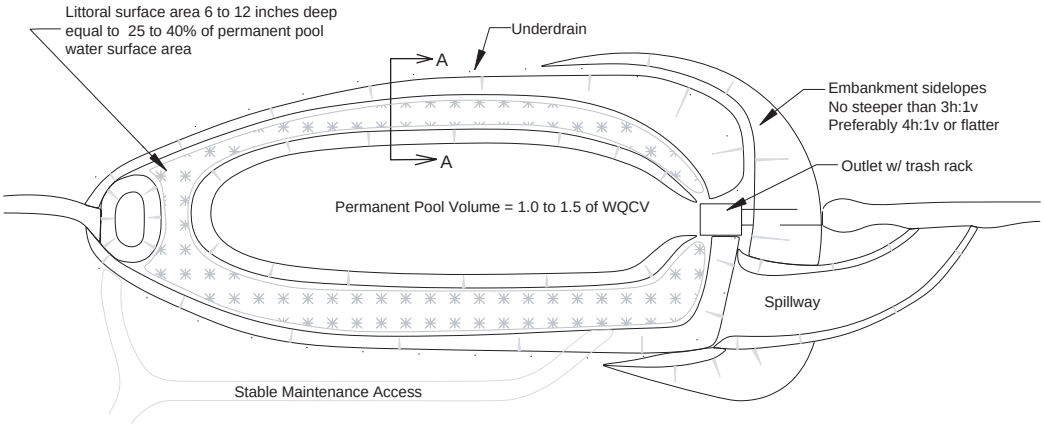
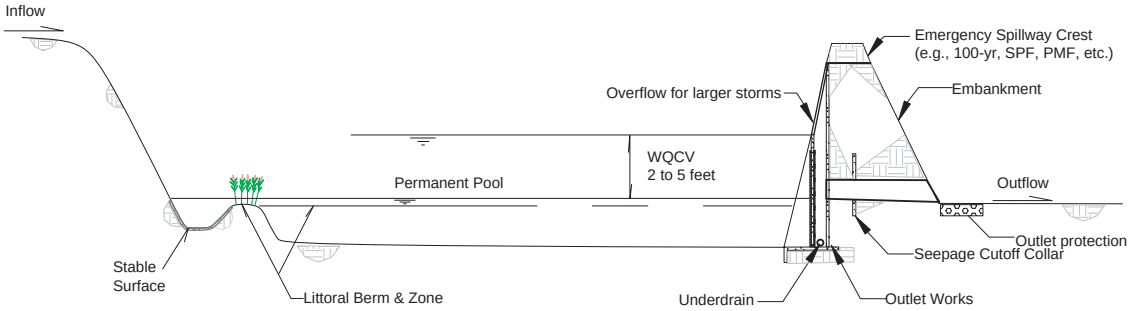
DESIGN PROCEDURE FORM: CONSTRUCTED WETLAND BASIN SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

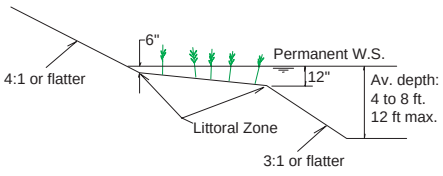
FIGURE NO. 11.67



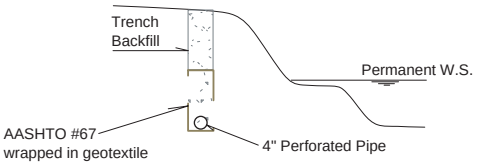
PLAN
Not to scale



PROFILE
Not to scale

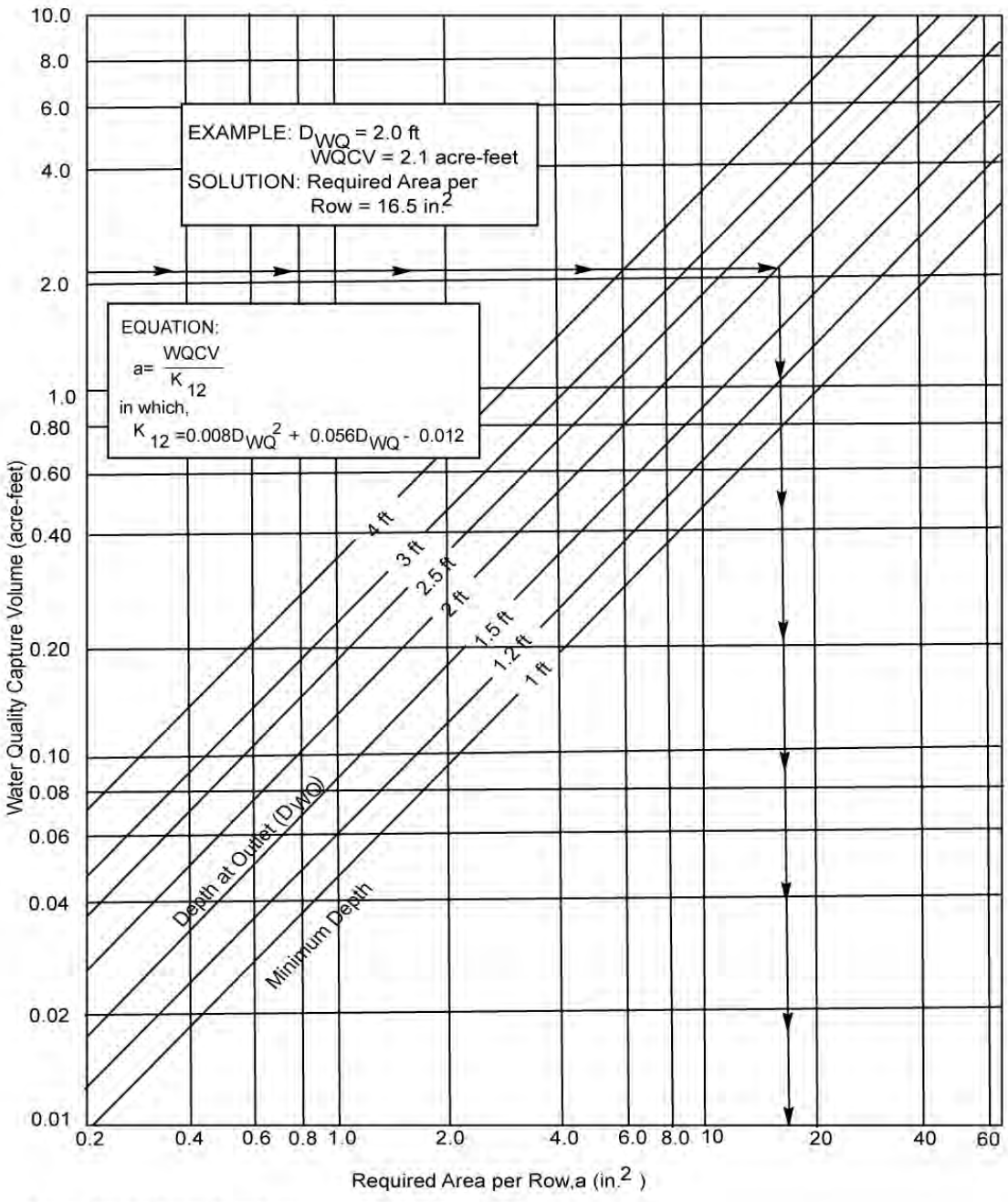


Section A - A



Underdrain Detail

DRAWN BY: _____ CHECKED BY: _____ APPROVED BY: _____	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	PLAN AND PROFILE OF A RETENTION POND SEDIMENTATION FACILITY	ISSUED: _____ REVISED: _____ FIGURE NO. 11.68



Source: *Douglas County Storm Drainage and Technical Criteria*, 1986.

DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	WATER QUALITY OUTLET SIZING: RETENTION POND, POROUS LANDSCAPE DETENTION WITH A 12 HOUR DRAIN TIME OF THE CAPTURE VOLUME	ISSUED: REVISED:
CHECKED BY:			FIGURE NO. 11.69
APPROVED BY:			

Design Procedure Form: Retention Pond (RP) - Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. Basin Storage Volume	
A) Tributary Area's Imperviousness Ratio (i = I_a / 100)	I_a = 50.00 % i = 0.50
B) Contributing Watershed Area (Area)	Area = 100.00 acres
C) Water Quality Capture Volume (WQCV) (WQCV = 1.26 * 0.8 * (0.91 * I^3 - 1.19 * I^2 + 0.78 * I))	WQCV = 0.21 watershed inches
D) Design Volume: Vol = (WQCV / 12) * Area	Vol = 1.73 acre-feet
2. Permanent Pool	
A) Volume: Vol-Pool = (1.0 to 1.5) * Vol in 1D, or 1.733 to 2.599 acre-feet	Vol-Pool = 2.00 acre-feet
B) Average Depth Zone 1 = Littoral Zone - 1' to 2' deep	Zone 1 = 0.75 feet
Zone 2 = Deeper Zone - 4 feet to 8 feet deep	Zone 2 = 6.00 feet
C) Maximum Zone 2 Pool Depth (not to exceed 12 feet)	Depth = 9.00 feet
D) Permanent Pool Water Surface Area (Estimated Minimum)	
(Zone 1 - Littoral Zone = 25% to 40% of the total surface area)	% = 37.3 acres = 0.185
(Zone 2 - Deeper Zone = 60% to 75% of the total surface area)	% = 62.700 acres = 0.310
Total Estimated Minimum Surface Area (A_{Total})	% = 100.000 acres = 0.495
3. Annual/Seasonal Water Balance (Q_{net} has to be positive)	Q_{inflow} = 181.00 acre-feet/year Q_{evap} = 1.30 acre-feet/year $Q_{seepage}$ = 2.10 acre-feet/year Q_{ET} = 0.80 acre-feet/year Q_{net} = 176.80 acre-feet/year
4. Outlet Works	
A) Outlet Type (Check One)	_____ Orifice Plate X Perforated Riser Pipe _____ Other: _____
B) Depth at Outlet Above Lowest Perforation (H)	H = 4.00 feet
C) Required Maximum Outlet Area per Row, (A_o)	A_o = 2.50 square inches
D) Perforation Dimensions **(enter one only)**: i) Circular Perforation Diameter **OR** ii) 2" Height Rectangular Perforation Width	D = 1.1880 inches, **OR** W = _____ inches
E) Number of Columns (nc)	nc = 2 Number

DRAWN BY: _____

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APPROVED BY: _____

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DESIGN PROCEDURE FORM: RETENTION POND SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.70

Design Procedure Form: Retention Pond (RP) - Sedimentation Facility

Designer: _____
Company: _____
Date: _____
Project: _____
Location: _____

F) Actual Design Outlet Area per Row (A_o)	A_o = 2.22 square inches
G) Number of Rows (nr)	nr = 12 Number
H) Total Outlet Area (A_{ot})	A_{ot} = 26.60 square inches
5. Trash Rack	
A) Needed Open Area: A_t = 0.5 * (Figure 11.57 Value) * A_{ot}	A_t = 884 square inches
B) Type of Outlet Opening (Check One)	X ≤ 2" Diameter **Round** 2" High **Rectangular** Other:
C) For 2", or Smaller, **Round Opening** (Ref.: Figure 11.50b):	
I) Width of Trash Rack and Concrete Opening (W_{conc}) from Table 11.13a	W_{conc} = 24 inches
ii) Height of Trash Rack Screen (H_{TR}) H	$_{TR}$ = 72 inches
iii) Type of Screen (Based on Depth H), Describe if "Other"	X S.S. #93 VEE Wire (US Filter) Other:
iv) Screen Opening Slot Dimension, Describe if "Other"	X 0.139" (US Filter) Other:
v) Spacing of Support Rod (O.C.) Type and Size of Support Rod (Ref.: Table 11.13b)	1 inches **TE 0.074 in. x 0.75 in.**
vi) Type and Size of Holding Frame (Ref.: Table 11.13b)	**1.00 in. x 1.50 in. angle**
D) For 2" High **Rectangular Opening** (Refer to Figure 11.50a):	
I) Width of Rectangular Opening form 4.D.ii. (W)	W = inches
ii) Width of Perforated Plate Opening (W_{conc} = W + 12")	W_{conc} = inches
iii) Width of Trash Rack Opening ($W_{opening}$) from Table 11.14a	$W_{opening}$ = inches
iv) Height of Trash Rack Screen (H_{TR}) H	$_{TR}$ = inches
v) Type of Screen (based on depth H) (Describe if "Other")	Klemp™ KPP Series Aluminum Other:
vi) Cross-bar Spacing (Based on Table 11.14a, Klemp™ KPP Grating). Describe if "Other"	inches Other:

DRAWN BY: _____
CHECKED BY: _____
APPROVED BY: _____

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DESIGN PROCEDURE FORM: RETENTION POND SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.70

Design Procedure Form: Retention Pond (RP) - Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

vii) Minimum Bearing Bar Size (Klemp™ Series, Table 11.14b) (Base on depth of WQCV surcharge)		
6. Basin length to width ratio		1.80 (L/W)
7. Basin Side Slopes (Z:1)		
A) Above the Permanent Pool:	Z=	5.0 (horizontal/vertical)
B) Below the Permanent Pool	Z=	Zone 1= 5.0 (horizontal/vertical)
	Z=	Zone 2= 3.0 (horizontal/vertical)
8. Dam Embankment Side Slopes	Z=	4.0 (horizontal/vertical)
9. Vegetation (Check the type used or describe if "Other")		___ Native Grass X Irrigated Turf Grass ___ Emergent Aquatic Species* ___ Other: ___ *Specify types and densities:
10. Forebay Storage (5% to 10% of Design Volume in 1D, or 0.0866 to 0.1733 acre-feet.)		Storage = 0.12 acre-feet
11. Underdrains		Yes yes/no

Notes: _____

DRAWN BY: _____

CHECKED BY: _____

APPROVED BY: _____

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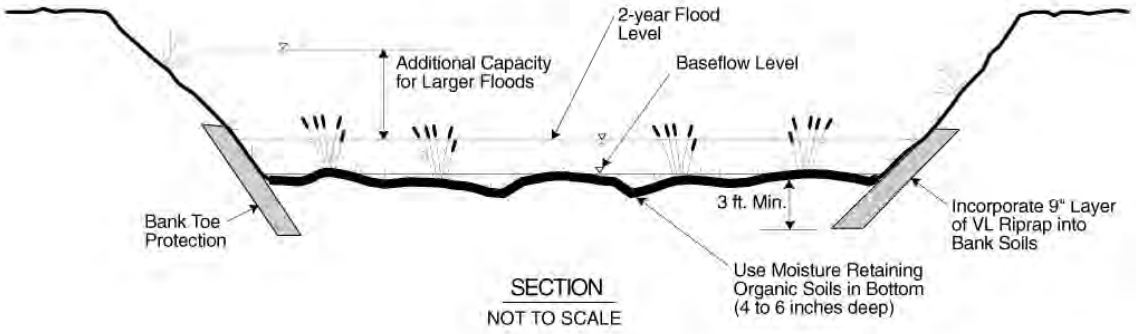
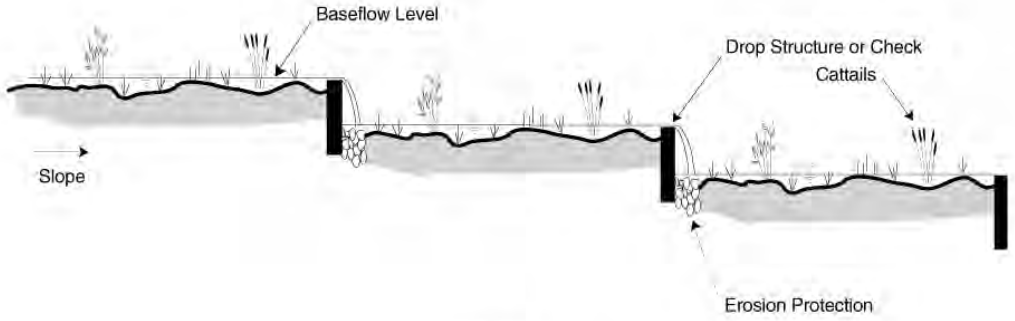
DESIGN PROCEDURE FORM: RETENTION POND SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.70



SECTION
NOT TO SCALE



SECTION
NOT TO SCALE

DRAWN BY:	SIOUX FALLS OFFICE OF THE CITY ENGINEER 224 WEST 9TH STREET SIOUX FALLS, S.D. 57102 (605) 367-7048	ISSUED: REVISED:
CHECKED BY:	PLAN AND SECTION OF A CONSTRUCTED WETLAND CHANNEL	FIGURE NO. 11.71
APPROVED BY:		

Design Procedure Form: Constructed Wetlands Channel (CWC) - Sedimentation Facility

Designer: _____

Company: _____

Date: _____

Project: _____

Location: _____

1. Design Discharge (total)	Q_2 = 200 cfs Q_{100} = 1,600 cfs
2. Channel Geometry (New Channel - No Wetland Veg. in Bottom)	
A) Channel Side Slopes (Z:1, i.e., H/V) (Z ≥ 2.5)	Z = 3.0 (horizontal/vertical)
B) 2-Year Design Flow Depth (D_2) D Maximum D_2 = 4', Minimum D_2 = 2'	$_2$ = 4.0 feet
C) Bottom width of the channel (B_2) - 8-foot minimum	B_2 = 13.0 feet
D) Top width of the 2-Year Design Water Surface (W_2) W	$_2$ = 37.0 feet
3. Longitudinal Slope (Based on a Manning's n = 0.03 for the 2-year Channel, velocity set to 2 fps)	S = 0.0005 feet/feet
4. Final Channel Goemetry - Wetland Vegetation in Bottom) (Based on a Manning's n = 0.08)	
A) Calculated channel geometry required to maintain design discharge during a 2-year event with mature vegetation	Z = 3.0 feet D_2 = 4.0 feet B_2 = 46.5 feet W_2 = 70.5 feet
B) Calculated discharge and velocity during a 2-year event with mature vegetation	Q_2 = 200.0 cfs V_2 = 0.9 fps
C) Geometry and velocity to use for the 100-year discharge if composite channel section is used.	D_{100} = 10.2 feet B_{100} = 43.5 feet W_{100} = 126.2 feet V_{100} = 2.2 fps
5. Number of grade control structures required	4 number
6. Vegetation (Check the type or describe "Other")	X Native Grass _ Irrigated Turf Grass X Wetland Species _ Other: _____

Notes: _____

DRAWN BY: _____

CHECKED BY: _____

APPROVED BY: _____

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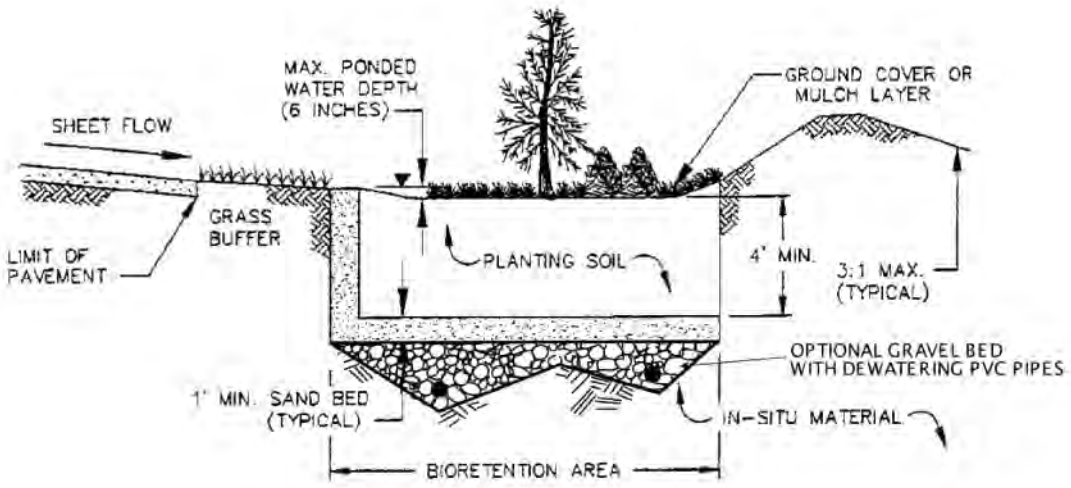
SIOUX FALLS, S.D. 57102
(605) 367-7048

DESIGN PROCEDURE FORM: CONSTRUCTED WETLANDS CHANNEL SEDIMENTATION FACILITY

ISSUED: _____
REVISED: _____

FIGURE NO. 11.72



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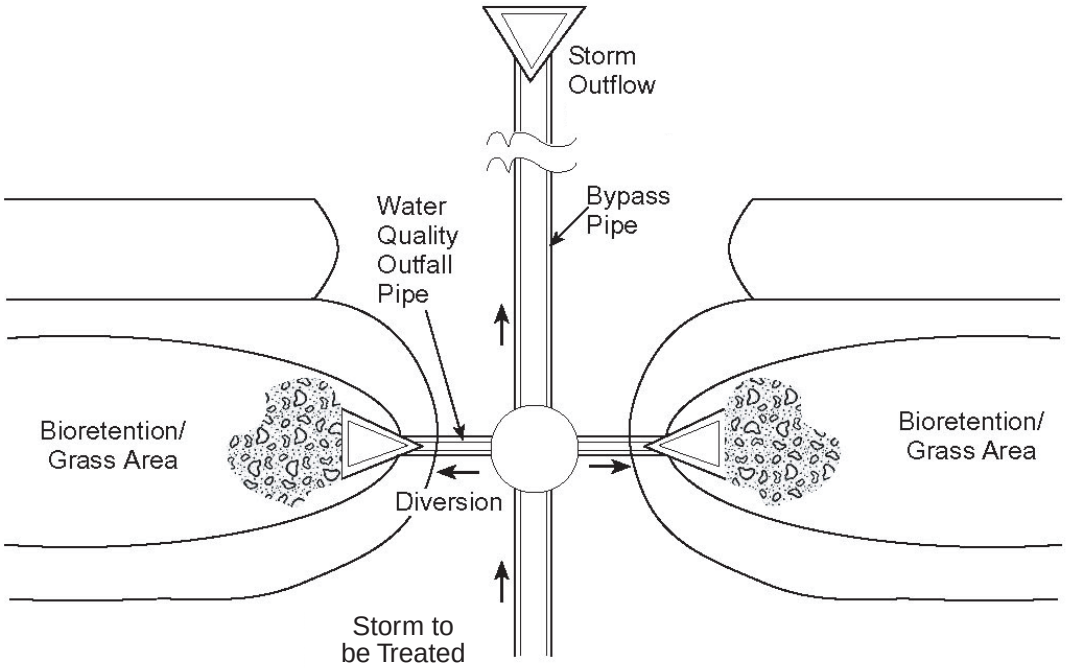
PROFILE OF A BIORETENTION AREA

ISSUED: _____
REVISED: _____

FIGURE NO. 11.73



W102001007WDC_001

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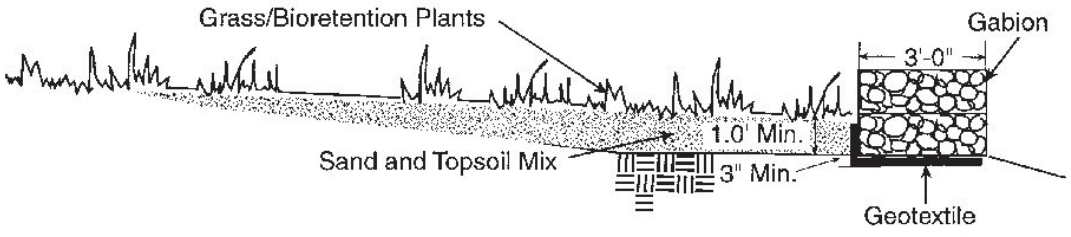

Bioretention cross section; bioretention facility incorporated in a grass swale with flat to mild slope

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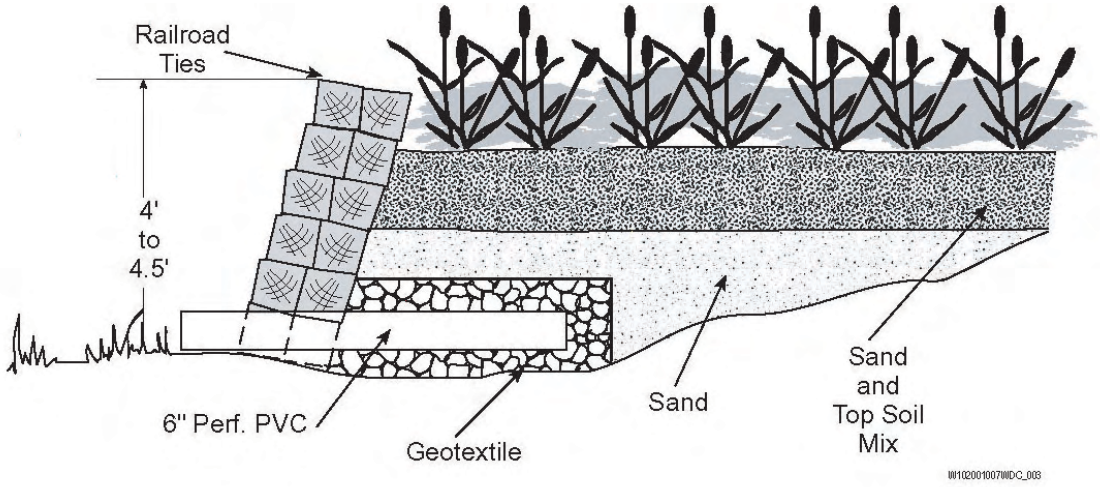

NOTE: Provide protective railing where required by code.

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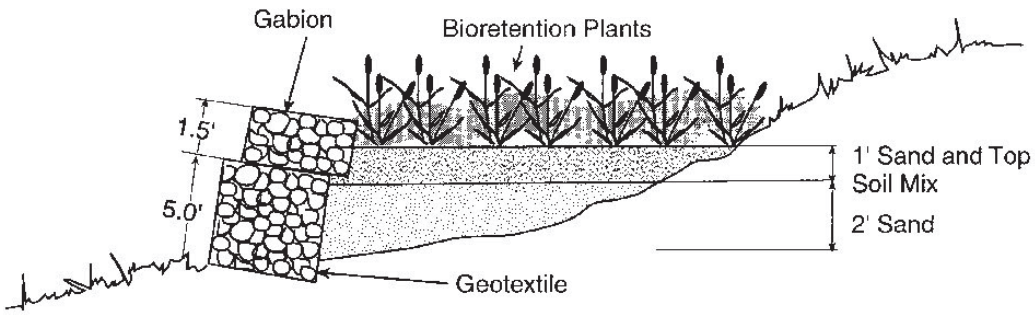

Bioretention cross section; bioretention facility incorporated in a grass swale with mild to moderate slope.

NOTE: Provide protective railing where required by code.

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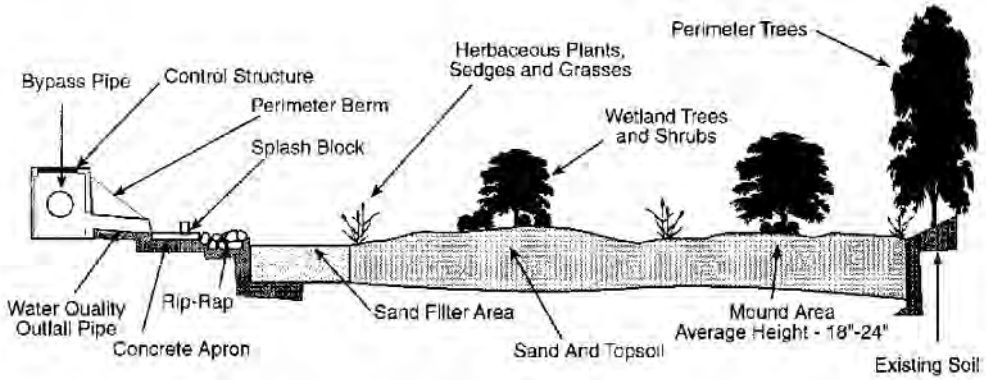

*Bioretention cross section: Runoff from large storms is bypassed through the main drainage system. Runoff from small storms is **diverted** at the control structure (manhole). The energy of the stormwater flow is **dissipated** by the splash block or the rip rap. The stormwater is **filtered** through an open sand filter. Excess stormwater is **treated** in the bioretention area.*

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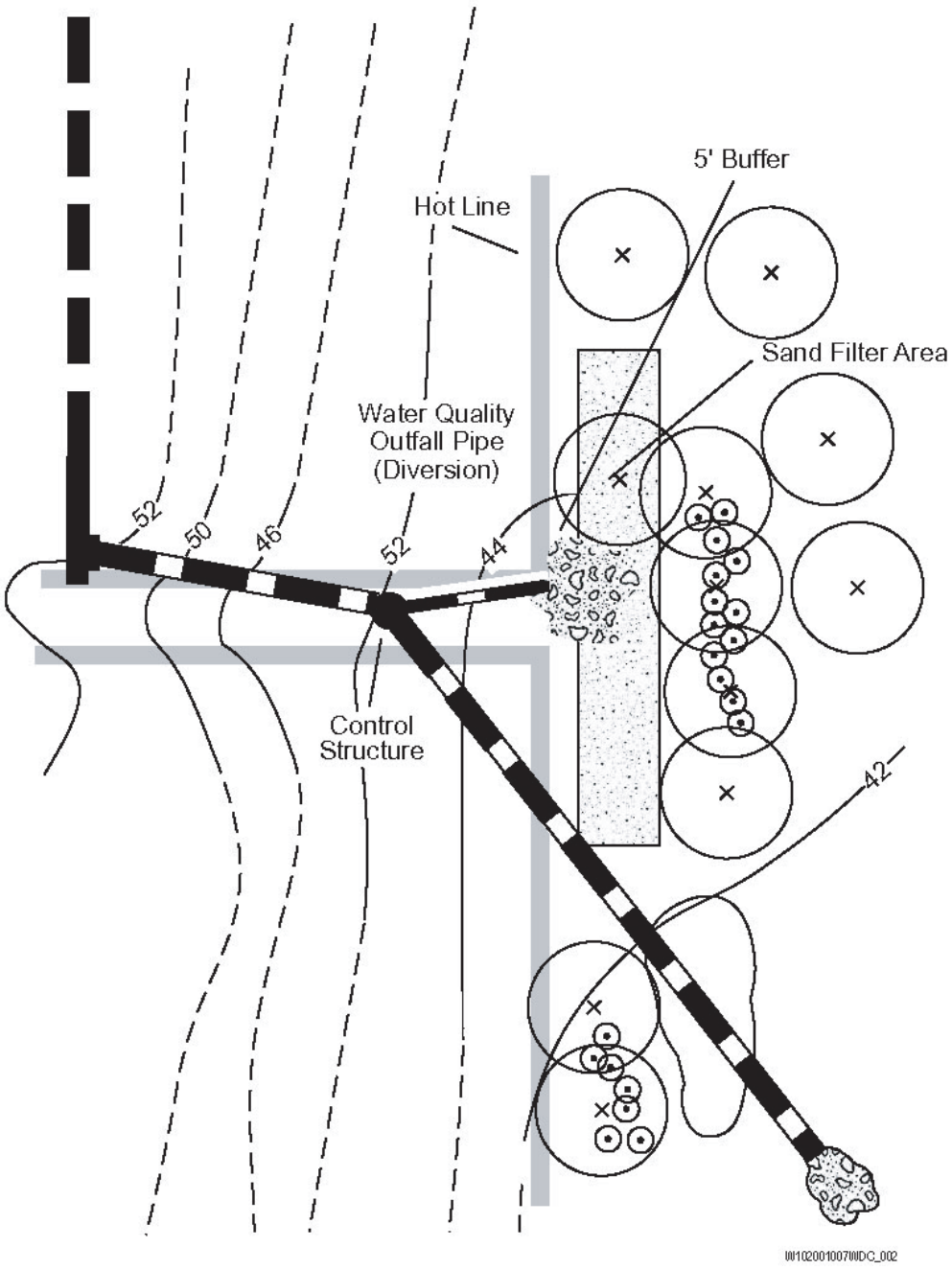
CHECKED BY:	BIORETENTION CROSS SECTION	FIGURE NO. 11.78
APPROVED BY:		



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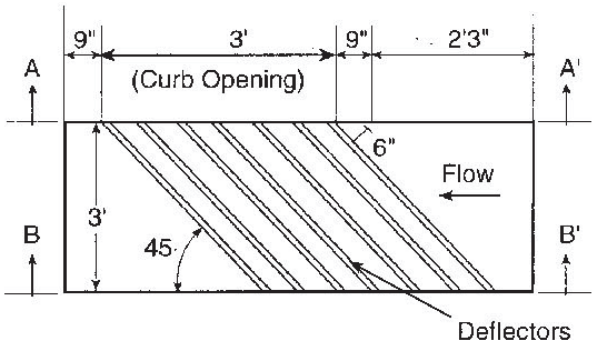
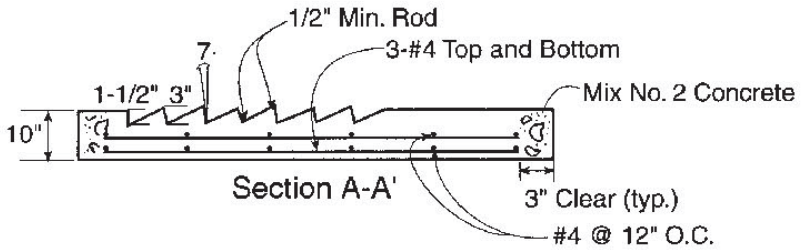
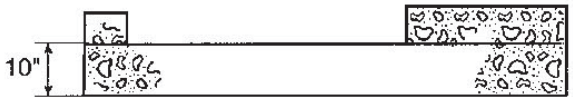
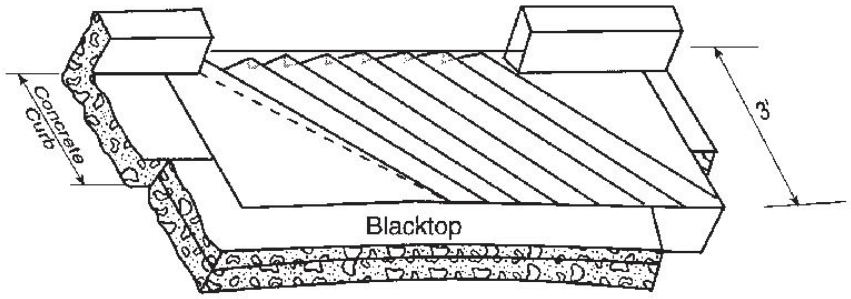


Plan





Section B-B'



Isometric

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