MN6-6 Drop Inlet Spillway

6-6.1 Drop Inlets

Drop inlet spillways should be fabricated in accordance with approved standard drawings.

Inlet and anti-vortex wall proportions for CMP vertical inlets shall be as shown in Table 6-6.1 and Table 6-6.2. The thickness of the CMP riser should be equal to or greater than that required for the conduit (Refer to Table 3 in Minnesota Conservation Practice Standard (378), Pond and Table 6-3.1 in section MN6-3 of the Minnesota Supplement to EFH Chapter 6).

6-6.2 Inlet Weir Flow

The weir flow capacity of the inlet should not limit conduit capacity.

$Q_{weir} = C_w L h_1^{3/2}$ (Eq. 6-6.1)

Where:

C_w = Weir coefficient (usually 3.1)

L = For circular inlets, L = πd – any obstructions for round inlets

= For rectangular inlets, L = Crest length (inside dimensions) – any obstructions

4R may be added to length of weir for rounded crests of concrete inlets when anti-vortex device is a headwall, 8R should be used when anti-vortex device is splitter wall

h_1 = Height of water over inlet crest in feet for design flow

π = 3.14

R = Radius of crest rounding in ft (See Figure 6-6.1)

d = Diameter of circular inlet or length of side of square box inlet, in feet

Table 6-6.2 may be used to obtain weir flow capacities for water level control structures.

Table 6-6.3 may be used to obtain weir flow capacities for circular drop inlets with an anti-vortex wall.

Figure 6-6.1 Reinforced Concrete and Corrugated Metal Pipe Vertical Inlets

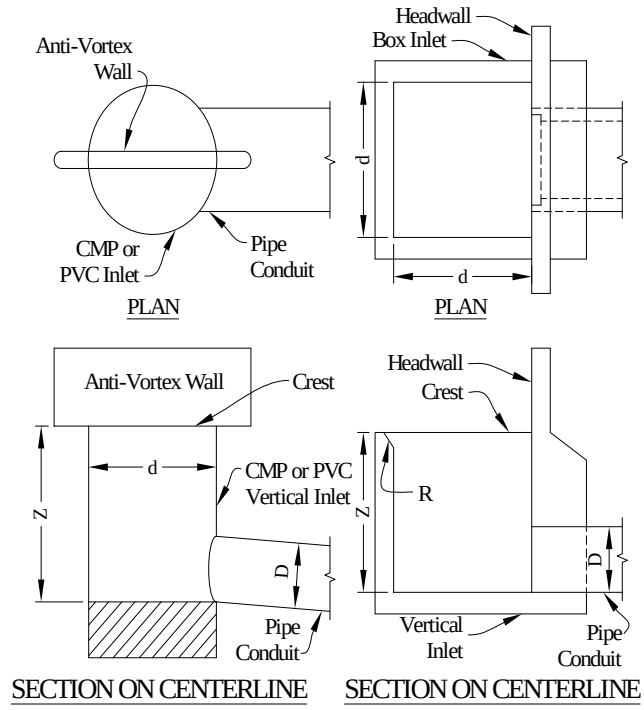


Table 6-6.1 Reinforced Concrete and Corrugated Metal Pipe Vertical Inlets

Inlet Proportions		Anti-Vortex Wall Proportions		
Pipe (D) Conduit (in)	Pipe (d) Inlet (in)	Length (ft)	Height (ft)	Thickness (in)
8 & 10	18	5	2	0.064
12	18	5	2	0.064
15	24	6	2	0.064
18	30	7	2	0.064
21	30	7	2	0.064
24	36	8	2	0.079
30	42	9	2.5	0.079
36	48	10	3	0.109
42	54	11	3.5	0.109
48	60	12	4	0.138

Table 6-6.2 Weir Flow for Water Level Control Structures

Weir Flow in cfs (Over Stoplogs Only)									
Riser Dia.	18"	24"	30"	36"	48"	54"	66"	78"	84"
Weir Length	1.11'	1.62'	2.12'	2.62'	3.73'	4.23'	5.23'	6.21'	6.71'
h									
0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.25	0.4	0.6	0.8	1.0	1.4	1.6	2.0	2.4	2.6
0.50	1.2	1.8	2.3	2.9	4.1	4.6	5.7	6.8	7.4
0.75	2.2	3.3	4.3	5.3	7.5	8.5	10.5	12.5	13.5
1.00	3.4	5.0	6.6	8.1	11.6	13.1	16.2	19.3	20.8
1.25	4.8	7.0	9.2	11.4	16.2	18.3	22.7	26.9	29.1
1.50	6.3	9.2	12.1	14.9	21.2	24.1	29.8	35.4	38.2
1.75	8.0	11.6	15.2	18.8	26.8	30.4	37.5	44.6	48.2
2.00	9.7	14.2	18.6	23.0	32.7	37.1	45.9	54.5	58.8
2.25	11.6	16.9	22.2	27.4	39.0	44.3	54.7	65.0	70.2
2.50	13.6	19.9	26.0	32.1	45.7	51.8	64.1	76.1	82.2

Table 6-6.3 Weir Flow for Circular Drop Inlets with Anti-Vortex Wall

h_1*	$h_1^{3/2}$	Flow in cfs						
		Inlet Dia.	18	24	30	36	42	48
		Weir Length	4.21	5.78	7.35	8.92	10.50	12.07
		Cond. Dia.**	12	15	18 & 21	24	30	36
0.00	0.000							
0.25	0.125		1.6	2.2	2.8	3.5	4.1	4.7
0.50	0.354		4.6	6.3	8.1	9.8	11.5	13.2
0.75	0.650		8.5	11.6	14.8	18.0	21.1	24.3
1.00	1.000		13.1	17.9	22.8	27.7	32.5	37.4
1.25	1.398		18.2	25.1	31.9	38.7	45.5	52.3
1.50	1.837		24.0	32.9	41.9	50.8	59.8	68.7
1.75	2.315		30.2	41.5	52.8	64.0	75.3	86.6
2.00	2.828		36.9	50.7	64.5	78.3	92.0	105.8
2.25	3.375		44.1	60.5	76.9	93.4	109.8	126.2
2.50	3.953		51.6	70.9	90.1	109.4	128.6	147.9

* Depth of flow in feet
** Based on area on inlet equalling at least 1.5 times the area of the conduit

$$Q = 3.1*(\pi d - 0.50)h_1^{3/2}$$

Inlet Depth: The inlet depth should equal at least:

(a) 5D for CM inlet and pipe, or

(b) 2D when the conduit is on less than normal slope

Normal slope (S_n) in feet/foot $= K_p \frac{V^2}{2g}$ (Eq. 6-6.2)

The Kp value used to obtain Sn should be determined using the lowest possible value of Mannings "n".

Velocity (V) is based on Q at point of pipe priming = Q/a where a is the area of the conduit in square feet.

Inlet area: The inlet area should be equal to or greater than 1.5 times the area of the conduit.

Footings: Footings that provide a reasonable factor of safety against flotation should be provided for all vertical inlets that are to be installed where the backfill will be saturated most of the time (for example, in water impounding structures). Footing sizes for corrugated metal vertical inlets are shown in Figure 6-6.2.

See Example 3-10 on page 3-13 of EFH Chapter 3 for an example of the design of a spread footing for a concrete box inlet drop spillway.

Trash racks and guard rails: Trash racks must be durable and adapted to the structure. The velocity through the trash rack should not exceed 2 ft/sec for structures with watersheds of 250 acres or less and 1.5 ft/sec if the watershed is more than 250 acres.

6-6.3 Orifice Flow

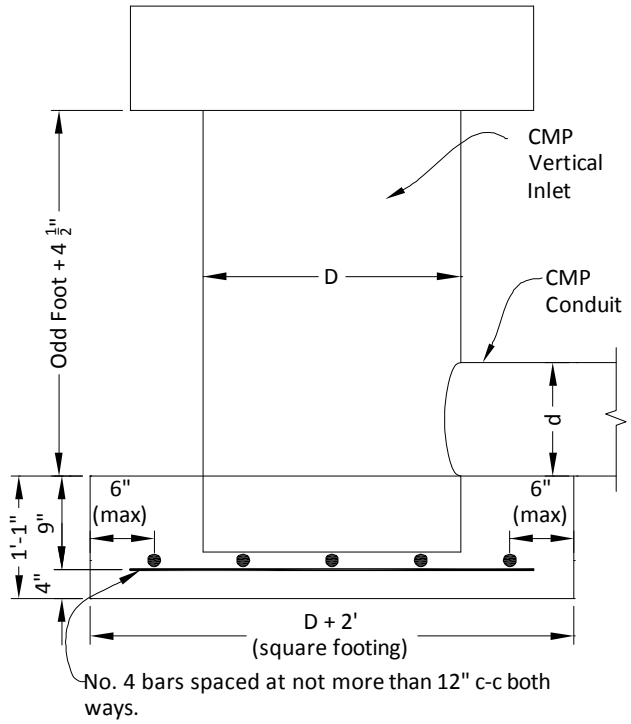
Orifice flow at the entrance to the riser and at the entrance to the barrel should be checked whenever the inlet is less than 5D deep. Orifice flow (Q) should be equal to or greater than full pipe flow in the conduit.

$$Q_{orifice} = Ca\sqrt{2gH} \quad \text{(Eq. 6-6.3)}$$

Where:

C = Orifice flow coefficient. Ranges between 0.5 and 0.9. A value is 0.60 is typically used for conservation structures. Additional guidance on the selection of orifice coefficients can be found in EFH Chapter 3.

Figure 6-6.2 Footing Sized for CMP Vertical Inlets



a = The area of the conduit in square feet

g = 32.2 ft/sec^2

H = The distance in feet from center of the barrel at the inlet to the design water surface or the distance from the top of the riser to the design water surface.

Exhibit 6-6.1 Head Discharge Table for Drop Inlets, Orifice Control Conditions

Dia.	Head in Feet																
Inches	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
12	4.1	5.0	5.8	6.5	7.1	7.7	8.2	8.7	9.2	9.6	10.0	10.5	10.8	11.2	11.6	12.0	12.3
15	6.7	8.2	9.5	10.6	11.6	12.5	13.4	14.2	15.0	15.7	16.4	17.1	17.7	18.3	19.0	19.5	20.1
18	10.1	12.4	14.3	16.0	17.5	18.9	20.2	21.4	22.6	23.7	24.7	25.8	26.7	27.7	28.6	29.4	30.3
21	13.8	16.9	19.5	21.8	23.9	25.8	27.6	29.3	30.9	32.4	33.8	35.2	36.5	37.8	39.0	40.2	41.4
24	18.4	22.5	26.0	29.1	31.9	34.4	36.8	39.0	41.1	43.2	45.1	46.9	48.7	50.4	52.0	53.6	55.2
30		35.2	40.6	45.4	49.8	53.8	57.5	61.0	64.3	67.4	70.4	73.3	76.0	78.7	81.3	83.8	86.2
36	Weir	50.8	58.7	65.6	71.8	77.6	83.0	88.0	92.7	97.3	101.6	105.7	109.7	113.6	117.3	120.9	124.4
42	Flow		79.8	89.2	97.7	105.6	112.9	119.7	126.2	132.3	138.2	143.9	149.3	154.5	159.6	164.5	169.3
48	Control		102.9	115.0	126.0	136.1	145.5	154.4	162.7	170.6	178.2	185.5	192.5	199.3	205.8	212.1	218.3

Dia.	Head in Feet																
Inches	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	16.0	17.0	18.0	19.0	20.0
12	12.6	12.9	13.2	13.6	13.9	14.2	14.5	14.7	15.0	15.3	15.6	15.8	16.4	16.9	17.3	17.8	18.3
15	20.7	21.2	21.8	22.3	22.8	23.3	23.7	24.2	24.7	25.1	25.6	26.0	26.9	27.7	28.5	29.3	30.0
18	31.1	31.9	32.7	33.5	34.2	35.0	35.7	36.4	37.1	37.8	38.4	39.1	40.4	41.6	42.8	44.0	45.1
21	42.7	43.8	44.9	45.9	47.0	48.0	49.0	50.0	50.9	51.8	52.8	53.7	55.4	57.1	58.8	60.4	62.0
24	56.7	58.2	59.6	61.0	62.4	63.7	65.0	66.3	67.6	68.8	70.0	71.2	73.6	75.8	78.0	80.2	82.3
30	88.6	90.9	93.1	95.3	97.5	99.6	101.6	103.6	105.6	107.6	109.5	111.3	115.0	118.5	122.0	125.3	128.6
36	127.8	131.1	134.4	137.5	140.6	143.6	146.6	149.5	152.3	155.1	157.9	160.6	165.9	171.0	175.9	180.7	185.4
42	173.6	178.1	182.5	186.8	191.0	195.1	199.1	203.1	206.9	210.7	214.5	218.1	225.3	232.2	239.0	245.5	251.9
48	223.7	229.5	235.2	240.7	246.1	251.4	256.6	261.7	266.7	271.6	276.4	281.1	290.3	299.2	307.9	316.4	324.6

Notes: 1. Discharge based on the formula

Q = Discharge in cfs

C = Orifice coefficient = "C" for 10 foot length minus 0.02 x pipe diameter in feet

A = Cross sectional area of the riser in square feet when checking the orifice flow at the riser crest or the cross sectional area of the barrel in square feet when checking the orifice flow at the entrance to the barrel

H = Distance from center of barrel at the inlet to the water surface for control at the entrance to the barrel or the distance from the top of the riser to the water surface for control at the crest of the riser.

g = Acceleration due to gravity = 32.2 ft/s^2

2. Use this table in conjunction with weir flow and full pipe flow conditions to determine capacity of drop inlet.