CORRUGATED STEEL / ALUMINUM DROP SPILLWAY

Aluminum and galvanized steel drop spillway structures are available as standard drawings in Iowa:

IA-1409 Galvanized Steel Drop Spillway with drop height up to 4 feet;
IA-1410 Aluminum Drop Spillway with drop height up to 4 feet;
IA-1415 Aluminum Drop Spillway with drop heights of 5 and 6 feet.

Dimensions are based on the standard corrugated aluminum sheet, sized to minimize waste. Corrugated steel structure sizes have been made the same as the aluminum for simplicity and ease of comparison between materials. The 5 and 6-feet toewall drop structure is only available in aluminum, to maintain a longer design life for this larger and more expensive structure.

National Practice Standard 410, Grade Stabilization Structure, currently restricts toewall structures to a drop of 4 feet or less, and thus required a variance from the national office (received March 2011) to exceed this limit. The variance contains monitoring and reporting requirements for any toewall structures built with a drop exceeding 4 feet. Contact the State Conservation Engineer for more information.

A hydraulic design spreadsheet, Semicircular_Drop_Structure.xlsx, is available to determine the hydraulic capacity of any semicircular weir drop structure, based upon model study data. Previous assumptions that the semi-circular weir could use the straight weir formula $Q=3.1LH^{3/2}$ were found to be inaccurate. The model study found that channel conditions and structure proportioning can affect hydraulic capacity. This has led to the following requirements for hydraulic design:

1. **Tailwater depth for the design storm must be determined for every structure**, including the smaller drops. Tailwater which submerges the weir decreases the hydraulic capacity. Tailwater which remains below the weir crest for the design storm may be considered a “free outlet” condition. Tailwater depth is affected by factors such as the size and slope of the downstream natural channel, or the presence of a downstream culvert or other obstruction. Area Office engineering staff can assist in estimating tailwater depth on a site-by-site basis.
2. If a specific structure is found to have free-outlet conditions, the hydraulic capacity may be taken from Tables IA6-1 and IA6-2. The tables list some of the more efficient structure size options, but are not all-inclusive lists of available sizes. Any size not found on the list may be evaluated using the hydraulic spreadsheet.
3. If the structure will have submerged-weir conditions for the design storm, the hydraulic design spreadsheet MUST be used to size the structure.
4. **Maintaining adequate approach channel width is critical** to achieving the structure’s optimum hydraulic capacity. Some previously available standard structure sizes have been modified to increase the headwall length to accommodate a wider upstream channel. This allows the weir to function more efficiently. Where $D \geq 3$ feet and the upstream channel is widened beyond W+4D, the downstream channel bottom width should remain at “W” with side slopes at 2:1 up to the weir crest elevation to provide support for the headwalls from the downstream fill material (unless computations are made to show structural adequacy with a wider downstream channel or flatter slopes). The variable “Wa” is used to define the width added to the approach channel beyond W+4D, on the spreadsheet tool, drawings, and in Table IA6-1.

The effect of approach channel width on structure capacity highlights the importance of keeping the upstream channel near the structure free of obstructions, heavy vegetation or significant sediment deposits. This should be noted in any Operation & Maintenance discussion and documentation.

For free-outlet structures, design storm tailwater depth of about 0.75D is recommended. The model study did not evaluate downstream erosion, but it is assumed that a certain amount of tailwater will provide some additional erosion protection.

For a given flow rate, the model study found there could be a variation in head of about 10% for free outlet conditions, and about 12% for submerged outlet conditions. The hydraulic spreadsheet computes the minimum amount of freeboard required to accommodate this variation.

Toewall Drop Spillways are available in the following standard dimensions (feet):

- Drop height (D): 1.9, 3.0, 4.0, 5.0, and 6.0
- Notch depth (H): 1.8, 1.9, 2.1, 2.25, 3.04, 2.04, and 2.84
- Notch width (W): 7, 8, 10, 12, 14, 16, 18, and 20
- Weir length (L): 14.2 – 49.5, in 1.6-feet increments
- Headwall length (S): 9.2, 11.3, 13.7, 15.8, 18.2, 20.3, and 22.7

Free-outlet capacities are tabulated below for a variety of structure sizes. **DO NOT USE TABLE IA6-1 or IA6-2 IF YOUR STRUCTURE HAS A SUBMERGED WEIR DURING DESIGN FLOW.** Flow capacity will be less, depending on the amount of submergence. Use the hydraulic spreadsheet.

Table IA6-1. Free-Outlet Design Capacity, 1.9 to 4 feet drop:

Structure Capacity Q (cfs)	Notch Width W (feet)	Weir Length L (feet)	Weir Tangent Length B (feet)	Headwall Length S (feet), min.	U/S Channel Bottom Width W_u (feet)	Added U/S Channel Width W_a (feet)
D = 1.9 ft and **H = 1.8** ft						
106	7	14.2	1.5	9.2	14.6	0
108	8	14.2	0.7	9.2	15.6	0
117	8	15.8	1.5	11.3	15.6	0
127	8	15.8	1.5	11.3	19.6	2
138	8	17.4	2.3	13.7	23.6	4
142	10	17.4	0.7	11.3	21.6	2
155	10	19.0	1.5	13.7	25.6	4
162	12	20.6	0.8	11.3	23.6	2
177	12	22.2	1.6	13.7	27.6	4
192	14	23.8	0.8	13.7	29.6	4
198	14	25.4	1.6	13.7	29.6	4
213	16	27.0	0.8	13.7	31.6	4
229	16	28.6	1.6	15.8	35.6	6
243	18	30.2	0.8	15.8	37.6	6
249	18	31.8	1.6	15.8	37.6	6
263	20	33.4	0.9	15.8	39.6	6
D = 3.0 ft and **H = 1.9** ft						
124	7	14.2	1.5	11.3	19	0
132	7	15.8	2.3	11.3	19	0
127	8	14.2	0.7	11.3	20	0
137	8	15.8	1.5	11.3	20	0
155	10	17.4	0.7	11.3	22	0
162	10	19.0	1.5	11.3	22	0
178	12	20.6	0.8	11.3	24	0
194	12	22.2	1.6	13.7	28	2
201	12	23.8	2.4	13.7	28	2
210	14	23.8	0.8	13.7	30	2
217	14	25.4	1.6	13.7	30	2
225	14	25.4	1.6	15.8	34	4
233	14	27.0	2.4	15.8	34	4
241	16	27.0	0.8	15.8	36	4
249	16	28.6	1.6	15.8	36	4
256	16	30.2	2.4	15.8	36	4

Structure Capacity Q (cfs)	Notch Width W (feet)	Weir Length L (feet)	Weir Tangent Length B (feet)	Headwall Length S (feet), min.	U/S Channel Bottom Width W_u (feet)	Added U/S Channel Width W_a (feet)
D = 3.0 ft and **H = 1.9** ft						
265	18	30.2	0.8	15.8	38	4
272	18	31.8	1.6	15.8	38	4
288	18	33.4	2.4	17.9	42	6
297	20	33.4	0.9	17.9	44	6
304	20	35.0	1.7	17.9	44	6
D = 4.0 ft and **H = 2.1** ft						
144	7	14.2	1.5	13.7	23	0
156	7	15.8	2.3	13.7	23	0
148	8	14.2	0.7	13.7	24	0
161	8	15.8	1.5	13.7	24	0
173	8	17.4	2.3	13.7	24	0
182	10	17.4	0.7	13.7	26	0
195	10	19.0	1.5	13.7	26	0
206	10	20.6	2.3	13.7	26	0
215	12	20.6	0.8	13.7	28	0
226	12	22.2	1.6	13.7	28	0
234	12	23.8	2.4	13.7	28	0
245	14	23.8	0.8	13.7	30	0
262	14	25.4	1.6	15.8	34	2
272	16	27.0	0.8	13.7	32	0
281	16	27.0	0.8	15.8	36	2
291	16	28.6	1.6	15.8	36	2
308	16	30.2	2.4	18.2	40	4
317	18	30.2	0.8	15.8	40	4
327	18	31.8	1.6	18.2	42	4
336	18	33.4	2.4	18.2	42	4
346	20	33.4	0.9	18.2	44	4
354	20	35.0	1.7	18.2	44	4
373	20	36.6	2.5	20.3	48	6
382	20	38.3	3.3	20.3	48	6
390	20	39.9	4.1	20.3	48	6
397	20	41.5	4.9	20.3	48	6

Structures with 5 or 6 feet drop, using standard drawing 1415, are Engineering Job Class V or more and should be designed using the hydraulic spreadsheet. Table IA6-2 below may be used as a guide for estimating a structure size for free-outlet conditions.

Table IA6-2. Free-Outlet Design Capacity, 5 and 6 feet drop:

Structure Capacity Q (cfs)	Notch Width W (feet)	Weir Length L (feet)	Weir Tangent Length B (feet)	Headwall Length S (feet)	U/S Channel Bottom Width W_u (feet)	Added U/S Channel Width W_a (feet)
D = 5.0 ft and **H = 2.25** ft						
164	8	14.2	0.7	18.2	28	0
202	10	17.4	0.7	18.2	30	0
239	12	20.6	0.8	18.2	32	0
277	14	23.8	0.8	18.2	34	0
312	16	27.0	0.8	18.2	36	0
D = 5.0 ft and **H = 3.04** ft						
250	8	14.2	0.7	18.2	28	0
317	10	17.4	0.7	18.2	30	0
375	12	20.6	0.8	18.2	32	0
434	14	23.8	0.8	18.2	34	0
493	16	27.0	0.8	18.2	36	0
556	16	33.4	4.0	18.2	36	0

Structure Capacity Q (cfs)	Notch Width W (feet)	Weir Length L (feet)	Weir Tangent Length B (feet)	Headwall Length S (feet)	U/S Channel Bottom Width W_u (feet)	Added U/S Channel Width W_a (feet)
D = 6.0 ft and **H = 2.04** ft						
174	10	17.4	0.7	18.2	34	0
206	12	20.6	0.8	18.2	36	0
239	14	23.8	0.8	18.2	38	0
271	16	27.0	0.8	18.2	40	0
D = 6.0 ft and **H = 2.84** ft						
286	10	17.4	0.7	20.3	34	0
339	12	20.6	0.8	20.3	36	0
392	14	23.8	0.8	20.3	38	0
446	16	27.0	0.8	20.3	40	0
516	16	33.4	4.0	20.3	40	0

When designing a drop structure, both weir control and headwall control should be considered. The hydraulic spreadsheet contains formulas to check both conditions. For the sizes listed above, structure proportions are such that weir control governs in most cases.

If site soils are easily erodible, a longer headwall length “S” may be selected to increase the embedment length into the abutments. Tables IA6-1 and IA6-2 show the minimum S for a given upstream channel width (Wu).

Downstream riprap is optional for structures with drop of 4 feet or less; its use should be based on structure size, design flow and site conditions.