

DROP STRUCTURE SELECTION

Part 1

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The first criteria in selecting a drop structure is to first determine if it is in fact a “drop Structure” and not a check structure. A check structure is defined as that type of structure that is drowned out by the tailwater at the design flow. It therefore follows that every drop structure will eventually turn into a check structure if the draingeway’s discharge is large enough. Or the opposite thinking is that every check structure will turn into a drop structure if the discharge is low enough. It is therefore the designer’s responsibility to tell his client or reviewing agency when the drop will turn into a check structure and analyze several flow regimes. For the Urban Drainage and Flood Control District, if a drop will still function as a drop at a 100-year discharge, there is no need to determine at what discharge the drop turns into a check. If you are building a structure on the Mississippi River near New Orleans, you may want to check a higher discharge.

When a designer is faced with the question of what type of drop to use for their project, the first place to check is Volume 2 of UDFCD’s Storm Drainage Criteria Manual, Section 2.2. Table HS-1 lists three accepted drop structure types: The Baffled Chute, the Grouted Sloping Boulder or GSB, and the Vertical Hard Basin. Volume 2 does not state that other types of drop structures are not acceptable. If the designer determines another type of structure is appropriate, further analysis will have to be performed for the reviewer. One example of this is a “Sculpted Drop” which has become popular with several communities because of its aesthetic appeal.

Within Section 2.2, its states the primary consideration for selecting a drop is “Functional Hydraulic Performance” and “Public Safety”. What this translates into in the Denver Metro area is “If it is in the criteria manual, use it. If its not, prove to us it works”. Now that you have narrowed your selection down to the three types of drops mentioned above, the other things outlined in Section 2.2 are: Land Use, Cost, Ecology, Aesthetics, Maintenance, and Environmental Permitting. Each of these items are discussed below.

Land Use. This can be also referred to as “Contextual Design”. The designer should choose the drop that “fits” into the natural surroundings. If the setting is in a highly urbanized area, a proper choice may be a vertical concrete drop because all of the surrounding buildings and structures are predominately concrete. When installing a drop on the west side of the Metro area, where rock formations can be found, a GSB may be the proper choice. And when working in the eastern plains, a vertical sheet pile drop with a metal cap may be the proper choice in addition to willow plantings to help mask the edges of the drop.

Cost. As with every design, cost should always be a determining factor in the selection of a drop. Typically drops structures are similar in cost for the amount of drop height needed. That is a GSB is similar in cost to a vertical sheet pile keeping in mind that the maximum height for a sheet pile would be three feet. Also, contractors are constantly finding new ways to construct drops at a lower cost. The theory of similar costs for drops has recently been proven with the new “sculpted” drops. In the late 1990’s when they were first introduced, they were higher in cost than the accepted GSB drops. Within the past few years contractors have determined new construction methods in constructing these drops and they are now similar in cost to a GSB, and sometimes are cheaper.

Ecology. When determining a drop type, the designer needs to examine the surrounding ecology of the site. Is it heavily forested or is it mostly plains grasses? Is it in a rural wildlife setting or highly urbanized with little wildlife use? A GSB typically requires a larger footprint of disturbance to construct versus a vertical drop. If minimal disturbance to the surrounding area is desired, a vertical drop may be the desired design.

Aesthetics. Aesthetics are “in the eye of the beholder,” or the eye of your client. An engineer should consult with a landscape architect who is skilled in drainageway design to determine, and direct, the type and finished “look” of the drop structure.

Maintenance. This topic is covered in detail in a parallel write-up by Mark Hunter, co-author of this paper and presentation.

Environmental Permitting. In today’s permitting world, more care is given to drainageway design to ensure that it is compatible with the surrounding environment. The majority of the time, wetlands is an issue. However, installing a drop with the proper cutoff wall will typically back up the groundwater above the drop thereby promoting increased wetland growth. The designer does however need to be aware of the grading upstream and downstream of the drop to allow the increase wetland growth to occur. Another issue involved in the design of drop-structures is to allow passage of fish and non-vertebrae. Special designs may be required to allow for this passage. The designer should consult with an environmental expert before proceeding with final design

After the drop structure type has been selected, several construction issues need to be considered to allow for a successful end product. The baffled chute has had many years of analysis and will not be discussed in detail here. For a complete description of this drop, refer to section 2.5 of the District’s Volume 2 criteria manual.

When designing a GSB structure, the designer should refer to section

2.4.3 of the criteria manual for detailed design issues. A few of the items, which are sometimes missed during construction, are as follows:

- The rocks must be carefully placed to create a stepped appearance, which helps to increase roughness.
- A row of boulders should be located at the basin end to create a sill transition to the downstream invert elevation. Also, burred riprap would be installed for a distance of 10 feet downstream of the sill to minimize any erosion that may occur due to secondary currents.
- A vertical cutoff, either constructed of sheet pile or concrete, should be located at the upstream face of the crest, at a minimum depth of $0.8H_d$ or 4 feet, whichever is deeper.
- The grout thickness should be $\frac{1}{2}$ of the mean diameter of the boulders, not $\frac{3}{4}$.
- An under drain system should be installed using the typical detail shown in Figure HS-7a3-2 for GSB drops in excess of 5 feet. For drops less than 5 feet, depending on soil conditions, weep holes may need to be installed using a pvc pipe, with granular bedding, wrapped in geotextile. This is sometimes referred to a “hobo” weep drain.

When designing a Vertical Hard Basin structure, the designer should refer to section 2.4.4 of the criteria manual for detailed design issues. A few of the items, which are sometimes missed during construction, are as follows:

- A rough basin is advantageous since increased roughness will result in a shorter, or economical basin.
- A sill at the basin end needs to be constructed to bring the invert elevation to that of the downstream channel and sidewalls extending from the crest wall to the sill. The sill is important in causing the hydraulic jump to form in the basin.
- The vertical face of the drop should extend into the ground to form the drop’s cutoff wall to a depth determined by performing a seepage analysis described in section 2.6.1. This author takes exception to the suitability of the cutoff types shown in table HS-8 for sands and gravel. Only sheet pile should be used for a cutoff. Excavation for a concrete cutoff, in sandy material, disturbs the surrounding material and therefore promotes seepage around the cutoff wall, ultimately causing failure of the drop.

In conclusion, the designer should analyze the site for many factors before selecting a drop structure type. Don’t assume that the latest trend or style of drop structure will fit your situation.