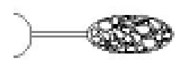
4.2.5 Slope Drain



Source: TNWRRC

Definition and Purpose

A slope drain is a flexible tubing or conduit designed to safely transport concentrated runoff down a disturbed slope. Slope drains transport runoff collected from a diversion at the top of the slope to an energy dissipator at the toe of the slope, thereby preventing runoff from eroding the face of the slope.

Appropriate Applications

These measures are most impactful when installed along the face of a disturbed slope that is subjected to concentrated runoff; however, they can be installed on practically any slope.

Limitations and Maintenance

To ensure proper function, inspection of slope drains is necessary. It is best to inspect them weekly and after each rainfall to check for blockages, leakage, secure anchoring, and potential undercutting at the inlet and outlet. Furthermore, inspect the diversion at the top of the slope and energy dissipator at the toe of the slope to ensure both are functioning as designed. Some sources suggest a single pipe should not drain an area larger than five acres (ALSWCC, 2018; ARDOT, 2016; USEPA, 2021) while others specify a maximum of one and a half acres (GSWCC, 2016, TDOT). Ultimately, the designer is responsible for ensuring slope drains can adequately convey runoff without exposing the slope to erosion.


Source: TDEC

Planning and Design Considerations

Slope drains are necessary because there are typically lengthy periods of time between when a cut or fill slope is graded and when final stabilization or a permanent drainage system is installed. During these extended periods of time, disturbed slopes are particularly vulnerable to erosion (VDEQ, 2024).

Slope drain conduit should be made from heavy duty, flexible materials, such as non-perforated corrugated plastic pipe, corrugated metal pipe, or specially designed flexible tubing. Pipes must maintain a uniform diameter along their entire length, in which the diameter is based on its contributing drainage area (Table 4.2.5-A). The drain must be securely anchored with reinforced, hold-down grommets or stakes spaced every ten feet or less to prevent movement under heavy flows. Additionally, the pipe should extend four feet beyond the toe and top of the slope (GSWCC, 2016; TDOT) as further explained in the subsequent paragraphs.

Table 4.2.5-A: Slope drain diameters based on contributing drainage area. Sources: ALSWCC (2018); GSWCC (2016); TDOT; VDEQ (2024).

Maximum Drainage Area (ac)	Pipe Diameter (in)
0.25	8
0.3	10
0.5	12
0.75	15
1.5	18
2.5	21
3.5	24
5	30

At the top of the slope, the slope drain inlet would ideally extend four horizontal feet beyond the crest of the slope and into a diversion berm or similar (Section 4.2.1). The pipe inlet should have a watertight flared end-section or T-section fitting extending into the diversion. The diversion berm often has a minimum height of six inches above the pipe diameter (TDOT; VDEQ, 2024). Other sources suggest a minimum height of 12 to 18 inches above the top of the pipe (ALSWCC 2018; GSWCC, 2016). When the total diversion height is greater than 18 inches at the centerline of the pipe inlet, slope the diversion at a rate of 3H:1V or flatter to connect with the remainder of the diversion. The top of the diversion should be at least two feet in width with side slopes no steeper than 2H:1V (TDOT). Further, the diversion must comply with all specifications in Section 4.2.1. Soil around the inlet must be thoroughly compacted and stabilized using gravel, conventional riprap, or sandbags. These specifications ensure that runoff does not undercut or bypass the slope drain. When the inlet of the slope drain is along a continuous slope, a ditch block (shown in the photo) should be constructed to divert flowing water into the pipe. The ditch block should be of sufficient height to redirect flowing water but not greater in height than the diversion along the top of the slope (TDOT). A stone filter ring or other inlet protection (Section 4.4.6) may be placed at the inlet for additional sediment removal capacity.

At the bottom of the slope, the slope drain outlet should ideally extend four horizontal feet beyond the toe. This section of horizontal pipe helps reduce the velocity of water and prevent scour. Alternatively, a T-section or fitting/extension may be placed at the outlet to reduce velocity. Often, outlets discharge to level spreaders (Section 4.3.5), conventional riprap apron, or other energy dissipators to further dissipate energy. These practices may be particularly necessary when a four foot horizontal section of pipe cannot be placed due to space limitations at the toe of the slope. Slope drains may also directly discharge into sediment basins, traps, check dams, etc.

Example Application

-Example courtesy of TDOT-

Given:

A proposed ramp has been designed to have a side slope of 2H:1V and a fill height of 20 feet. The ramp is in normal crown with one 16 foot lane, an outside shoulder eight feet wide and an inside shoulder six feet wide. The ramp is 800 feet long at a profile grade of 2%. The designer has determined that the best erosion prevention and sediment control measure for the ramp is a diversion berm with slope drains.

Determine:

The required temporary slope drain quantities for the outside shoulder of the 800 foot ramp.

Solution:

Step 1- Determine the drainage area: The drainage area includes the 16 foot lane and the eight foot shoulder for 800 feet. Thus:

$$\text{Area} = W \times L = (16 + 8) \times 800 = 19200\ \text{ft}^2 = 0.44\ \text{ac}$$

Step 2- Determine the size and number of temporary slope drains: According to Table 4.2.5-A, the maximum drainage area for a 12 inch diameter pipe is 0.5 acres. Since the area to be drained is 0.44 acres, a single 12 inch slope drain is sufficient.

When considering this site, however, it was judged that an 800 foot flow length from the top of the ramp to the drain-pipe would be excessive. Given that the slope along the berm will be 2%, there is a possibility that shear stresses exerted by the flow could become excessive. Thus, based upon engineering judgment, it is decided to use two 8 inch slope drains with drainage areas of 0.22 acres each. This will break up the length of the concentrated flow. Therefore, two 8 inch slope drains, spaced 400 feet apart, are the ideal size and number of pipes.

Step 3- Determine Quantities: The length of each pipe along a 20 foot high 2H:1V slope can be computed:

$$\text{Slope length} = \sqrt{(L^2 + W^2} = \sqrt{(20^2 + 40^2} = 59.7\ \text{ft.}$$

Therefore, the total length of each slope drain is 60 feet, or 120 feet of conduit for both. If T- or L- sections are not used at the outfall, a minimum of four feet of conduit would ideally be added on to the length of each pipe at the inlet and outlet. Thus, the total required length is 136 feet.

References

ALSWCC. (2018). *Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas.*

ARDOT. (2016). *Erosion and Sediment Control Design and Construction Manual*.

GSWCC. (2016). *Manual for Erosion and Sediment Control in Georgia.*

TDOT. *Drainage Manual Ch10*.

USEPA. (2021). *Stormwater Best Management Practices: Temporary Slope Drains*.

VDEQ. (2024). *Virginia Stormwater Management Handbook.*