

6.41

OUTLET STABILIZATION STRUCTURE

Definition A structure designed to control erosion at the outlet of a channel or conduit.

Purpose To prevent erosion at the outlet of a channel or conduit by reducing the velocity of flow and dissipating energy.

Conditions Where Practice Applies This practice applies where the discharge velocity of a pipe, box culvert, diversion, open channel, or other water conveyance structure exceeds the permissible velocity of the receiving channel or disposal area.

Planning Considerations The outlet of channels, conduits, and other structures are points of high erosion potential because they frequently carry flows at velocities that exceed the allowable limit for the area downstream. To prevent scour and undermining, an outlet stabilization structure is needed to absorb the kinetic energy of the flow and reduce the velocity to non-erosive levels. A riprap apron is the most commonly used practice for this purpose because of its relatively low cost and ease of installation. The riprap apron should be extended downstream until stable conditions are reached even though this may exceed the length calculated for design velocity control.

Riprap aprons or plunge pools reduce flow velocity rapidly. They should be considered in lieu of aprons where pipe outlets are cast-in-place or where high flows would require excessive apron length (Figure 6.41a). Consider other energy dissipaters such as concrete apron basins or paved outlet structures where site conditions warrant.

Alternative methods of energy dissipation can be found in Hydraulic Design of Energy Dissipaters for Culverts and Channels, Hydraulic Engineering Center No. 14, U.S. Department of Transportation, Federal Highway Administration.

The installation of a culvert in a stream is subject to the conditions of a U.S. Army Corps of Engineers 404 Permit and a N.C. Division of Water Quality 401 Certification. These permit conditions may allow the use of a riprap apron, and may require that the bottom of the culvert be bedded below the natural stream bed elevation. A pre-formed riprap apron or plunge pool should be considered in these situations. Plunge pool design in streams should not use a cantilevered outlet because it would pose a barrier to migration of aquatic life through the culvert. Reducing the outlet velocity may require a combination of techniques, including a culvert with a flat bottom, a downstream concrete vane create tail-outlet pipe outlet, and a riprap apron.

Design Criteria Capacity—10-year peak runoff or the design discharge of the water conveyance structure, whichever is greater.

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Practice Standards and Specifications

6.41a Typical plunge pool design showing variable dimensions.

6.41b Riprap apron apron—The apron length and width can be determined according to the tail-water condition. If the water conveyance structure discharges directly into a well-defined channel, extend the apron across the channel bottom and up the channel banks to an elevation of 0.5 above the maximum tail-water depth or to the top of the bank, whichever is less (Figure 6.41a).

Determine the maximum allowable velocity for the receiving stream, and design the riprap apron to reduce flow to this velocity before flow leaves the apron. Calculate the apron length for velocity control or use the length required to meet stable channel conditions downstream, whichever is greater.

Grade—Ensure that the apron has zero grade. There should be no overfall at the end of the apron; that is, the elevation of the top of the riprap at the downstream end should be the same as the elevation of the bottom of the receiving channel or the adjacent ground if there is no channel.

Alignment—The apron should be straight throughout its entire length, but if a curve is necessary to align the apron with the receiving stream, locate the curve in the upstream section of riprap.

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6.32

TEMPORARY SLOPE DRAINS

Definition A flexible tubing or conduit extending temporarily from the top to the bottom of a cut or fill slope.

Purpose To convey concentrated runoff down the face of a cut or fill slope without causing erosion.

Conditions Where Practice Applies This practice applies to construction areas where streamflow runoff above a cut or fill slope will cause erosion in alluvial or fine-grained soil. Temporary slope drains are generally used in conjunction with diversions to convey runoff down a slope until permanent water disposal measures can be installed.

Planning Considerations There is often a significant lag between the time a cut or fill slope is graded and the time it is permanently stabilized. During this period, the slope is very vulnerable to erosion, and temporary slope drains together with temporary diversions can provide valuable protection (Practice 6.29, Temporary Diversions).

It is very important that these temporary structures be sized, installed, and maintained properly because their failure will usually result in severe erosion of the slope. The entrance section to the drain should be well extended and stable so that surface water can enter freely. The drain should extend down-slope beyond the top of the slope to a stable area or appropriately stabilized outlet.

Other points of concern are failure from overtopping from inadequate pipe inlet capacity and lack of maintenance of drainage channel capacity and ridge height.

Design Criteria Capacity—Peak runoff from the 10-year storm.

Pipe size—18 inches are individually designed, size drains according to Table 6.32a.

Table 6.32a Size of Slope Drain	Maximum Drainage Area per Pipe (acres)	Pipe Diameter (inches)
0.50	12	18
0.75	16	18
1.00	18	18
>1.00	as designed	as designed

*Inlet design becomes more complex beyond this size.

Construction Specifications A common failure of slope drains is caused by water saturating the soil and causing soil pipe. This occurs while flow consolidation and piping and causes washouts. Proper backfilling around and under the pipe "haunches" with stable soil material and hand compacting in 6-inch lifts to achieve firm contact between the pipe and the soil at all points will eliminate this type of failure.

- Place slope drains in undisturbed soil or well compacted fill at locations and elevations shown on the plan.

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Practice Standards and Specifications

6.32a Cross section of temporary slope drain.

6.32b Temporary diversion—Generally, use an earthen diversion with a filter ridge to direct surface runoff into the temporary slope drain. Make the height of the ridge over the drain a minimum of 1.5 feet and at least 6 inches higher than the adjoining ridge on either side. The lowest point of the diversion ridge should be a minimum of 1 foot above the top of the drain so that design flow can freely enter the pipe.

6.32c Temporary diversion—Protect the outlet of the slope drain from erosion (Practice 6.41, Outlet Stabilization Structure).

Construction Specifications A common failure of slope drains is caused by water saturating the soil and causing soil pipe. This occurs while flow consolidation and piping and causes washouts. Proper backfilling around and under the pipe "haunches" with stable soil material and hand compacting in 6-inch lifts to achieve firm contact between the pipe and the soil at all points will eliminate this type of failure.

- Place slope drains in undisturbed soil or well compacted fill at locations and elevations shown on the plan.

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2. AFTER SOLIDS REMOVAL ALLOW WASHWATER TO EVAPORATE OR ADD GEL GRANULES AND REMOVE INNER FILTER BAG WITH GEL TO APPROVED DISPOSAL SITE.

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Vinyl washout container

The vinyl washout container (Fig. 11) is portable, reusable, and easier to install than a hay bale washout pit. The biodegradable filter bag (Fig. 12) assists in extracting the concrete solids and prolongs the life of the vinyl container. When the bag is lifted, the water is filtered out and the remaining concrete solids and the bag can be disposed of together in a landfill, or the hardened concrete can be delivered to a recycler. After the solids have been removed several times and the container is full of washwater, the washwater can be allowed to evaporate, so the container can be reused. The washwater can be removed more quickly by placing another filter bag in the container and spreading water gelling granules evenly across the water. In about five minutes, the water in the filter bag will turn into a gel that can be removed with the bag. Then the gel and filter bag can be disposed of together.

Figure 11. Vinyl washout pit with filter bag.

Figure 12. Extracting the concrete solids or gelled washwater.

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6.20

TEMPORARY DIVERSIONS

Definition A temporary ridge or excavated channel or combination ridge and channel constructed across sloping land on a predetermined grade.

Purpose To protect work areas from up-slope runoff, and to divert sediment-laden water to appropriate traps or stable outlets.

Conditions Where Practice Applies This practice applies to construction areas where runoff can be diverted and disposed of properly to control erosion, sedimentation, or flood damage. Specific locations and conditions include:

- above disturbed existing slopes, and above cut or fill slopes to prevent runoff over the slope;
- across unexpected slopes, as slope breaks, to reduce slope length;
- below slopes to divert excess runoff to stabilized outlets;
- where needed to divert sediment-laden water to sediment traps;
- at or near the perimeter of the construction area to keep sediment from leaving the site; and
- above disturbed areas before stabilization to prevent erosion, and maintain acceptable working conditions.

Temporary diversions may also serve as sediment traps when the site has been overexcavated on a grade; they may also be used in conjunction with a sediment fence.

Planning Considerations It is important that diversions be properly designed, constructed and maintained since they concentrate water flow and increase erosion potential (Figure 6.20a). Particular care must be taken in planning diversion grades. Too much slope can result in excessive velocity in the diversion channel or at the outlet. A change of slope from steeper grade to flatter may cause deposition to occur. The deposition reduces carrying capacity, and may cause overtopping and failure. Frequent inspection and timely maintenance are essential to the proper functioning of diversions.

Sufficient area must be available to construct and properly maintain diversions. It is usually less costly to excavate a channel and form a ridge or dike on the

Figure 6.20a Temporary diversion dike.

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Practice Standards and Specifications

6.20b Temporary diversion dike for vehicle crossing modified from VA DWG02.

Design Criteria: Drainage area—5 acres or less. Capacity—peak runoff from 10-year storm. Velocity—See Table 8.05a, Permissible Velocities for Erosion Protection, Appendix 8.05. Ridge design—side slope: 2:1 or flatter at points where cross top width: 2 ft minimum; crestwidth: 0.5 ft minimum; settlement: 10% of total fill height minimum.

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Practice Standards and Specifications

Channel design—slope: parabolic, trapezoidal, or V-shaped; side slope: 2:1 or flatter; 3:1 or flatter where vehicles cross.

Grades—Either a uniform or a gradually increasing grade is preferred. Sudden decreases in grade accumulate sediment and should be expected to cause overtopping. A large increase in grade may erode.

Outlet—Design the outlet to accept flow from the diversion plus any other contributing areas. Direct sediment-laden runoff and release through a sediment-trapping device (Practice 6.05, Temporary Sediment Trap and Practice 6.01, Sediment Basin). Flow from undisturbed areas can be dispersed by a level spreader (Practice 6.02, Level Spreader).

Small diversions—Where the diversion channel grade is between 0.2 and 3%, a permanent vegetative cover is required. A parabolic channel and ridge 1.5 feet deep and 12 feet wide may be used for diversions with flows up to 5 cfs. This depth does not include crestwidth or settlement. Side slopes should be 3:1 or flatter, and the top of the dike must be at least 2 feet wide.

Construction Specifications

- Remove and properly dispose of all trees, brush, stumps, and other objectionable material.
- Ensure that the minimum constructed cross section meets all design requirements.
- Ensure that the top of the dike is not lower at any point than the design elevation plus the specified settlement.
- Provide sufficient cross around diversions to permit machine regaling and cleanup.
- Vegetate the ridge immediately after construction, unless it will remain in place less than 30 working days.

Maintenance Inspect temporary diversions once a week and after every rainfall. Immediately remove sediment from the flow area and repair the diversion dike. Carefully check outlets and make timely repairs as needed. When the area protected is permanently stabilized, remove the ridge and the channel to blend with the natural ground level and appropriately stabilize it.

References Surface Stabilization 6.10, Temporary Seeding 6.11, Permanent Seeding 6.14, Mulching 6.14, Outlet Protection 6.40, Level Spreader 6.41, Outlet Stabilization Structure

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6.00

TEMPORARY SEDIMENT TRAP

Definition A small, temporary ponding basin formed by an embankment or excavation to capture sediment.

Purpose To detain sediment-laden runoff and trap the sediment to protect receiving streams, lakes, drainage systems, and prevent sediment disposal.

Conditions Where Practice Applies Specific criteria for installation of a temporary sediment trap are as follows:

- At the outlet of diversions, channels, slope drains, or other runoff conveyances that discharge sediment-laden water.
- Where areas that are draining 5 acres or less.
- Where access can be maintained for sediment removal and proper disposal.
- In the approach to a structure located below a disturbed area as part of a site-protection system.
- Structure life limited to 2 years.

A temporary sediment trap should not be located in an intermittent or perennial stream.

Planning Considerations Select locations for sediment traps during site evaluation. Note natural drainage divides and select trap sites so that runoff from potential sediment-producing areas can easily be diverted into the traps. Locate the drainage area for each trap to not exceed 5 acres. Install temporary sediment traps before land disturbing takes place within the drainage area.

Make traps readily accessible for periodic sediment removal and other necessary maintenance. This location for sediment disposal is part of trap site selection. Clearly designate all disposal areas on the plan.

In preparing plans for sediment traps, it is important to consider provisions to prevent the embankment from storm runoff that exceeds the design capacity. Locate bypass outlets so that flow will not damage the embankment. Three emergency bypasses to undisturbed natural, stable areas. If a bypass is not possible and failure would have severe consequences, consider alternative sites.

Sediment trapping is achieved primarily by settling within a pool formed by an embankment. The sediment pool may also be formed by excavation, or by a combination of excavation and embankment. Sediment-trapping efficiency is a function of surface area and inflow rate (Practice 6.45, Porous Buffers). Therefore, maximize the surface area in the design. Because porous buffers improve flow distribution across the basin, high length-to-width ratios are not necessary to reduce short-circuiting and to optimize efficiency.

Because well-planned sediment traps are key measures to preventing off-site sedimentation, they should be installed in the first stages of project development.

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Design Criteria

Parameter	Requirement
Primary Spillway	Stone Spillway
Maximum Drainage Area	5 acres
Minimum Surface Area	3600 cubic feet per acre of disturbed area
Minimum L/W Ratio	4:1 square feet per ft of spillway crest
Minimum Depth	1.5 feet, 1.5 feet excavated below grade
Maximum Height	Wall elevation 3.5 feet above grade
Drainage Mechanism	Stone Spillway
Minimum Dewatering Time	N/A
Barriers Required	3

Storage capacity—Provide a minimum volume of 3600 ft³ of disturbed area draining into the basin. Required storage volume may also be determined by modeling the spill flow with the Rational Universal Soil Loss Equation or other acceptable methods. Measure volume to the crest elevation of the stone spillway outlet.

Trap placement—Remove sediment from the trap, and restore the capacity to original trap dimensions when sediment has accumulated to one-half the design depth.

Trap efficiency—The following design elements must be provided for adequate trapping efficiency:

- Provide a surface area of 9:1 area (435 square feet per acre based on 10-year storm).
- Convey runoff into the basin through multiple diversions or temporary slope drains.
- Locate sediment inflow to the basin away from the dam to prevent short circuiting into the outlet.
- Provide porous buffers (Practice 6.45, Porous Buffers).
- Excavate 1.5 feet of the depth of the basin below grade, and provide minimum storage depth of 2 feet above grade.

Embankment—Ensure that embankments for temporary sediment traps do not exceed 5 feet in height. Measure from the center line of the original ground surface to the top crest of the embankment. Keep the crest of the spillway outlet a minimum of 1.5 feet below the top of the embankment. Preexcavate trap to a minimum of 1.5 feet below the top of the embankment. Preexcavate trap to a minimum of 1.5 feet below the top of the embankment. Preexcavate trap to a minimum of 1.5 feet below the top of the embankment. Preexcavate trap to a minimum of 1.5 feet below the top of the embankment.

Outlet section—Construct the outlet section using a stone spillway, or a combination of excavation and embankment. Sediment-trapping efficiency is a function of surface area and inflow rate (Practice 6.45, Sediment Basin). Therefore, maximize the surface area in the design. Because porous buffers improve flow distribution across the basin, high length-to-width ratios are not necessary to reduce short-circuiting and to optimize efficiency.

Stone spill—Construct the outlet using well-graded stone with a 4:1 side of 9 inches (Class B) or coarse stone (recommending) and a maximum stone of 12 inches (Class D) or coarse stone (recommending) and a maximum stone of 12 inches.

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6.00a Plan view and cross-section view of a temporary sediment trap.

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**Table 6.00a
Design of Spillways**

Drainage Area (acres)	Wall Length* (ft)
1	4.0
2	5.0
3	6.0
4	7.0
5	8.0
6	9.0
7	10.0
8	11.0
9	12.0

*Dimensions shown are minimum.

Construction Specifications

- Class, grade, and strip the area under the embankment of all vegetation and roots. Remove all surface soil containing high amounts of organic matter, and discharge it to a disposal area if properly. Use all objectionable material in the designated disposal area.
- Ensure that fill material for the embankment is free of roots, woody vegetation, organic matter, and other objectionable material. Place the fill 10% wet or excess 7 inches, and machine compact it. Over the embankment 6 inches is allowed for settlement.
- Construct the outlet section in the embankment. Protect the connection between the trap and the soil from piping by using filter fabric or a fabric cutoff trench between the trap structure and soil.
- Place the filter fabric between the trap and the soil. Extend the fabric across the spillway foundation and side to the top of the dam, or excavate a keyway trench along the center line of the spillway foundation extending up the side to the height of the dam. The trench should be at least 2 feet deep and 2 feet wide with 1:1 side slopes.
- Clear the pond area below the elevation of the crest of the spillway to facilitate sediment clearance.
- All cut and fill slopes should be 2:1 or flatter.
- Ensure that the stone (drainage) section of the embankment has a minimum bottom width of 1 foot and maximum side slopes of 1:1 that extend to the bottom of the embankment. Keep the crest of the spillway outlet on the plan, with 2:1 side slopes extending to the top of the over-filled embankment. Keep the thickness of the side of the spillway outlet structure at a minimum of 24 inches. The wall must be level and constructed to grade to prevent displacement.

Excavation—Where sediment ponds are formed or enlarged by excavation, keep side slopes at 2:1 or flatter for stability.

Outlet section—Construct the outlet section using a stone spillway, or a combination of excavation and embankment. Sediment-trapping efficiency is a function of surface area and inflow rate (Practice 6.45, Sediment Basin). Therefore, maximize the surface area in the design. Because porous buffers improve flow distribution across the basin, high length-to-width ratios are not necessary to reduce short-circuiting and to optimize efficiency.

Stone spill—Construct the outlet using well-graded stone with a 4:1 side of 9 inches (Class B) or coarse stone (recommending) and a maximum stone of 12 inches.

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6.00b Cross-section view of a temporary sediment trap.

Rev. 006 6.00.5

REVISIONS

NO.	DATE	DESCRIPTION	BY
1	6-7-23	TOWN OF BOONE	WKSJ
2	7-30-23	TOWN OF BOONE	WKSJ
3	1-22-24	ISSUE FOR CONSTRUCTION	RAWG

Sheet No. **23** of **25**

Date: MARCH 29, 2023

Scale: 1" = 20'

Project No.

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