4.4.8 Sediment Trap

Source: TDEC

Definition and Purpose

A sediment trap is a small, temporary basin created by excavating within a low area, creating an embankment, or both, to capture sediment-laden stormwater runoff. Its primary purpose is to temporarily detain the runoff, allowing suspended particles to settle before the runoff is released. Sediment traps are commonly paired with check dams, stone spillways, or other outlet controls that slowly release the water to reduce downstream erosion.

Appropriate Applications

Sediment traps, or their engineered equivalents (Chapter 5), are to be used where treatment of sediment-laden runoff is necessary, as specified by the Tennessee CGP. They are commonly installed at the outlets of stormwater diversion structures, slope drains, channels, or ditches where runoff is expected to carry high sediment loads (USEPA, 2021). Their placement is typically below disturbed areas, at low points such as swales, ditches, or near site perimeters where concentrated flows leave construction zones.

Limitations and Maintenance

A Sediment trap is not recommended for use in a drainage area greater than 10 acres. When a drainage area exceeds 10 acres, consider the use of a temporary sediment basin (Section 4.4.7) or a treatment train that may include multiple sediment traps (or a sediment trap in combination with other EPSC measures) in order to sufficiently treat the stormwater. Further, sediment traps have a relatively short lifespan, often functioning effectively for less than two years. Projects longer than two years should account for the complete reconstruction of sediment traps. While these structures effectively capture coarse sediments, their detention times are not always sufficient to settle out finer particles such as silts and clays (USEPA, 2021). Sediment traps are to be removed once the contributing area has been permanently stabilized.

Proper maintenance is essential to ensure that sediment traps continue to function as designed. Sediment should be removed once it has accumulated to half the sediment storage volume. Removed sediment must be disposed of properly or stabilized onsite so as not to re-contribute to sediment loss. Regular inspections are critical to assess structural integrity and verify that the trap is draining properly. Further, check for erosion, seepage, or settlement of the embankment. Any displaced riprap, clogged filter stone, or damaged outlets should be repaired or replaced immediately. Embankments should be restored to design grade if settlement occurs, and all woody vegetation should be cleared from the structure to maintain stability. Once construction is complete and drainage areas are stabilized, the trap and all accumulated sediment needs to be removed, then the area backfilled and stabilized to prevent future erosion and sediment loss.

Planning and Design Considerations

Sediment traps are to be installed before land disturbance begins and located according to natural drainage patterns so that runoff from disturbed areas is directed into them. Placement should prioritize intercepting flow as close as possible to the source of sediment, while runoff from undisturbed areas would ideally be diverted around the construction. While applicable for larger drainage areas, to maintain trapping efficiency and structural stability, it is recommended to limit the drainage area contributing to a single trap to five acres (Line & White, 2001; USEPA, 2021). Traps are to be positioned where construction crews can readily perform inspections, sediment removal, and repairs without interfering with ongoing site activities (NCDEQ, 2013).

Design plans should address both performance and safety concerns. The designer and developer should be aware of the potential hazards that a temporary wet pond represents to the health and safety of a neighborhood, as specified in the sediment basin section (Section 4.4.7). Storage capacity is achieved through excavation, embankment construction, or both. To prevent embankment failure during extreme events, bypass outlets or stabilized emergency spillways should be incorporated, with flow directed toward stable, undisturbed areas. Traps are not to be located in wetlands, streams, buffer zones, or on steep, unstable slopes, as these conditions compromise effectiveness and increase risk of failure (VDEQ, 2024). Additional measures, such as outlet protection, porous baffles to improve flow distribution, and compost filter sock traps in suitable conditions, can enhance sediment retention performance.

The formal design and dimensions of a sediment trap should be documented in the EPSC plans. The minimum total storage volume of a sediment trap is to be 134 cubic yards (3,618 cubic feet) per acre of disturbed area draining to the trap. This volume, at minimum, is divided evenly between the sediment storage and live storage zones (see Section 4.4.7 for definitions and functions of these zones). It is recommended that a minimum length-to-width ratio of 2:1 be used to promote settling time and sedimentation. The spillway should be able to convey the design storm, and the live storage should be able to dewater between 48 and 72 hours. Embankments should not exceed five feet in height from the top of sediment storage to the crest of the berm; they are to be machine-compacted, with side slopes no steeper than 2H:1V, and have a width that corresponds to the associated drainage area for stability and discharge purposes (Table 4.4.8-A). Freeboard of at least one foot should be provided from the highwater elevation of the design storm and the crest of the berm. The emergency spillway will be used to pass the design storm (2-year, 24-hour or 5-year, 24-hour) corresponding to the entire drainage area, as the resiliency of the measure(s) is increasingly important as rainfall patterns change and more intense storm events occur. The sediment storage is excavated below the existing ditch bottom and serves as the primary sedimentation zone, while the live storage zone, measured from the top of the sediment storage zone to the invert of the overflow weir on the check dam, provides detention after rainfall (Figure 4.4.8-A). Sediment storage design dimensions can be figured from Figure 4.4.8-B.

Table 4.4.8-A: Recommended embankment widths for sediment traps with various drainage areas. Sources: Adapted from MPCA (2023) and Roberts (1995).

Contributing Drainage Area (ac)	Embankment Width (ft)
1	4
2	6
3	8
4	10
5	12
6	14
7	16
8	18
9	20
10	22

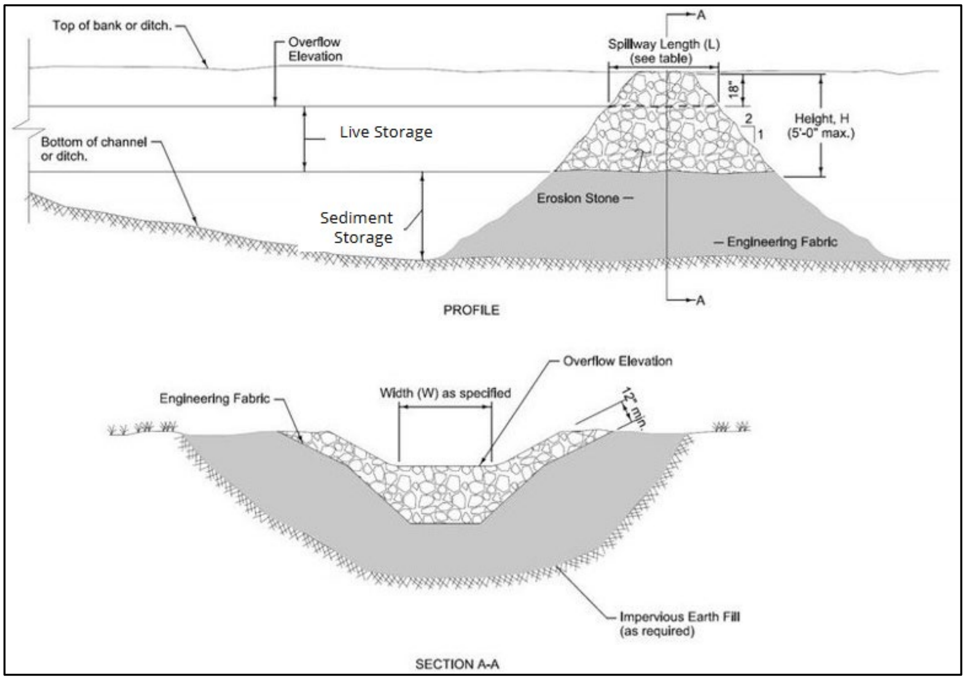

Figure 4.4.8-A: Sediment trap components. Source: Iowa Sudas (2019).

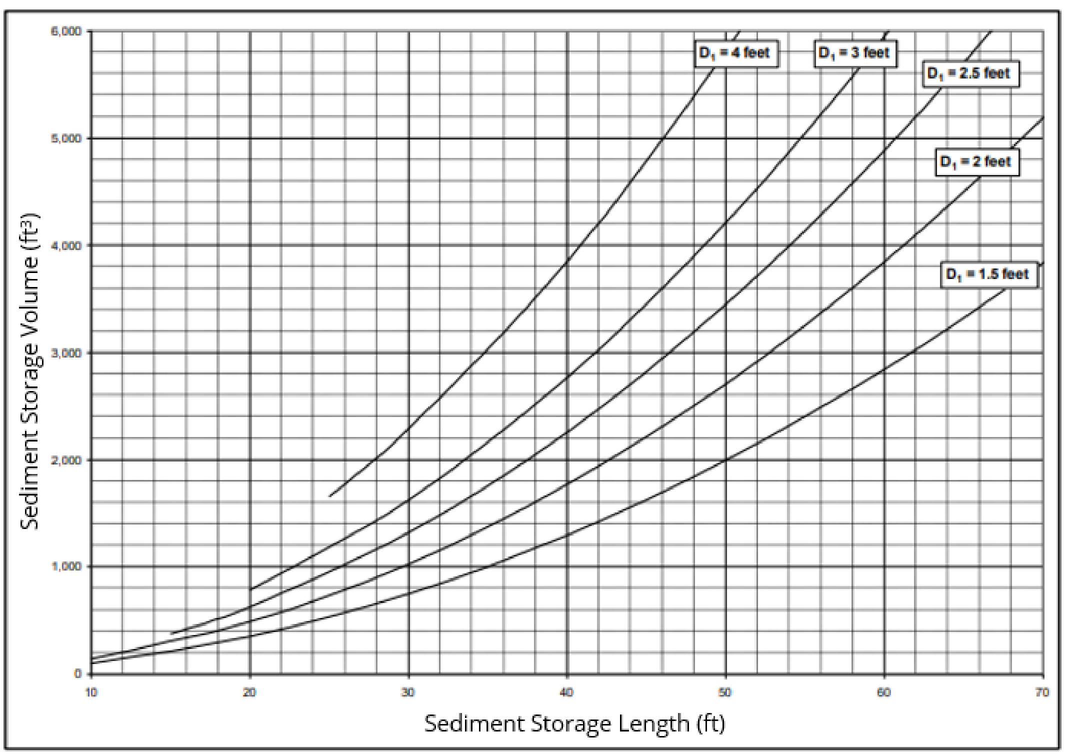

Figure 4.4.8-B: Sediment storage length (at the top of sediment storage) and depth dimensions based on sediment storage volumes. Source: TDOT.

The outlet of a sediment trap usually consists of a stone (conventional riprap) weir built into the embankment, which slows the rate and velocity of runoff and creates a temporary pool (Iowa SUDAS, 2019). This can be achieved through the construction of a riprap check dam, enhanced check dam, or gabion check dam (Figure 4.4.8-A). As such, follow the design recommendations in Sections 4.3.3 and 4.3.3.1. The height of the check dam is often between one and a half and three feet above the sediment storage elevation (TDOT), and the check dam should be able to convey the design storm. Though not necessary, TDOT recommends a two-foot offset between the storage basin and check dam, which is shown on the corresponding standard drawing. A geotextile fabric must be placed between the conventional rip rap and soil to prevent piping and erosion of the spillway(s). The width of the weir embankment (and earthen embankment) can be sized in accordance with the associated drainage area (Table 4.4.8-A). The crest of the outlet should be set at least one foot below the embankment to ensure controlled discharge.

To enhance settling efficiency, the trap should be designed with an elongated flow path, providing a minimum 2L:1W ratio, as previously mentioned. Porous baffles (Section 4.4.12.1.1) should be incorporated to reduce short-circuiting, particularly if high velocities are anticipated. Typically, at least two rows of porous baffles are recommended; refer to Section 4.4.12.1 for further details on porous baffles. In addition, a check dam, enhanced check dam, or gabion check dam may be used at the entrance of a sediment trap to create a treatment train and to decrease the maintenance of the trap itself. Refer to the forebay design of sediment basins (Section 4.4.7) for details regarding the use of check dams as a sediment basin/trap forebay. It is quicker and more cost-effective to remove sediment from a check dam than from the sediment storage zone of a sediment trap. Lastly, the condition that live storage surface area at capacity (acres) should be at least 100 times the peak inflow (cubic feet per second), as discussed for sediment basins (Section 4.4.7, Eqn 28), would be an ideal design consideration to improve settling within a sediment trap.

Sediment traps can include an excavated area that allows water to be detained and settling to occur, and a place for sediment to be stored. In this case, if the entire storage area was below grade, dewatering through pumping is likely necessary. When pumping, a skimmer (Section 4.4.12.2.2) and/or sediment filter bag (Section 4.4.12.6) should be used. The inflow or outflow should be treated with the proper mechanism. No erosion should occur from the pumps' discharge; appropriate energy dissipation (Section 4.3.4) measures should be used.

Sediment traps should remain in service until the drainage area is stabilized or replaced with a permanent measure. Once contributing areas are stabilized, the structure, including stone outlets and spillways, is to be removed, and the area is to be graded and stabilized in accordance with site plans.

Example Application

-Example courtesy of TDOT-

Given:

A drainage area of 2.5 acres that is fully disturbed, channel slope of 1.7% with a bottom width of 6 feet and side slopes of 4H:1V.

Determine:

The design for a sediment trap.

Solution:

Step 1 – Determine the required storage volume: The total storage volume is calculated as 3,618 cubic feet per acre of the 2.5-acre drainage area. Thus, the required storage volume is 9,045 cubic feet, where 4,522.5 cubic feet are designated to the live storage volume and sediment storage volume.

Step 2 - Determine the sediment storage design dimensions: To determine the length of the sediment storage area, L, a horizontal line corresponding to 4,522.5 cubic feet of storage is projected from the Y-axis of Figure 4.4.8-B. Inspection of the graph shows that the basin could be approximately 44 to 65 feet long, depending on the desired depth of sediment storage, D1. Based on the conditions of the site, it is decided that the basin can be constructed along a section of the roadway side ditch. This allows a trade-off between the depth of the basin and its length, and basin length at the top of sediment storage is determined to be 44 feet, so that the maximum sediment storage depth of 4 feet can be utilized. It is decided to use a 2:1 length-to-width ratio, and therefore, the sediment storage width is determined to be 22 feet. The sediment storage of the trap is assumed to be a rectangular prism with no side slopes. Thus, the sediment storage surface area at the top elevation (A1) is computed as 44 multiplied by 22 or 968 square feet.

Step 3 – Determine the height of a rock check dam: The storage volume offered by the live storage area is determined by D2, the height of the enhanced rock check dam spillway above the top of the wet storage. The live storage volume is computed as the average of A1 and A2 (live storage surface area at top elevation), multiplied by D2. A1 has been determined in the previous step. Thus, designing the dry storage area involves determining a spillway height such that the resulting value of A2 will produce a dry storage volume that is approximately half of the total required storage volume. Due to the number of variables, finding the spillway height is a trial-and-error process.

The goal is to use a minimum possible value of D2 to size the appropriate surface area at the top of live storage (A2). This will produce the most economic design in terms of land used to construct the sediment trap. However, this will yield the greatest maintenance burden. Knowing the side slope of the embankment, the live storage volume can be computed. If this volume is greater than required, no further computations will be required. Otherwise, D2 will be increased until an adequate live storage volume is obtained. During periods of high flow, water will collect in the live storage area until it spills over the weir built into the rock check dam. The minimum possible value of D2 can be computed as the product of the length across the top of the sediment storage (L) by the slope of the bed (S_0). This results in a minimum D2 value of 0.75 feet. This value is less than the minimum height of 1.5 feet; thus, an initial trial value of 1.5 feet for the minimum value of D2 will be used.

The volume of the live storage is a trapezoidal prism that extends from the upstream end of the sediment storage to the point at which the pool intersects the ditch bottom. Assuming the embankment has side slopes of 2H:1V, A2 would be 50 feet by 28 feet or 1400 square feet at a D2 of 1.5 feet. The volume of the trapezoidal prism can be approximated by averaging A1 and A2 and multiplying by D2, which yields 1701 cubic feet. This is less than the 4,522.5 cubic feet required. Thus, this process is repeated with larger D2 heights until an appropriate volume is identified, as shown in the table below:

D2 (ft)	A1 (ft^2)	A2 (ft^2)	Live Storage Volume (ft^3)
1.5	968	1300	1701.0
2	968	1456	2424.0
3	968	1792	4140.0
3.5	969	1972	5146.8
3.2	970	1863.04	4532.9

A D2 value of 3.2 feet yields a live storage of 4,533 cubic feet, which is just greater than the required storage. Thus, it is selected as the design value. It may be of importance to note that TDOT recommends a maximum D2 value of 3 feet while NCDEQ (2013) suggests a maximum D2 value of 3.5 feet. Other sources do not explicitly indicate a maximum weir impoundment height. Options to lessen the depth of the sediment storage and to create greater lengths and widths would be the next step if basing the design off of the greatest D1 did not yield an appropriate overall design.

References

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