Frequently Asked Questions for Sedimen Basin

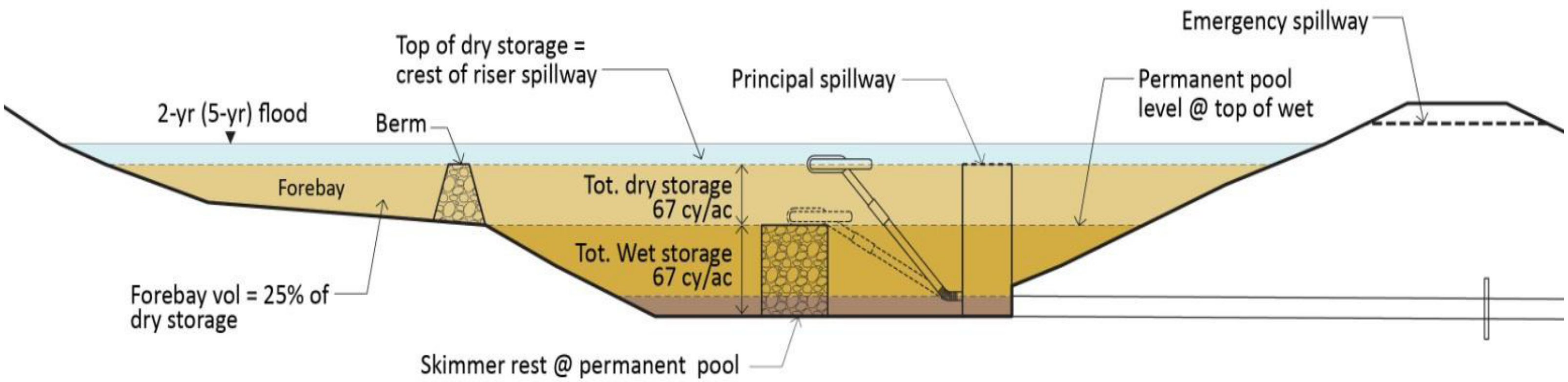
Tennessee Design Principles for Erosion Prevention and Sediment Control for Construction Sites

Frequently Asked Questions (FAQ) about sizing and dewatering Temporary Sediment Basins [SB]

1. What is the purpose of a temporary Sediment Basin?

A sediment basin is formed by excavation and/or embankment dam and is an integral part of the overall erosion prevention, sediment control and storm water management system of practices for keeping sediment on a construction site. The main purpose of a sediment basin is to capture and retain eroded construction site sediment before storm water runoff is discharged to a receiving stream or waters. The reader is referred to Section 7.31 of the Tennessee Sediment & Erosion Control Handbook (i.e., Tennessee Handbook) for detailed performance and design requirements.

An embankment-formed sediment basin shown below consists of a dam (and/or excavation), wet and dry sediment treatment & retention zones, permanent pool, forebay cell formed by a low porous berm, dewatering device (floating skimmer shown), principal (primary) spillway and outlet pipe, and emergency (secondary) spillway. Calculations, design and plans must be prepared by a licensed professional engineer or landscape architect and included in the Storm Water Pollution Prevention Plan (SWPPP)..



Temporary sediment basin formed by an embankment dam and showing various features, including wet and dry storage volume components, forebay cell, surface water skimmer, and separate principal and emergency spillways (Note: 25-yr flood level and spillway design freeboard distances not shown).

2. What construction site conditions require a Temporary Sediment Basin?

a. Where total drainage area at an outfall from a construction site is ten (10) acres or more for sites draining into Unimpaired streams and waters.
b. Where total drainage area at an outfall from a construction site is five (5) acres or more for sites that discharge into Impaired or Exceptional

Tennessee streams and waters, as defined by TDEC. Current lists of Exceptional Tennessee Waters (ETW) and Impaired streams can be found in TDEC's publications website at: http://www.state.tn.us/environment/water/water-quality_publications.shtml (tabulating) and http://tnmap.tn.gov/wpc/

3. What is the basis for sizing a Temporary Sediment Basin?

A temporary sediment basin, working in conjunction with other site erosion prevention and sediment control practices, must be designed, constructed, and maintained so that discharged water does not cause, have the reasonable potential to cause, or contribute to violations of water quality standards. This includes, but is not limited to, discharges causing an objectionable color contrast with the receiving stream. Stormwater discharges into Impaired waters should not add loadings of pollutants identified as causing or contributing to the impairment of a water body on the TDEC current 303(d) list of Impaired waters. Similarly, stormwater discharges should not cause degradation of TDEC-designated Exceptional Tennessee Waters (ETW).

Size and shape of ponds are critical design factors in sediment removal and trapping efficiency.

Shape, represented by the flow length to effective basin width, W, ratio, L/W (defined in terms of the pond surface area, A, L^2/A), is important in providing sufficient inlet to outlet distance for maximizing travel & settling time of small particles through the basin, while minimizing the possibility of short-circuiting of sediment-laden water from inlet to outlet and reducing dead spaces within the basin during the design storm event. The flow path length, L, is the distance from the point of inflow to the riser outflow point. Required minimum surface area, A, is based on particle size and incoming flow as discussed later. A minimum L:W = L^2/A of 4:1 is required with L and A measured at the top of the "dry" storage zone or principal spillway crest, including forebay, as shown in the above figure.

Size, including both surface area and volume, is very important to overall trapping efficiency. Sediment trapping efficiency is primarily a function of sediment particle size and the ratio of basin surface area to inflow rate. Basins with a large surface area-to-volume ratio are most effective in trapping sediment. Generally, the smaller the sediment particle size, the lower the settling velocity, and the larger the required basin surface area. Additionally, the larger the storm water flow into the basin, the larger the required basin surface area.

One commonly-used formula for sizing basin surface area, based on particle settling as water flows through a basin, is $A_s = 1.2Q/V_s$

where A_s = Basin surface area in square feet; Q = incoming design storm event flow (cubic feet per second) often assumed to be the average storm water flow; and V_s = settling velocity (feet per second) of the smallest practical particle size to be trapped.

The Tennessee Handbook specifies the use of an empirical formula for sizing basin surface area: $A_s = 0.01Q_p$ (Barfield and Clar - 1986)

where A_s = Basin surface area in acres and Q_p = incoming peak discharge (cubic feet per second) for sediment basin design.

Both formulae produce surface area loading rates that would result in sediment removal rate efficiencies up to about 70 to 80% for assumed medium silt and larger particles. Application of the required latter formula provides about 75% trapping efficiency for silt loams and higher efficiencies for coarser particles. Additional treatment measures such as use of baffles and chemical flocculants (see below) may be needed for trapping high fractional fine silts and clay particles. In every situation, primary emphasis should be on using and maintaining effective practices that prevent erosion of fine sediment particles at their source.

Total basin volume consists of wet and dry sediment treatment storage, hydrologic control storage for incoming design storms, and freeboard to prevent overtopping. Minimum treatment storage volume is required in temporary sediment basin design to provide adequate settling zone space to both capture and retain sediment in the bottom of the pond between cleanings, to satisfy the permit requirements for incoming discharge loading from the construction site drainage area during the specified design storm event, and to produce minimum permanent pond pool depths of 2 or 3 feet to prevent resuspension of bottom sediment. Sediment Pond volumes are discussed below.

<u>Sediment Pond Volume Criteria</u>

The total capacity of the sediment basin includes the (1) lower sediment treatment and storage zones and (2) upper stormwater inflow containment zones. The sediment treatment and storage zones contain “wet” and “dry” storage compartments. The bottom half of the wet compartment is reserved as a chamber for retaining sediment between cleanings. The upper dry compartment includes the forebay cell, which can be credited to 25% of the total dry storage volume. The dry storage compartment, including forebay cell, is required to be dewatered down to the bottom of the dry zone over a period of 72 hours following the end of stormwater inflow to the basin. The bottom of the dry zone, establishes the permanent pool level. The wet zone below the permanent pool allows sediment-laden water to remain in the pond long after the storm is over and after dewatering to allow continued settlement of very fine particles. The overflow crest of the forebay berm is set at the top of the dry zone, the same elevation as the principal spillway crest, as shown in the above figure. The base of the forebay berm is set at the permanent pool level, so that the forebay can dewater between storms thus allowing for easier sediment removal.

Two options for determining total sediment treatment volume are as follows:

a. General sediment loading rate for establishing <u>minimum</u> sediment treatment storage :

1. Total sediment treatment volume for establishing the crest elevation of the principal spillway riser is 3618 cubic feet (134 cubic yards) x total acres drained. This volume criteria represents the total dry and wet storage and is based on the assumption of 1-inch of eroded sediment per acre (refer to figure above):

2. The upper half of the total sediment storage is 1809 cubic feet (67 cubic yards) x total acres drained represents the dry storage compartment of the total treatment volume.

3. The lower half of the total sediment storage is1809 cubic feet wet sediment volume for establishing the permanent pool elevation (PPE) is 1809 cubic feet (67 cubic yards) x total acres drained

4. Total sediment retention volume component of wet storage for establishing the bottom clean-out elevation (COE) of the pond is 905 cubic feet (34 cubic yards) x total acres drained.

5. The emergency spillway crest elevation is determined after routing the 2-year (or 5-year for Impaired or ETW), 24-hour flood through the principal spillway and adding a minimum freeboard as discussed in the Spillways Question #3 below.

6. Dam crest elevation is established by routing the 25-year, 24-hour flood through the pond and adding minimum freeboard requirements discussed in the Spillways Question #4 below.

b. Calculated sediment loading estimate (<u>may be used if greater than the above General minimum loading rate method</u>):

1. Total sediment volume for establishing the crest elevation of the principal spillway riser, is determined by calculating sediment yield from construction site based on Universal Soil Loss Equation factors such as size of total contributing disturbed and undisturbed drainage areas, soil type and erodibility factor, topographic factors of land slope and slope length, applicable cover factors and practice methods, and sediment delivery.

2. The principal spillway, emergency spillway, and dam crest elevations are established by routing the appropriate 24-hour floods through the pond as discussed above and in the Spillways Question #4 below.

<u>Equivalent Control Measures</u>

Where the total drainage area is 10 acres or more, but temporary sediment basins are not practical, equivalent control measures may be substituted for a sediment basin. TDEC will review each equivalency case based on the justified merits determined from submitted SWPPP calculations and narrative

4. What are the principal and emergency spillway capacity requirements?

a. Principal Spillway

Once the principal spillway crest elevation has been established from the sediment calculations, the combined capacity of the principal spillway riser and pipe through the dam should be designed for one of the following applicable conditions:

For discharges into unimpaired waters the 2-year, 24-hour, storm is routed through the pond and spillway

For discharges into ETW and impaired waters, the 5-year, 24-hour, storm is routed through the pond and spillway.

b. Emergency Spillway

Starting with an initial pond elevation at the permanent pool level, the 25-year, 24-hour flow is routed through the pond, giving outflow credit to both the principal and emergency spillway discharges, to determine the maximum flood level. The emergency spillway crest elevation should be set a minimum of 1 foot above the routed 2- year flood level or 5-year flood level, as appropriate. The top of the dam should be set at least 1 foot above the maximum 25-year flood level.

c. Top of Dam (crest)

The dam crest elevation is established by adding a minimum freeboard of 1 foot to the routed 25-year flood level. If no separate emergency spillway is used, the top of the embankment dam must be set at a minimum 3 feet above the crest of the combined principal/emergency spillway, with a minimum freeboard of 2 feet between the 25-year pool level and the top of the dam.

5. How is a sediment basin dewatered?

The water contained in the sediment volume space (dry volume between the principal spillway riser crest and the permanent pool level) should be slowly dewatered to allow most of the finer suspended sediment particles (primarily clay and fine silts) contained in the upper water column to settle out before releasing to a receiving stream. This is best achieved by "skimming" off the upper, cleaner part of the pond water over a relatively long period of time. Proper design, correct installation, and regular inspection and maintenance are vital to effective operation of any dewatering device. Two methods are currently recommended by TDEC for dewatering:

Floating skimmer dewatering device attached to principal spillway.

I. The most effective dewatering device is a floating type of skimmer configured to always draw or skim water through a small orifice opening located just below the water surface until the volume of water between the riser crest and permanent pool is dewatered over the recommended 72-hour period. The orifice in a floating skimmer, protected with a trash screen, is always under constant head and can be properly sized to ensure a constant discharge and accurate dewatering time. A resting pier is constructed beneath the skimmer to establish the permanent pool elevation and to prevent the skimmer from becoming mired in the mud (shown in above basin sketch). Floating skimmer design guidelines and size selection procedures are available from commercial vendors.

II. Another, less effective, dewatering device is a perforated or slotted vertical pipe or tubing attached to the principal spillway riser at the permanent pool elevation and designed to draw down or dewater the volume of water between the riser crest and permanent pool over a recommended period of 72 hours. This device is less effective than a surface skimmer because dewatering takes place over the entire 2 to 3 ft. vertical drawdown column, rather than at the surface. The number, size, and spacing of the perforations need to be determined and specified. A slide gate type of valve or outlet orifice should be used in conjunction with the vertical pipe to achieve accurate drawdown time control.

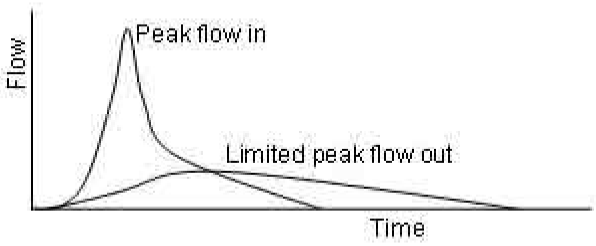
Perforated dewatering device attached to principal spillway.

6. When should a flocculent or coagulant aid be used in a sediment basin?

In site situations involving problematic fine-grained soils such as loess or clays, where conventional erosion prevention and sediment control methods either do not, or are not expected to, satisfactorily achieve the water quality performance criteria of having construction site discharge suspended sediment into receiving streams without an “objectionable color contrast,” design professionals should consider the use of chemical flocculants to enhance the treatment efficiency of a sediment basin. In fact, contingency plans for using chemical flocculants should be built into the SWPPP in case conventional settling treatment is not adequate and TDEC deems its use necessary. One common and effective flocculant, polyacrylamide (PAM), is sometimes used for increasing the sediment-removal efficiency of a sediment basin. The dosage rate, introduction point, and method of PAM application are critical to its safe and overall performance for clarifying muddy water. Improper introduction of PAM may result in waste, poor performance, or undesirable environmental effects. Design professionals should carefully develop a plan and protocol for introducing flocculants and appropriate dosage by consulting closely with PAM vendors and TDEC officials before implementing its use. Readers also should refer to Sections 7.31(Sediment Basins) and 7.40 (Flocculants) in the Tennessee Handbook on the use of flocculants.

7. Does a sediment basin need to control or limit peak stormwater discharge?

Watershed disturbance, whether during construction or post-construction phases, can increase the peak flow of runoff water for all levels of storms before leaving the project site. Local MS4 community, county or city stormwater or development regulations commonly limit the peak flows from project sites to the peak flows that existed prior to site disturbance (i.e., pre-construction) conditions for specified level(s) of storm events. For example, a local government stormwater regulation may specify that the peak flow from a project site shall not exceed the pre-construction peak flow for one or more storm frequency events such as the 2-, 5-, 10-, 25-, 50-, and/or 100-year return period storm event(s). While there is no direct Tennessee statute governing stormwater control requirements, settled case law and requirements established through TDEC’s



administration of EPA's Phase II, MS4 rule for stormwater runoff quality and quantity management, recognize the need for restraint and control. Where there are no local regulations or where the MS4 rule does not apply, the general practice standard is to limit the post-construction peak flow to the pre-construction or pre-disturbance peak flow for a 10-year storm event. There are many methods and Best Management Practices (BMPs) for controlling peak flow releases from project developments. One common and recognized method for limiting peak flow(s) during the construction phase to pre-construction peak(s) is through weir- and/or orifice-controlled, slow discharge release from constructed ponds for specified or assumed storm event(s). A temporary sediment basin provides a convenient opportunity to serve a dual purpose of controlling peak discharge(s) while trapping suspended sediment. Modification or adaptation of temporary basins into permanent stormwater detention or retention ponds may extend their use beyond the construction phase into the "post-construction" phase. For detailed information on converting temporary sediment basins to permanent stormwater ponds, the reader is referred to a paper, Converting Temporary Sediment Basins to Permanent Stormwater Detention Ponds in Tennessee, available through linkage in this website http://tnepsc.org/ >> Information >>Resources.

Therefore, developers and their design professionals should be familiar with all local government regulations and best management practice (BMPs) requirements concerning stormwater releases from project developments both during the construction and post-construction phases. The March 2003 TDEC Guide to the Selection & Design of Stormwater Best Management Practices (BMPs) is a manual that discusses the requirements for controlling post-construction stormwater discharge and is available on-line through the Tennessee Water Resources Research Center website: http://eerc.ra.utk.edu/divisions/wrrc/BMP/bmp.htm

8. Why shouldn't an opening be placed at or near the bottom of a sediment pond?

An opening placed at the bottom of a sediment pond such as in a principal spillway riser or pipe through a dam would eventually force the pond to empty, along with most of the fine sediment particles concentrated near the bottom of the pond, during and after the storm. The purpose of retaining a permanent pool of water is to establish a wet storage to allow sediment particles to settle out and remain in the pond after a storm is over and not become resuspended during a subsequent storm, while skimming off or dewatering the upper layer of relatively clear water near the pond surface. A riser with a bottom opening, surrounded by rock and or geotextile, is not effective in removing fine sediment particles.

9. What other considerations should be given in planning, designing and operating a sediment basin?

Other important requirements beyond the scope of the above engineering and design principles should be considered in providing an effective and safe temporary sediment basin. These considerations include dam safety requirements (i.e., Tennessee Safe Dams Program requirements at http://www.tn.gov/environment/permits/safedam.shtml), mosquito prevention & control; neighborhood safety; as-built inspections for Quality Assurance of intended installation, functionality & performance of structures; timely cleaning & maintenance; sediment disposal plan; environmental & other consequences of basin failure; construction phase stormwater peak and volume reduction; and consideration of future basin use (i.e., conversion to a post-construction storm water detention pond or decommissioning altogether). The reader should refer to specific MS4 and local requirements and to useful references and resources located under the Information link of this website, including TDEC Construction General Permit (CGP) and other regulatory requirements, the Tennessee Erosion & Sediment Control Handbook (Section 7.31 on Sediment Basins), and the Level 1 training course handbook on Fundamentals of Erosion Prevention & Sediment Control Inspections.