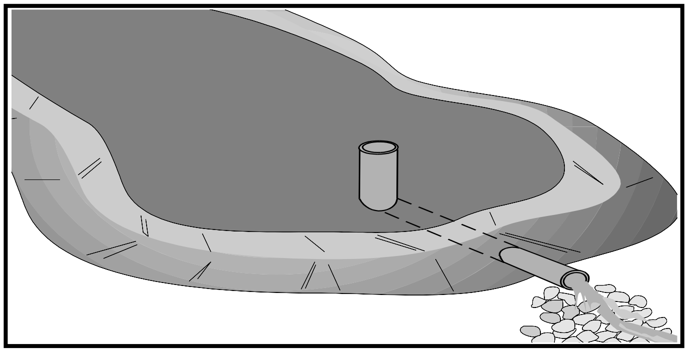
ACTIVITY: Sediment Basin	ES – 19



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

● Sediment	○ Heavy Metals	◗ Floatable Materials	○ Oxygen Demanding Substances	
◗ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	◗ Construction Wastes

Description

A sediment basin is an impoundment for the purpose of detaining runoff to allow excessive sediment to settle. A temporary sediment basin can be an impoundment (using natural divides and favorable topography where possible) to remove sediment during a construction project or other land-disturbing activity. A detention basin can also be refitted to temporarily perform as a sediment basin for handling large amounts of silt and eroded soil if good practices such as frequent inspection and maintenance are performed. A sediment basin will significantly reduce sediment.

Suitable Applications

- At the outlet of any disturbed area with major grading, particularly for disturbed watersheds that are larger than 5 acres.
- At locations with very steep slopes, sloughing or severely eroded soils, or industrial activities that generate sediment and soil particles.

Approach

A sediment basin is a carefully constructed impoundment with a controlled stormwater release structure and is usually formed by combination of excavation and embankment to have balanced cut/fill volumes. Sediment basins are more effective in retaining eroded soil and silt than temporary sediment traps (see ES-18); the principal feature distinguishing a sediment basin from a temporary sediment trap is the presence of a pipe, riser, or other outlet structure. A temporary sediment basin shall generally have a maximum lifespan of 2 years, unless designed as a permanent structure by a professional engineer.

Sediment basins may be designed as temporary or permanent structures, depending on the nature of the sediment-generating activity. This BMP is intended to principally cover temporary sediment basins. Permanent sediment basins must be designed to handle much larger flows, typically 25-year to 100-year storm events, with a designed emergency spillway, keyed construction with impermeable soils, anti-seep collars, etc. Permanent sediment basins are generally constructed with much larger sediment volumes in order to reduce the cleanout frequency and maintenance.

Sediment basins must be located and designed so that failure of structure would not result in danger to human life, damage to personal property, inundation of public streets or highways, interruption of public services or utilities, or inconvenience to the general public. Place sediment basins at locations that will require minimal clearing and grading. Natural draws or swales are usually favorable places to build a sediment basin. Sediment basins should be easily accessible for frequent maintenance and inspection, but not located in the middle of major construction areas.

A sediment basin requires frequent maintenance and inspection until the site is permanently protected against erosion. Less maintenance and fewer cleanouts will be required if adequate erosion and sediment control devices are placed upstream. Undisturbed areas should generally be routed around sediment basins early during the construction process. This can be achieved by temporary diversions or by permanent channels. This allows "clean" stormwater runoff to remain clean. In addition to keeping offsite stormwater clean, the total stormwater runoff volume to the sediment basin is reduced. This allows silt and clay particles to have less stormwater runoff depth to travel through as they settle, and they are also less likely to be resuspended.

The City of Knoxville requires stormwater detention for most development and redevelopment projects. Since stormwater detention volumes are generally larger than the sediment-detaining volumes, a detention basin can usually function as a temporary sediment basin with relatively few modifications. However, a permanent detention basin must be designed by a professional engineer using stormwater calculations as described in ST-01 and ST-02.

Dam Requirements

Embankments which impound more than 30 acre-feet of volume (and minimum 6 feet high) or which are higher than 20 feet (and minimum 15 acre-feet of volume) are subject to the Tennessee Safe Dams Act of 1973 and any further amendments by law. The impounded volume of a dam is measured at the top of embankment. The height of a dam is measured from the lowest point of natural grade (at downstream toe of embankment) to the top of embankment.

The Safe Dams Act is administered by the TDEC Division of Water Supply; further information on design standards, regulations, and permit applications is available at the TDEC website:

http://www.state.tn.us/environment/permits/safedam.htm

A regulated dam is required to have a principal spillway with trash rack, an emergency spillway, a means of dewatering, minimum top width for embankment, compaction requirements, spillway design and analysis for large storms, a seepage control system designed by seepage analysis, permanent benchmark, etc.

Volume

- Minimum volume of a sediment basin shall be 67 cubic yards per acre for the total drainage area, measured below the top of principal spillway or riser.
- Optimal design volume of sediment basin depends on type of soil, size and slope of drainage area, amount of land disturbance, desired sediment removal efficiency, and desired cleanout frequency. A recommended volume for temporary sediment basins in heavily disturbed areas is 134 cubic yards per acre, which equates to 1 inch of stormwater runoff per acre. Optimal design of this type of sediment basin includes an upper zone of at least 67 cubic yards per acre (to be dewatered using one of the outlet design alternatives) and a lower wet zone for sediment storage and settling.
- Volume of a sediment basin should generally be computed from existing and proposed contour lines, or by using measured cross sections. A very rough method for approximating volume for a sediment basin within a natural draw or swale is:

$$V = 0.4 \times A \times D$$

V = storage volume (below the invert of the emergency spillway)

A = surface area (at the level of the emergency spillway invert)

D = maximum depth (as measured from the emergency spillway invert)

- The recommended minimum surface area for an effective sediment removal of 75% for most soils is provided by the following formula. Please note that this efficiency is for smaller rainfall events, typically less than 1 inch, which allow sediment to settle out without too much turbulence or mixing.

  $A = 0.01 \times Q_2$

  A = surface area at the level of the emergency spillway invert (in acres)

  Q_2 = peak inflow rate for a 2-year, 24-hour storm (in cfs)

- The recommended cleanout volume is 1/4 to 1/3 of the total storage volume of a sediment basin. The nominal volume for sediment removal is therefore 17 cubic yards per acre (which is 1/4 x 67 cubic yards per acre). The recommended sediment depth for the cleanout volume shall be computed. A stake or post may be installed and marked to assist in identifying the need for sediment cleanout.

Other Physical Parameters

Maximum slopes shall be 2:1 (H:V) for excavated areas and for compacted embankments. Most side slopes should be to 3:1 (H:V) or flatter, which will allow people and equipment to safely negotiate slopes or to enter the sediment basin for maintenance or repair purposes. See Figure ES-19-1 for a typical sediment basin layout.

- Top width of embankment shall be at least as wide as the actual height of sediment basin embankment, with a minimum width of 5 feet. If the top of embankment is required for vehicle access to other areas, then the minimum width is 12 feet.
- An anchor trench or key, consisting of compacted impervious soil, should be constructed along the center of the embankment to prevent seepage and potential slipping. Minimum dimensions are 2 feet deep and 2 feet wide. The subgrade soils should be compacted and proofrolled prior to installing the anchor trench.
- Stormwater travel distances should be maximized across the sediment basin. The length to width ratio must be greater than 2:1 (L:W) for the principal flowpaths in order to maximize residence time of stormwater within the sediment basin. Baffles may be required to prevent short-circuiting of flow.
- A typical baffle design is to use 4’ x 8’ sheets of exterior grade plywood ½ inch thick, mounted on 4” x 4” hard wood posts. Posts shall be firmly set at least 2 feet into solid ground with maximum spacing of 8 feet. Posts and plywood shall not be lower than 6 inches below the top of embankment elevation. Other materials may be preferable in areas which are frequently submerged for long periods.

Principal Outlet

The principal outlet or spillway should be sized to adequately convey stormwater runoff from the 2-year, 24-hour storm. The principal outlet should have a trash rack to prevent debris from clogging the structure. It is recommended that smaller orifices, less than 4 inches diameter, should also have some sort of wire cage structure to prevent clogging from trash or debris.

A pipe and riser outlet combination, shown in Figure ES-19-2, is typically used as the principal outlet for a temporary sediment basin. Typical materials for the pipe culvert are corrugated metal pipe (CMP) and reinforced concrete pipe (RCP). The circular riser is typically made from CMP or from precast manhole sections. A rectangular structure will serve the same purpose as a circular riser, and is often made from precast units, pour-in-place concrete, or even cement block construction.

CMP is often used because it is an inexpensive material, sturdy, easy to transport, and can be handled in manageable lengths. The most commonly available CMP is helically (spirally) corrugated throughout its length, with rerolled ends to allow metal coupling bands for watertight pipe connections. CMP material should be structurally sound and of sufficient gauge to resist traffic loadings.

The pipe culvert should be designed to handle the 2-year, 24-hour storm without using the emergency spillway. The minimum pipe size should be 12 inches diameter, and the minimum riser size should be at 1.5 times the pipe diameter. At least one anti-seep collar should be provided around the outlet pipe, to prevent seepage through the embankment. Metal collars are inexpensive and easy to install for corrugated metal pipe. The anti-seep collar should extend 18 inches beyond the pipe in all directions. See ST-01, Dry Detention Basin, for a typical anti-seep collar detail.

A riser may have the tendency to float if the orifices become clogged at some point. An anti-flotation concrete block shall be securely fastened to the riser by placing two #6 reinforcing bars through the riser, at right angles to each other, and then embedded within the concrete block. The block size should be sufficient to resist the buoyancy of an empty riser with a 1.25 factor of safety. For instance,

An outlet has a 24” diameter CMP riser which is 6.0 feet tall.
Use a square concrete block 18 inches thick; weight of concrete = 150 lb / ft^3
Ignore the weight of the CMP riser.

Then,

Force of buoyancy = π x (1.0 ft)^2 x 6.0 ft x 62.4 lb / ft^3 = 1176 pounds
Area of block = (1176 pounds x 1.25) / (1.5 ft x (150 – 62.4 lb / ft^3)) = 11.19 ft^2
Side of square block = 3.34 ft = 40 inches

Emergency Spillway

An emergency spillway is typically an overflow weir, preferably at the edge of the embankment and constructed in cut material (native soil) rather than fill material. The overflow weir must be stabilized with rock, geotextile, vegetation or another suitable material which is resistant to erosion. The spillway should have a designed control section which is level and straight, typically with a weir coefficient of 2.6 to 2.7 for a broad-crested weir when using riprap. The outlet channel of the emergency spillway should also be protected from erosion.

A stable emergency spillway must be installed to safely convey stormwater runoff for the 10-year storm event with a minimum freeboard of 1 foot for temporary sediment basins (with a lifespan of less than 2 years). The emergency spillway elevation should be at least 1 foot above the top of the principal outlet (riser) and must be at least 1.5 feet below the top of the embankment. See the detail shown in Figure ES-19-2.

Dewatering Methods

The temporary sediment basin can be dewatered by several means, as long as the dewatering outflows are small to allow suspended soils to settle. The dewatering mechanism can either draw water from the top of the storage pool (such as a floating skimmer) or can filter water from any portion of the storage pool. Examples of both methods are shown in Figure ES-19-3 as possible considerations in modifying a permanent detention basin for use as a temporary sediment basin.

The sediment basin should generally have a minimum draindown time of at least 1 day for settling. The maximum draindown time should be less than 3 days in order to recover the runoff storage volume. A factor that can affect the selection of dewatering method is whether a temporary sediment basin will be converted into a permanent detention basin.

The most common method is to perforate a CMP riser with small holes typically ½ inch diameter and then cover with a layer of rock or aggregate to filter out sediment. Aggregate size should be approximately ¾ to 1 inch (such as TDOT #5) to prevent stones from entering holes. This method of dewatering a temporary sediment basin may also be applicable for a permanent detention basin if design procedures in ST-01 and ST-02 are used.

An alternate method to dewater a basin with a CMP riser or a concrete outlet structure is to wrap geotextile filter fabric around the riser. Chain-link fencing should be used on the inside of the fabric, in order to allow water to flow through the filter fabric. Chain-link fencing can also be used to wrap around the outside of the filter fabric, to protect it from floating debris. The geotextile fabric and chain-link fencing should be fastened securely to the structure to prevent movement.

A floating skimmer can be constructed of any type of lightweight pipe, such as PVC or flexible polyethylene pipe, that can be made to float by attaching buoyant materials. The floating skimmer is connected to an orifice in the side of the outlet structure in order to provide elevation drop within the lightweight pipe. This type of skimmer is hard to design because the rate of dewatering is dependent on the type and number of perforations in addition to how deep the lightweight pipe would float on the surface.

Installation Guidelines

Temporary sediment basins are usually installed at the beginning of a construction project, immediately after perimeter erosion control measures have been performed. Most of the grading, earthwork, trenching and other land-disturbing activities usually take place early in the construction process, but in some cases, it may beneficial to phase grading activities to reduce sediment loads.

Step 1: Place perimeter erosion control measures around sediment basin location. Clear and grub, particularly underneath embankments. Grade and/or excavate to construct the required volume and to provide fill material for any embankments.

Step 2: Construct any embankments needed by using fill material made of clay, which is free of roots, large rocks, and organic material. Place fill in layers 6 inches thick and compact well by traversing with a dozer or other equipment. Embankments in critical areas should be compacted to at least 95% of standard maximum density.

Step 3: Install outlet structures, such as a pipe and riser system or an emergency overflow weir, as the embankment is being constructed. Install geotextile fabric and wire fencing at potential locations of stone outlet failure. Install baffles if necessary to maximize stormwater residence time within the sediment basin.

Step 4: Stabilize slopes using temporary vegetation, erosion control matting, straw mulch or other measures. Inspect final work for safety and function. Mark or otherwise locate sediment cleanout elevations and thicknesses. Install warning signs, barricades, perimeter fence or other measures necessary to protect construction workers and equipment.

Maintenance

- Inspect sediment basins weekly and after each rainfall event for excessive sediment buildup, undercutting flows or seepage, slope failure, settlement and structural soundness. Regularly inspect water quality being discharged for suspended sediment and color. Identify and perform necessary repairs to improve water quality. Check downstream channel for erosion or sedimentation.
- Remove accumulated sediment whenever it reaches the designated cleanout level from one-fourth to one-third of the total sediment volume. The nominal volume of sediment (1/4 x 67 cubic yards = 17 cubic yards per acre) usually requires heavy equipment and good weather for sediment cleanout. Shovel by hand adjacent to outlet control structures to prevent equipment damage in this area. Dispose accumulated sediment at protected location onsite to prevent resuspension of sediment.

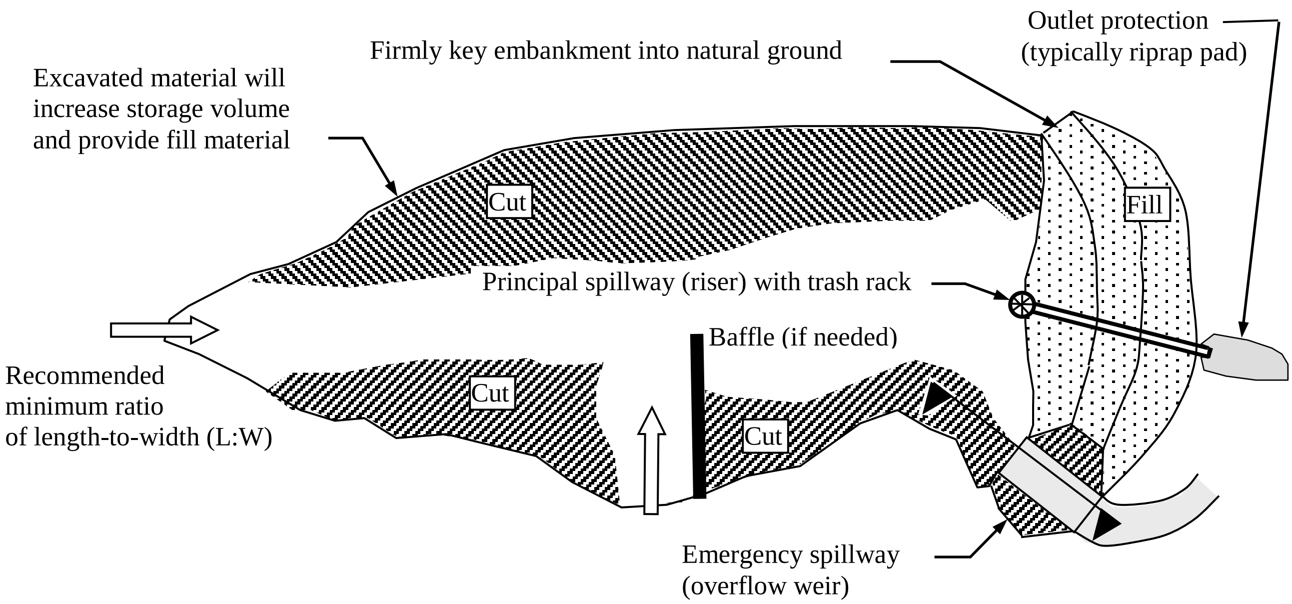
Limitations

- Sediment basins shall not be located in live or continuously-flowing streams. Sediment basins may kill nearby vegetation by excessive sediment or by long periods of submergence.
- Sediment basins may not be effective for fine-grained soils such as silt or clay. Additional upstream erosion control measures are necessary.
- Sediment basins can be attractive and dangerous to children. Large deposits of sediment can act as "quicksand" to young children who may not have the strength to exit. Protective fencing or other access control measures for the project site are highly recommended. Sediment basins with steep slopes may be difficult for someone to exit.

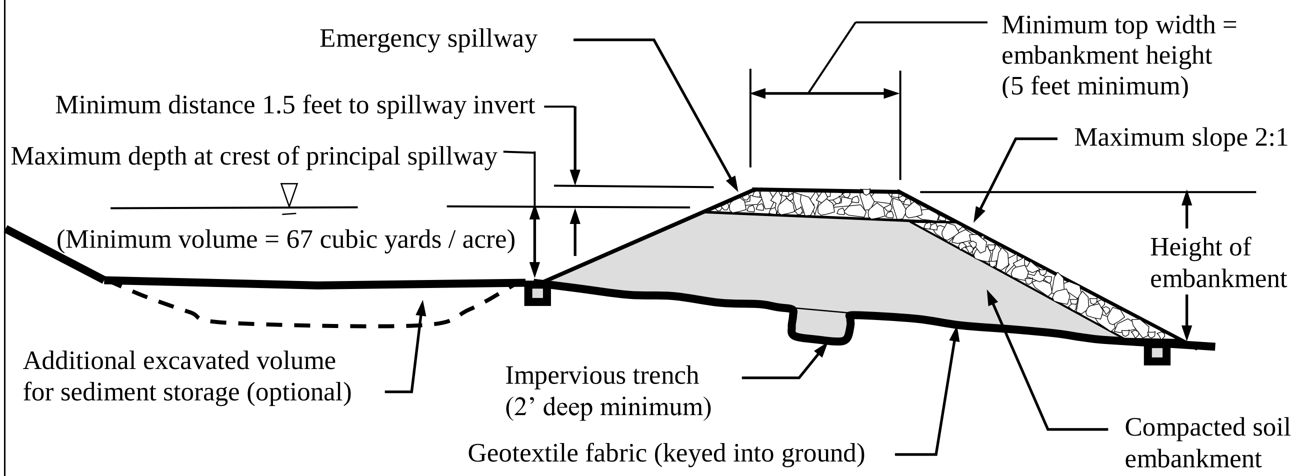
References

8, 9, 30, 31, 32, 33, 34, 35, 43, 114, 135, 136, 141, 144, 162, 167, 179

(see BMP Manual Chapter 10 for list)



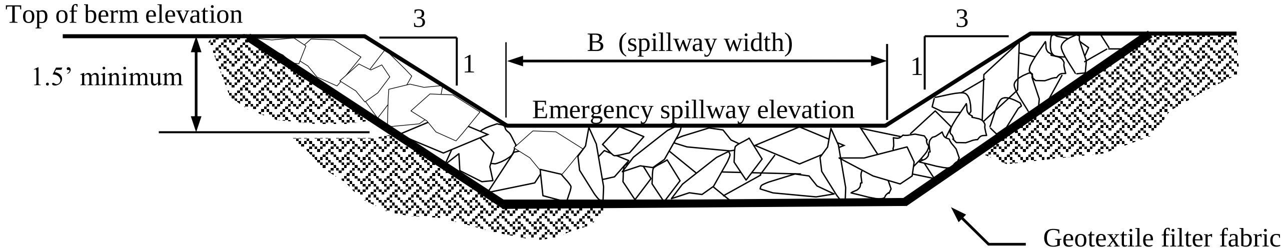
TYPICAL PLAN VIEW



TYPICAL CROSS SECTION

NOT TO SCALE

Figure ES-19-1
Typical Sediment Basin

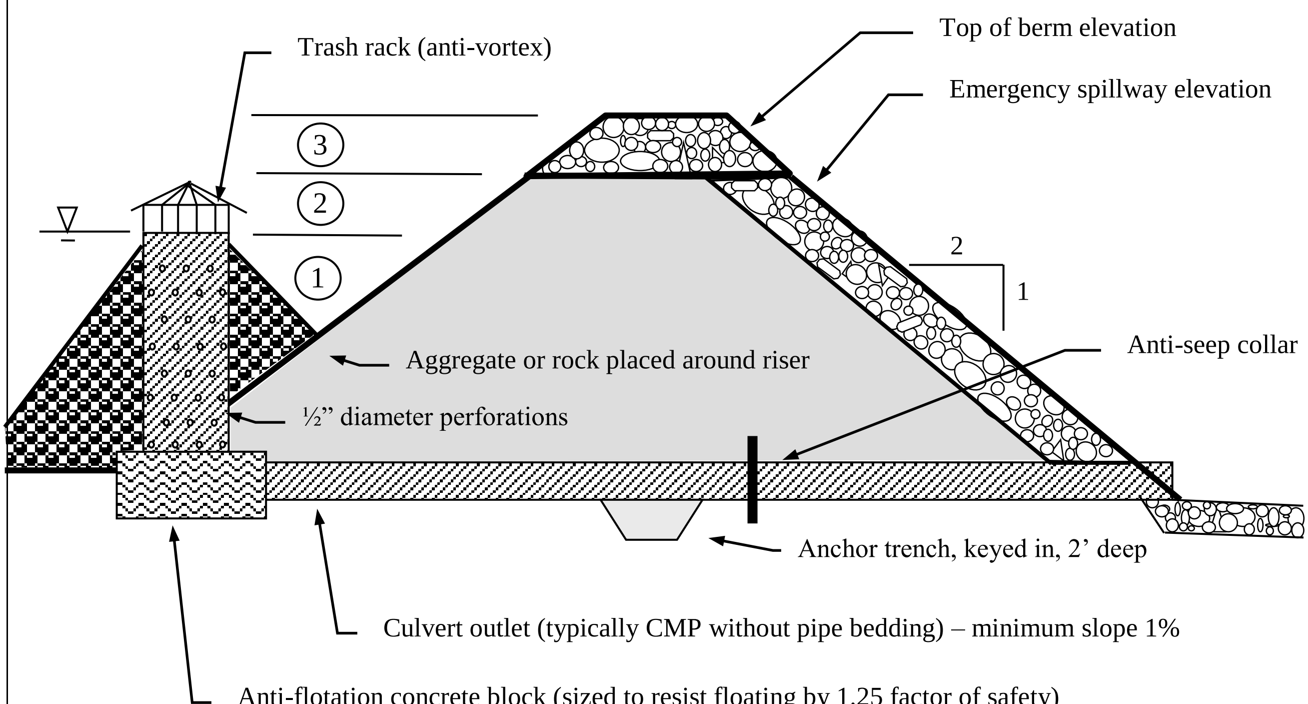


EMERGENCY SPILLWAY

(3) Minimum 1.5' from emergency spillway invert to top of berm (and minimum 1.0' freeboard for 10-year storm)

(2) Minimum 1.0 feet from top of riser to emergency spillway elevation

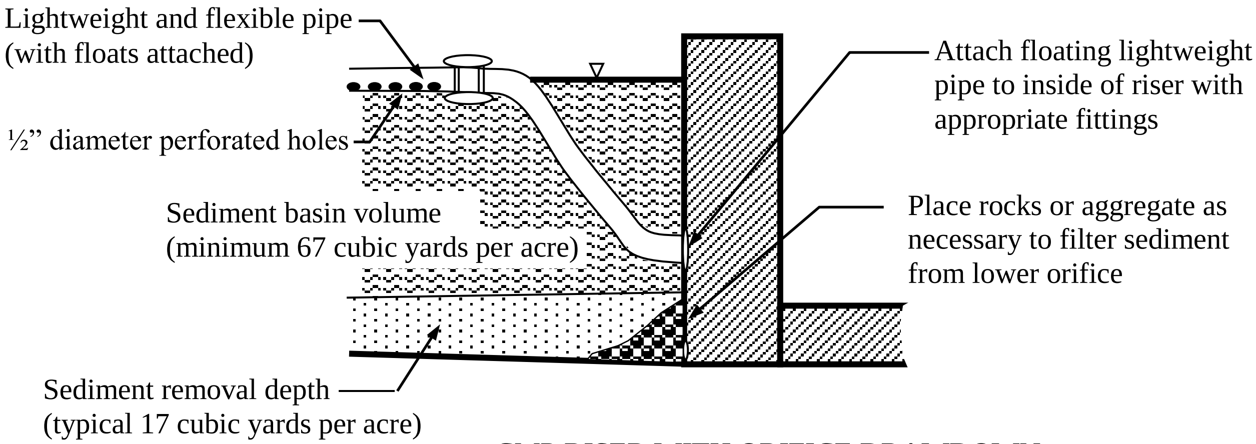
(1) Trying to maximize surface area (therefore trying to minimize depth), minimum volume = 67 cubic yards per acre



PRINCIPAL SPILLWAY (RISER AND PIPE)

NOT TO SCALE

Figure ES-19-2
Temporary Sediment Basin – Riser and Pipe Outlet

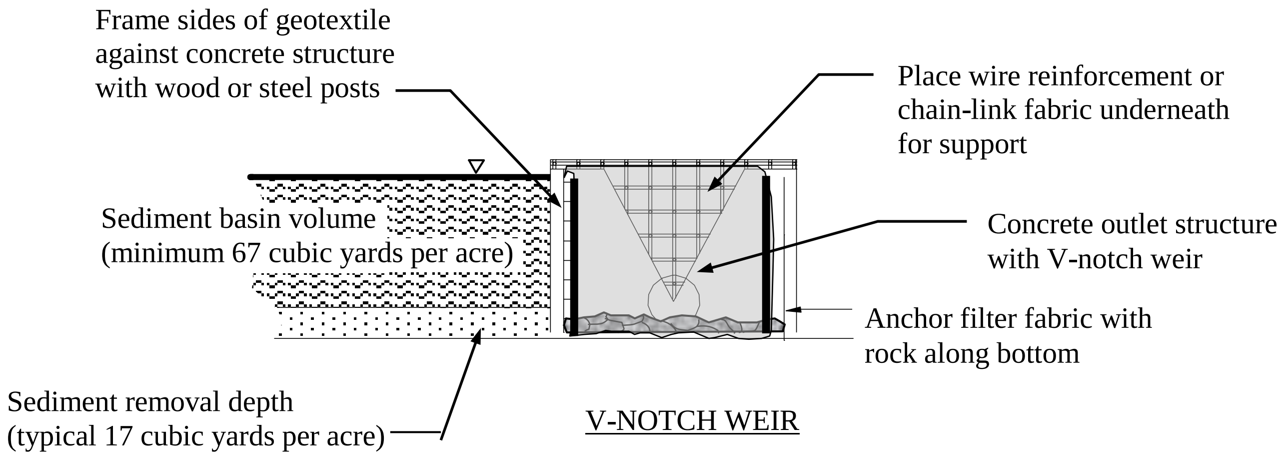


CMP RISER WITH ORIFICE DRAWDOWN

Notes:

1. The two details on this sheet suggest ways of modifying a permanent detention basin to serve as a temporary sediment basin. The basic methods shown here demonstrate a floating skimmer and geotextile filtration.

2. A permanent detention basin must always be designed by a professional engineer using hydrologic computations and different criteria than presented in this BMP. See ST-01 and ST-02 for detention basin design.



V-NOTCH WEIR

NOT TO SCALE

Figure ES-19-3
Possible Alterations to Permanent Detention Basin Outlet Structures