Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-01

Activity: Check Dams

PLANNING CONSIDERATIONS:

Design Life:
6 mo – 1 year

Acreage Needed:
Minimal

Estimated Unit Cost:
Approx:
$100/dam

Monthly Maintenance:
60% of Installation

CD

Target Pollutants

Significant ♦ Partial ◈ Low or Unknown ♢

Sediment ♦ Heavy Metals ♢ Nutrients ♢ Oxygen Demanding Substances ♢ Toxic Materials ♢
Oil& Grease ♢ Bacteria & Viruses ♢ Floatable Materials ♢ Construction Waste ♢

Description

To reduce the velocity of concentrated stormwater flows, small temporary constructions such as dams are built across swale or drainage ditch. This construction reduces erosion and promotion of sedimentation behind the dam.

Suitable Applications

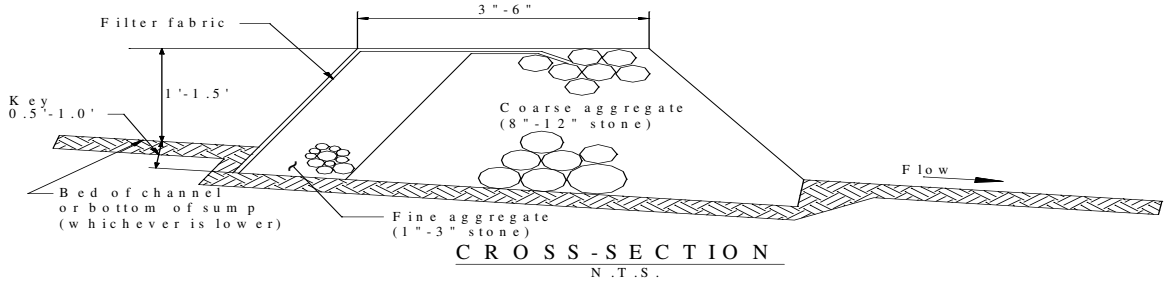
Reduction of velocity flow in small intermittent channels and swales.
Weekly collection of sediment materials to avoid scour and re-suspension.
Used in conjunction with filter fabric on upstream end.
Areas which equal 10 ac (4 ha) or less.
To protect against erosion and reduce stormwater run-off in steep channel areas.
During the establishment of grass lining in drainage ditches or channels
Installation of erosion-resistant lining is not allowed for short length of service for temporary ditches or channels.
Not for use in streams or rivers.

Approach

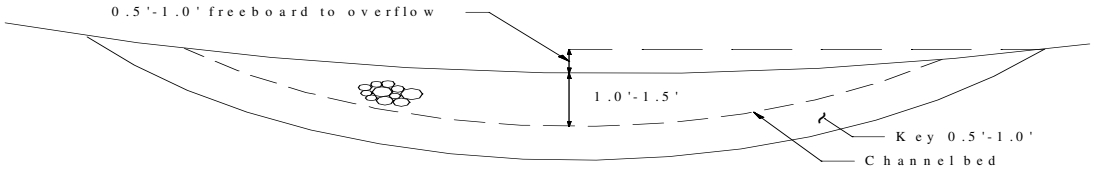
Log check dams
Rock check dams
Sand bags (filled with pea gravel)

Activity: Check Dams

SMP-01



CROSS-SECTION
N.T.S.



ELEVATION
N.T.S.

Installation Procedures

Check dams should be properly constructed to reduce chances of flooding or washout. These dams can be constructed of rock or logs or other sturdy material available on the worksite and should be properly maintained. Material such as straw bales, silt fences or like porous materials should never be used to construct check dams.

Pools 1 to 2 ft deep should be able to form between each check dam.

Rock check dams should be placed by hand or mechanically and should be constructed with 1”-3” rock .

Backwater from a downstream check dam should reach but not exceed the toe of the upstream check dam.

Check dams should be keyed into, or inset into, the swale/channel bottom.

Filter fabric should be placed on the upstream face. Major floods (2-year storm or larger) should safely flow over the check dam without an increase in upstream flooding or destruction of the check dam.

Primarily used in small, steep channels where velocities exceeding 2 ft/s (0.61 m/s) need to be reduced.

A sump may be provided immediately upstream of the check dam to capture sediment.

Check dams may be built of stone or logs, which are secured against damage during significant floods.

Rock shall be individually placed by hand or by mechanical methods (no dumping of rock) to achieve complete ditch or swale coverage.

If grass is planted to stabilize the ditch or swale, the check dam should be removed when the grass has matured (unless the slope of the swale/ditch is greater than 4 percent).

Activity: Check Dams	SMP-01

Maintenance

Inspection of sediment and erosion behind check dam after each rain.

Lift filter fabric and shovel or backhoe silt whenever sediment reaches one-half the sump depth of the dam.

Check area once a week on active sites and every two weeks on in-active sites.

Inspection Checklist

- q Diameters of 1” to 3” (2.5 cm to 7.6 cm) should use crushed stone.
- q Check dam spans the entire width of the channel.
- q Sump is 12” (30.5 cm) deep.
- q Filter fabric on upstream face is keyed into the bed.
- q Check dams can be removed when needed.
- q Sites with rain accumulation of 0.5” should be checked within 24 hours.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-02

Activity: Silt Fence

PLANNING CONSIDERATIONS:

Design Life:
6 months

Acreage Needed:
Minimal

Estimated Unit Cost:
$1 - $8 per LF

Monthly Maintenance:
100% of Installation

SF

Target Pollutants

Significant ♦ Partial ◈ Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◊ Construction Waste ◊

Description

To detain sediment-laden water, silt fences are used to promote deposit behind the fence before it can reach the non-construction site area. These fences are made of filter fabric that has been entrenched, attached to support poles and on occasion supported by a wire fence. This temporary sediment barrier does not stop sediment from entering the water ways, but it does slow it down enough to settle out of the runoff water.

Suitable Applications

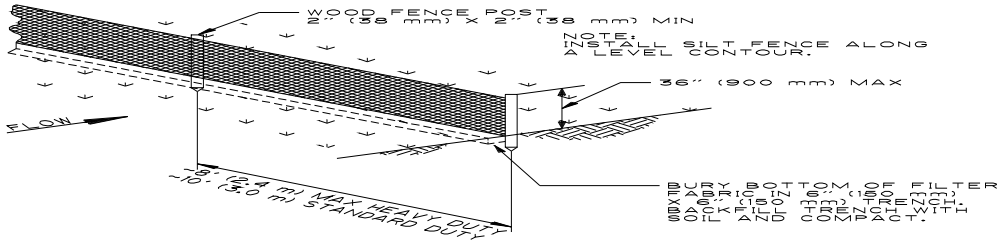
Phase construction should allow silt fencing along the downstream perimeter, below the toe of a cleared slope, upstream of sediment traps or basins, along streams and channels and around temporary spoil areas.
Across swales with catchments less than 1 acre and below other small cleared areas.

Approach

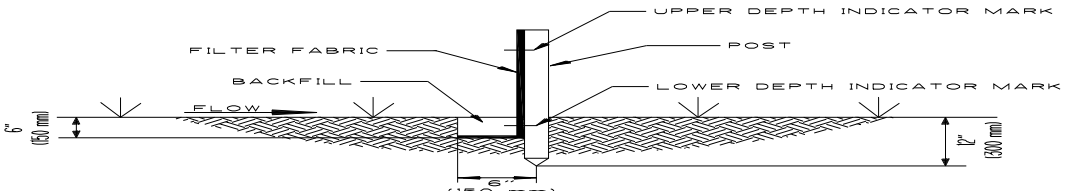
Installed with 0.25 area draining to every 100-feet of silt fence.
Used for downstream perimeter control.
Use in areas where sheet flow occurs.
Areas of level contour to prevent water from ponding more than 1.5 feet at any point.
Maximum slope perpendicular to the fence line should be 1:1.
Select filter fabric which retains 85% of the soil, by weight, based on sieve analysis but is not finer than an equivalent opening size of 70.
Heavy duty prefabricated silt fence should be selected based on slope and time criteria.

Activity: Silt Fence

SMP-02



TYPICAL PREFABRICATED
SILT FENCE INSTALLATION
N.T.S.



SECTION
N.T.S.

Installation Procedures

Silt fences are typically installed with ¼ area draining to every 100-feet (31.4 m) of silt fence. They are designed to function under a 10-year storm event and may be operated for as long as 5 to 8 months. Silt fences are designed to pond water behind them, so it is crucial that they are sufficiently anchored and follow contours. Silt fences that are not entrenched and follow contours can result in worsened erosion.

Silt fences may be used for downstream perimeter control, placed upstream of the point(s) of discharge of sheet flow from a site. They may also be used as interior controls below disturbed areas where runoff may occur in the form of sheet and rill erosion, and perpendicular to minor swales or ditch lines for up to one acre contributing drainage areas. Silt fences are generally ineffective in locations where the flow is concentrated and are only applicable for sheet or overland flows.

Use principally in areas where sheet flow occurs.

Install along a level contour, so water does not pond more than 1.5 feet (0.5 m) at any point.

The maximum slope perpendicular to the fence line should be 1:1.

No more than 0.25 acre (0.1 ha) per 100 ft. (31.4 m), or 0.5 cfs (1.4×10^{-2} m^3/s) of concentrated flow should drain to any point along the silt fence.

Turn ends of fence uphill to prevent scour from wash around.

Provide area behind the fence for runoff to pond and sediment to settle (Approx. 1200 sq. ft. (111.5 m^2) per acre (0.4 ha) draining to the silt fence).

Select filter fabric that retains 85% of the soil, by weight, based on sieve analysis, but is not finer than an equivalent opening size of 70.

Installation Procedures (Continued)

Select standard duty or heavy duty prefabricated silt fence based on criteria shown below:

Standard Duty Silt Fence

Slope of area draining to fence is 4:1 (H:V) or less.
Use is generally limited to less than five months.
Area draining to fence produces low sediment loads.
Use prefabricated standard duty silt fence.

Heavy Duty Silt Fence

Slope of area draining to fence is 1:1 (H:V) or less.
Use generally limited to eight months. Longer periods may require fabric replacement.
Area draining to fence produces moderate sediment loads.
Use prefabricated heavy-duty silt fence. Heavy duty silt fences typically have the following physical characteristics:

(1) Fence fabric has greater tensile strength than other fabric types available from manufacturer.
(2) Fence fabric has a greater permittivity than other fabric types available from manufacturer.
(3) Fence fabric may be reinforced with a backing or additional support to increase fabric strength.
(4) Posts may be spaced closer together than other premanufactured silt fence types available from manufacturer.

Most manufactured silt fencing has a colored band that indicates the depth of trenching required. If the lower colored band is visible then the silt fence is not trenched deep enough.

Install silt fence along a level contour, with the last 6 ft (1.9 m) of fence turned up slope.
Except for the ends, the difference in elevation between the highest and lowest point along the top of the silt fence shall not exceed one-third the fence height.
Posts should be spaced a maximum of 6 feet (1.9 m) apart and driven securely into the ground a minimum of 30 inches (0.8 m).

A trench should be excavated approximately 8 inches (20.3 cm) wide and 12 inches (30.5 cm) deep along the line of posts and upslope from the barrier.
When standard strength filter fabric is used, a wire mesh support fence should be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch (2.5 cm) long, tie wires or hog rings. The wire should extend into the trench a minimum of 4 inches (10.2 cm).

Activity: Silt Fence

Installation Procedures (Continued)

The standard strength filter fabric should be stapled or wired to the fence, and 40 inches (102 cm) of the fabric should extend into the trench. When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated and the filter fabric stapled or wired directly to the posts.

Avoid the use of joints. The filter fabric should be purchased in a continuous roll, then cut to the length of the barrier. When joints are necessary, filter cloth should be spliced together only at a support post, with a minimum 6-inch (15.2-cm) overlap, and both ends securely fastened to the post.

The trench should be backfilled with compacted native material.

Generally, silt fencing should be used in conjunction with erosion source controls up slope to provide effective control.

Maintenance

Inspect after every rainfall.
Repair fence when damaged.
Sediment height not to exceed 1/3 height of the fence.
Perform required maintenance before a storm event.
Remove fence when it is no longer needed and perform required maintenance to restore the site to its normal condition.

Inspection Checklist

- q Silt fence follows a contour.
- q The last 6 feet of the silt fence is turned uphill and secured to the post.
- q Color band of the anchor trench is visible.
- q Accumulated sediment does not exceed 1/3 height of the fence.
- q If washaround or underwash occurs then fence should be reset.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-03

Activity: Straw Bale Barrier

PLANNING CONSIDERATIONS:

Design Life:
6 months

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg: $4/LF
Range: $2-$6/LF

Annual Maintenance:
100% of Installation

SB

Target Pollutants

Significant ♦ Partial ◈ Low or Unknown ♢

Sediment ♦ Heavy Metals ♢ Nutrients ♢ Oxygen Demanding Substances ♢ Toxic Materials ♢
Oil& Grease ♢ Bacteria & Viruses ♢ Floatable Materials ♢ Construction Waste ♢

Description

Straw bale barriers detain for runoff by creating a pond behind the barrier for sedimentation to occur. These barriers consist of straw bales placed end to end along a level contour in a shallow trench and held in place with stakes. This practice does not remove sediment as efficiently as other practices; however, it is likely to have a significant reduction in sediment.

Suitable Applications

Straw bale barriers should be applied along the perimeter of the site, streams and channels. Around temporary spoil areas and other small cleared areas.
Below the toe of exposed and significant erodible slopes and downslope of exposed soil areas.

Approach

Use in areas where sheet or rill flow occurs.
Barrier should drain water of no more than 0.25 acre per 100 feet.

Activity: Straw Bale Barrier

SMP-03

Installation Procedures

Install along a level contour; make sure ends are turned uphill at least 6 feet.

Locate barriers away from the toe of slopes with bales embedded in the soil 4 inches (minimum) and placed so the bindings are horizontal.

Secure each bale with a minimum of two stakes. One placed vertical and the other placed at an angle toward the adjacent bale.

Leave enough space behind the barrier for runoff and sediment settle.

Maintenance

Inspect weekly and after each rainfall.

Fill gaps tightly.

Replace bale needing attention.

Remove sediment when it h as reached ¼ the height of the barrier.

Remove barrier when no longer needed and stabilize the area.

Take proactive measures when rain is forecasted.

Recycle used straw as mulch for temporary or permanent seeding on other sites.

Inspection Checklist

- q Barrier follows a contour.
- q Ends of barrier should turn uphill for the last 6 feet.
- q Posts are secured with every other post angled.
- q Accumulate sediment behind the barrier does not exceed ¼ the height of the bale.
- q Barrier should be removed if wash around or under wash occurs.
- q No washed –out barriers.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-04

Activity: Sand Bag Barrier

PLANNING CONSIDERATIONS:

Design Life:
3-6 months

Acreage Needed:
None

Estimated Unit Cost:
Avg: $8/LF
Range: $6-$10/LF

Monthly Maintenance:
0% of Capital Costs

SB

Target Pollutants

Significant ♦	Partial ◊	Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◊ Construction Waste ◊

Description

Sand barriers provide detainment from sedimentation and runoff by allowing barriers to be formed as a result of the bags being stacked. While stacking these bags does not filter runoff, it does slow it down enough for sediment to settle out of the water. A reduction to sediment is a result of this practice.

Suitable Applications

Sand barriers should be used along the perimeters of the site, at check dams, along streams and channels, across swales, at division dikes, below the toe of a cleared slope, around temporary sediment trap and parallel to roadways

Approach

Utilized when construction of check dams or sumps in a stream is undesirable
Allows undisturbed vegetation and/or stream
Provide semi-permeable barrier in potentially wet areas

Installation Procedures

Berm height should be 18 inches minimum from ground to top of barrier. Width should be 48 inches minimum
Length of the sand bags should be 24 to 30 inches, width 16 to 18 inches, thickness 6 to 8 inches and weight 90 to 125 pound
Bag material must weigh a minimum of 4 ounces per square yard and should be polypropylene, polyethylene or polyamide.
Sand grade should be course or gravel
Sediment trap BMP should determine the area behind the sand bags

Activity: Sand Bag Barrier	SMP-04

Maintenance

Damaged sand bags need to be replaced or reshaped immediately upon inspection after each rainfall or weekly throughout the rainy season.

When sediment reaches 1/3 the height of the barrier, sediment should be removed and disposed.

When barriers are no longer needed, sand bags should be properly disposed.

Barriers should be inspected and maintained regularly.

Inspection Checklist

- q Barrier follows a contour.
- q End of the barriers turn uphill for the last 6 feet.
- q Barriers are cleaned as sediment exceeds 1/3 height of barrier.
- q Barrier 100 feet serves 5 acres or less of exposed area.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-05

Activity: Brush or Rock Filters and Continuous Berms

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
None

Estimated Unit Cost:
Avg:
Range:

Monthly Maintenance:
None

CB

CB

Target Pollutants

Significant ♦	Partial ◊	Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◊ Construction Waste ◊

Description

Filters, brushes and berms are used to dissipate sediment in construction runoff by anchoring rock deposits, roles of fabric and/or brush barriers. These barriers are constructed of rocks ¾ to 5 inches in diameter which make up a berm to be placed along a contour. Brush wrapped in filter cloth and anchored to the toe of the slope creates a brush barrier which acts as another trapping method. Additionally, a continuous role of fabric that captures sand, rock or native soil is an example of one more method to capture sediment. This BMP is used for sediment trapping and velocity reduction that will aid in significantly reducing sediment.

Suitable Applications

Rock filters should be applied near the toe of the slope, along the site perimeter, stream channels, spoil areas, small cleared areas, sediment traps

Rock filters may also be used as check dams and with temporary roads

Installation Procedures

A rock filter consists of open graded rock installed at the toe of a slope, along the perimeter of a developing or disturbed area, and as a check dam across construction roads. Their purpose is to intercept sediment-laden runoff from disturbed areas of the site, allow the runoff to pond, promote sedimentation behind the filter, and slowly release the water as sheet flow.

Rock filters are less costly than other temporary barriers, and are relatively efficient at sediment removal when installed and maintained properly.

Installation Procedures (Continued)

Brush filters trap and filter sediments in a manner similar to other barriers in this handbook (e.g., silt fence, straw bale barrier, rock filter), but have the advantage of being constructed from brush cleared from the site and usually disposed off-site at a cost.

Use principally in areas where sheet or rill flow occurs.

For rock filter, use larger rock and place in a staked, woven wire sheathing if placed where concentrated flows occur.

Rock filters should be placed along a level contour to intercept sheet flow. Allow ample room for ponding, sedimentation, and access by sediment removal equipment between the berm and the toes of slopes.

Flow through the filter should occur as sheet flow into an undisturbed or stabilized area.

Leave area behind berm where runoff can pond and sediment can settle.

Brush shall consist of site-cleared brush.

Stakes: 1.5 in. x 1.5 in. (38 mm x 38 mm) wooden stake, or metal stake with equal holding capabilities.
Rock: open-graded rock, 1- to 3-in. (2.5- to 7.6-cm) stone reinforced with 8- to 12-in. (20.3- to 30.5-cm) stone as illustrated in Figure TCP-16-1 for concentrated flow applications.

Woven wire sheathing: 1-in. (25-mm) diameter, hexagonal mesh, galvanized 20 gauge (used with rock filters in areas of concentrated flow).

Maintenance

Daily Inspection is required when installing in stream beds

After each heavy rainfall inspect berms

Maintain berms to guarantee proper utilization

Inspect for sediment accumulation removing when depth reaches ¼ of berm height or 12 inches

Remove berms upon completion of the project

Inspection Checklist

- q Sufficient space for ponded water.
- q Brush filters are performing.
- q Drainage to structure does not exceed 5 acres.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-06

Activity: Sediment Traps

PLANNING CONSIDERATIONS:

Design Life:
1.5 - 2 years

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg:
$1100/drainage acre

Monthly Maintenance:
20% of Installation

ST

Target Pollutants

Significant ♦	Partial ◊	Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ♦ Construction Waste ◊

Description

Floatable materials and sediment are reduced from runoff as a result of using sediment traps. These traps act in small tributary areas as exhumed detainments that help sediment settle off from the runoff on the construction site.

Suitable Applications

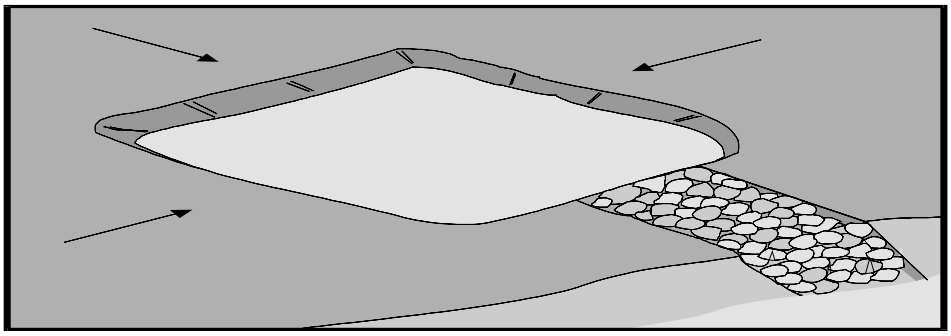
Install detention in areas less than 5 acres having temporary construction issues.
After stabilization of the construction area, re-establishment of the sediment trap should be installed.
Along the perimeter of the site at locations where sediment-laden runoff is discharged off-site or areas where runoff can enter stabilized areas or waterways.

Approach

Prepare sediment traps prior to beginning of construction.
Traps are to be located to areas by hollowing out areas across swales or low embankments, places where damages are excluded and areas needing maintenance to reduce sediment accumulation.
Create larger traps to include a greater amount of sediment buildup.

Activity: Sediment Traps

SMP-06



Installation Procedures

Build outside the area prior to starting grading of the area.

Basin side slopes should be restricted to 4:1 or flatter.

The outline of the trap must be stabilized with rock, geotextile, vegetation, etc. to prevent erosion.

Traps depend on the size of the drainage area, type of soil and the amount of sediment needing to be removed.

Traps should have a minimum volume of 134 square yards/acre and 45 square yards/acre or drainage area.

Inlet location should maximize the travel distance to the trap outlet.

Length to width ratio shall be greater than 3:1.

Baffles to be constructed of 4 in. x 4 in post and 4 ft x 8 ft x 0.5 in exterior plywood.

Post to be 3 ft into the ground and 8 ft apart from the center points, with a height of 6 inches.

Maintenance

Inspect traps weekly and before and after heavy rainfall.

Maintain traps to guarantee correct utilization.

Remove sediment after it reaches 1/3 the height of the trap.

Inspection Checklist

- q Constructed traps serve 5 acres or less.
- q Type of outlet structure used matches EPSC plan.
- q Structure is stabilized to prevent erosion.
- q Gage is visible and correctly indicates the depth of the trap.
- q Sediment accumulation does not exceed height of trap.
- q Trap is constructed in such a way that no damage occurs to life or property.
- q Trap is maintained.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-07

Activity: Temporary Sediment/Detention Basin

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg: $100
Range: $50-$150

Monthly Maintenance:
60% of Installation

TSB

Target Pollutants

Significant ♦	Partial ◊	Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◊ Construction Waste ◊

Description

The purpose of this large temporary sediment/detention basin is to detain large runoff while allowing excessive amounts of sediment to settle out. The abundant area permits a severe reduction in sediment.

Suitable Applications

For disturbed areas 5 acres or larger, basins should be placed at the outlet, or smaller more disturbed areas with potential erosion problems.

Used with devices to divert disturbed areas into the basin.

Used in areas where sediment-laden runoff may enter usable waterways.

Approach

Suitable for almost all construction projects.

Intended to trap sediment before it leaves the construction area.

Installation Procedures

Securely anchor and install anti-seep collar on the outlet pipe/riser for events larger than 2-year storm events.

Basin volume should capture at least a 2 year 24 hour storm.

Activity: Temporary Sediment/Detention Basin	SMP-07

Maintenance

Inspect weekly and before and after rainfalls.

Maintain all aspects of the basin (outlet area, outlet structures, etc.).

Remove sediment when storage is 1/3 full.

Basin failure should not affect loss in life, property, roads, or utilities.

Inspection Checklist

- q Structure has appropriate outlet design.
- q Stabilized outlet prevents erosion.
- q Sediment accumulation does not exceed 1/3 depth of basin.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-08

Activity: Bank Stabilization

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg:
Range:

Monthly Maintenance:
None

BS

Target Pollutants

Significant ♦ Partial ◈ Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◈ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◊ Construction Waste ◊

Description

The reduction of velocity and erosion to a construction site is due to the implementation of this BMP. Bank stabilization prevents or reduces the amount of discharge to a stormwater management system through the use of vegetation, regrading and simple retaining structures.

Suitable Applications

Provides instantaneous protection from surface erosion and other forms of degradation. Forms such as shallow mass wasting, cut and fill slope stabilization, and earth embankment protection.

Approach

Low retaining structures.
Simple timber check dams.
Standard earth retaining structures.

Installation Procedures

Groove or stair step cut grading is recommended for slopes steeper than 3:1 (H:V)
To control erosion vegetation and simple retaining structures should be considered
Retaining structure must meet two minimums: pressure beneath the base must not exceed the allowable soil pressure, structure should possess adequate strength under loaded conditions.
Cribwall structures consisting of vegetative matters are called “live” cribwall.
Cribwall structures should start 2-3 feet below ground elevation at the lowest point of the slope to stabilize the structure.

Activity: Bank Stabilization	SMP-08

Installation Procedures

The first course of reinforcement should start 4-5 feet apart and parallel to the slope contour. This enforcement may consist of concrete beams, logs and timber.

(Continued)

Place next course of reinforcement at right angles on top of the first course of action overhanging the front and back of the first course by 3-6 inches

Other courses of reinforcement will follow the same pattern as the first and second course while being fastened with nails, bars, or bands to the previous course.

Rock Gabions follows the same procedures for foundation stabilization as Cribwall.

The back of the foundation should be exhumed slightly deeper than the front to add stability.

Fabricated wire baskets should be placed at the bottom of the exhumed site prior to rock filling. Rock filling should be between and behind the basket wire.

Continue filling area with wire baskets and rock fill until desired height is reached.

ALL structure construction must be performed by a Licensed Professional Engineer.

Maintenance

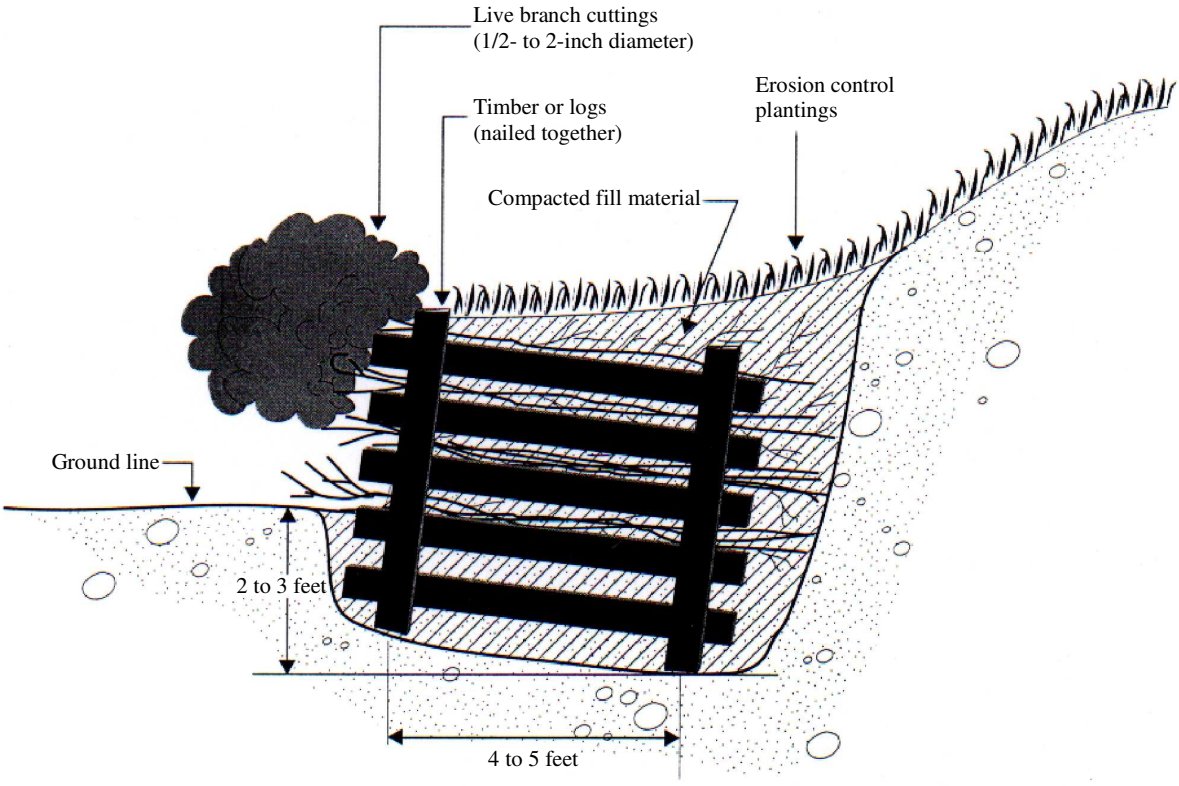
Inspect structure before and after rainfalls.

Make repairs when necessary.

Inspection Checklist

- q Licensed Professional Engineer's stamp is clearly placed on plans in order to construct the appropriate retention structure.
- q Changes to site conditions have been transmitted for review by the Project Engineer.

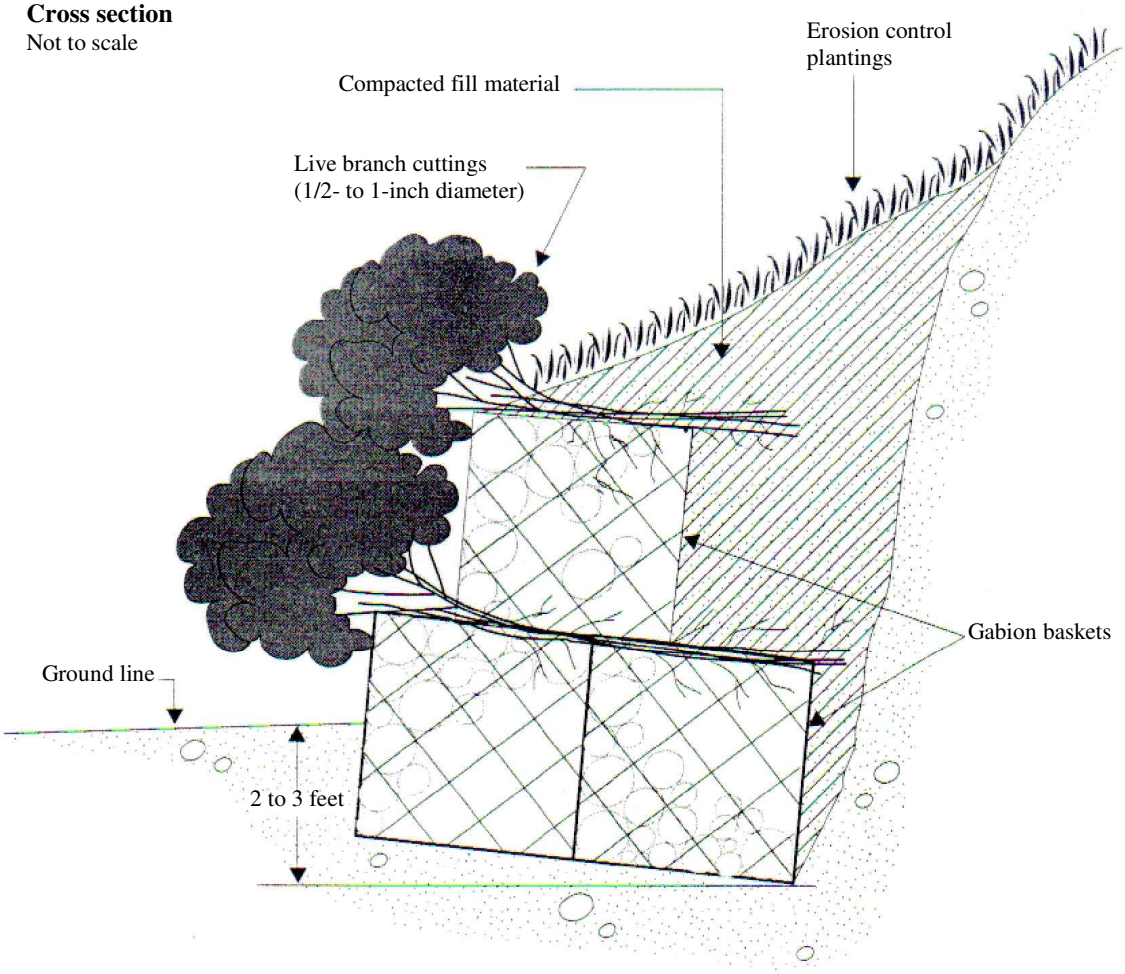
Cross section
Not to scale



Note:
Rooted/leafed condition of the living plant material is not representative of the time of installation.

Figure SMP-08-1
Live Cribwell

Cross section
Not to scale



Note:
Rooted/leafed condition of the living plant material is not representative of the time of installation.

Figure SMP-08-2
Vegetated Rock Gabions

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-09

Activity: Rip-Rap

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
None

Estimated Unit Cost:

Monthly Maintenance:
0% of Capital Costs

RR

RR

Target Pollutants

Significant ♦	Partial ◈	Low or Unknown ◇

Sediment ♦ Heavy Metals ◇ Nutrients ◇ Oxygen Demanding Substances ◇ Toxic Materials ◇
Oil& Grease ◇ Bacteria & Viruses ◇ Floatable Materials ◇ Construction Waste ◇

Description

Used to protect slopes, stream banks, channels, or other areas subject to erosion.

Suitable Applications

Areas subject to wave actions, channels desiring infiltration and around outlets and/or inlets to prevent scour and undercutting are all suitable applications for this BMP

Installation Procedures

Clear the area of all brush, trees, stumps, debris, and trash ensuring that no reduction in the design waterway occurs while preparing the rip-rap subgrade.

When used as slope protection, rip-rap should be keyed into the slope toe by at least the greater of 6 inches (15.2 cm) or one half the designed rip-rap diameter.

Rip-rap should not be placed until final subgrade elevation has been verified by the licensed engineer overseeing design and/or construction.

If a filter or sand/gravel filter on subgrade is required, placement should fall under the direction of approved site plans. Care shall be taken to place rip-rap in such a manner as to avoid displacing or tearing the filter.

When subgrade filters are not required, the subgrade should be compacted as to prevent undercutting or slumping from occurring.

Rip-rap should be of masonry stone that is sound, dense, and durable as described below.

Installation Procedures (Continued)

Rubble-Stone Rip-rap (Plain)

Rubble-stone rip-rap should consist of at least 90% of the stone not less than 8 inches (20.3 cm) wide by 12 inches (30.5 cm) long by 12 inches (30.5 cm) deep and should be approximately rectangular in shape. Rubble-stone should be hand placed so that the stones are close together, are staggered at all joints as far as possible, and are placed so as to reduce the voids to a minimum. The main stone should be thoroughly "chinked" or anchored in place with 1-in. to 3-in. (2.5- to 7.6- cm) stones by throwing them over the surface in any manner that is practical for the smaller stones to fill the voids.

The standard depth should be 24 inches (61 cm). The average depth should not be less than the required depth and is determined from evaluation of a 25 square foot (2.3 m^2) surface area.

When rubble-stone rip-rap is constructed in layers, the layers should be thoroughly tied together with large stones protruding from one layer into the other.

Rubble-Stone Rip-rap (Grouted)

Stone placement for rubble-stone rip-rap (grouted) is the same as for rubble-stone rip-rap (plain). The grouting procedure is as follows:

When grouting is used, care should be taken to prevent earth or sand from filling the spaces between the stones before the grout is poured. Grout should be composed of one part portland cement and four parts of sand, measured by volume, and mixed thoroughly with sufficient water to a consistency that it will flow into and completely fill the voids.

Immediately before pouring the grout, the stones should be wetted by sprinkling. Beginning at the lower portion of the rip-rap, the grout should be carefully poured into the voids between the stone and at a slow enough rate to prevent oozing to the surface. The pouring of the grout should be accomplished by the use of vessels, chutes, tubes, or hoses of adequate size and shape. Broadcasting, slopping, or spilling of grout from the vessels on the surface of the rip-rap is not allowed.

As soon as any section of the grouted rip-rap has hardened sufficiently, it should be kept moist with water that is free from salt or alkali for a period of not less than 72 hours.

Sacked Sand-Cement Rip-rap

Sand for sacked sand-cement rip-rap may be manufactured or natural but should conform to state regulations. The same is true for Hydraulic cement. The sand and cement should be mixed dry, with a mechanical mixer, in the proportion of one bag (94 pounds (43.3 kg)) of cement to 5 cubic feet (0.14 m^3) of dry sand, until the mixture is uniform in color. The sand-cement mix should be poured into sacks of approximately 1 cubic foot (0.03 m) capacity until they are approximately ¾ full. Sacks should be of either cotton or jute standard grade of cloth which will hold the sand-cement mixture without leakage during handling and tamping. The sacks should then be securely fastened with hog rings, by sewing, or by other suitable methods that prohibit leakage of the mixture from the bags.

Installation Procedures (Continued)

The sacks of sand-cement should be bedded by hand on the prepared grade with all the fastened ends on the grade and with the joints broken. The completed rip-rap should have a minimum thickness of 10 inches (25.4 cm) with a tolerance of 3 inches (7.6 cm).

The sacks should be rammed and packed against each other in such a manner as to form close contact and secure a uniform surface. Immediately after tight placement, the sacks of sand-cement should be thoroughly soaked by sprinkling with water. Water should not be applied under high pressure. Sacks that are ripped or broken in placement should be removed and replaced before being soaked with water.

Machined Rip-rap

Machined rip-rap should be clean shot rock containing no sand, dust, or organic materials and should be the size designated for the class specified. The stone should be uniformly distributed throughout the size range.

Class A-1

Class A-1 rip-rap should vary in size from 2 inches (5.1 cm) to 1.25 feet (0.4 m) with no more than 20% by weight being less than 4 inches (10.2 cm). The thickness of the stone should be 1.5 feet (0.5 m) with a tolerance of 3 inches (7.6 cm). The material should be dumped and placed by the use of appropriate power equipment in a manner that will produce a surface uniform in appearance. Hand work may be required to correct irregularities.

Class A-2

Class A-2 rip-rap is the same as Class A-1 rip-rap except the depth may be decreased to a minimum of 1 foot when hand placed in accordance with the rubble-stone classification.

Class B

Class B rip-rap should vary in size from 3 inches (7.6 cm) to 2.25 feet (0.71 m) with no more than 20% by weight being less than 6 inches (15.2 cm). The thickness of the layer should be 3 feet (0.91 m) with a tolerance of 4 inches (10.2 cm). The material should be dumped and placed by the use of appropriate power equipment in a manner that will produce a surface uniform in appearance. Hand work may be required to correct irregularities.

Class C

Class C rip-rap should vary in size from 5 inches (12.7 cm) to 3 feet (0.94 m) with no more than 20% by weight being less than 9 inches (22.9 cm). The thickness of the layer should be 3.5 feet (1.1 m) with a tolerance of 6 inches (15.2 cm). The material should be dumped and placed by the use of appropriate power equipment in a manner that will produce a surface uniform in appearance. Hand work may be required to correct irregularities.

Activity: Rip-Rap	SMP-09

Maintenance

Rip-rap requires minimum maintenance.

Check after storm events for maintenance purposes, replace any portion of the rip-rap that needs attention.

Check for brush growth, remove the evidence which appears.

Inspection Checklist

- q Verify that displacement does not occur due to too steep slopes or small rip-rap.
- q Proper filter cloth is used.
- q Rip-rap graded properly according to contract documents.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-10

Activity: Channel Linings

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
None

Estimated Unit Cost:

Monthly Maintenance:
0% of Capital Costs

CL

CL

Target Pollutants

Significant ♦	Partial ◈	Low or Unknown ◊

Sediment ♦	Heavy Metals ♦	Nutrients ♦	Oxygen Demanding Substances ♦	Toxic Materials ◊
Oil& Grease ♦	Bacteria & Viruses ◊	Floatable Materials ◈	Construction Waste ◊	

Description

To protect against erosion to soil, artificial surfacing of bed, banks, shores or embankments are channel lined. Channel lining is the application of rip-rap (SMP-09) to channels, creeks, streams, ditches and other waterways to provide a barrier against the erosions of the environment during construction.

Suitable Applications

Channel lining is used for several different purposes, one being the promotion of vegetative growth in a drainage way, while another application would result from seeding and mulch not being able to withstand the maximum shear force of channel flow for 2-year, 24-hour flow.

Approach

Channel Lining is most effective in wet-weather conveyances and has applicable materials such as: Excelsior, jute mats and cells, wood fiber mats and cells, geosynthetic mats or cells, brush layering.

Activity: Channel Linings	SMP-10

Maintenance

Inspect after every storm event

Check Rip-rap BMP for appropriate installation and maintenance processes

Repair damaged material immediately

Inspection Checklist

- q Adequate coverage is provided to prevent washout.
- q Repair torn netting or mats.
- q Slope of channel is consistent with contract documents.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-11

Activity: Temporary Diversions, Drains and Swales

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
None

Estimated Unit Cost:

Monthly Maintenance:
0% of Capital Costs

☐ TD ☐

TD

Target Pollutants

Significant ♦	Partial ◈	Low or Unknown ◊

Sediment ♦	Heavy Metals ♦	Nutrients ♦	Oxygen Demanding Substances ♦	Toxic Materials ◊
Oil& Grease ♦	Bacteria & Viruses ◊	Floatable Materials ◈	Construction Waste ◊	

Description

The offset of runoff on a construction site to sediment basins or traps happens as a result of slope drains, swales and other numerous drainage systems. These temporary drains offer functionalities such as conveyance of runoff down cut or fill slopes, subsurface drains that drain off excessive soil saturation, minimize the sheet flow over slope surfaces and rescue sedimentation.

Suitable Applications

The digression of upslope runoff through drains and diversions around un-stabilized or disturbed areas can be accomplished by utilizing temporary drains and swales. These two methods bypass disturbed or sensitive areas on the construction site and transport runoff to stable and/or protected areas or to permanent infrastructures.

Drains act to prevent slope failures, damage to adjacent property, erosion and sediment control and removes excess water from soil.

Diversions act to catch runoff at the end of an undisturbed slope before entering a bared area, direct runoff, preserve stable conveyance and to prevent overflow.

Installation Procedures

A diversion does not itself control erosion or remove sediment from runoff; it prevents erosion by directing runoff to an erosion control device such as a sediment trap or directing runoff away from an erodible area. Temporary diversions should not adversely impact adjacent properties and must conform to local floodplain management regulations, and should not be used in areas with slopes steeper than 10%. The advantages of the temporary earth dike include the ability to handle flows from large tributary areas. Once

Installation Procedures (Continued)

(cont.) stabilized, diversions require relatively little maintenance. Additionally, they are relatively inexpensive to install since the soil material required for construction may be available on-site, and can be constructed as part of the initial grading operations, while the equipment is on-site. Temporary swales will effectively convey runoff and avoid erosion if constructed and maintained properly:

Size temporary swales in the same manner as a permanent channel.

A permanent channel must be designed by a licensed professional civil engineer.

At a minimum, the swale should conform to predevelopment flow patterns and capacities.

Construct the swale with an uninterrupted, positive grade to a stabilized outlet.

Drains

Diversion drains are only effective if they are properly installed. Swales are more effective than dikes because they tend to be more stable. The combination of a swale with a dike on the downhill side is the most cost-effective diversion.

Can be placed on or buried underneath the slope surface.

Should be anchored at regular intervals of 50 to 100 ft. (15.2 to 30.5 m).

If a slope drain conveys sediment-laden water, direct flows to a sediment trap or basin.

When using slope drains, limit tributary area to 2 acres (0.8 ha) per pipe. For larger areas, use a rock-lined channel or a series of pipes.

Maximum slope generally limited to 2:1 (H: V), as energy dissipation below steeper slopes is difficult.

Drain or swale should be laid at a grade of at least 1 percent, but not more than 15 percent.

The swale must not be overtopped by the 10-year, 24-hour storm, meeting or exceeding the design criteria stated above.

Remove all trees, stumps, obstructions, and other objectionable material from the swale when it is built.

Compact any fill material along the path of the swale.

Stabilize all swales immediately. Seed and mulch swales at a slope of less than 5 percent, and use rip-rap or sod for swales with a slope between 5 and 15 percent.

Installation Procedures (Continued)

Do not operate construction vehicles across a swale unless a stabilized crossing is provided.

Direct surface runoff to slope drains with diversion swales, dikes and berms.

When installing slope drains:

Install slope drains perpendicular to slope contours.
Compact soil around and under entrance, outlet, and length of pipe.
Securely anchor and stabilize pipe and appurtenances into soil.
Check to ensure that pipe connections are watertight.
Protect inlet and outlet of slope drains: use standard flared end section at entrance for pipe slope drains 12 in. (300 mm) and larger.
Protect area around inlet with filter cloth.
Protect outlet with geosynethics and rip-rap or other energy dissipation device.
For high-energy discharges, reinforce rip-rap with concrete or use reinforced concrete devices.

When installing subsurface drains:

Slightly slope subsurface drain towards outlet.
Check to ensure that pipe connections are watertight.
Review relative size of soil and slot/perforation size in the pipe to prevent sediment from entering pipe.
Relief drains lower groundwater table. Install parallel to slope and drain to side of slope. Use gridiron, herringbone or random pattern.
Interceptor drains prevent excessive soil saturation on sensitive slopes. Install perpendicular to slope and divert discharge to the side of the slope.

Diversions

Select design flows and safety factor based on careful evaluation of risks due to erosion of the measure, over topping, flow backups, or washout.

High flow velocities may require the use of a lined ditch, or other methods of stabilization.

When installing diversion ditches and berms:

Protect outlets from erosion.

Utilize planned permanent ditches/berms early in construction phase when practicable.

All dikes and berms should be compacted by earth-moving equipment.

All dikes should have positive flow to a stabilized outlet.

Top width may be wider and side slopes may be flatter at crossings for construction traffic.

Dikes should direct sediment-laden runoff into a sediment trapping device.

Installation Procedures (Continued)

Dikes should be stabilized with vegetation, chemicals, or physical devices.

Compact any fills to prevent unequal settlement.

Dikes should remain in place until disturbed areas are permanently stabilized.

Examine the site for run-on from off-site sources (control off-site flows through or around site).

Select flow velocity limit based on soil types and drainage flow patterns for each project site

Establish a maximum flow velocity, shear stress or 3-5 ft/s (0.91-1.5 m/s), for using earth dikes and swales, above which a lined ditch must be used.

Design an emergency overflow section or bypass area for larger storms that exceed the 10-year design storm.

Conveyances must be lined or reinforced when velocities exceed allowable limits for soil. Consider use of geotextiles, engineering fabric, vegetation, rip-rap or concrete.

Maintenance

Inspect drains before and after each storm event

Inspect weekly until drainage area is stabilized

Maintain drains and swales to eliminate erosion, accumulation of debris and sediment

Check status of water ponding activities. Remove water if such activities occur

Temporary conveyances should be removed when surroundings become stable or when the construction is complete

Inspection Checklist

- q Routine visit after every heavy net water event.
- q No evidence of washout, accumulated debris and build up in ditches or berms.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-12

Activity: Filter Strips

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg: $100
Range: $50-$150

Monthly Maintenance:
60% of Installation

FS

FS

Target Pollutants

Significant ♦	Partial ◈	Low or Unknown ◇

Sediment ♦	Heavy Metals ◈	Nutrients ◈	Oxygen Demanding Substances ◈	Toxic Materials ◈	
Oil& Grease ◈	Bacteria & Viruses ◇	Floatable Materials ◈	Construction Waste ◇		

Description

Utilizing vegetation allows soil to be protected from erosion and velocity flow while reducing or preventing discharge of pollutants to the storm system or waterways. This method uses filter strips to accomplish the goal of filtering sediment needing to be settled out of runoff.

Suitable Applications

Areas that need immediate cover (such as sodding and plugging) due to having turf prior to construction, areas subject to erosion (graded or cleared areas), and permanent vegetative areas

Wetlands and/or sensitive water bodies

Steep and unstable slopes

Temporary or permanent buffer areas that include the floodway and 50 feet perpendicular to the floodway. If a floodway has not been determined then the buffer bust be 25 feet perpendicular from each side of the stream bank, creek, or unnamed waterway under “bank-full conditions”

Area within the buffer must not be cleared. It should be surveyed, flagged and delineated by a colored temporary fence and these instructions explained to each employee on the site

Activity: Filter Strips	SMP-12

Installation Procedures

Cultivate the area then install the irrigation system

Areas should be excavated and backfilled (plant holes)

Areas are to be fine graded and rolled prior to sodding

Sodded areas are to be uniform and smooth (prior to sodding) and distributed with top soil were needed (to even out the area)

Sod end of adjacent strips should stagger by half the width or length

Areas adjacent to sidewalks, concrete headers, header boards and other paved borders shall be 1.5 in-0.25 in below the top grade of the facilities

Seed beds should be added to fertilizers and added to the correct site condition to slow the velocity of runoff and allow sediment to take place

Roll sod to eliminate air pockets and allow a closer contact with the soil.

Water sod so that the soil at a minimum depth of 4 feet is moistened

Do not allow sod to dry out

Sod should not be planted on slopes that are greater than 3:1 (H:V) if no mowing is to occur

Vegetate sodded areas

Do not use buffer strip for vehicular traffic

All fertilization efforts should follow the outline of the state, county, and/or local government

Maintenance

Inspect weekly after rainfall events until turf is established

Mowing shall consist of “tall” mowing, weeding and the irrigation system is growing and operating properly

Fertilize as needed and as indicated by soil testing

Overseed, repair bare spots, or apply additional mulch as necessary

Inspection Checklist

- q Check for vehicular traffic.
- q Dead areas requiring seeding, plugging or resodding
- q Under wash turf compacted.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-13

Activity: Temporary Inlet Protection

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg: $100
Range: $50-$150

Annual Maintenance:
60% of Installation

TIP

Target Pollutants

Significant ♦	Partial ◊	Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◊ Construction Waste ◊

Description

This BMP allows sediment to settle prior to entering into a stormwater catch basin or inlet. The detainment of sediment-laden runoff through filtering devices allows for a cleaner runoff to be discharged into the environment.

Suitable Applications

Protection of storm drain inlets or catch basins stems from promoting sedimentation upstream of the inlet or covering the inlet that receives runoff.
Areas where ponds are not encroached into access road or highway traffic.
Disturbed tributary areas have not yet been permanently stabilized.
Areas where drainage is ½ acre or less.
Areas with drainage more than ½ acre must be accompanied by a downstream sediment trap or basin.

Installation Procedures

Sediment filters are used as storm inlet protectors.
Filter Fabric Fences are desired for basins less than one acre with less than a 5% slope. Place 2 in. by 2 in. wooden stakes around the perimeter of the inlet a max. of 3 ft apart with an ending depth of at least 8 in. into the ground. Stakes should be 3 ft long. Excavate trench 8 in. wide and 12 in. deep around the outside perimeter of the stakes. Staple fabric to the stakes so that 32 in. of the fabric extends out and can be formed into the trench (use heavy-duty wire staples at least 1 in length). Backfill trench with a ¾ in or less washed gravel all the way around.

Activity: Temporary Inlet Protection	SMP-13

Installation Procedures (Continued)

Block and Gravel Filter is desired for flows greater than 0.5 cfs. Hardware cloth should be dropped ½ in over drop inlet so that wire extends a minimum of 1 ft on each side. Concrete blocks should be placed lengthwise on their sides in a single row around the perimeter of the inlet with ends abut adjacently. Height can be 4, 8 or 12 in. wide by stacking combinations of concrete. Rows should be no greater than 24 inches high. Wire mesh should be over the outside vertical face of the concrete blocks to prevent stone from washing through blocks. Pile wash stone against the wire mesh to the top of the blocks. Use ¾ to 3 in. gravel.

Gravel and Wire Mesh Filter is used on curb or drop inlets where construction equipment may drive over the inlet. Place over drop inlet so that wire extends on both sides at a minimum of 1 ft. Use hardware cloth or wire mesh with ½ in. opening. Place ¾ to 3 in. gravel over the filter fabric/wire mesh. Depth should be 12 inches over the entire inlet opening. Excavate drop inlet sediment trap, minimum storage capacity calculated at the rate of 67 cubic yards per acre (yd^3/ac) of tributary area should be sized.

Sand Bag Barriers are used to create a small sediment trap upstream of inlets on sloped, paved streets. Bags should be made of geotextile material and fill with ¾ in. rock or ¼ in. pea gravel. Leave room upstream for settlement and ponding. Place several layers of bags and pack them tightly together leaving a gap of one bag on the top row to serve as a spillway.

Excavated Drop Inlet Sediment Traps are excavated areas around inlets to trap sediment.

Gates and inlets should be a sealed to prevent seepage of sediment-laden water.

Excavate sediment sumps 1 to 2 feet with 2:1 (H:V) side slopes around the inlet.

Provide areas around the inlet for water to pond without flooding structures and property.

Maintenance

Replace clogged fabric immediately.

Remove sediment when depth exceeds half the height of the filter or half the depth of the sediment trap.

Inspect all inlets and catch basins weekly before and after each rain event.

Inspect once every 24 hours during heavy rainfall events.

After site is stabilized remove all inlet devices within 30 days.

Bring disturbed area to final grade and smooth and compact it.

Clean around and inside the storm drain inlet.

Inspection Checklist

- q The stakes of filter fabric fence are secure.
- q The filter fabric is clean and not torn or clogged.
- q Sediment behind the silt fence does not exceed 1/3 height of the fabric fence.
- q Blocks of the block gravel filter are in good working conditions. Gravel around the blocks is preventing wash through.
- q Sediment from behind the gravel pack does not exceed 1/3 height of the fabric fence.
- q Bags are cleaned and properly maintained.
- q Structures have not been displaced.
- q Volume of sediment is less than ½ of the basin's volume.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-14

Activity: Temporary Outlet Protection

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg: $100
Range: $50-$150

Monthly Maintenance:
60% of Installation

TOP

Target Pollutants

Significant ♦ Partial ◊ Low or Unknown ◊

Sediment ♦ Heavy Metals ◊ Nutrients ◊ Oxygen Demanding Substances ◊ Toxic Materials ◊
Oil& Grease ◊ Bacteria & Viruses ◊ Floatable Materials ◊ Construction Waste ◊

Description

This protection outlet is constructed of rock, grouted rip-rap or concrete rubble. This prevents scour of the soil due to high pipe flow velocities. The dissipation of flow energy to produce non-erosive velocities is also a function of this BMP.

Suitable Applications

Areas where culverts, conduits or channels are sufficient to erode the immediate downstream reach.

Outlets of pipes, drains, culverts, conduits, channels, locations at the bottom of mild to steep slopes, outlets of which carry continuous flows of water, short intense flows of water, lined conveyances discharge to unlined conveyance

Sediment trap is recommended if runoff is sediment laden

Do not use grouted rip-rap during freezing, will cause grout to break

Activity: Temporary Outlet Protection	SMP-14

Installation Procedures

Should be designed and sized by a licensed professional engineer as a part of the culvert, conduit or channel design.
Apply a rip-rap apron for temporary use during construction
Apron should consist of a zero grade, alignment with receiving stream, avoid damaging the underlain filter fabric. Keep apron straight throughout the length of the stream curving in the upper section of the harpoon if curve is needed. Bank reinforcement should be downstream to account for the curved apron

Maintenance

Grouted or wire-tied rock rip-rap minimizes maintenance requirements
Inspect weekly and before and after rainfall events
Inspect apron for displacement and/or damage to the underlying fabric, scour beneath the rip-rap and around outlet.
Remove devices as soon as work is completed to the construction site

Inspection Checklist

- q Rock washed out by large storms is replaced.
- q Sediment captured by the rock outlet protection may be difficult to remove without removing the rock.
- q Grouted rip-rap may break up in areas of freeze and thaw.
- q Grouted rip-rap may break up from hydrostatic pressure without adequate drainage.