Best Management Practices
Stormwater Management Manual
for Southern Indiana

Madison, Indiana

PREFACE

This manual contains specific recommendations and criteria to be considered when implementing Best Management Practices within your community; however, it should not be confused with a design document. The manual does not contain complete detailed design information for all practices that are referenced.

The examples, recommendations and criteria highlight some of the major principles and notable points related to the practices based upon the best information available from a variety of sources. These sources should be used with caution since you must demonstrate the appropriateness and applicability of the practice to Indiana, your community and to your project in particular.

Some of the examples shown in this document represent projects which, under state or federal laws, may require permits or design by a registered design professional. This manual, the source references, and professional integrity should be seen as three legs providing a stable foundation for the community's project BMPs.

Acknowledgements

The Stormwater Management Manual of Best Management Practices was created with the shared input of all who participated in the Southern Indiana Stormwater Advisory Committee. This manual would not be complete without the collaborative effort between Clark County, Clarksville, Jeffersonville, Sellersburg, Oak Park Conservancy District, and Floyd County with assistance from Stantec Consulting Services, Inc. (formerly Fuller, Mossbarger, Scott, and May Engineers, Inc.) and Jacobi Toombs and Lanz, Inc. It was developed based upon the review and consideration of a number of other existing manuals including related materials from Indiana Department of Environmental Management (IDEM), the City of Nashville, TN, the National Association of Home Builders, the City of Knoxville, TN, the State of Georgia, the Minnesota Pollution Control Agency, and related American Society of Civil Engineers (ASCE) and American Public Works Association (APWA) documents.

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from land surfaces by wind, water or gravity. Natural erosion generally occurs at slow rates. However, the rate of erosion increases when land is cleared or altered and left disturbed. Erosion rates will increase when flow rates and velocities discharged from a site exceed the erosive range.

Clearing and grubbing activities during construction remove vegetation and disrupt the structure of the soil surface, leaving the soil susceptible to rainfall erosion, stream and channel erosion, and wind erosion, if left untreated. Ultimately, the sediment suspended by erosion settles in downstream reaches. This process, termed sedimentation, can lead to increased maintenance needs and flooding problems.

1.3.1.1 Water Erosion

The rainfall erosion process begins when raindrops impact the soil surface and dislodge minute soil particles. These soil particles then become suspended in the water droplet. Sediment laden water droplets accumulate on the soil surface until a sufficient quantity has developed to begin flowing under the forces of gravity.

The initial flow of sediment-laden water generally consists of a thin, slow-moving sheet, known as sheet flow. While sheet flow is generally not highly erosive on its own, it does begin the transport of previously suspended sediment. Due to irregularities in the soil surface and uneven topography, sheet flow will usually begin to concentrate into rivulets, where the flow picks up velocity, and erosive energy increases as a result of gravitational forces.

The increasing erosive energy of water flowing in rivulets will cut small grooves, or rills, in the soil surface. Rill erosion of the soil surface tends to concentrate more flows, which then flow faster and gain erosive energy as a result of gravitational forces. In turn, the rills become deeper and larger, and join adjacent rills. Typically, rills run parallel with the slope and each other, are small enough to be stepped across, and are generally enlarged by direct erosion of the rill's sides and bottom by the action of flowing water.

The communion of several adjacent rills, or sufficient enlargement of a single rill, begins gully erosion. Gully erosion of the soil surface tends to concentrate more flows, which then flow faster and gain erosive energy as a result of gravity. Typically, gullies running parallel with the slope, may have one or more lateral branches, and are enlarged by four key actions. First, gullies often have a "head cut" at the upstream end which progresses its way upstream as water flowing into the gully erodes the lip of the head. This mechanism is similar to a waterfall working its way upstream. Second, the flow in a gully tends to under cut the banks. Once sufficiently under cut, the banks collapse into the gully where the collapsed soil is then washed away. Third, when banks collapse into the gully, flowing water is diverted around the temporary blockage of soil. This temporary blockage increases velocities along one or both banks, which results in increased bank erosion. Fourth, the concentration of flows in the gully can result in scour of the gully floor until a stable slope is obtained.

1.3.1.2 Stream and Channel Erosion

One or more of the following factors that disrupt the delicate balance required for stable streams and channels generally precipitate erosion within streams and channels.

1. Disturbing the banks of streams and channels is often required during construction. Once vegetation or other bank protection measures are disturbed, flows may begin to erode the unprotected soil.

2. Disturbing the flow within a stream or channel is often necessary to facilitate construction activities. However, this should only be allowed when traversing banks such as temporary stream crossing, culvert installation, bridge construction, etc. By diverting flows within the channel, velocities are increased in some areas to compensate for decreases in other areas. The increases in velocity may exceed those normally experienced by the channel, resulting in bank erosion and bottom scour.

3. Increasing the quantity and rate of flow to streams and channels often results from construction activities and construction of facilities that increase the quantity and rate of runoff as well as how runoff is conveyed to the discharge point. The increased quantity and rate of flow can cause bank erosion and bottom scour.

1.3.1.3 Wind Erosion

Dust is defined as solid particles or particulate matter small enough to remain suspended in the air for a period of time and large enough to eventually settle out of the air. Dust from a construction site originates as inorganic particulate matter from rock and soil surfaces and material storage piles. The majority of dust generated and emitted into the air at a construction site is related to earth moving, demolition, construction traffic on unpaved surfaces, and wind over disturbed soil surfaces.

1.3.1.4 Factors Influencing Erosion

There are five primary factors that influence erosion: soil characteristics, vegetative cover, topography, climate, and rainfall.

1. Soil characteristics that determine the erodibility of the soil include particle size, particle gradation, organic content, soil structure, and soil permeability. Soil characteristics affect soil stability and infiltration capacity. The less permeable the soil, the higher the likelihood for increased runoff and erosion. Soils with a high percentage of silt and clays are generally the most erodible.

   The soil characteristics play a different role for channel flow. The tractive-force or shear stresses developed by flowing water over the channel banks and bottom can cause the soil particles to move and become suspended into the runoff. The “permissible shear” stress indicates the stress that the channel banks and bottom can sustain without compromising stability. Protecting the channel bottom and banks with a variety of “soft/green” or “hard” armoring increases the permissible shear stress in the channel.

2. Vegetative cover plays an important role in controlling erosion by shielding the soil surface from the impacts of falling rain, and slowing the velocity of runoff. This permits greater infiltration, maintains the soil’s capacity to absorb water, and holds soil particles in place. Vegetative root structures create a favorable soil structure, improving its stability and permeability.

3. Topography, including slope length and steepness are key elements in determining the volume and velocity of runoff. As slope length, and /or steepness increases, so does the rate of runoff and the erosion potential.

4. Climate is a key factor that influences erosion. High rainfall areas and areas with freeze/thaw cycles have significant effects on soil stability and structure.

5. Wet weather frequency, intensity, and duration are fundamental factors in determining the amounts of erosion produced. When storms are frequent, intense, or of long duration, erosion risks are high. In Southern Indiana, the erosion risk period is typically highest in the wet season (typically December through May) which coincides with the period of minimal vegetative cover.

1.3.2 Sedimentation Process

Once soil particles are eroded by and suspended in water or wind, they can be carried from a few inches or feet to many miles before conditions are such that gravity will force soil particles to settle. The settling of soil particles is known as the process of sedimentation. Excessive levels of sedimentation can plug storm drains, block streams and channels, damage habitat, and in some cases result in formation of habitats in undesirable locations. Generally, sedimentation can be forced to occur by creating conditions that slow the flow of water or air, allowing particles to settle. Conversely, creating conditions of rapid and/or turbulent flow that prevent particles from settling can prevent sedimentation.

1.3.3 Other Stormwater Pollutants and Impacts

Sediment from erosion is the pollutant most frequently associated with construction activities. However, other pollutants of concern include nutrients, metals, pesticides, oil and grease, fuels, other toxic chemicals, and miscellaneous wastes. These pollutants originate from a variety of activities including paving operations, demolition, materials storage, equipment fueling, and other daily activities necessary for project construction or site (commercial or industrial) management. By taking an activities inventory, the contractor/operator can identify potential pollutant sources and then select appropriate BMPs to address these sources. Appropriate BMPs are usually specific to the construction activity or site (commercial or industrial) management activity.

1.3.3.1 Nutrients

Phosphorous and nitrogen from fertilizers, pesticides, construction chemicals, and solid waste are often generated by site activities. These nutrients can result in excessive or accelerated growth of vegetation or algae resulting in impaired use of water in lakes and other sources of water supply through taste and odor problems. Excess algae can also deplete dissolved oxygen levels resulting in fish kills. Collectively, the problems associated with excessive levels of nutrients in a receiving water are referred to as *eutrophication* impacts.

1.3.3.2 Oxygen Demanding Substances

Lower dissolved oxygen (DO) levels are often the cause of fish kills in streams and reservoirs. The degree of DO depletion is measured by the biochemical oxygen demand (BOD) test that expresses the amount of easily oxidized organic matter present in water. The chemical oxygen demand (COD) test measures all the oxidizable matter present in urban runoff. BOD is caused by the decomposition of organic matter in stormwater that depletes DO. Other non-organic materials in the water can intensify DO depletion.

1.3.3.3 Metals

Many artificial surfaces (e.g., galvanized metal, paint, or preserved wood) contain metals that can enter stormwater as the surfaces corrode, flake, dissolve, decay, or leach. However, significant portions of metals in urban runoff are from cars and trucks. Over half the trace metal load carried in stormwater is associated with sediments to which these eroded metals attach. Heavy metals are of concern because they are toxic to aquatic organisms, can be bioaccumulative, and have the potential to contaminate drinking water supplies.

1.3.3.4 Pesticides

Herbicides, insecticides and rodenticides (collectively termed *pesticides*), are commonly used on construction sites, lawns, parks, golf courses, etc. Unnecessary, excessive, or improper application of these pesticides may result in direct water contamination, indirect water pollution by aerosol drift, or erosion of treated soil and subsequent transport into surface waters.

1.3.3.5 Oil, Grease and Fuels

These products are widely used and can be spilled/leaked/dumped on the ground where they can wash into waterways. Sources include leakage during normal vehicle use, hydraulic line failure, spills during fueling, and inappropriate disposal of drained fluids. These products can cause harm to plant and animal life.

1.3.3.6 Other Toxic Chemicals

Often synthetic organic compounds (adhesives, cleaners, sealants, solvents, etc.) are widely applied and may be improperly stored and disposed. Accidental spills and leakage or deliberate dumping of these chemicals onto the ground or into storm drains causes environmental harm in receiving waters.

1.3.3.7 Miscellaneous Wastes

Miscellaneous wastes include wash water from concrete mixers, paints and painting equipment cleaning activities, solid organic wastes resulting from trees and shrubs removed during land clearing, wood and paper materials derived from packaging of building products, food containers, such as paper, aluminum, and metal cans, industrial or heavy commercial process wash/cooling water, vehicle washing, other commercial or industrial wastes and sanitary wastes. The discharge of these wastes can lead to unsightly and polluted receiving waters.

1.4 Post Construction Management for Stormwater Quality

Temporary BMPs are intended to address construction activities while permanent BMPs address long-term stormwater management objectives / requirements.

Temporary BMPs may include a variety of “good housekeeping” measures and short-term EPSC activities. An appropriate professional such as the construction site operator and/or licensed professional civil engineer should apply temporary BMPs. A licensed professional engineer must design some of the more complicated or sensitive BMPs. The temporary management practices should be designed and submitted to the plan review engineer with the community in which the development is being built. The contractor is responsible for properly constructing, implementing and maintaining the temporary practices and seeking guidance when the measures do not appear to be meeting the stormwater management objectives (namely that sediment and other pollutants do not leave the construction site).

Permanent BMPs may include swales, sediment or detention ponds, and a variety of other features. These permanent management practices are selected by licensed professional civil engineers, incorporated into the plans and specifications for the project, and long-term maintenance responsibilities are identified. The contractor is responsible for properly constructing the permanent controls.

Permanent BMPs are the final improvements to and configuration of the project. They are designed to control long-term stormwater pollution. Permanent BMPs are normally selected in the planning phase in conjunction with the approval of the tentative map designed during the design phase of a project and completed to the satisfaction of the community in which it is being built. Occasionally, unforeseen natural or manmade factors may require revisions to or additions of permanent BMPs during the construction phase.

During construction, the contractor must ensure that the post-construction BMPs are installed properly and that any maintenance that may be necessary during construction is performed. After the project is complete it will then be the responsibility of the private or public owner (or other entity formally identified) to provide for long term operation and maintenance.

1.5 BMP Selection Process

1.5.1 Define BMP Objectives

Each construction project is unique. Therefore, an understanding of the pollution risks of the construction activity is essential for selecting and implementing BMPs. Defining these risks requires review of the characteristics of the site and the nature of the construction, information which should be assembled for the construction plans. Once these pollution risks are defined, BMP objectives are developed, and BMPs selected. The BMP objectives for construction projects are as follows:

1. Practice Good Housekeeping: Perform activities in a manner which keeps potential pollutants from either draining or being transported off-site by managing pollutant sources and modifying construction activities.

2. Contain Waste: Dispose of all construction waste in designated areas, and keep stormwater from flowing on to or off of these areas.

3. Minimize Disturbed Areas: Only clear land which will be actively under construction in the near term (e.g., within the next 3-4 months), minimize new land disturbance during the rainy

season, and do not clear or disturb sensitive areas (e.g., steep slopes, buffers and natural watercourses) and other areas where site improvements will not be constructed.

4. Stabilize Disturbed Areas: Provide temporary stabilization of disturbed soils whenever active construction is not occurring on a portion of the site. Provide permanent stabilization during finish grade and landscape the site.

5. Protect Slopes and Channels: Outside of approved grading plan area, avoid disturbing steep or unstable slopes. Safely convey runoff from the top of the slope, and stabilize disturbed slopes as quickly as possible. Avoid disturbing natural channels. Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in runoff velocity caused by the project do not erode the channel.

6. Control Site Perimeter: Upstream runoff should be diverted around or safely conveyed through the construction project. Such diversions must not cause downstream property damage. Runoff from the project site should be free of excessive sediment and other constituents.

7. Control Internal Erosion: Detain sediment laden waters from disturbed, active areas within the site to minimize the risk that sediment will have the opportunity to leave the site.

Site characteristics and contractor activities affect both the potential for erosion and contamination by other constituents used on the construction site. Before defining BMP objectives, you should carefully consider:

1. Site conditions that affect erosion and sedimentation including:

    a. Soil type, including underlying soil strata that are likely to be exposed to stormwater.
    b. Natural terrain and slope.
    c. Final slopes and grades.
    d. Location of concentrated flows, storm drains, and streams.
    e. Existing vegetation and ground cover.

2. Climatic factors, which include:

    a. Seasonal rainfall patterns.
    b. Appropriate design storm
        i. quantity of rainfall
        ii. intensity of rainfall
        iii. duration of rainfall

3. Type of construction activity.
4. Construction schedules, construction sequencing and phasing of construction.
5. Size of construction project and area to be graded.
6. Location of the construction activity relative to adjacent uses and public improvements.
7. Cost-effectiveness considerations.
8. Types of construction materials and potential pollutants present or that will be brought on-site.

9. Floodplain, Floodway, and buffer requirements.

1.5.2 Identify BMP Categories

Once the BMP objectives are defined, it is necessary to identify the category of BMPs that is best suited to meet each objective.

To determine where to place categories of BMPs, a map of the project site can be prepared with sufficient topographic detail to show existing and proposed drainage patterns and existing and proposed permanent stormwater control structures. The project site map should identify the following:

1. Locations where stormwater enters and exits the site. Include both sheet and channel flow for the existing and final grading contours.

2. Identify locations subject to high rates of erosion such as steep slopes and unlined channels. Long, steep slopes over 100 feet in length are considered as areas of moderate to high erosion potential.

3. Categorize slopes as:

   a. Low Erosion Potential (0 to 5 percent slope)
   b. Moderate Erosion Potential (5 to 10 percent slope)
   c. High Erosion Potential (slope greater than 10 percent)

4. Identify wetlands, springs, sinkholes, floodplains, floodways, sensitive areas or buffers which must not be disturbed, as well as other areas where site improvements will not be constructed. Establish clearing limits around these areas to prevent disturbance by the construction activity.

5. Identify the boundaries of tributary areas for each outfall location. Then calculate the approximate area of each tributary area.

6. Define areas where various contractor activities have a likely risk of causing a runoff or pollutant discharge.

With this site map in hand, categories of BMPs can be selected and located. It is more cost-effective to prevent erosion/pollution than to remove sediment/pollutants, and erosion prevention is achieved most cost-effectively by planning before construction begins and phasing construction activities.

BMPs that can achieve more than one BMP objective should be taken into account when selecting BMPs to achieve maximum cost-effectiveness. For instance, it is not always necessary to install extensive sediment trapping controls during construction. In fact, sediment trapping should be used only as a short-term measure for active construction areas, and replaced by permanent stabilization measures as soon as possible. However, it should be noted that perimeter/outfall control in the form of permanent detention ponds should be built first and used as temporary sediment control by placing a filter on the outlet. After construction is complete and tributary area is stabilized, the permanent outlet configuration can be reestablished.

1.5.3 Selecting BMPs for Construction Site Management (Sections SPD, EPP, SMP)

Certain contractor activities may cause pollution if not properly managed. Not all of the BMPs will apply to every construction site. However, all of the suggested BMPs should be considered, and those which are appropriate for the project at hand should be selected. Considerations for selecting BMPs for contractor activities include the following:

1. Is it expected to rain? BMPs may be different on rainy days vs. dry days, winter vs. summer, etc. For instance, a material storage area may be covered with a tarp during the rainy season, but not in the summer. However, it should be noted that plans should be made for some amount of rain even if it is not expected to generate a flooding event.

2. How much material is used? Less intensive BMP implementation may be necessary if a “small” amount of pollutant containing material is used (however, remember that different materials pollute in different amounts).

3. How much water is used? The more water used and wastewater generated, the more likely that pollutants transported by this water will reach the stormwater system or be transported off-site. Washing out one concrete truck on a flat area of the site may be sufficient (as long as the concrete is safely removed later), but a pit should be constructed if a number of trucks will be washed out at the same site.

4. What are the site conditions? BMPs selected will differ depending on whether the activity is conducted on a slope or flat ground, near a stormwater structure or watercourse, etc. Anticipating problems and conducting activities away from certain sensitive areas will reduce the cost and inconvenience of performing BMPs.

5. What about accidents? Pre-establishing a BMP for each conceivable pollutant discharge may be very costly and significantly disrupt construction. As a rule of thumb, establish controls for common (daily or weekly) activities and be prepared to respond quickly to accidents. Define the difference, not everything can be called an accident and maybe classified as negligent disregard of proper practices.

Therefore, keep in mind that the BMPs for contractor activities are suggested practices which may or may not apply in every case. Construction personnel should be instructed to develop additional or alternative BMPs which are more cost-effective for a particular project. The best BMP is a construction work force aware of the pollution potential of their activities and committed to a clean worksite.

Effective EPSC management first minimizes erosion by keeping the soil protected (e.g. minimize disturbed areas) as long as possible (EP) and second, directs runoff from disturbed areas to locations where suspended soil materials can be removed prior to discharge from the site (SC). The use of source control BMPs to control erosion before its starts is the preferred method of long-term sediment control. However, on active construction areas, there may not be sufficient time for EP BMPs to become established to the point at which they are fully effective before the onset of erosive events. In these situations, SC BMPs can provide a more immediate level of protection by removing suspended sediment from flows before being transported. However, the best protection on active construction sites is generally obtained through simultaneous application of both EP BMPs and SC BMPs. This combination of controls is effective because it prevents most erosion before it starts and has the ability to capture sediments that become suspended before the transporting flows leave the construction site.

BMPs for erosion and sediment control are selected to meet the BMP objectives based on specific site conditions, construction activities, and cost-effectiveness. Different BMPs may be needed at different times during construction since construction activities are constantly changing site conditions.

The following general items are provided to aid in preparing the project plans and choosing appropriate erosion and sediment control BMPs.

1.5.3.1 Minimize Disturbed Areas

The first step for selecting BMPs is to compare the project layout and schedule with on-site management measures that, where appropriate, can limit the exposure of the project site to erosion and sedimentation. Scheduling and planning considerations are the least expensive way to limit the need for EPSC controls. Consider the following BMPs:

1. Do not disturb any portion of the site unless an improvement is to be constructed there.

2. The staging and timing of construction can minimize the size of exposed areas and the length of time the areas are exposed and subject to erosion.

3. The staging of grading operations should limit the amount of areas exposed to erosion at any one time. Only the areas that are actively involved in cut and fill operations or are otherwise being graded should be exposed. Exposed areas should be stabilized as soon as grading is complete in that area.

4. Retain existing vegetation and ground cover where feasible, especially along watercourses and along the downstream perimeter of the site.

5. Do not clear any portion of the site until active construction begins.

6. Construct outfall detention or perimeter sedimentation control (with filter weirs/berms and temporary sedimentation control barriers first).

7. Quickly complete construction on each portion of the site.

8. Install landscaping and other improvements that permanently stabilize each part of the site immediately after the land has been graded to its final contour.

9. Minimize the amount of denuded areas and any new grading activities during the wet months of December through May.

10. Construct permanent stormwater control facilities (e.g., detention basins) early in the project and use for sediment trapping, slope stabilization, velocity reduction, etc. during the construction period.

1.5.3.2 Stabilize Disturbed Areas

The purpose of site stabilization BMPs is to prevent erosion by covering disturbed soil. This covering may be vegetative, chemical, or physical. Any exposed soil is subject to erosion—either by rainfall striking the ground, runoff flowing over the soil, wind blowing across the soil, and vehicles driving on the soil. Thus all exposed soils should be stabilized except where active construction is in progress. Locations on a construction site which are particularly subject to erosion and should be stabilized as soon as possible include:

1. Slopes
2. Highly erosive soils
3. Construction entrances
4. Stream channels
5. Soil stockpiles

1.5.3.3 Site Perimeter

1. Disturbed areas or slopes that drain toward adjacent properties, storm drain inlets or receiving waters, should be protected with temporary linear barriers (continuous berms, silt fences, sand bags, etc.) to reduce or prevent sediment discharge while construction in the area is active. In addition, the contractor should be prepared to stabilize those soils with EP measures prior to the onset of rain.

2. When grading has been completed, the areas should be protected with EP controls such as mulching, seeding, planting, or emulsifiers. The combination of EP measures and SC measures should remain in place until the area is permanently stabilized.

3. Significant offsite flows (especially concentrated flows) that drain onto disturbed areas or slopes should be controlled through use of continuous berms, earth dikes, drainage swales, and lined ditches that will allow for controlled passage or containment of flows.

4. Concentrated flows that are discharged off of the site should be controlled through outlet protection and velocity dissipation devices in order to prevent erosion of downstream areas.

5. Perimeter controls should be placed everywhere runoff enters or leaves the site. They are usually installed just before clearing, grubbing and rough grading begin. Perimeter controls for all but the smallest projects will become overloaded by both runoff and sediment. Additional controls within the interior of the construction site should supplement perimeter controls once rough grading is complete.

1.5.3.4 Internal Swales and Ditches

1. More often, flows are directed toward internal swales, curbs, and ditches. Until the permanent facilities are constructed, temporary stormwater facilities will be subjected to erosion from concentrated flows.

2. These facilities should be stabilized through temporary check dams, geotextile mats, and under extreme erosive conditions by lining with concrete.

3. Long or steep slopes should be terraced at regular intervals (per local requirements). Terraces will slow down the runoff and provide a place for small amounts of sediment to settle out.

4. Slope benches may be constructed with either ditches along them or back-sloped at a gentle angle toward the hill. These benches and ditches intercept runoff before it can reach an erosive velocity and divert it to a stable outlet.

5. Overland flow velocities can be reduced by creating a rough surface for runoff to cross (e.g. tall grass).

1.5.3.5 Internal Erosion

Once all other erosion and sediment control BMPs have been exhausted, excessive sediment should be removed from the stormwater both within and along the perimeter of the project site. The appropriate controls work on the same principle: the velocity of sediment-laden runoff is slowed by temporary barriers or traps which pond the stormwater to allow sediments to settle out. Appropriate strategies for implementing sedimentation controls include:

1. Direct sediment-laden stormwater to temporary sediment traps.

2. Locate sediment basins and traps at low points below disturbed areas.

3. Protect all existing or newly-installed storm drainage structures from sediment clogging by providing inlet protection for area drains and curb inlets.

4. Construct temporary sediment traps or ponds at the stormwater outfall(s) for the site.

5. Excavate permanent stormwater detention ponds early in the project, use them as sedimentation ponds during construction, remove accumulated sediment, and landscape the ponds when the upstream drainage area is stabilized.

6. Temporary sediment barriers such as:
   a. Continuous Berms
   b. Silt Fences
   c. Straw Bale Barriers
   d. Sand Bag Barriers
   e. Brush or Rock Filter

   These barriers should only be used in areas where sheet flow runoff occurs. They are less effective or ineffective if the runoff is concentrated into rill or gully flow.

Section 1

INTRODUCTION

1.1 Background and Purpose

The intent of this manual is to provide guidance on BMP selection, design, and implementation to developers, engineers, reviewers, construction site operators, and site inspectors. There is special emphasis on Erosion Prevention and Sedimentation Control (EPSC) during construction and long-term (or permanent) stormwater quality treatment devices and facilities after construction is complete. There are also guidance materials for activities at commercial and industrial facilities.

The fact sheets are categorized, focused, and concise so that they may be used as quick references for design, inspection, and maintenance guidance. In this way, the fact sheets are designed to be stand-alone documents that may be distributed to facilitate focused discussion about design and/or implementation of the management practice. Many of the practices are considered structural practices in that they involve construction. However, several of the BMPs cover non-structural practices where normal activities are performed in a different manner with stormwater quality in mind.

1.2 Stormwater Quality and Quantity Management

Many of the communities in Southern Indiana, including Clark County, Floyd County, Clarksville, Jeffersonville, Sellersburg, and Oak Park are now requiring that stormwater quality management techniques be applied to new development and redevelopment in the form of structural and non-structural Best Management Practices (BMPs). Stormwater quality management involves pollutant control, capture, and/or treatment. Some of the pollutants are referred to as “point sources” and appear in the form of regulated discharges, spills, dumping, illicit connections, etc. This manual briefly discusses minimizing the chance of unregulated point sources, but primarily focuses on nonpoint source pollution.

Nonpoint source pollution comes in the form of particulate or dissolved pollutant matter conveyed by runoff over surfaces and conveyed to separate storm sewer system, creeks, and waterways. This principally includes sediment eroded from denuded areas during construction and other pollutants from impervious surfaces after construction. Nonpoint source pollution is most prevalent in runoff from small very frequent storm events. Typically these events are less than 1.25-inches of rainfall and that fact was used in preparing the selection, sizing, approach, and maintenance criteria presented in the BMP fact sheets.

1.3 Construction Site Management for Stormwater Quality

1.3.1 Erosion Process

Stormwater quality management predominately focuses on erosion prevention and sedimentation control (EPSC) for construction sites. However, for some fully developed sites EPSC can also be a concern. Soil erosion is the process by which soil particles are removed

1.5.3.6 Stormwater Inlets and Outfalls

1. Stormwater inlets, including drop inlets, and pipe inlets, should be protected from sediment intrusion if the area draining to the inlet has been disturbed.

2. Stormwater inlet protection can utilize sand bags, sediment traps, or other similar devices.

3. Internal outfalls must also be protected to reduce scour from high velocity flows leaving pipes or other drainage facilities.

1.5.4 BMPs for Good House Keeping

Most permanent BMPs will be proposed by the developer early in the planning stage of a project. For most projects, there will be no single BMP which addresses all the long-term stormwater quality problems. Instead, a multi-level strategy will be worked out with the community in which the development is being built, which incorporates source controls, a series of on-site treatment controls, and community-wide treatment controls.

In most cases permanent BMPs can be implemented most effectively when they can be integrated into other aspects of the project design. This requires that conceptual planning consider stormwater controls rather than as an afterthought to site design. The following should be considered early in the design process.

1. Is a detention/retention facility required for flood control? Often, facilities are required to maintain peak runoff at predevelopment levels to reduce downstream conveyance system damage and other costs associated with flooding. Most permanent BMPs can be incorporated into flood control detention/retention facilities with modest design refinements and limited increases in land area and cost.

2. Planned open space which will be relatively flat (e.g., final grade slopes less than 5 percent) may be merged with stormwater quality/quantity facilities. Such integrated, multi-use areas may achieve several objectives at a modest cost.

3. Infiltration BMPs may serve as groundwater recharge facilities, detention/retention areas may be created in landscaped areas of the project, and vegetated swales/filters may be used as roadside/median or parking lot median vegetated areas.

1.5.5 BMPs for Post Construction

After construction, water quality can be impacted by increased sedimentation and/or pollutant loading. This section will describe BMPs that will fulfill permit requirements to implement and enforce a program to address storm water runoff from new development and redevelopment projects that drain into existing storm drainage systems and streams. Typical development and redevelopment projects include municipal and commercial operations connecting and discharging storm water into local systems.

SPD – 01

Protecting Sensitive Features

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-01.1

Activity: Stream Corridors

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

Sensitive areas such as stream corridors (waterways and riparian land) are subject to special protection due to their unique characteristics. These waterways provide habitat for fish, aquatic plants, and bottom dwelling organisms. The modification to these inhabitants destroys physical features essential to a good habitat including: stable stream banks and bottom substrates, pools and riffles, meanders and spawning areas.

The vegetative habitat surrounding riparian land adjacent to stream banks filters pollutants from storm and floods and provides habitats for a variety of amphibians, aquatic birds and mammals. These creatures and their functions are impaired when development occurs within the corridor or riparian. Development causes more flooding to the area as well as meandering of natural streams.

To combat the developmental construction to the corridor or riparian, filter strips or forested buffers should be created or preserved along the banks of streams. Another method of preservation to corridors and riparian is the presence of vegetation along shorelines of ponds, lakes and wetlands. This aids in preventing erosion caused by wave action.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-01.2

Activity: Wetlands

PLANNING CONSIDERATIONS:

Planning:
Required

Training:
Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

Wetlands impart an aesthetically pleasing aspect to the environment while providing a unique habitat for plant and wildlife, including sensitive and endangered species. Wetlands also add value to flood storage, groundwater recharge and pollutant-filtering functions.

There are some wetlands that avoidance is recommended. These wetlands are very difficult to replace and are moderate to high-quality in nature. Sites where scattered and small low-quality wetlands are readily replaceable, mitigation is recommended to enhance the wetlands function and reduce potential constraints to development.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-01.3

Activity: Steep Slopes and Highly Erodible Lands

PLANNING CONSIDERATIONS:

Planning:
Required

Training:
Not Required

Recommended Personnel Involvement:
Town Engineer
Developers

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

Steep slopes can be characterized as any slope exceeding 10% which is measured by 1 foot of vertical drop per 10 feet of horizontal distance. Yet the variation on surface soil can make this definition debatable. The erodibility of surface soil can make flatter slopes fall under this classification if it is highly erodible along with the surface geology which is another aspect that determines the steepness of a slope.

The instability of slopes due to development causes destruction to the vegetative state, root systems and soil structures. The increase in flow velocity introduced by developmental construction exposes steep slopes to destructive and unsightly erosion, bare slopes, the chances of difficult re-vegetation and sediment deposition.

The minimization of the area and time of disturbance to the natural terrain should be a top priority with developers as construction takes place on a site. The protection of the site, vegetation, and all other inhabitants living in this constructed area should be protected and stabilized during development.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-01.4

Activity: Karst Topography

PLANNING CONSIDERATIONS:

Planning:
Not Required

Training:
Not Required

Recommended Personnel Involvement:
Town Engineer
Developers

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

Karst bedrock areas are underlain by bedrock containing soluble minerals. Karst areas develop voids and solution channels as groundwater gradually dissolves the bedrock. In these terrains, groundwater flow can be extremely rapid and unpredictable. Furthermore, the concentration of runoff may stimulate the formation of sinkholes. Sinkholes can develop as flowing water exposes and then washes into the mouths of the near surface openings of subterrain channels and caverns. Rapid degradation of groundwater resources can result when sediment or pollutant- laden runoff percolates into karst bedrock aquifers.

Few areas of Southern Indiana are susceptible to the development of karst conditions. Before introducing site alterations, which could concentrate or pond runoff, the presence or absence of carbonate bedrock should be established. If carbonate rocks do occur, a professional geologist or civil engineer should be consulted to determine whether sink hole activity is likely. The United States Geological Survey is a good source of information on karst bedrock in Indiana. If an area is prone to sink hole development, site drainage should be planned to minimize the concentration of runoff. This can be accomplished by reducing the hydraulic connectivity of impervious surfaces and by the use of filter strips. Where they are required, channels or ponds should be lined.

BMPs for the recharge of groundwater in karst areas provide infiltration opportunities over a very large area. Examples are filter strips, large bioretention facilities, and permeable pavement. These practices mimic the natural process by which rainfall enters the subsurface. Point sources of infiltration, such infiltration trenches or dry wells, should be avoided.

SPD – 02

Minimizing Impervious Surfaces

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-02.1

Activity: Parking Lot Design

PLANNING CONSIDERATIONS:

Planning:
Required

Training:
Required

Recommended Personnel Involvement:
Town Engineer
Developers

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 amount of runoff volume in parking lot designs, infiltration swales and vegetation incorporation to reduce paved surfaces may occur. These two alternatives would provide water quality benefits to the parking lot design.

Reduced paved surfaces increases the amount of sediment-laden runoff that can be filtered through vegetation and settlement provided by swales. Vegetation acts as a sponge where runoff is concerned. Leaves, stems and branches intercept rainwater which then evaporates. Depending on the type of vegetation, some may even encourage infiltration (deep-rooted prairie plants).

While vegetation increases the amount of sediment-laden runoff captured and evaporated, swales enable sediment to settle out producing a cleaner runoff for the environment.

Suitable Applications

- To compensate overly generous parking ration requirements.
- Lots desiring minimum stall dimensions.
- To use the most space-efficient stall configuration for a site.

Approach

Pavement Reduction can be established in 3 main ways:

1. Changing Municipal Codes.
2. Reducing stall dimensions.
3. Promoting shared parking lots.

Activity: Parking Lot Design	SPD-02.1

Installation Procedures	➢ Avoid compaction by not driving on areas during construction. ➢ Loosen soils in planting areas to a depth of 24 inches, to a maximum compaction of 85% standard proctor density.
Maintenance	➢ Planted areas must be weeded monthly during the first two to three years. After initial years, once or twice a growing season will be sufficient. ➢ Water regularly during dry spells. ➢ Irrigation should be two inches per week maximum. ➢ Push street snow away from swales during winter seasons to avoid road sand accumulation.
Inspection Checklist	❑ Plants are watered regularly during dry weather. ❑ Weeds are under control.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-02.2

Activity: Street Design

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers

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 design of a street will determine the effects of stormwater runoff. This gives a developer numerous opportunities to reduce impervious areas and aid in the reduction of runoff and management requirements associated with runoff. Natural drainage patterns should be preserved whenever possible during street design planning. This ensures that maximum stormwater filtration and infiltration can take place.

Suitable Applications

- Siting of streets.
- Design width.
- Street drainage.

Approach

- Siting of Streets: This is a large consideration when planning the layout of a new street network layout or the siting of a road. To maximize stormwater filtration and infiltration, municipalities should aim to preserve natural drainage patterns whenever possible and avoid locating streets (and other impervious surfaces) in low areas or on highly permeable soils. The network selected should also be considered due to the total amount of pavement to be affected.
- Design Width: Streets should be designed with the minimum pavement width that will support the area's traffic volume; on street parking needs; and emergency, maintenance and service vehicles.
- Street Drainage: Curbless road design, such as the so-called "rural residential section" encourages infiltration via roadside swales. On low-traffic streets without curbs, grass shoulders can serve as an occasional parking lane, allowing a narrower paved area.

Activity: Street Design	SPD-02.2

Advantages

- Thoughtful siting and design of streets helps achieve stormwater control "at the source", which means less runoff requiring management, less stormwater infrastructure, and less impact on downstream water bodies.
- Reducing paving lowers development and maintenance costs.
- Forgoing curb-and-gutter in favor of a rural residential section in major cost savings
- Rural-section streets can incorporate attractive "rain garden" planting in low areas adjacent to the roadway, when soil permits.
- Narrower streets tend to slow traffic and create a more pedestrian-friendly environment.
- Reducing pavement lessens the urban heat island effect-the increase in air temperature that occurs when highly developed areas are exposed to the sun.

Limitations

- Local ordinances may preclude narrowed or curbless street design.
- Cities' desire to design roads to accommodate future growth may impede innovations.
- Roadside swales are difficult to accommodate in single family residential developments with net densities above 8 units per acre.
- Good drainage for road subgrade must be provided when using roadside infiltration methods.
- Soil and topography may limit street siting opportunities.

Design Requirements

- Design residential streets with the minimum pavement width necessary to support: the traffic volume; on-street parking needs; and emergency, maintenance, and service vehicles.
- Use shallow, grassed roadside swales (rural residential cross section) instead of curb and gutter when net densities are 6 to 8 units or acre or less.
- Swales to catch road runoff should be sloped no more than 3:1.
- Limit sidewalks to one side on roads with less than 400 Average Daily Traffic (ADT) (or 200 ADT for cul-de-sacs).
- Resist designing for distant future growth.

Construction Requirements

- Take care not to compact adjacent, permeable soils during road construction.
- Protect swales and other infiltrations areas from sediment influx during construction, or remove sediment after construction is complete.

Maintenance

- Swales planted with perennials grasses and wildflowers rather than turf grass must be weeded at least monthly during the first two to three years. After that, weeding once or twice a growing season may suffice.
- Swales will need periodic sediment removal to maintain volume and filtering ability.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPDs)

SPD-02.3

Activity: Cul-de-sac Design

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

Impervious areas can greatly be decreased with the Cul-de-sac design in subdivisions. The smallest possible radius to this area ensures that stormwater runoff has less impact on downstream water bodies. The smallest design with a radius of 40 feet will accommodate the turning of most emergency service vehicles, while a 30 feet radius will allow the largest of these same vehicles one backing movement in order to turn around. This difference in radius can reduce the imperious coverage by 50%. Other combating methods of runoff acceptance in a Cul-de-sac stem from the application of flat apron curbs, islands to accept runoff from surrounding area and T-shaped turnarounds.

Suitable Applications

- Subdivisions with tight developmental budgets.
- Small subdivisions have 10 or fewer homes will benefit from the T-shaped turnaround.
- Highly developed areas desiring a solution to the urban heat island effect.

Advantages

- Cul-de-sac designs like those suggested here result in less management of stormwater runoff and less impact on downstream water bodies.
- Planted Cul-de-sac islands are attractive amenities.
- Less paving can lower development costs.
- Reducing pavement lessens the urban heat island effect-the increase in air temperature than can occur when highly developed areas are exposed to the sun.
- Reducing pavement can help reduce the increased runoff temperature commonly associated with impervious cover.

Activity: Cul-de-sac Design

SPD-02.3

Limitations

- City ordinances may not accommodate small radii cul-de-sacs, due to accommodations for emergency vehicles.
- Hammerhead turnarounds require vehicles to make a three-point-turn to exit.
- In first two to three years, planted islands require more maintenance than paving.

Installation Procedures

- Avoid compacting soil in center island, till soil to a 2 foot depth.
- Select vegetation that thrives on high rainfall and drought.

Design Criteria

- Areas with low traffic volume (10 or fewer homes) should consider a T-shaped turnaround.
- Design Cul-de-sac with radius of 30 feet or less to reduce runoff from the area.
- Widen rear pavements in Cul-de-sacs to ensure a easier turning.
- Islands should be maintained and vegetation planted for the appropriate soil type.
- Include an unpaved, depressed island, using whatever radius will allow a 20-foot road width.

Construction Criteria

- During paving, care should be taken to avoid compacting soil in center island. Should compaction occur, it may be necessary to rip or till soils to a depth of 2 ft.
- Choose plants that will thrive when rainfall is high, as well as during droughts without watering.

Maintenance

- Cul-de-sac island planting areas must be weeded monthly during the first two to three years. After that, weeding once or twice a growing season may suffice.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-02.4

Activity: Permeable Pavements (Turf Pavers)

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Developers
Contractors

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

Infiltration and the reduction of runoff are a result of turf paving. The decrease arises from modular paving blocks or grids, cast-in-place concrete grids and soil enhancement technologies. Healthy grass growth as well as foot and vehicular traffic occur as a result of the site's increased load bearing capacity.

Suitable Applications

- Areas desiring roadside right-of-ways
- Emergency access lanes.
- Delivery access routes.
- Overflow parking areas.

Approach

- Modular Paving Blocks and Grids
  Modular paving blocks or grass pavers consist of concrete or plastic interlocking units that provide structural stability while a series of gaps planted with turf grass allow for infiltration. Some blocks may also be filled with gravel and left unplanted. Depending on the use and soil type, a sand setting bed and gravel sub base is often added underneath to help further infiltration and prevent settling.
- Cast-in-Place Concrete Systems
  Monolithic concrete pavements incorporate gaps that are filled with topsoil and grass for a free-draining "pavement" with the structural capacity to handle most heavy vehicle loads. The surface is similar to that of modular concrete paving blocks.
-

Activity: Permeable Pavements (Turf Pavers)

Approach (Continued)

- Soil Enhancements
  The soil-amendment technology discussed here employs synthetic mesh elements blended with a sandy growing medium, resulting in a natural turf surface and an engineered load-bearing root zone. Appropriate for summer overflow parking, golf courses, recreational fields and areas where the aesthetic appeal of uninterrupted grass is important.

Advantages

- Turf pavers reduce or eliminate other stormwater management techniques by reducing runoff.
- Applied in combination with other BMP's, pollutant removal and stormwater management can be further improved.
- There may be a construction cost savings due to reduced curb-and-gutter requirements.
- Turf pavers are appropriate for driveways, walkways and overflow parking areas where handicapped access is not required or provided elsewhere.
- Turf helps soften the look of an area and make it more pleasant for pedestrians.
- Soil-enhanced turf systems are advantageous for sports and recreation fields as they resist compaction, thus increasing infiltration, and provide a soft playing surface.
- The mesh elements stabilize soil without reducing its permeability. The elements combat compaction, as they flex under pressure and "cultivate" the surrounding soils.
- Snow melts faster on a porous surface because of rapid drainage below the snow surface.
- Porous pavement can help to reduce the increased runoff temperature commonly associated with impervious cover.

Limitations

- For reasons of durability and maintenance, turf pavers are not recommended for high-traffic areas.
- Turf paving systems limit wheelchair access.
- Snow removal can be difficult, as plow blades can remove vegetation and catch the edge of the blocks, damaging the surface.
- Salt and sand in runoff from adjacent impervious pavement can damage turf and clog gaps in the blocks.
- Construction costs for turf paving may be higher than conventional pavements. Maintenance costs are generally higher.
- Clay soils will limit infiltration.
- Since turf paving encourages infiltration, it should not be applied on stormwater hotspots, places where land use or activities generate highly contaminated runoff, due to potential for groundwater contamination.

Design Criteria

- Infiltration rates are affected by soil types and should be considered when designing turf areas.
- Soil type also affects the sub base depth.
- Fill voids with sand or sandy loam planting base (adhere to manufacturer's recommendations).

Activity: Permeable Pavements (Turf Pavers)	SPD-02.4

Construction Requirements

- Modular and Cast-in-Place Concrete Systems

  Cells may be planted in one of three ways:

  1. Fill with a porous backfill mix (some products require sharp sand), scrape or back rake the entire surface to expose pattern. Broadcast seed or stolons or hydroseed and then top dress and fertilize as required.
  2. Fill and scrape or back rake as above, then lay 5/8- inch sod on the assembled pavers. Water the sod, then use a hand water roller or power-driven roller to compress the sod and root system completely into the cells.
  3. Do not fill the cells with any type of soil mixture. Lay 1-inch sod on the assembled pavers. Water the sod and compress as above.

- Soil Enhancements

  Sand or a proprietary growing medium is blended with a specific proportion of mesh elements using a mechanical shovel. A 20 kg sample of mixed material will contain 55.4-66.7 g of mesh elements (or approximately 44 lb. mesh for 5 cubic yards of sand mix). Manufacturer will supply precise proportions.

  For some proprietary systems, materials are sourced locally and the patent-holder acts as project manager for the installation, using specially designed machines.
  Grass cover is established using pre-germinated seed, washed turf or conventional seed.

  Nonessential traffic should be kept off the area until grass is well-established.

Maintenance

- Maintain turf pavers by irrigation, mowing, and fertilizing. Do not aerate.
- Grass cover is established using pre-germinated seed, wash turf or conventional seed.
- Nonessential traffic should be kept off the area until grass is well-established.
- Wear patterns occur due to high frequency traffic, rest periods will allow turf to grow back to its kept height.
- Plow outfitted with a flexible plastic/rubber piece on the bottom will help to protect the product while maintaining the turf area.

Inspection Checklist

- ☐ Turf method matches soil type.
- ☐ Turf is maintained to accommodate traffic patterns.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-02.5

Activity: Open-Space Preservation

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

An open space conservation program involving a combination of method merging long-range planning with an opportunistic action approach. Those methods include: outright purchase of land at full or "bargain-sale" prices; establishment of permanent Conservation Restrictions through gift or purchase; exercise of the local first refusal right; limited development purchases; and others.

Suitable Applications

When prime open space in a community becomes available the opportunity to create blocks or greenbelts of local conservation land should be taken advantage of by the community.

Planning Considerations

- Land preserved through acquisition, deed restriction, or other methods should be representative of each major land or habitat type within the town, and should be joined to form connecting corridors wherever possible.
- A multi-faceted local approach to the preservation of open space requires the support of Town Meetings, a willingness to work with local or regional land trusts, the existence of a working open space plan, and the maintenance of a healthy conservation fund.

	Southern Indiana **Stormwater Best Management Practices (BMPs)** **Site Planning and Design Practices (SPD's)**	SPD-02.6
	Activity: Construction Phasing	

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

A work schedule that coordinates the sequence of land-disturbing activities with the installation of erosion and sedimentation control practices.

A construction sequence schedule is a specified work schedule that coordinates the timing of land-disturbing activities and the installation of erosion protection and sedimentation-control measures.

Approach

To reduce on-site erosion and off-site sedimentation from land-disturbing activities by installing EPSC practices in accordance with a planned schedule.

Reduce on-site erosion and off-site sedimentation by performing land-disturbing activities and installing EPSC practices in accordance with a planned schedule.

Preserving the natural vegetation on-site to the maximum extent practicable will minimize the impacts of development on stormwater runoff. Preferably 65% or more of the development sit should be protected fro the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors.

Suitable Applications	Purpose of the construction sequence schedule is to address EPSC in an efficient and effective manner. Appropriate sequencing of construction activities can be a cost-effective way to help accomplish this goal. The plan can be open to changes that would be discussed at the erosion control project meetings. The generalized construction activities shown in the following Table SPD 02.6-01, do not usually occur in a specified linear sequence, and schedules will vary due to weather and other unpredictable factors. However, the proposed construction sequence should be indicated in the EPSC plan.
Maintenance	➢ Follow the construction sequence throughout project development. ➢ When changes in construction activities are needed, amend the sequence schedule in advance to maintain management control. ➢ Vegetation and trees should not be removed from the natural growth retention area, except for approved timber harvest activities and the removal of dangerous diseased trees.

Table SPD-02.6-1
SEQUENCING TABLE

	CONSTRUCTION ACTIVITY	SCHEDULE CONSIDERATION
1	Identify and label protection areas (e.g. buffer zones, filter strips, trees)	Site delineation should be completed before construction begins
2	Construction access. Construction entrance, construction routes, equipment parking areas and cutting of vegetation (necessary perimeter controls.	First land-disturbing activity. - Establish protected areas and designated resources for protection. Stabilize bare areas immediately with gravel and temporary vegetation as construction takes place.
3	Sediment traps and barriers. Basin traps, sediment fences, and outlet protection	Install principal basins after construction site is accessed. Install additional traps and barriers as needed during grading
4	Runoff control. Diversions, silt fence, perimeter dikes, and outlet protection.	Install key practices after principal sediment traps and before land grading. Install additional runoff control measures during grading.
5	Runoff conveyance system. Stabilize stream banks, storm drains, channels, inlet and outlet protection, and slope drains.	Where necessary, stabilize stream banks as early as possible. Install principal runoff conveyance system with runoff-control measures. Install remainder of system after grading.
6	Grubbing and grading. Site preparation: cutting, filling and grading, sediment traps, barriers, diversions, drains, surface roughening.	Begin major grubbing and grading after principal sediment and key runoff control measures are installed. Clear borrow and disposal areas only as needed. Install additional control measures as grading progresses.
7	Surface stabilization: temporary and permanent seeding, mulching, sodding, and installing riprap.	Apply temporary r permanent stabilization measures immediately on all disturbed areas where work is delayed or complete.
8	Building construction: buildings, utilities, paving	Install necessary erosion and sedimentation control practices as work takes place.
9	Landscaping and final stabilization: topsoiling, planting trees and shrubs, permanent seeding, mulching, sodding, installing riprap.	Last construction phase - Stabilize all open areas including borrow and spoil areas. Remove and stabilize all temporary control measures.
10	Maintenance	Maintenance inspections should be performed weekly, and maintenance repairs should be made immediately after periods of rainfall.

SPD – 03

Vegetative Practices

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-03.1

Activity: Vegetative Buffers

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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 buffer consist of an undisturbed vegetation that has been enhanced or restored surrounding an area of disturbance or bordering streams, ponds, wetlands or lakes. This buffer filters and infiltrates runoff, reduces storm runoff velocities, protects channel banks, provides flood protection and a number of other enhancing traits.

Suitable Applications

- Areas desiring enhancement to wildlife inhabitant.
- Areas needing temperature regulation and replenishment of wildlife victuals.

Installation Procedures

- Planting can consists of bare root seeding.
- Container grown seeding, grown plants and balled and burlapped plants.
- Soil preparation and maintenance are essential for the establishment of planted vegetation.
- Standard permanent erosion control grasses and legumes may be used in denuded areas for quick stabilization.

Maintenance

- Areas closest to the stream should be maintained with minimum impact.
- Water during periods of drought as well as during the initial year, watering may be necessary in all buffer areas planted or seeded for enhancement.
- It is imperative that the structure of the vegetated stream buffer be maintained.
- If the buffer has been planted, it is suggested that the area be monitored to determine if plant material must be replaced. Provisions for the protection of new plantings from destruction or damage from beavers or other damaging pests should be incorporated into the plan.

Design Criteria

- Buffer width should be selected to permit the zone to perform its intended purpose.
- Slope, hydrology, width and structure shall be considered.

	Southern Indiana **Stormwater Best Management Practices (BMPs)** **Site Planning and Design Practices (SPD's)**	SPD-03.2
	Activity: Disturbed Stabilization (Temporary Seeding)	

PLANNING CONSIDERATIONS:

Planning:
Not Required

Training:
Not Required

Recommended Personnel Involvement:
Town Engineer
Developers
Contractors

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

For seasonal protection and areas with fast growing species the establishment of temporary seeding is desired to reduce storm water runoff velocity, maintain sheet flow, protect the soil surface from erosion, to promote infiltration of runoff into the soil, improve wildlife habitat, aesthetics and soil condition for permanent planting.

Suitable Applications

- Coordinate with permanent measures to assure economical and effective stabilization.
- Used as companion crops until permanent seeding is established.

Installation Procedures

- Seedbeds are to be compacted by equipment or rainfall unless hydraulic seeder is used
- Soil shall be disked, plowed, tiled or otherwise scarified for seed lodgment and germination.
- Select grass or grass-legume mix to coincide with the area and season.
- Apply uniformly by hand, cyclone seeder, drill, cultipacker seeder, or hydraulic seeder.
- Drill or cultipacker should place seed ½ -1/4 inch deep.
- Watering of area should be at a rate not to cause runoff or erosion during drought season.
- Water depth should ensure germination of the seed.

Maintenance

- Inspection of area made before anticipated rain events and within 24 hours after the end of a storm event of 0.5 inches or greater.
- Maintenance should be corrected prior to the next known storm event or within 7 days after identification.

Inspection Checklist

- ❑ Identified areas that require re-seeding.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-03.3

Activity: Disturbed Area Stabilization (Permanent Seeding)

PLANNING CONSIDERATIONS:

Planning:
Not Required

Training:
Not Required

Recommended Personnel Involvement:
Town Engineer
Developers
Contractors

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

Final stabilization occurs when perennial vegetation is introduced to construction areas. This stabilization occurs as a result of planting trees, shrubs, vines, grasses or legumes on exposed areas. The result of this aesthetic overture reduces stormwater runoff velocity, maintains sheet flow, protect soil surface from erosion, promotes infiltration of runoff into the soil and improves wildlife habitat. Permanent stabilization also acts as a protective cover for cuts, fills, and other denuded areas that will not be regarded.

Suitable Applications

- Areas where topsoil was never stripped.
- Topsoil has been returned and incorporated into the soil surface.

Design Criteria

- Stripped sites should save stockpile for later use.
- Stockpiled topsoil should be stabilized using vegetation.
- Topsoil shall be incorporated into the site if a suitable medium is not present.
- Irrigation should be done when soil is dry or summer planting is done.
- To ensure erosion control, low maintenance plants and native species should be used. Wildlife planting is to be applied when applicable.

Installation Procedures

- Grade and shape slope unless hydraulic seeding has taken place.
- Divert erosion causing concentrations of water to safe outlets.
- Plants should be selected based on characteristics specific to soil conditions, site, planned and maintenance of the area, method of planting, etc.
- Topsoil should be friable and loamy, free of debris with a uniform application of 5 inches recommended.
- Seedbed preparations: When conventional seeding is to be used, topsoil should be applied to any are where the disturbance results in subsoil being the final grade surface.

Broadcast Planting

1. Seedbed preparation may not be required where hydraulic seeding equipment is to be used.
2. Tillage, at a minimum, shall adequately loosen the soil to a depth of 4 to 6 in.; alleviate compaction; incorporate topsoil, lime, and fertilizer; smooth and firm the soil; allow for the proper placement of seed, sprigs, or plants; and allow for the anchoring of plants; and allow for the anchoring of straw or hay mulch if a crimper is to be used.
3. Tillage may be done with any suitable equipment
4. Tillage should be done parallel to the contour where feasible
5. On slopes too steep for the safe operation of tillage equipment, the soil surface shall be pitted or trenched across the slope with appropriate hand tools to provide consecutive beds, 6 to 8 in. apart, in which seed may lodge and germinate. Hydraulic seeding may also be used.

Individual Plants

1. Where individual plants are to be set, the soil shall be prepared by excavating holes, opening furrows, or dibble planting.
2. For nursery stock plants, holes shall be large enough to accommodate roots without crowding.
3. Where pine seedlings are to be planted, use a subsoiler under the row to a depth of 36 in. on the contour four to six months prior to planting. Subsoiling should be done when the soil is dry, preferably in August or September.
4. Trees should not be planted in power line right-a-ways or under power lines.

Inoculants

1. All legume seeds shall be inoculated with appropriate nitrogen fixing bacteria. The inoculants shall be pure culture prepared specifically for the seed species and used within the dates on the container.
2. A mixing medium recommended by the manufacturer shall be used to bind the inoculants to the seed. For conventional seeding, twice the amount of inoculants recommended by the manufacturer. For hydraulic seeding, four times the amount of inoculant recommended by the manufacturer shall be used.
3. All inoculant seed shall be protected from the sun and high temperatures and shall be planted the same day inoculated. No inoculated seed shall remain in the hydroseeder longer than one hour.

Installation Procedures (Continued)

Planting

1. Hydraulic Seeding: Mix the seed (inoculant if needed), fertilizer, and wood cellulose or wood pulp fiber mulch with water and apply in a slurry uniformly over the area to be treated. Apply within one hour after the mixture is made.
2. Conventional Seeding: Seeding will be done on a freshly prepared seedbed. For broadcast planting, use a cultipacker seeder, drill, rotary seeder, other mechanical seeder, or hand seeding to distribute the seed uniformly over the area to be treated. Cover the seed lightly with 1/8 to ¼ in. of soil for small seed and ½ to 1 in. for large seed when using a cultipacker or other suitable equipment.
3. No-Till Seeding: No-till seeding is permissible into annual cover crops when planting is done following maturity of the cover crop or if the temporary cover stand is sparse enough to allow adequate growth of the permanent (perennial) species. No-till seeding shall be done with appropriate no-till seeding equipment. The seed must be uniformly distributed and planted at the proper depth.
4. Individual Planting: Shrubs, vines and sprigs may be planted with appropriate planters or hand tools. Pine trees shall be planted manually in the subsoil furrow. Each plant shall be sent in a manner that will avoid crowding the root.

Nursery stock plants shall be planted at the same depth or slightly deeper than they grew at the nursery. The tips of the vines and sprigs must be at slightly above the ground surface.

Where individual holes are dug, an appropriate amount of fertilizer shall be placed in the bottom of the hole, two in. of soil shall be added, and the plant shall be set in the hole and the hole filled.

Applying Mulching

Mulch is required for all permanent vegetation applications. Mulch applied to seeded areas shall achieve 75% soil cover. Select the mulching material from the following and apply as indicated.

1. When using temporary erosion control blankets or block sod, mulch is not required.
2. Dry straw or dry hay of good quality and free of weed seeds can be used. Dry straw shall be applied at the rate of 2 tons per acre. Dry hay shall be applied at a rate of 2 ½ tons per acre. *Sericea lespedeza* hay containing mature seed shall be applied at a rate if three tins per acre.
3. Straw or hay mulch will be spread uniformly within 24 hours after seeding and/or planting. The mulch may be spread by blower type spreading equipment, other spreading equipment or by hand.
4. Wood cellulose mulch or wood pulp fiber shall be used with hydraulic seeding. It shall be applied at the rate of 500 pounds per acre. Dry straw or dry hay shall be applied (at the rate indicated above) after hydraulic seeding.
5. One thousand pounds per acre of wood pulp fiber, which includes a tackifier, shall be used with hydraulic seeding on slopes ¾:1 or steeper.
6. Wood cellulose and wood pulp fibers shall not contain germination or growth inhibiting factors. They shall be evenly dispersed when agitated in water. The fibers shall contain a dye to aid in uniform application during seeding.

Activity: Distributed Area Stabilization (Permanent Seeding)	SPD-03.3

Installation Procedures (Continued)

Anchoring Mulch

1. Emulsified asphalt can be (a) sprayed uniformly onto the mulch as it is ejected from the blower machine or (b) sprayed on the mulch immediately following mulch application when straw or hay is spread by methods other than special blower equipment. The combination of asphalt emulsion and water shall consist if a homogeneous mixture satisfactory for spraying. The mixture shall consist of 100 gallons of water per ton of mulch. Care shall be taken at all times to protect state waters, the public, adjacent property, pavements, curbs, sidewalks, and all other structures from asphalt discoloration.
2. Hay and straw mulch may be pressed into the soil immediately after the mulch is spread. A special "crimper" or disk harrow with the disks set straight may be used. Serrated disks are preferred, and should be 20 in. or more in diameter and 8 to 12 in. apart. The edges f the disks shall be dull enough to press the mulch into the ground without cutting it, leaving much of it in an erect position. Mulch shall not be plowed into the soil.
3. Synthetic tackifiers or binders may be applied in conjunction with or immediately after the mulch is spread. Synthetic tackifiers should be mixed and applied according to manufacturer's specifications.

Irrigation

Irrigation will be applied at a rate that will not cause runoff.

Maintenance

- Inspect seeding and mulch regularly.
- Any washout areas should be repaired immediately.
- Maintenance needs that have been identified should be repaired before the next storm event or within seven days of identification.

Inspection Checklist

- [ ] Inspect all applications and make appropriate repairs.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-03.4

Activity: Disturbed Area Stabilization (Mulch)

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

Mulch is used to promote vegetation during vegetative stabilization practices to reduce stormwater runoff and erosion, conserve moisture, promote germination of seed, prevent surface compaction or crusting, protect seed from birds, modify soil temperature and increase biological activities in the soil.

Suitable Applications

- Cleared areas where seed may not promote an erosion –retardant cover.
- Protection of seed from birds.
- Reduction of soil surface temperature is desired.

Design Criteria:

- Select mulching material depending on desired soil coverage.
- Anchor mulch immediately after application.

Installation Procedures

- Grade to enable use of equipment for mulch application.
- Install BMP as required (diversions, terraces, and/or sediment barriers).
- Loosen compacted soil to a minimum depth of 4 inches if using mulch while seeding.
- Anchor mulch by using emulsified asphalt, hay and straw mulch or synthetic tackifiers.
- Emulsified asphalt should be sprayed uniformly onto the mulch with 100 gallon water to 100 gallon of asphalt ratio per ton of mulch.
- Hay and straw are to be pressed into the soil immediately after the mulch is spread.

Activity: Distributed Area Stabilization (Mulch)	SPD-03.4

Maintenance

- When applying mulch, protect state waters, the public, adjacent property, pavements, sidewalks and curbs, and other structures from asphalt discoloration.
- Mulch should not be plowed into the soil.
- Synthetic tackifiers should be mixed and applied according to manufacturer's specification.
- Areas disturbed by blowing wind should be retreated.
- Maintenance needs identified should be repaired before the next storm event or within 7 days after being identified.

Inspection Checklist

- ❑ Inspection should coincide with other erosion and sediment control inspections.
- ❑ Site reviewed after wet weather event.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-03.5

Activity: Disturbed Area Stabilization (Sodding)

PLANNING CONSIDERATIONS:

Planning:
Required

Training:
Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

Areas needing immediate vegetative cover such as grass swales, drop inlets, and waterways with intermittent flow use sod brought from other locations. This BMP is referred to as Disturbed Area Stabilization. The stabilization establishes immediate ground cover, reduces stormwater runoff, protects soil surface from erosion, reduces damage from sediment and runoff to downstream areas as well as improves aesthetics.

Installation Procedures

- Bring soil surface to final grade.
- Clear surface of trash.
- Apply sod to soil surfaces only (not frozen).
- Do not use top soil recently treated with herbicides.
- Mix fertilizer and/or lime into soil surface.
- Lay sod with tight joints and in straight lines.
- Stagger joints, do not stretch sod.
- Sod should be anchored with pins for slopes deeper than 3:1.
- Irrigate sod and the top 4 inches of soil immediately after installation.
- Excessive watering should not be performed. Irrigation should be used to supplement rainfall for a minimum of 2-3 weeks.

Design Criteria

- Sod selected material should be certified.
- Sod grown in the area is preferred.
- Sod should be machine cut and contain ¾ (+ or – ¼ inch) of soil.
- Cuts should be installed within 36 hours of digging.
- Avoid planting when subject to frost heave or hot weather if irrigating is not available.

Activity: Distributed Area Stabilization (Sodding)	SPD-03.5

Maintenance

- Re-sow areas where an adequate stand of sod is not obtained.
- New sod should be moved sparingly.
- Grass height should not be cut to less than 2-3 in.

Inspection Checklist

- ❑ Sod inspected after wet weather event.
- ❑ Sod is maintained to ensure grass height remains in specified range.

	Southern Indiana **Stormwater Best Management Practices (BMPs)** **Site Planning and Design Practices (SPD's)**	SPD-03.6
	Activity: Erosion Control Mats/Blankets	

PLANNING CONSIDERATIONS:

Planning:
Required

Training:
Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

In areas where erosion hazards are high matting and blankets can be applied. This protective blanket or stabilization mat aids in establishing temporary or permanent vegetation on steep slopes, channels or stream banks. The presence of this BMP prevents erosion to the soil surface or seed, promotes seed germination, protects young vegetation and prevents the dispersion of seed or mulch.

Suitable Applications

- All concentrated flow areas with slopes steeper than 2.5:1, with a height of 10 ft. or greater and cuts and fills within stream buffers.
- Temporary blankets should be (at a minimum) used to stabilize concentrated flow areas.
- Vegetative lining is desired in stormwater conveyance channels where velocity is projected to be between 5 and 10 ft. per second.

Design Criteria

- Care must be taken to choose the type of blanket or matting appropriate for each project.
- Rolled erosion control blankets are made of plastic netting intertwined with a natural organic or manmade mulch.
- Jute mesh is a typical homogeneous design that can act alone as a stabilization blanket.

Activity: Erosion Control Mats/Blankets	SPD-03.6

Installation Procedures

- Temporary blankets consist of straw blankets, excelsior, coconut, wood fiber and jute mesh.
- Straw blanket consist of weed free straw with a 5/16 x 5/16 top side and a minimum thickness of 3/8 in. and minimum dry weight of 0.5 lbs per square yard.
- Excelsior blankets are curled wood excelsior formed into a blanket with 1 ½ x 3 in. mesh sides and a minimum thickness of ¼ in. with a 0.8 dry weight lbs per square yard.
- Coconut blankets consist of 100% coconut fiber with a ¼ thickness, a minimum dry. weight of 0.5 lbs per square yard and a 5/8 x 5/8 in. maximum mesh .
- Wood fiber blankets consist of reprocessed wood fiber with a maximum mesh size of 5/8 x ¾ in. and a 0.35 lbs per square yard minimum dry weight.
- Jute mesh consist of woven root fiber or yarn with regularly spaced openings between strands and a 1.0 lbs per square yard dry weight for basic slope applications.
- Shape and grade site.
- Prepare a friable seedbed free from clods and rocks.
- Temporary blankets should be installed vertically from the top of the slope to bottom.
- For shallower slopes (less than 2:1) with height twice as much as the width, and a maximum height of 16 feet, the blanket may be applied horizontally. Concentrated flow area blankets should be placed in the direction of water flow.
- Entrench blanket beyond the top and bottom of the slope and at any horizontal joint a minimum of 6 in.
- Permanent matting begins installation at the bottom of the slope and works towards the top while being centered in the middle of the channel.
- Shingle upstream layer over downstream layer overlapping 3 ft.
- Temporary blankets should be anchored with staples per manufacturing directions.

Maintenance

- Manufacturer's recommendations should be followed when choosing products.
- All preliminary seeding and soil amendments should be done prior to installation of temporary blankets.
- Permanent matting areas should be brought to final grade before installation of matting. After installation and backfilling of topsoil, seeding and mulch should be applied.

Inspection Checklist

- ☐ Inspection completed before a storm event.
- ☐ Inspection completed within 24 hours after the end of a storm event of 0.5 inches or greater.

SPD – 04

Land Use Planning

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-04.1

Activity: Covenants

PLANNING CONSIDERATIONS:

Planning:
Required

Training:
Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

Conservation covenants are voluntary, legally binding agreements between a landowner and the State Government which are designed to provide permanent protection for areas or species that have conservation value. The covenant is registered on the title of the land and travels with the title to future landowners. Once a covenant is in place it can only be modified or revoked with the agreement of the landowner and the relevant state or local agency.

A management agreement is usually provided with a covenant and will detail how the conservation values are to be managed. Some activities such as grazing and firewood collection may be allowed within a conservation covenant. For those activities that are allowed, the details of how they will be undertaken are outlined in detail within the management plan. Both documents are drafted in consultation with the landowner.

The aim of conservation covenants is to ensure that land use is compatible with the natural values of that area. A conservation covenant will apply to all or most of the native vegetation on a property. However, a landowner may also choose to exclude parts of their property from the covenant for example to allow for building a house in the future.

Description (Continued)

Participation in a conservation covenant is entirely voluntary and the details of the covenant and management agreement are agreed only with the cooperation and consent of the landowner.

Management Agreements

Management agreements are agreements between a landowner and the State Government that are not registered on the land title. Management agreements set out required management practices to protect the nature conservation values.

Benefits of Covenanting Land

There are many benefits gained by having a conservation covenant on your land, they include:

- Rate rebates in some areas or districts.
- Exemption from land tax
- Having a conservation covenant helps if you are applying for grants for environmental work.
- By maintaining remnant native vegetation you benefit from erosion and salinity protection; and you provide shade and shelter for livestock; and protect wetlands, catchments and water quality.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-04.2

Activity: Setbacks and Buffers

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

A *setback* is the area between intensive development (i.e., buildings, parking lots, roads) and a protected area, such as a wetland. Setbacks are necessary for:

- Controlling the peripheral effects of development
- Protecting developments
- Providing access for maintenance

For example, a highway or parking lot built directly on the edge of a high-quality wetland may adversely affect water quality and wildlife habitat from pollutant runoff or spray and traffic noise. Setback requirements for structures, particularly adjacent to streams, reflect the fact that streams naturally meander or expand over time. Placing structures in the natural path of a meandering stream virtually guarantees that expensive stabilization measures will be needed in the future as the stream approaches building foundations, threatening their collapse.

Only limited activities are recommended for approval in a setback. The types of activities include minor improvements, such as walkways, foot bridges, and observation decks; roadways necessary for crossing a water body; maintenance and repair of existing roads and utilities; and the establishment of landscaped lawns or parks. In general, major modifications to the land surface should be avoided in setbacks.

Suitable

Description (Continued)	Limiting activities in a *floodway* to appropriate uses is similar to a setback requirement. A floodway is the part of the floodplain, centered on the stream, which will convey most of the flow during a high water event. Appropriate uses exclude most buildings and structures. However, other uses that are allowed may adversely affect water quality and habitat. These include: • Parking lots • Roadways parallel to the waterbody • Garages and storage sheds • Treatment plants and pumping facilities Within a setback, a *buffer strip* is the transitional vegetated area closest to the waterbody or wetland. The purposes of a buffer are to: • Minimize erosion • Stabilize the stream bank or lakeshore • Filter runoff pollutants from adjacent developments • Preserve fish and wildlife habitat • Screen manmade structures and preserve aesthetic values • Provide access for maintenance or trails Buffers reflect that natural aquatic systems may not function well in isolation and that a gradual continuum exists from natural riparian or wetland systems to upland. Ideally, a buffer should be maintained or planted in native riparian vegetation to maximize pollutant filtering, soil stabilization, and habitat functions.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Site Planning and Design Practices (SPD's)

SPD-04.3

Activity: Conservation Easements

PLANNING CONSIDERATIONS:

Planning: Required

Training: Required

Recommended Personnel Involvement:
Town Engineer
Town Attorney
Developers
IDEM
IDNR

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

Another useful tool for protecting sensitive areas is a conservation easement. A conservation easement incorporates legal provisions into a property deed that limits the use of the property. Conservation easements allow for the continued private ownership of the land but restrict land uses to current uses or to non-damaging activities. The legal concession may be donated by or purchased from the owner. The land owner also may be compensated by reduced property taxes on the land in the easement.

Erosion Prevention Practices

EPP – 01	Tire Washing Facility
EPP – 02	Construction Road Stabilization
EPP – 03	Stabilized Construction Entrance
EPP – 04	Buffer Zones
EPP – 05	Temporary Seeding
EPP – 06	Surface Roughening
EPP – 07	Top Soiling
EPP – 08	Mulching
EPP – 09	Nets and Mats
EPP – 10	Geotextiles
EPP – 11	Terracing

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-01

Activity: Tire Washing Facility

TW

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

Estimated Unit Cost:
Avg: $3000
Range: $1000-$5000

Annual Maintenance:
Negligible

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 application supports a stabilized construction entrance, to prevent or reduce the discharge of pollutants to the storm drain system or watercourses. As a result of vehicular ingress and egress to the construction site, the facility would remove mud and dirt from vehicle tires and the undercarriage to prevent materials from deposit onto public roads.

Suitable Applications

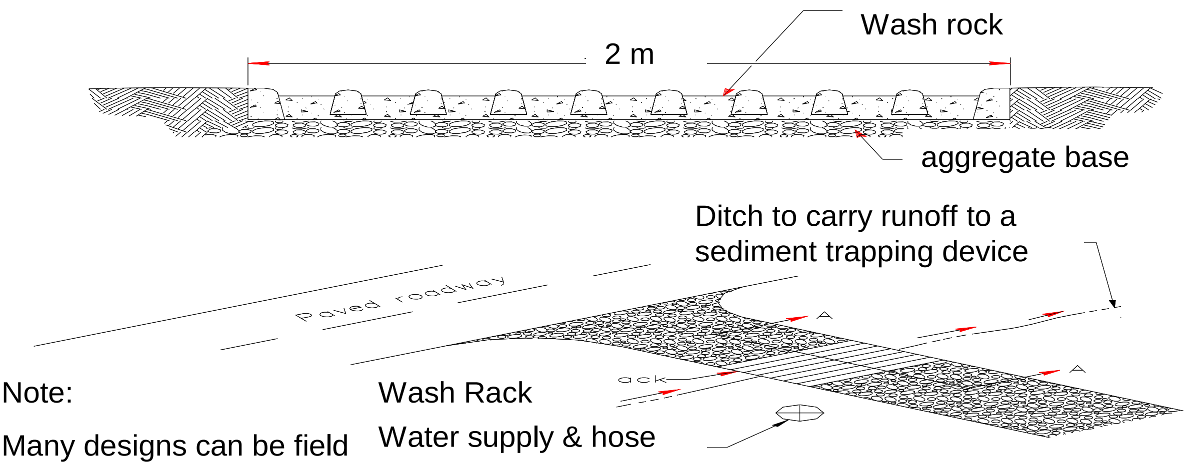
- Temporary construction traffic, phased construction projects and off-site road access.
- Typically used for large construction sites.

Approach

- Incorporate with the stabilized construction entrance, EPP-03.
- Place a layer of 2 to 3 inch stone across the full width of exit/entrance.
- Construct on level ground when possible, on a pad of course aggregate.
- Design tire rock to withstand anticipated traffic loads and drain to a detention pond or swale.
- If a swale is required, then it shall provide sufficient grade, width, and depth to carry wash off.
- The swale shall carry runoff from the wash area to a sediment-trapping device.
- All employees, contractors, subcontractors, and others that leave the site with mud caked tires and/or undercarriages shall use construction entrance.
- Limit egress to the designated construction exit(s) by encouraging perimeter fencing around the construction entrance.

Activity: Tire Washing Facility

EPP-01



Note:

Many designs can be field fabricated or fabricated units may be used.

Installation Procedures for Tire Washing Facility

- Incorporate with a stabilized construction entrance.
- Place a layer of 2- to 3-inch (5.1- to 7.6-cm) stone across the full width of the exit and construct on level ground.
- If a wash rack is necessary, it shall be designed for anticipated traffic loads and drain to a detention pond or swale.
- If a swale is required, then it shall meet specific requirements needed to carry the wash runoff.
- The swale shall convey the runoff from the wash area to a sediment-trapping device.
- Require that all employees, subcontractors, and others that leave the site with mud-caked tires and/or undercarriages use the construction entrance.

Maintenance

- In the wash rack and/or sediment trap, remove accumulated to maintain system performance.
- Inspect routinely for damage ad repair as needed.

Inspection Checklist

- ❑ Vehicles are leaving the site through designated construction exit(s).
- ❑ Mud, dust or dirt is removed prior to exit onto the adjacent road.
- ❑ The construction exit is sufficiently maintained to prevent mud, dirt, and dust from being tracked off-site.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-02

Activity: Construction Road Stabilization

PLANNING CONSIDERATIONS:

Design Life:
2 yrs

Acreage Needed:
Variable

Estimated Unit Cost:
Avg: $2000
Range: $1000-$4000

Monthly Maintenance:
Negligible

CRS

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

Significant reduction in sediment will be created by stabilizing access roads, subdivision roads, parking areas, and other on-site vehicle transportation immediately after grading. Frequent preventative maintenance practices will help to control dust and erosion.

Suitable Applications

- Temporary construction traffic, phased construction projects and off-site road access.
- Detour roads for local or temporary construction traffic.
- Construction during wet weather.
- Construction roads utilizing a temporary stream crossing must be indicated and approved.

Approach

- Road should follow topographic contours to reduce erosion of the roadway. The roadway slope should not exceed 15 percent.
- Gravel roads should be a minimum 6-in.(15.2-cm) thick, 2-3 in.(5.1-7.6 cm) coarse aggregate base applied immediately after grading, or as recommended by a soils engineer or erosion control specialist.
- Chemical stabilizers or water are usually required on gravel or dirt roads to prevent dust. No additional costs for dust control on construction roads should be required above that needed to meet local air quality requirements.

Activity: Construction Road Stabilization	EPP-02

Installation Procedures for Construction Road Stabilization

- The implementation of this BMP depends largely on climate and weather conditions. Alternative routes should be established to incorporate these measures to account for conditions such as dry areas, wet conditions and other circumstances that would inhabit a safe and stable route for construction traffic. Permanent roads and parking areas should be paved as soon as possible after grading. The early application of gravel or chemical stabilization may solve potential erosion and stability problems where construction will be phased. Temporary gravel roadway should be considered during the rainy season and/or on slopes greater than 5 percent.
- When gravel roads are needed, a minimum 4-in. (10.2 cm) course of 2 to 4-in. (5.1- to 10.2-cm) crushed rock, gravel base, or crushed surfacing base course should be applied immediately after grading or the completion of utility installation within the right-of-way. Chemical stabilization may also be used upon compacted native sub-grade. These chemical controls should be applied per the manufacturer's directions.
- Roadways should be carefully graded to drain transversely. Provide drainage swales on each side of the roadway in the case of a crowned section, or one side in the case of super-elevated section. Simple gravel berms without a trench can also be used.
- Installed inlets should be protected to prevent sediment-laden water from entering the storm sewer system.

Maintenance

- Periodically apply additional aggregate on gravel roads.
- Active dirt construction roads are commonly watered three or more times per day during the dry season.
- Inspect weekly, and after each rain event. Repair any eroded areas immediately.

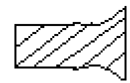
Inspection Checklist

- [ ] Gravel roads are preventing mud and dirt from leaving project area.
- [ ] Dirt and gravel roads do not show signs of erosion, including but not limited to, rill and gully erosion.
- [ ] All stream crossings are maintained as mandated by the appropriate general or individual permit.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-03

Activity: Stabilized Construction Entrance



SCE

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

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

Monthly Maintenance:
60% of Installation

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 construction entrance practice receives all incoming and outgoing traffic of the construction site. By stabilizing the construction entrance there will be a significant reduction in the amount of sediment to and from public right-of-ways, streets, alleys, sidewalks or parking areas. The construction entrance practice is a stabilized pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving. This management practice is likely to create a significant reduction in sediment, nutrients, toxic materials, and oil and grease.

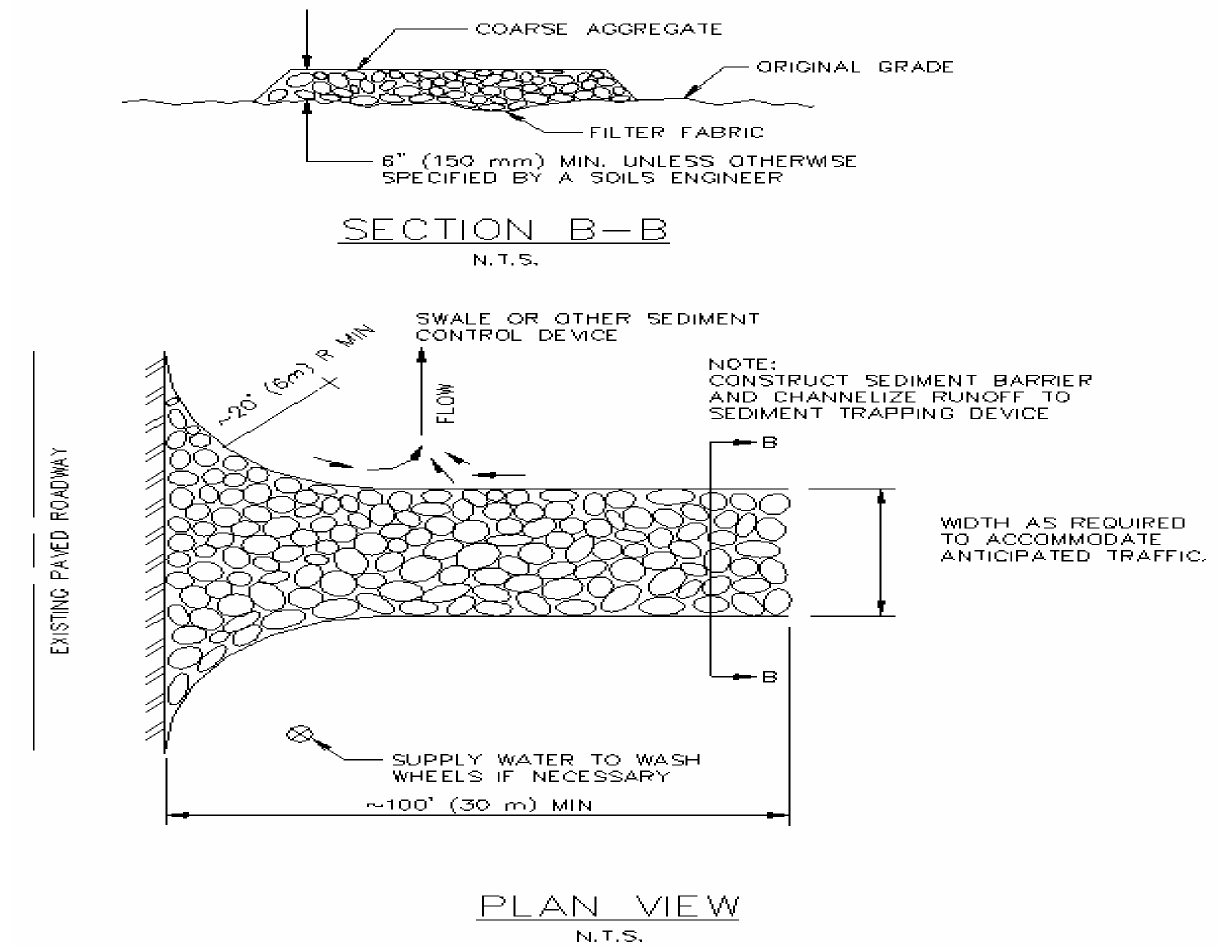
Suitable Applications

- All points of construction ingress and egress.
- Unpaved areas where sediment tracking occurs from site onto paved or public roads.

Approach

- Construct on level ground where possible.
- Stones should be 2-3 inch (5.1-7.6 cm) crushed, washed, and well graded rock to at least a 6-inch (15.2) depth. Length should be 100-foot (30.5 m) minimum, and 20-foot (6.1 m) minimum width.
- Provide ample turning radii as part of entrance.
- Should be used in conjunction with street sweeping on adjacent public right-of-way.
- Limit egress to the designated construction exit(s) by installing perimeter fencing.

Activity: Stabilized Construction Entrance	EPP-03



Installation Procedures

- A stabilized construction entrance is a pad of aggregate that may be enhanced with an underlain filter cloth.
- Wash rack may be included (depending on the type of tire washing facility to be constructed) to increase efficiency.
- Institute a sediment trap to collect wash water runoff.
- Sediment barriers, such as sames with check dams, must be provided to prevent sediments from entering into the stormwater sewer system, ditch, or waterway.

Maintenance

- Inspect weekly and after each rainfall.
- Periodically requires addition of stones for top; add gravel material when soil sub grade becomes visible.
- Remove all sediment deposited on paved roadways at the end of the work day.
- Remove gravel and filter fabric at completion of construction.

Inspection Checklist

- ❑ Vehicles are leaving the site in designated as construction exit(s).
- ❑ Mud, dust and dirt are not being tracked onto the roads adjacent to the construction entrance.
- ❑ The construction exit is sufficiently maintained to prevent mud, dirt, and dust from being tracked off-site.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-04

Activity: Buffer Zones

PLANNING CONSIDERATIONS:

Design Life:
Permanent

Acreage Needed:
Minimal

Estimated
Unit Cost:
Est. from Existing Vegetation: $0
Est. from Sod:
Avg: $11,000 Acre
Range: $4500 - $48000/Acre

Monthly Maintenance:
60% of Installation

BZ

BZ

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

Buffer Zones allow the utilization of vegetation to protect soils from erosion as well as decelerate the velocity of sediment runoff. This BMP allows the removal of sediment through filtering and settling. Temporary relief, permanent placement or buffer requirements may be needed for a no construction activity site to warrant the need for this BMP. This management practice is likely to create a significant reduction in sediment by reducing erosion and retaining plant vegetation along waterways.

Suitable Applications

- A buffer must at least include the floodway plus 50 feet (15.2 m) perpendicular to the floodway. If a floodway has not been determined, the buffer must be at least 25 feet (7.6 m) perpendicular from each side of the stream bank, creek, or unnamed waterway under “bank-full conditions.”
- Utilization or reinforcement of existing vegetation is preferred. However, where improvements are required; sodding, plugging, use of stockpiled vegetation or seeding is acceptable.
- Sodding is appropriate if it is part of the no construction activity area required by the Public Works Agency for areas that contained turf prior to construction, or for any graded or cleared areas that might erode and where a robust plant cover is needed immediately.

Activity: Buffer Zones

Approach

Sodding and Grass Plugging

- Sod shall be protected with tarps or other protective covers during delivery and shall not be allowed to dry out between harvesting and placement.
- All weeds and debris shall be removed before cultivation of the area to be planted and shall be disposed in accordance with local waste management ordinances.
- After cultivation, installation of irrigation systems, and excavation and backfilling of plant holes are completed, areas to be planted with sod shall be fine graded and rolled. Topsoil may be needed in areas where the soil textures are inadequate. Areas to be planted with sod shall be smooth and uniform prior to placing sod. Areas to be planted with sod adjacent to sidewalks, concrete headers, header boards, and other paved borders and surface areas shall be 1.5 in.-0.25 in. (38 mm-6 mm) below the top grade of such facilities after fine grading, rolling, and settlement of the soil. Sod shall be placed so that ends of adjacent strips of sod are staggered by half the width. All edges and ends of sod shall be placed firmly against adjacent sod and against sidewalks, concrete headers, header boards, and other paved borders and surfaced areas.
- After placement of the sod, the entire sodded area shall be lightly rolled to eliminate air pockets and to ensure close contact with the soil. After rolling, the sodded areas shall be watered so that the soil is moistened to a minimum depth of 4 in. (100 mm). Sod shall not be allowed to dry out. Sod should not be planted during very hot or wet weather. Sod should not be placed on slopes that are greater than 3:1 (H:V) if they are to be mowed.
- If irregular or uneven areas appear before or during the plant establishment period, such areas shall be restored to a smooth and even appearance.
- Sod shall be healthy, field-grown sod containing not more than 0.5-in. (13-mm) thick thatch. The sod shall be free from disease, weeds, insects, and undesirable types of grasses and clovers. Sod shall be machine cut at a uniform soil thickness of 0.625 in.-0.25 in. (16 mm-6 mm), not including top growth and thatch.

Vegetative Buffer Strips

For development of a vegetative buffer strip from new vegetation, the following steps shall be followed:

- Strip and stockpile good topsoil during construction. Use stockpiled topsoil for surface preparation prior to seeding operations.

Activity: Buffer Zones	EPP-04

Approach

- Prepare a good, firm seedbed by adding soil amendments such as fertilizer as needed. After seeding, apply mulch (straw layer, etc.) to protect the vegetation during establishment. Select a seed mixture appropriate to the site conditions, remembering that dense grasses are the most effective in slowing flow velocities and removing pollutants such as sediment. A thick root structure is needed to control erosion.
- Plant during the best time for the particular grass or vegetation selected.
- Use planting equipment and methods that provide uniform distribution and proper placement of seed.
- Water or irrigate the vegetation as needed to supplement rainfall until established.
- Fertilize in accordance with label instructions and the needs of the grass and soil as indicated by soil tests.
- Overseed, repair bare spots, or apply additional mulch as necessary.
- Avoid using the buffer strip for vehicular traffic as it will damage the vegetation and reduce its effectiveness as a buffer.

Maintenance

- Inspect sod installations weekly and after significant storm events, until the turf is established, and routinely thereafter.
- Maintenance shall consist of mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth.
- Inspect buffer strips weekly and after significant storm events until vegetation is established, and routinely thereafter. Repair eroded or damaged areas as needed to maintain original purpose and effectiveness of the buffer strip.

Inspection Checklist

- ☐ Flagging and fencing are kept in repair as needed.
- ☐ Sod is properly maintained and watered.
- ☐ Buffer strips are properly maintained.
- ☐ Significant rainstorm events have not deteriorated Buffer Zone.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-05

Activity: Temporary Seeding

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
As Needed

Estimated Unit Cost:
Avg: $100/acre
Range: $200-$1000/acre

Annual Maintenance:
20% of Capital Costs

TS

TS

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

For disturbed areas not suitable for seeding and areas with rapidly growing annual plants used to prevent erosion, this BMP helps to temporarily stabilize the soil. This management practice is likely to create a significant reduction in sediment and a partial reduction in nutrients and toxic materials. Temporary seeding may also prevent costly maintenance operations on other erosion control systems.

Suitable Applications

- Apply where final grading of exposed surfaces are to be completed within 15 days to a year.
- Apply to bare areas, soil stockpiles, dikes, dams, sides of sediment basins and temporary diversions.

Activity: Temporary Seeding	EPP-05

Approach

- Protect area against seed wash-out using surface roughening diversions or terraces.
- Soil should be analyzed for fertilizer and lime requirements.
- Apply fertilizer at a rate of 800 lbs. per acre with commercial grade 6-12-12 or apply fertilizer and lime per soil requirements.
- Weather conditions should be taken into account when seeding areas. Seeding should not take place during traverse weather conditions.
- Sod if required, should follow requirements for the State of Indiana.
- Sod should be Kentucky 31 Fescue, Bluegrass, or Bermuda grass.
- Sod shall be set or reset only when the soil is mist and favorable to growth. Setting will be as follows unless permission is granted by the engineer.
- Kentucky 31 Fescue – Anytime weather permits
- Bermuda grass – April 15 through August 14
- Bluegrass – March 1 through April 30; September 1 through October 31

Maintenance

- Inspect frequently within the first six weeks of planting to assure that appropriate moisture levels are maintained and determine if stands are uniform and dense.
- Make provisions to water as needed to penetrate to a depth of 6 inches (15.2 cm).
- Check for damage caused by equipment or heavy rains. Damaged areas should be repaired, fertilized, seeded, and mulched. Tack or tie down mulch as necessary.

Installation

- The chart below displays the recommended blend for seeding by season.

Recommended Seed Blend for Indiana.

Species or Mixture	**Seeding Rates (lbs / ac)**	**Seeding Dates (without mulch)**
General mix		
white clover Perennial rye grass Annual rye grass Creeping red fescue	8 5 8 10	Aug. 1-Sept. 1 Aug. 15-Sept. 15 Mar.1-May 1
Sun and Partial Shade Mix		
Kentucky 31 fescue and one of the following: spring oats, buckwheat creeping red fescue	20 30 20	Mar.1-May 1 and Aug.1-Oct. 1 Mar. 1-May 1 Mar. 1-May 1
Appalow sericea lespedeza: red top birdsfoot trefoil flatpea cereal rye, wheat, barley	10 2 10 30 30	Mar. 1-June 1 Mar. 1-Sept. 15 Mar. 1-Sept.15 Aug. 1-Sept. 15 Sept. 15-Oct.1
Full and Partial Shade Mix		
creeping red fescue & white clover	20 2	Mar. 1-May 1 Aug. 1-Sept. 1

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-06

Activity: Surface Roughening

SR

SR

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

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

Monthly Maintenance:
60% of Installation

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 corrects the affects of runoff velocities, sediment trapping and sheet flow length by constructing furrows across a slope, and utilizing construction equipment to track soil surface. This corrective measure is referred to as surface roughing, which corrects uneven bare soil. The primary function of surface roughening is to prepare a slope to receive permanent vegetation.

Suitable Applications

- On all construction slopes.
- On exposed soils where seeding, planting, and mulching will benefit from surface roughening.
- Areas that have the potential for erosion of clay (smooth, hard surfaces), silt or sand sized particles.
- Where the slope length needs to be shortened by terracing. Terracing is usually permanent and should be designed under the direction of and approved by a licensed professional civil engineer based on site conditions. Terraces must be designed with adequate drainage and stabilized outlets for the flow

Approach

Roughening methods include:
- stair-step grading
- furrowing

This must be done across the slope and along the contour. Tracking must be done up and down the slope. Factors to be considered in choosing a method are:
- slope steepness
- mowing requirements
- soil type
- whether the slope is formed by cutting or filling

Activity: Surface Roughening	EPP-06

Installation Procedures

Cut Slope Roughening

- Use stair-step grading or furrows (groove cuts) on slopes that are steeper than 3:1 (H:V).
- Use stair-step grading on erodible material that is soft enough to be ripped by a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the step in towards the slope.
- Do not make individual vertical cuts more than 600 mm (24 in.) high in soft materials or more than 1 m (3 ft.) high in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run across the slope and on the contour.

Fill Slope Roughening

- Place fill slopes with a gradient steeper than 3:1 (H:V) in lifts not to exceed 8 in. (200 mm), and make sure each lift is properly compacted.
- The face of the slope should consist of loose, uncompacted fill 4 in. (100 mm) to 6 in. (150 mm) deep.
- Use grooving or tracking to roughen the face of the slopes, if necessary.
- Apply seed, fertilizer and mulch then track or punch in the mulch. See Permanent Grass, Vines and Other Vegetation, Temporary Seeding, and Mulching BMPs.
- Do not blade or scrape the final slope face.

Cuts, Fills, and Graded Areas

- Slopes that will be maintained by mowing should be no steeper than 3:1 (H:V).
- To roughen these areas, create shallow grooves by normal tilling, disking, harrowing, or use a cultipacker-seeder. Make the final pass of any such tillage on the contour.
- Make grooves formed by such implements close together, less than 10 in. (250 mm) apart and not less than 1 in. (25 mm) deep.
- Excessive roughness is undesirable where mowing is planned.

Roughening with Tracked Machinery

- Limit roughening with tracked machinery to soils with a sandy textural component to avoid undue compaction of the soil surface.
- Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back blade during the final grading operation.
- Seed and mulch roughened areas to obtain optimum seed germination and growth.

Maintenance

- Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events, greater than 0.5 in. (1.2 mm).
- Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

Inspection Checklist

- ☐ Surface roughened are inspected after recent wet weather events.
- ☐ Rills and washed have been re-roughened and re-seeded.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-07

Activity: Top Soiling

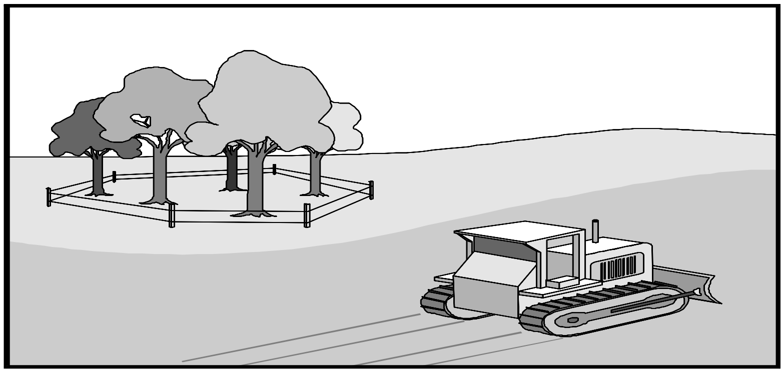
PLANNING CONSIDERATIONS:

Design Life:
Permanent

Acreage Needed:
Varies

Estimated Unit Cost:
Avg: $6/cy
Range: $5-$8/cy

Monthly Maintenance:
10% of Capital Cost



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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

Topsoil is used to enhance the final product of a construction site area. This act is done to support temporary and permanent seeding, as well as aiding in erosion control methods. By implementing this BMP a reduction in construction waste and some reduction in sediment will occur.

Suitable Applications

- Where construction activities expose subsoil layers that may not be able to support vegetative growth.
- Areas where reusing and preserving topsoil increases the success rate of new vegetation.

Approach

- Compost used on site as a recycled aspect of construction clearing.
- Verify proper placement of down slope sediment control practices prior to removing topsoil.
- Strip topsoil only from those areas that will be disturbed by excavation, filling, road building, or compaction by equipment. Normally, 4 to 6 inches (10.2 to 15.2 cm) are stripped for topsoil use.
- Position topsoil stockpiles where they will not erode, block drainage, or interfere with site work.
- Before topsoil is applied to the site, disk the subsoil to insure topsoil bonding. Apply a minimum of 4 inches (10.2 cm) of topsoil evenly.
- If site is excavated down to rock, such as sandstone or shale, 8 to 12 inches (20.3 to 30.5 cm) of topsoil is recommended for good plant growth.

Activity: Top Soiling	EPP-07

Installation Procedure

- Strip topsoil (4 to 6 in.) from areas to be disturbed by excavation, filling, road building or compaction by equipment and preserve for later use.
- Disk the subsoil to insure topsoil bonding before applying to site. Applying a minimum of 4 in. of topsoil evenly.

Maintenance

- Maintain areas where vegetation has been reestablished to remedy erosion and damage or vegetation failure by frequently checking the newly applied topsoil.

Inspection Checklist

- ❑ Effective management practices such as netting, temporary seeding, mulch and other traditional methods are used to ensure correct storage of the soil. If these practices are not available, other equivalent practices are to be enforced.
- ❑ Appropriate layer of topsoil has been established.
- ❑ Storage piles do not interfere with site drainage.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-08

Activity: Mulching

PLANNING CONSIDERATIONS:

Design Life:
6-8 Months

Acreage Needed:
None

Estimated Unit Cost:
Straw Mulch:
Avg: $1700/acre
Range: $500-$5000/acre
Wood Fiber:
Avg: $1000
Range: $500-$2300 Per acre

Monthly Maintenance:
60% of Installation

M M M
M M

M

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 secure temporary or permanent freshly seeded areas, mulching is used as a stabilizer. There are several types of mulches to be utilized, some of which include organic materials, straw, wood chips, and bark or other wood fibers. This management practice has the possibility to significantly reduce sediment and partial reduction of nutrients.

Suitable Applications

- Temporary stabilization of freshly seeded and planted areas, sometimes during periods of unsuitable vegetative growth.
- Temporary stabilization of areas that cannot be seeded or planted (e.g., insufficient rain, steep slope, non-growth season).
- Areas that have been permanently seeded to assist in retaining moisture, and to hold seeding.
- On areas to increase the survival of temporary and/or permanent vegetative cover.
- As short term, non-vegetative ground cover on steepened slopes to reduce rainfall impact, decrease the velocity of sheet flow, and settle out sediment.
- As ground cover around established plants, such as trees or shrubs, and on unprotected flat to minor slopes.
- Apply to planting areas where slopes are 2:1 (H: V) or less steep. Tacking agents or devices may be necessary for steeper slopes.
- Areas where climatic conditions require soil moisture retention aid to avoid cracking.

Activity: Mulching

Approach

The term "mulch" is commonly used to describe a variety of materials, such as:
Shredded tree bark and other woody materials, to protect trees and shrubs
Straw or hay, scattered across a slope or disturbed area
Peat mulch, used in planting trees and shrubs.

Vegetative Fibers

Loose hay or straw are the most common mulch materials used in conjunction with direct seeding of soil. Straw mulch is preferable over hay mulch, which may contain weeds and other objectable material. Straw mulch is the short-term protection most commonly used with seeding. Wheat or oat straw is recommended from the current season's crop (less than 12 months old). Average fiber length should exceed 6 in. Straw mulch is applied immediately after seeding, wither by machine or by hand distribution. Anchor the mulch in place using a tacking agent, plastic netting, or punching into the soil mechanically. Plastic netting requires wire staples, widen stakes, or plastic stakes. If the slopes are too steep for netting, then tacking agents should be selected based on longevity and the ability to hold the fibers in place.

Shredded Vegetation

"Green" mulch is produced by recycling of vegetation trimmings such as grass, shrubs, and trees. Methods of application are generally by hand, although pneumatic methods are currently being developed. It can be used as a temporary ground cover with or without seeding. The green mulch in place with a tacking agent on steep slopes and in areas where overland sheet flow is anticipated. The quality of green mulch may vary, and there is a strong potential for establishing unwanted weeds and plants.

Wood and Bark Chips

Wood and bark chips are suitable for landscaped areas that will not be closely mowed. Wood and bark chips may require nitrogen treatment (12 lbs/ton typical rate) to prevent nutrient deficiency. Bark chips do not require additional nitrogen fertilizer.

If there is a wood source near the project site, wood and bark chips can be very inexpensive. Caution must be used on steep slopes, since both wood and bark chips tend to wash down slopes exceeding 6 percent. Wood and bark chips are also used around trees and shrubs, or in ornamental or landscape gardens. A typical depth is 2 to 3 in.

Hydraulic Mulch

Hydraulic mulch can be made from virgin wood fibers or from recycled waste paper sources (newsprint, magazine). There are also mulches available that are a combination. In general, virgin wood fibers contain a linger fiber length than recycled paper mulch.

Hydraulic mulch is mixed in a hydraulic application machine (such as a hydroseeder or a mulch blower) and then applied as a liquid slurry. The hydroseeder slurry contains recommended rates of seed and fertilizer for the site, usually specified with a tacking agent. Slurry must be constantly agitated to keep the proper application rate and achieve uniform effective coverage.

Activity: Mulching

Approach (Continued)

General Description
Mulch is basically defined as a layer of material spread uniformly over a ground surface to prevent weeds and/or retain soil moisture. Mulch is usually an organic material such as shredded tree bark, hay, straw sawdust or leaves. Mulch prevents erosion by protecting the soil surface from rain and runoff impact and fostering growth of new seeds or seedlings. The choice of mulch should be based on the size of the area, site slopes, amount of sunlight or shade, proximity to drainage features and natural streams, soil hardness and moisture, weed potential, and availability of mulch materials. Organic materials may also decompose and aid the soil in providing nutrients for vegetation.

Inorganic materials such as inert black plastic or manufactured landscaping fabric can also be used to prevent weeds and retain moisture, but are not considered as mulch. Newspaper is also commonly used to control weeds, but is subject to leaching of ink and chemicals. The use of newspaper within soil for weed control is discouraged.

Grass Vegetation
Mulch helps establish temporary or permanent grass vegetation for disturbed soils after a construction project or land-use reclamation project. Straw and hay mulch are often selected due to the ease of application and good results. Alternatively, hydroseeding (including hydraulic application of mulch) is often performed, especially on steep slopes and locations that require quick establishment of grass.

Applying straw or hay mulch to a slope or hillside will require wither physical measures (crimping, erosion control mats) or chemical binders (special asphalt emulsions) to keep the mulch from washing away or blowing away. The binder is also called a tacking agent or tackifier. A typical application rate might be 100 lbs pf straw or hay mulch per 100 square feet.

Hydraulic application of seeding and other materials (hydroseeding) can be done quickly and efficiently with the correct equipment and ingredients. Also, hydraulic application must be done when no rainfall is expected, preferably within a 24-hour time period.

Virgin wood fiber mulch consists of specially prepared wood fiber that does not contain any growth-inhibiting factors. The mulch is manufactured and processed so the fibers will remain in uniform suspension in water under agitation to form a homogeneous slurry. The fiber lengths should be as long as possible to increase the effectiveness for erosion control. Wood fiber mulching should not be used in areas if extremely hot summer and late fall seasons because of fire danger. When used as a tacking agent with straw mulch, wood fiber mulches are good for steep slopes and severe climates.

A wood mulch can be manufactured containing a tacking agent in each bag or specified without a tacking agent. A typical construction specification for wood fiber mulch is as follows:

- Composed of 100% wood fiber.
- Moisture content (total weight basis) not to exceed 12%.
- Controlled pH values.

Activity: Mulching

Approach (Continued)

- Organic matter content (dry weight) = 99.3% minimum.
- Inorganic matter (ash) content (dry weight) =0.7% maximum.
- Water-holding capacity (dry weight) = minimum 1.2 gallons per pound.

A high quality type of hydraulic matrix known as a Bonded Fiber Matrix (BFM) is generally manufactured for easy application by the appropriate equipment. It generally contains a tacking agent mixed with the wood fibers.

A combination mulch may include wood fiber and paper fiber, with a tacking agent. A hydraulic matrix can be formulated using varying quantities of these components. A typical mixture is as follows

- 12 lbs per 1000 square feet wood fiber mulch.
- 24 lbs per 1000 square feet recycled paper mulch.
- 2 gallons per 1000 square feet acrylic copolymer (55% solids content).

Maintenance

- Must be inspected weekly and after rain for damage or deterioration.
- Maintain an unbroken, temporary mulched ground cover throughout the period of construction that the soils are not being reworked. Inspect before expected rainstorms, repair any damaged ground cover, and remulch exposed areas of bare soil.

Inspection Checklist

- ☐ Organic mulches are not permanent erosion control measures.
- ☐ Check soil surface temperatures to ensure no germination delays.
- ☐ Intensive practices require specific mulching measures, determine if straw or hay is needed.
- ☐ Large ground surface areas can use recycled paper hydraulic mulches and wood fiber based hydraulic mulches.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-09

Activity: Nets and Mats

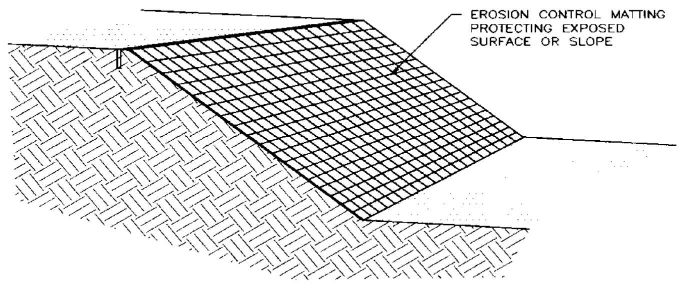
PLANNING CONSIDERATIONS:

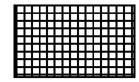
Design Life:
1 yr

Acreage Needed:
None

Estimated Unit Cost:
Avg: $2/ ft (20 ft Roll)
Range: $5/ft (20 ft Roll)

Monthly Maintenance:
60% of Installation





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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 security measures ensured by jute mesh, excelsior matting, erosion control fabric and other matting materials help to prevent and reduce erosion on preceding shaped and seeded swales, channels and slopes. The implementation of this BMP will create a significant reduction in sediment.

Suitable Applications

Matting, such as erosion control matting, can be applied to several areas that require actions against attrition. Matting aids in effectively protecting areas such as steep slopes and ditches where design flow may exceed 3.5 feet per second and areas with potential high soil erosion.

Approach

Areas that are to receive erosion control matting should be prepared to the specification of the Engineer prior to any initial matting. The area is to be shaped, fertilized, and seeded. A smooth surface free of depressions and eroded areas is required.

Installation

Erosion control matting may apply to many different soil types; therefore there are several different matting controls in existence that are applicable for the eroding area. There are a few matting controls that are commonly used, however it is recommended that erosion control products should always be installed with the manufacture's instructions.

A few of the commonly known matting controls are as follows:

Erosion Control Fabrics

- Matting should be unrolled in the direction of flow with edges and ends butted snugly against each other. Anchor ditches should be required on the upgrade side of the fabric when directed by the Engineer. When unrolled, the netting should be on top and fibers should be in contact with the soil.

- Staples should be driven vertically into the ground, anchoring the mat firmly to the soil, and driven flush with the surface of the mat. Slopes flatter than 4:1 (H:V) should be stapled no more than 5 feet (1.5 m) apart on all edges and 1 foot (0.3 m) apart at all joints and ends. On all slopes steeper than 4:1 (H:V) and in all ditches, three staggered rows of staples should be spaced 2.5 to 3 feet (0.76 to 0.91 m) apart. Additionally, all joints and ends should be spaced not more than 6 inches (15.2 cm) apart. The spacing of staples may be modified to fit the conditions as directed by the Engineer.

Jute Mesh

- When jute mesh is to be used, the upslope end should be in a trench at least 6 inches (15.2 cm) deep with the soil firmly tamped against it and unrolled in the direction of the water flow. It should be anchored around the edges as well. The matting should not be stretched but should be spread evenly and smoothly so that it is in close contact with the ground at all points.

- Successive strips of matting should overlap at least 6 inches (15.2 cm) at the ends, with the upgrade strip on top. Parallel strips of matting should overlap at least 4 inches (10.2 cm).

- Check slots should be spaced not more than 50 feet (15.2 m) from an end slot or another check slot. Check slots should be placed with a tight fold of matting anchored at least 6 inches (15.2 cm) vertically into the ground and tamped firmly.

- After the matting is stapled into place, it should then be pressed into the ground with a light lawn roller or by similar means.

Activity: Nets and Mats	EPP-09

Installation *Staples*

- Staples should be No. 11 gauge new steel wire formed into a "U" shape. Staples should be 6 to 10 inches (15.2 to 25.4 cm) long, with the longer staples used on loose, unstable soils. Staples should be spaced not more than 4 feet (1.2 m) apart in three rows for each strip, with one row along each edge and one row alternately spaced in the center. On overlapping edges of parallel strips, staples should be spaced not more than 2 feet (0.61 m) apart. All anchor, junction, and check slot staples should be spaced not more than than 6 inches (15.2 cm) apart.

Maintenance

- Inspect erosion control matting after rainfall events to check for movement of topsoil, mulch or erosion. Continue checking until vegetation is firmly established.
- Repair or replace netting that has been washed out, broken, eroded, and/or needing surface repair, reseeding, resoding, remulching or topsoil replacement.

Inspection Checklist

- ☐ Channel grades are adequately managing runoff velocity.
- ☐ Staples are appropriately spaced to avoid loss of seed, topsoil and mulch to stormwater runoff and winds.
- ☐ Nets are adequately covered or anchored to prevent erosion, washout, and poor plant establishment.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-10

Activity: Geotextiles

G

PLANNING CONSIDERATIONS:

Design Life:
N/A

Acreage Needed:
None

Estimated Unit Cost:
Avg: N/A
Range: N/A

Monthly Maintenance:
N/A

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

Runoff and pollution caused by construction activities can be prevented or reduced with this BMP. By utilizing rolled and bound fiber material, erosive impacts from rain, intercept runoff and pollutants to the storm drain system or to watercourses can be lessened. Geotextiles provides reduced flow velocity, releases runoff as sheet flow, removes some sediment from runoff and is likely to create a significant reduction in sediment.

Suitable Applications

- Construction sites desiring stability for disturbed soils.
- Sloppy area where anchoring must take place.
- Slopes steeper than 3:1 (H:V) and/or where erosion hazard is high.
- Slow growing vegetated areas.
- Critical slopes adjacent to sensitive areas (streams, wetlands, etc.).

Installation Procedures

Material Selection

There are many types of erosion control blankets and mats, and selection of the appropriate type should be based on the type of application and site conditions. The following criteria should be considered in the selection of the appropriate material:

- Cost
  - Material cost
  - Preparation cost
  - Installation cost
  - Add-ons
- Effectiveness
  - Reduction of erosion
  - Reduction of flow velocity
  - Reduction of runoff
- Acceptability
  - Environmental compatibility
  - Institutional/regulatory acceptability
  - Visual impact
- Vegetation Enhancement
  - Native plant compatibility
  - Germination rate
  - Growth rate
  - Moisture retention
  - Temperature modification
  - Open space/coverage
  - Nutrient uptake
- Installation
  - Durability
  - Longevity
  - Ease of installation
  - Safety
- Operation and Maintenance
  - Maintenance frequency

Site Preparation

- Proper site preparation is essential to ensure complete contact of the blanket or matting with the soil.

- Grade and shape the installation area.

- Remove all rocks, clods, vegetation or other obstructions so that the installed blankets or mats will have complete, direct contact with the soil.

Activity: Geotextiles

Installation Procedures (Continued)

- Prepare seedbed by loosening 2 in. (50 mm) to 3 in. (75 mm) of topsoil.

- Incorporate amendments, such as lime and fertilizer, into the soil according to soil tests, the seeding plan, and manufacturer's recommendations.

Seeding

Seed the area before blanket installation for erosion control and revegetation. Seeding after mat installation is often specified for turf reinforcement application. When seeding prior to blanket installation, all check slots and other areas disturbed during installation must be reseeded. Where soil filling is specified, seed the matting and the entire disturbed area after installation and prior to filling the mat with soil.

Anchoring

U-shaped wire staples, metal geotextile stake pins or wooden stakes can be used to anchor mats and blankets to the ground surface. Organic stakes may be used for temporary erosion prevention and sediment control blankets and mats. Wire staples should be minimum of 11 gauges. Metal stake pins should be 0.188-in. (5-mm) diameter steel with a 1.5-in. (40-mm) steel washer at the head of the pin. Wire staples and metal stakes should be driven flush to the soil surface. All anchors should be 6 in. (150 mm) to 18 in. (450 mm) long and have sufficient ground penetration to resist pullout. Longer anchors may be required for loose soils.

Installation on Slopes

- Always consult the manufacturer's recommendations for installation. In general, these will be as follows:

- Begin at the top of the slope and anchor the blanket in a 6-in. (150-mm) deep by 6-in. (150-mm) wide anchor trench. Backfill anchor trench and tamp earth firmly.

- Unroll blanket down slope in the direction of water flow.

- Overlap the edges of adjacent parallel rolls 2 in. (50 mm) to 3 in. (75 mm) and staple every 3 ft (1 m).

- When blankets must be spliced, place blankets end over end (shingle style) with 6-in. (150-mm) overlap. Staple through overlapped area, approximately 12 in. (300 mm) apart.

- Lay blankets loosely and maintain direct contact with the soil do not stretch.

- Staple blankets sufficiently to anchor blanket and maintain contact with the soil. Staples shall be placed down the center and staggered with the staples placed along the edges. Steep slopes, 1:1 (H: V) to 2:1 (H: V), require a minimum of 2 staples/yd^2 (2 staples/m^2). Moderate slopes, 2:1 (H:V) to 3:1 (H:V), require a minimum of 12 staples/yd^2 (12 staples/m^2), placing 1 staple/yd (1 staple/m) on centers. Gentle slopes require a minimum of 1 staple/yd^2 (1 staple/m^2).

Installation Procedures (Continued)

Installation in Channels

Always consult the manufacturer's recommendations for installation. In general, these will be as follows:

- Dig initial anchor trench 12 in. (300 mm) deep and 6 in. (150 mm) wide across the channel at the lower end of the project area.
- Excavate intermittent check slots, 6 in. (150 mm) deep and 6 in. (150 mm) wide across the channel at 25 ft. (8 m) to 30 ft. (10 m) intervals along the channels.
- Cut longitudinal channel anchor slots 4 in. (100 mm) deep and 4 in. (100 mm) wide along each side of the installation to bury edges of matting, whenever possible, extend matting 2 in. (50 mm) to 3 in. (75 mm) above the crest of the channel side slopes.
- Beginning at the downstream end and in the center of the channel, place the initial end of the first roll in the anchor trench and secure with fastening devices at 12-in. (300-m) intervals. Note: matting will initially be upside down in anchor trench.
- In the same manner, position adjacent rolls in anchor trench, overlapping the preceding roll a minimum of 3 in. (75 mm)
- Secure these initial ends of mats with anchors at 12-in. (300-mm) intervals, backfill and compact soil.
- Unroll center strip of matting upstream. Stop at next check slot or terminal anchor trench.
- Unroll adjacent mats upstream in similar fashion, maintaining a 3-in. (75-mm) overlap.
- Fold and secure all rolls of matting snugly into all transverse check slots. Lay mat in the bottom of the slot then fold back against itself. Anchor through both layers of mat at 12-in. (300-mm) intervals, then backfill and compact soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.
- Anchor, fill, and compact upstream end of mat in a 12-in. (300-mm) by 6-in. (150-mm) terminal trench.
- Secure mat to ground surface using wooden or organic stakes, U-shaped wire staples, or geotextile pins.
- Seed and fill turf reinforcement matting with soil, if specified.

Soil Filling (if specified for turf reinforcement)

- Always consult the manufacturer's recommendations for installation. In general, these will be as follows:
- After seeding, spread and lightly rake 0.25 in. (6 mm) to 0.5 in. (13 mm) of fine topsoil into the mat apertures to completely fill mat thickness. Use backside of rake or other flat implement.
- Spread topsoil using lightweight loader, backhoe, or other power equipment. Avoid sharp turns with equipment.
- Do not drive tracked or heavy equipment over mat.
- Avoid any traffic over matting if loose or wet soil conditions exist.

Activity: Geotextiles	EPP-10

Installation Procedures (Continued)

- Use shovels, rakes or brooms for fine grading and touch up.
- Smooth out soil filling; just exposing top netting of mat.

Maintenance

- Inspection to occur periodically, if any portion of the material is damaged, immediate correction is required.
- Inspection to occur after significant rain storms to check for erosion and undermining. Any failures are to be replaced immediately.
- Repairs to the slope and re-installation should occur as a result of wash-out or breakage.
- Perform required maintenance.

Inspection Checklist

- ❑ Site is adequately prepared (grading or shaping, rocks, vegetation and debris removal, etc.).
- ❑ Seeding meets geotextile requirements.
- ❑ Anchoring is established at an acceptable depth.
- ❑ Anchoring trenches are used at the top and bottom of slopes.
- ❑ Trenches start, join and terminate geotextiles placed in channels.
- ❑ Soil filling is even and flat.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Erosion Prevention Practices (EPPs)

EPP-11

Activity: Terracing

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
As Required

Estimated Unit Cost:
Negligible

Monthly Maintenance:
Negligible

T

T

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 is likely to reduce sediment by creating small areas to establish vegetation to reduce runoff velocity, increase infiltration and trap sediment. This reduces the amount of sediment leaving a site.

Suitable Applications

- Cleared areas prior to temporary or permanent seeding and planting or erodible slopes steeper than 3:1 (H:V) and higher than 5 ft.
- Graded areas with smooth, hard surfaces.
- Areas where slopes need to be shortened. Adequate drainage and stabilized outlets must be a part of the design and should follow the guidelines of a licensed professional civil engineer based on site conditions.

Approach

Slope roughening/terracing is performed in several ways:

- Stair-step grading
- Grooving
- Furrowing
- Tracking
- Rough grading
- No grading

Activity: Terracing

Installation Procedures

Graded areas with smooth, hard surfaces give a false impression of "finished grading" and a job "well done". It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but they encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity. Rough, loose soil surfaces give lime, fertilizer, and seed some natural coverage. Niches in the surface provide microclimates which generally provide a more favorable moisture level that aids seed germination.

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

1. Disturbed areas which will not require mowing may be stair-step graded, grooved, or left rough after filling.
2. Graded areas steeper than 3:1 (H:V) should be stair-stepped with benches. The stair-stepping will help vegetation become attached and also trap soil eroded from the slopes above. Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material which sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment.
3. Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the step in towards the slope.
4. Do not make individual vertical cuts more than 24 in. (600 mm) high in soft materials or more than 3 ft. (1 m) high in rocky materials.
5. Groove the slope using machinery to create a series of ridges and depressions that run across the slope and on the contour.

Fill Slope Roughening

- Place fill slopes with a gradient steeper than 3:1 (H:V) in lifts not to exceed 8 in. (200 mm), and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4 in. (100 mm) to 6 in. (150 mm). This is not to be confused with proper compaction necessary for slope stabilization.
- Use grooving or tracking to roughen the face of the slopes, if necessary.
- Apply seed, fertilizer, and mulch and then track or crimp in the mulch. See EPP-05, EPP-06: Temporary Seeding and Temporary Mulching, respectively.
- Do not blade or scrape the final slope face.

Activity: Terracing

Installation Procedures (Continued)

Cuts, Fills, and Graded Areas

- Slopes that will be maintained by mowing should be no steeper than 3:1 (H:V).
- To roughen these areas, create shallow grooves by normal tilling, disking, harrowing, or use a mechanical seeder. Make the final pass of any such tillage on the contour.
- Make grooves formed by such implements close together, less than 10 in. (250 mm), and not less than 1 in. (25 mm) deep.
- Excessive roughness is undesirable where mowing is planned.

Maintenance

- Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events greater than 0.5 in. (12 mm). Fill these areas slightly above the original grade, then re-seed and mulch as soon as possible.
- Inspect roughened slopes weekly and after rainfall for excessive erosion.

Inspection Checklist

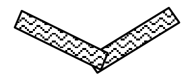
- [ ] Furrows at least 6 in. deep.
- [ ] Furrows are spaced no more than 50 ft. apart.
- [ ] Horizontal distance is greater than vertical distance on stepped slopes.
- [ ] Stepped slopes or terraced slopes cut so that they drain in on themselves.

Sediment Management Practices

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

SMP-01

Activity: Check Dams



CD

PLANNING CONSIDERATIONS:

Design Life:
6 mo – 1 year

Acreage Needed:
Minimal

Estimated Unit Cost:
Approx:
$100/dam

Monthly Maintenance:
60% of Installation

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.

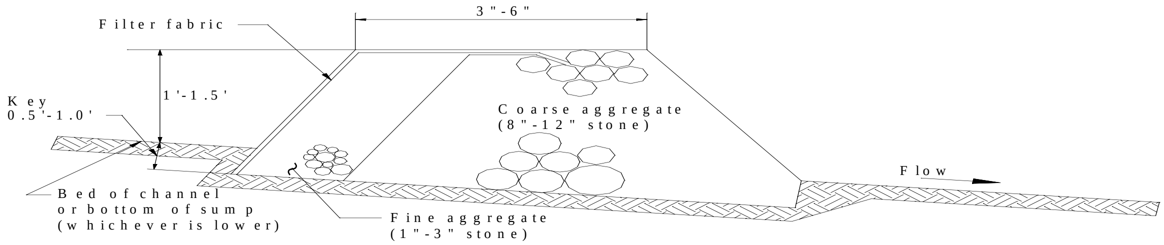
Suitable Applications

- 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.

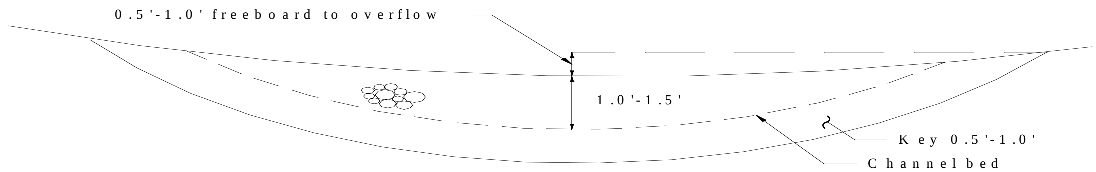
Approach

- 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

- ❑ Diameters of 1" to 3" (2.5 cm to 7.6 cm) should use crushed stone.
- ❑ Check dam spans the entire width of the channel.
- ❑ Sump is 12" (30.5 cm) deep.
- ❑ Filter fabric on upstream face is keyed into the bed.
- ❑ Check dams can be removed when needed.
- ❑ 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

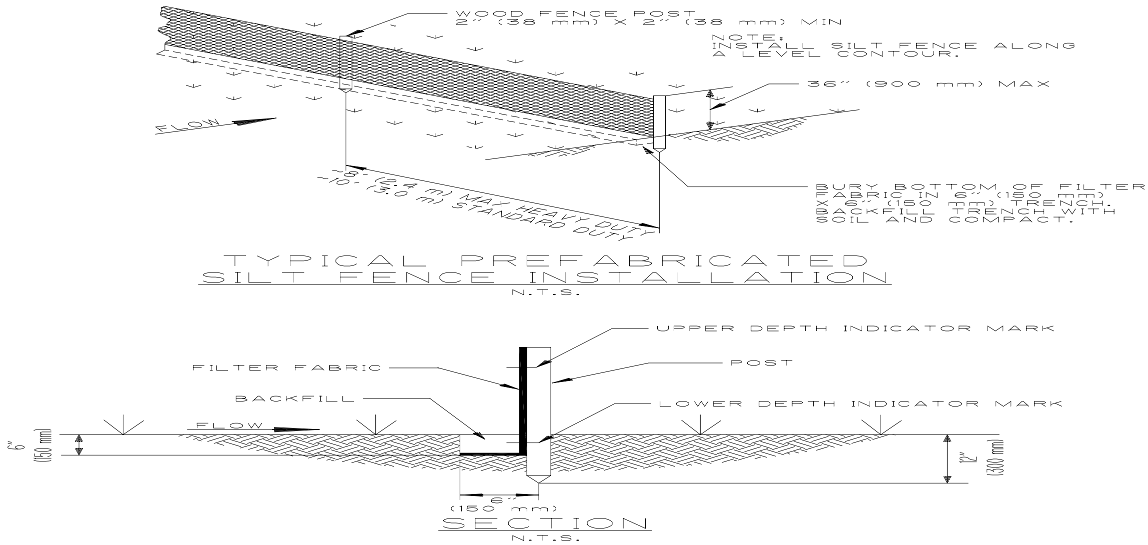
- Phase construction should allow silt fencing along the downstream perimeter, below the toe of a cleared slope, upstream of sediment traps or basins, along streams and channels and around temporary spoil areas.
- Across swales with catchments less than 1 acre and below other small cleared areas.

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



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 x 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.

Activity: Silt Fence	SMP-02

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	SMP-02

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	❑ Silt fence follows a contour. ❑ The last 6 feet of the silt fence is turned uphill and secured to the post. ❑ Color band of the anchor trench is visible. ❑ Accumulated sediment does not exceed 1/3 height of the fence. ❑ 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

SB

PLANNING CONSIDERATIONS:

Design Life:
6 months

Acreage Needed:
Minimal

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

Annual Maintenance:
100% of Installation

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.

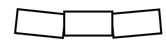
Inspection Checklist

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

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

SMP-04

Activity: Sand Bag Barrier



SB

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

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

- ☐ Barrier follows a contour.
- ☐ End of the barriers turn uphill for the last 6 feet.
- ☐ Barriers are cleaned as sediment exceeds 1/3 height of barrier.
- ☐ 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.

Activity: Brush or Rock Filters and Continuous Berms

SMP-05

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

- [ ] Sufficient space for ponded water.
- [ ] Brush filters are performing.
- [ ] 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.

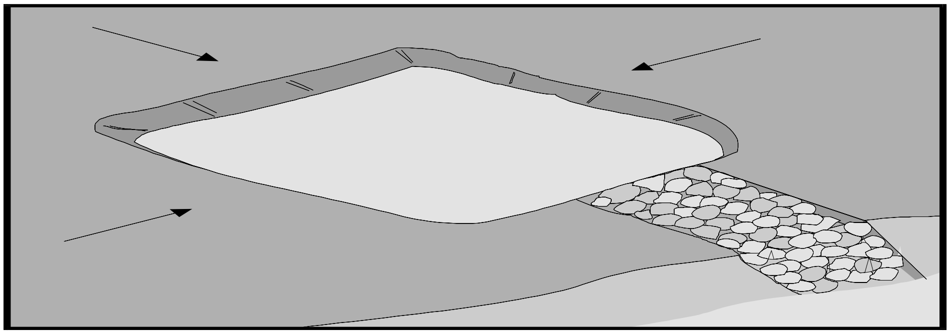
Suitable Applications

- 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.

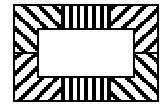
Inspection Checklist

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

Oak Park Conservancy District
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-07

Activity: Temporary Sediment/Detention Basin



TSB

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

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

Monthly Maintenance:
60% of Installation

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

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

Oak Park Conservancy District
Stormwater Best Management Practices (BMPs)
Sediment Management Practices (SMPs)

SMP-08

Activity: Bank Stabilization

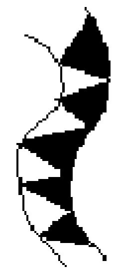
PLANNING CONSIDERATIONS:

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

Installation Procedures (Continued)

- 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.
- 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.

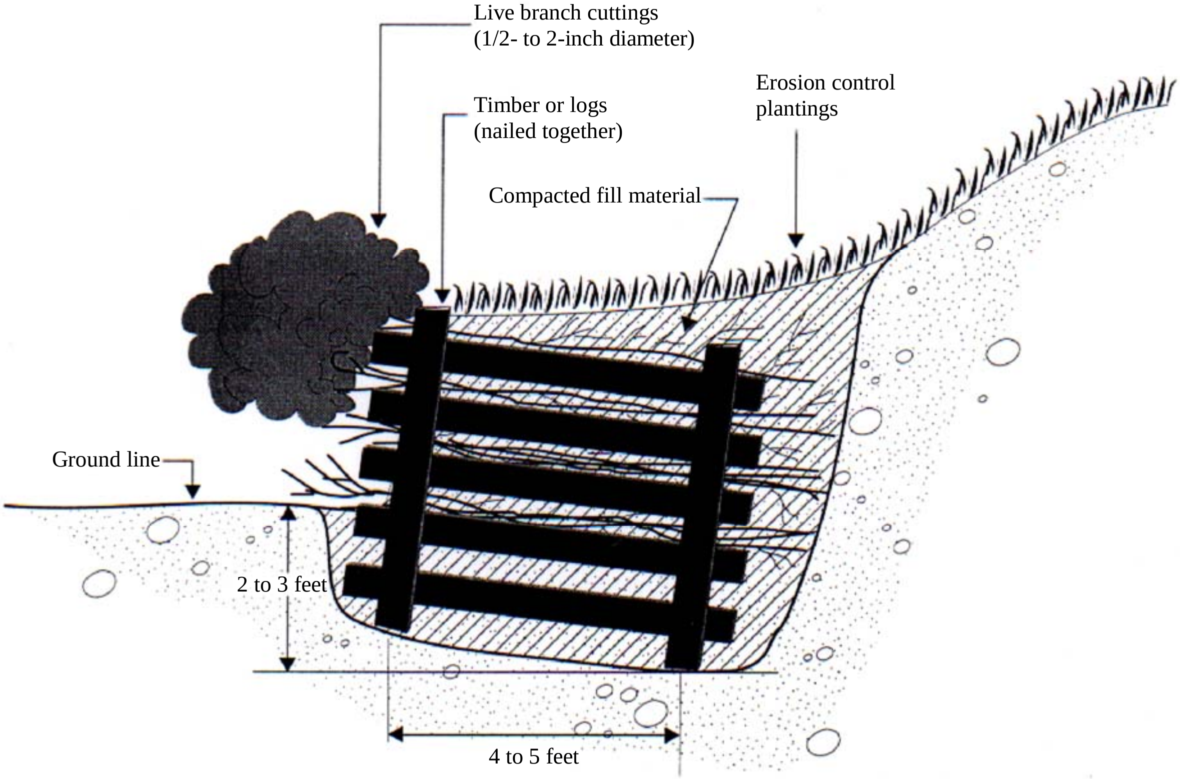
Maintenance

- Inspect structure before and after rainfalls.
- Make repairs when necessary.

Inspection Checklist

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

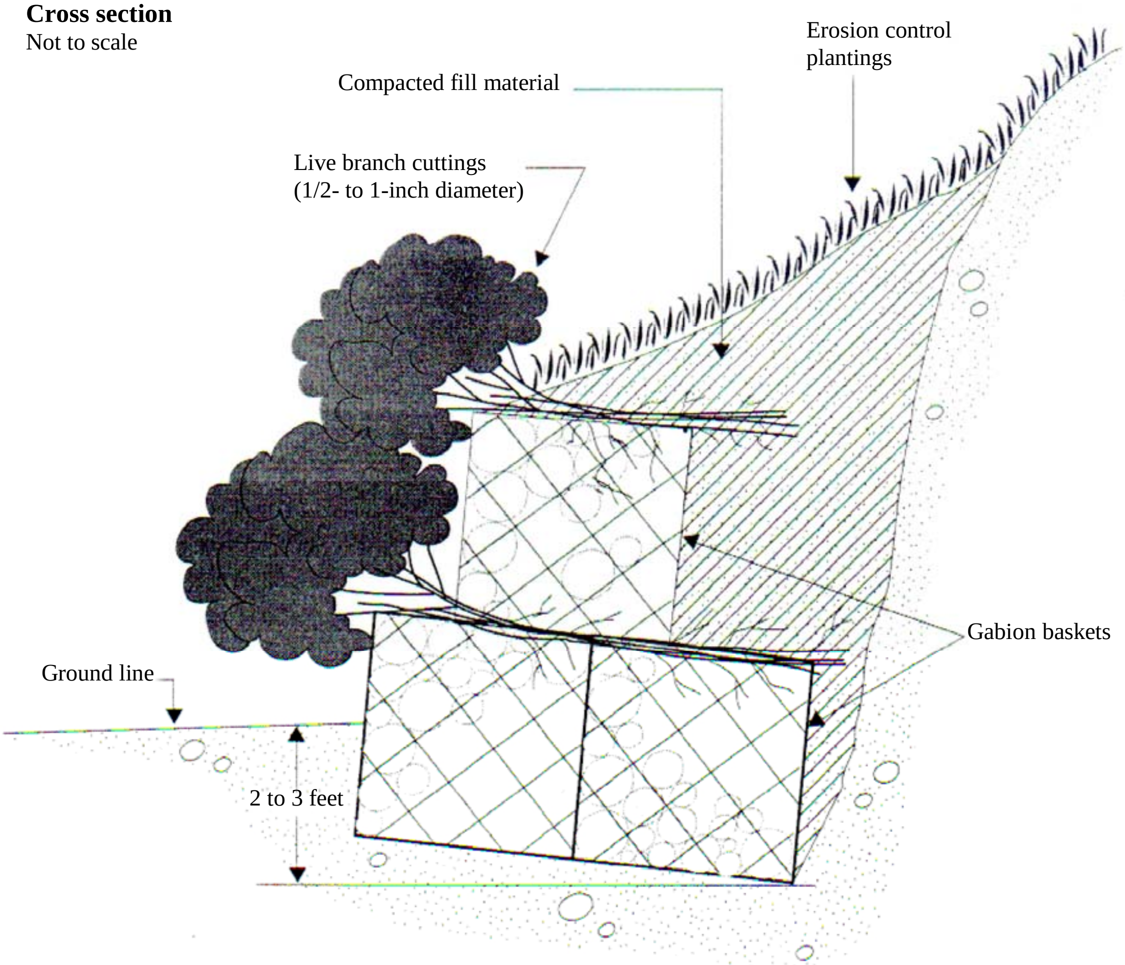
Cross section
Not to scale



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

Figure SMP-08-1
Live Cribwell

Activity: Bank Stabilization



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.

Activity: Rip-Rap	SMP-09

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.

Activity: Rip-Rap

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.

<u>Class A-1</u>

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.

<u>Class A-2</u>

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.

<u>Class B</u>

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.

<u>Class C</u>

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

- ❑ Verify that displacement does not occur due to too steep slopes or small rip-rap.
- ❑ Proper filter cloth is used.
- ❑ 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	❑ Adequate coverage is provided to prevent washout. ❑ Repair torn netting or mats. ❑ 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.

Activity: **Temporary Diversions, Drains and Swales**

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 geosynthetics 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.

Activity: **Temporary Diversions, Drains and Swales**	SMP-11

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

- [ ] Routine visit after every heavy net water event.
- [ ] 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	☐ Check for vehicular traffic. ☐ Dead areas requiring seeding, plugging or resodding ☐ Under wash turf compacted.

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

SMP-13

Activity: Temporary Inlet Protection

TIP

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

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

Annual Maintenance:
60% of Installation

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

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

TOP

PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

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

Monthly Maintenance:
60% of Installation

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

Good Housekeeping Practices

GHP – 01 Dewatering Operations

GHP – 02 Paving Operations

GHP – 03 Structure Construction and Painting

GHP – 04 Material Delivery, Storage, and Use

GHP – 05 Spill Prevention and Control

GHP – 06 Solid Waste Management

GHP – 07 Hazardous Waste Management

GHP – 08 Contaminated Soil Management

GHP – 09 Concrete Waste Management

GHP – 10 Sanitary/Septic Waste Management

GHP – 11 Vehicle and Equipment Cleaning

GHP – 12 Vehicle and Equipment Fueling

GHP – 13 Vehicle and Equipment Maintenance

GHP – 14 Employee/Subcontractor Training

GHP – 15 Pesticides, Herbicides, and Fertilizer Use

GHP – 16 Dust Control and Tracking

GHP – 17 Maintenance of Collection Facilities and Appurtenances

GHP – 18 Preservation and Maintenance of Existing Vegetation

GHP – 19 System Flushing

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-01

Activity: Dewatering Operations

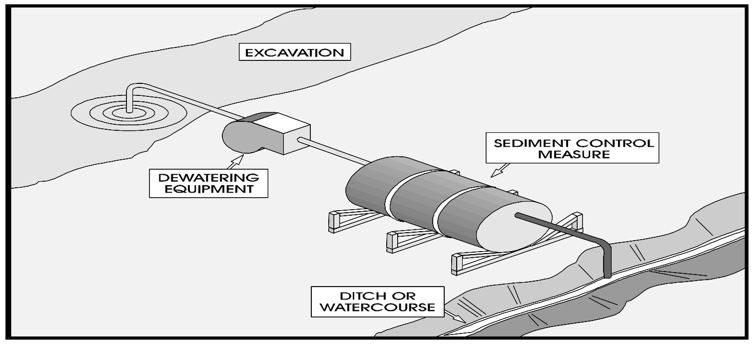
PLANNING CONSIDERATIONS:

Training:
Low

PE Design Approval:
Not Required

Maintenance:
Moderate

Inspection Frequency:
Weekly
As needed (due to wet weather)



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

Testing of groundwater for pollution accumulation by using sediment controls is the basis of this BMP. This dewatering operation will reduce or prevent discharge of pollutants and aid in a partial reduction in toxic materials.

Approach

Sediment and toxic and petroleum products are two general classes of pollutants that may result from dewatering operations. Toxics and petroleum are rarely found in dewatering discharges unless the site or surrounding has been used for light or heavy industrial activities. Sediment, on the other hand, usually has a high content in dewatering discharges due to the commonality of the operation. This BMP only addresses capture of sediment. If it is determined that dewatering will result in transferor accumulation of toxics or petroleum products then the Indiana Department if Environmental Management (IDEM) should be consulted before any dewater activities are performed.

Maintenance and Inspection Checklist

- ❑ Inspect filtering device frequently and repair or replace once the sediment build-up prevents the structure from functioning as designed.
- ❑ Sediment removal must be disposed of at a disposal site or spread and stabilized onsite.
- ❑ Inspect excavated areas daily for signs of contaminated water (signs such as discolored water, oily sheen or odor).

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-02

Activity: Paving Operations

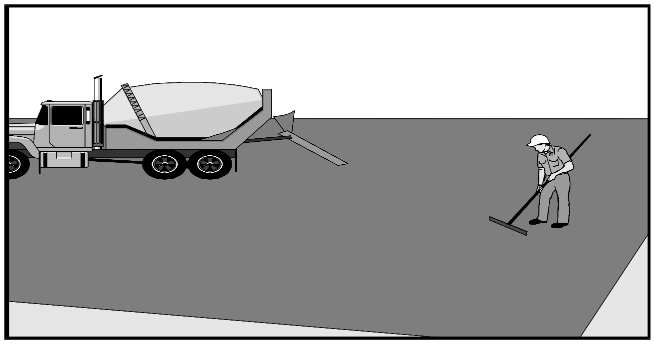
PLANNING CONSIDERATIONS:

Training:
Moderate

PE Design Approval:
Not required

Maintenance:
Low

Inspection Frequency:
Monthly, more frequently during summer months



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

Paving operations have the potential to introduce a large amount of pollutants to into the environment. This BMP will reduce or prevent the discharge of pollutants by using measures to prevent run-on and runoff pollution along with proper disposal of waste, and proper training of employees and subcontractors.

Approach

- Avoid paving during wet weather.
- Store material away from water courses to prevent stormwater run-on.
- Protect water courses, particularly in areas with a grade, by employing BMPs to divert runoff or trap/filter sediment (see SMP-06, -07, -11, -13, -14).
- Leaks and spills can contain toxic levels of heavy metals and oil and grease generated from paving equipments. To alleviate these pollutants into the area place drip pans or absorbent materials under paving equipment when they are not being used. When spills do occur, clean up spills with absorbent materials (see GHP-12 and GHP-06).
- Cover catch basins and manholes when applying seat coat, tack coat, slurry seal or fog seal.
- Commercial covers (most) will magnetically seal flat catch basins and inlets.
- If paving involves Portland cement concrete, see GHP-09 Concrete Waste Management
- If paving involves asphalt concrete do the following:
    1. Do not allow sand or gravel placed over new asphalt to wash into storm drains, streets or creeks by sweeping Refer to GHP-06 for proper disposal.
    2. Old asphalt must be disposed of properly. Collect and remove all broken asphalt from the site and recycle.
    3. If paving involves on-site mixing plant, follow the stormwater permitting requirements for Industrial activities.

Activity: Paving Operations	GHP-02

Maintenance

- Maintain inlet protection so that water is not allowed to back up onto areas subject to traffic. Alternative measures should be employed if back up occurs.
- When sediment reaches storage capacity inlets need to be cleaned and repair as needed.
- Keep ample supplies of drip pans or absorbent materials on-site.

Inspection Checklist

- ☐ Machinery is not leaking and properly maintained.
- ☐ Inspect employees and subcontractors to ensure that measures are being followed.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-03

Activity: Structure Construction and Painting

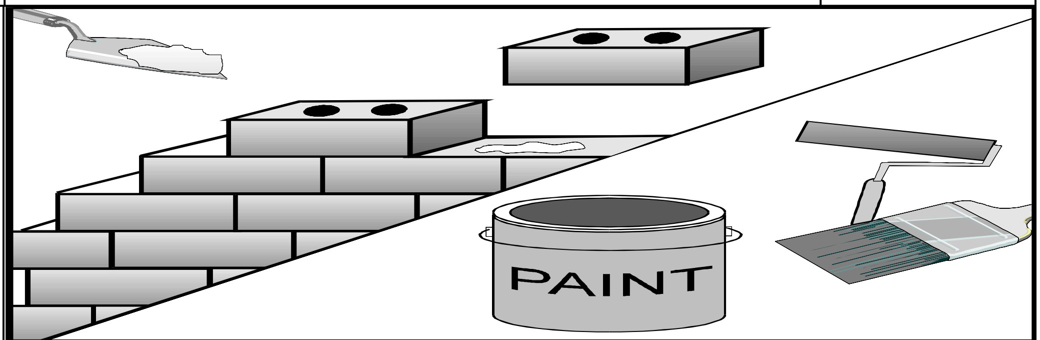
PLANNING CONSIDERATIONS:

Training:
Minimal

PE Design Approval:
Not required

Maintenance:
Low

Inspection Frequency:
N/A



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

A number of preventive measures around the construction site greatly decrease the amount of pollution entering the environment. Enclosing, covering or berming building material storage areas, using good housekeeping practices, utilizing safer products and training employees and subcontractors will make a significant difference in the amount of pollutants entering stormwater runoff. This will cause a significant reduction in floatable materials, other construction waste and a partial reduction of toxic materials.

Approach

- Keep the work site clean and orderly. Remove debris in a timely fashion. Sweep the area regularly.
- Use soil erosion control techniques if bare ground is exposed. See Erosion Prevention Practices.
- Buy recycled or less hazardous products to the maximum extent practicable.
- Conduct painting operations consistent with local air quality and OSHA regulations.
- Properly store paints and solvents. See GHP-04: Material Delivery, Storage and Use in this section.
- Properly store and dispose waste materials generated from the activity. See the waste management BMPs GHP-06,-07, -08,-09and -10 in this section.
- Recycle residual paints, solvents, lumber, and other materials to the maximum extent practicable.
- Make sure that nearby storm drains are well marked to minimize the chance of inadvertent disposal of residual paints and other liquids.

Activity: Structure Construction and Painting	GHP-03

Approach (Continued)

- Clean the storm drain system in the immediate construction area after construction is completed.
- Educate employees who are doing the work of the importance of keeping pollutants out of the stormwater system.
- Inform subcontractors of company policy on these matters and include appropriate provisions in their contract to make certain proper housekeeping and disposal practices are implemented.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.
- For oil-based paints, paint out brushes to the extent practical, and filter and reuse thinners and solvents.
- Never clean paintbrushes or rinse paint containers into a street, gutter, storm drain or watercourse.
- Dispose of any paint, thinners, residue, and sludges that cannot be recycled as hazardous waste. For a quick reference on disposal alternatives for paint, thinners, residue and sludges see the table presented in the Employee/Subcontractor Training BMP fact sheet.
- Latex paint and paint cans, used brushes, rags, absorbent materials, and drop cloths, when thoroughly dry and are no longer hazardous, may be disposed of with other construction debris.
- Use recycled and less hazardous products when practical.
- Recycle residual paints, solvents, lumber, and other materials.

Maintenance

- Minimum maintenance required.
- Spot check employees and subcontractors monthly to assure appropriate practices are being employed.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-04

Activity: Material Delivery, Storage and Use

PLANNING CONSIDERATIONS:

Training:
Minimal

PE Design Approval:
Not required

Maintenance:
Low

Inspection Frequency:
Weekly

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

Material delivery and storage plays a role in stormwater runoff pollution if not performed correctly. By limiting the amount of onsite hazardous materials, storing materials in designated areas, installing secondary containment, conducting regular inspections and training employees and subcontractors pollution can be prevented or reduced. A partial reduction in sediment, nutrients, toxic materials oil and grease and floatable materials will occur as a result of these preventive measures.

Approach

The following materials are commonly stored on construction sites:

- Soil,
- Concrete compounds,
- Pesticides and herbicides,
- Fertilizers,
- Detergents,
- Plaster or other products,
- Petroleum products such as fuel, oil, and grease, and
- Other hazardous chemicals such as acids, lime, glues, paints, solvents, and curing compounds.

Activity: Material Delivery, Storage and Use	GHP-04

Approach (Continued)

Storage of these materials on-site can pose various degrees of the following risks:
- Stormwater pollution,
- Injury to workers or visitors,
- Groundwater pollution, and
- Soil contamination.

Therefore, the following steps should be taken to minimize your risk:
1. Designate areas of the construction site for material delivery and storage.
2. Place near the construction entrances and away from waterways.
3. Avoid transport near drainage paths or waterways.
4. Surround with earth berms, dikes, swales or other containment practices.
5. Place in an area which will be paved.
6. Storage of reactive, ignitable, or flammable liquids must comply with the fire codes of your area. Contact the local Fire Marshal to review site materials, quantities, and proposed storage area to determine specific requirements. See the Flammable and Combustible Liquid Code, NFPA30.
7. Follow manufacturer's instructions regarding uses, protective equipment, ventilation, flammability, and mixing of chemicals.
8. For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.
9. Keep an accurate, up-to-date inventory of materials delivered and stored on-site.
10. Keep your inventory as close to "when you need it" levels as possible.
11. Minimize hazardous materials stored on-site and handle hazardous materials as infrequently as possible.
12. Consider storing materials in a covered area. Store materials in secondary containment's such as an earthen dike, horse trough, or even a children's wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in 'bus boy' trays or concrete mixing trays.
13. Do not store chemicals, drums, or bagged materials directly on the ground unless otherwise contained. Place these items on a pallet and, when possible, in secondary containment.
14. Try to keep chemicals in their original containers, and keep them well labeled. If other containers are used then be sure they are well marked and can be adequately sealed and stored in an appropriate place.
15. Train employees and subcontractors.

Maintenance

- Keep designated storage area clean and well organized.
- Conduct routine weekly inspections and check for external corrosion of material containers.
- Keep an ample supply of clean up material on hand.
- Inspect storage areas before and after rainfall events.
- Repair or replace perimeter controls, containment structures and covers needed for functionality.

Inspection Checklist

- ❑ Inspect storage area frequently for cleanliness and spills and leaks.
- ❑ Functions are appropriately utilized and ensured to allow proper procedures for delivery, storage and use.

	Southern Indiana **Stormwater Best Management Practices (BMPs)** **Good Housekeeping Practices (GHPs)**	GHP-05
	Activity: Spill Prevention and Control	

CONSIDERATIONS:

Training:
High

PE Design Approval:
Recommended

Maintenance:
High

Inspection Frequency:
Weekly

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

Leaks and spills promote the amount of pollution entering stormwater runoff. The reduction of chances of spills, stopping the source of spills, containing and cleaning up spills, properly disposing of spill material, and training employees all lead to a cleaner environment. The incorporation of this BMP and GHP-04 (Material, Delivery, Storage, and Use) has information that will lead to a reduction toxic materials and oil and grease.

A number of familiar hazardous substances that affect construction sites are: soil stabilizers, palliatives, herbicides, growth inhibitors, fertilizers, deicing/anti-icing chemicals, fuels, lubricants, and other petroleum distillates.

Approach

Define significant spills and the material used for each, along with the appropriate response for significant and insignificant spills. This definition should become clear after review of the Materials Safety Data Sheet or other evocative documentation. There are a few measures to follow concerning spill prevention and control:

General Measures

- Hazardous materials and wastes should be stored in covered containers and protected from vandalism.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Train employees in spill prevention and cleanup procedures for the site.
- Educate employees and subcontractors on potential dangers to humans and the environment from spills and leaks.

Activity: Spill Prevention and Control	GHP-05

Approach (Continued)

- Hold regular meetings to discuss and reinforce appropriate disposal procedures (incorporate into regular safety meetings).

- Establish a continuing education program to indoctrinate new employees.

- Designate a foreman or supervisor to oversee and enforce proper spill prevention and control measures.

Cleanup

- Clean up leaks and spills immediately.

- On paved surfaces, clean up spills with as little water as possible. Use a rag for small spills, a damp mop for general cleanup, and absorbent material for larger spills. If the spilled material is hazardous, then the used cleanup materials are also hazardous and must be sent to either a certified laundry (rags) or disposed of as hazardous waste.

- Never hose down or bury dry material spills. Clean up as much of the material as possible and dispose of properly. See the waste management BMPs in this section for specific information.
- Minor Spills.
- Minor spills typically involve small quantities of oil, gasoline, paint, etc. which can be controlled by the first responder at the discovery of the spill.

- Use absorbent materials on small spills rather than hosing down or burying the spill.

- Remove the absorbent materials promptly and dispose of properly.

- The practice commonly followed for a minor spill is:

  1. Contain the spread of the spill.
  2. Recover spilled materials.
  3. Clean the contaminated area and/or properly dispose of contaminated materials.

- Semi-Significant Spills

- Semi-significant spills still can be controlled by the first responder along with the aid of other personnel such as laborers and the foreman, etc. This response may require the cessation of all other activities.

- Clean up spills immediately:

  1. Notify the project foreman immediately. The foreman shall notify the Engineer or Safety Manager.
  2. Determine if spill response construction personnel are qualified to perform the cleanup in a safe manner. Alert additional trained personnel if necessary including a Haz-Mat team or dial 911 for local authorities.

Activity: Spill Prevention and Control

Approach (Continued)

3. Contain spread of the spill.
4. If the spill occurs on paved or impermeable surfaces, clean up using "dry" methods (absorbent materials, cat litter and/or rags). Contain the spill by encircling with absorbent materials and do not let the spill spread widely.
5. If the spill occurs in dirt areas, immediately contain the spill by constructing an earthen dike. Dig up and properly dispose of contaminated soil.
6. If the spill occurs during rain, cover spill with tarps or other material to prevent contaminating runoff.

Significant/Hazardous Spills

For significant or hazardous spills that cannot be controlled by personnel in the immediate vicinity, the following steps shall be taken:

1. Notify the Engineer immediately and follow up with a written report.
2. Notify the local emergency response by dialing 911. In addition to 911, the contractor will notify the proper county officials. It is the contractor's responsibility to have all emergency phone numbers at the construction site.
3. For spills of state reportable quantities or into a waterbody or adjoining shoreline, the contractor shall notify the IDEM general hotline – environmental assistance at 1-888-233-7745 (IDEM).
4. For spills of federal reportable quantities or into a waterbody or adjoining shoreline, the contractor shall notify the National Response Center at (800) 424-8802.
5. Notification should first be made by telephone and followed up with a written report.
6. The services of a spills contractor or a Haz-Mat team shall be obtained immediately. Construction personnel should not attempt to clean up until the appropriate and qualified staff has arrived at the job site.
7. Other agencies which may need to be consulted include, but are not limited to, the Fire Department, the Public Works Department, the City/County Police Department, OSHA, etc.

See GHP-12 and -13 for details about spill prevention and control while maintaining or fueling vehicles and equipment.

Maintenance

- Keep an ample supply of spill control and cleanup material on-site, near storage, unloading and maintenance areas.

Inspection Checklist

- ☐ Required amount of clean up material available at the site.

Activity: Solid Waste Management

PLANNING CONSIDERATIONS:

Training: Minimal

PE Design Approval: Not required

Maintenance: Moderate

Inspection Frequency: If reported

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 management of waste in and out of a construction site reduces and in some cases prevents the discharge of pollutants to stormwater. This waste may be solid or construction waste, and can be disposed of at designated waste collection areas and in containers. The reduction of floatable materials and other construction wastes result in this management practice.

Approach

- Solid waste is one of the major pollutants resulting from construction. Construction debris includes:
- Solid waste generated from trees and shrubs removed during land clearing, demolition of existing structures (rubble), and building construction;
- Packaging materials including wood, paper and plastic;
- Scrap or surplus building materials including scrap metals, rubber, plastic, glass pieces, and masonry products;
- Concrete, brick, and mortar;
- Pipe and electrical cuttings;
- Pavement planning or grinding and removal;
- Wood framing or false work; and
- Domestic wastes including food containers such as beverage cans, coffee cups, paper bags, and plastic wrappers, and cigarettes.
- The following steps will help keep a clean site and reduce stormwater pollution:

Activity: Solid Waste Management	GHP-06

Approach (Continued)

The following steps will help keep a clean site and reduce stormwater pollution:

- Designate waste storage areas that are away from storm drain inlets, stormwater facilities, or watercourses.
- Provide containers in areas where employees congregate for breaks and lunch.
- Inform trash hauling contractors that you will accept only watertight dumpsters for on-site use. Inspect dumpsters for leaks or open drain valves and repair any dumpster that is not watertight and tightly close the drain valve.
- Do not hose out dumpsters on the construction site. Leave dumpster cleaning to trash hauling contractor.
- Arrange for regular waste collection before containers overflow.
- If a container does spill, clean up immediately.
- Locate storage containers in a covered area and/or in secondary containment.
- Segregate potentially hazardous waste from non-hazardous construction site waste.
- Provide an adequate number of containers with lids or covers that can be placed over the container to keep rain out or to prevent loss of wastes when it's windy.
- Plan for additional containers and more frequent pickup during the demolition phase of construction.
- Collect site trash daily, especially during rainy and windy conditions.
- Erosion and sediment control devices tend to collect litter. Remove this solid waste promptly.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
- Salvage or recycle any useful material. For example, trees and shrubs from land clearing can be used as a brush barrier or converted into wood chips, then used as mulch on graded areas.
- Make sure that construction waste is collected, removed, and disposed of only at authorized disposal areas.

Activity: Solid Waste Management	GHP-06

Approach (Continued)

- Train employees and subcontractors in proper solid waste management.
- Require that employees and subcontractors follow solid waste handling and storage procedures.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.

Maintenance

- Collect site trash daily.
- Inspect construction waste area regularly.
- Arrange for regular waste collection.

Inspection Checklist

There are no major limitations to this best management practice.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-07

Activity: Hazardous Waste Management

PLANNING CONSIDERATIONS:

Training:
Moderate

PE Design Approval:
Not required

Maintenance:
High

Inspection Frequency:
As reported

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

Proper material use, storage, waste disposal and training of employees and subcontractors help to reduce and prevent pollution to stormwater. The resulting aspect being a partial reduction in toxic materials.

Approach

Many of the chemicals used on-site can be hazardous materials which become hazardous waste upon disposal. These wastes may include:

- Paints and solvents;
- Petroleum products such as oils, fuels, and grease;
- Herbicides and pesticides;
- Acids for cleaning masonry; and
- Concrete curing compounds.

In addition, sites with existing structures may contain wastes which must be disposed of in accordance with Federal, State, and local regulations. These wastes include:

- Sandblasting grit mixed with lead-, cadmium-, or chromium-based paints;
- Asbestos; and
- PCBs (particularly in older transformers).

Activity: Hazardous Waste Management	GHP-07

The following steps will help reduce stormwater pollution from hazardous wastes:

Approach (Continued)

Material Use

- Use all of the product before disposing of the container.
- Do not remove the original product label, it contains important safety and disposal information.
- Material Safety Data Sheets should be provided for each product being handled. All persons using or handling the product should be made aware of the safety information and the location of the readily available Material Safety Data Sheets.
- Do not over-apply herbicides and pesticides. Prepare only the amount needed. Follow the recommended usage instructions. Over-application is expensive, environmentally harmful and generally doesn't provide the intended additional benefit. Apply surface dressings in several smaller applications, as opposed to one large application, to allow time for infiltration and to avoid excess material being carried off-site by runoff. Do not apply these chemicals just before it rains. People applying pesticides must be trained and certified in accordance with Federal and State regulations.
- Do not clean out brushes or rinse paint containers into the dirt, street, gutter, storm drain, or stream. "Paint out" brushes as much as possible. Rinse water-based paints to the sanitary sewer. Filter and re-use thinners and solvents. Dispose of excess oil-based paints and sludge as hazardous waste.

Waste Recycling/Disposal

- Select designated hazardous waste collection areas on-site.
- Regularly schedule hazardous waste removal to minimize on-site storage.
- Hazardous materials and wastes should be stored in covered containers and protected from vandalism. They should be stored in the original containers or in other well marked containers.
- Place hazardous waste containers in secondary containment.

Storage Procedures

- Ensure that adequate hazardous waste storage volume is available.
- Ensure that hazardous waste collection containers are conveniently located.
- Designate hazardous waste storage areas on site, away from storm drains or watercourses.
- Minimize production or generation of hazardous materials and hazardous waste on the jobsite.

Activity: Hazardous Waste Management

Approach (Continued)

- Use containment berms in fueling and maintenance areas and where the potential for spills is high.
- Segregate potentially hazardous waste from non-hazardous construction site debris.
- Store hazardous materials and wastes in covered containers and protected from vandalism.
- Keep liquid or semi-liquid hazardous waste in appropriate containers (closed drums or similar) and under cover.
- Clearly mark on all hazardous waste containers which materials are acceptable for the container.
- Place hazardous waste containers in secondary containment.
- Do not allow potentially hazardous waste materials to accumulate on the ground.
- Do not mix wastes as this can cause unforeseen chemical reactions, make recycling impossible, and complicate disposal.
- Recycle any useful material such as used oil or water-based paint.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for non-hazardous construction debris.
- Arrange for regular waste collection before containers overflow.
- Make sure that hazardous waste (e.g. excess oil-based paint and sludges) is collected, removed, and disposed of only at authorized disposal areas.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.

Training

- Educate employees and subcontractors on hazardous waste storage and disposal procedures.
- Educate employees and subcontractors of potential dangers to humans and the environment from hazardous wastes.
- Instruct employees and subcontractors on safety procedures for common construction site hazardous wastes.

Activity: Hazardous Waste Management	GHP-07

Approach (Continued)

- Instruct employees and subcontractors in identification of hazardous and solid waste.
- Hold regular meetings to discuss and reinforce disposal procedures (incorporate into regular safety meetings).
- Designate a foreman or supervisor to oversee and enforce proper solid waste management procedures and practices.
- Make sure that hazardous waste is collected, removed, and disposed of only at authorized disposal areas.
- Train employees and subcontractors in proper hazardous waste management including review of material safety data sheets.
- Warning signs should be placed in areas recently treated with chemicals.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- If a container does spill, clean up immediately.

Maintenance

- Inspect hazardous waste receptacles and area regularly.
- Arrange for regular hazardous waste collection.

Inspection Checklist

- [ ] This practice is not intended to address site-assessments and pre-existing contamination.
- [ ] Major contamination, large spills, and other serious hazardous waste incidents require immediate response from specialists.
- [ ] Demolition activities and potential pre-existing materials, such as asbestos, are not addressed by this program.
- [ ] Hazardous waste that cannot be reused or recycled must be disposed of by a licensed hazardous waste hauler.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-08

Activity: Contaminated Soil Management

PLANNING CONSIDERATIONS:

Training:
Extensive

PE Design Approval:
As needed

Maintenance:
High

Inspection Frequency:
As required

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

Contaminated soil and highly acidic or alkaline soils produce pollutants in stormwater. Contaminated Soil Management allows preventive measures such as pre-construction surveying, inspecting excavations regularly, and remediating contaminated soil promptly all reduce or prevent the discharge of pollutants to stormwater.

Suitable Applications

- Applicable to many construction projects, especially those in highly urbanized or industrial areas, where soil contamination may have occurred due to spills, illicit discharges, and underground storage tanks.

- Applicable to highway widening projects in older areas where median and shoulder soils may have been contaminated by aerially deposited lead.

Approach

Contaminated soils are often identified in the project material report with known locations identified in the plans and specifications. The contractor shall review applicable reports and investigate appropriate callouts in the plans and specifications.

Contaminated soils may occur on your site for several reasons including:

- Past site uses and activities;
- Detected or undetected spills and leaks; and
- Acid or alkaline solutions from exposed soil or rock formations high in acid or alkaline-forming elements.

Activity: Contaminated Soil Management

Approach (Continued)

Most developers conduct pre-construction environmental assessments as a matter of routine. Recent court rulings holding contractors liable for cleanup costs when they unknowingly move contaminated soil, highlight the need for contractors to confirm that a site assessment is completed before earth moving begins.

The following steps will help reduce stormwater pollution from contaminated soil:

- Conduct thorough site planning including pre-construction geologic surveys.
- Look for contaminated soil as evidenced by discoloration, odors, differences in soil properties, abandoned underground tanks or pipes, or buried debris.
- Prevent leaks and spills to the maximum extent practicable. Contaminated soil can be expensive to treat and/or dispose of properly. However, addressing the problem before construction is much less expensive than after the structures are in place.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.

Application of this BMP Fact Sheet

Excavation, transport, and disposal of contaminated material and hazardous material shall be in accordance with the rules and regulations of the following agencies (the specifications of these agencies shall supersede the procedures outlined in this BMP):

- United States Department of Transportation (USDOT)
- United States Environmental Protection Agency (USEPA)
- Indiana Department of Environmental Management (IDEM)
- Indiana Division of Occupation Safety and Health Administration (I-OSHA)

Education

- Prior to performing any excavation work at the locations containing material classified as hazardous, employees and subcontractors shall complete a safety-training program.
- Educate employees and subcontractors on contaminated soil handling and disposal procedures.
- Instruct employees and subcontractors in identification of contaminated soil.
- Hold regular meetings to discuss and reinforce disposal procedures (incorporate into regular safety meetings).

Activity: Contaminated Soil Management	GHP-08

Approach (Continued)

- Provide additional training for field supervisors and inspectors, including hazardous material safety training.

Handling Procedures for Material with Aerially Deposited Lead

- Materials from areas designated as containing aerially deposited lead may, if allowed by the contract special provisions, be excavated, transported, and used in the construction of embankments and/or backfill.
- Excavation, transportation, and placement operations shall result in no visible dust.
- Use caution to prevent spillage of lead containing material during transport.
- Monitor the air quality during excavation of soils contaminated with lead.

Handling Procedures for Contaminated Soils or Hazardous Materials

- Test suspected soils at a certified laboratory.
- If the soil is contaminated, work with IDEM to develop options for treatment and/or disposal.
- Avoid temporary stockpiling of contaminated soils or hazardous material.
- If temporary stockpiling is necessary:

  1. Cover the stockpile with plastic sheeting or tarps.
  2. Install a berm around the stockpile to prevent runoff from leaving the area.
  3. Do not stockpile in or near storm drains or watercourses.
  4. Implement stockpile controls as presented in GHP-04: Material Delivery, Storage, and Use.

- Contaminated material and hazardous material on exteriors of transport vehicles shall be removed and placed either into the current transport vehicle or the excavation prior to the vehicle leaving the exclusion zone.
- Monitor the air quality continuously during excavation operations at all locations containing hazardous material.
- Procure all permits and licenses, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work, including registration for transporting vehicles carrying the contaminated material and the hazardous material.
- Collect water from decontamination procedures and dispose of at an appropriate disposal site.

Activity: Contaminated Soil Management	GHP-08

Approach (Continued)

- Collect non-reusable personal protective equipment (PPE), once used by any personnel, and dispose of at an appropriate disposal site.
- Install temporary security fence to surround and secure the exclusion zone. Remove fencing when no longer needed.

Procedures for Underground Storage Tank Removals

- Prior to commencing tank removal operations, obtain the required underground storage tank removal permits and approval from IDEM, which has jurisdiction over such work.
- Arrange to have tested, as directed by the Engineer, any liquid or sludge found in the underground tank prior to its removal to determine if it contains hazardous material.
- Following the tank removal, take soil samples beneath the excavated tank and perform analysis as required by IDEM and the local agency representative(s).
- The underground storage tank, any liquid and/or sludge found within the tank, and all contaminated material and hazardous material removed during the tank removal shall be transported to disposal facilities permitted to accept such material by a licensed hazardous waste hauler.

Water Control

- Take all necessary precautions and preventive measures to prevent the flow of water, including ground water, from entering hazardous material or underground storage tank excavations. Such preventative measures may consist of, but are not limited to berms, cofferdams, grout curtains, freeze walls, and seal course concrete or any combination thereof.
- If water does enter an excavation and becomes contaminated, such water, when necessary to proceed with the work, shall be discharged to clean, closed top, watertight, transportable holding tanks, and disposed of in accordance with federal, state, and local laws.

Maintenance

- Inspect excavated areas daily for indications of contaminated soil.
- Implement GHP-05: Spill Prevention and Control, to prevent leaks and spills as much as possible.
- Monitor air quality continuously during excavation operations at all locations containing hazardous material.
- Coordinate contaminated soils and hazardous material management with the appropriate federal, state, and local agencies.
- Inspect hazardous waste receptacles and areas regularly.

Activity: Contaminated Soil Management	GHP-08

Inspection Checklist	❑ The procedures and practices presented in this BMP are general. The contractor shall identify appropriate practices and procedures for the specific contaminants known to exist or discovered on site. ❑ Contaminated soils that cannot be treated on-site must be disposed of off-site by a licensed hazardous waste hauler. ❑ The presence of contaminated soil may indicate contaminated water as well. See GHP-01: Dewatering Operations for more information.

	Southern Indiana **Stormwater Best Management Practices (BMPs)** **Good Housekeeping Practices (GHPs)**	GHP-09
	Activity: Concrete Waste Management	

PLANNING CONSIDERATIONS:

Training:
None

PE Design Approval:
Not required

Maintenance:
Low

Inspection Frequency:
If reported

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 avert concrete pollutant discharge to stormwater a number of precautionary measures should be taken. These measures include conducting off-site washouts, performing on-site washout in a designated area and training employees and subcontractors.

Approach

The following steps will help reduce stormwater pollution from concrete wastes:

- Store dry and wet materials under cover, away from drainage areas.
- Avoid mixing excess amounts of fresh concrete or cement on-site.
- Perform washout of concrete trucks off site or in designated areas only – such as a specially designed soil mixing sump protected by a sediment trap.
- Do not wash out concrete trucks into storm drains, open ditches, streets, or streams.
- Do not allow excess concrete to be dumped on-site, except in designated areas. For on-site washout:
- Locate washout area at least 50 feet (15.2 m) from storm drains, open ditches, or water bodies. Do not allow runoff from this area by constructing a temporary pit or bermed area large enough for liquid and solid waste;

Activity: Concrete Waste Management	GHP-09

Approach (Continued)

- Wash out wastes into the temporary pit where the concrete can set, be broken up, and then disposed of properly.
- Be sure the stormwater collection system is protected by means of a sediment trap or similar practice.
- When washing concrete to remove fine particles and expose the aggregate, avoid creating runoff by draining the water to a bermed or level area.
- Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile, or dispose in the trash.
- Train employees and subcontractors in proper concrete waste management.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.
- Illicit dumping on-site or off-site without property owner's knowledge and consent is unacceptable.
- Washout locations may be flagged with lath and surveyors tape or designated as necessary to insure that truck drivers utilize proper areas.

Education

- Instruct drivers and equipment operators on proper disposal and equipment washout practices.
- Educate employees, subcontractors, and suppliers on concrete waste storage and disposal procedures.
- Designate a foreman or supervisor to oversee and enforce concrete waste management procedures. Make supervisors aware of the potential environmental consequences of improperly handled concrete wastes.

Demolition Practices

- Monitor weather and wind direction to ensure concrete dust is not entering storm drains, watercourses, or surface waters.
- Where appropriate, construct sediment traps or other types of sediment detention devices downstream of demolition activities.

Maintenance

- Inspect subcontractors to ensure that concrete wastes are being properly managed.
- If using a temporary pit, dispose hardened concrete on a regular basis that will prevent the pit from being more than half full.
- Foreman and/or construction supervisor shall monitor on site concrete waste storage and disposal procedures at least weekly.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-10

Activity: Sanitary/Septic Waste Management

P PLANNING CONSIDERATIONS:

Training: Moderate

PE Design Approval: Required

Maintenance: High

Inspection Frequency: Monthly

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

Providing convenient well-maintained facilities with regular service and disposal reduces or prevents discharge of pollutants to stormwater from sanitary/septic waste.

Approach

- Sanitary or septic wastes should be treated or disposed of in accordance with IDEM requirements. These requirements may include:
- Locate sanitary facilities in a convenient location.
- Untreated or raw wastewater should never be discharged to a ditch, creek or other waterway, or buried.
- Temporary septic systems should treat wastes to appropriate levels before discharging. IDEM should be consulted to determine appropriate levels.
- If using an on-site disposal system (OSDS), such as a septic system, comply with local health agency requirements. IDEM should be consulted.
- Temporary sanitary facilities that discharge to the sanitary sewer system should be properly connected and inspected by the local sewer authority to avoid illicit discharges to the storm sewer system.

Activity: Sanitary/Septic Waste Management	GHP-10

Approach

- If discharging to the sanitary sewer, contact the local sewer authority for their requirements.
- Privately held sanitary/septic facilities should be maintained in good working order by a licensed service.
- Arrange for regular waste collection by a licensed hauler before facilities overflow.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.
- Anchor portable sanitary facilities, when needed, to prevent them from blowing over or being turned over by vandals.

Maintenance

- Inspect facilities regularly.
- Arrange for regular waste collection.

Inspection Checklist

- [ ] There are no major limitations to this best management practice other than those that may be imposed by the local sewer authority.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-11

Activity: Vehicle and Equipment Cleaning

PLANNING CONSIDERATIONS:

Training:
None

PE Design Approval:
Not required

Maintenance:
Low

Inspection Frequency:
If reported

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 source of pollution through improper vehicle and equipment cleaning can be abated by cleaning equipment using an off-site facility, washing in designated contained areas only, infiltrating or recycling the wash water and by training employees and subcontractors.

Approach

- Use off-site commercial washing businesses as much as possible except for removing mud and dirt off equipment while on site. Washing vehicles and equipment outdoors or in areas where wash water flows onto paved surfaces or into drainage pathways can pollute stormwater. If you wash a large number of vehicles or pieces of equipment, consider conducting this work at an off-site commercial business.

- Off-site commercial businesses are better equipped to handle and dispose of the wash waters properly. Performing this work off-site can also be economical by eliminating the need for a separate washing operation at your site.

- If washing must occur on-site, use designated, bermed wash areas to prevent wash water entering stormwater infrastructure, creeks, rivers, and other water bodies. The wash area can be sloped for wash water collection and subsequent infiltration into the ground.

Activity: Vehicle and Equipment Cleaning

Approach (Continued)

- Use phosphate-free, biodegradable soaps.
- Educate employees and subcontractors on pollution prevention measures about the importance of this practice.
- Do not permit steam cleaning on-site. Steam cleaning can generate significant pollutant concentrations.
- Clean all vehicles/equipment off-site that regularly enter and leave the construction site.
- When vehicle/equipment washing/cleaning must occur on-site, and the operation cannot be located within a structure or building equipped with sanitary sewer facilities, the outside cleaning area shall have the following characteristics:
  1. Located away from storm drain inlets, drainage facilities, or watercourses;
  2. Paved with concrete or asphalt, or stabilized with an aggregate base;
  3. Configured wash area with a sump to allow collection and disposal of wash water;
  4. Discharge wash water to a sanitary or process waste sewer (where permitted), or to a dead end sump. Wash waters shall not be discharged to storm drains or watercourses.
- When cleaning vehicles/equipment with water:
  1. Use as little water as possible to avoid having to install erosion and sediment controls for the wash area. High-pressure sprayers may use less water than a hose, and should be considered.
  2. Use positive shutoff valve to minimize water usage.
- DO NOT use solvents to clean vehicles/equipment on site.

Maintenance

- Minimal, some berm repair may be necessary, inspect weekly.
- Service sump regularly.

Inspection Checklist

- ☐ Sending vehicles/equipment off-site should be done in conjunction with a stabilized construction entrance and mud tracking removal.
- ☐ The local sewer authority may require pretreatment and monitoring of wash water discharges to the sanitary sewer and should be consulted first.

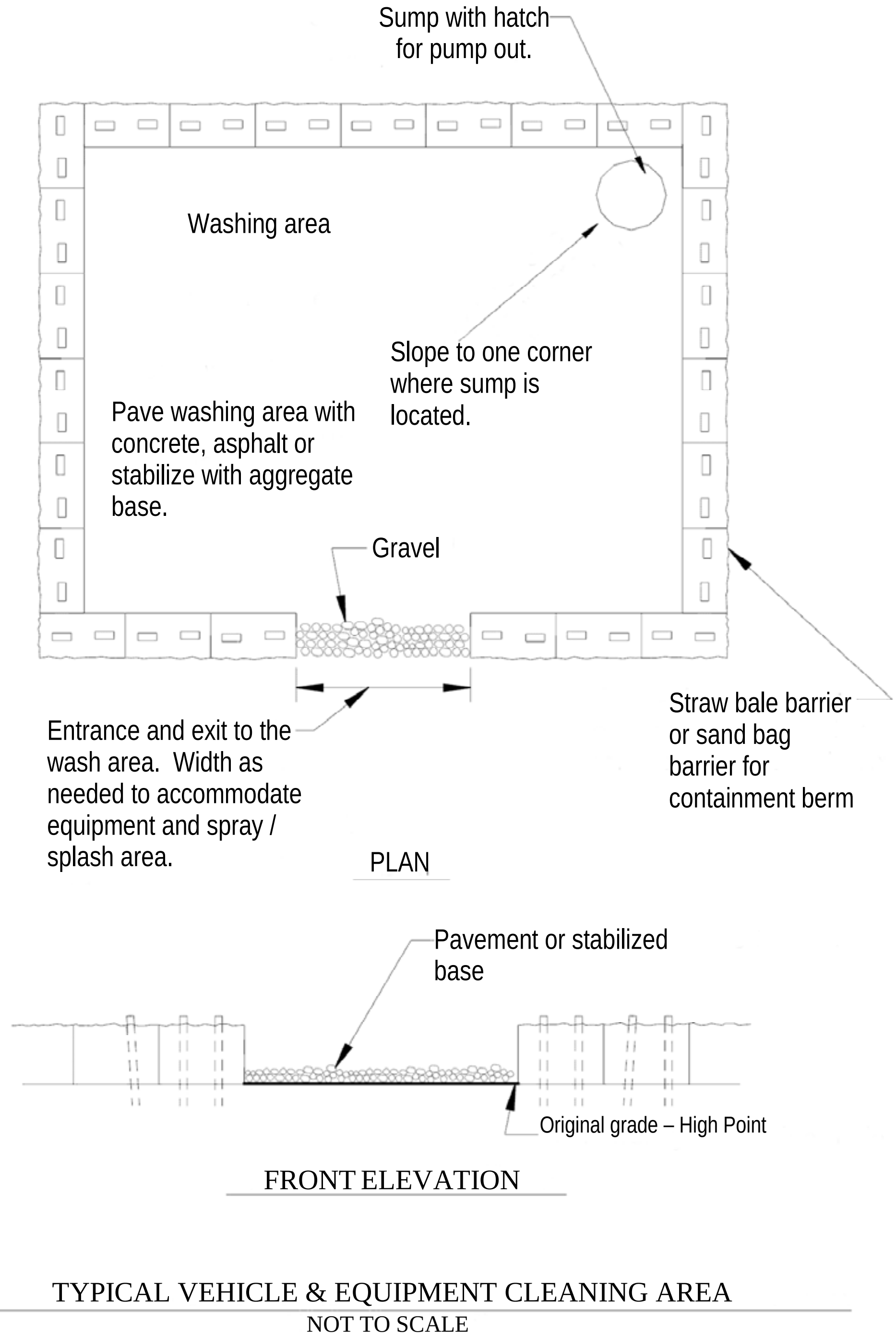


Figure GHP-11-01

Typical Vehicle & Equipment Cleaning Area

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-12

Activity: Vehicle and Equipment Fueling

PLANNING CONSIDERATIONS:

Training:
High

PE Design Approval:
Required

Maintenance:
Low

Inspection Frequency:
Weekly

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 prevents fuel spills and leaks and their impact to stormwater by using off-site facilities, fueling in designated areas only, enclosing or covering stored fuel, implementing spill controls, and training employees and subcontractors.

Approach

- Use off-site fueling stations as much as possible. Fueling vehicles and equipment outdoors or in areas where fuel may spill/leak onto paved surfaces or into drainage pathways can pollute stormwater. If you fuel a large number of vehicles or pieces of equipment, consider using an off-site fueling station. These businesses are better equipped to handle fuel and spills properly. Performing this work off-site can also be economical by eliminating the need for a separate fueling area at your site.

- If fueling must occur on-site, use designated areas, located away from drainage courses, to prevent the run-on of stormwater and the runoff of spills.

- Discourage "topping-off" of fuel tanks.

- Always use secondary containment, such as a drain pan or drop cloth, when fueling to catch spills/leaks.

- Place a stockpile of spill cleanup materials where it will be readily accessible.

Activity: Vehicle and Equipment Fueling

Approach (Continued)

- Use adsorbent materials on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.
- Carry out all Federal and State requirements regarding stationary above ground storage tanks with special attention given to secondary containment.
- Avoid mobile fueling of mobile construction equipment around the site; rather, transport the equipment to designated fueling areas. With the exception of tracked equipment such as bulldozers and perhaps forklifts, most vehicles should be able to travel to a designated area with little lost time.
- Train employees and subcontractors in proper fueling and cleanup procedures.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.
- Locate fueling areas on a paved surface where practical.
- Protect fueling areas with berms and/or dikes to prevent run-on, runoff, and to contain spills.
- Use vapor recovery nozzles to help control drips as well as air pollution where required by Air Quality Management Districts.

Maintenance

- Keep ample supplies of spill cleanup materials on-site.
- Inspect fueling areas and storage tanks on a regular schedule.

Inspection Checklist

- [ ] Vehicles/equipment leaving site are using a stabilized construction entrance.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-13

Activity: Vehicle and Equipment Maintenance

PLANNING CONSIDERATIONS:

Training:
Moderate

PE Design Approval:
Not required

Maintenance:
Low

Inspection Frequency:
If reported

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

Running a “dry site” will reduce or prevent discharge of pollutants to stormwater from vehicles and equipment maintenance. A “dry site” involves using off-site facilities, performing work in designated areas only, providing cover for materials stored outside, checking for leaks and spills, containing and cleaning up spills immediately and training employees and subcontractors.

Approach

- Keep vehicles and equipment clean; don’t allow excessive build-up of oil and grease.

- Use off-site repair shops as much as possible. Maintaining vehicles and equipment outdoors or in areas where vehicle or equipment fluids may spill or leak onto the ground can pollute stormwater. If you maintain a large number of vehicles or pieces of equipment, consider using an off-site repair shop. These businesses are better equipped to handle vehicle fluids and spills properly. Performing this work off-site can also be economical by eliminating the need for a separate maintenance area.

Waste Reduction

- Parts are often cleaned using solvents such as trichloroethylene, 1,1,1-trichloroethane, or methylene chloride. Many of these parts cleaners are harmful and must be disposed of as a hazardous waste. Reducing the number of solvents makes recycling easier and reduces hazardous waste management costs. Often, one solvent can perform a job as well as two different solvents. Also, if possible, eliminate or reduce the amount of

Approach (Continued)

- *(cont'd)* hazardous materials and waste by substituting non-hazardous or less hazardous materials. For example, replace chlorinated organic solvents (1,1,1-trichloroethane, methylene chloride, etc.) with non-chlorinated solvents. Non-chlorinated solvents like kerosene or mineral spirits are less toxic and less expensive to dispose of properly. Check list of active ingredients to see whether it contains chlorinated solvents. The "chlor" term indicates that the solvent is chlorinated. Also, try substituting a wire brush for solvents to clean parts.
- If maintenance must occur on-site, use designated areas, located away from water courses, to prevent the run-on of stormwater and the runoff of spills.
- Always use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Place drip pans or absorbent materials under paving equipment when not in use.
- Use adsorbent materials on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.
- Regularly inspect on-site vehicles and equipment for leaks, and repair immediately.
- Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around.
- Check incoming vehicles and equipment (including delivery trucks, and employee and subcontractor vehicles) for leaking oil and fluids. Do not allow leaking vehicles or equipment on-site.
- Oil filters disposed of in trashcans or dumpsters can leak oil and pollute stormwater. Place the oil filter in a funnel over a waste oil recycling drum to drain excess oil before disposal. Oil filters can also be recycled. Ask your oil supplier or recycler about recycling oil filters.
- Store cracked batteries in a non-leaking secondary container. Do this with all cracked batteries, even if you think all the acid has drained out. If you drop a battery, treat it as if it is cracked. Put it into the containment area until you are sure it is not leaking.
- Segregate and recycle wastes, such as greases, used oil or oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic, and transmission fluids.
- Train employees and subcontractors in proper maintenance and spill cleanup procedures.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.
- Perform maintenance activities on paved surfaces where practical.

Activity: Vehicle and Equipment Maintenance	GHP-13

Approach (Continued)

- Provide spill containment dikes or secondary containment around stored oil and chemical drums.
- For long-term projects, consider using portable tents or covers over maintenance areas.
- Do not dump fuels and lubricants onto the ground.
- Do not place used oil in a dumpster or pour into a storm drain or watercourse.
- Do not bury used tires.

Recycling/Disposal

- Separating wastes allows for easier recycling and may reduce disposal costs. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents (like 1,1,1-trichloroethane) separate from non-chlorinated solvents (like kerosene and mineral spirits).
- Do not dispose of extra paints and coatings by dumping liquid onto the ground or throwing it into dumpsters. Allow coatings to dry or harden before disposal into covered dumpsters.

Maintenance

- Keep ample supplies of spill cleanup materials on-site.
- Inspect maintenance areas on a regular schedule.
- Maintain waste fluid containers in leak proof condition.
- Vehicle and equipment maintenance areas shall be inspected regularly.
- Inspect equipment for damaged hoses and leaky gaskets routinely. Repair or replace as needed.

Inspection Checklist

- [ ] Sending vehicles/equipment off-site should be done in conjunction with a stabilized construction entrance.
- [ ] Outdoor vehicle or equipment maintenance is a potentially significant source of stormwater pollution. Activities that can contaminate stormwater include engine repair and service, particularly changing or replacement of fluids, and outdoor equipment storage and parking (dripping engines). For further information on vehicle or equipment servicing, see GHP-12: Vehicle and Equipment Fueling.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-14

Activity: Employee/Subcontractor Training

PLANNING CONSIDERATIONS:

Training: Required

PE Design Approval: Not required

Maintenance: None

Inspection Frequency: N/A

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 importance of a competently trained employee or subcontractor will determine the success of the stormwater pollution prevention program. This BMP points out general methodologies used when implementing stormwater pollution prevention techniques and objectives. This training guide will focus on approaches to assure that employees and subcontractors are verse in the Storm Water Pollution Prevention Plan (SWPPP) and will turn the attention from an individualized source control into a comprehensive training program.

Suitable Applications

Employee/subcontractor training should be based on four objectives:

- Promote a clear identification and understanding of the problem, including activities with the potential to pollute stormwater;
- Identify solutions (BMPs);
- Promote employee/subcontractor ownership of the problems and the solutions; and
- Integrate employee/subcontractor feedback into training and BMP implementation.

Approach

- Integrate training regarding stormwater quality management with existing training programs that may be required for your business by other regulations such as the 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) standard (29 CFR 1910.120); and the Spill Prevention Control and Countermeasure (SPCC) Plan (40 CFR 112).

Activity: Employee/Subcontractor Training

Approach (Continued)

- Supervisors and inspectors should receive additional annual 8-hour refresher courses.
- Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, may use the information in this BMP Manual to develop a training program to reduce their potential to pollute stormwater.
- Use the quick reference on disposal alternatives (Table GHP-14-01) to train employee/ subcontractors in proper and consistent methods for disposal.
- Consider posting the quick reference table around the job site or in the on-site office trailer to reinforce training.
- Train employee/subcontractors in standard operating procedures and spill cleanup techniques described in the fact sheets. Employee/subcontractors trained in spill containment and cleanup should be present during the loading/unloading and handling of materials.
- Personnel who use pesticides should be trained in their use.
- Proper education of off-site contractors is often overlooked. The conscientious efforts of well trained employee/subcontractors can be lost by unknowing off-site contractors, so make sure they are well informed about what they are expected to do on-site.

TABLE GHP-14-1 QUICK REFERENCE – DISPOSAL ALTERNATIVES

All of the waste products on this chart are prohibited from discharge to the storm drain system. Use this matrix to decide which alternative disposal strategies to use. ALTERNATIVES ARE LISTED IN PRIORITY ORDER.

Key: HHW — Household hazardous waste
POTW — Publicly Owned Treatment Plant
NPDES — National Pollutant Discharge Elimination System (NPDES) Office.
"Dispose to sanitary sewer" means dispose into sink, toilet, or sanitary sewer clean-out connection.
"Dispose as trash" means dispose in dumpsters or trash containers for pickup and/or eventual disposal in landfill.
"Dispose as hazardous waste" for business/commercial means contract with a hazardous waste hauler to remove and dispose.

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	BUSINESS/COMMERCIAL Approval	RESIDENTIAL Disposal Priorities
General Construction and Painting: Street and Utility Maintenance			
Excess paint (oil based)	1. Recycle/reuse. 2. Dispose as hazardous waste.		1. Recycle/reuse. 2. Take to HHW drop-off.
Excess paint (water based)	1. Recycle/reuse 2. Dry residue in cans, dispose as trash. 3. If volume is too much to dry, dispose as hazardous waste.		1. Recycle/reuse. 2. Dry residue in cans, dispose as trash. 3. If volume is too much to dry, take to HHW drop-off.
Paint cleanup (oil based)	Wipe paint out of brushes, then: 1. Filter & reuse thinners, solvents. 2. Dispose as hazardous waste.		Wipe paint out of brushes, then: 1. Filter & reuse thinners, solvents. 2. Take to HHW drop-off.
Paint cleanup (water-based)	Wipe paint out of brushes, then 1. Rinse to sanitary sewer.		Wipe paint out of brushes, then 1. Rinse to sanitary sewer.
Empty paint cans (dry)	1. Remove lids, dispose as trash.		1. Remove lids, dispose as trash.
Paint stripping (with solvent)	1. Dispose as hazardous waste.		1. Take to HHW drop-off.
Building exterior cleaning (high-pressure water)	1. Prevent entry into storm drain and remove offsite. 2. Wash onto dirt area, spade in. 3. Collect (e.g. mop up) and discharge to sanitary sewer.	POTW-MWS	
Cleaning of building exteriors which have HAZARDOUS MATERIALS (e.g. mercury, lead) in paints	1. Use dry cleaning methods. 2. Contain and dispose washwater as hazardous waste (Suggestion: dry material first to reduce volume).		

General Construction and Painting: Street and Utility Maintenance (cont'd.)			
Non-hazardous paint scraping/sand blasting	1. Dry sweep, dispose as trash.		1. Dry sweep, dispose as trash.
HAZARDOUS paint scraping/sand blasting (e.g. marine paints or paints containing lead or tributyl tin)	1. Dry sweep, dispose as hazardous waste.		1. Dry sweep, take to HHW drop-off.
Soil from excavations during periods when storms are forecast Note: Thoroughly sweep following removal of dirt in all four alternatives.	1. Should not be placed in street or on paved areas. 2. Remove from site or backfill by end of day. 3. Cover with tarpaulin or surround with silt fences, or use other runoff controls. 4. Place filter mat over storm drain.		
Soil from excavations placed on paved surfaces during periods when storms are not forecast	1. Keep material out of storm conveyance systems and thoroughly remove via sweeping following removal of dirt.		
Cleaning streets in construction areas	1. Dry sweep and minimize tracking of mud. 2. Use silt ponds and/or similar pollutant reduction techniques when flushing pavement.		
Soil erosion, sediments	1. Cover disturbed soils, use erosion controls, block entry to storm drain. 2. Seed or plant immediately.		
Fresh cement, grout, mortar	1. Use/reuse excess 2. Dispose to trash		1. Use/reuse excess 2. Dispose to trash
Washwater from concrete/mortar (etc.) cleanup	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.	POTW-MWS	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.
Aggregate wash from driveway/patio construction	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.	POTW-MWS	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.
Rinse water from concrete mixing trucks	1. Return truck to yard for rinsing into pond or dirt area. 2. At construction site, wash into pond or dirt area.		

General Construction and Painting: Street and Utility Maintenance (cont'd.)			
Non-hazardous construction and demolition debris	1. Recycle/reuse (concrete, wood, etc.). 2. Dispose as trash.		1. Recycle/reuse (concrete, wood, etc.). 2. Dispose as trash.
Hazardous demolition and construction debris (e.g. asbestos)	1. Dispose as hazardous waste.		1. Do not attempt to remove yourself. Contact asbestos removal service for safe removal and disposal. 2. Very small amounts (less than 5 lbs.) may be double-wrapped in plastic and taken to HHW drop-off.
Saw-cut slurry	1. Use dry cutting technique and sweep up residue. 2. Vacuum slurry and dispose off-site. 3. Block storm drain or berm with low weir as necessary to allow most solids to settle. Shovel out gutters; dispose residue to dirt area, construction yard or landfill.		
Construction dewatering (Nonturbid, uncontaminated groundwater)	1. Recycle/reuse. 2. Discharge to storm drain.		
Construction dewatering (Other than nonturbid, uncontaminated groundwater)	1. Recycle/reuse. 2. Discharge to sanitary sewer. 3. As appropriate, treat prior to discharge to storm drain.	POTW-MWS MDPW-NPDES	
Portable toilet waste	1. Leasing company shall dispose to sanitary sewer at POTW.	POTW-MWS	
Leaks from garbage dumpsters	1. Collect, contain leaking material. Eliminate leak, keep covered, return to leasing company for immediate repair. 2. If dumpster is used for liquid waste, use plastic liner.		
Leaks from construction debris bins	1. Insure that bins are used for dry non-hazardous materials only (Suggestion: Fencing, covering help prevent misuse).		
Dumpster cleaning water	1. Clean at dumpster owner's facility and discharge waste through grease interceptor to sanitary sewer. 2. Clean on site and discharge through grease interceptor to sanitary sewer.	POTW-MWS POTW-MWS	

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
General Construction and Painting: Street and Utility Maintenance (cont'd.)			
Cleaning driveways, paved areas (Special Focus = Restaurant alleys, grocery dumpster areas)	1. Sweep and dispose as trash (Dry cleaning only). 2. For vehicle leaks, restaurant/grocery alleys, follow this 3-step process: a. Clean up leaks with rags or absorbents. b. Sweep, using granular absorbent material (cat litter). c. Mop and dispose of mop water to sanitary sewer (or collect rinse water and pump to the sanitary sewer). 3. Same as 2 above, but with rinse water (2c)(no soap) discharged to storm drain.		1. Sweep and dispose as trash (Dry cleaning only). 2. For vehicle leaks follow this 3-step process: a. Clean up leaks with rags or absorbents; dispose as hazardous waste. b. Sweep, using granular absorbent material (cat litter). c. Mop and dispose of mop water to sanitary sewer.
Steam cleaning of sidewalks, plazas	1. Collect all water and pump to sanitary sewer. 2. Follow this 3-step process: a. Clean oil leaks with adsorbents. b. Sweep (Use dry absorbent as needed). c. No soap discharge to storm drain.		
Potable water/line flushing Hydrant testing	1. Deactivate chlorine by maximizing time water will travel before reaching creeks.		
Super-chlorinated (above 1 ppm) water from line flushing	1. Discharge to sanitary sewer. 2. Complete dechlorination required before discharge to storm drain.		
Landscape/Garden Maintenance			
Pesticides	1. Use up. Rinse containers, use rinse water as product. Dispose rinsed containers as trash. 2. Dispose unused pesticide as hazardous waste.		1. Use up. Rinse containers, use rinse water as pesticide. Dispose rinsed container as trash. 2. Take unused pesticide to HHW drop-off.
Garden clippings	1. Compost. 2. Take to Landfill.		1. Compost. 2. Dispose as trash.
Tree trimming	1. Chip if necessary, before composting or recycling.		1. Chip if necessary, before composting or recycling.

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Landscape/Garden Maintenance (cont'd.)			
Swimming pool, spa, fountain water (emptying)	1. Do not use metal-based algicides (i.e. Copper Sulfate). 2. Recycle/reuse (e.g. irrigation). 3. Determine chlorine residual = 0, wait 24 hours and then discharge to storm drain.	POTW-MWS	1. Do no use metal-based algicides (i.e. Copper Sulfate). 2. Recycle/reuse (e.g. irrigation). 3. Determine chlorine residual = 0, wait 24 hours and then discharge to storm drain.
Acid or other pool/spa/fountain cleaning	1. Neutralize and discharge to sanitary sewer.	POTW-MWS	
Swimming pool, spa filter backwash	1. Reuse for irrigation. 2. Dispose on dirt area. 3. Settle, dispose to sanitary sewer.		1. Use for landscape irrigation. 2. Dispose on dirt area. 3. Settle, dispose to sanitary sewer.
Vehicle Wastes			
Used motor oil	1. Use secondary containment while storing, send to recycler.		1. Put out for curbside recycling pickup where available. 2. Take to Recycling Facility or auto service facility with recycling program. 3. Take to HHW events accepting motor oil.
Antifreeze	1. Use secondary containment while storing, send to recycler.		1. Take to Recycling Facility.
Other vehicle fluids and solvents	1. Dispose as hazardous waste.		1. Take to HHW event.
Automobile batteries	1. Send to auto battery recycler. 2. Take to Recycling Center.		1. Exchange at retail outlet. 2. Take to Recycling Facility or HHW event where batteries are accepted.
Motor home/construction trailer waste	1. Use holding tank. Dispose to sanitary sewer.		1. Use holding tank, dispose to sanitary sewer.
Vehicle washing	1. Recycle. 2. Discharge to sanitary sewer, never to storm drain.	POTW-MWS	1. Take to Commercial Car Wash. 2. Wash over lawn or dirt area. 3. If soap is used, use a bucket for soapy water and discharge remaining soapy water to sanitary sewer.
Mobile vehicle washing	1. Collect washwater and discharge to sanitary sewer.	POTW-MWS	
Rinse water from dust removal at new car fleets	1. Discharge to sanitary sewer. 2. If rinsing dust from exterior surfaces for appearance purposes, use no soap (water only); discharge to storm drain.	POTW-MWS	

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Vehicle Wastes (cont'd.)			
Vehicle leaks at Vehicle Repair Facilities	Follow this 3-step process: 1. Clean up leaks with rags or absorbents. 2. Sweep, using granular absorbent material (cat litter). 3. Mop and dispose of mop water to sanitary sewer.		
Other Wastes			
Carpet cleaning solutions & other mobile washing services	1. Dispose to sanitary sewer.	POTW-MWS	1. Dispose to sanitary sewer.
Roof drains	1. If roof is contaminated with industrial waste, discharge to sanitary sewer. 2. If no contamination is present, discharge to storm drain.		
Cooling water Air conditioning condensate	1. Recycle/reuse. 2. Discharge to sanitary sewer.	POTW-MWS	
Pumped groundwater, infiltration/foundation drainage (contaminated)	1. Recycle/reuse (landscaping, etc.) 2. Treat discharge to sanitary sewer. 3. Treat and discharge to storm drain.	MDPW-NPDES POTW-MWS MDPW-NPDES	
Fire fighting flows	If contaminates present, Fire Dept. will try to prevent flow to stream, storm drain.		
Kitchen Grease	1. Provide secondary containment, collect, send to recycler. 2. Provide secondary containment, collect, send to POTW via hauler.	POTW-MWS	1. Collect, solidify, dispose as trash.
Restaurant cleaning of floor mats, exhaust filters, etc.	1. Clean inside building with discharge through grease trap to sanitary sewer. 2. Clean outside in container or bermed area with discharge to sanitary sewer.		
Clean-up wastewater from sewer back-up	1. Follow this procedure: a. Block storm drain, contain, collect, and return spilled material to the sanitary sewer. b. Block storm drain, rinse remaining material to collection point and pump to sanitary sewer (no rinse water may flow to storm drain).		

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-15

Activity: Pesticides, Herbicides and Fertilizer Use

PLANNING CONSIDERATIONS:

Training:
Minimal

PE Design Approval:
Not Required

Maintenance:
Moderate

Inspection Frequency:
If reported

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

Potentially harmful chemicals such as fertilizers, herbicides and pesticides desire an efficient and safe housekeeping practices to assure that pollution does not enter into stormwater.

Approach

- Integrate this best management practice as much as possible with your existing programs.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.
- Contractors/subcontractors should develop controls on the application of pesticides, on-site. Controls may include:
- List of approved pesticides and selected uses.
- Product and application information for users.
- Equipment use and maintenance procedures.
- Record keeping and public notice procedures.

Activity: Pesticides, Herbicides and Fertilizer Use	GHP-15

Approach (Continued)

The following discussion provides some general information on good housekeeping:

- Always use caution when handling any pesticide or fertilizer product. Many products contain toxic chemicals that can cause severe injury or death.
- Store pesticide or fertilizer products securely and away from children, pets, and sources of heat, sparks, and flames.
- Store products in their original containers and keep them well labeled. Do not store chemicals in food containers.
- Read and follow use instructions provided on packaging and in Material Safety Data Sheets. Periodically review the Material Safety Data Sheets and discuss use and handling precautions with people using or handling the pesticides, herbicides, or fertilizers.
- Avoid contact with eyes and skin. Wear gloves and eye protection when using or handling hazardous substances. Do not wear contact lenses, which can absorb hazardous vapors.
- Work in only well ventilated areas.
- Use up all of the product before disposing the container.
- Do not dispose of pesticide or fertilizer wastes:
    1. in trash
    2. down storm drains or into creeks
    3. onto the ground
    4. by burning.
- Do dispose of hazardous wastes at household hazardous waste collection events or facilities. Metro operates a permanent household hazardous waste collection facility at ___________________. For more information call __________.

Maintenance

- Training
- Contractor and subcontractor employees who handle potentially harmful materials should be trained in good housekeeping practices. Personnel who use pesticides must be trained in their use.
- The primary cost is for staff time as noted above.

Inspection Checklist

- [ ] There are no major limitations to this best management practice.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-16

Activity: Dust Control and Tracking

PLANNING CONSIDERATIONS:

Training:
Minimal

PE Design Approval:
Not required

Maintenance:
Low

Inspection Frequency:
Weekly

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

Dust control measures are used to stabilize soil from wind erosion and reduce dust generated by construction activities. This temporary measure-an intermediate treatment between disturbance in either construction, paving, or vegetation reduces the amount of eroded material available for stormwater runoff.

Suitable Applications

- Clearing and grading activities.
- Construction vehicle traffic on temporary or unpaved roads or construction site access paths.
- Drilling and blasting activities.
- Sediment tracking onto paved roads.
- Soil and debris storage piles.
- Batch drop from front end loaders.
- Areas with unstabilized soil.
- Final grading/site stabilization usually is sufficient to control post-construction dust sources.
- Dust control should be practiced at all construction sites by performing phased clearing and grading operations, using temporary stabilization methods, and/or placing undisturbed vegetative buffers of at least 50 ft. (15 m) length between areas being graded and those areas to remain undeveloped.
- Dust control is particularly important in windy or wind-prone areas.

Activity: Dust Control and Tracking

Approach

- Schedule construction activities to minimize exposed area by clearing only areas where phased construction is to take place.
- Quickly stabilize exposed soils using vegetation, mulching, spray-on adhesives, calcium chloride, sprinkling, and stone/gravel layering.
- Identify and stabilize key access points prior to commencement of construction. See SMP-02, 03 and 04.
- Minimizing the impact of dust by anticipating the direction of prevailing winds.
- Direct most construction traffic to stabilized roadways within the project site.
- Dust control BMP's generally stabilize exposed surfaces and minimize activities that suspend or track dust particles. Table GHP-16-1 shows which Dust Control BMPs apply to site conditions which cause dust. For heavily traveled and disturbed areas, wet suppression (watering), chemical dust suppression, gravel or asphalt surfacing, temporary gravel construction entrances, equipment wash-out areas, and haul truck covers can be employed as dust control applications. Permanent or temporary vegetation and mulching and sand fences can be employed for areas of occasional or no construction traffic.
- Preventive measures would include minimizing surface areas to be disturbed, limiting on-site vehicle traffic to 15 miles per hour (24 km per hour), and controlling the number and activity of vehicles on a site at any given time.
- Pave, vegetate, or chemically stabilize access points where unpaved traffic surfaces adjoin paved roads.
- Provide covers for haul trucks transporting materials that contribute to dust.
- Provide for wet suppression or chemical stabilization of exposed soils.
- Provide for rapid clean-up of sediments deposited on paved roads. Furnish stabilized construction road entrances and vehicle wash down areas.
- Stabilize unpaved haul roads, parking and staging areas. Reduce speed and trips on unpaved roads.
- Implement dust control measures for material stockpiles.
- Prevent drainage of sediment-laden stormwater onto paved surfaces.
- Stabilize abandoned construction sites using vegetation or chemical stabilization methods.
- For the chemical stabilization, there are many products available for chemically stabilizing gravel roadways and stockpiles. The types of chemicals available and

Approach (Continued)

recommendations for their use are tabulated in Table GHP-16-2, Commonly Used Chemicals for Dust Control.

Selection of Methods

Selection of dust control agents should be based primarily on cost-effectiveness and environmental hazards.

Chemical methods are dust suppressant or binding agents that are used on the soil surface to bind finer particles together. Chemical dust control agents must be environmentally benign, easily applied, easily maintained, economical and not significantly detrimental to traffic ability.

Approximately three-quarters of chemical dust control agents are inorganic compounds which are compatible with soil and biota. After application, the compounds dampen and penetrate into the soil; a hygroscopic reaction pulls moisture from the atmosphere into the surface and adheres fines to aggregate surface particles. The compounds may not penetrate soil surfaces made up primarily of silt and clay, so soil tests are required.

Key factors in determining the method include the following:

- Soil types and surface materials - both fines and moisture content are key properties of surface materials.
- Properties of the agents - the five most important properties are penetration, evaporation, resistance to leaching, abrasion, and aging.
- Traffic volumes – the effectiveness and life span of dust control agents decreases as traffic increases. For high traffic areas, agents need to have strong penetrating and stabilizing capabilities.
- Climate - some hygroscopic agents lose their moisture-absorbing abilities with lower relative humidity, and some may lose resilience. Under rainy conditions, some agents may become slippery or even leach out of the soil.
- Environmental requirements - the primary environmental concern is the presence and concentration of heavy metals in the agent that may leach into the immediate ecosystem, depending on the soil properties.
- Frequencies of application - rates and frequencies of application are based on the type of agent selected, the degree of dust control required, sub grade conditions, surface type, traffic volumes, types of vehicles and their speeds, climate, and maintenance schedule.

Application of Methods

For dust control agents, once all factors have been considered, the untreated soil surface must first contain sufficient moisture to assist the agent in achieving uniform distribution (except when using a highly resinous adhesive agent). The following steps should be followed in general:

Activity: Dust Control and Tracking

GHP-16

Approach (Continued)

- Ideally, application should begin in late spring, after seasonal rains - not during or just before heavy rainfall- so that sub grade and surface materials will not have dried.
- If the surface has minimal natural moisture, the area to be protected must be pre-wetted so that the chemicals can uniformly penetrate the surface.
- In general, cooler and/or more humid periods result in decreased evaporation, increased surface moisture, and thus significant increase in control efficiency. However, chemical and organic agents should not be applied under frozen conditions, rainy conditions, or when the temperature is below 4^{o} C (40^{o} F). Tar and bitumen agents should not be applied in fog or in rain or below 13^{o} C (55^{o}F).
- More than one treatment with salts or organic compounds per year is often necessary, although the second treatment should probably be significantly diluted.

Maintenance

- Most dust control measures require frequent, often daily, attention.
- The primary maintenance requirement is the reapplication of the selected dust control agent at intervals appropriate to the agent type. High traffic areas shall be inspected on a daily basis, and lower traffic areas shall be inspected on a weekly basis.

Inspection Checklist

- ☐ Watering is preventing dust.
- ☐ Watering is not causing further erosion adjacent to streets.
- ☐ Watering freshly tacked roads is avoided for a minimum of 24 hours.
- ☐ Contaminants are not being washed into adjacent storm appurtenances.

TABLE GHP-16-1 DUST CONTROL BMPs FOR GIVEN SITE CONDITIONS

	DUST CONTROL BMPs								
SITE CONDITION	Permanent Vegetation	Mulching	Wet Suppression (Watering)	Chemical Dust Suppression	Gravel or Asphalt Surfacing	Silt or Sand Fences	Temporary Gravel Construction Entrances/ Equipment Wash Down	Haul Truck Covers	Minimize Extent of Area Disturbed
Disturbed Areas not Subject to Traffic	X	X	X	X	X				X
Disturbed Areas Subject to Traffic			X	X	X				X
Material Stock Pile Stabilization			X	X		X			X
Demolition			X				X	X	
Clearing/ Excavation			X	X					X
Truck Traffic on Unpaved Roads			X	X	X			X	
Mud/Dirt Carry-Out					X		X		

TABLE GHP-16-2 COMMONLY USED CHEMICALS FOR DUST CONTROL

	SALTS	ORGANIC, NON PETROLEUM-BASED	PETROLEUM BASED PRODUCTS [1]
CHEMICAL TYPES	Magnesium Chloride Natural Brines	Calcium Lignosulfonate Sodium Lignosulfonate Ammonium Lignosulfonate	Bunker Oil Asphalt Primer Emulsified Asphalt
LIMITATIONS	Can lose effectiveness in dry periods with low humidity. Leaches from road in heavy rain. Not recommended for gravel road surfaces with low fines. Recommended 10-20% fines.	Not affected by dry weather and low humidity. Leached from road in heavy rain if not sufficiently cured. Best performance on gravel roads with high surface fines (10-30%) and dense compact surface with loose gravel.	Generally effective regardless of climatic conditions may pothole in wet weather. Best performance on gravel roads with 5-10% fines.
COMMENTS	Calcium Chloride is popular. May become slippery when wet on gravel surfaces with high fines.	Ineffective on gravel surfaces low in fines. May become slippery when wet on gravel surfaces with high fines content.	Creates a hardened crust.

1 Motor oils and oil treatments are not recommended due to adverse effects on plant life and groundwater. They should only be applied in areas that will soon be paved.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-17

Activity: Maintenance of Collection Facilities and Appurtenances

PLANNING CONSIDERATIONS:

Training:
Moderate

PE Design Approval:
Not Required

Maintenance:
Moderate

Inspection Frequency:
Monthly, and as needed following significant wet weather events

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

Catch basins have a sediment sump at its base designed to catch and retain sediment below the overflow point. This basin removes pollutants, reduce high pollutant concentration during first flush of storms, prevent clogging of the downstream conveyance system and restore the catch basins' sediment trapping capacity. The proper maintenance and siltation removal is required to have an effective storm water pollutant removal system for both wet and dry detention ponds and infiltration devices.

Approach

- Regular maintenance of catch basins and inlets is necessary to ensure their proper functioning. Clogged catch basins are not only useless but may act as a source of sediments and pollutants.

- In the same way, if sediment traps and basins, dry detention and wet detention ponds are not routinely cleaned and dredged then they can act as pollutant sources under certain storm conditions. Proper maintenance of detention pond and infiltration device systems is a source control procedure necessary to ensure effective stormwater pollutant removal efficiency. Routine and corrective maintenance needs should be monitored after storms for proper function of wet ponds, detention basins, and infiltration device structures. Proper maintenance of these structures requires periodic silt/sediment and trash debris removal, as well as timely vegetation control. They should be cleaned out when it is recognized that they have filled from 1/5 to 1/3 of their pollutant (sediment) storage capacity.

Activity: Maintenance of Collection Facilities and Appurtenances	GHP-17

Approach

- More frequent sediment removal is recommended, especially in areas where roadway drainage provides a significant runoff component. High accumulation rates of heavy metal contaminants (lead, zinc, and copper) have been identified in these BMP structures adjacent to high traffic areas. In order to avoid situations of hazardous waste disposal, sediment dredging and excavation should be given frequent priority.
- Clean catch basins in high pollutant load areas just before the wet season to remove sediments and debris accumulated during the summer.
- Catch basins should be inspected weekly and cleaned if necessary to reduce the possibility of sediment and other pollutants from leaving the construction site. This should be checked after all areas have been stabilized and at the end of the project.
- To prevent sediment and pollutant build-up in on-site catch basins, be sure to follow the guidelines set out in Temporary Inlet Protection, SMP-13.
- Maintain a clean work site, free of litter that can build-up and clog catch basins and downstream conveyance systems.
- Do not allow dumping into catch basins and stormwater inlets.
- Clean accumulated sediment and silt out of pre-treatment inlets when they have reached 1/3 of their capture volume.
- Removal of accumulated paper, trash, and debris should occur weekly or as needed to prevent clogging of control devices throughout the construction project.
- Vegetation growth in stormwater quality devices should not be allowed to exceed 24 inches (0.61 m) in height.
- Mow the slopes periodically and check for clogging, erosion and tree growth on the embankment.
- Corrective maintenance may require more frequent attention (as required).
- Maintenance of accurate logs to evaluate materials removed and improvements made.

Maintenance

- Maintenance crews may require access vehicles, dump trucks, bulldozers, and dredging/excavation equipment. Manual use equipment (such as rakes, shovels, sickles, and machetes) may suffice for maintenance of dry detention ponds and infiltration device systems. Staffing will require a minimum of two (2) person crews for health and safety reasons and effective structural BMP maintenance.
- Training
- Crews must be trained in proper maintenance, including record keeping and disposal.

Activity: Maintenance of Collection Facilities and Appurtenances	GHP-17

Maintenance

- Appropriate excavation and maintenance procedures.
- Proper waste disposal procedures.
- Channel maintenance and use of heavy equipment.
- Identification and handling of hazardous materials/wastes.
- Application of this technique in "blue line" streams requires permits from the U.S. Army Corps of Engineers, and the Indiana Department of Environmental Management.
- Frequent sediment removal is labor and cost intensive.

Inspection Checklist

- ☐ Dredged sludge is dried prior to removal to waste management facility. (See GHP-01: Dewatering Operations.)
- ☐ All drainage activities are approved by IDEM.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-18

Activity: Preservation and Maintenance of Existing Vegetation

PLANNING CONSIDERATIONS:

Training:
None

PE Design Approval:
Recommended

Maintenance:
Minimal

Inspection Frequency:
N/A

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 careful preservation of existing vegetation minimizes the potential of removing or injuring existing trees, vines, shrubs and/or grasses that serve as erosion controls or otherwise stabilize or slopes.

Suitable Applications

This technique is applicable to all types of construction sites. Areas where preserving vegetation can be particularly beneficial are floodplain, buffers, wetlands, streambanks, steep slopes, and other areas where erosion control would be difficult to establish, install, and maintain, or areas where there are critical resources downstream.

- Preservation of existing vegetation should be practiced in the following locations:
- Areas within site where construction activity is not permitted (such as buffers) or does not occur or occurs at a later date.
- Sensitive areas where natural vegetation exists and should be preserved, such as: steep slopes, watercourses, and building sites in wooded areas.
- Areas where local, state and federal government requires preservation, such as: vernal pools, wetlands, marshes, certain oak trees, etc.

Activity: Preservation and Maintenance of Existing Vegetation	GHP-18

Installation Procedures (Continued)

- Preservation of vegetation on a site should be planned before any site disturbance begins. Preservation requires good site management to minimize the impact of construction activities on existing vegetation, which may adversely affect their respiration, food processing, and growth.

- During a pre-construction conference, vegetation preservation and protection measures for that project should be reviewed with the contractor and any subcontractors.

Planning

- The following planning steps should be taken to preserve existing vegetation:

- A plan for vegetation preservation should be completed before clearing and construction begins.

- Critical areas, such as floodplains, buffers, steep slopes, and wetlands should be left in their natural condition unless disturbance is unavoidable and permitted by buffer and floodplain/floodway requirements.

- Decisions on which vegetation to save should be based on the following considerations:

    1. Life expectancy and present age
    2. Health and disease susceptibility
    3. Structure
    4. Cleanliness
    5. Aesthetic values
    6. Comfort relative to site temperature variations and wind
    7. Wildlife benefits
    8. Adaptability to the proposed project
    9. Survival needs of the vegetation
    10. Relationship to other vegetation

- Areas for buffers where construction is not permitted should be delineated in the field with flags or colored temporary construction fencing.

- All vegetation to be retained should be delineated and identified (species and size) on the site plan and identified in the field by an easily seen colored flag.

- Plans should include the maintenance of existing grade around vegetation to be preserved. Most vegetation damage due to construction activities is to the root zone, which can result in the vegetation dying within a few years. Raising the grade can suffocate roots, and lowering the grade may expose roots.

- Plans for tree preservation should: avoid compaction of the soil within the drip line of a tree which can block off air and water from the roots and avoid changes in soil chemistry that can result from refuse of chemicals deposited on the soil surface.

Activity: Preservation and Maintenance of Existing Vegetation	GHP-18

Installation Procedures (Continued)

- Temporary roadways should be located to minimize damage to shrub and tree stands, following contours to reduce cutting and filling.
- Locate multiple utilities in the same trench to minimize trenching. Excavations should be outside the drip line of trees.
- Construction material storage and crew parking should be noted on the site plan and located where they will not cause root compaction. They can eventually kill a tree.
- For retention of existing trees in paved areas, at least 5 ft. (1.5 m) of ungraded ground beyond the drip line should be left to help ensure tree survival.
- Soil stabilization measures should be located at the limits of clearing to prevent sediment deposition within the area where vegetation is being preserved.
- Wind damage can result from exposure of vegetation to increased wind velocities, therefore this must be considered when removing adjacent vegetation.
- Equipment must be kept away from trees to be preserved to avoid trunk damage caused by equipment nicking or scarring the trunk.

Timing

The following timing considerations should be taken to preserve existing vegetation:

- Preservation of existing vegetation should be planned before any site disturbance begins. Preservation of existing vegetation should be planned during the design stages by the design engineer and the contractor should meet onsite with the design engineer.
- No vegetation should be destroyed or altered until the design of roads, buildings, and utility systems is finalized.

Tree and Vegetation Marking and Protection

- Clearing limits should be outside of the drip line of any retained tree, and at a minimum of 5 ft (1.5 m) from the trunk regardless of the size of the tree. A protective device, such as a colored temporary construction fence, to guard against damage to roots, trunk, and tops of trees, should be placed at these limits.
- Individual trees, stands of trees, and areas of vegetation to be retained should be marked before construction at a height visible to equipment operators. Orange-colored plastic construction fencing or other suitable material should be used. Within 40 ft (12 m) of a proposed building or excavation, however, retained trees should be protected by fencing. The following are alternatives for tree and vegetation protection:
- Board fencing on 4-in. (100-mm) square posts set securely and 6 ft (1.8 m) apart, and protruding at least 4 ft (1.2 m) above the ground, placed at clearing limits.

Installation Procedures (Continued)

- A cord fence with 2 rows of cord at least 3 in. (6 mm) in thickness running between posts. Each post should be at least 2 in. (50 mm) thick set securely and 6 ft (1.8 m) apart, protruding at least 4 ft. (1.2 m) above the ground placed at clearing limits. Strips of colored surveyor's flagging should be tied securely to the cord at intervals of no more than 3 ft (90 cm).

- Plastic fencing of 40 in. (1.0 m) high orange polyethylene webbing, secured to metal "T" or "U" posts driven to a depth of at least 18 in. (450 mm), on 6 ft. (1.8 m) minimum centers, placed at the clearing limits. The posts should be chemically inert to most chemicals and acids.

- An earth berm constructed according to specifications, but only if its presence does not conflict with drainage patterns. The base of the berm on the tree or vegetation side should be located at the clearing limits.

- Leaving a buffer zone of existing trees between the trunks of retained trees and the clearing limits. Trees in this buffer zone should be a maximum of 6 ft (1.8 m) apart so that equipment and material cannot pass. These trees should be re-examined before construction is completed to check for and ensure survival or be removed.

- As a last resort, a tree trunk may be armored with burlap wrapping and 2-in. (50-mm) studs wired vertically, no more than 2 in. (50 mm) apart encircling the trunk to a height of 5 ft (1.5 m). No nailing should ever be done to a retained tree. The root zone, however, will still require protection.

- Employees and subcontractors should be instructed to honor protective devices. No heavy equipment, vehicular traffic, or storage piles of any construction materials should be permitted within the drip line of any tree to be retained. Removed trees should not be felled, pushed, or pulled into any retained trees. Fires should not be permitted within 100 ft. (30 m) of the drip line of any retained trees. Any fires should be of limited size, and should be kept under continual surveillance. No toxic or construction materials including paint, acid, nails, gypsum board, chemicals, fuels, and lubricants should be stored within 50 ft. (15 m) of the drip line of any retained trees, nor disposed of in any way which would injure vegetation. This also precludes vehicle fueling or maintenance in these areas.

Grade Protection

- If the ground level must be raised around an existing tree or tree group, a tree well can be constructed. A professional arborist should be consulted if a tree well appears to be warranted or desired. A well may be created around the tree slightly beyond the drip line to retain the natural soil in the area of the feeder roots.

- If the grade is being lowered, trees can be protected by constructing a surrounding tree wall of large stones, brick, or block, filled with topsoil. Fertilizer and water should be applied thoroughly and drainage provided so that water does not accumulate.

- Remove vegetation and organic matter from beneath the retained tree(s) to at least 3 ft. (1 m) beyond the drip line, loosening the soil to at least 3 in. (75 mm) in depth without damaging roots.

Installation Procedures (Continued)

- Apply fertilizer to the loosened soil at rates not to exceed those recommended by the fertilizer manufacturer.
- Construct a dry well to allow for trunk growth. Provide 12 in. (300 mm) between the trunk and the wall for older, slow-growing trees, and at least 24 in. (600 mm) for younger trees.
- The well should be just above the level of the proposed fill, and the wall should taper away from the trunk by 1 in./ft. (80 mm/m) of wall height.
- The well wall should be constructed of large stone, brick, building tile, concrete blocks, or cinder blocks, with openings left in the wall for the flow of air and water. Mortar should be used only near the top of the well and above the porous fill.
- Drain lines beginning at the lowest point inside the well should be built extending outward from the trunk in a radial pattern with the trunk as the hub. They should be made of 4-in. (100-mm) drain tiles, sloping away from the well at a rate of 0.125 in./ft. (10 mm/m). A circumferential line of tiles should be located beneath the drip line; vertical tiles or pipes should be placed over the intersections of the two tile systems for fills greater than 24 in. (600 mm) in depth, held in place with stone fill. All tile joints should be tight. Drainage may be improved by extending a few radial tiles beyond each intersection and slope sharply downward. Coarse gravel may be substituted for tile in areas where water drainage is not a problem. Stones, crushed rock, and gravel may be added instead of vertical tiles or pipes, so the upper level of these porous materials slopes toward the surface near the drip line.
- Tar paper or an approved equivalent should be placed over the tile or pipe joint to prevent clogging, and a large stone placed around and over drain tiles or pipes for protection.
- Layer 2 in. (50 mm) to 6 in. (150 mm) of stone over the entire area under the tree from the well outward at least to the drip line. For fills up to 24 in. (600 mm) deep, a layer 8 in. (200 mm) to 12 in. (300 mm) should be adequate. Deeper fills require thicker layers of stone to be built to a maximum of 30 in. (760 mm).
- A layer of 0.75-in. (19-mm) to 1-in. (25-mm) stone covered by straw, fiberglass mat, or filter fabric should be used to prevent soil clogging between stones. Do not use cinders as fill material.
- Complete filling with porous soil (to sustain vegetation) until the desired grade is reached.
- Crushed stone should be placed inside the dry well over the openings of the radial tiles to prevent clogging of the drain lines. Vertical tiles should also be filled with crushed rock and covered with a screen.
- The area between the trunk and the well wall should be covered by an iron grate or filled with a 1:1 mixture of crushed charcoal and sand to prevent anyone from falling into the well or to prevent leaves, debris, rodents, or mosquitoes from accumulating.
- One-half of these systems may be constructed if the grade is being raised on only one side of the tree(s).

Installation Procedures (Continued)

Trenching and Tunneling

- Trenching should be as far away from tree trunks as possible, usually outside of the tree crown. Curve trenches around trees to avoid large roots or root concentrations. If roots are encountered, consider tunneling under them. When trenching and/or tunneling proximate to trees to be retained, tunnels should be at least 18 in. (450 mm) below the ground surface, and not below the tree center to minimize impact on the roots.

- Tree roots should not be left exposed to air; they should be covered with soil as soon as possible, protected, and kept moistened with wet burlap or peat moss until the tunnel and/or trench can be completed.

- The ends of damaged or cut roots should be cut off smoothly and protected by painting them with a tree-wound dressing.

- Trenches and tunnels should be filled as soon as possible. Careful filling and tamping will eliminate air spaces in the soil, which can damage roots. Be careful not to over-compact as this can smother and kill the tree.

- To induce and develop root growth, peat moss should be added to the fill material.

- The tree should be mulched to conserve moisture and fertilized to stimulate new root growth.

- Remove any trees intended for preservation if those trees are damaged seriously enough to affect their survival. If replacement is desired or required, the new tree should be of similar species and of at least 2-in. (50-mm) caliper balled and burlapped nursery stock, unless otherwise required by the contract documents.

- Because protected trees may be destroyed by carelessness during the final cleanup and landscaping, fences and barriers should be removed last, after all other work is complete.

Vegetation Control

- Mechanical control of vegetation includes mowing, “bush-hogging”, and hand cutting. Large scale mowing is typically done by tractor-type mowers similar to farm machinery. “Bush-hogging” usually refers to tractor mounted mowing equipment with hydraulically mounted cutting machinery. On smaller areas, lawn tractors or push mowers may be used. In areas that are inaccessible by machinery, such as steep grades and rocky terrain, hand cutting using gas powered weed trimmers and scythes may be used.

- Clippings and cuttings are the primary waste produced by mowing and trimming. Clippings and cuttings are almost exclusively leaf and woody materials. Minimize transportation of clippings and cuttings into the stormwater conveyance system. Compost piles are encouraged to create mulch and topsoil for landscaping.

Installation Procedures (Continued)

- Clippings/cuttings carried into the stormwater system and receiving streams can degrade water quality in several ways. Suspended solids will increase causing turbidity problems. Since most of the constituents are organic, the biological oxygen demand will increase causing a lowering of the available oxygen to animal life. In areas where litter and other solid waste pollution exists, toxic materials may be released into receiving streams with a resulting degradation of water quality.

- Mowing should be performed at optimal times (e.g., when it is dry). Mowing should not be performed if significant rain events are predicted.

- Mulching mowers may be recommended for certain areas. Mulching mowers should be encouraged for homeowners in flat areas. Mulching mowers have the added benefit of reducing the fertilizer demand through reuse of organic material. Other techniques may be employed to minimize mowing such as selective vegetative planting using low maintenance grasses and shrubs. Alternatively, the grass clippings can be bagged and used in composting.

Maintenance

- During construction, the limits of disturbance should remain clearly marked at all times. Irrigation or maintenance of existing vegetation should conform to the requirements in the landscaping plan.

- If damage to protected trees still occurs, maintenance guidelines described below should be followed:

- Soil, which has been compacted over a tree's root zone, should be aerated by punching holes 12 in. (300 mm) deep with an iron bar, and moving the bar back and forth until the soil is loosened. Holes should be placed 18 in. (450 mm) apart throughout the area of compacted soil under the tree crown.

Any damage to the crown, trunk, or root system of a retained tree should be repaired immediately.

- Damaged roots should be immediately cut cleanly inside the exposed area and surfaces painted with approved tree paint, and moist soil or soil amendments should be spread over this area.
- If bark damage occurs, all loosened bark should be cut back into the undamaged area, with the cut tapered at the top and bottom, and drainage provided at the base of the wound. Cutting of the undamaged area should be as limited as is possible.
- Serious tree injuries should be attended to by an arborist, forester or tree specialist.
- Stressed or damaged broadleaf trees should be fertilized to aid recovery.
- Trees should be fertilized in the late fall or early spring.
- Fertilizer should be applied to the soil over the roots and in accordance with label instructions, but never closer than 3 ft. (1 m) to the trunk. The fertilized area should be increased by one-fourth of the crown area for conifers that have extended root systems.

Activity: Preservation and Maintenance of Existing Vegetation	GHP-18

Inspection Checklist

- ❑ Protecting existing vegetation requires detailed planning, and may constrict the area available for construction activities.
- ❑ It is appropriate to evaluate the existing vegetation for species type for use in landscaping plans. Natural vegetation and invasive or “alien” species should be delineated. The use of natural vegetation is preferred.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Good Housekeeping Practices (GHPs)

GHP-19

Activity: System Flushing

PLANNING CONSIDERATIONS:

Training:
Moderate

PE Design Approval:
Not Required

Maintenance:
Moderate

Inspection Frequency:
Monthly, and as needed following significant wet

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 suspension and removal of deposited materials are “flushed” out of storm drains. Flushing is beneficial for storm drain pipes with grades to flat to be self cleansing. This helps to maintain flow as well as removes pollutants from the storm drain system.

Approach

- Locate reaches of storm drain with deposit problems and develop a flushing schedule that keeps the pipe clear of excessive buildup.
- Whenever possible, flushed effluent should be collected and pumped to a sediment trap, or basin, or a detention pond.
- Storm drain flushing usually takes place along segments of pipe with grades that are too flat to maintain adequate velocity to keep particles in suspension. An upstream manhole is selected to place an inflatable device that temporarily plugs the pipe. Further upstream, water is pumped into the line to create a flushing wave. When the upstream reach of pipe is sufficiently full to cause a flushing wave, the influted device is rapidly deflated with the assistance of a vacuum pump, releasing the backed up water and resulting in the cleaning of the storm drain segment.

Activity: System Flushing

Approach (Continued)

- If the flushed water does not drain to a stormwater treatment device (e.g., detention pond or swale), then a second inflatable device, placed well downstream, may be used to re-collect the water after the force of the flushing wave has dissipated. A pump may then be used to transfer the water and accumulated material to a stormwater treatment practice. In some cases, an interceptor structure may be more practical or required to re-collect the flushed waters.

Regulations

- IDEM regulations exist prohibiting the discharge of soil, debris, refuse, hazardous waste, and other pollutants that may hinder the designed conveyance capacity or damage stormwater quality or habitat in the storm drain system. This includes flushing a system to "Waters of the State". IDEM should be consulted if this practice is planned.

Equipment

- Water source (water tank truck, fire hydrant).
- Sediment collector (educator/vacuum truck, dredge).
- Inflatable devices to block flow.
- Sediment/turbidity containment/treatment equipment required if flushing to an open channel.

Inspection Checklist

- [ ] Flushing is being used for smaller diameter pipes (less than 36")
- [ ] Water source is available.
- [ ] Discharging to an approved, downstream appurtenance.

Stormwater Pollution Prevention

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-01

Activity: Permanent, Grass, Vines and Other Vegetation

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
As Needed

Estimated Unit Cost:
Variable

Monthly Maintenance:
Negligible

PV

PV

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 long term stabilization of soil occurs as a result of ground cover provided by seeding of grasses and planting of trees, shrubs and vines. The long-term aesthetics reduces erosion by slowing runoff velocities, enhance infiltration and transpiration, trap sediment and other particulates, protect soil from raindrop impact, and provide habitat for wildlife.

Suitable Applications

This BMP is suitable for:
- Site stabilization both during construction and post-construction.
- Any graded/cleared areas where construction activities are completed.
- Open space cut and fill areas.
- Steep slopes not requiring more robust permanent stabilization techniques.
- Spoil or stock piles.
- Vegetated swales and ditches.
- Landscape corridors.
- Areas of stream banks with low velocities under storm conditions.

Installation Procedures

- These systems should be designed by a licensed professional civil engineer. Many of the measures presented in EPP-05: Temporary Seeding, EPP-09: Nets and Mats, and EPP-10: Geotextiles are applicable for establishing, stabilizing and maintaining permanent vegetation.
- Application of appropriate vegetation must consider: the seedbed or plant bed, proper seasonal planting times, water requirements, fertilizer requirements and availability of the selected vegetation within the project's region.
  Type of vegetation, site and seedbed preparation, planting time, fertilization and water requirements should be considered for each application.

Activity: Permanent, Grass, Vines and Other Vegetation	SPP-01

Installation Procedures (Continued)

- Seeding and planting should be applied as soon as final grading is done to all graded and cleared areas of the construction site where plant cover is ultimately desired. For example, vegetation may be established along landscaped corridors and buffer zones where they may act as filter strips.

- Vegetated swales, steep and/or rocky slopes and stream banks can also serve as appropriate areas for seeding and plantings.

- Permanent plantings during the construction stage of projects require careful coordination between the local agency inspectors, project managers, construction managers, and landscape contractor. Protocols for coordination and implementation procedures regarding site access, construction staging, and short- and long-term planting areas should be developed prior to the construction bid process. Where possible, these protocols should be established by and remain the responsibility of the site owner.

Grasses

- Grasses, depending on the type, provide short-term soil stabilization during construction or can serve as long-term/ permanent soil stabilization for disturbed areas. In general, grasses provide low maintenance to areas that have been cleared, graded and mechanically stabilized.

- They are generally tolerant of short-term temperature extremes and waterlogged soil conditions.

- Appropriate soil conditions for unreinforced grasses: shallow soil base, good drainage, slope 2:1 (H: V) or flatter.

- Develop well and quickly from seeds.

- Mowing, irrigating, and fertilizing are vital for promoting vigorous grass growth.

<u>Selection</u>:

The selection of the grass type is determined by the climate, irrigation, mowing frequency, maintenance effort and soil bed conditions. Although grasses provide quick germination and rapid growth, they also have a shallow root system and are not as effective in stabilizing deep soils, where trees, shrubs and deep rooted ground covers may be more appropriate. Bluegrass is good on dry, sandy soils that have good drainage. Bermuda grass, on the other hand is well adapted to regions where soils are dry, coarse and heavier. Specific seed mix and/or varieties for each site should be provided by an approved/qualified plant materials specialist.

Activity: Permanent, Grass, Vines and Other Vegetation	SPP-01

Installation Procedures (Continued)

Planting:

The following steps should be followed to ensure established growth:

1. Select the proper grass for the site.
2. Prepare the seedbed; soil should be fertilized and contain good topsoil or soil at a 2:1 (H: V) or flatter slope, unless stabilized with permanent geotextiles, nets or mats.
3. Broadcast the seedings in the late fall or early spring.
4. Initial irrigation will be required often for most grasses, with follow-up irrigation and fertilization as needed. Light mulching may be required during drought years or to limit seed lost to wind and birds.

Trees and Shrubs

- Soil conditions: select species appropriate for soil, drainage & acidity.
- Other Factors: wind/exposure, temperature extremes, and irrigation needs.

Selection:

Trees and shrubs, when properly selected, are low maintenance plantings that stabilize adjacent soils, moderate the adjacent temperatures, filter air pollutants, and serve as a barrier to wind. Some desirable characteristics to consider in selecting trees and shrubs include: vigor, species, age, size and shape, and use as a wildlife food source and habitat.

Transplanting:

Time of Year – Late fall through winter (November to February) is the preferred time for transplanting.

Preparation – Proper digging of a tree/shrub includes the conservation of as much of the root system as possible. Soil adhering to the roots should be damp when the tree is dug, and kept moist until re-planting. The soil ball should be 12 inches in diameter for each inch of diameter of the trunk.
Site preparation – Refer to landscape plans and specifications for site and soil preparation, and for ability to coordinate construction strategy with permanent vegetation.

Supporting the trunk – Many newly planted trees/shrubs need artificial support to prevent excessive swaying.

Watering – Soil around the tree should be thoroughly watered after the tree is set in place. When the soil becomes dry, the tree should be watered deeply, but not often. Mulching around the base of the tree is helpful in preventing roots from drying out.

Vines and Ground Covers

- Ground preparation: lime and fertilizer preparation.
- Appropriate soil conditions: drainage, acidity, slopes.
- Generally avoid invasive species (Kudzu, etc.).

Activity: Permanent, Grass, Vines and Other Vegetation	SPP-01

Installation Procedures (Continued)

- Generally avoid species requiring frequent irrigation.

Selection:

Vines, ground covers, and low growing plants, that can quickly spread, come in many types, colors, and growth habits. Some are suitable only as part of a small maintained landscape area, while some can stabilize large areas with little maintenance. Flowers, which provide little long-term erosion control, may be planted to add color and veritable appearances.

Site Preparation:

Ground covers are plants that naturally grow very close together, causing severe competition for space, nutrients and water. Soil for ground covers should be well prepared. The entire area should be spaded, disked, or roto-tilled to a depth of six to eight inches. Two to three inches of organic material, such as good topsoil or peat, should be spread over the entire area.

Planting:

The following steps will help ensure good plant growth.

1. Position the plantings to follow the contours of the land.
2. Dig the holes 1/3 larger than the plant root ball.
3. Know what depth to place the plants.
4. Use good topsoil or soil mixture with a lot of organic matter.
5. Fill hole to ½ full, shake plants to settle soil among roots, then water.
6. Leave saucer-shaped depression around the plant to hold water.
7. Water thoroughly and regularly.
8. Space plants according to the type of plant and the extent of covering desired.

Materials:

There are many different species of vines and ground covers from which to choose, but care must be taken in their selection. It is essential to select planting materials suited to both the intended use and specific site characteristics. Additional information can be obtained from local nurserymen, landscape architects, and extension agents.

Activity: Permanent, Grass, Vines and Other Vegetation	SPP-01

Maintenance

- Grass maintenance should be minimal to none. Irrigation and regular fertilizing may be required for some types of grasses. Mowing is only required in areas where aesthetics or fire hazards are a concern.
- Permanent vegetation may require supplemental irrigation where the natural rainfall is insufficient to establish and/or maintain the selected plant materials. Selecting native plants should be considered where supplemental irrigation is not available. However, even native plants benefit from supplemental irrigation during the establishment period.
- Young trees should receive an inch of water each week for the first two years after planting. The tree should be watered deeply, but not more often than once per week.
- Transplanted trees should be fertilized on an annual basis.
- Proper pruning, watering, and application of fertilizer are necessary to maintain healthy and vigorous shrubs. A heavy layer of mulch applied around the shrubs reduces weeds and retains moisture.
- Trim old growth as needed to improve the appearance of ground covers. Most covers need once-a-year trimming to promote growth.

See GHP-15: Pesticides, Herbicides and Fertilizer Use.

Inspection Checklist

- ❑ If the site is susceptible to erosion, additional control measures may be necessary during the establishment of vegetation.
- ❑ Caution should be exercised in introducing non-native vegetation because of impacts to native vegetation on adjacent lands. For example, species that may be planted at the construction site can quickly spread and compete with originally undisturbed vegetation.
- ❑ Permanent and temporary vegetation establishment may not be appropriate during dry periods without irrigation.
- ❑ Over-application of fertilizers, herbicides and pesticides may create stormwater pollution.
- ❑ Construction activities are likely to injure or kill trees unless adequate protective measures are taken. Direct contact by equipment is the most obvious problem, but damage is also caused by root stress from filling, excavation, or compacting soil too close to trees.
- ❑ Temporary seeding can only be viable when adequate time is available for plants to grow and establish.
- ❑ Irrigation source and supply may be limiting or expensive.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-02

Activity: Geotextiles

PLANNING CONSIDERATIONS:

Design Life:
N/A

Acreage Needed:
N/A

Estimated Unit Cost:
N/A

Monthly Maintenance:
Negligible

G

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

Geotextiles are used to prevent or reduce the discharge of pollutants to the storm drain system or to watercourses for sloped areas that would otherwise be unstable or have high erosion potential. By stabilizing soil to utilize rolled and bound fiber material to intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide some sediment removal from runoff.

Suitable Applications

Slopes where soils must be stabilized. Site conditions that may warrant use of geotextile blankets and mats include:

- Steep slopes, general steeper than 3:1 (H:V).
- Slopes where erosion hazard is high.
- Critical slopes adjacent to sensitive areas, such as streams, wetlands, or other highly valued resources needing protection.
- Channels with flows exceeding 2 ft/s (0.6 m/s) to 4 ft/s (1.2 m/s).
- Channels intended to be vegetated and where the design flow exceeds the permissible velocity. The allowable velocity for turf reinforcement mats after vegetative establishment is up to 10 ft/s. Check with the mat manufacturer for allowable velocities.

Appropriate mat and/or blanket materials must be selected for the specific site application.

Activity: Geotextiles	SPP-02

Installation Procedures

These systems should be designed by a licensed professional civil engineer.

Refer to EPP-10: Geotextiles for discussion of material selection, site preparation, seeding, anchoring, installation on slopes, installation in channels, soil filling, and fiber roles. Figures SPP-02-01 through 3 has also been provided to aid in evaluating geotextiles in permanent applications.

Applying geotextiles permanently is most often done in support of permanent vegetation, upland and in-channel slope stabilization and erosion prevention. They are also often applied in construction of sediment traps, basins or dry/wet detention ponds outlets or emergency overflow structures.

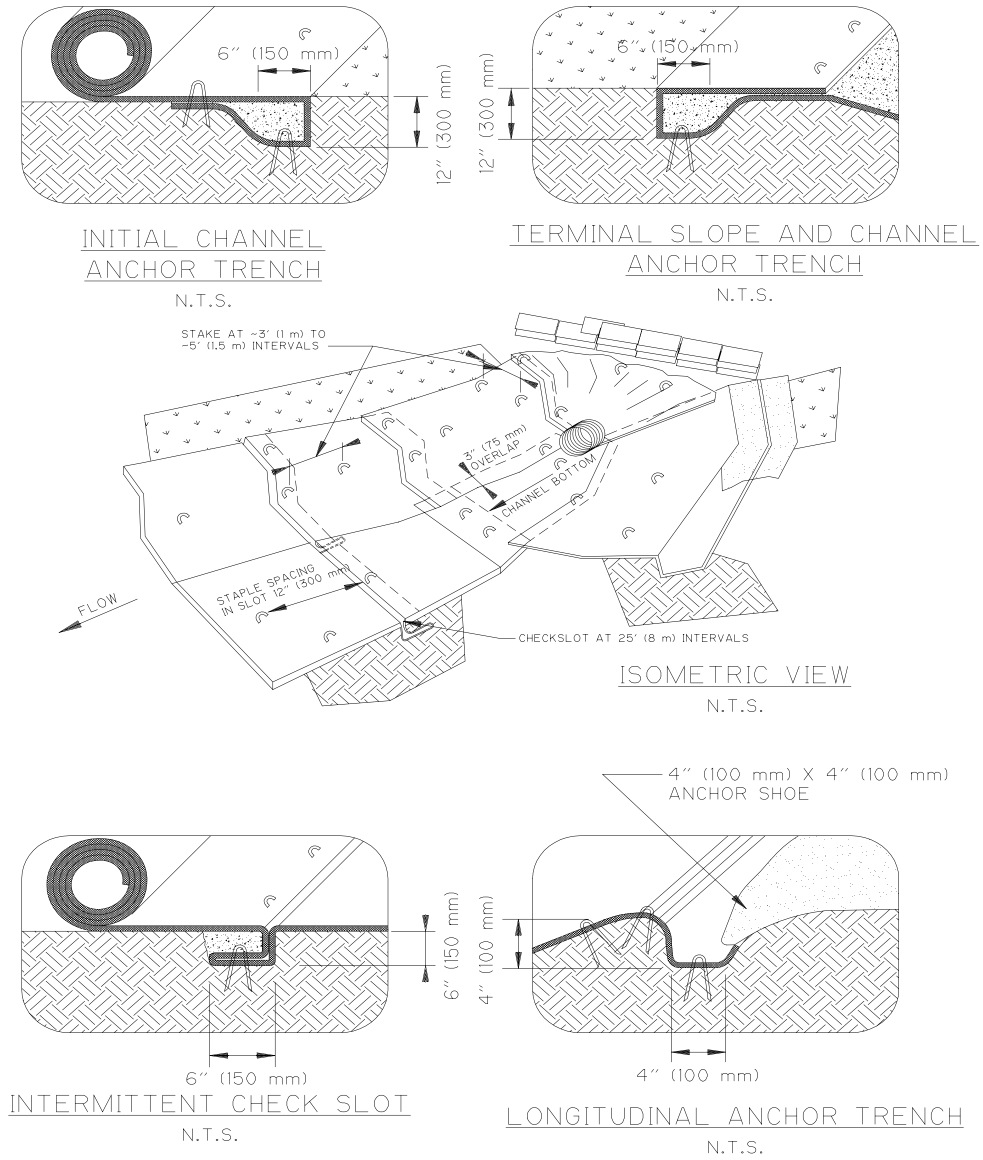
Maintenance

In the long-term, regular inspection and maintenance is critical to guarantee the geotextile effectiveness.

- All blankets and mats should be inspected periodically after installation.
- Depending on the sensitivity of the protected area, inspections should be performed quarterly or biannually to ensure that any soil settlement or other unforeseen factors have not affected the geotextile fabric or fasteners. Thereafter inspections may be reduced to annually or biennially (every two years).
- Protected areas should be inspected after significant rain storms to check for erosion and undermining. Any failures should be repaired immediately, including replacement of fasteners.
- If washout or breakages occur, re-install the material after repairing the damage to the slope or channel.
- Inspect fiber rolls biannually (twice a year), preferably in late fall and early spring. Perform required maintenance including repair or replacement of split, torn, unraveling, or slumping fiber rolls.
- Geotextiles should also be inspected after extremely long or intensive storm events such as 10-year or less frequent storm events.

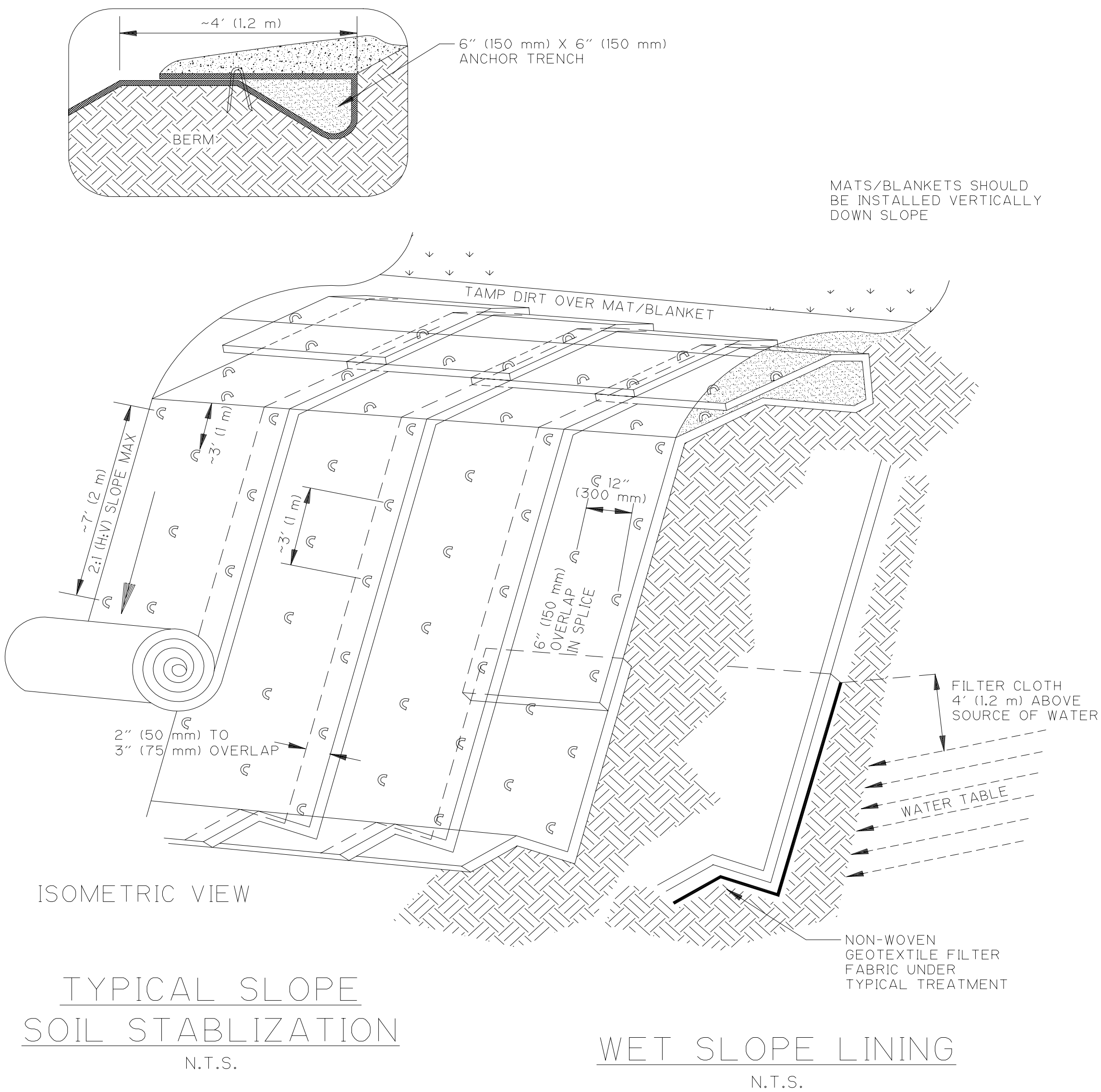
Inspection Checklist

- [ ] Blankets and mats are typically more expensive than other erosion control measures, primarily due to labor costs. This usually limits their application to areas inaccessible to hydraulic equipment, or where other measures are not applicable, such as channels. Blankets and mats are generally not suitable for excessively rocky sites or areas where the final vegetation will be mowed (since staples and netting can catch in mowers).



NOTES:
1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURER'S SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURER'S SPECIFICATIONS.

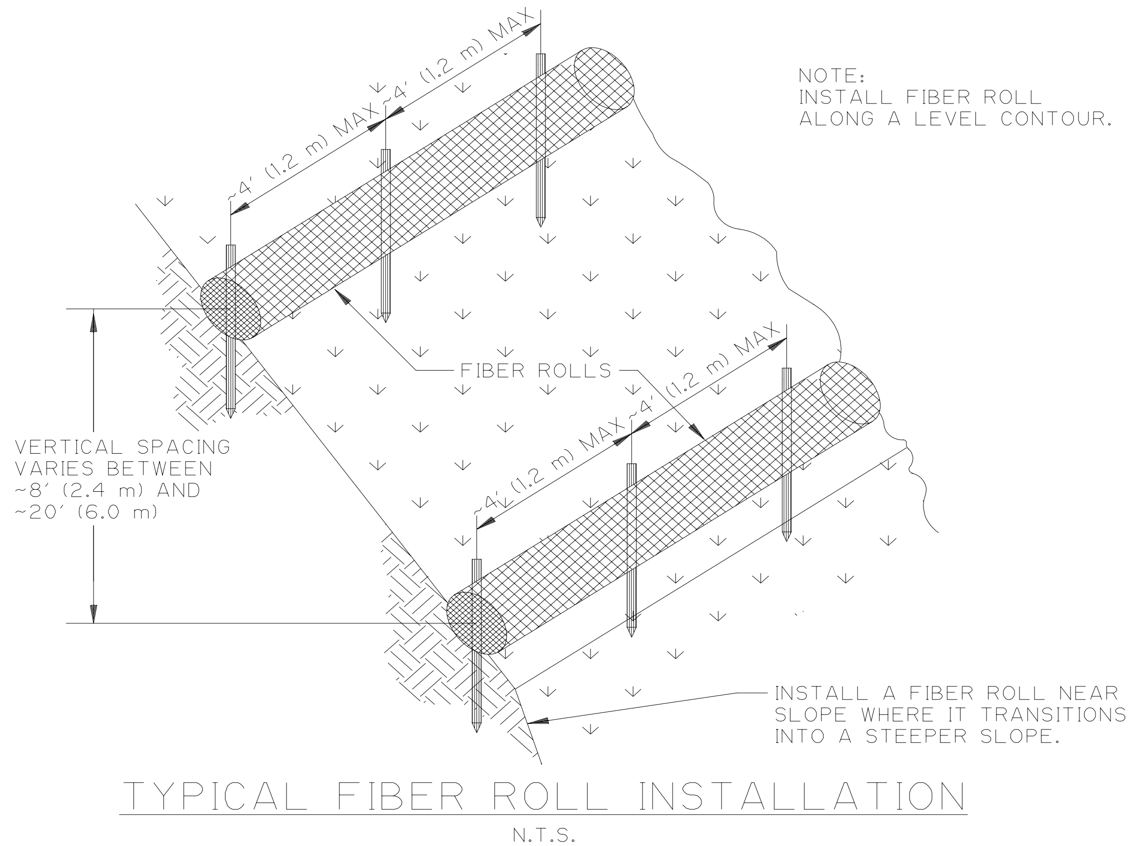
Figure SPP-02-1
Anchoring Geotextiles in Channels



NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, SOIL CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

Figure SPP-02-2
Anchoring Geotextiles on Embankments



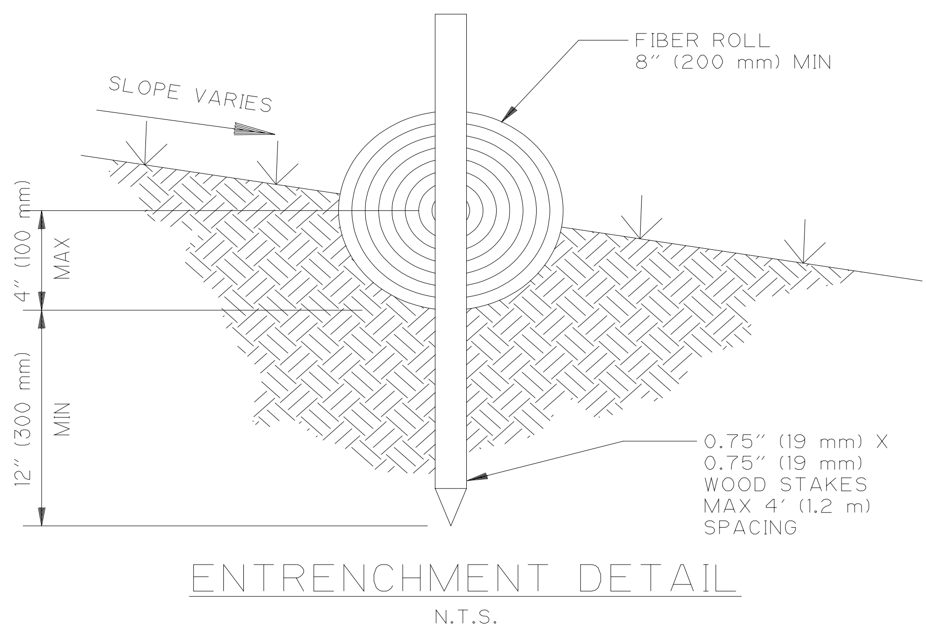


Figure SPP-02-3
Fiber Rolls

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-03

Activity: Buffer Zones

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
N/A

Estimated Unit Cost:
N/A

Monthly Maintenance:
Negligible

PV

PV

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

Buffer Zones act as shields against pollutants to the drain system or to watercourses by reducing or preventing discharge through vegetation utilization. The utilization protects soils from erosion and slows the velocity of runoff to allow the removal of sediment and other pollutants through filtering and settling.

Suitable Applications

- Buffer zones are effective along stream banks, grassed dikes, swales, slopes, outlets, level spreaders, and filter strips.
- Vegetative buffer strips may be used on any site that will support vegetation.
- Buffer strips are particularly effective on flood plains, adjacent to wetlands or other sensitive water bodies, and on steep, unstable slopes.
    - Any area within a buffer required by the local regulations <u>SHALL NOT BE CLEARED</u>. They should be surveyed, flagged, and delineated by a colored temporary construction fence. This should be explained to all construction employees and supervisors.
    - Utilization or reinforcement of existing vegetation is preferred. However, where improvements are required; sodding, plugging, use of stockpiled vegetation or seeding is acceptable.

Activity: Buffer Zones	SPP-03

Suitable Applications (Continued)

- Sodding is appropriate if it is part of the no construction activity area required by MDPW for areas that contained turf prior to construction, or for any graded or cleared area that might erode and where a robust plant cover is needed immediately. Examples of locations where sodding may be used include stream banks, grassed dikes, swales, steep slopes, outlets, and level spreaders. Sod along edge of buffer for at least two rows (offset).

- Plugging is appropriate for the same areas as sodding, except that a longer establishment period before protection is provided as required. Plugging stabilizes an area by planting clumps of grass material, which then grow and spread to provide complete covers. Plugging is generally used for hybrid grasses that cannot be established from seed.

- Vegetative buffer strips may be used at any location on-site that will support vegetation stockpiled from other areas of the site or from seed. Buffer strips are particularly effective on flood plains, adjacent to wetlands or other sensitive water bodies, and on steep, unstable slopes.

Installation Procedures

These systems should be designed by a licensed professional civil engineer.

- Many of the measures presented in EPP-05: Buffer Zones and SMP-12: Filter Strips are applicable for establishing and maintaining permanent buffer zones.

Maintenance

- Inspect buffer zones monthly for the first year after construction and annually thereafter.
- Maintenance shall consist of mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth.
- Inspect buffer strips after significant storm events (10-year storm event or larger). Repair eroded or damaged areas as needed to maintain original purpose and effectiveness of the buffer strip.

Inspection Checklist

- [ ] Site conditions will dictate need and design of vegetative buffer strips. Vegetative buffer strips are most economical when there is existing vegetation that can be retained to serve as the buffer strip; otherwise, vegetation will need to be established.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-04

Activity: Soil Bioengineering and Bank Stabilization

PLANNING CONSIDERATIONS:

Design Life:
N/A

Acreage Needed:
N/A

Estimated Unit Cost:
N/A

Monthly Maintenance:
Negligible

BS

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

Sediment reduction or prevention is the result of the occurrence of this BMP. By handling the amount of discharge into storm drain systems or watercourses slope stabilization is provided, protection and erosion reduction through the use of woody vegetative structures alone or in combination with simple retaining structures also takes place. Many of the measures presented in SMP-08 Bank Stabilization are applicable to this BMP fact sheet.

Suitable Applications

For protection of slopes against surface erosion, shallow mass wasting, cut and fill slope stabilization, earth embankment protection, and small gully repair treatment.

Installation Procedures

These systems should be designed by a licensed professional civil engineer.

Site Considerations

- Observe surrounding slopes for vegetation density and overall plant health. Also observe the directions they are facing (some plantings generally do better in eastern exposure and do not survive in southern exposure). Plant health is a good indicator of soil moisture and/or soil conditions. These will help indicate the success of your specific bioengineering project.

- Make geologic observations of the project site noting soil types and their proneness to slide or fail.

- Retain existing vegetation whenever possible.

Activity: Soil Bioengineering and Bank Stabilization

Installation Procedures (Continued)

- Limit removal of vegetation by keeping the cleared area to the smallest practical size, limiting duration of the surface disturbance, and retaining existing woody vegetation for future planting.

- Stockpile and protect topsoil removed during clearing.
- Protect areas exposed during construction with erosion prevention (EPP) and sediment management practices (SMP).

Construction Techniques and Materials

- Grade or terrace to flatten or make a steep undercut or slumping bank less severe.

- Make sure the vegetation chosen does not grow in such a way as to damage simple retaining structures in combination bioengineering systems.

- Retention backfill is to have sufficient fines and drainage so as to support chosen vegetation.

- Bioengineering systems' installation is best accomplished in the late fall at the onset of plant dormancy. Plants that are not dormant are less likely to survive.

- Live stake – the insertion of live, rootable vegetative cuttings into the ground.
    - Appropriate technique for repair of small earth slips and slumps that are frequently wet.
    - Live stakes shall be ½" to 1 ½" (1.3 to 3.8 cm) in diameter, 2 to 3' (0.63 to 0.94 m) long, with the basal end cut to an angled point for easy insertion. The top should be cut square.
    - Tamp the live stake into the ground at right angles to the slope. The installation may be started at any point on the slope face.
    - The live stakes should be installed 2 to 3 ft. (0.63 to 0.94 m) apart using triangular spacing. The density of the installation will range from 2 to 4 stakes per square yard (0.8 m^2).

    - The buds should be oriented up.
    - Four-fifths of the length of the live stake should be installed into the ground and soil firmly packed around it after installation.
    - Do not split the stakes during installation. Stakes that split should be removed and replaced.
    - An iron bar can be used to make a pilot hole in firm soil. Drive the stake into the ground with a dead blow hammer (hammer head filled with shot or sand).

- Live fascine-long bundles of branch cuttings bound together into sausage-like structures.
    - An effective stabilization technique for slopes.
    - Live materials should be from species that easily root and have long, straight branches.

Installation Procedures (Continued)	➢ Cuttings tied together to form live fascine bundles vary in length from 5 to 30 ft. (1.6 to 9.4 m) or longer, depending on site conditions and limitations in handling. ➢ The completed bundles should be 6 to 8 in. (15.2 to 20.3 cm) in diameter, with all of the growing tips oriented in the same direction. Stagger the cuttings in the bundles so that tops are evenly distributed throughout the length of the uniformly sized live fascine. ➢ Live stakes should be 2 ½ ft. (0.8 m) long in cut slopes and 3 ft. (0.94 m) long in fill slopes. ➢ Dead stout stakes used to secure the live fascines should be 2 ½-foot (0.8 m) long, untreated, 2 by 4 (5.1 by 10.2 cm) lumber. Each length should be cut diagonally across the 4 in. (10.2-cm) face to make two stakes from each length. ➢ Prepare the live fascine bundles and live stakes immediately before installation. ➢ Beginning at the base of the slope, dig a trench on the contour just large enough to contain the live fascine. The trench will vary in width from 12 to 18 in. (30.5 to 45.7 cm), depending on the angle of the slope to be treated. The depth will be 6 to 8 in. (15.2 to 20.3 cm), depending on the individual bundle's final size. ➢ Place the live fascine into the trench. ➢ Drive the dead stout stakes directly through the live fascine every 2 to 3 ft. (0.63 to 0.94 m) to along its length. Extra stakes should be used at connections or bundle overlaps. Leave the top of the stakes flush with the installed bundle. ➢ Live stakes are generally installed on the down slope side of the bundle. Drive the live stakes below and against the bundle between the previously installed dead stout stakes. The live stakes should protrude 2 to 3 in. (5.1 to 7.6 cm) above the top of the live fascine. Place moist soil along the sides of the live fascine. The top of the fascine should be slightly visible when the installation is completed (Figure SPP-04-1). ➢ Next, at intervals on contour or at an angle up the face of the bank, repeat the preceding steps to the top of the slope (Table SPP-04-1). ➢ Long straw or similar mulching material should be placed between rows on 2.5:1 (H: V) or flatter slopes, while slopes steeper than 2.5:1 (H: V) should have jute mesh or similar material placed in addition to the mulch.

Installation Procedures (Continued)

Table SPP-04-1
Live Fascine Installation Guidelines

Slope (H:V)	Slope distance Between trenches (ft)	Maximum slope length (ft)
1:1 to 1.5:1	3 - 4 (0.94 – 1.26 m)	15 (4.7 m)
1.5:1 to 2:1	4 - 5 (1.26 – 1.57 m)	20 (6.3 m)
2:1 to 2.5:1	5 - 6 (1.57 – 1.89 m)	30 (9.4 m)
2.5:1 to 3:1	6 - 8 (1.89 – 2.51 m)	40 (12.6 m)
3.5:1 to 4:1	8 - 9 (2.51 – 2.83 m)	50 (15.7 m)
4.5:1 to 5:1	9 - 10 (2.83 – 3.14 m)	60 (18.9 m)

- Bushlayering - similar to live fascine systems, however, in brushlayering the cuttings are oriented more or less perpendicular to the slope contour.
- Branch cuttings should be ½ to 2 in. (1.3 to 5.1 cm) in diameter and long enough to reach the back of the bench. Side branches should remain intact for installation.
- Starting at the toe of the slope, benches should be excavated horizontally, on the contour, or angled slightly down the slope, if needed to aid drainage. The bench should be constructed 2 to 3 ft. (0.63 to 0.94 m) wide.
- The surface of the bench should be sloped so that the outside edge is higher than the inside.
- Live branch cuttings should be placed on the bench in a crisscross or overlapping configuration.
- Branch growing tips should be aligned toward the outside of the bench.
- Backfill is placed on top of the branches and compacted to eliminate air spaces. The brush tips should extend slightly beyond the fill to filter sediment.
- Each lower bench is backfilled with the soil obtained from excavating the bench above.
- Long straw or similar mulching material with seeding should be placed between rows on 3:1 (H: V) or flatter slopes, while slopes steeper than 3:1 (H: V) should have jute mesh or similar material placed in addition to the mulch.
- The brushlayer rows should vary from 3 to 5 ft. (0.94 to 1.57 m) apart, depending upon the slope angle and stability (Table SPP-04-2).

Table SPP-04-2
Brushlayer Installation Guidelines

Slope	Slope distance between benches		Maximum slope
(H:V)	Wet slopes (ft)	Dry slopes (ft)	length (ft)
2:1 to 2.5:1	3 (0.94 m)	3 (0.94 m)	15 (4.7 m)
2.5:1 to 3:1	3 (0.94 m)	4 (1.26 m)	15 (4.7 m)
3.5:1 to 4:1	4 (1.26 m)	5 (1.57 m)	20 (6.3 m)

Installation Procedures (Continued)

- Branchpacking – consists of alternating layers of live branch cuttings and compacted backfill to repair small localized slumps and holes in slopes.
  - Live branch cuttings may range from ½ in. to 2 in. (1.3 to 5.1 cm) in diameter. They should be long enough to touch the undisturbed soil at the back of the trench and extend slightly from the rebuilt slope face.
  - Wooden stakes should be 5 to 8 ft. (1.57 to 2.51 m) long and made from 3- to 4-inch (7.6 to 10.2 cm) diameter poles or 2 by 4 (5.1 by 10.2 cm) lumber, depending upon the depth of the particular slump or hole.
  - Starting at the lowest point, drive the wooden stakes vertically 3 to 4 ft. (0.94 to 1.26 m) into the ground. Set them 1 to 1 ½ ft. (0.31 to 0.47 m) apart.
  - A layer of living branches 4 to 6 in. (10.2 to 15.2 cm) thick is placed in the bottom of the hole, between the vertical stakes, and perpendicular to the slope face (Figure SPP-04-2). They should be placed in a crisscross configuration with the growing tips generally oriented toward the slope face. Some of the basal ends of the branches should touch the back of the hole or slope.
  - Subsequent layers of branches are installed with the basal ends lower than the growing tips of the branches.
  - Each layer of branches must be followed by a layer of compacted soil to ensure soil contact with the branch cuttings.
  - The final installation should match the existing slope. Branches should protrude only slightly from the filled face.
  - The soil should be moist or moistened to insure that live branches do not dry out.
  - Branchpacking is not effective in slump areas greater than 4 or 5 feet (1.26 to 1.57 m) wide.

- Live gully repair – utilizes alternating layers of live branch cuttings and compacted soil to repair small rills and gullies.
- Limited to rills or gullies which are a maximum of 2 ft. (0.63 m) wide, 1 foot deep (0.31 m), and 15 ft. (4.71 m) long.
- Live branch cuttings may range from ½ in. to 2 inches (1.3 to 5.1 cm) in diameter. They should be long enough to touch the undisturbed soil at the back of the rill or gully and extend slightly from the rebuilt slope face.
- Starting at the lowest point of the slope, place a 3- to 4-in. (7.6- to 10.2-cm) layer of branches at lowest end of the rill or gully and perpendicular to the slope (Figure SPP-04-3).
- Cover with a 6- to 8- in. (15.2 to 20.3 cm) layer of fill soil.
- Install the live branches in a crisscross fashion. Orient the growing tips toward the slope face with basal ends lower than the growing tips.
- Follow each layer of branches with a layer of compacted soil to ensure soil contact with the live branch cuttings.
- Live cribwall – a hollow, box-like interlocking arrangement of untreated log or timber members. The structure is filled with suitable backfill material and layers of live branch cuttings which root inside the crib structure and extend into the slope.

Installation Procedures (Continued)

- This technique is appropriate at the base of a slope where a low wall may be required to stabilize the toe.
- Live branch cuttings should be ½ to 2 inches (1.3 to 5.1 cm) in diameter and long enough to reach the back of the wooden crib structure.
- Logs, timbers or reinforced concrete beams should range from 4 to 6 inches (10.2 to 15.2 cm) in diameter or dimension. The lengths will vary with the size of the crib structure.
- Large nails or rebar are required to secure the logs or timbers together.
- Starting at the lowest point of the slope, excavate loose material 2 to 3 feet (0.63 to 0.94 m) below the ground elevation until a stable foundation is reached.
- Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability to the structure.
- Place the first course of logs, timbers or reinforced concrete beams at the front and back of the excavated foundation, approximately 4 to 5 feet (1.26 to 1.57 m) apart and parallel to the slope contour.
- Place the next course of logs or timbers at right angles (perpendicular to the slope) on top of the previous course to overhang the front and back of the previous course by 3 to 6 inches (7.6 to 15.2 cm).
- Each course of the live cribwalls is placed in the same manner and nailed to the preceding course with nails or reinforcement bars.
- When the cribwall structure reaches the existing ground elevation, place live branch cuttings on the backfill perpendicular to the slope; then cover the cuttings with backfill and compact.
- Live branch cuttings should be placed at each course to the top of the cribwall structure with growing tips oriented toward the slope face. Follow each layer of branches with a layer of compacted soil to ensure soil contact with the live branch cuttings. Some of the basal ends of the live branch cuttings should reach to undisturbed soil at the back of the cribwall with growing tips protruding slightly beyond the front of the cribwall (Figure SPP-04-4).

- Vegetated gabions – Vegetated gabions begin as rectangular containers fabricated from a triple twisted, hexagonal mesh of heavily galvanized steel wire. Empty gabions are placed in position, wired to adjoining gabions, filled with stones and then folded shut and wired at the ends and sides. Live branches are placed on each consecutive layer between the rock-filled baskets. These will take root inside the gabion baskets and in the soil behind the structures. In time the roots consolidate the structure and bind it to the slope.

- Vegetated rock wall – a combination of rock and live branch cuttings used to stabilize and protect the toe of steep slopes.
  - Live cuttings should have a diameter of ½ to 1 inch (1.3 to 2.5 cm) and be long enough to reach beyond the rock structure into the fill or undisturbed soil behind.
  - Inert materials consist of rocks and fill material for the wall construction. Rock used should normally range from 8 to 24 inches (20.3 to 61 cm) in diameter. Larger boulders should be used for the base.

Installation Procedures (Continued)

- Starting at the lowest point of the slope, remove loose soil until a stable base is reached. This usually occurs 2 to 3 feet (0.63 to 0.94 m) below ground elevation. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability to the structure.
- Excavate the minimum amount from the existing slope to provide a suitable recess for the wall.
- Provide a well-drained base in locations subject to deep frost penetration.
- Place rocks with at least a three-point bearing on the foundation material or underlying rock course. They should also be placed so that their center of gravity is as low as possible, with their long axis slanting inward toward the slope if possible.
- When a rock wall is constructed adjacent to an impervious surface, place a drainage system at the back of the foundation and outside toe of the wall to provide an appropriate drainage outlet.
- Overall height of the rock wall, including the footing, should not exceed 5 feet (1.57 m).
- A wall can be constructed with a sloping bench behind it to provide a base on which live branch cuttings can be placed during construction. Live branch cuttings should also be tamped or placed into the openings of the rock wall during or after construction. The butt ends of the branches should extend into the backfill or undisturbed soil behind the wall.
- The live branch cuttings should be oriented perpendicular to the slope contour with growing tips protruding slightly from the finished rock wall face (Figure SPP-04-5).

- Joint planting – involves tamping live cuttings of rootable plant material into soil between the joints or open spaces in rocks that have previously been placed on a slope.
  - Roots improve drainage by removing soil drainage.
  - Effective with existing rip-rap structures.
  - The cuttings must have side branches removed and bark intact. They should range in diameter from ½ to 1 ½ inches (1.3 to 3.8 cm) and be sufficiently long to extend into soil below the rock surface.
  - Tamp live branch cuttings into the openings of the rock during or after construction. The butt ends of the branches should extend into the backfill or undisturbed soil behind the rip-rap.

  Orient the live branch cuttings perpendicular to the slope with growing tips protruding slightly from the finished face of the rock (Figure SPP-04-6).

Activity: Soil Bioengineering and Bank Stabilization	SPP-04

Maintenance

- During the establishment period, inspect cuttings daily removing any dead stock and replacing it with fresh stock.
  - Inspect biweekly for the first 2 months. Inspections should note insect infestations, soil moisture, and other conditions that could lead to poor survivability. Immediate action, such as the application of supplemental water, should be taken if conditions warrant.
  - Inspect monthly for the next 6 months. Systems not in acceptable growing condition should be noted and, as soon as seasonal conditions permit, should be removed from the site and replaced with materials of the same species and sizes as originally specified.
  - Needed reestablishment work should be performed every 6 months during the initial 2-year establishment period. This will usually consist of replacing dead material.
  - Extra inspections should always be made during periods of drought or heavy rains. Damaged sections should always be repaired immediately.

- Final inspection – A final inspection should be held 2 years after installation is completed. Healthy growing conditions should exist.

- Healthy growing conditions in all areas refer to overall leaf development and rooted stems defined as follows:

  Live stakes -------------------- 70%-100% growing
  Live fascines ------------------ 20%-50% growing
  Live cribwall ------------------ 30%-60% growing
  Brushlayers -------------------- 40%-70% growing
  Branchpacking ---------------- 40%-70% growing
  Live gully repair -------------- 30%-50% growing
  Vegetated rock wall ---------- 50%-80% growing
  Vegetated gabion ------------- 40%-60% growing
  Joint planting ------------------ 50%-70% growing

- Growth should be continuous with no open spaces greater than 2 feet in linear systems. Spaces 2 feet (0.63 m) or less will fill in without hampering the integrity of the installed living system.

Inspection Checklist

- ❑ Where labor is either scarce or extremely expensive, the cost of soil bioengineering systems may be higher than traditional structural measures. However, it should be noted that soil-bioengineering techniques generally are less expensive.
- ❑ Constraints on planting times or the availability of the required quantities of suitable plant materials during allowable planting times may limit soil bioengineering methods.
- ❑ Rapid vegetative establishment may be difficult on extremely steep slopes.
- ❑ Rocky or gravelly slopes can lack sufficient fines or moisture for plant growth.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-05

Activity: Gradient Terraces and Slope Roughening

SR

SR

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
N/A

Estimated Unit Cost:
N/A

Monthly Maintenance:
Negligible

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

Prevent or reduce the discharge of pollutants to the storm drain system or to watercourses as a result if construction activity by terracing slopes to reduce erosion by decreasing runoff velocities, tapping sediment, increasing infiltration, and aiding in supporting vegetative cover.

Suitable Applications

Slopes steeper than 3:1 (H:V) and greater than 5 ft. in height
Graded areas with smooth hard surfaces
Where length of slopes needs to be sirtened by terracing. Note: terracing is usually permanent, and should be designed under the direction of and approved by a licensed professional civil engineer based in site conditions. Terraces must be designed with adequate drainage and stabilized outlets.

Installation Procedures

- These systems should be designed by a licensed professional civil engineer.
- Terracing installation techniques are presented in EPP-11: Terracing. Refer the BMP to review Technical Figures.
- In the event that terraced slopes become unstable or flow is diverted to them to an extent that the practice becomes ineffective in limiting erosion or stabilizing vegetation, then alternative measures should be considered. Alternative measures can include flow diversion, drains, swales, level spreaders, geotextiles and bank stabilization practices described in the EPP section. These measures should be designed to consider the permanent structure/slope and other site conditions.

Activity: Gradient Terraces and Slope Roughening

Maintenance

- Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events greater than 0.5 in. (12 mm). Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

- Inspect monthly for the first year after construction. The slope should be inspected in early fall thereafter.

Inspection Checklist

- [ ] Stair-step grading may not be practical for sandy, steep, or shallow soils.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-06

Activity: Flow Diversion, Drains and Swales

PLANNING CONSIDERATIONS:

Design Life:
Life

Acreage Needed:
N/A

Estimated Unit Cost:
N/A

Monthly Maintenance:
Negligible

PS

PS

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

Permanent drains and swales are used to divert runoff from stabilized areas around disturbed areas, and direct runoff into sediment basins or detention ponds.

Suitable Applications

The primary function of a slope drain is to convey runoff down cut or fill slopes. The primary function of a subsurface drain is to drain excessive soil saturation in sloping areas. The primary function of top and toe of slope diversion swales, ditches, and berms is to minimize sheet flow over slope surfaces and reduce sedimentation by conveying collected runoff to a protected drainage system. These management practices are likely to create a significant reduction in sediment.

Installation Procedures

These systems should be designed by a licensed professional civil engineer.

- Installation/Application criteria for permanent flow diversions, drains and swales are presented in SMP-11: Temporary Diversions, Drains and Swales. The principal differences between temporary and permanent measures of this type are factor of safety over sizing to account for large storm events and less frequent inspections. These practices should be designed by a licensed professional civil engineer.

Maintenance

- Drains should be inspected monthly the first year after construction and annually thereafter.
- Diversions should be inspected every other month the first year after construction and annually thereafter.

Activity: Flow Diversion, Drains and Swales

Maintenance (Continued)

- The diversions and drains should be inspected immediately after any storm event equal to or larger than the 10-year storm event.
- Inspect outlet for erosion and downstream scour. If eroded, repair damage and install additional energy dissipation measures. If downstream scour is occurring, it may be necessary to reduce flows being discharged into the channel unless other preventative measures are implemented.
- Inspect slope drainage for accumulations of debris and sediment.
- Remove built-up sediment from entrances and outlets as required. Flush drains if necessary; capture and settle out sediment from discharge.
- Inspect ditches/berms for washouts. Replace lost riprap, damaged linings or soil stabilizers as needed.
- To avoid creating indentions that could reconcentrate flows, avoid operation of vehicles and heavy equipment in the level spreader. When indentions are formed, grade, fill, and revegetate as needed.
- Inspect for debris and sediment accumulation in spreader channel. Remove accumulated debris and sediment as needed. Sediment should be removed from the level spreader if it has reached ½ of sediment storage capacity.
- Inspect level spreaders prior to the rainy season and after significant rainfall events.
- Inspect level spreader lip to verify a zero percent slope.
- Inspect for evidence of erosion below spreader. This could indicate lip is no longer level.
- Inspect for evidence of flow reconcentration of spreader discharge.

Inspection Checklist

- ❑ Subsurface drains may remove fine soils which can result in collapse of the slope. Filter cloth should be used in this case.
- ❑ Severe erosion may result if slope drains fail by over topping, soil piping, or pipe separation.
- ❑ Maximum flow into the spreader should not exceed 30 cfs (0.85 m^3/s).
- ❑ Lip of level spreader must have a zero slope for proper operation.
- ❑ A level spreader is not a sediment trapping or filtering device, but may accumulate sediment that must be removed.
- ❑ Ditches/berms are not sediment trapping devices, but may accumulate sediment that must be removed.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-07

Activity: Outlet Protection

TOP

PLANNING CONSIDERATIONS:

Design Life: Permanent

Acreage Needed: Minimal

Estimated Unit Cost: Varies

Monthly Maintenance: Varies

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

By utilizing devices placed at outlets to pipes and channels to reduce the velocity and/or energy of exiting water pollutants are reduced or prevented to storm drain systems or to watercourses. This is a means of controlling erosion and scour to the constructed areas.

Suitable Applications

- Outlets of pipes, drains, culverts, conduits or channels.
- Outlets located at the bottom of mild to steep slopes.
- Outlets of channels which carry continuous flows of water.
- Outlets subject to short, intense flows of water, such as flash floods.
- Where lined conveyances discharge to unlined conveyances.

Installation Procedures

- These systems should be designed by a licensed professional civil engineer.
- Carefully place rip-rap to avoid damaging the filter fabric.
- For proper operation of apron:
  - Construct apron at zero grade.
  - Align apron with receiving stream and keep straight throughout its length. If a curve is needed to fit site conditions, place it in upper section of apron.
  - If size of apron rip-rap is 12 in. (300 mm) or larger, protect underlying filter fabric with 4 in. (100 mm) minimum gravel blanket.
- Outlets at top of cut slopes or on slopes steeper than 10% should have additional protection due to reconcentration and large velocity of flow leaving the structural apron.
- Temporary devices should be completely removed as soon as the surrounding
- drainage area has been stabilized, or at the completion of construction. However, temporary devices can serve as permanent devices if properly sized and reinforced with a factor of safety to account for less frequent inspection and maintenance.

Activity: Outlet Protection	SPP-07

Maintenance

- Permanent outlet protection should be inspected monthly through the first year after construction and annually thereafter.
- Permanent outlet protection should be inspected after any storm events equal to or larger than a 10-year storm event.
- Inspect apron for displacement of the rip-rap and/or damage to the underlying fabric. Repair fabric and replace rip-rap which has washed away.
- Inspect for scour beneath the rip-rap and around the outlet. Repair damage to slopes or underlying filter fabric immediately.

Inspection Checklist

- [ ] Large storms can wash away the rock outlet protection and leave the area susceptible to erosion.
- [ ] Sediment captured by the rock outlet protection may be difficult to remove without removing the rock.
- [ ] While reducing flow velocities, outlet protection may negatively impact the channel habit.
- [ ] Grouted rip-rap may break up in areas of freeze and thaw.
- [ ] Grouted rip-rap may break up from hydrostatic pressure without adequate drainage.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Prevention (SPPs)

SPP-08

Activity: Channel Lining

PLANNING CONSIDERATIONS:

Design Life: Permanent

Acreage Needed: Minimal

Estimated Unit Cost: Varies on design and materials

Monthly Maintenance: Minimal

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

Channel lining is the artificial surfacing of bed, banks, shore or embankments to resist erosion or scour.

Suitable Applications

- Soft (geotextiles) channel lining can be used to support permanent vegetative growth in a drainage way or as protection prior to placement of a permanent protective layer.
- Permanent (hard or soft) channel lining can be used when an ordinary seeding and mulch application would not be expected to withstand the force of channel flow.
- Permanent lining can only be applied in dry-weather channels (having flow most the year) with expressed permission from IDEM.

Installation Procedures

- These systems should be designed by a licensed professional civil engineer.
- The following materials are applicable for soft (or “green”) channel linings. Generally, these types of practices are not applied in dry-weather streams (have water flowing most of the year). These practices are most often effective in wet-weather conveyances (only have flow when it rains).
  - Excelsior
  - Jute mats and cells
  - Wood fiber mats and cells
  - Geosynthetic mats or cells
  - Brushlayering

Activity: Channel Lining	SPP-08

Installation Procedures (Continued)

- The following “hard” materials are applicable for permanently lining channels.
  - Pre-cast concrete block (“woven” or individually placed)
  - Rip rap
  - Cast-in-place concrete
  - Gabions
  - Sacked concrete
  - Soil cement
  - Air blown mortar
- Rip rap, cast-in-place concrete, and pre-cast concrete blocks should only be utilized with expressed permission from the Engineering Department.
- Application of the net and matting materials above is described in the Nets and Mats (EPP-09), and Geotextiles (EPP-10) BMPs.
- Brushlayering applications are discussed in detail in SMP-05: Brush or Rock Filter.
- Riprap installation is detailed in SMP-09: Riprap.

Maintenance

- Soft (or “green”) channel linings should be inspected monthly for the first year after construction, quarterly through the second year after construction and biannually (twice per year) thereafter.
- Hard channel linings should be inspected monthly for the first year after construction and annually thereafter.
- If net or matting materials are damaged, repair or replace immediately.
- Any spaces left bare in riprap or brushlayering applications due to erosion or scouring are to be repaired and replaced with their respective lining materials.

Inspection Checklist

- ❑ Hard (concrete, rip rap, etc.) permanent channel linings often result in prevention of habitat establishment.
- ❑ Inadequate coverage results in erosion, washout, and poor plant establishment.
- ❑ If the channel grade and liner are not appropriate for the amount of runoff, channel bottom erosion may result.
- ❑ If the channel slope is too steep or riprap is too small, displacement may occur.
- ❑ Riprap may block channel resulting in erosion along the edge.

Stormwater Pollution Treatment Practices

STP – 01 Infiltration Systems

STP – 02 Wet Detention Ponds

STP – 03 Dry Detention Ponds

STP – 04 Constructed Wetlands

STP – 05 Biofilter, Swales and Strips

STP – 06 Media Filtration/Media Filters and Water Quality Inlets

STP – 07 Oil/Water Separators and Water Quality Inlets

STP – 08 Multiple Systems

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Treatment Practices (STPs)

STP-01

Activity: Infiltration Systems

PLANNING CONSIDERATIONS:

Design Life:
N/A

Acreage Needed:
Minimal

Estimated Unit Cost:
N/A

Monthly Maintenance:
Negligible

IS

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

A majority of runoff from small storms is infiltrated into the ground rather than discharged to a surface water body through a family of systems. These acceptable systems include vaults, exfiltration trenches, dry wells and porous modular pavement grids. Along with these acceptable systems swales and filter strips can also achieve a limited degree of infiltration. SPP-06: Flow Diversion, Drains and Swales and STP-05: Biofilter Swales and Strips should also be reviewed.

Suitable Applications

- Where conditions are suitable, infiltration systems may be the preferred choice because stormwater is placed into the ground thereby reducing excess runoff and providing groundwater recharge (volume control).
- Need to achieve high level of particulate and dissolved pollutant removal.
- Suitable site soils and geologic conditions; low potential for long-term erosion in the catchments.
- Multiple management objectives (e.g., ground water recharge or runoff volume control).
- Retention basins are generally not preferred in this area (shallow bedrock conditions), thus they are not discussed in detail in this BMP. Small scale infiltration devices have a higher success potential if given local soil conditions promote such devices.

Activity: Infiltration Systems	STP-01

Suitable Applications (Continued)

- Porous pavements are generally not preferred in this area due to durability problems. Porous modular paving grids are preferred in areas with light use traffic conditions
- May not be suitable near drinking water wells, foundations, septic tanks, drain fields, or unstable slopes.
- Acceptable infiltration systems include:
  - Infiltration or exfiltration trench which is an underground chamber filled with rock, also called a rock well (Figure STP-01-1).
  - Dry well or "vertical" infiltration trench (Figure STP-01-2).
  - Concrete grid and modular pavement which are lattice grid structures with grassed, pervious material placed in the openings (Figure STP-01-3).
- Infiltration basins may be used if it can be demonstrated that soil, geology, and groundwater conditions are suitable and there is a permanent mechanism to perform maintenance (including funding requirements).
- Recommended minimum preconstruction infiltration rates have ranged from 0.25 to 4 inches (0.64 to 10.2 cm) per hour with a safety factor of 2.0 in the wet season water table condition. Drawdown should occur within 72 hours using the safety factor of 2.0.
- Not less than 3 feet (0.91 m) separation from seasonal high ground water (4 to 8 feet (1.22 to 2.44 m) in distance if soils are very coarse) and not less than 4 feet (1.22 m) in separation from bedrock.
- Avoid steep (10%) slopes or other geologic conditions that would be made unstable by the infiltrating water.
- The degree of treatment achieved by infiltration is a function of the amount of stormwater that is captured and infiltrated over time (e.g. 80-95% of average annual volume).
- For basins and trenches, pretreat the stormwater to remove the floatables and settleable solids, particularly when placing these systems in finer soils. This can be accomplished using swales, filter inlets, or baffle boxes.

Design and Sizing Considerations

- These systems should be designed by a licensed professional civil engineer.
- Size the volume to capture 85-95% of the average annual runoff value.
- Pretreatment will be required in fine soils.
- Emergency overflow or bypasses for larger storms are required on all infiltration systems.
- Observation wells are required in trenches every 50 to 100 feet (15.2 to 30.5 m).

Activity: Infiltration Systems	STP-01

Design and Sizing Considerations (Continued)

- Infiltration Systems should be designed to capture no less than the "maximized storm runoff capture volume" of 80-95% TSS removal and drain over a 12-hour period. The maximized storm runoff capture volume can be calculated by:

$$V = (a \cdot C) \cdot P_6$$

where:

V = maximized capture volume determined using either the event capture ratio or the volume capture ratio as its basis, watershed in. (mm);
a = regression constant from least-square analysis;
Event capture ratio: at least 1.109 for 12-hour drain time,
Volume capture ratio: at least 1.312 for 12-hour drain time (for approximately 85th percentile runoff event – 82-88%).
C = watershed runoff coefficient.
P_6 = mean storm precipitation volume, watershed in. (mm).

To determine if the captured runoff volume can be percolated into the ground through the sides of the system, consider the percolation flow rate:

$$U = k \cdot I$$

where:

U = flow velocity ft/s (m/s);
k = saturated hydraulic conductivity ft/s (m/s); and
I = hydraulic gradient (wet season).

- Assume I = 1.0 if the bottom of the system is above the high seasonal groundwater level.

Maintenance

- Inspect the facility at least annually and after extreme events. If there is still water in the pond or trench 72 hours after a storm it is time to clean the facility.
- The primary objective of maintenance/inspection activities is to ensure that the infiltration facility continues to perform as designed and to substantially lengthen the required time interval between major rehabilitation.
- Frequent (at least twice per year) cleaning of porous pavement grids.
- Till infiltration surfaces when needed to restore the infiltration capacity and to control weed growth. Tilling should generally be accomplished using rotary tillers.
- Remove debris and sediment annually to avoid excessive concentrations of pollutants and loss of infiltrative capacity.

Sediment Removal

- A primary function of STPs is to collect sediments. The sediment accumulation rate is dependant on a number of factors including watershed size, facility sizing, construction upstream, industrial or commercial activities upstream, etc. The sediment contents should be identified before it is removed and disposed.

Activity: Infiltration Systems	STP-01

Maintenance (Continued)

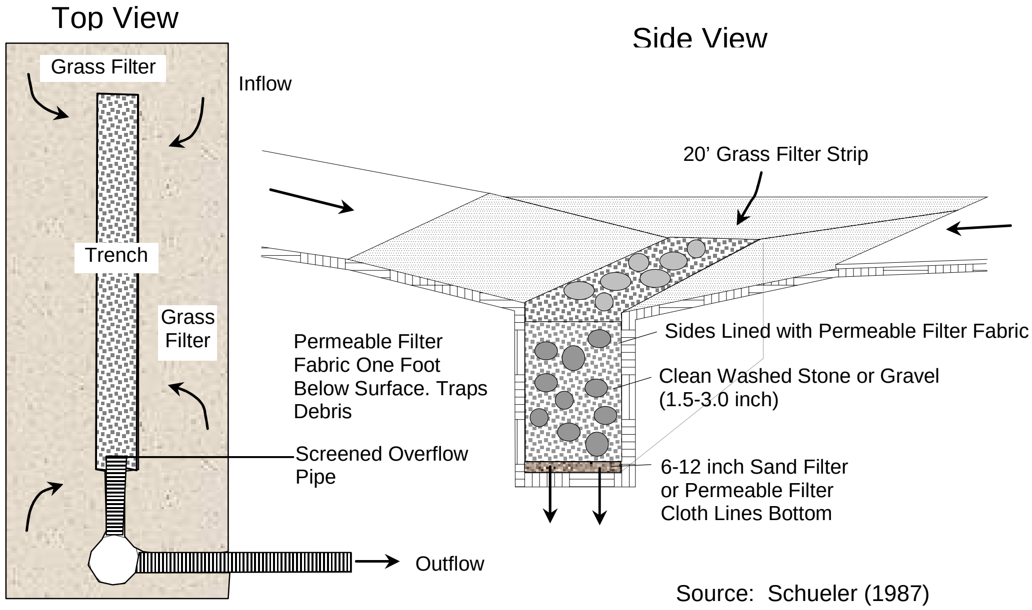
- Some sediment may contain contaminants of which the Indiana Department of Environmental Management (IDEM) requires special disposal procedures. If there is any uncertainty about what the sediment contains or it is known to contain contaminants, then IDEM should be consulted and their disposal recommendations followed. The IDEM – Division of Water Pollution Control should be contacted. Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants (other than "clean" soil) are suspected to accumulate and be conveyed via storm runoff.

- Some sediment collected may be innocuous (free of pollutants other than "clean" soil) and can be used as fill material, cover or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm runoff. The sediment should not be placed within the high water level area of the STP, other BMP, creek, waterway, buffer, runoff conveyance device, or other infrastructure. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

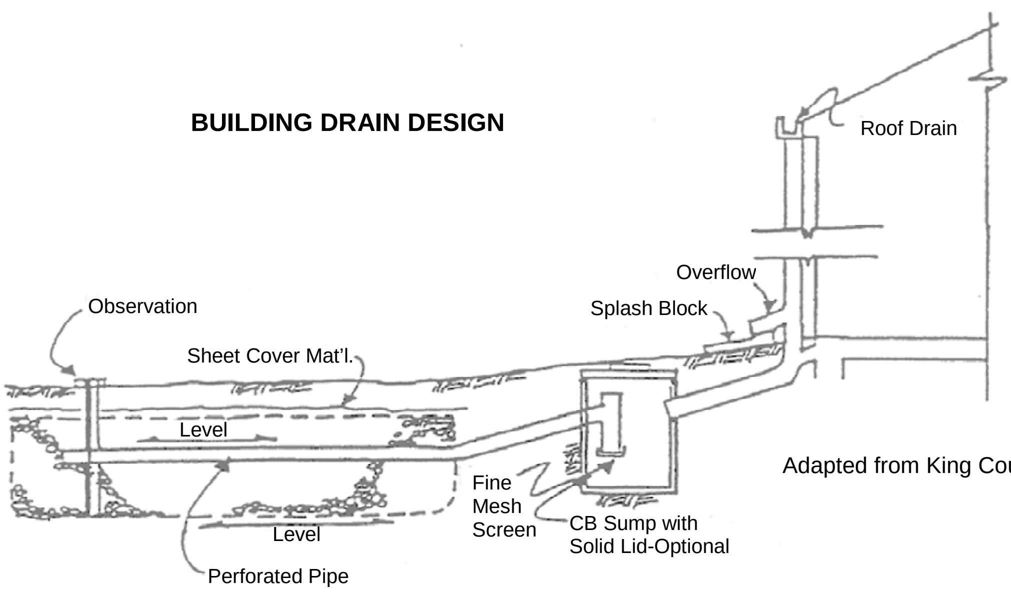
Inspection Checklist

- ❑ Use of lighter equipment is used to minimize compaction.
  Note: If this prohibition is not feasible in particular situations, do not excavate the facility to final grade until after all construction is complete upstream.
- ❑ Infiltration surface is protected during construction.
- ❑ System is free of clogging, accumulation of metals, and ground water contamination during construction.
- ❑ System is not located on fill sites or steep slopes.

No significant risk for a hazardous chemical spill.



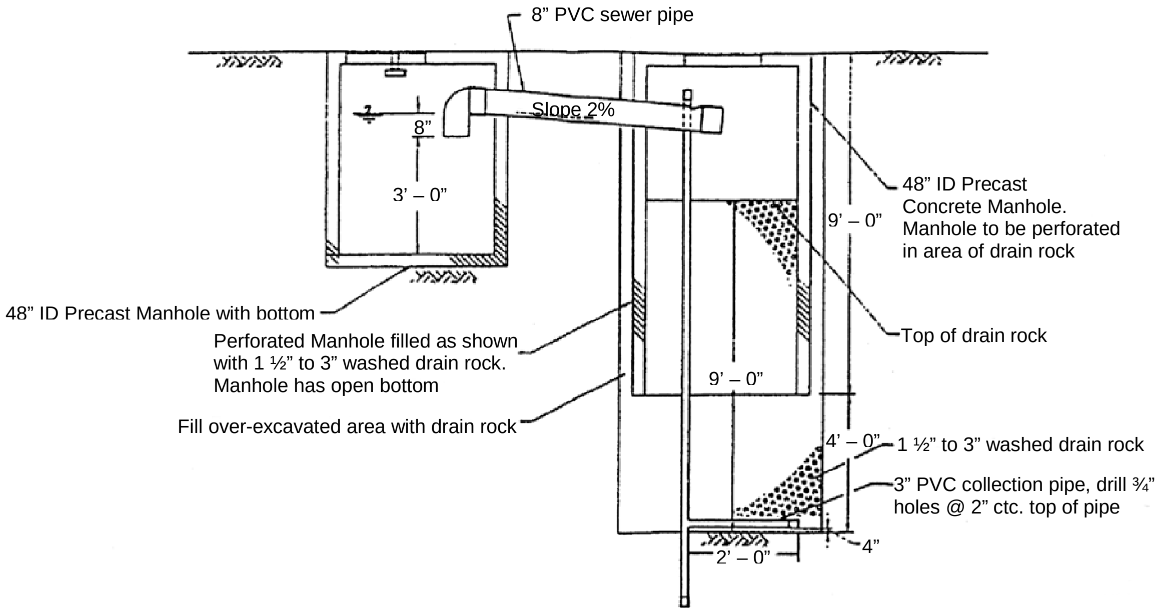
Source: Schueler (1987)



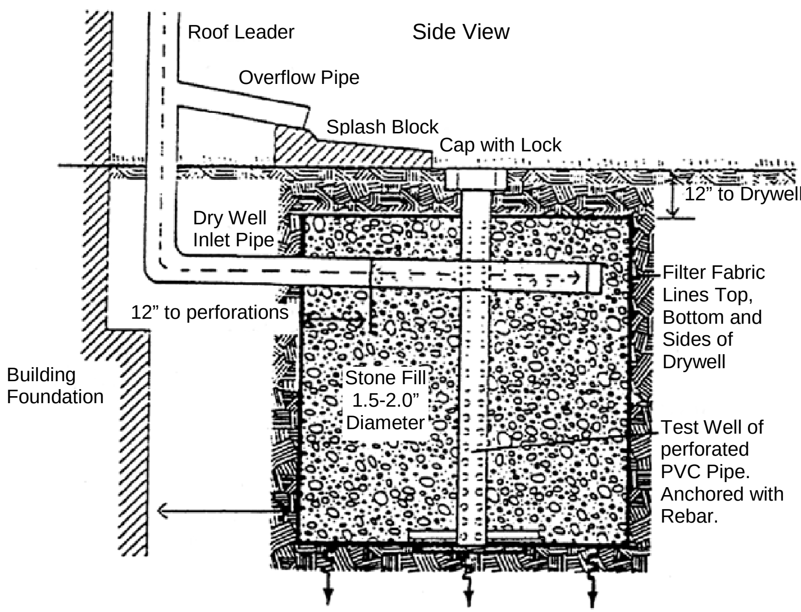
Adapted from King County

Figure STP-01-1
Infiltration Trench

Activity: Infiltration Systems

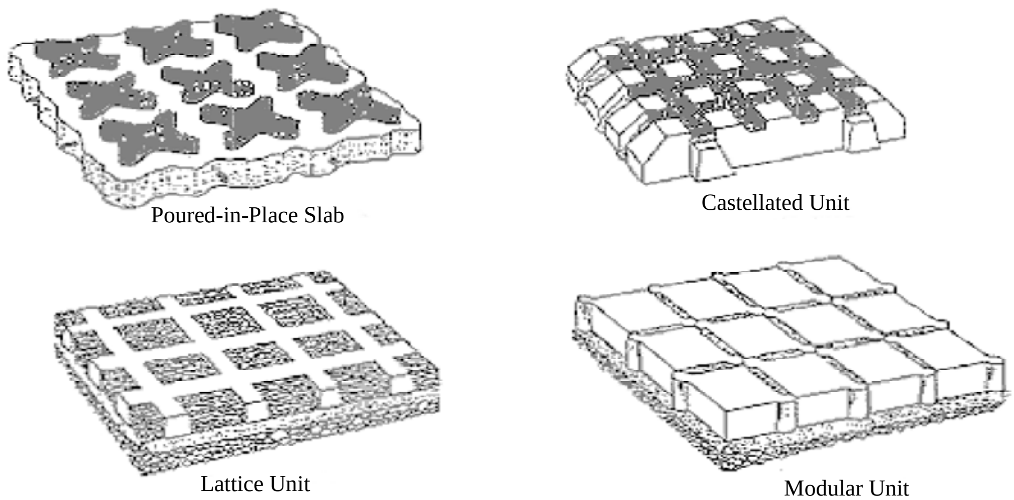


WITH PRETREATMENT



WITHOUT PRETREATMENT

Figure STP-01-2
Dry Well Configurations



Source: State of Florida

Figure PTP-01-3
Grid and Modular Pavement Types

Activity: Wet Detention Ponds

PLANNING CONSIDERATIONS:

Design Life: Permanent

Acreage Needed: Significant

Estimated Unit Cost: Avg: $.50 per CF of Storage

Monthly Maintenance: 3% of Capital Costs

W

WDP

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

A wet detention pond has a permanent water pool to treat incoming stormwater. A wet detention pond can be enhanced with a pretreatment sediment forebay, baffle box, or stormwater quality inlet. This management practice will provide a significant reduction in sediment, heavy metals, toxic materials, and floatable materials as well as partial reductions in the impacts due to nutrients, oxygen demanding substances, oil and grease, and bacteria and viruses.

Suitable Applications

- Need to achieve high level of particulate and some dissolved contaminant removal.
- Ideal for large, regional tributary areas.
- Multiple benefits of passive recreation (e.g., multi-purpose facilities, bird watching, wildlife habitat). See figure STP-02-9.

Design and Sizing Considerations

- These systems should be designed by a licensed professional civil engineer.
- Wet detention ponds should be designed as “off-line” structures to limit environmental impacts downstream when maintaining the facility. On-line facilities may be acceptable depending on specific site characteristics.

Design and Sizing Considerations (Continued)

The major features of a wet detention pond are shown in Figures STP-02-1 and STP-02-2. It is essentially a small lake with rooted wetland vegetation along the perimeter. The permanent pool of water (below the weir crest, culvert, or inlet) provides a quiescent volume for continued settling of particulate contaminants and uptake of dissolved contaminants by aquatic plants between storms.

- The wetland vegetation is present to improve the removal of dissolved contaminants and to reduce the formation of algal mats. The “live” pool provides flood control, erosion control, and additional treatment benefits.
- The permanent pool should have a hydraulic residence time of at least 2 to 4 weeks.
- The maximum depth of the permanent pool is generally less than 12 feet (3.7 m), although greater depths are possible with artificial mixing or aerators at maximum depth. The objective is to avoid thermal stratification that could result in odor problems associated with anaerobic conditions. Gentle artificial mixing may be needed in small ponds because they are effectively sheltered from the wind.
- In industrial applications ground water or treated process water will have to be pumped into the facility to maintain the water level. The permanent pond could be allowed to dry during maintenance periods.
- The outlet of the facility should be restricted so as to detain a treatment design storm in a “live” pool on top of the permanent pool for 24 to 60 hours. The effect of restricting the outflow is to reduce the overflow rate during the storm reducing downstream erosion, flood control and slightly increasing the capture of settleable solids.
- Water quality detention ponds should be sized to collect the first flush of stormwater runoff. For this area, the first flush is generally the first 0.5 to 1.1 inches (1.3 to 2.8 cm) of runoff over the tributary area.
- About 10 to 25% of the surface area determined in the above procedure should be devoted to the forebay. The forebay can be distinguished from the remainder of the pond by one of several means: a lateral sill with rooted wetland vegetation, two ponds in series, differential pool depth, rock-filled gabions or retaining wall, or a horizontal rock filter placed laterally across the pond. A baffle box or water quality inlet(s) can be used in lieu of a forebay.

<u>Sizing the “Live” Pool</u>

The following two methods should be used to calculate the “live” pool volume. The most conservative (largest volume) should be selected.

- The recommended performance goal is at least 85 to 95% capture of the annual average runoff volume. The live pool may be calculated using long-term hourly hydrologic data and runoff capture simulation curves that consider a runoff coefficient for land use to determine a unit basin storage volume (v).

$$V_L = (A_T * v)/12$$

where: V_L = pond volume (acre-feet);
A_T = Total Tributary Area (acres); and
v = unit basin storage volume – taken from Figure STP-02-3 (0.5 to 1.1 inches (1.3 to 2.8 cm))

Activity: Wet Detention Ponds

Design and Sizing Conditions (Continued)

- Alternatively, the live pool portion of the wet pond can also be designed to capture the "maximized storm runoff capture volume," and drain over a 24-60 hour period. The maximized storm runoff capture volume can be calculated by:

$$V_L = (a \cdot C) \cdot P_6$$

where:

V_L = maximized capture volume determined using either the event capture ratio or the volume capture ratio as its basis, watershed in. (mm);
a = regression constant from least-square analysis;
Event capture ratio: 1.299 for 24-hour drain time,
Volume capture ratio: 1.582 for 24-hour drain time (for approximately 85th percentile runoff event – 82-88%).
C = runoff coefficient
P_6 = mean storm precipitation volume, watershed in. (mm).

- Using this technique, the desired removal efficiency and land use characteristics can be applied to local hydrologic data to determine the optimal live pool volume. Note that A_T and the runoff coefficient selected can be modified to consider Directly Connected Impervious Area (DCIA) if the data is available.

- This live pool volume will add to the overall volume and will benefit the downstream waterways by reducing erosive velocities, providing flood control and an incremental increase in treatment.

Sizing the Permanent Pool

- Two methods are available for the sizing of the permanent pool portion of the wet detention ponds. One proposed on the removal of phosphorus (Florida, 1988; Maryland, 1986) It provides a detention time of 14 days based on the wettest month to allow sufficient time for the uptake of dissolved phosphorus by algae and the settling of fine solids where the particulate phosphorus tends to be concentrated. The following two methods should be used to calculate the permanent pool volume. The most conservative (largest volume) should be selected.

Size the permanent pool portion of the wet pond using the wettest 14-day period using the following formula:

$$V_p = (CA_TR)/12$$

Where: V_p = permanent pool volume (acre-ft)
C = contributing area weighted average runoff coefficient
A_T = Total Tributary Area (acres)
R = 14 day wet season rainfall (inches)
= 2.04 inches (5.18 cm)

The second method predicts the removal of particulate contaminants only (USEPA, 1986). It relates the removal efficiency of suspended solids to pond volume. Using this method, the volume of the permanent pool may be calculated as follows:

$$V_P = V_{B/R}S_dA_i43560/12 = 10890S_dA_i$$

Activity: Wet Detention Ponds	STP-02

Design and Sizing Conditions (Continued)

where: V_P = permanent pool volume (ft^3)
$V_{B/R}$ = Ratio of Basin to Runoff Volume (Figure STP-02-7)
(a value of at least 4.0 should be used)
S_d = mean storm depth (inches)
A_i = impervious acres in the tributary watershed

For A_i the engineer may use directly connected impervious acres because it more correctly represents the area being treated and would allow a smaller facility. Although impervious area and directly connected impervious area are not the same, they are reasonable given the uncertainty of the methodology and expected pond performance.

- Wetland vegetation, occupying 25-50% of water surface area.
- Side slopes should be 6:1 (H:V) or flatter to provide a littoral shelf and safety bench from the side of the facility out to a point 2 to 3 feet (0.61 to 0.91 m) below the permanent pool elevation. Side slopes above the littoral zone should be no steeper than 4:1 (H:V). Side slopes below the littoral zone can be 2:1 (H:V) to maximize permanent pool volumes where needed. A short (1.0 foot (0.3 m)) drop-off can be constructed at the edge of the pond to control the potential breeding of mosquitoes.
- Skimmers – Facilities that receive stormwater from contributing areas with greater than 50 percent impervious surface or that are a potential source of oil and grease contamination must include a baffle, skimmer, and grease trap to prevent these substances from being discharged from the facility.
- The permanent pool may be excavated into bedrock for a wet or dry detention pond, but the cost may be prohibitive. Furthermore, if there is highly fractured bedrock or karst topography, then the modification of a detention pond should be carefully considered because it may not hold water and the additional water flow and/or weight could intensify karst activity.
- The interaction with other utilities must be considered as it may not be practical to develop a permanent pool in an area that is needed by another utility. Furthermore, the cost of designing around utilities or utility relocation must be considered.
- Access must be considered to account for maintenance crews and public interaction. Maintenance crews must have access to the site for proper maintenance. Ponds that are not designed with access for maintenance crews often become more of a nuisance than a beneficial part of a stormwater management program. It may also be desirable to encourage or discourage access for the public. Public education and recreation may be facilitated by access to the pond, provided public safety is sufficiently addresses. In some cases including some source land use conditions, however, it may be desirable to restrict public access such as in especially sensitive or dangerous areas.
- Design to minimize short-circuiting by including energy dissipaters on inlets, shape the pond with at least a 3:1 length to width ratio, and locate the inlets as far away from the outlet as possible. It should be noted that a length to width ratio of up to 7:1 is preferred. The inlet and outlet can be placed at the same end if baffling is installed to direct the water to the opposite end before returning to the outlet. If topography or aesthetics requires the pond to have an irregular shape, the pond area and volume should be increased to compensate for the dead spaces.

## Activity: Wet Detention Ponds	STP-02

Design and Sizing Conditions (Continued)

- Except for very small facilities, include a forebay, baffle box, or stormwater quality inlet to facilitate maintenance. However, note that a forebay will require less frequent maintenance.
- Use side slopes of at least 4:1 (H:V) or flatter unless vertical retaining walls are used.
- To maintain the wet pool to the maximum extent possible, excessive losses by infiltration through the bottom must be avoided. Depending on the soils, this can be accomplished by compaction, incorporating clay into the soil, or an artificial liner.
- With earthen walls, place an antiseep collar around the outlet pipe.
- The outlet should incorporate an antivortex device if the facility is large (a 100-year storm must safely pass through or around the device).
- The sides of an earthen wall should be vegetated to avoid erosion. Drought tolerant groundcover species should be used if irrigation can not occur during the summer. See STP-04, Biofilters regarding recommended plant species.

Ponds that serve smaller local site runoff do not offer as much recreational benefit as ponds serving larger regional runoff. Regional facilities can often be landscaped to offer recreational and aesthetic benefits. Jogging and walking trails, picnic areas, ball fields, and canoeing or boating are some of the typical uses. For example, portions of the facility used for flood control can be kept dry, except during floods, and can be used for exercise areas, soccer fields, or football fields. Wildlife benefits can also be provided in the form of islands or preservation zones, which allow a view of nature within the park schemes.

- The public's safety must be a foremost consideration. For the design of wet detention ponds, this usually takes place in the grading, fencing, landscaping, pipe cover, grating and signage. The most important design feature affecting public safety during a pond's operation is grading. The contours of the pond should be designed to eliminate "drop-offs". When possible, terraces or benches are used to transition into the permanent pool. Within the permanent pool, it is desirable to have a wet terrace 12 to 18 inches (30.5 to 45.7 cm) below the normal pool level. In some cases there is not sufficient room for grading of this type and the pond may require a perimeter fence.

Outlet Design

- Proper hydraulic design of the outlet is critical to achieving good performance of the detention basin. The two most common outlet problems that occur are: 1) the capacity of the outlet is too great resulting in partial filling of the basin and less than designed for drawdown time and 2) the outlet clogs because it is not adequately protected against trash and debris. To avoid these problems, two alternative outlet types are recommended for use: 1) V-notch weir, and 2) perforated riser. The V-notch weir will not clog as easily.

Design and Sizing Conditions (Continued)

Flow Control Using a "V" Notch Weir

- The outlet control "V" notch weir should be sized using the following formula (Merritt et.al., 1996).

$$Q = C_1 H^{5/2} \tan\left(\frac{\theta}{2}\right)$$

Where

θ = notch angle
H = head or elevation of water over the weir, ft
C_1 = discharge coefficient (see Figure STP-02-8)

The notch angle should be 20° or more. If calculations show that a notch angle of less than 20° is appropriate, then the outlet should be designed as a uniform width notch. This will generally necessitate some sort of floatables control such as a skimmer on the outlet or trash rack on the inlet.

Flow Control Using a Single Orifice

- The outlet control orifice should be sized using the following equation (GKY, 1989).

$$a = \frac{2A(H-H_o)^{0.5}}{3600CT(2g)^{0.5}} = \frac{(7x10^{-5})A(H-H_o)^{0.5}}{CT} \qquad (1)$$

where: a = area of orifice (ft^2)
A = average surface area of the pond (ft^2)
c = orifice coefficient
T = drawdown time of full pond (hrs.)
g = gravity (32.2 ft/sec^2)
H = elevation when the pond is full (ft)
H_o = final elevation when pond is empty (ft)

With a drawdown time of 40 hours the equation becomes:

$$a = \frac{(1.75x10^{-5})A(H-H_o)^{0.5}}{CT} \qquad (2)$$

TABLE - PERFORATED OUTLET RISER PIPE ORIFICES (Austin, 1988)

Riser Pipe	Vertical Spacing Between Rows (center to center)	Number of Perforations	Perforation Diameter
6 in. (15.2 cm)	2.5 in. (6.4 cm)	9 per row	1 in. (2.54 cm)
8 in. (20.3 cm)	2.5 in. (6.4 cm)	12	1 in. (2.54 cm)
10 in. (25.4 cm)	2.5 in. (6.4 cm)	16	1 in. (2.54 cm)

Design and Sizing Conditions (Continued)

Flow Control Using the Perforated Riser

For outlet control using the perforated riser as the outflow control, it is recommended that the procedure illustrated in STP-03-5 and 6. This design incorporates flow control for the small storms in the perforated riser but also provides an overflow outlet for large storms. If properly designed, the facility can be used for both water quality and drainage control by: 1) sizing the perforated riser as indicated for water quality control; 2) sizing the outlet pipe to control peak outflow rate from the 2-year storm; and 3) using a spillway in the pond berm to control the discharge from larger storms up to the 100-year storm.

Maintenance

- Remove floatables and sediment build-up.
- Correct erosion spots in banks.
- Check at least annually and after each extreme storm event. The facility should be cleaned of accumulated debris. The banks of surface ponds should be checked and areas of erosion repaired. Remove nuisance wetland species and take appropriate measures to control mosquitoes. Remove sediments if they are within 18 inches (45.7 cm) of an orifice plate.

Sediment Removal

- A primary function of STPs is to collect sediments. The sediment accumulation rate is dependant on a number of factors including watershed size, facility sizing, construction upstream, industrial or commercial activities upstream, etc. The sediment contents should be identified before it is removed and disposed.

Some sediment may contain contaminants of which the Indiana Department of Environmental Management (IDEM) requires special disposal procedures. If there is any uncertainty about what the sediment contains or it is known to contain contaminants, then IDEM should be consulted and their disposal recommendations followed. Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants (other than “clean” soil) are suspected to accumulate and be conveyed via storm runoff.

Some sediment collected may be innocuous (free of pollutants other than “clean” soil) and can be used as fill material, cover or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm runoff. The sediment should not be placed within the high water level area of the STP, other BMP, creek, waterway, buffer, runoff conveyance device, or other infrastructure. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

- Solids should be removed when 10 to 15% of the storage capacity has been lost.
- The pond’s success as a mechanism to benefit water quality is dependent on maintaining the permanent pool, skimmer devices, and inlet and outlet structures. This maintenance typically includes sediment, floatable, and debris removal from inlets, outlets and skimmers.
- Pond vegetation need to be trimmed or harvested as appropriate, grassy areas frequently mowed and repairs made to signage, walkways, picnic tables, or any other public recreation equipment.
- If both the operational aesthetic characteristics of a wet pond are not maintained, then it will be viewed as an eyesore and negative environmental impact even if it is functioning properly

Activity: Wet Detention Ponds	STP-02

Inspection Checklist

- ❑ Concern for mosquitoes and maintaining oxygen in ponds.
- ❑ Cannot be placed on steep unstable slopes or on shallow fractured bedrock.
- ❑ Infeasible in very dense urban areas.
- ❑ For larger detention facilities, the structural integrity of the impounding embankment should also be considered. The embankment should be protected against catastrophic dam failure. Pending volume and depth, pond designs may require approval from IDEM or USACOE for various reasons including dam safety.
- ❑ May require permits from various regulatory agencies, e.g., IDEM, USACOE

Activity: Wet Detention Ponds

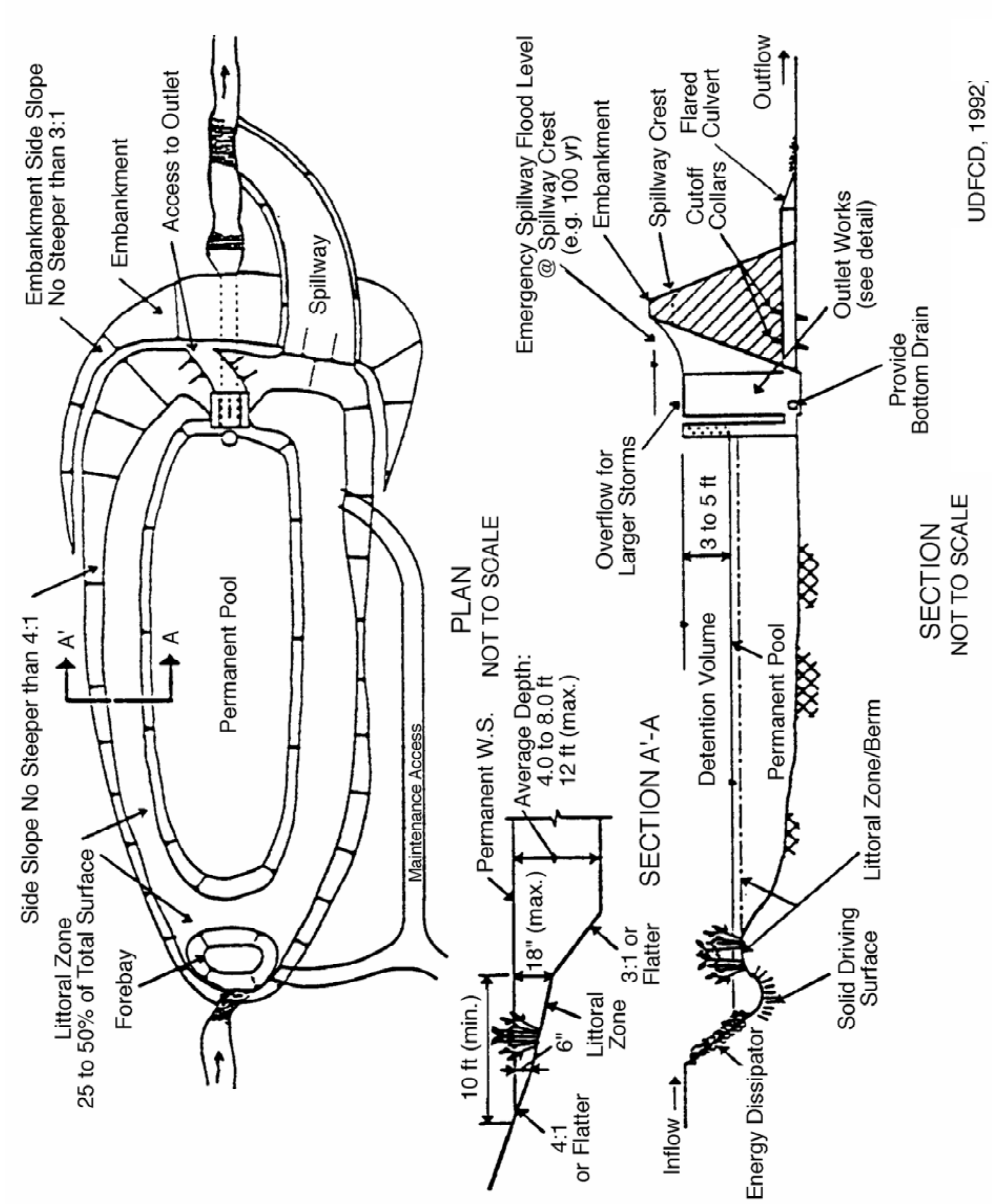


Figure STP-02-1
Wet Pond Layout

Activity: Wet Detention Ponds

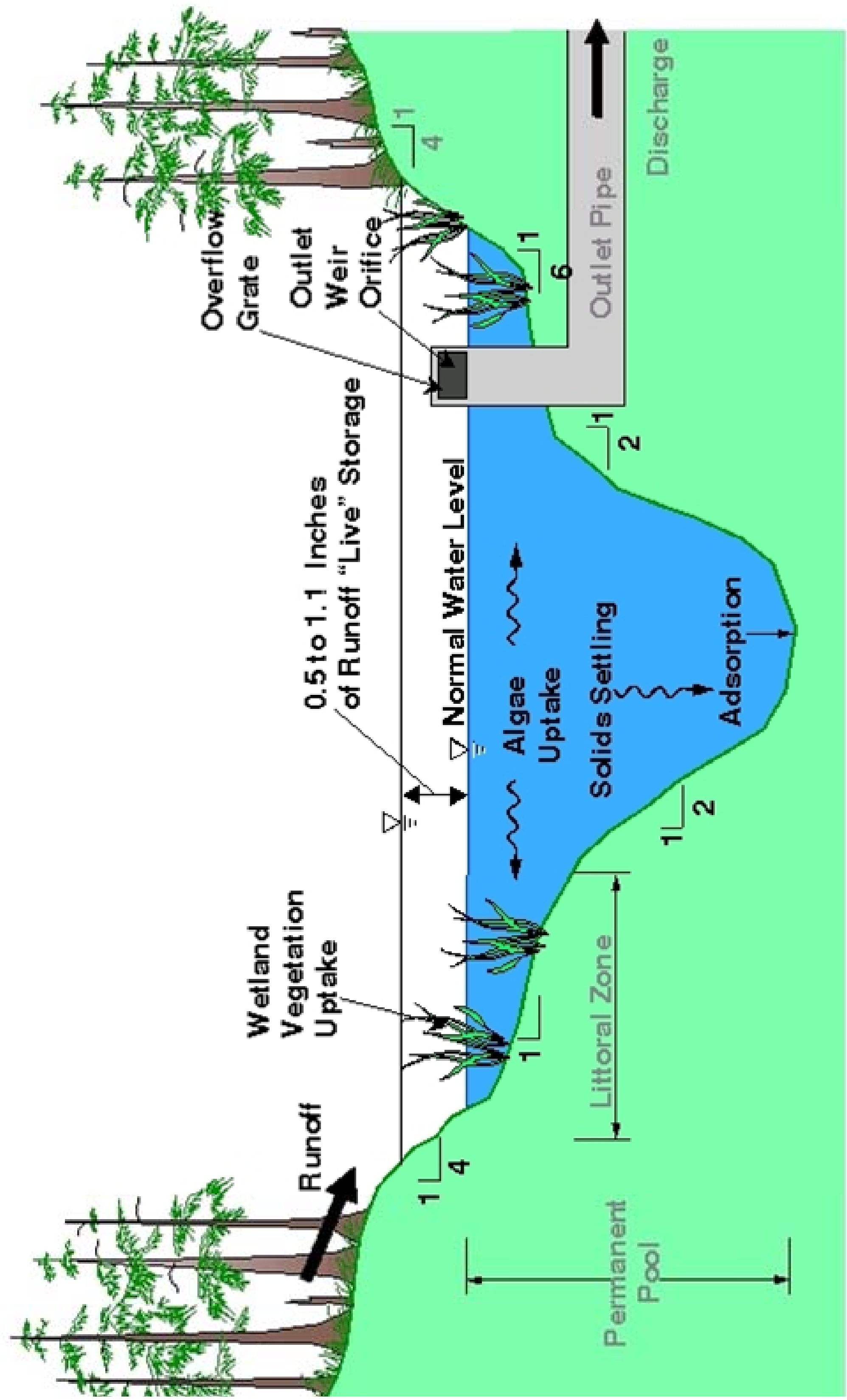
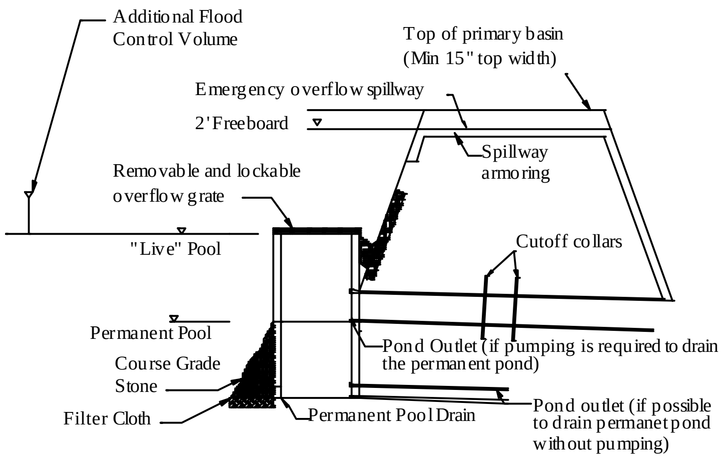


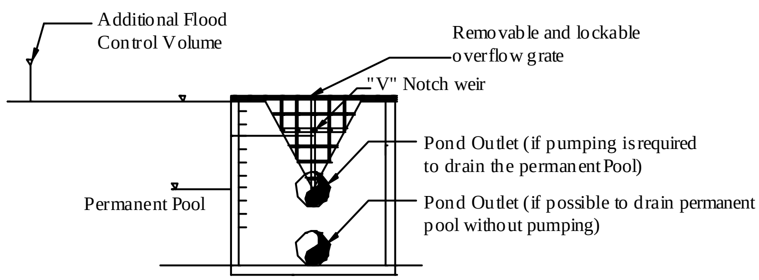
Figure STP-02-2
Wet Pond Layout

Source: City of Nashville, TN



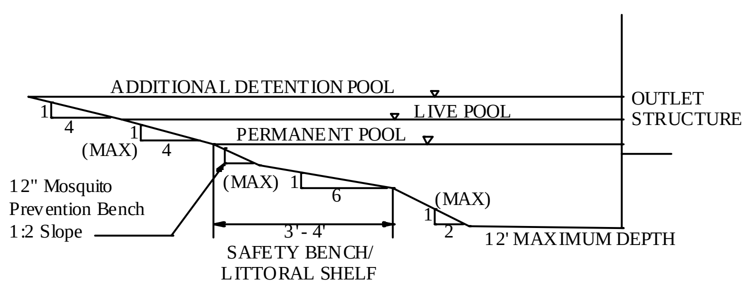
SECTION OUTLET STRUCTURE

NTS



PROFILE OUTLET STRUCTURE

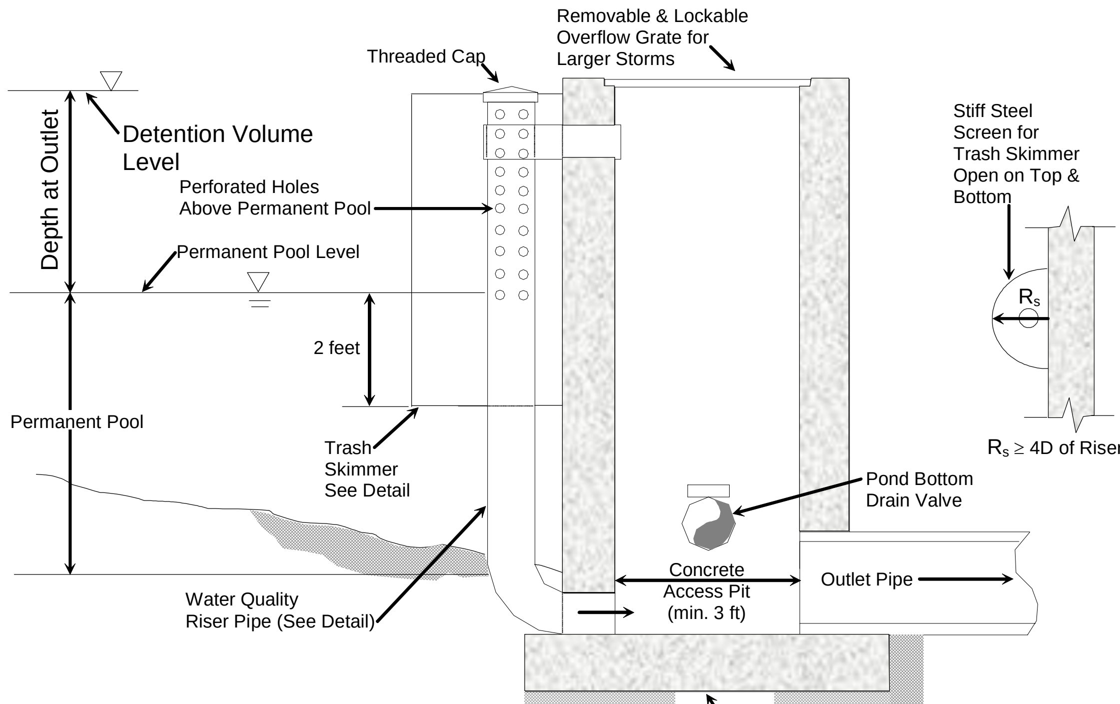
NTS



POND GRADING

NTS

Figure STP-02-3
“V” Notch Weir Outlet Structure



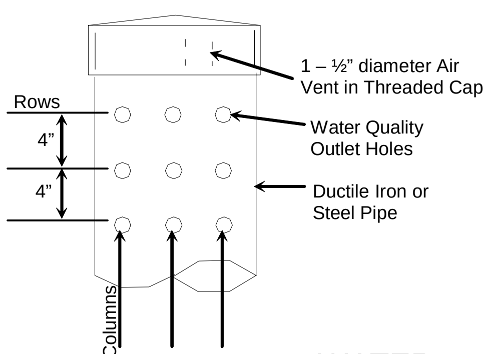
Notes: 1. Alternate designs are acceptable as long as the hydraulics provides the required emptying times.
2. Use trash skimmer screens of stiff green steel material to protect perforated riser. Must extend from the top of the riser to 2 ft. below the permanent pool level.

OUTLET WORKS
NOT TO SCALE

Notes: 1. Minimum number of holes = 8
2. Minimum hole diameter = 1/8" Dia.

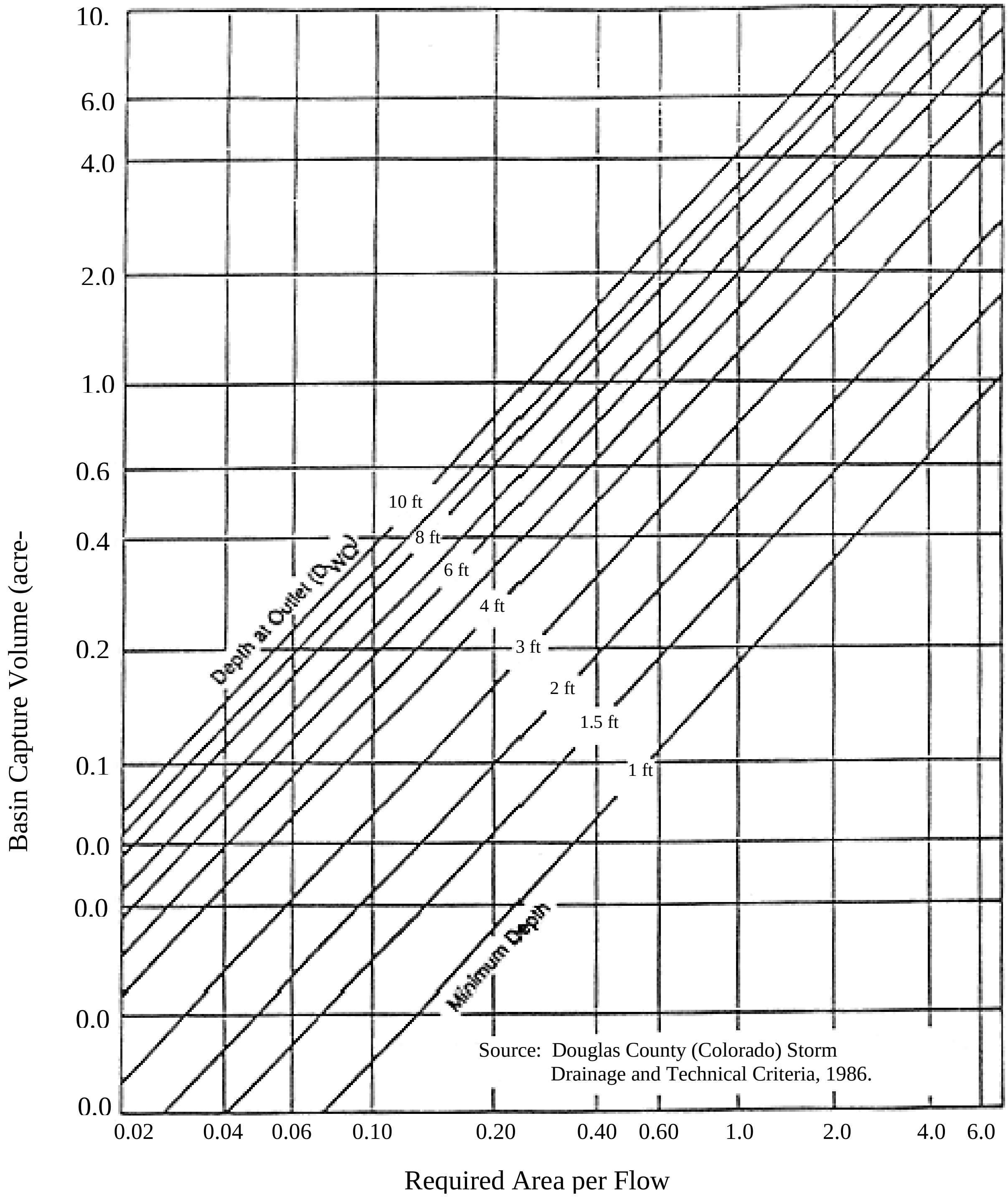
Maximum Number of Perforated Columns				
Riser Diameter (in.)	Hole Diameter, inches			
	¼"	½"	¾"	1"
4	8	8	-	-
6	12	12	9	-
8	16	16	12	8
10	20	20	14	10
12	24	24	18	12

Hole Diameter (in.)	Area (in.^{2})
1/8	0.013
1/4	0.049
3/8	0.110
1/2	0.196
5/8	0.307
3/4	0.442
7/8	0.601
1	0.785

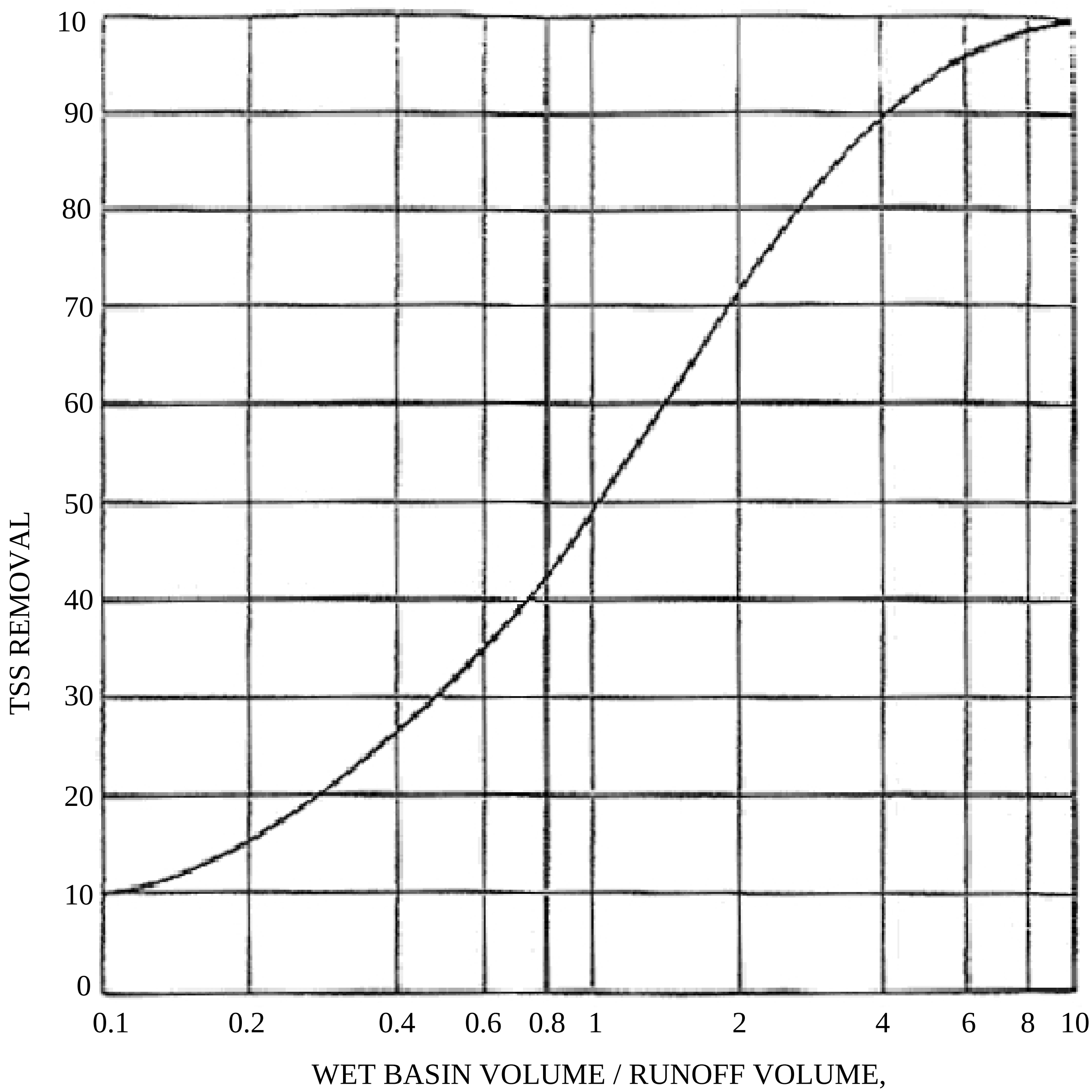


WATER
QUALITY
RISER PIPE
NOT TO SCALE

Figure STP-02-4
Perforated Riser Pipe Outlet Structure



STP-02-5
Water Quality Outlet Sizing: Extended Detention Basin
(40-hour Drain Time of Capture Volume)



Source: FHWA

Figure STP-02-6
TSS Removal Efficiency
Versus V_B/V_R Ratio

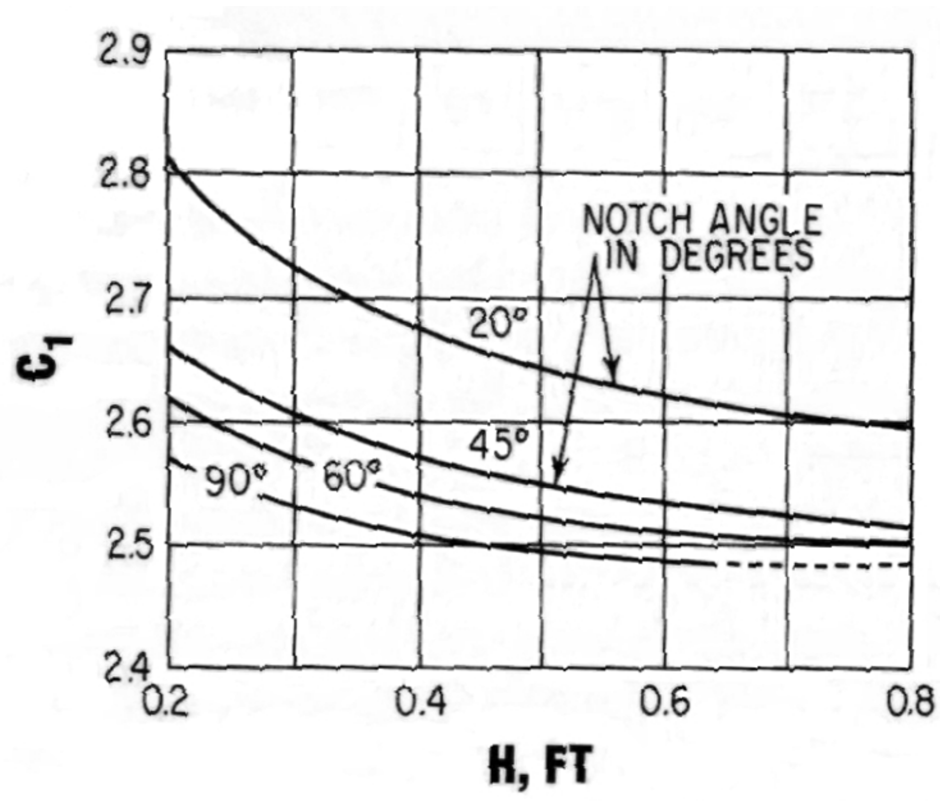


Figure STP-02-7
Sharp -Crested "V" Notch Weir Discharge Coefficients

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution treatment Practices (STPs)

STP-03

Activity: Dry Detention Ponds

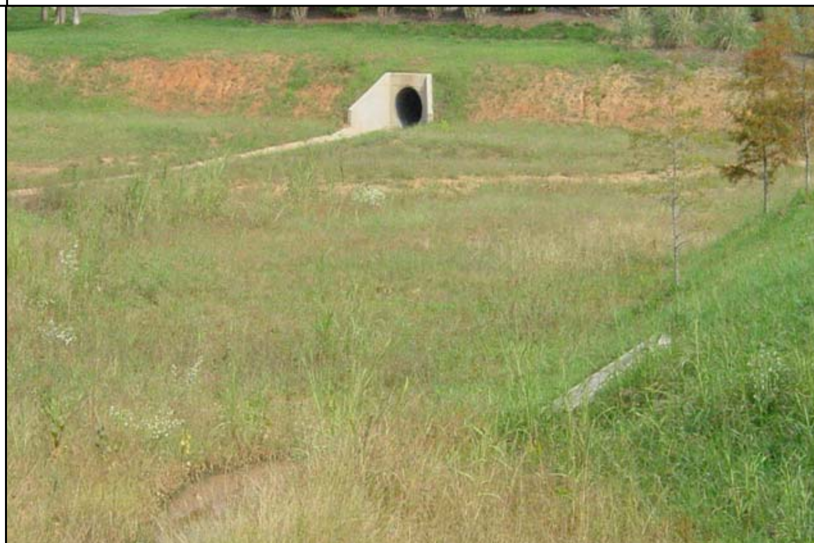
PLANNING CONSIDERATIONS:

Design Life: Permanent

Acreage Needed: Significant

Estimated Unit Cost: Avg: $.50 per CF of Storage

Monthly Maintenance: 3% of Capital Costs



D

DDP

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

Extended detention ponds are dry between storms. During a storm the pond fills. A bottom outlet releases the stormwater slowly to provide time for sediments to settle. This management practice is likely to provide a significant reduction in sediments and heavy metals as well as a partial reduction in nutrients, toxic materials, floatable materials, oxygen demanding substances, and oil and grease.

Suitable Applications

- Objective is to remove only particulate pollutants (soluble pollutants are not intended to be removed).
- Use where lack of water prevents the use of wet ponds, wetlands or biofilters.
- Use where shallow wet ponds or wetlands would cause unacceptable mosquito conditions.
- Multiple benefits for passive recreation during dry periods (multi-purpose facilities, ball fields, picnicking etc.).
- The quality of the runoff and the intent of the basin should be considered. If the basin is being considered for highly soluble pollutant removal such as nutrients, then a wet detention pond is preferred over a dry detention pond.

Activity: Dry Detention Ponds

Suitable Applications (Continued)	➢ Dry detention ponds and vaults may be particularly appropriate to areas where dry weather base flow cannot be used to maintain water levels, as is required for wet ponds and constructed wetlands. These systems are suitable for essentially any size tributary area from an individual commercial development to a large residential area. Surface ponds are less expensive to construct, but underground vaults may be appropriate in commercial developments. Use of concrete retaining walls will reduce the space required by a pond. The basic elements of a dry detention basin are illustrated in Figures STP-03-1 and 2. Additional details are provided in Figures STP 3-3 through 10. ➢ Dry ponds provide lower removal efficiency for dissolved pollutant parameters than wet ponds and constructed wetlands.
Design and Sizing Considerations	➢ These systems should be designed by a licensed professional civil engineer. ➢ Dry detention ponds should be designed as “off-line” structures to limit environmental impacts downstream when maintaining the facility. On-line facilities may be acceptable depending on specific site characteristics. ➢ Pond volume is sized to capture 85-95% of theoretical annual volume of the runoff. Generally, the pond is sized to capture and “treat” at least the “first flush” volume. ➢ Drawdown time of 24 to 48 hours. ➢ A shallow pond with large surface area performs better than a deep pond with the same volume. Design to minimize short-circuiting by including energy dissipaters on inlets, shape the pond with at least a 3:1 length to width ratio, and locate the inlets as far away from the outlet as possible. It should be noted that a length to width ratio of up to 7:1 is preferred. The inlet and outlet can be placed at the same end if baffling is installed to direct the water to the opposite end before returning to the outlet. If topography or aesthetics requires the pond to have an irregular shape, the pond area and volume should be increased to compensate for the dead spaces. • Place energy dissipaters at the entrance to minimize bottom erosion and re-suspension. • Vegetate side slopes and bottom to the maximum extent practical. • If side erosion is particularly severe, consider soil stabilization, armoring or lastly paving. • If floatables are a problem, protect outlet with trash rack, skimmer at inlet, or other device.

Activity: Dry Detention Ponds

Design and Sizing Considerations (Continued)

- Do not locate on fill sites or on or near steep slopes if it is expected that much of the water will exit through the bottom, or modify the bottom to prevent excessive infiltration.
- Embankment freeboard of at least 2 feet (0.61 m).
- Side slopes of at least 4:1 (H:V) unless vertical retaining walls are used.
- Provide dedicated access to the basin bottom (minimum 4:1 (H:V)) for maintenance vehicles.
- With a riser structure, include an anti-vortex device and a debris barrier.
- Skimmers – Facilities that receive stormwater from contributing areas with greater than 50 percent impervious surface or that are a potential source of oil and grease contamination must include a baffle, skimmer, and grease trap to prevent these substances from being discharged from the facility.
- Bedrock must be considered in the Nashville area because excavation may be required for grading. The "live" pool may be excavated into bedrock for a dry detention pond, but the cost may be prohibitive. Furthermore, if there is highly fractured bedrock or karst topography, then the modification of a detention pond should be carefully considered because it may not hold water and the additional water flow and/or weight could intensify karst activity.
- The interaction with other utilities must be considered as it may not be practical to develop a permanent pool in an area that is needed by another utility. Furthermore, the cost of designing around utilities or utility relocation must be considered.

Access must be considered to account for maintenance crews and public interaction. Maintenance crews must have access to the site for proper maintenance. Ponds that are not designed with access for maintenance crews often become more of a nuisance than a beneficial part of a stormwater management program. It may also be desirable to encourage or discourage access for the public. Public education and recreation may be facilitated by access to the pond, provided public safety is sufficiently addresses. In some cases, however, it may be desirable to restrict public access such as in especially sensitive or dangerous areas.

- Include a forebay to facilitate maintenance.
- With earthen walls, place an antiseep collar (or collars) around the outlet pipe.
- The outlet should incorporate an antivortex device if the facility is large (A 100-year storm must safely pass through or around the device).
- The sides of an earthen wall should be vegetated to avoid erosion. Drought tolerant groundcover species should be used if irrigation can not occur during the summer. See STP-04, Biofilters regarding recommended plant species.
- Ponds that serve smaller local site runoff do not offer as much recreational benefit as ponds serving larger regional runoff. Regional facilities can often be landscaped to offer recreational and aesthetic benefits. Jogging and walking trails, picnic areas, ball fields, and canoeing or boating are some of the typical uses. For example, portions of the facility used for flood control can be kept dry, except during floods, and can be used for exercise areas.

Activity: Dry Detention Ponds	STP-03

Design and Sizing Considerations (Continued)

- The public's safety must be a foremost consideration. For the design of dry detention ponds, this usually takes place in the grading, fencing, landscaping, pipe cover, grating and signage. The most important design feature affecting public safety during a pond's operation is grading. The contours of the pond should be designed to eliminate "drop-offs". When possible, terraces or benches are used to transition into the permanent pool. Within the permanent pool, it is desirable to have a wet terrace 12 to 18 inches (30.5 to 45.7 cm) below the normal pool level. In some cases there is not sufficient room for grading of this type and the pond may require a perimeter fence.
- Provide bypass or pass through capabilities for 100-year storm.

Pond Sizing

- Water quality requirements for detention ponds should be sized to collect the first flush of stormwater runoff; and release it over a 24- to 48-hour period. For this region, the first flush is generally the first 0.5 to 1.0 inches of runoff depending on the density and percent imperviousness of the land use.

The following two methods should be used to calculate the "live" pool volume. The most conservative (largest volume) should be selected.

- The recommended performance goal is 85 to 95%.
- The live pool portion of the dry pond can also be designed to capture the "maximized storm runoff capture volume," and drain over a 24-60 hour period. The maximized storm runoff capture volume can be calculated by:

$$V_L = (a \cdot C) \cdot P_6$$

where:

V_L = maximized capture volume determined using either the event capture ratio or the volume capture ratio as its basis, watershed in. (mm);

a = regression constant from least-square analysis;
Event capture ratio: 1.299 for 24-hour drain time,
Volume capture ratio: 1.582 for 24-hour drain time (for approximately 85^{th} percentile runoff event – 82-88%).

C = Contributing area weighted runoff coefficient

P_6 = mean storm precipitation volume, watershed in. (mm).

Refer to ASCE Manual and Report on Engineering Practices No. 87 for additional information on this technique.

- Using this technique, the desired removal efficiency and land use characteristics can be applied to local hydrologic data to determine the optimal live pool volume. Note that A_T and the runoff coefficient selected can be modified to consider Directly Connected Impervious Area (DCIA) if the data is available.
- The live pool volume will benefit the downstream waterways by reducing erosive velocities, providing stormwater quality benefit, and some flood control.

Activity: Dry Detention Ponds

Design and Sizing Considerations (Continued)

- To achieve an equivalent pollutant capture percentage as a wet pond, 85 to 95 percent of the runoff must be captured and detained. Capture volumes over 95 percent are generally not cost effective. Therefore it is recommended that an average capture volume of 90 percent be used for determining the detention basin size required. Because of the possibility of re-suspension of materials during extreme storms, consideration should be given to placing the basin off-line. That is, it should have a bypass for the extreme events. Bypassing larger events will also allow the bed load earned by the storm and is necessary for beach replenishment to move downstream.
- A drawdown time of 24 to 48 hours is recommended in order to settle out the finer clay particles as stated above; however, 24 hours can be used if it can be demonstrated that this rate will remove 90% of the solids.
- About 10 to 25% of the surface area determined in the above procedure should be devoted to the forebay. The forebay can be distinguished from the remainder of the pond by one of several means: a lateral sill with rooted wetland vegetation, two ponds in series, differential pool depth, rock-filled gabions or retaining wall, or a horizontal rock filter placed laterally across the pond.

<u>Outlet Design</u>

- Proper hydraulic design of the outlet is critical to achieving good performance of the detention basin. The two most common outlet problems that occur are: 1) the capacity of the outlet is too great resulting in partial filling of the basin and less than designed for drawdown time and 2) the outlet clogs because it is not adequately protected against trash and debris. To avoid these problems, two alternative outlet types are recommended for use: 1) V-notch weir, and 2) perforated riser. The V-notch weir will not clog.
- Three different approaches can be used to control the outflow. One is to use a "V" notch weir. One is to use a single orifice outlet with or without the protection of a riser pipe. Lastly, a perforated riser itself may be used for discharge control. These approaches are presented below.
- <u>Flow Control Using a "V" Notch Weir</u>
- The outlet control "V" notch weir should be sized using the following formula (Merritt et.al., 1996).

$$Q = C_1 H^{5/2} \tan\left(\frac{\theta}{2}\right)$$

Where

θ = notch angle
H = head or depth of water over weir, ft
C_1 = discharge coefficient (see Figure STP-03-9)

Design and Sizing Considerations (Continued)

The notch angle should be 20^o or more. If calculations show that a notch angle of less than 20^o is appropriate, then the outlet should be designed as a uniform width notch. This will generally necessitate some sort of floatables control such as a skimmer on the outlet or trash rack on the inlet.

Flow Control Using a Single Orifice

The outlet control orifice should be sized using the following equation (GKY, 1989).

$$a = \frac{2A(H-H_o)^{0.5}}{3600CT(2g)^{0.5}} = \frac{(7x10^{-5})A(H-H_o)^{0.5}}{CT}$$

where:
- a = area of orifice (ft^2)
- A = average surface area of the pond (ft^2)
- c = orifice coefficient
- T = drawdown time of full pond (hrs.)
- g = gravity (32.2 ft/sec^2)
- H = elevation when the pond is full (ft)
- H_o = final elevation when pond is empty (ft)

With a drawdown time of 40 hours the equation becomes:

$$a = \frac{(1.75x10^{-6})A(H-H_o)^{0.5}}{C}$$

Care must be taken in the selection of "c": 0.60 is most often recommended and used. However, based on actual tests GKY (1989) recommends the following:

c = 0.66 for thin materials, that is, the thickness is equal to or less than orifice diameter

c = 0.80 when the material is thicker than the orifice diameter

Drilling the orifice into an outlet structure that is made of concrete can result in considerable impact on the coefficient, as does the beveling of the edge. The experiments by GKY (1989) were with sharp edged orifices.

Design and Sizing Considerations (Continued)

- Additional steps may be necessary to be certain that the small storms, which represent the majority of pollution, are effectively treated. One approach would be to check the design analysis to determine if the facility takes 24-48 hours to drain when half full. If not, either modify the design to achieve this objective, or install a two orifice outlet. The lower outlet is sized to drain a half-full facility in 24 hours. The second orifice is placed at the mid-water elevation and is sized in combination with the lower orifice to drain the entire facility in 48 hours. Another approach is to install the outlet about one foot above the bottom of the pond (essentially enlarging the micropool area). This lower area will dry up between storms and will capture much of the volume of small storms and improving pollutant removal.

- To prevent clogging of an orifice and the bottom orifices of the riser pipe, wrap the bottom three rows of orifices with geotextile fabric and a cone of one to three inch rock. The holes in the riser pipe should not be modified to achieve a 48-hour drawdown time.

TABLE - PERFORATED OUTLET RISER PIPE ORIFICES (Austin, 1988)

Riser Pipe	Vertical Spacing Between Rows (center to center)	Number of Perforations	Perforation Diameter
6 in. (15.2 cm)	2.5 in. (6.4 cm)	9 per row	1 in. (2.54 cm)
8 in. (20.3 cm)	2.5 in. (6.4 cm)	12	1 in. (2.54 cm)
10 in. (25.4 cm)	2.5 in. (6.4 cm)	16	1 in. (2.54 cm)

<u>Flow Control Using the Perforated Riser</u>

For outlet control using the perforated riser as the outflow control, it is recommended that the procedure illustrated in Figures STP-03-5, 6 and 7. This design incorporates flow control for the small storms in the perforated riser but also provides an overflow outlet for large storms. If properly designed, the facility can be used for both water quality, flood, and erosion control by: 1) sizing the perforated riser as indicated for water quality control; 2) sizing the outlet pipe to control peak outflow rate from the 2-year storm; and 3) using a spillway in the pond berm to control the discharge from larger storms up to the 100-year storm.

Maintenance

- Check outlet regularly for clogging and remove any debris.

- Check banks and bottom of surface basin for erosion and correct as necessary.

- Remove sediment when accumulation reaches 6 inches (15.2 cm), or if re-suspension is observed or probable. Sediment may be permitted to accumulate deeper than 6 inches (15.2 cm) if there is a permanent marker indicating the depth where sediment needs to be removed, and that mark has not been met.

Maintenance (Continued)

Sediment Removal

- A primary function of STPs is to collect sediments. The sediment accumulation rate is dependant on a number of factors including watershed size, facility sizing, construction upstream, industrial or commercial activities upstream, etc. The sediment contents should be identified before it is removed and disposed.
- Some sediment may contain contaminants of which the Indiana Department of Environmental Management (IDEM) requires special disposal procedures. If there is any uncertainty about what the sediment contains or it is known to contain contaminants, then IDEM should be consulted and their disposal recommendations followed. Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants (other than "clean" soil) are suspected to accumulate and be conveyed via storm runoff.
- Some sediment collected may be innocuous (free of pollutants other than "clean" soil) and can be used as fill material, cover or land spreading. It is important that this material not be placed in a way that will promote or allow re-suspension in storm runoff. The sediment should not be placed within the high water level area of the STP, other BMP, creek, waterway, buffer, runoff conveyance device, or other infrastructure. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.
- Check at least annually and after each extreme storm event. The facility should be cleaned of accumulated debris. The banks of surface ponds should be checked and areas of erosion repaired. Remove nuisance wetland species and take appropriate measures to control mosquitoes. Remove sediments if they are within 18 inches (45.7 cm) of an orifice plate.
- The pond's success as a mechanism to benefit water quality is dependent on maintaining the permanent pool, skimmer devices, and inlet and outlet structures. This maintenance typically includes sediment, floatable, and debris removal from inlets, outlets and skimmers.
- Pond vegetation need to be trimmed or harvested as appropriate, grassy areas frequently mowed and repairs made to signage, walkways, picnic tables, or any other public recreation equipment.
- If both the operational aesthetic characteristics of a dry pond are not maintained, then it will be viewed as an eyesore and negative environmental impact even if it is functioning properly.

Activity: Dry Detention Ponds	STP-03

Inspection Checklist

- ❑ Make sure the outlet is installed as designed. Special attention should be given to the elevations of each outlet geometry change, shape of the various weirs or orifices, and installation of cut-off collars in embankments.
- ❑ Require more frequent maintenance then wet ponds.
- ❑ Inability to vegetate banks and bottom may result in erosion and pollutant re-suspension.
- ❑ Limitation of the orifice diameter may preclude use in small watersheds.
- ❑ Pending their volume and depth basin designs may require approval from State Division of Safety of Dams. Generally, any embankment 15 ft (4.6 m) or taller must meet special requirements. For larger detention facilities, the structural integrity of the impounding embankment should also be considered. The embankment should be protected against catastrophic dam failure. Pending volume and depth, pond designs may require approval from IDEM, or USACOE for various reasons including dam safety.
- ❑ Dry detention ponds require a large surface area (0.5 to 3% of the contributing drainage area) to provide sufficient pond volume for settling of sediment.
- ❑ If upstream erosion is not properly controlled, dry detention ponds can be maintenance intensive with respect to sediment removal, nuisance odors, and insects (i.e., mosquitoes), etc.
- ❑ Dry detention ponds require a differential elevation between inlets and outlets and thus, may be limited by terrain.
- ❑ May require permits from various regulatory agencies, e.g., IDEM, USACOE.

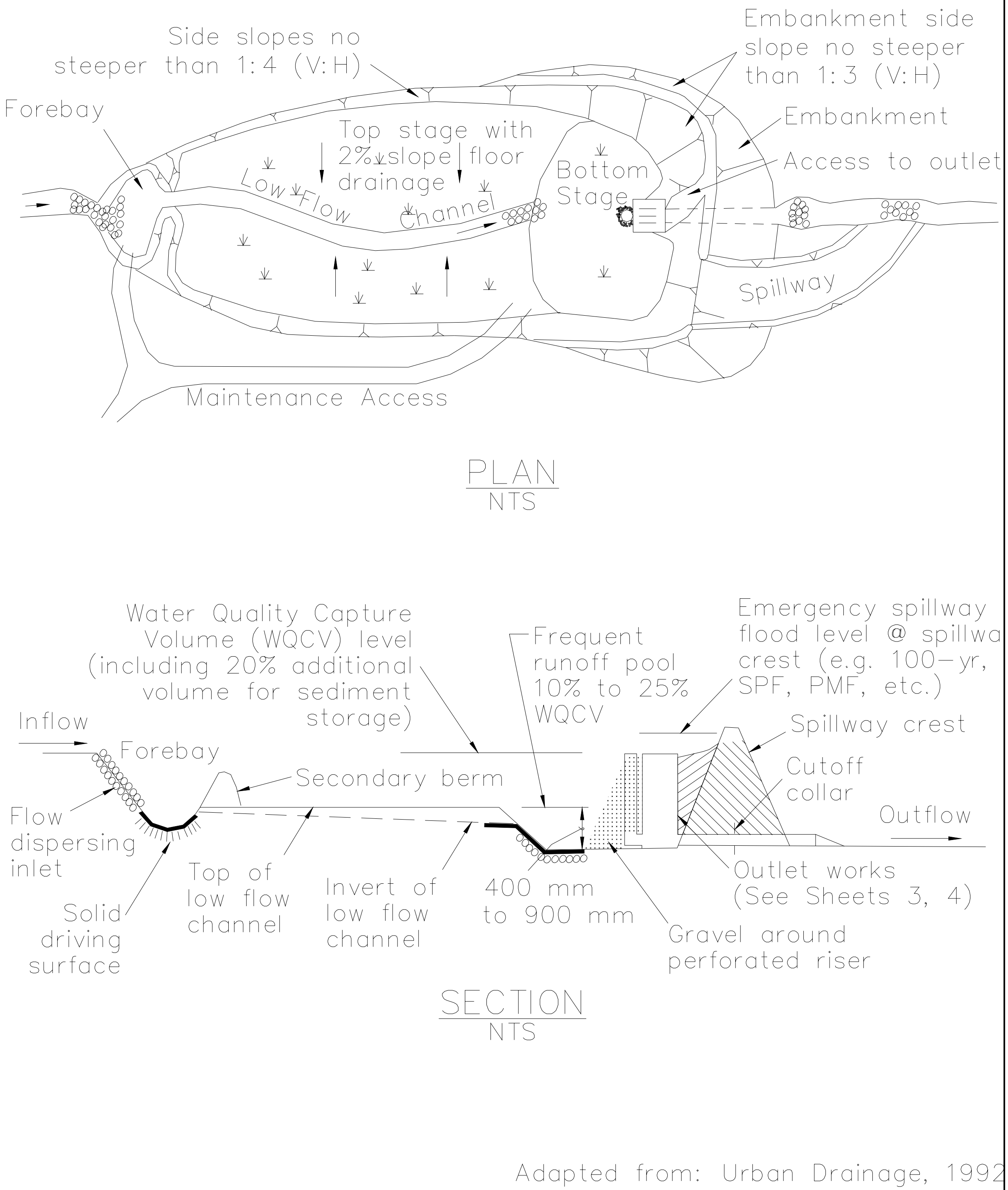
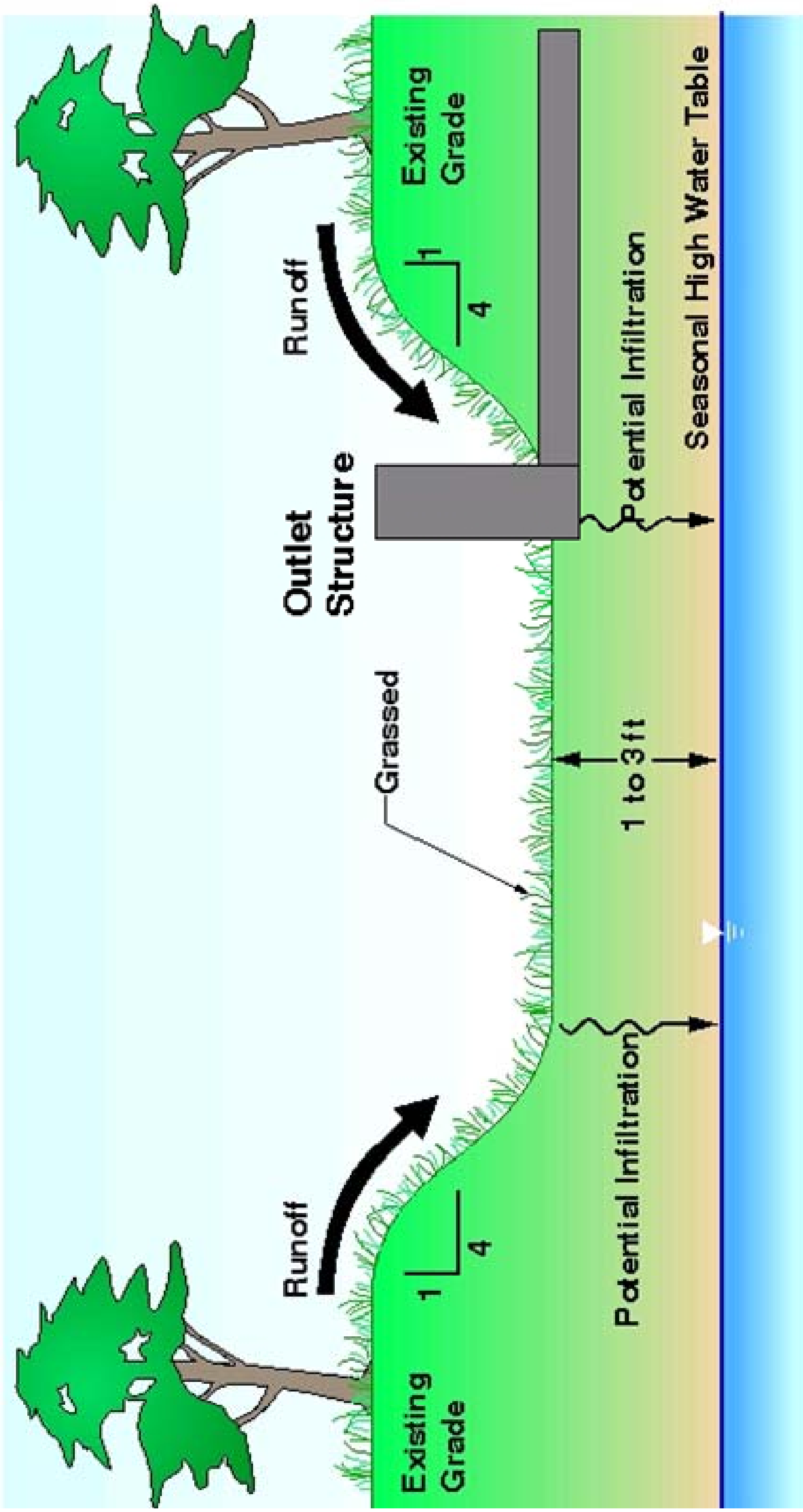


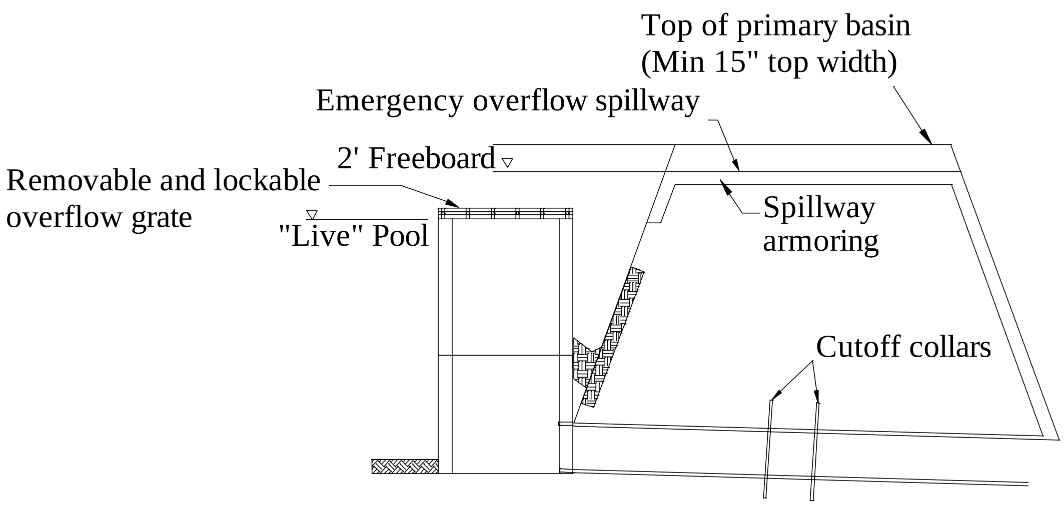
Figure STP-03-1
Dry Detention Pond Layout

Activity: Dry Detention Ponds	STP-03



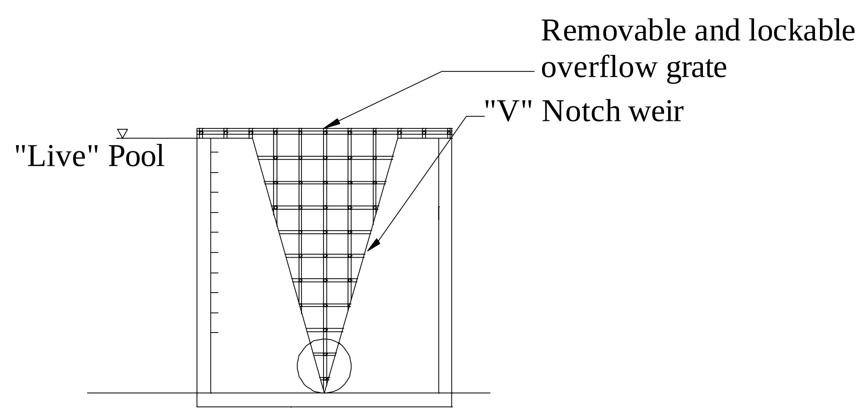
Source: City of Nashville

Figure STP-03-2
Dry Detention Pond Layout



SECTION OUTLET STRUCTURE

NTS



PROFILE OUTLET STRUCTURE

NTS

Figure STP-03-3
“V” Notch Weir Outlet Structure

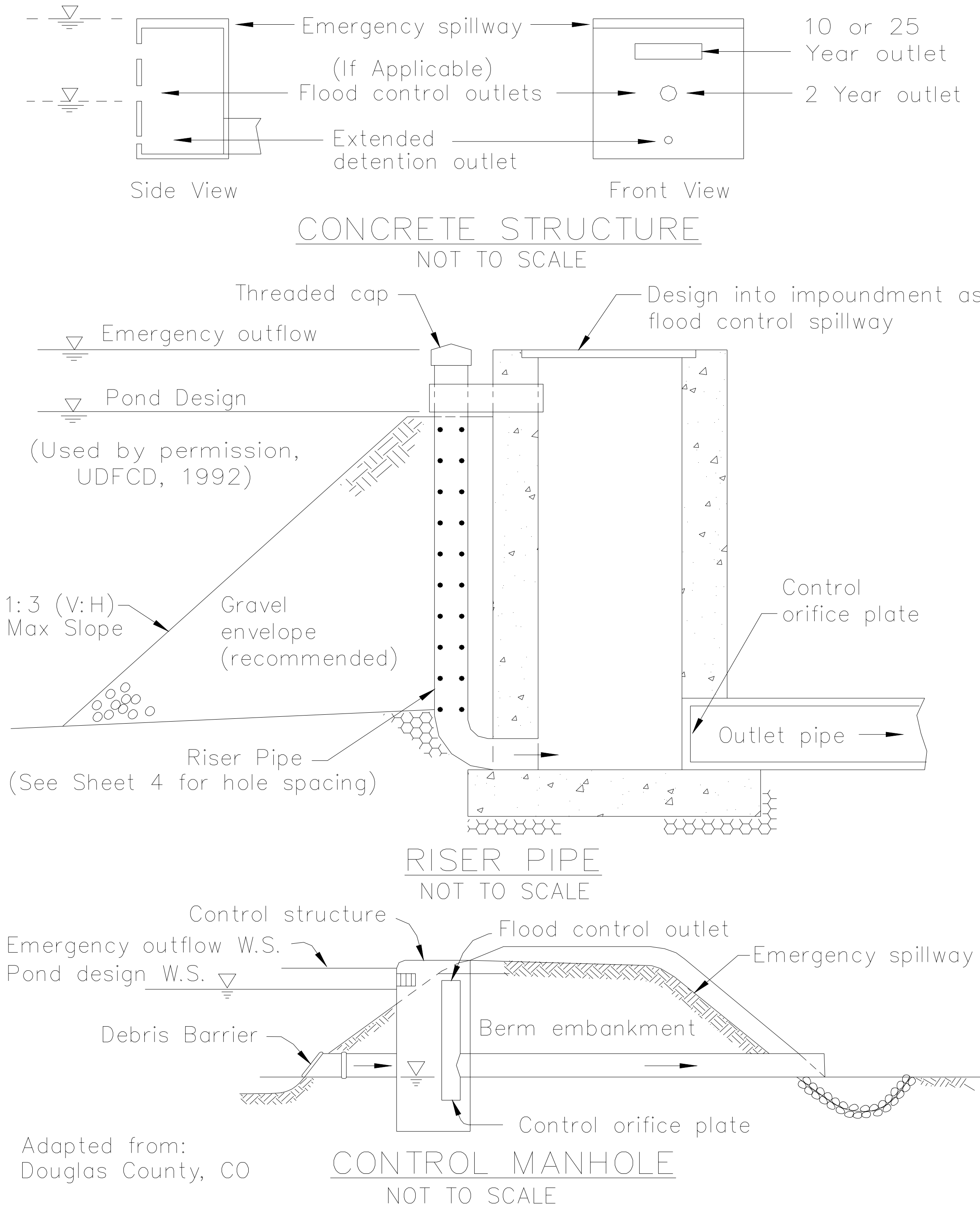
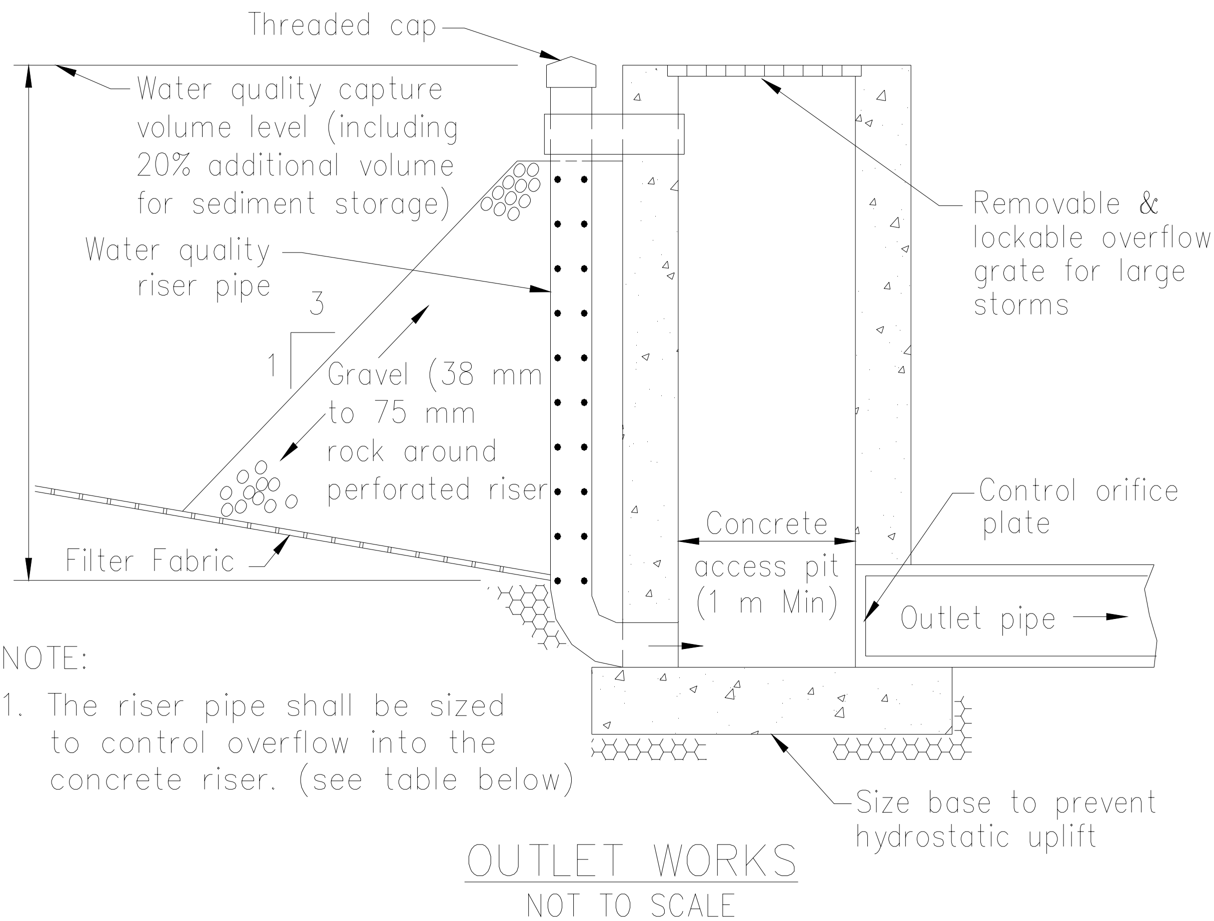


Figure STP-03-4
Other Outlet Structures



Perforated Outlet Riser Pipe Orifices (Austin, 1988)			
Riser Pipe Diameter	Vertical Spacing Between Rows (center to center)	Number of Perforations	Perforation Diameter
150 mm	64 mm	9 per row	25 mm
200 mm	64 mm	12 per row	25 mm
250 mm	64 mm	16 per row	25 mm

Figure STP-03-5
Riser Pipe Sizing

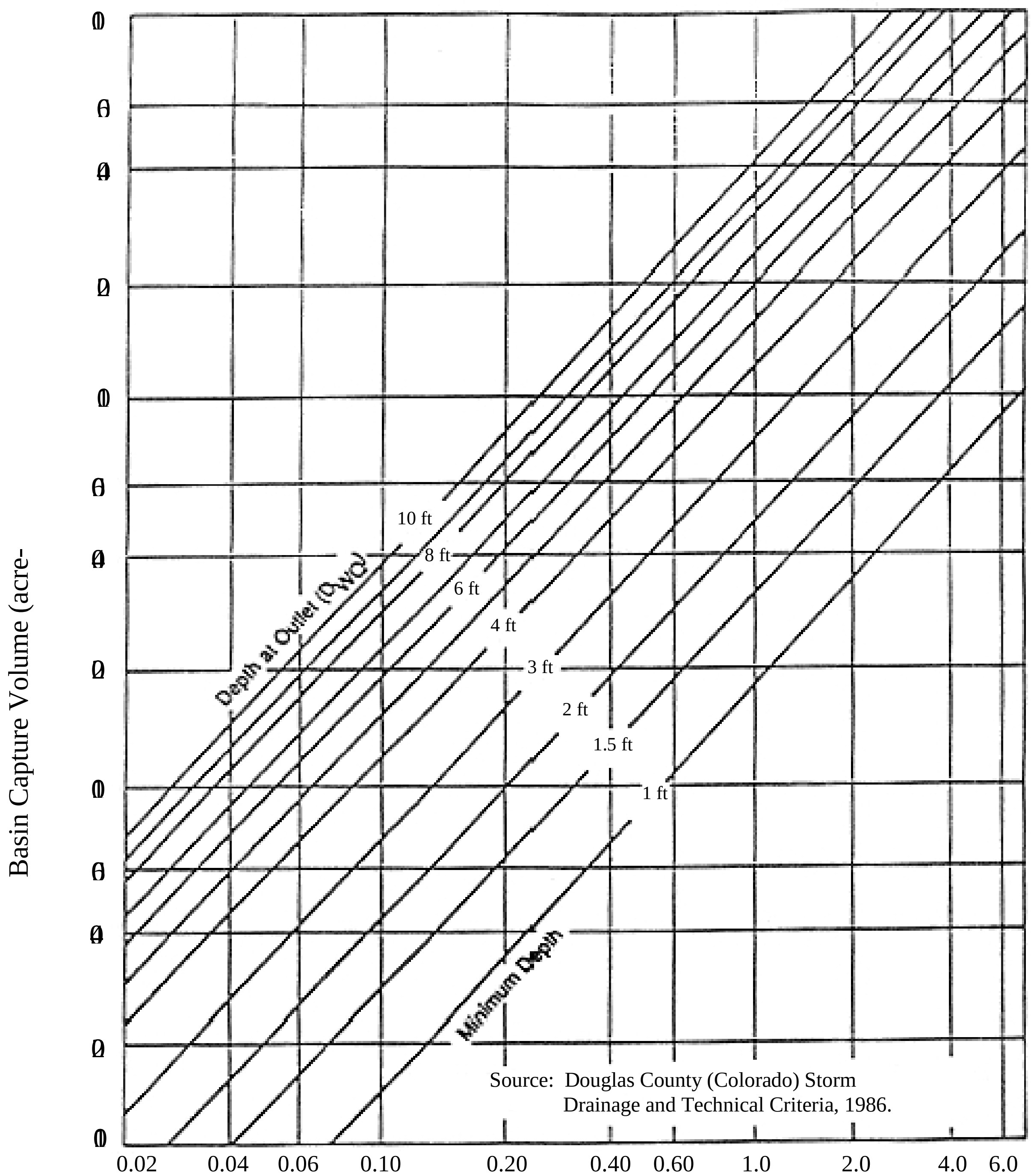
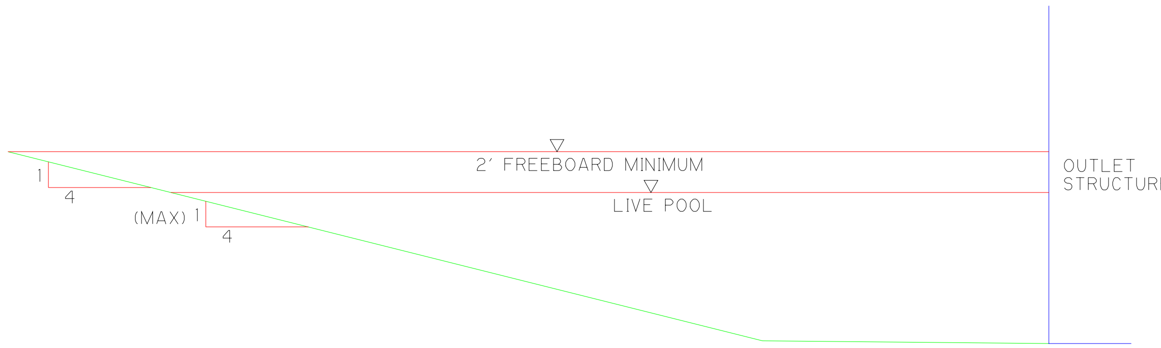


Figure STP-03-6
Perforated Riser Pipe Sizing
(Dry Detention Pond with 40-hour Drain Time of Capture Volume)

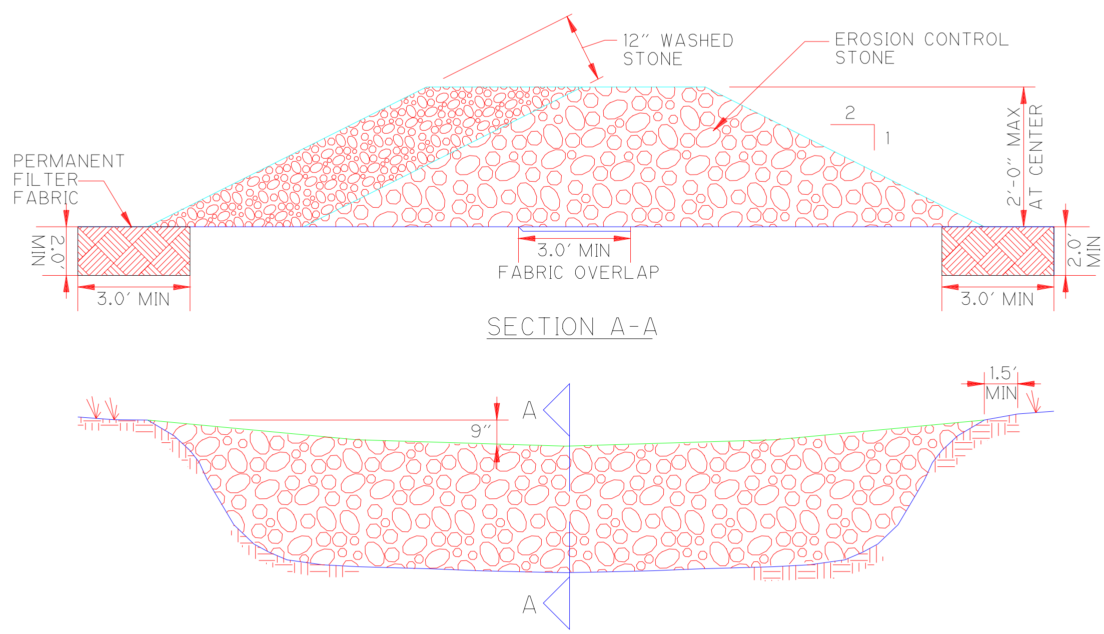
Activity: Dry Detention Ponds	STP-03



POND GRADING

DETAIL

NTS



FORE BAY - STONE CHECK DAM

DETAIL

NTS

Figure STP-03-7
Dry Detention Pond Layout Details

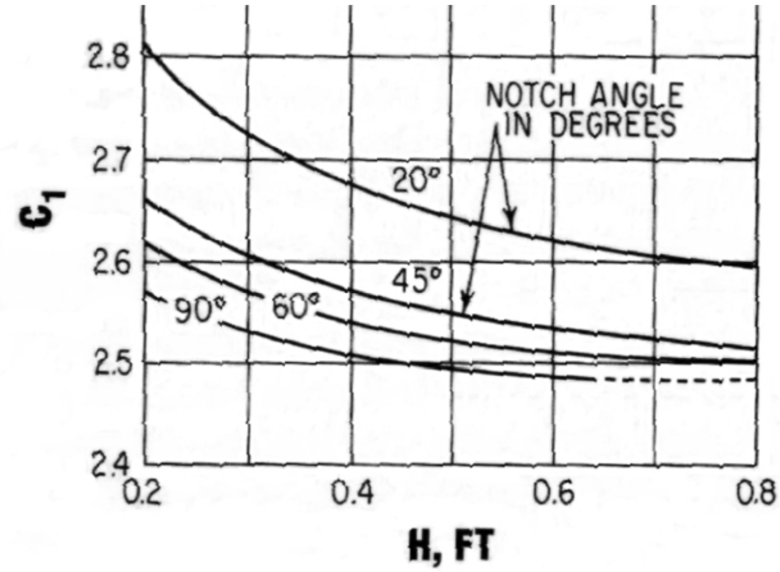


Figure STP-03-8
Sharp-Crested "V" Notch Weir Discharge Coefficients

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution treatment Practices (STPs)

STP-04

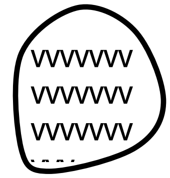
Activity: Constructed Wetlands

PLANNING CONSIDERATIONS:

Acreage Needed: Significant

Estimated Unit Cost: Avg: $.50 per CF of Storage

Monthly Maintenance: 3% of Capital Costs



CW

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

Constructed wetlands have a significant percentage of the facility covered by wetland vegetation. This management practice is likely to provide significant reductions in sediment, nutrients, heavy metals, toxic materials, floatable materials, oxygen demanding substances, oil and grease, as well as a partial reduction in bacteria and viruses.

Suitable Applications

- Need to achieve high level of particulate and some dissolved contaminant removal.
- Ideal for large, regional tributary areas.
- Multiple benefits of passive recreation and wildlife.
- Although natural wetlands are being used to treat stormwater, regulatory agencies do not favor this use, except as a final "polishing" step after treatment by one or more of the treatment control BMPs presented in this manual. Constructed wetlands, in contrast, are built specifically for treating stormwater runoff. They are not wetlands created as mitigation for the loss of natural wetlands. Consequently, there is no intention to replicate the complete array of ecological functions of a wetland (e.g., the presence of wildlife), although it can be done. A constructed wetland is generally one of better aesthetics than the treatment systems. It is likely that constructed wetlands will be used only in very large industrial sites, but small facilities with concrete retaining walls to conserve space will also likely be effective.

Activity: Constructed Wetlands	STP-04

Design and Sizing Considerations

- These systems should be designed by a licensed professional civil engineer.
- Suitable soils for wetland vegetation.
- Surface area equal to at least 1% and preferably 2% of the tributary watershed. Surface area greater than about 1 or 2% of the tributary watershed is not justified, given the uncertainty of any improvement in performance with the increase in size.
- A Forebay, baffle box, or other stormwater quality inlets are often required to remove floatable debris and course sediments.
- The simplest form of a constructed wetland includes a basin with a forebay and wetland vegetation area. The deeper forebay (3 to 6 feet) traps floatables and the larger settleable solids, facilitating maintenance as well as protecting the wetland vegetation. Alternatively, a detention pond may be placed before the wetland, to remove settleable solids and to protect the wetland from extreme increases in water elevation. The wetland vegetation is placed in a shallow pool that extends laterally across the basin. Construction of low flow channels through emergent vegetation can cause stormwater to short circuit through channels rather than through the wetland vegetation.
- Placing rooted wetland species through the majority of the facility adds to the cost, in comparison to a wet pond. However, it is believed by many practitioners that the vegetation improves performance. Placing the vegetation across the facility improves settling of particulates and uptake of dissolved contaminants. As the constructed wetland is shallower than a wet pond, there may be better contact between the water and soil which may be the primary remover of dissolved phosphorus and metals.
- The vegetation reduces the effect of wind which can cause significant short-circuiting in a wet pond. Water loss in a wetland may not be greater and possibly less than a wet pond. Evapo-transpiration from the plants will be greater in a wetland but evaporation from the water surface may be less because the dense vegetation eliminates the effect of the wind. The net result may be a slower rate of water loss. Conceivably a constructed wetland could be made smaller than a wet pond, given the benefits of the vegetation.
- Relying on volunteer plants to cover the vegetated area will delay complete coverage for several years and may allow the invasion of undesirable species or dominance by one or two species such as cattails which tend to flourish in disturbed conditions. Complexity is promoted by varying water depth through the vegetated area rather than keeping the depth uniform.
- Using gravel as the substrate may be a suitable approach in small facilities. Because the gravel is lacking in nutrients certain emergent species will take their nutrients from the water (Thut, 1988). See Reddy and Smith (1988). Harvesting may also be more practical with this approach.

Activity: Constructed Wetlands

Design and Sizing Considerations (Continued)

- Of particular concern in many areas will be mosquitoes. Thick stands of emergent vegetation provide an ideal breeding habitat. If Gambusia (mosquito fish) are introduced into the facility the design must include a deep pool area where the fish can reside during the dry season. The forebay can serve this function.

- The facility can be sized using the same procedure outlined for Wet Detention Ponds, STP-02. However, inasmuch as a wetland is shallower than a wet pond, sizing the wetland for the same V_b/V_r as a wet pond requires considerably more surface area. Given the likely advantages of a constructed wetland over a wet pond, some may consider this to be an unreasonable penalty. It is therefore recommended that the surface area of the constructed wetland not exceed that which would be determined for a wet pond.

- Additional design considerations include:
- Have 25% to 50% (forebay and afterbay) 3 to 6 ft. deep, and remaining area 6 in. to 24 in. deep or as appropriate for the wetland species selected. This geometry should provide satisfactory conditions for wetland wildlife (Adams et al., 1983).
- Side slopes of at least 4:1 (H: V) to a water depth of 2 ft. except on very small facilities where retaining walls may be used to conserve space. If retaining walls are used, the area must be fenced for safety.
- Access for maintenance vehicles to the forebay, the outlet, and around the perimeter.
- Freeboard of at least 2 feet.
- With earthen contained facilities, install an antiseep collar on the outlet pipe.
- The soils must be suitable for wetland vegetation. If necessary, organic soils (18 to 24 in.) must be imported to the site.
- The soil must have an affinity for phosphorus. Soils with aluminum and iron are best. Soils saturated with phosphorus or a metal specie may cause the concentrations of these contaminants to increase in the overlying water.
- Minimize short-circuiting by placing energy dissipaters at the inlet, and by having a high length to width ratio.

- Short-circuiting must be minimized by using a generally rectangular or irregular shaped configuration with a length to width ratio of at least 3:1 to 7:1 and by placing the inlet and outlet at opposite ends. The inlet and outlet can be placed at the same end if baffling (islands) is installed to direct the water to the opposite end before returning to the outlet. If topography or aesthetics requires the wetland to have an irregular shape, the wetland area and volume should be increased to compensate for the dead spaces. Energy dissipaters and entrance baffles will spread the water laterally across the facility.
- Minimize water loss by infiltration through the wetland bottom.
- Supplemental water may be needed to avoid loss of rooted vegetation during the dry period.

Activity: Constructed Wetlands

Design and Sizing Considerations (Continued)

- To maintain the wet pool to the maximum extent possible excessive losses by infiltration through the bottom must be avoided. Depending on the soils, this can be accomplished by compaction, incorporating clay into the soil, or an artificial liner. Wetland vegetation species have evolved to handle the stress of seasonal variations in water availability. However, during the dry season there must be sufficient water to avoid complete desiccation of plant roots. Consequently, constructed wetlands are infeasible in areas where there is a lack of either a base flow or near-surface ground water during the dry season. Supplemental water such as pumped ground water and treated process wastewater may have to be used.

- Constructed wetlands may not need antivortex and trash rack devices on their outlets like a wet pond because of the rooted vegetation. See STP-02, Wet Detention Ponds regarding inlet design. Design concepts for outlet devices are discussed in STP-02 and 3, Detention Ponds. See Josselyn (1982) regarding wetland plant considerations. Establishing wetland vegetation initially may be difficult and require multiple plantings.

- Another consideration is the regulatory implications of removing accumulated material from constructed wetlands. Some actions will require a 404 or other permit. At present, constructed wetlands are excluded from this requirement (Ritchie, 1992).

Maintenance

- Remove foreign debris and sediment build-up.

- Areas of bank erosion should be repaired.

- Remove nuisance species.

- Check at least annually and after each extreme storm event.

- Clean deposits from the forebay when a loss of capacity is significant, probably every 3 to 5 years depending on the land use, or when the concentrations of toxicants in the sediments are reaching a level of concern. If baffle boxes are used instead of a forebay, it will require annual inspection. If a stormwater quality inlet(s) is used, then it will require inspections every 6 months.

Sediment Removal

- A primary function of STPs is to collect sediments. The sediment accumulation rate is dependant on a number of factors including watershed size, facility sizing, construction upstream, industrial or commercial activities upstream, etc. The sediment contents should be identified before it is removed and disposed.

- Some sediment may contain contaminants of which the Indiana Department of Environmental Management (IDEM) requires special disposal procedures. If there is any uncertainty about what the sediment contains or it is known to contain contaminants, then IDEM should be consulted and their disposal recommendations followed. Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants (other than "clean" soil) are suspected to accumulate and be conveyed via storm runoff.

Activity: Constructed Wetlands

Maintenance (Continued)

- Some sediment collected may be innocuous (free of pollutants other than "clean" soil) and can be used as fill material, cover or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm runoff. The sediment should not be placed within the high water level area of the STP, other BMP, creek, waterway, buffer, runoff conveyance device, or other infrastructure. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

- There is some question as to whether annual harvesting of rooted vegetation is either practical or effective at reducing seasonal losses of nutrients and prolonging the life of the facility (USEPA, 1988). The benefits of harvesting may depend upon the wetland specie (Suzuki, T. et al., 1991). Placing rooted vegetation in gravel beds rather than soil may make harvesting practical. If harvesting is to be done, it should occur twice per season, in the early summer when nutrient content in the plant material is at its peak, and in the fall before plant dormancy. Given the significant role of the bottom soil in removing metals and phosphorus its replacement may be required, although, probably not more frequently than once every few decades. Cleaning the forebay more frequently is important as noted above.

Inspection Checklist

- Concern for mosquitoes.
- Cannot be placed on steep unstable slopes.
- Need base flow to maintain water level.
- Not feasible in densely developed areas.
- Nutrient release may occur during winter.
- Overgrowth can lead to reduced hydraulic capacity.
- Regulatory agencies may limit water quality to natural wetlands.
- Establishing wetland vegetation may be difficult.
- Wetlands are generally shallower than wet ponds and result in larger area requirements.
- Costs for providing supplemental water may be prohibitive.

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution treatment Practices (STPs)

STP-05

Activity: Biofilter, Swales and Strips

PLANNING CONSIDERATIONS:

Design Life: Permanent

Acreage Needed: Varies

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

Monthly Maintenance: 10% of Installation

BF

BF

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

There are two types of biofilters: swales and filter strips. A swale is a vegetated channel that treats concentrated flow. A filter strip treats sheet flow and is placed parallel to the contributing surface. This management practice is likely to provide a significant reduction in sediment, heavy metals, toxic materials, oil and grease and partial reductions in nutrients, floatable materials, and oxygen demanding substances.

Suitable Applications

- Biofilters are often used in conjunction with other stormwater management practices.
- Biofilters are often placed along or serve parking lots. See Figure STP-05-2 for an illustration of how swales draining to slightly raised inlets can be used as pretreatment.
- Performance somewhat less than wet ponds and constructed wetlands.
- Limited to treating a few acres.
- Minimizing DCIA (directly connected impervious areas) involves ensuring that as much runoff as possible from impervious areas is routed over relatively large pervious areas and, in some cases, choosing an alternative surface to pavement or concrete that allows for some degree of infiltration. Figure STP-05-3 is an illustration of an example parcel that has been modified to convert a portion of the DCIA into non-directly connected impervious area by rerouting the roof gutters over the lawn (properly graded between houses) and to convert a portion of the DCIA to pervious area by using a porous surface.

Activity: Biofilter, Swales and Strips	STP-05

Suitable Applications

- Landscaped swales can be used around parking lots, houses, and other structures. The swales will provide pretreatment and also provide conveyance to larger secondary or primary stormwater management systems.

- Connections from the curbs to roadside swales can be provided to route street flow to grass-lined swales before discharge to the secondary or primary stormwater management system. Since roadway runoff may contain a greater pollutant load than runoff from most other surfaces, providing swale pretreatment of roadway runoff will reduce pollutant loads to the regional ponds and improve the overall efficiency of the BMP treatment train. The swale space required for pretreatment of roadway runoff in roadside swales can be incorporated into green space requirements and be used to enhance the aesthetics of the roadways.

Design and Sizing Considerations

- These systems should be designed by a licensed professional civil engineer.

- A biofilter swale is a vegetated channel that looks similar to, but is wider than, a ditch that is sized only to transport flow. The biofilter swale must be wider to maintain low flow velocities and to keep the depth of the water below the height of the vegetation up to a particular design event. A filter strip is placed along the edge of the pavement (its full length if possible). The pavement grade must be such as to achieve sheet flow to the maximum extent practical along the strip.

- The type of filter strip discussed here is not to be confused with the natural vegetated buffer strip used in residential developments to separate the housing from a stream.

- Properly designed swales are useful for proper grading around houses as well as detention / retention prior to discharge into a secondary or primary system. Fill from the shallow swale area may be used elsewhere on the property to improve the grading plan. Landscaped swales would typically be 0.5 to 1.0 foot (0.15 to 0.3 m) deep and should have side slopes no steeper than 4:1 (H:V), with side slopes of 6:1 (H:V) or greater being less noticeable and more attractive.

- Grass-lined swales may be constructed around parking lots and commercial centers as recessed planters for landscaping. The swales could be part of the landscaping and would incorporate raised inlets (4 to 6 inches (10.2 to 15.2 cm)) into the design, which will allow for the initial 0.25 inch (0.64 cm) retention volume for pretreatment. Although groundwater tables in the developable area are generally within 1 to 2 feet (0.3 to 0.61 m) of the surface, recovery times for retention volumes of approximately 0.25 inches (0.64 cm) should be sufficiently small to allow the use of limited retention. Minimum infiltration rates of 0.1 inch (0.25 cm) / hour are expected, allowing a relatively quick drawdown. Swales incorporated within commercial areas can enhance aesthetics and be used as credit towards green space and landscaping requirements. Figure STP-05-2 shows an example of a landscaped swale with a raised inlet. These landscaped swales use runoff to water plants and improve aesthetics.

Design and Sizing Conditions (Continued)

- The connections between the curb and the swale can be implemented in two ways. The first method is to provide regularly spaced flumes in the curb as the connection to the swale. This method would be less expensive and will be aesthetically appealing (Figure STP-05-4). Another way is to provide a 4- to 6-inch (10.2 to 15.2 cm) diameter pipe approximately every 200 feet (61 m) between the curb and the swale. This method may provide better erosion control at the edge of the curb by preventing flowing water over the interface of the curb and the swale. The disadvantage to this method is the potential for clogging, and thus the requirement for increased maintenance, in these small pipes.

- The problem of spreading the flow across the width of the swale may limit its use to tributary catchments of only a few acres.

- The length of pavement prior to the filter strip should not exceed a few hundred feet to avoid channelization of large aggregates of runoff along the pavement before it reaches the pavement edge. To avoid channelization, care must be taken during construction to make sure that the cross-section of the biofilter is level and that its longitudinal slope is even. Channelization will reduce the effective area of the biofilter used for treatment and may erode the grass because of excessive velocities.

- The design engineer must determine the width of a swale using Manning's Equation and the 2-year rainfall intensity appropriate to the site. An n value of 0.20 to 0.24 is recommended depending on the expected height of the turf (dependent upon mowing frequency). The design engineer must also calculate the peak flow of the 100-year event to determine the depth of a swale to convey flood flows. Since a width using an "n" of 0.20 is generally wider than what is required of a grass lined channel, channel stability should not be of concern. It is generally not necessary to have a bypass for the extreme events because the minimum width specification limits erosive velocities if there is a relatively gentle slope. If erosion at extreme events is of concern, consider the above concepts to minimize erosion. The design engineer can make the swale wider than determined in the above step, with a corresponding shortening of the swale length to obtain the same surface area. However, there is a practical limitation on how wide the swale can be and still be able to spread the flow across the swale width.

- Splitting the flow into multiple inlets and/or placing a flow spreader near the storm inlet should be incorporated into the design. A concept that may work is to place a level 2" x 12" (5.1 cm x 30.5 cm) timber or equivalent concrete, aluminum or gravel structure across the width of the swale 8-15 feet (2.4-4.6 m) from the pipe outlet. Place gravel between the outlet and the timber, to within 2 inches (5.1 cm) or so of the top of the timber. Place large rock immediately near the outlet to dissipate the flow energy: the rock also may help distribute the flow.

- Residence time for "maximized" captured runoff should be at least 5 minutes. See STP-01 for discussion of "maximized" capture runoff. Use a runoff coefficient of C=1.0 assuming complete runoff and no infiltration.

Activity: Biofilter, Swales and Strips

Design and Sizing Conditions (Continued)

- The maximum velocity should be no more than 0.9 ft/sec (0.3 m/s).
- Maximum bottom width of 8 ft (2.4 m) unless level spreaders are installed frequently (every 50 feet (15.2 m)).
- Average depth of flow should be no more than 1.0 in. (25 mm), and maximum depth should be no more than 3 in. (75 mm) for grass or approximately 2 in. (50 mm) below the height of the shortest wetland plant species in the biofilter. Furthermore, the maximum flow depth should be no greater than one-third of the gross or emergent wetland vegetation height for infrequently moved swales or greater than one-half of the vegetation height for regularly mowed swales.
- The minimum width for a swale is determined by Manning's Equation.
- Minimum length of a swale is 100 feet (30.5 m) unless level spreaders are used at least every 50 feet (15.2 m) or as necessary to prevent flow channelizations.
- Minimum length of a filter strip is 10 feet (3 m).
- Maximum length without a level spreader is 80 feet (24.4 m) for a filter strip or swale.
- The longitudinal slope must not exceed 5%.
- Use a flow spreader and energy dissipater at the entrance of a swale.
- Good soils are important to achieve good vegetation cover.
- WEF Manual of Practice No. 23 / ASCE Manual and Report on Engineering Practice No. 87 (1998) should be consulted for additional guidance on the design, construction, and maintenance of biofilters.

Maintenance

- Achieve sheet flow with filter strips.
- The facility should be checked annually for signs of erosion, vegetation loss, and channelization of the flow.
- The grass should be mowed when it reaches a height of 8 inches (20.3 cm). Allowing the grass to grow taller may cause it to thin and become less effective. The clippings should be bagged and removed.
- Keep all level spreaders even (level) and free of debris.
- Mow grass covered biofilters regularly to promote growth and pollutant uptake. Remove cuttings and dispose of properly (preferably through composting).

Activity: Biofilter, Swales and Strips	STP-05

Maintenance (Continued)

- Remove sediment by hand with a flat-bottomed shovel during dry periods.
- Remove only the amount of sediment necessary to restore hydraulic capacity, leaving as much of the vegetation in place as possible. Reseed or plug any damaged turf or vegetation.
- Eventually, sufficient sediment will be trapped that the entire biofilter will need to be removed with sediment and reconstructed to begin a new cycle of stormwater quality control.

Sediment Removal

- A primary function of STPs is to collect sediments. The sediment accumulation rate is dependant on a number of factors including watershed size, facility sizing, construction upstream, industrial or commercial activities upstream, etc. The sediment contents should be identified before it is removed and disposed.
- Some sediment may contain contaminants of which the Indiana Department of Environmental Management (IDEM) requires special disposal procedures. If there is any uncertainty about what the sediment contains or it is known to contain contaminants, then IDEM should be consulted and their disposal recommendations followed. Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants (other than "clean" soil) are suspected to accumulate and be conveyed via storm runoff.
- Some sediment collected may be innocuous (free of pollutants other than "clean" soil) and can be used as fill material, cover or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm runoff. The sediment should not be placed within the high water level area of the PTP, other BMP, creek, waterway, buffer, runoff conveyance device, or other infrastructure. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.
- The grass should be mowed no shorter than 3 inches (7.6 cm).

Inspection Checklist

- [ ] Poor performance occurs when the swale or filter strip is undersized, or when runoff is allowed to channelize in the swale or filter strip.
- [ ] Cannot be placed on steep slopes.
- [ ] Proper maintenance required to maintain health and density of vegetation.

COLD TOLERANCE (winter color persistance)

High
- Creeping bentgrass
- Kentucky bluegrass
- Red fescue
- Colonial bentgrass
- Highland bentgrass
- Perennial ryegrass
- Tall fescue
- Weeping alkaligrass
- Dichondra
- Zoysiagrass
- Common bermudagrass
- Hybrid bermudagrass
- Kikuyugrass
- Seashore paspalum
- St. Augustinegrass

Low

HEAT TOLERANCE

High
- Zoysiagrass
- Hybrid bermudagrass
- Common bermudagrass
- Seashore paspalum
- St. Augustinegrass
- Kikuyugrass
- Tall fescue
- Dichondra
- Creeping bentgrass
- Kentucky bluegrass
- Highland bentgrass
- Perennial ryegrass
- Colonial bentgrass
- Weeping alkaligrass
- Red fescue

Low

MOWING HEIGHT ADAPTATION

High cut
- Tall fescue
- Red fescue
- Kentucky bluegrass
- Perennial ryegrass
- Weeping alkaligrass
- St. Augustinegrass
- Common bermudagrass
- Dichondra
- Kikuyugrass
- Colonial bentgrass
- Highland bentgrass
- Zoysiagrass
- Seashore paspalum
- Hybrid bermudagrass
- Creeping bentgrass

Low Cut

DROUGHT TOLERANCE

High
- Hybrid bermudagrass
- Zoysiagrass
- Common bermudagrass
- Seashore paspalum
- St. Augustinegrass
- Kikuyugrass
- Tall fescue
- Red fescue
- Kentucky bluegrass
- Perennial ryegrass
- Highland bentgrass
- Creeping bentgrass
- Colonial bentgrass
- Weeping alkaligrass
- Dichondra

Low

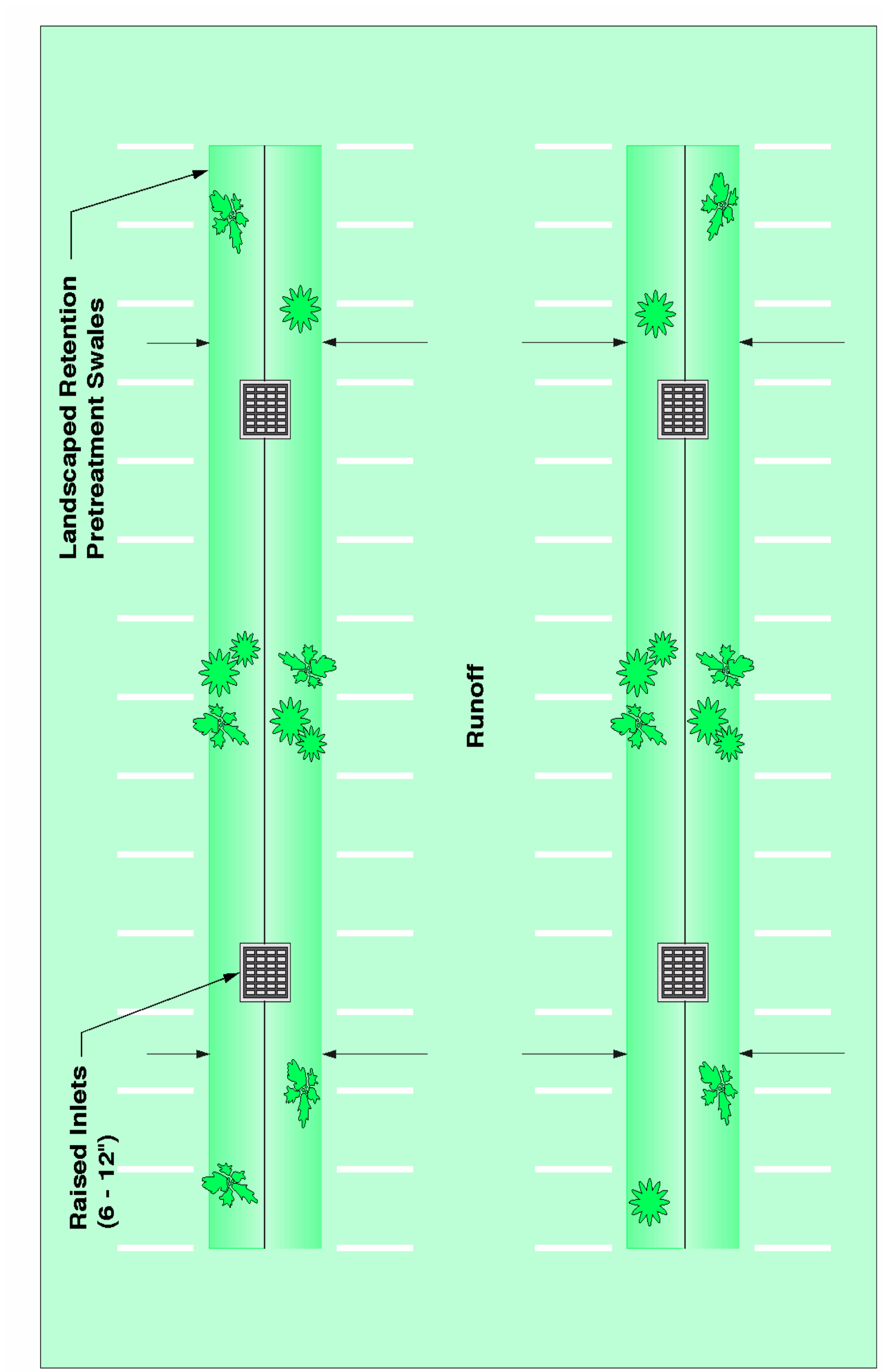
MAINTENANCE COST AND EFFORT

High
- Creeping bentgrass
- Dichondra
- Hybrid bermudagrass
- Kentucky bluegrass
- Colonial bentgrass
- Seashore paspalum
- Perennial ryegrass
- St. Augustinegrass
- Highland bentgrass
- Zoysiagrass
- Tall fescue
- Common bermudagrass
- Kikuyugrass

Low

Note: Consult *Landscaping with Native Plants – Middle Tennessee Central Basin and Highland Rim,* Tennessee Exotic Pest Plant Council, May 1998.

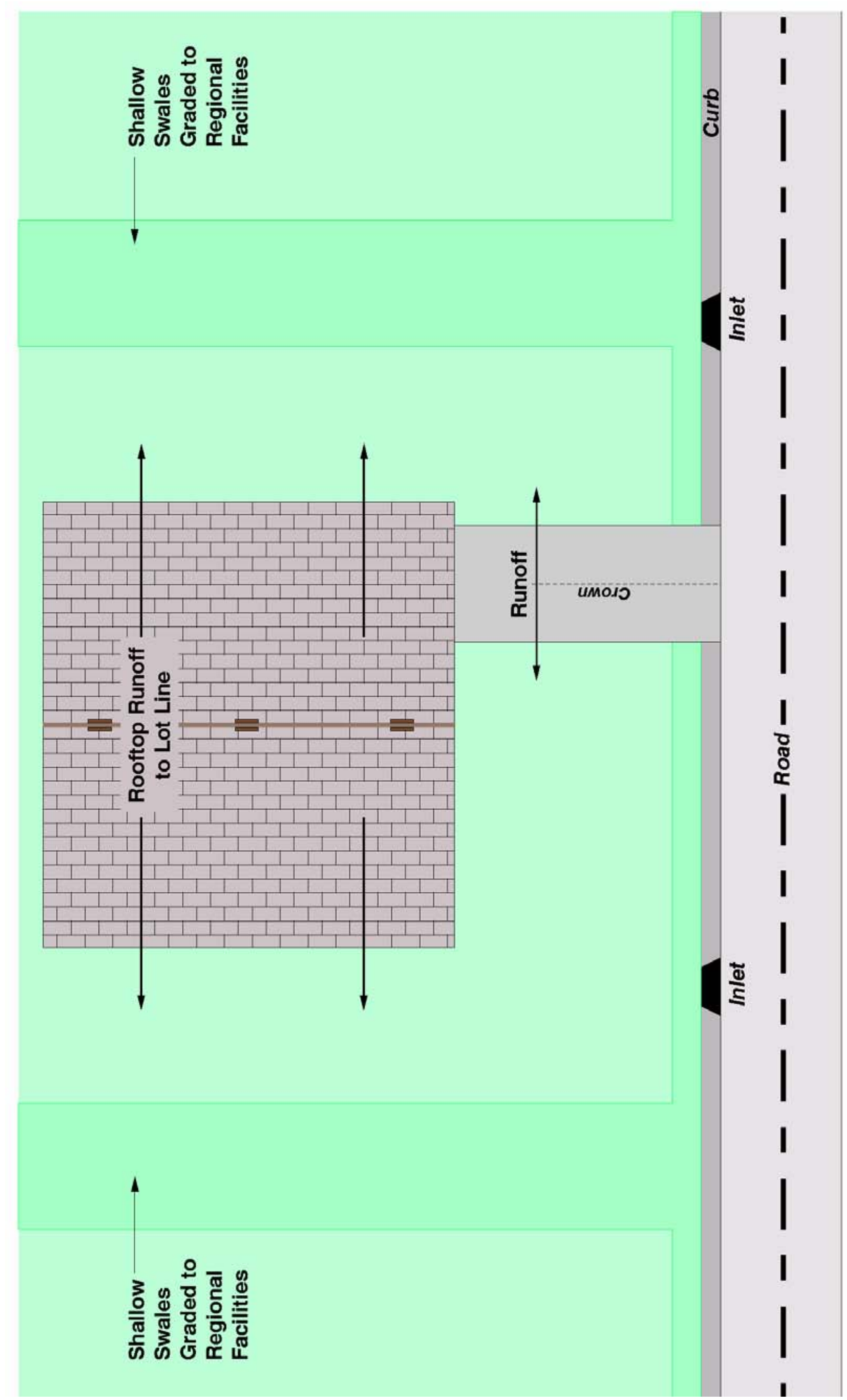
FIGURE STP-05-1
TURF GRASS SPECIES



Source: City of Nashville

Figure STP-05-2
Landscaped Retention Pretreatment Swales
With Raised Inlets

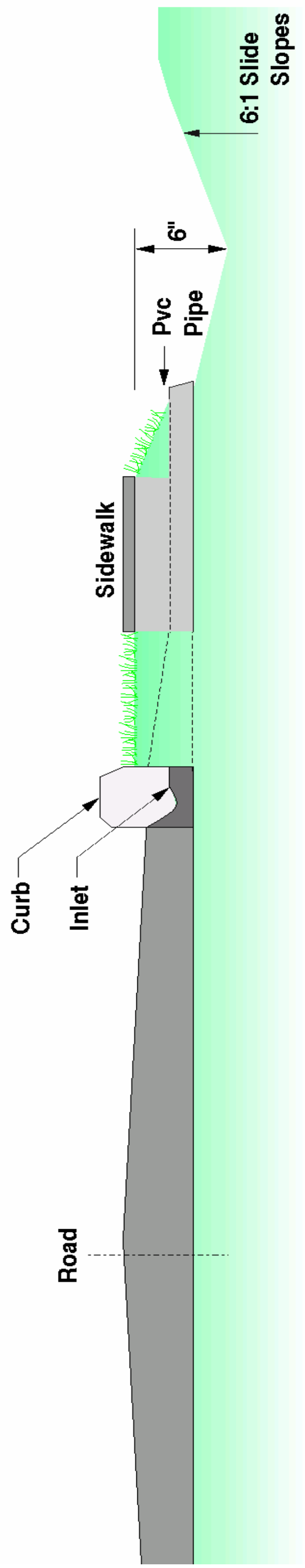
Activity: Biofilter, Swales and Strips	STP-05



Source: City of Nashville

Figure STP-05-3
Landscaped Retention Pretreatment Swales
With Raised Inlets

Activity: Biofilter, Swales and Strips



Source: City of Nashville

Figure STP-05-4
Roadside Swalse

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution treatment Practices (STPs)

STP-06

Activity: Media Filtration/Media Filters and Water Quality Inlets

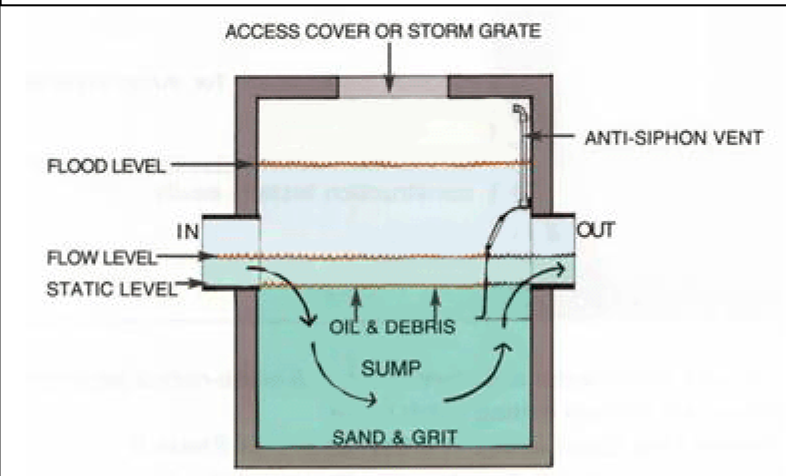
PLANNING CONSIDERATIONS:

Design Life:
Permanent

Acreage Needed:
Minimal

Estimated Unit Cost:
N/A

Monthly Maintenance:
N/A



WQI

WQI

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

Consists of a settling basin followed by a filter. The most common filter media is sand; some use peat/sand or filter cloth, sorbent materials and other commercial available mixtures. This management practice is likely to create a significant reduction in sediment, heavy metals, oil and grease, and floatable materials and partial reductions in nutrients, toxic materials, and oxygen demanding substances, and bacteria and viruses. It is important that these systems “dry out” between storm events to allow oxidation of pollutants.

This BMP fact sheet discusses general uses of filters and separators in the form of simple catch basin inserts to complex multi-chambered and multi-staged filters. The practices presented in STP-07: Oil/Water Separators should also be reviewed.

Some of the systems presented in this BMP fact sheet represent or are similar to commercially available products. This fact sheet is not intended to demonstrate a preference by the Engineering Department toward a particular manufacturer. However, this fact sheet does describe the types of products known to be available, the Engineering Department’s understanding of their suitability and general effectiveness.

Suitable Applications

- The various systems discussed in this fact sheet should be selected based on the targeted constituents, site area constraints, cost and frequency of maintenance, and inspection requirements. Many of the systems are readily available in a variety of layouts through commercial vendors.

Suitable Applications (Continued)

- One of the most important selection criteria that must be evaluated is the ability to bypass or convey large storm events without damaging the system, exceeding design flow capacity or re-suspending collected pollutants. See figure STP-06-1.

    - Another very important selection criterion is consideration of long-term inspection and maintenance resources. If there is not a plan to regularly inspect and maintain the selected system on a long-term basis, and a fiscal guarantor that the required maintenance resources will be available for the life of the system, then the system should not be installed. If these types of systems are not periodically inspected, cleaned, and otherwise maintained, they will fail and could result in more intense impacts to stormwater quality than if they were not installed at all.

    - Can be placed underground.

    - Some systems are suitable for individual developments and small tributary areas up to about 100 acres.

    - Some water quality inlets (or separators) can be used as pretreatment for filters, ponds, wetlands or biofilters.

    - May require less space than other treatment control BMPs.
    - Sand or cartridged media filters may be particularly suitable for industrial sites because they can be located underground and industrial facilities generally have the resources to routinely inspect and maintain the systems.
    - Sand and cartridged media filtration systems are suitable for commercial or other dense / highly impervious land uses provided there is a plan and sufficient resources to inspect and maintain the systems.

- Separators and separator / filter systems are suitable for smaller catchments including parking and roadways where sediment, trash, or other debris may collect.

- Some separators and separator / filter systems have some success in capturing oil and grease. However, it should be noted that these systems generally require more frequent inspection and maintenance. If the systems can be easily inspected and maintained, then they are suitable for small catchments in parking lots and roadways. It should be noted that in areas frequently receiving oil and grease oil / water separator system, as discussed in STP-07, should be considered.

- The most experience to date is with surface facilities shown conceptually in Figure STP-06-2 with a sand media. It can be used on catchments up to 50 acres.

Activity: Media Filtration/Media Filters and Water Quality Inlets	STP-06

Suitable Applications (Continued)

- Two other systems are most suitable for small catchments of a few acres. An underground "linear" filter (Figure STP-06-3) that accepts sheet flow from adjacent pavement. It, therefore, may be ideal for industrial applications. An underground design, the vault sand filter (Figure STP-06-3), may also be ideal for industrial developments. It accepts concentrated flow.

- Both underground systems presented in STP-06-3 require a pretreatment device such as a wet vault or other separation system as illustrated in Figures STP-06-4 through 8. It is essentially a conventional gravity separator but without the appropriate geometric configuration. They have been found to be generally ineffective because the recommended size (200 to 400 ft^3/acre (5.7 to 11.3 m^3/acre)) of tributary area) is too small. To be effective, a water quality inlet must have the surface area and volume that is similar to that of conventional separators. They may exhibit odor problems during the summer because of the lack of bacterial degradation of accumulated organic matter and the lack of re-aeration of the wet pool. Some facilities have been observed to have odor, but it has been noticeable only when the system is opened for inspection.

- The concepts illustrated in Figures STP-06-8, 9, and 10 can be inserted into catch basins. They should only be used where maintenance staff is available to check the filters frequently and where local flooding will not occur if the filters clog.

Design and Sizing Conditions

- These systems should be designed by a licensed professional civil engineer.

- The filtered separator systems are designed to be most effective under small or medium sized flows such as the "first flush". They generally are not effective under flooding conditions. Furthermore, some systems can be damaged or pollutants resuspended if operating under high flow or flooding conditions. To prevent overloading filter and separation systems, there should be a mechanism to bypass or divert large flows. Some commercially available systems have a high flow bypass built into the "device". Other systems, especially sand filters, must have a separate bypass or diversion device upstream. A diversion weir in a manhole is illustrated in Figure STP-06-1.

- Must be dry between events.

- Spread flow across filter in a way that minimizes pollutant resuspension and prevents damage to the system.

- It is preferable to place filters "off-line" with a diversion weir or catch basin to protect from extreme events.

Design and Sizing Conditions (Continued)

Determine the volume of the pretreatment unit

To size the pretreatment basin or water quality inlet, refer to the sizing methods for dry or wet detention (STP-02, 03). With the sand or carbrided media filter, the pretreatment basin need not be as efficient as a full size system. The pretreatment system, however, should be large enough to provide a removal efficiency that avoids rapid clogging of the filter. It is suggested that the volume of a wet vault be such as to achieve a removal efficiency of 50 to 75% of TSS.

The volume of a pretreatment unit can be decreased by reducing the drawdown time, which results in a lower but acceptable removal efficiency. The facility volume can be determined from STP-03 Dry Detention using a drawdown time of 24 hours.

Determining the size of Commercial Products

When using commercial products such as water quality inlets (separators and/or filters) the manufacturer's recommendations should be considered in the product sizing and applicability. Special attention should be given to high flow bypass or diversion requirement to ensure pollutants are not resuspended and that the systems' media will not be damaged or displaced.

Determining the surface area of a sand filter

The following equation is derived from the City of Austin (1988) for a maximum (full pretreatment basin) filtration time of 24 hours:

Filter area (ft^2) = $3630 S_u A H / K(D+H)$

where:

S_u = unit storage (inches-acre) (See STP-02 or 03)
A = area in acres draining to facility
H = depth (ft) of the sand filter
D = average water depth (ft) over the filter taken to be one-half the difference between the top of the filter and the maximum water surface elevation
K = filter coefficient recommended as 3.5 (Austin)

Equation (1) is appropriate for the filter media size of 0.02 to 0.04 inches (5 mm to 10 mm) in diameter. The filter area must be increased if a smaller media is used (see Austin, Texas (1988)).

Configuring a surface sand filter (City of Austin concept).

Additional design criteria for the settling basin (Austin, 1988):

- For the outlet use a perforated riser pipe, as described in STP-02 or 03, Detention.
- Size the outlet orifice for a 24-hour drawdown.

Activity: Media Filtration/Media Filters and Water Quality Inlets	STP-06

Design and Sizing Conditions (Continued)

- Energy dissipater at the inlet to the settling basin.
- Trash rack at outlets to the filter.
- Vegetate slopes to the extent possible (see Vegetated Biofilters).
- Access ramp (4:1 (H:V) or less) for maintenance vehicles.
- One foot (0.3 m) of freeboard.
- Length to width ratio of at least 3:1 and preferably 5:1.
- Sediment traps at inlet to reduce resuspension.
- Additional design criteria for the filter:
- Use a flow spreader (Figure STP-06-2).
- Safety factor of 2.0.
- Filter cloth on top.
- Dry out time required.
- Use clean sand 0.02- to 0.04-inch (5 to 10 mm) diameter.
    - Some have placed geofabric on sand surface to facilitate maintenance.
    - Under drains (Figure STP-06-2).
    - Schedule 40 PVC.
    - 4 inch (10.2 cm) diameter.
    - 3/8-inch (1 cm) perforations placed around the pipe, with 6-inch (15.2 cm) space between each perforation cluster.
    - Maximum 10-foot (3 m) spacing between laterals.
    - Minimum grade of 1/8" per foot (1 cm per meter).
    - Or other considerations recommended by the manufacturer of the water quality inlet.

Configuring a linear filter

Take the volume for the pretreatment unit and the filter area identified above and configure into a structure similar to that shown in Figure STP-06-3. The structural design in Figure STP-06-3 assumes traffic loads over the filter. The structure can be less robust if it is located along the edge of the pavement, away from traffic. Other recommendations (Shaver, 1991):

- Depth of sand 18" (45.7 cm)
- Diameter of the outlet pipe should be 6" (15.2 cm) or less; use multiple outlets if necessary

Activity: Media Filtration/Media Filters and Water Quality Inlets	STP-06

Design and Sizing Conditions (Continued)

The filter must be positioned relative to the pavement in a manner that evenly distributes the flow as it enters the sedimentation chamber. Pavement design and construction is therefore critical.

Configuring a wet vault filter

Similarly the volume of the wet vault and filter area are configured into a rectangular unit similar to that shown in Figure STP-06-3. Other considerations for the wet vault include:

- A length to width ratio of at least 3:1 to minimize short-circuiting.
- Baffles to reduce entrance velocities and to retain floatables.
- Access ports to facilitate maintenance.
- Depth of the wet pool of at least 3 feet (0.91 m) but not more than 10 feet (3 m).

Catch basin insert

- The catch basin insert filter may be ideal for industrial sites as it can be placed in existing catch basins, and therefore may avoid the need for an "end-of-pipe" facility. The system is illustrated in Figure STP-06-8, 9, and 10. It consists of a series of trays or sorbent roles/tubes. The top tray is a sediment trap. Filter material is placed in the lower trays. Of several materials examined, the most suitable appears to be household fiberglass insulation. Limited tests indicate over 90% removal of metals and oil (McPherson, 1992). As the insert requires frequent attention it should only be used where a maintenance person is located on-site. The insert should have a bypass along one side should the filter material clog and is hydraulically designed so as to not compromise the primary purpose of a catch basin, to get stormwater into the drain system.

Maintenance

- Inspect filter systems at least twice annually or more often if watershed is excessively erosive. Clean or replace any media as needed to prevent clogging.
- Inspect separation systems at least quarterly or more often if there is a higher potential for sediment or debris accumulation.
- Inspect semiannually, and after major storms.
    - Sediment should be removed from the settling basin when 4 inches (10.2 cm) accumulates and from the filter when ½ inch (1.3 cm) accumulates, or when there is still water in the basin or over the filter 40 hours after the storm. Remove floatables.

Activity: Media Filtration/Media Filters and Water Quality Inlets	STP-06

Maintenance (Continued)

Sediment Removal

A primary function of STPs is to collect sediments. The sediment accumulation rate is dependant on a number of factors including watershed size, facility sizing, construction upstream, industrial or commercial activities upstream, etc. The sediment contents should be identified before it is removed and disposed.

Some sediment may contain contaminants of which the Indiana Department of Environmental Management (IDEM) requires special disposal procedures. If there is any uncertainty about what the sediment contains or it is known to contain contaminants, then IDEM should be consulted and their disposal recommendations followed Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants (other than “clean” soil) are suspected to accumulate and be conveyed via storm runoff.

Some sediment collected may be innocuous (free of pollutants other than “clean” soil) and can be used as fill material, cover or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm runoff. The sediment should not be placed within the high water level area of the STP, other BMP, creek, waterway, buffer, runoff conveyance device, or other infrastructure. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

- Failure to clean the filter regularly may result in the need to replace the entire media because of penetration of fines into the filter.
- It is more cost effective for pollutant removal over the long term to clean the filter fabric on top regularly as recommended.
- If there are open space areas in the tributary that are erosive or if construction is occurring, more frequent cleaning will be necessary.
- It will likely be necessary to replace the filter media after construction activity has ceased and the soils are stabilized.

Inspection Checklist

- Filter and separation systems may require more frequent maintenance than most of the other BMPs.
- These systems will contribute to a large head loss that may require special consideration in the hydraulic design of the overall stormwater collection system.
- Dissolved pollutants are not captured by sand.
- Potential for severe clogging or reduced pollutant removal efficiencies in filter systems if there are exposed soil surfaces upstream.

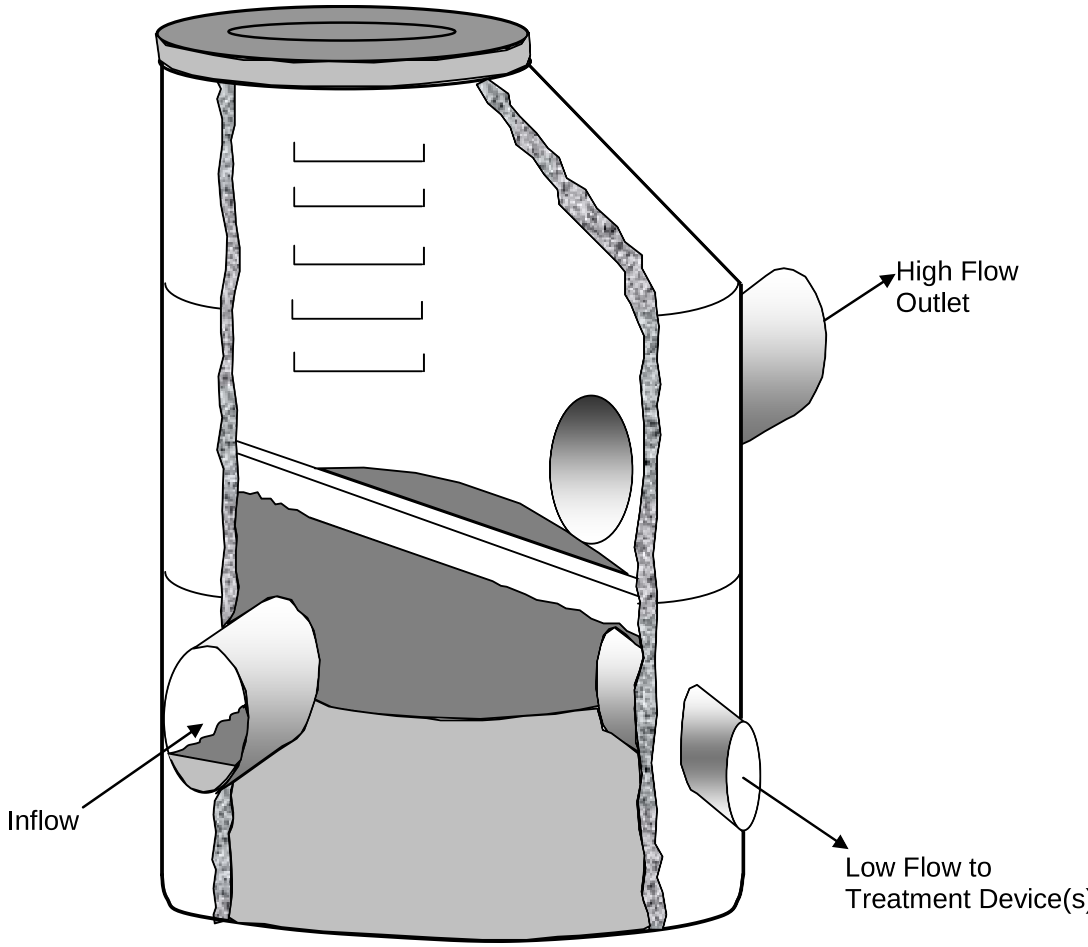


Figure STP-06-1
Stormwater High Flow Bypass

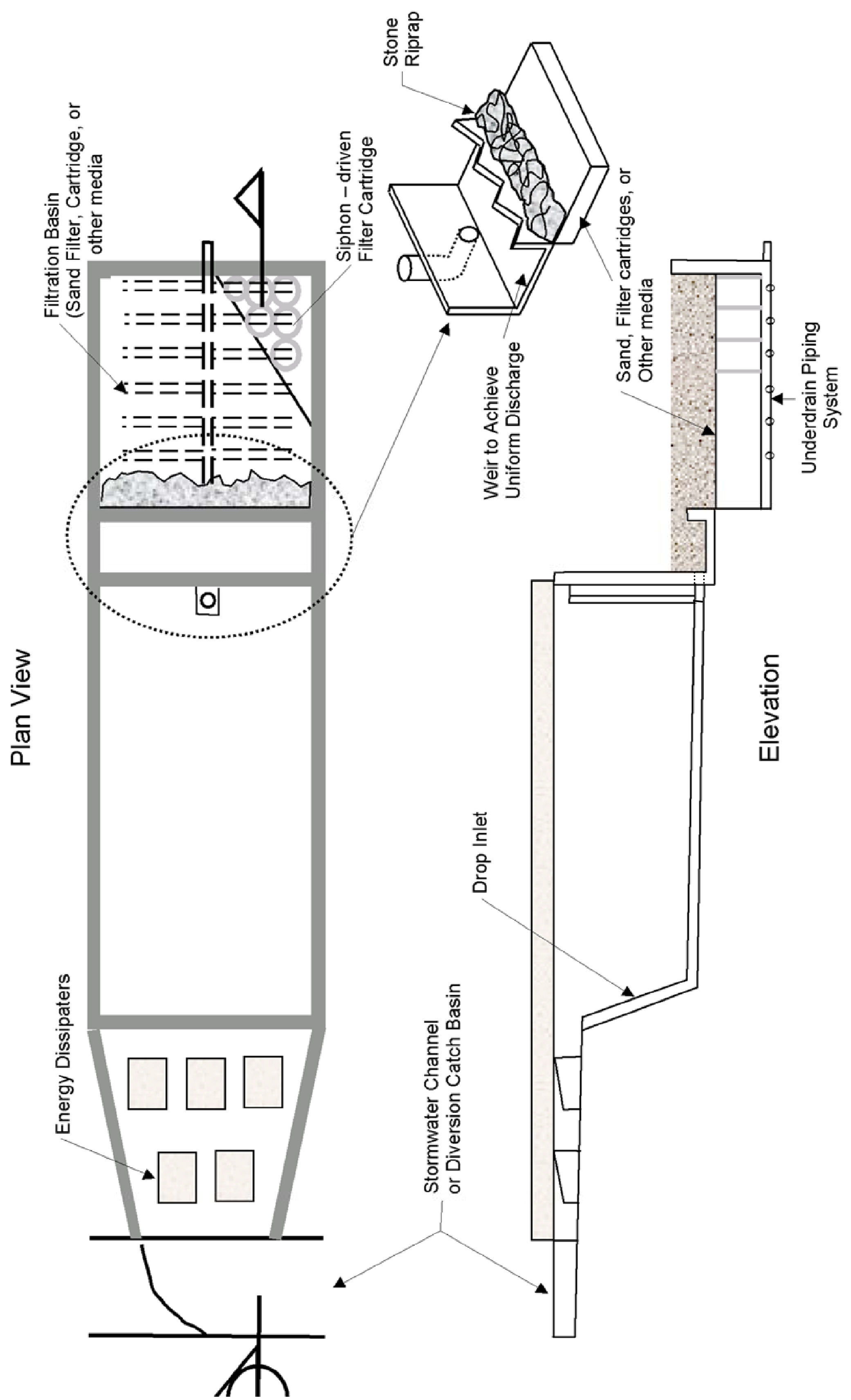
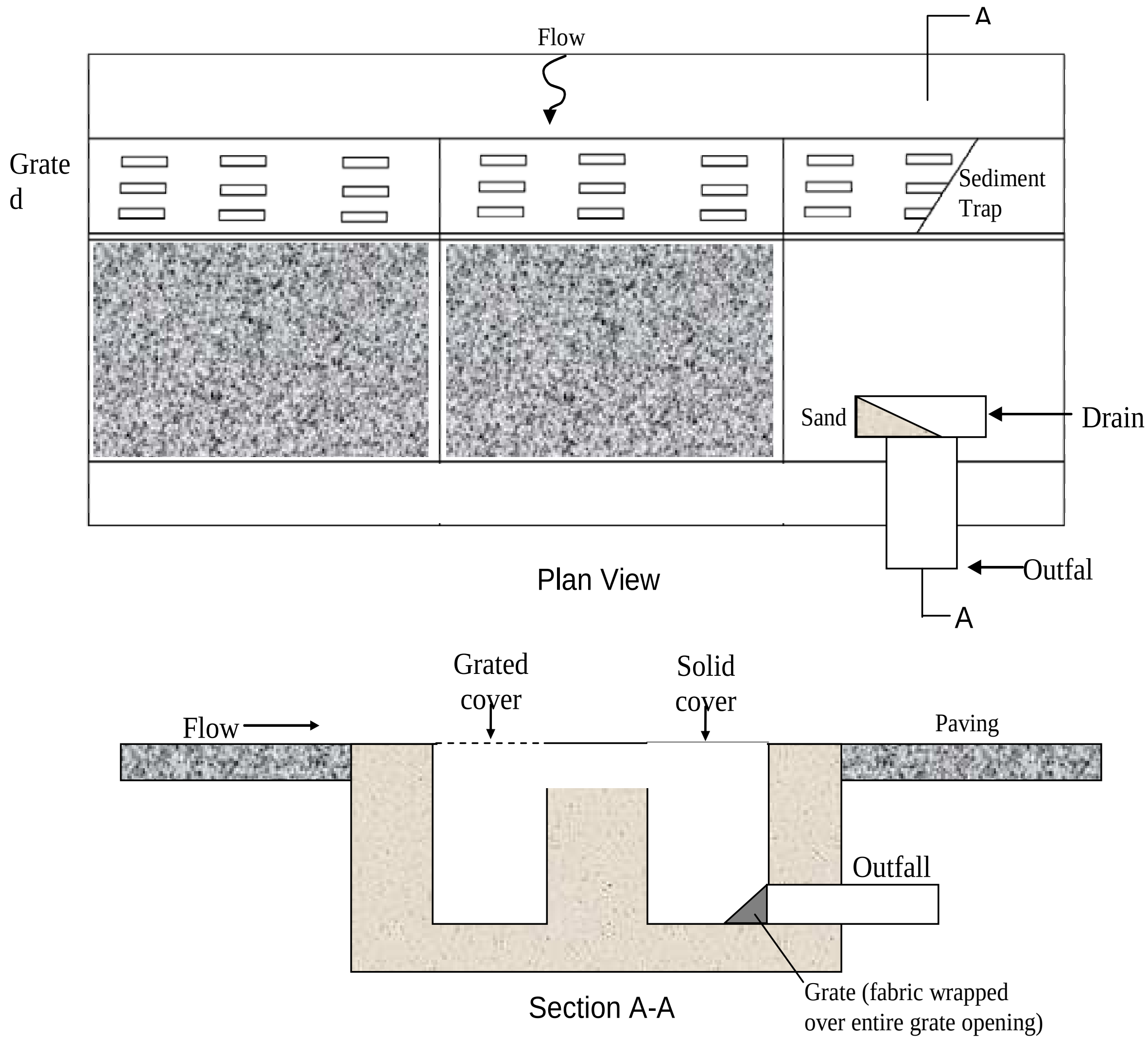
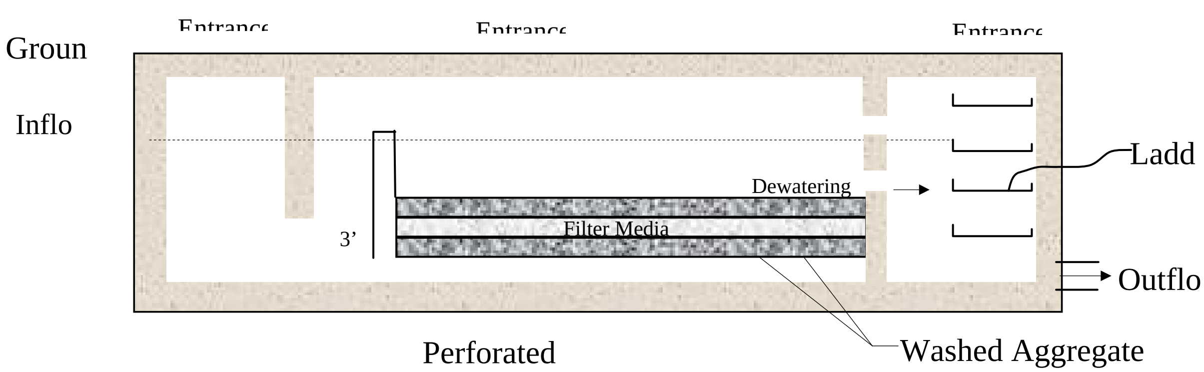


Figure STP-06-2
Multistage Sand Filter Layout

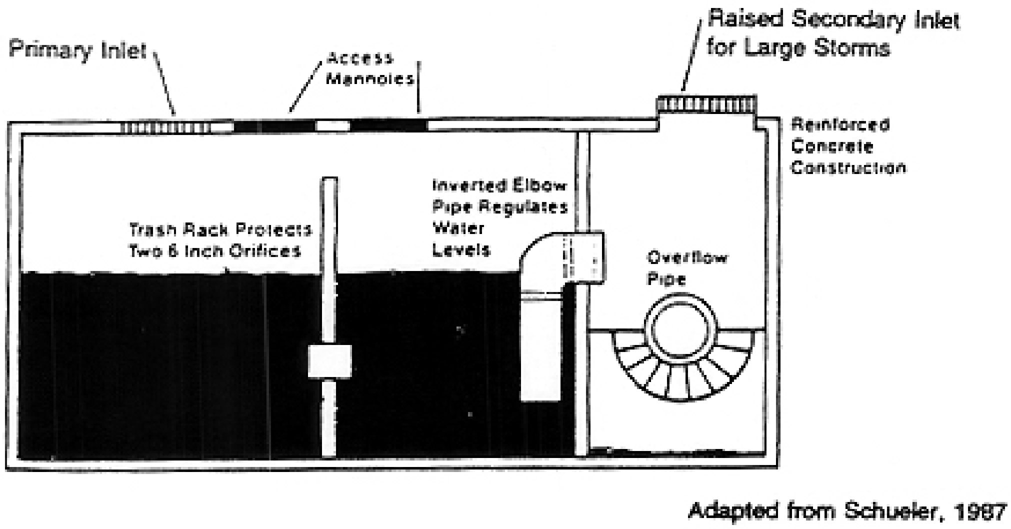


LINEAR SAND FILTER



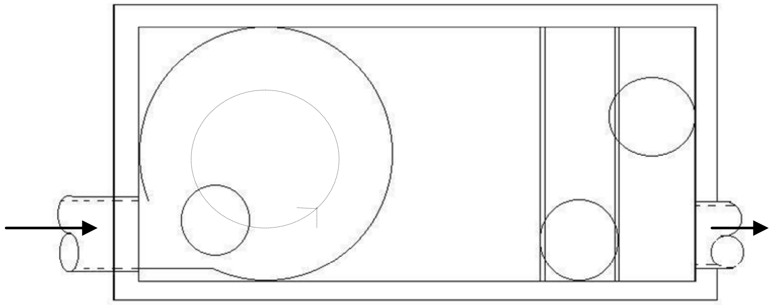
VAULT SAND FILTER

Figure STP-06-3
Midsize Media Filter System Layouts

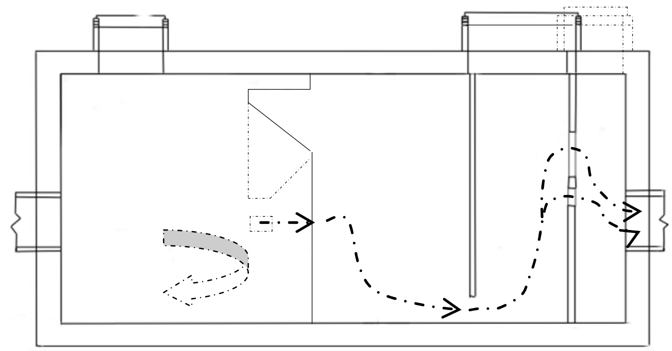


NOTE:
1. Size as conventional separator.
2. Design outlet orifice in elbow to limit outflow to the design rate for the unit.

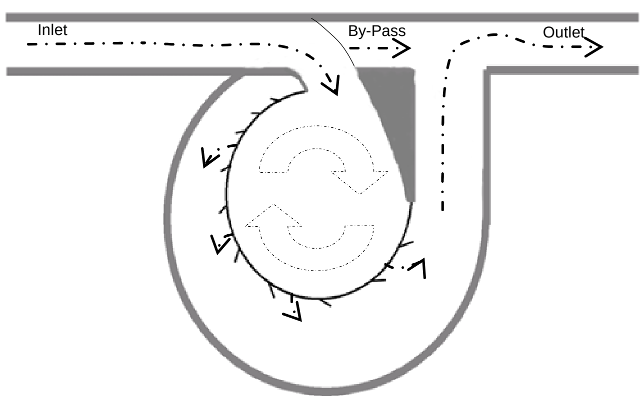
<u>Figure STP-06-4</u>
Horizontal Trash and Debris Separator



Swirl Deflector Plan View

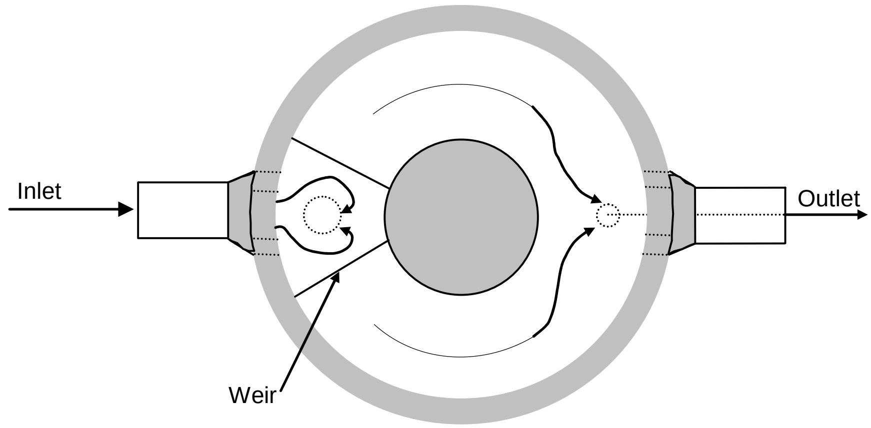


Swirl Deflector Elevation View



Continuous Deflection Plan View

Figure STP-06-5
Swirl / Continuous Deflection Separators



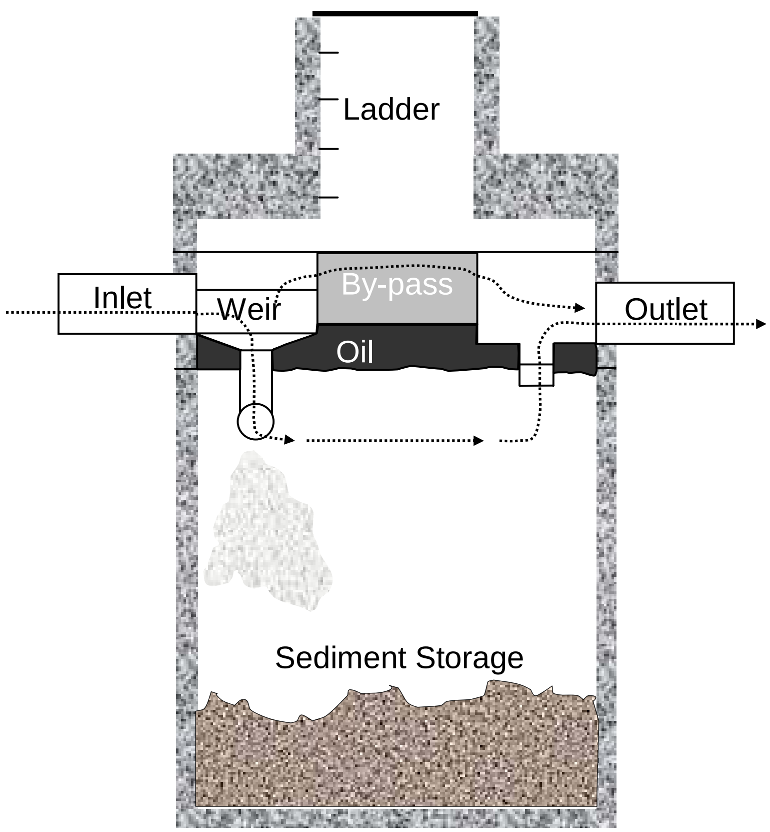


Figure STP-06-6
Separator / Filter
(Manhole Insert)

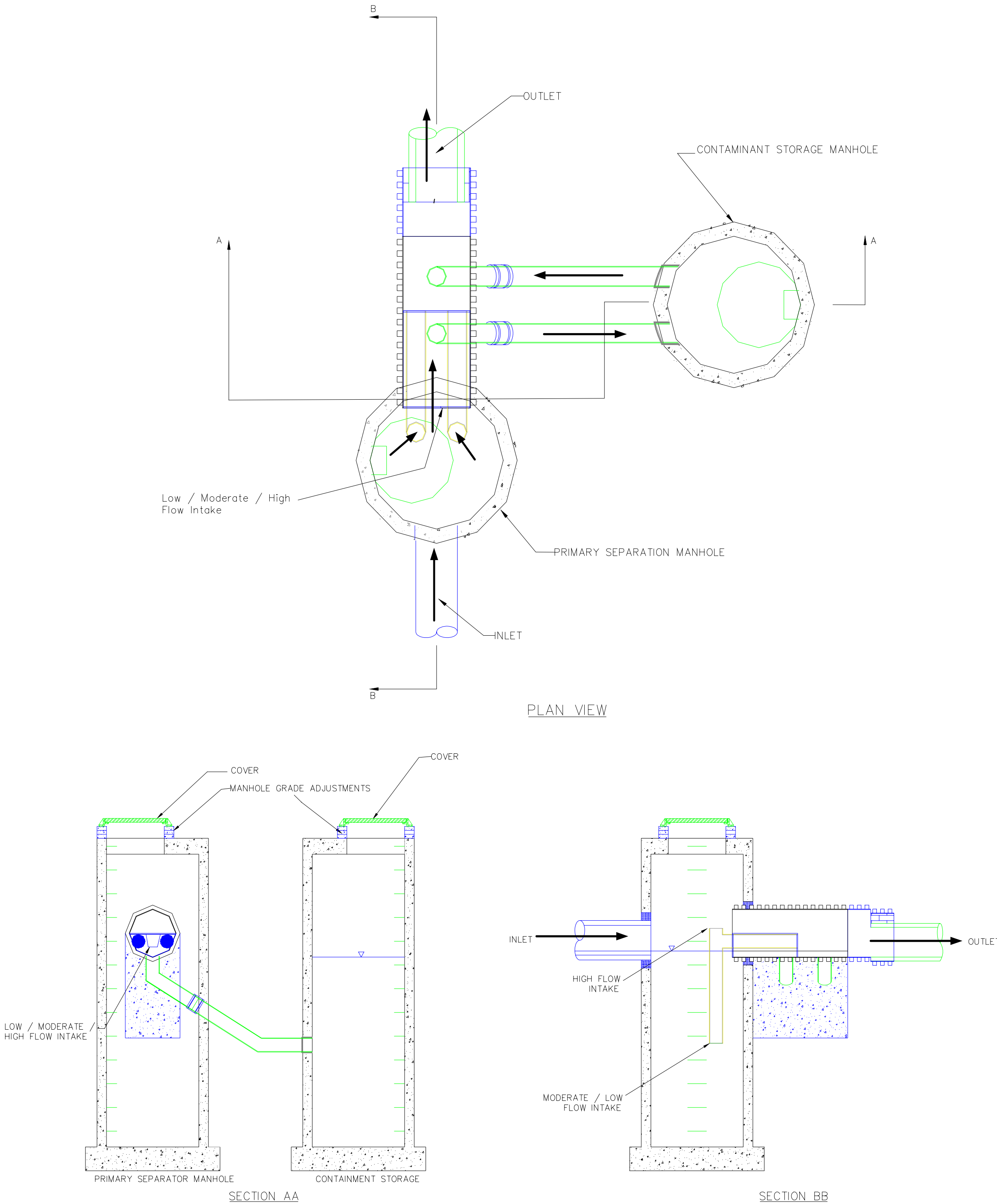
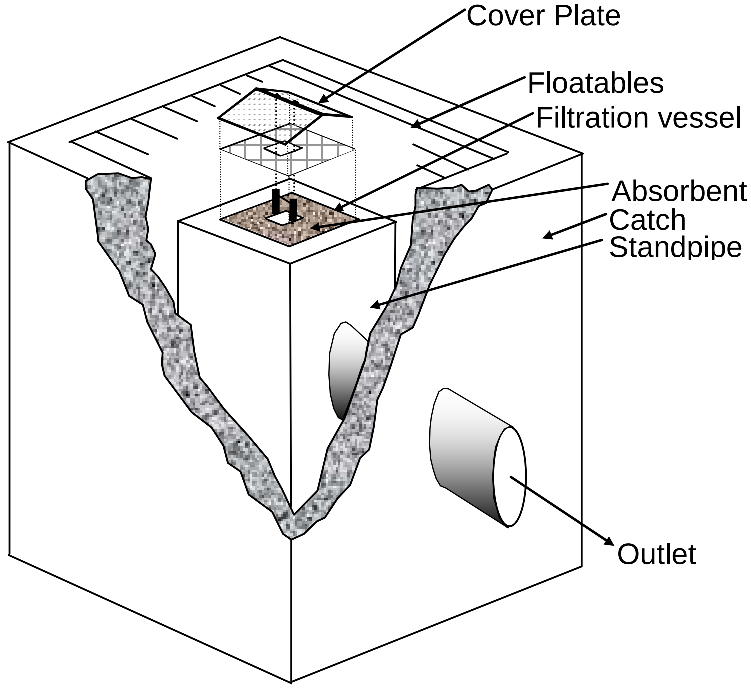


Figure STP-06-7
Dual Tank System
(Separator)



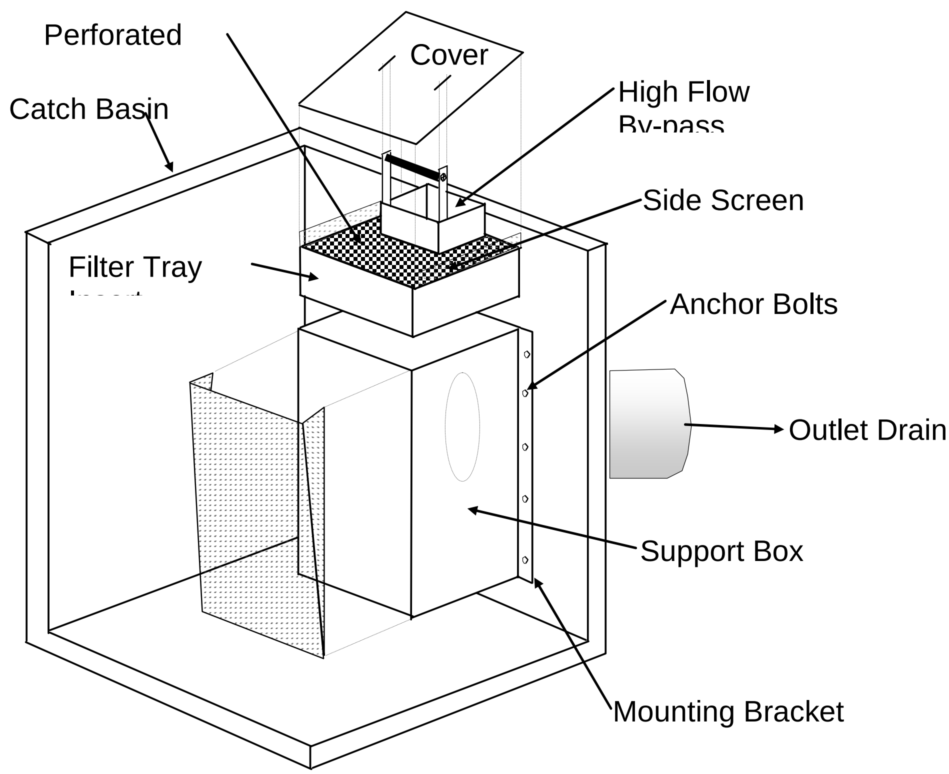


Figure STP-06-8
Catch Basin Insert Filters

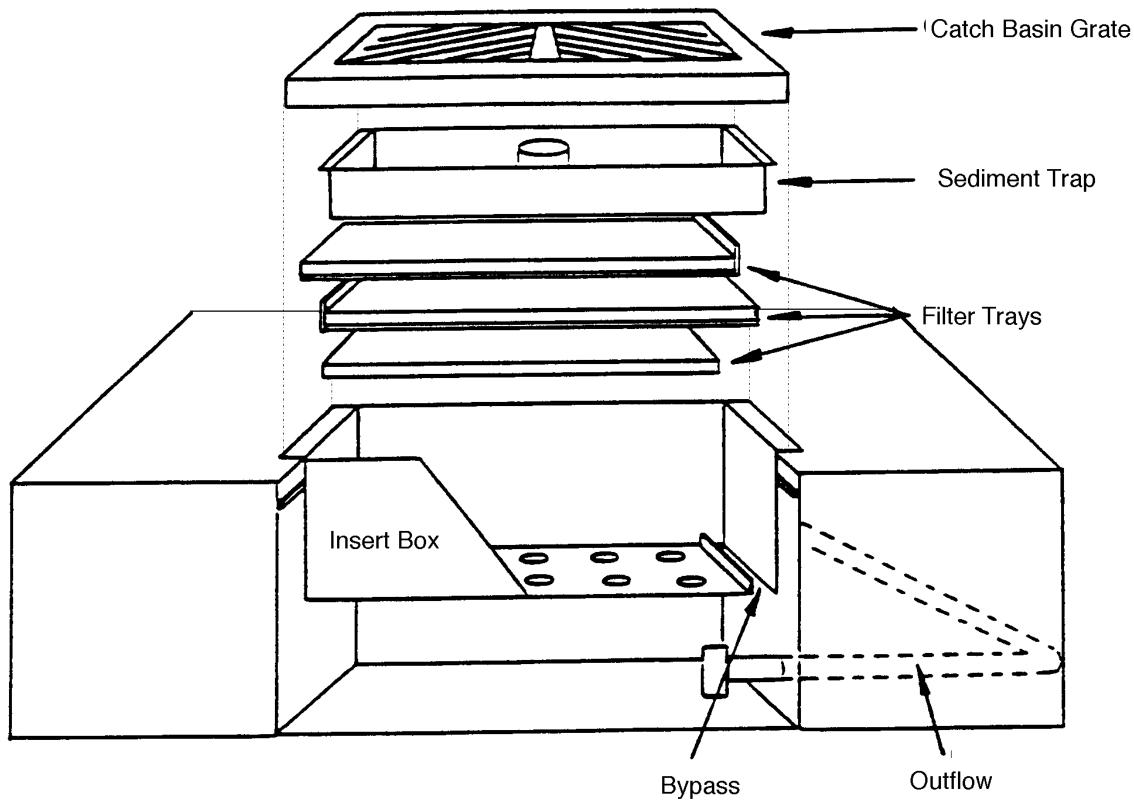


Figure STP-06-9
Grate Inlet Filter
(With Trays)

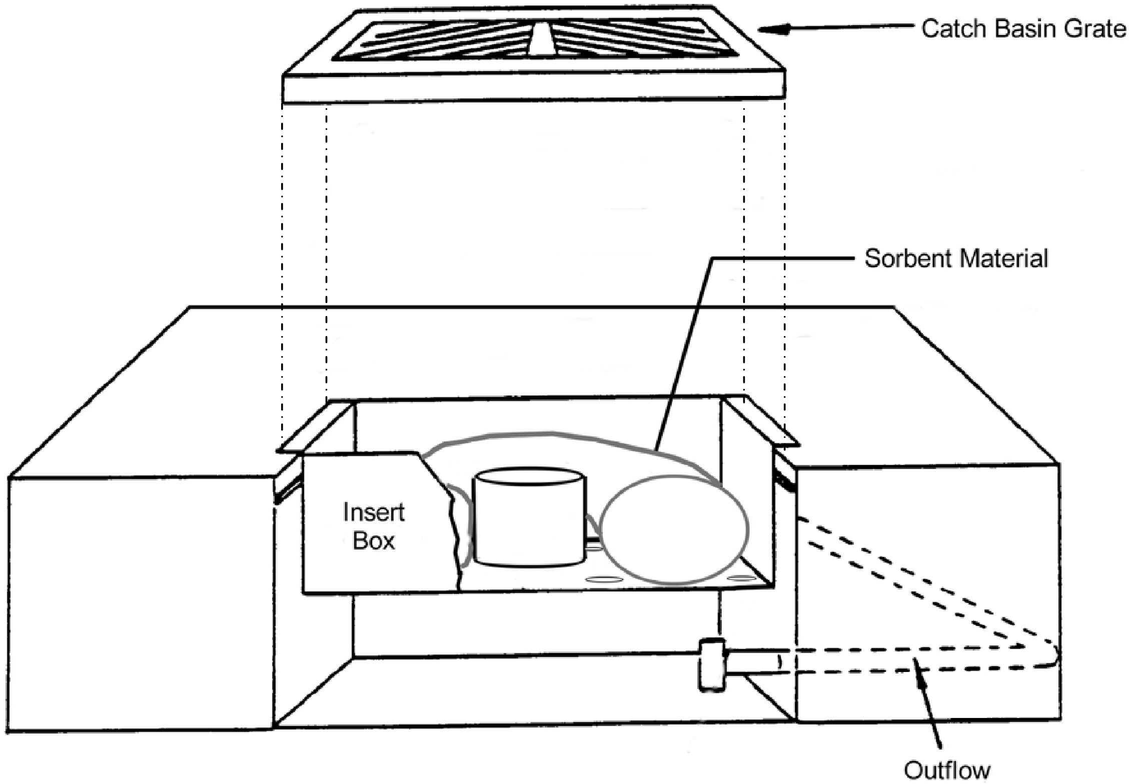


Figure STP-06-10
Grate Inlet Filter
(With Sorbent Material)

THE CITY OF MADISON INDIANA 1809	**Southern Indiana** **Stormwater Best Management Practices (BMPs)** **Stormwater Pollution treatment Practices (STPs)**	STP-07
	Activity: Oil/Water Separation	

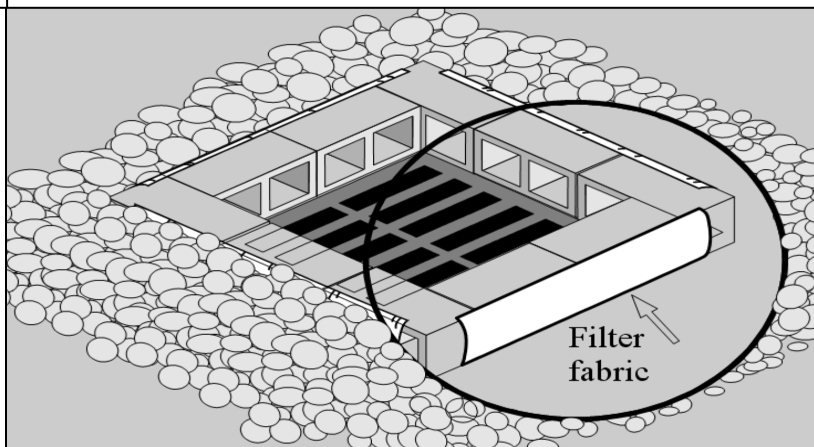
PLANNING CONSIDERATIONS:

Design Life:
1 yr

Acreage Needed:
Minimal

Estimated Unit Cost:
N/A

Monthly Maintenance:
N/A



Oil
Water

O/W

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

Oil/water separators are designed to remove one specific group of contaminants: petroleum compounds and grease. However, separators will also remove floatable debris and settleable solids. Two general types of oil/water separators are used: conventional gravity separator and the coalescing plate interceptor (CPI). This management practice is likely to create a significant reduction in the impacts of floatable materials and oil and grease as well as partial reductions in the impacts of sediment, nutrients, heavy metals, toxic materials, and oxygen demanding substances.

This BMP fact sheet discusses oil/water separators. Other systems can be used in conjunction with or as a simpler alternative to the complex design, inspection, operation and maintenance requirements of oil/water separators. STP-06: Media Filtration/Media Filters and Water Quality Inlets should also be reviewed.

Suitable Applications

- The various systems discussed in this fact sheet should be selected based on the targeted constituents, site area constraints, cost and frequency of maintenance and inspection requirements. Many of the systems are readily available in a variety of layouts through commercial vendors.
- One of the most important selection criteria that must be evaluated is the ability to bypass or convey large storm events without damaging the system, exceeding design flow capacity or resuspending collected pollutants.

Activity: Oil/Water Separation

Suitable Applications (Continued)

- Another very important selection criterion is consideration of long-term inspection and maintenance resources. If there is not a plan to regularly inspect and maintain the selected system on a long-term basis, and a fiscal guarantor that the required maintenance resources will be available for the life of the system, then the system should not be installed. If these types of systems are not periodically inspected, cleaned and otherwise maintained, they will fail and could result in more intense impacts to stormwater quality than if they were not installed at all.

- Applicable to situations where the concentration of oil and grease related compounds will be abnormally high and source control cannot provide effective control.

- The general types of businesses where this situation is likely are truck, car, and equipment maintenance and washing businesses, as well as a business that performs maintenance on its own equipment and vehicles. Public facilities where separators may be required include marine ports, airfields, fleet vehicle maintenance and washing facilities, and mass transit park-and-ride lots.
- Conventional separators are capable of removing oil droplets with diameters equal to or greater than 150 microns. A CPI separator should be used if smaller droplets must be removed.

- Oil/water separators will be needed for a few types of industrial sites where activities result in abnormal amounts of petroleum products lost to exposed pavement, either by accidental small spills or normal dripping from the vehicle undercarriage (gas stations, auto shops, etc.)

- Separators may also be advisable where an area is heavily used by mobile equipment such as loading wharfs at marine ports. Limited data indicates oil/water separators can reduce the oil/grease concentration below 10 mg/l.

- The sizing of separators is based upon the rise rate velocity of oil droplets and rate of runoff. However, with the exception of stormwater from oil refineries there are no data describing the characteristics of petroleum products in urban stormwater that are relevant to design: either oil density and droplet size to calculate rise rate or direct measurement of rise rates.

Design and Sizing Conditions

- These systems should be designed by a licensed professional civil engineer.

- Sizing related to anticipated influent oil concentration, water temperature and velocity, and the effluent goal. To maintain reasonable separator size, it should be designed to bypass flows in excess of “first flush”. The bypass mechanism should be designed to minimize potential for captured pollutants from being “washed out” or resuspended under flows in excess of the “first flush”.

Design and Sizing Conditions (Continued)

- It is known that a significant percentage of the petroleum products are attached to the fine suspended solids and therefore are removed by settling not flotation. Consequently, the performance of oil/water separators is uncertain.

- The basic configurations of the two types of separators are illustrated in Figure STP-07-1. With small installations, a conventional gravity separator has the general appearance of a septic tank, but is much longer in relationship to its width. Larger facilities have the appearance of a municipal wastewater primary sedimentation tank. The CPI separator contains closely spaced plates which enhance the removal efficiency. In effect, to obtain the same effluent quality a CPI separator requires considerably less space than a conventional separator. The angle of the plates to the horizontal ranges from 0° (horizontal) to 60°, although 45° to 60° is the most common. The perpendicular distance between the plates typically ranges from 0.75 to 1 inch (1.9 to 2.5 cm). The stormwater will either flow across or down through the plates, depending on the plate configuration.

Design of Conventional Separators

The sizing of a separator is based upon the calculation of the rise rate of the oil droplets using the following equation:

$$V_p = 1.79(d_p - d_c)d^2 \times 10^{-8}/n \qquad (1)$$

where: V_p = rise rate (ft/second)

n = absolute viscosity of the water (poises)

d_p = density of the oil (gm/cc)

d_c = density of the water (gm/cc)

d = diameter of the droplet to be removed (microns)

A water temperature must be used to select the appropriate values for water density and viscosity from Table STP-07-1. The engineer should use the expected temperature of the stormwater during the December-January period. There are no data on the density of petroleum products in urban stormwater but it can be expected to lie between 0.85 and 0.95. To select the droplet diameter the engineer must identify an efficiency goal based on an understanding of the distribution of droplet sizes in stormwater. However, there is no information on the size distribution of oil droplets in urban stormwater. Figure STP-07-2 is a size and volume distribution for stormwater from a petroleum products' storage facility. The engineer must also select a design influent concentration, which carries considerable uncertainty because it will vary widely within and between storms.

To illustrate Equation 1: if the effluent goal is 10 mg/l and the design influent concentration is 50 mg/l, a removal efficiency of 80% is required. From Figure STP-07-2: this efficiency can be achieved by removing all droplets with diameters 90 microns or larger. Using a water temperature of 10°C gives a water density of 0.998. Using an oil density of 0.898, the rise rate for a 90 micron droplet is 0.0011 feet per second.

Design and Sizing Conditions (Continued)

It is generally believed that conventional separators are not effective at removing droplets smaller than 150 microns. Theoretically, a conventional separator can be sized to remove a smaller droplet but the facility may be so large as to make the CPI separator more cost effective:

Sizing conventional Separator

$$D = (Q/2V)^{0.5}$$

Where: D = depth, which should be between 3 and 8 feet.
Q = design flow rate (cfs)
V = allowable horizontal velocity which is equal to 15 times the design oil rise rate but not greater than 0.05 ft/s (0.2 m/s)

<u>Application of the Conventional Oil/Water Separator</u>
Assume that a conventional oil/water separator is to be used to treat runoff from a 1/2 acre parking lot. Assume further it is to be sized to treat runoff from a rainfall rate of 0.50 inches/hr (which translates to a runoff rate of 0.50 cfs/acre when the area is 100 percent impervious).

Using the example above, the computed Vp is 0.0011 ft/sec (3.4×10^{-4} m/s). Using Equation 2, V = 15 x 0.0011 = 0.0165 ft/sec (5.0×10^{-3} m/s) which is less than 0.05 ft/sec (1.5×10^{-2} m/s); thus,

D = (Q/2V)0.05 = (1/2 x 0.05/(2 x 0.0165)) x 0.05
D = 3.8 ft (1.16 m)

L = VD/Vp = 0.0165 x 3.8/0.0011
L = 57 ft (17.4 m)

W = Q/(VD) = 0.25/(0.0165 x 3.8)
W = 4.0 ft (1.22 m), since W is less than 2 x D, increase width to W = 3.8 x 2 = 7.6 ft (2.32 m).

Thus, a conventional oil/water separator sized to capture runoff from a 0.5 in/hr (1.3 cm/hr) rainfall on a 1/2 acre parking lot would be:

D = 3.8 ft (1.16 m)
W = 7.6 ft (2.32 m)
L = 57 ft (17.4 m)

<u>Sizing CPI separator</u>
Manufacturers can provide packaged separator units for flows up to several cubic feet per second. For larger flows, the engineer must size the plate pack and design the vault. Given the great variability of separator technology among manufacturers with respect to plate size, spacing, and inclination, it is recommended that the design engineer consult vendors for a plate package that will meet the engineer's criteria. Manufacturers typically identify the capacity of various standard units.

Activity: Oil/Water Separation

Design and Sizing Conditions (Continued)

The engineer can size the facility using the following procedure. First identify the expected plate angle, H (as degrees), and calculate the total plate area required,

$$A(ft^2).\ A = Q/V_p \cos(H) \qquad (3)$$

However, the engineer's design criteria must be comparable to that used by the manufacturer in rating its units. CPI separators are not 100% hydraulically efficient; ranging from 0.35 to 0.95 depending on the plate design (Aquatrend, undated). If the engineer wishes to incorporate this factor, divide the result from Equation 3 by the selected efficiency.

- Select spacing, S, between the plates, usually 0.75 to 1.5 inch (1.91 to 3.81 cm).
- Identify reasonable plate width, W, and length, L.
- Number of plates, N = A/WL.
- Calculate plate volume, $P_v(ft^3)$.

$$P_V = (\underline{NS} / 12 + L \cos(H))(WL \sin(H)) \qquad (4)$$

- Add a foot (0.3 m) beneath the plates for sediment storage.
- Add 6" to 12" (15.2 to 30.5 cm) above the plates for water clearance so that the oil accumulates above the plates.
- Add one foot (0.3 m) for freeboard.
- Add a forebay for floatables and distribution of flow if more than one plate unit is needed.
- Add after bay for collection of the effluent from the plate pack area.
- For larger units include device to remove and store oil from the water surface.
- Horizontal plates require the least plate volume to achieve a particular removal efficiency. However, settleable solids will accumulate on the plates complicating maintenance procedures. The plates may be damaged by the weight when removed for cleaning. The plates should be placed at an angle of 45° to 60° so that settleable solids slide to the facility bottom. Experience shows that even with slanted plates some solids will "stick" to the plates because of the oil and grease. Placing the plates closer together reduces the plate volume. However, if debris is expected such as twigs, plastics, and paper, select a larger plate separation distance. Or install ahead of the plates a trash rack and/or screens with a diameter somewhat smaller than the plate spacing.

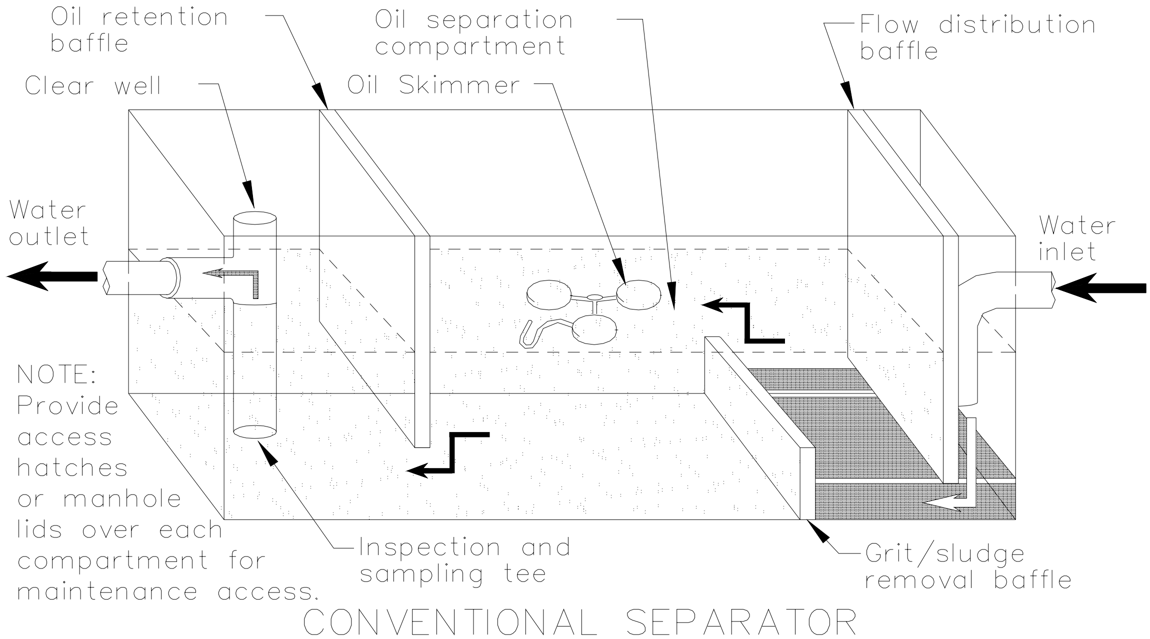
Activity: Oil/Water Separation

Inspection Checklist

- It is known that a significant percentage of the petroleum products are attached to the fine suspended solids and therefore are removed by settling not flotation. Consequently, the performance of oil/water separators is uncertain.
- The design loading rate for oil/water separators is low, therefore, they can only be cost-effectively sized to detain and treat nuisance and low flows (small storm or first flush events). Sizing to accommodate an average to large storm results in a large sized facility and is not economical and often not feasible.
- Undersizing or conveying flows in excess of the first flush for small catchments can result in poor performance or resuspension of collected pollutants.
- Oil/water separators require frequent periodic maintenance for the life of the structure.

Table STP-07-1
Water Viscosities & Densities

Temperature		Absolute Viscosity		Density of pure water in air	
°C	°F	(Poises)	(slugs/ft.sec)	(gm/cc)	(lbs/ft^3)
0	32.0	0.017921	0.00120424	0.999	62.351
1	33.8	0.017343	0.00116338	0.999	62.355
2	35.6	0.016728	0.00112407	0.999	62.358
3	37.4	0.016191	0.00108799	0.999	62.360
4	39.2	0.015674	0.00105324	1.000	62.360
5	41.0	0.015188	0.00102059	0.999	62.360
6	42.8	0.014728	0.00098968	0.999	62.359
7	44.6	0.014284	0.00095984	0.999	62.357
8	46.4	0.013860	0.00093135	0.999	62.354
9	48.2	0.013462	0.00090460	0.999	62.350
10	50.0	0.013077	0.00087873	0.999	62.345
11	51.8	0.012713	0.00085427	0.999	62.339
12	53.6	0.012363	0.00084870	0.999	62.333
13	55.4	0.012028	0.00080824	0.999	62.326
14	57.2	0.011709	0.00078681	0.999	62.317
15	59.0	0.011404	0.00076631	0.999	62.309
16	60.8	0.011111	0.00074662	0.999	62.299
17	62.6	0.010828	0.00072761	0.999	62.289
18	64.4	0.010559	0.00070953	0.999	62.278
19	66.2	0.010299	0.00069206	0.999	62.266
20	68.0	0.010050	0.00067533	0.998	62.254



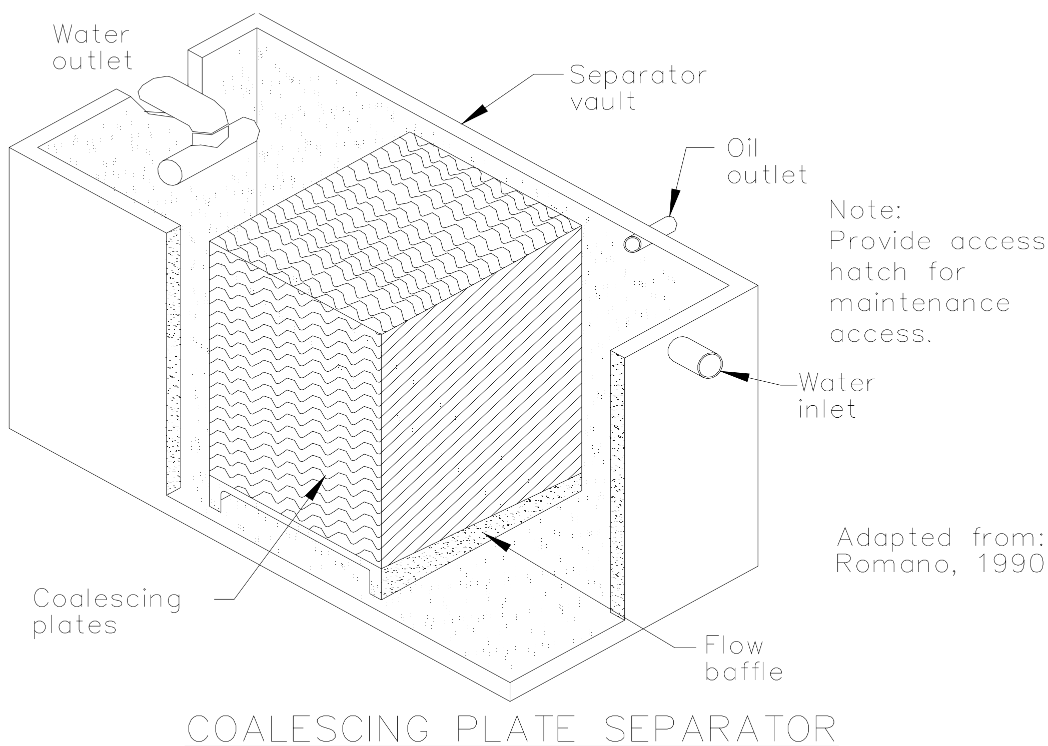


Figure STP-07-1
Oil/Water Separator Types

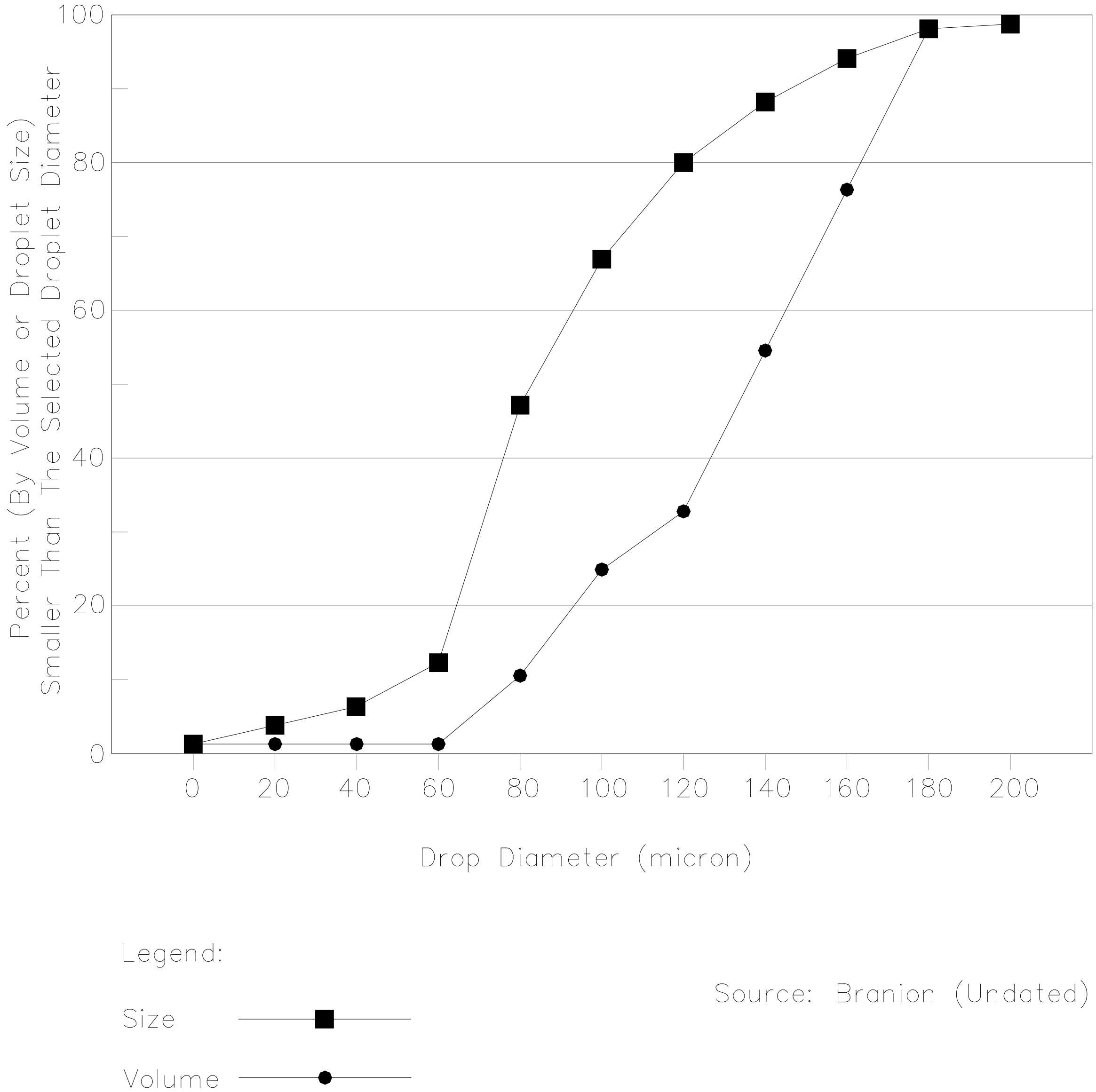


Figure STP-07-2
Particle Size, Capture, Distribution and Volume

Southern Indiana
Stormwater Best Management Practices (BMPs)
Stormwater Pollution treatment Practices (STPs)

STP-08

Activity: Multiple Systems

PLANNING CONSIDERATIONS:

Design Life:
N/A

Acreage Needed:
N/A

Estimated Unit Cost:
N/A

Monthly Maintenance:
N/A

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

A multiple treatment system uses two or more of the preceding BMPs in series. This management practice is likely to create significant reductions in sediment, floatable materials, nutrients, heavy metals, toxic materials, oxygen demanding substances, oil and grease, and partial reductions in bacteria and viruses.

Suitable Applications

- Need to protect particularly sensitive stream or various site uncertainties warrant staged treatment.
- Enhanced reliability.
- Optimum use of the site.
- Generally less expensive to maintain more, but more effective.

Design and Sizing Conditions

- These systems should be designed by a licensed professional civil engineer.
- Refer to individual treatment control BMPs, SPP and STP sections.

Maintenance

- Refer to individual treatment control BMP's, SPP and STP sections.

Activity: Multiple Systems	STP-08

Inspection Checklist

Available space.

- ❑ Multiple systems may occur in series or by stacking vertically. Multiple systems that have been tried or that appear to be feasible are presented below:
- ❑ High flow bypass manhole, gate, weir or orifice above a forebay, pond, filter, oil/water separator, swale, or water quality manhole/insert. This is preferred for all stormwater quality systems to ensure that flows in excess of the design flow do not damage the system or resuspend collected pollutants.
- ❑ Dry detention above wet detention pond: recommended by several practitioners because of the uncertainty about the performance of wet ponds.
- ❑ Wet detention pond above media filter: desirable because settleable solids that can quickly clog media filters are removed.
- ❑ Dry detention basin – media filter: settling basin is needed to avoid excessive maintenance on the sand filter.
- ❑ Wet or dry detention basin – media filter – wetland: for a larger system draining to an especially sensitive water body.
- ❑ Wet detention pond – wetland: where an unusually high loading of sediment is expected, a full size wet pond, rather than just a forebay in the wetland, may be desirable to minimize the amount of sediment reaching the wetland where it would be more costly to remove.
- ❑ Biofilter – wet or dry detention pond: used frequently to enhance reliability or as an alternative to a forebay.
- ❑ Forebay (or baffle box) – wet or dry detention: collection of floatable debris and coarse sediment reduces frequency of detention pond cleanout while making debris and sediment removal easier.
- ❑ Biofilter – infiltration trench: for pretreatment of the stormwater before it enters an infiltration system.
- ❑ Oil/water separator – wetland or biofilter: the oil/water separator is used to protect the vegetated treatment system where high concentrations of oil may frequently occur.

Additional Resources

IV. Additional Resources

This Stormwater Management Manual of Best Management Practices (BMP) was created using information from many sources. To find out more information regarding Stormwater BMP's, please feel free to visit the websites of the agencies and other resources provided below.

American Water Work Association	http://www.awwa.org/
Gwinnett County (GA) Stormwater Management	http://www.co.gwinnett.ga.us/
Environmental Protection Agency	http://www.epa.gov/
Environmental Protection Agency - Region 5	http://www.epa.gov/region5/
Indiana Department of Natural Resources	http://www.in.gov/dnr/
Indiana Department of Transportation	http://www.in.gov/dot/
Indiana Department of Environmental Management	http://www.in.gov/idem/
Metropolitan Council of Minnesota	http://www.metrocouncil.org/
Pennsylvania Association of Conservation Districts	http://www.pacd.org/
Kentucky Division of Water	http://www.water.ky.gov/
Water Environment Federation	http://www.wef.org/