VOLUME 4

Best Management Practices

STORMWATER MANAGEMENT MANUAL

Prepared for

METROPOLITAN GOVERNMENT
NASHVILLE AND DAVIDSON COUNTY

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Section 1
INTRODUCTION

1.1 Background and Purpose

This volume presents a brief introduction to stormwater Best Management Practices (BMPs). It describes how they should be selected, and contains a series of focused and concise fact sheets for each type of BMP to be used in the Metropolitan Nashville and Davidson County (Metro) area. It is part of the Stormwater Management Manual, which is composed of the following volumes:

Volume 1 – Regulations
Volume 2 – Procedures
Volume 3 – Theory
Volume 4 – Best Management Practices (BMP)

The intent of this volume is to provide guidance on BMP selection, design, and implementation to plan submitters, reviewers, construction site operators, and site inspectors. There is special emphasis on Erosion Prevention and Sedimentation Control (EP&SC) 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.

The original version of this manual was released in March 2000. It was prompted by requirements in Metropolitan Nashville and Davidson County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit issued by the Tennessee Department of Environment and Conservation (TDEC). In 2006 and 2009, Metro updated the manual, including the TCP and PTP sections of this volume. Other sections within this volume were not revised. Metro Water Services has the authority to change any provisions in Volume 4 so long as it is in support of policies and regulations defined in Volume 1 of the Stormwater Management Manual. Any future release of this manual supersedes any and all previous manual releases. Each page is dated to indicate the release date.

1.2 Stormwater Quality and Quantity Management

Since 2000, Metro has been 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). In 2006, Metro revised its stormwater program to require a uniform, specific, post-construction pollution reduction goal for new development and redevelopment sites. Stormwater quality management involves pollutant control, capture, and treatment. There are two pollutant delivery categories: Point sources and non-point sources. Point sources deliver pollutants in the form of regulated discharges, spills, dumping, illicit connections, etc. Non-point sources deliver pollutants through stormwater runoff from different types of land uses. This volume 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 being picked up by runoff over surfaces and conveyed to Metro's 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 frequent storm events. Typically these events are less than 1.1-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 Erosion Prevention and Sediment Control (EP&SC)

1.3.1 Erosion Process

Short-term stormwater quality management predominately focuses on erosion prevention and sedimentation control (EP&SC) for construction sites. However, for some fully developed sites EP&SC can also be a concern. Soil erosion is the process by which soil particles are removed 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 material suspended by erosion settles during sedimentation in downstream reaches. This 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. The 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 as a result of gravitational forces.

The increasing erosive energy of water flowing in rivulets will begin to 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 may join together with adjacent rills. Typically, rills run parallel to 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 joining together 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 gravitational forces. Typically, gullies run parallel to 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 away 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 of soil 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. Construction activities can disturb the banks of streams and channels. Once vegetation or other bank protection measures are disturbed, flows may begin to erode the unprotected soil, causing an "unraveling" of the stream or channel. One of the benefits of Metro's water quality buffer program is that it mandates an undisturbed area along the top of the stream bank or floodway, reducing the potential for stream bank disturbances during construction activities.

2. Construction activities can disturb the flow within a stream or channel. However, these types of activities should be avoided and the disturbance should be minimized. Stream or channel

disturbances are often necessary when traversing banks with temporary stream crossings, culvert installations, bridge construction, etc. By diverting flows within the channel, velocities are generally 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. These issues should be addressed in the development plans and minimized to the extent feasible.

3. Development can increase the quantity and rate of flow to streams and channels. The increased quantity and rate of flow can cause bank erosion and bottom scour. Metro's detention policies address this issue for new development.

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 stress 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. Rainfall, including the 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 Tennessee, 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 the forces of gravity will cause the 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. However, it is more effective to control erosion than to control sedimentation.

1.4 Other Pollutant Sources and Impacts

Sediment from erosion is the pollutant most frequently associated with construction activities. However, other pollutants 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.

1.4.1.1 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.

1.4.1.2 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.

1.4.1.3 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.

1.4.1.4 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.

1.4.1.5 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.

1.4.1.6 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.

1.4.1.7 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.

1.5 Temporary and Permanent BMPs

Temporary BMPs are intended to address construction activities while permanent BMPs address long-term stormwater management objectives / requirements. Both temporary and permanent BMPs should be included in the grading plan and SWPPP.

Temporary BMPs may include a variety of “good housekeeping” measures and short-term EP&SC activities. A licensed professional engineer must design BMPs. The temporary management practices should be designed and submitted to the plan review engineer with the Department of Water Services. The permit holder is responsible for identifying an EPSC professional that will act as the contact person for Metro and that will ensure that temporary practices are properly constructed, implemented and maintained and will seek 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 must be selected by licensed professional civil engineers and incorporated into the plans and specifications for the project. The short- and long-term maintenance responsibilities must be identified.

Permanent BMPs are the final improvements to and configuration of the project. They are designed to convey and control stormwater long-term. 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 Metro prior to issuing a grading permit. Occasionally, unforeseen natural or manmade factors may require revisions to or additions of permanent BMPs during the construction phase.

During construction, the grading permit holder 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, as required by the maintenance agreement.

1.6 Temporary and Permanent BMP Selection Process

1.6.1 Define BMP Objectives

Each new development site is unique. Therefore, an understanding of the natural features within the project boundaries and the pollution risks related to the construction activity and land use is essential for selecting and implementing BMPs. Identifying these features and risks requires review of the characteristics of the site and the nature of the construction. This information should be assembled for the construction plans. Once these natural features and pollution risks are defined, BMP objectives can be effectively developed, and BMPs selected. The BMP objectives for new development projects are as follows:

1. Practice Good Housekeeping: Perform activities in a manner which keeps potential pollutants from coming into contact with stormwater by containing potential 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. Control Erosion: Provide temporary stabilization of disturbed soils whenever active construction is not occurring on a portion of the site. Provide permanent stabilization as phases are brought to the final grade and landscape the site. Focus stabilization efforts on slopes and areas of concentrated flow.

5. Protect Slopes and Channels: Outside of the 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 from other developments or sites 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 Sedimentation: 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.

8. Protect Natural Features: Identify natural features such as wetlands, streams, sinkholes, and springs. Install BMPs to protect these features. Consider leaving natural features within areas that are not to be disturbed.

9. Implement Better Site Design Principles: Design a development to minimize the roadway length and width and parking lot size. Use pervious materials, such as pervious pavers or permeable concrete, where possible. Use grass-lined channels where site conditions allow.

10. Reduce Pollutants from the Development After Construction (Post-Construction Water Quality): Long-term BMP selection must be based upon the ability to meet Metro's requirement of an 80% TSS reduction of an average annual urban pollutant load. Select permanent treatment practices based upon the TSS reduction provided, the proposed land use, and the level of maintenance required.

Site characteristics and contractor activities affect both the potential for erosion and contamination by other constituents used on the construction site. Before identifying BMPs, 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, sinkholes, 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.

1.6.2 Identify BMP Categories

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

To determine where to place BMPs, a map of the project site should 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 higher 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 stormwater 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, BMPs can be selected and located. It is more cost-effective to prevent erosion/pollution than to remove sediment/pollutants. Erosion prevention is achieved most cost-effectively by planning before construction begins and phasing once construction activities begin.

Once the BMP objectives and categories are identified, the BMP Treatment Train illustrated in Figure 1-1 can be utilized. It can focus the search for specific BMPs to match the site specific conditions and characteristics.

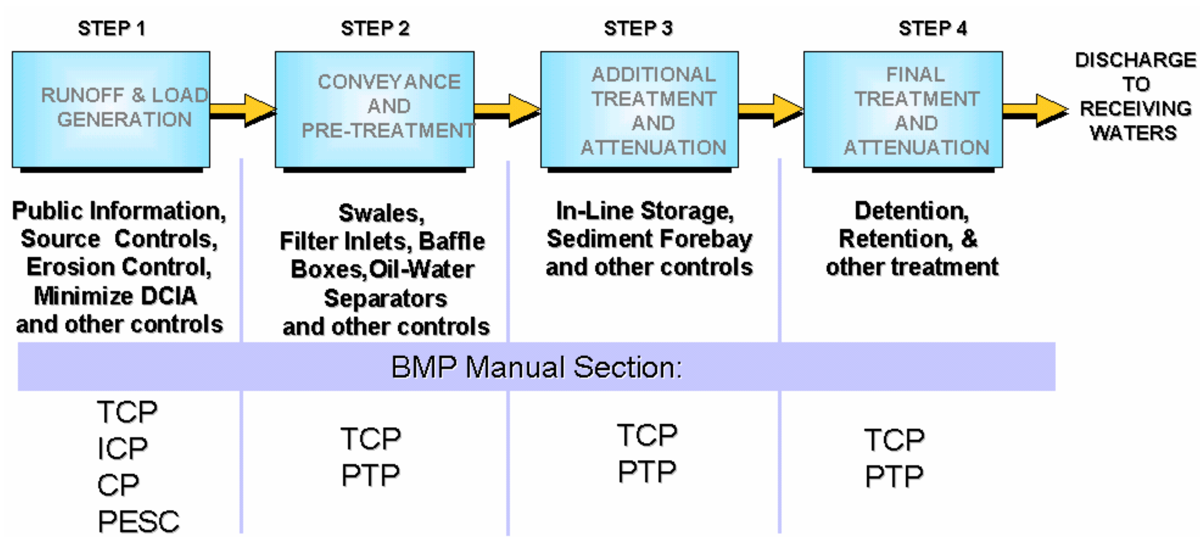


Figure 1-1: Development planning from construction through post-construction

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.

1.6.3 Selecting BMPs for Contractor Activities (Sections CP, TCP and ICP)

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.

1.6.4 Selection of Erosion Prevention and Sediment Control (EP&SC) Activities (Sections TCP and PESC)

Effective EP&SC 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.

1.6.4.1 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 EP&SC 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.

1.6.4.2 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

1.6.4.3 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.

1.6.4.4 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).

1.6.4.5 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. Weighted Sediment Tubes
   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.

1.6.4.6 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.

1.6.5 Selection of Permanent Treatment Practices (Sections PESC and PTP)

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 Metro Water Services, which incorporates source controls, a series of on-site treatment controls, and community-wide treatment controls. This was demonstrated in Section 1.6.2 in the discussion on the BMP Treatment Train.

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.

References

California Storm Water Best Management Practice Handbooks, Camp Dresser & McKee et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, Camp Dresser & McKee et.al. for the California Department of Transportation, 1997.

Chow, Ven Te. *Open Channel Hydraulics*, McGraw-Hill, Inc., 1959.

Roesner, L.A., Aldrich, J., Hartigan, J.P., et.al., *Urban Runoff Quality Management – WEF Manual of Practice No. 23 / ASCE Manual and Report on Engineering Practice No. 87*, 1998.

Sevenmile Creek Basin Pilot Stormwater Quality Master Plan, Camp Dresser & McKee et.al. for the Metropolitan Nashville and Davidson County Department of Public Works, February, 2000.

Storm Water Management for Construction Activities – Developing Pollution Prevention Plans and Best Management Practices, U.S. Environmental Protection Agency, 482N, September 1992.

Users Manual 1.06: Watershed Management Model, Camp Dresser & McKee. For Rouge River National Wet Weather National Demonstration Project for the U.S. Environmental Protection Agency. August 1998.

SECTION 2
CONTRACTOR MANAGEMENT PRACTICES
(CPs)

Section 2
CONTRACTOR MANAGEMENT PRACTICES (CPs)

2.1 Introduction

This section presents the BMP fact sheets for the Contractor Management Practices (CPs). CPs predominately focus on practices relating to construction site "Good Housekeeping" measures. Other frequently used practices that address containing or capturing pollutants are also included.

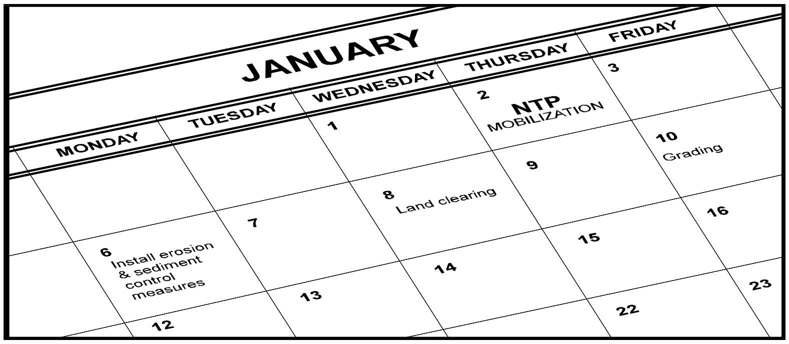
This section contains the following BMP fact sheets.

CP – 01	Scheduling – Phased Construction/Clearing	CP – 12	Vehicle and Equipment Cleaning
CP – 02	Dewatering Operations	CP – 13	Vehicle and Equipment Fueling
CP – 03	Paving Operations	CP – 14	Vehicle and Equipment Maintenance
CP – 04	Structure Construction and Painting	CP – 15	Employee/Subcontractor Training
CP – 05	Material Delivery, Storage, and Use	CP – 16	Pesticides, Herbicides, and Fertilizer Use
CP – 06	Spill Prevention and Control	CP – 17	Dust Control
CP – 07	Solid Waste Management	CP – 18	Maintenance of Collection Facilities and Appurtenances
CP – 08	Hazardous Waste Management	CP – 19	Preservation and Maintenance of Existing Vegetation
CP – 09	Contaminated Soil Management	CP – 20	System Flushing
CP – 10	Concrete Waste Management		
CP – 11	Sanitary/Septic Waste Management		

Each fact sheet has a quick reference guide indicating what pollutant constituents the BMP is targeting and implementation requirements.

The BMPs presented in this section are intended to coincide with construction activity (lasting only as long as construction activities). Additional details are provided in sections covering Industrial / Commercial Management Practices (ICP) for practices that are intended to be used for non-construction activities.

ACTIVITY: Scheduling – Phased Construction/Clearing	CP – 01



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

○ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances

○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Reduce the discharge of pollutants to the storm drain system or to watercourses as a result of construction activities by scheduling construction activities in a manner that minimizes the exposure of disturbed soils to wind, rain, run-on, and runoff. If this management practice makes full use of the BMPs outlined in this text, significant reductions can be made in sediment and nutrient impact.

Approach

- Plan project to incorporate the use of a schedule or flow chart to layout the construction plan.
- Work out the sequencing and timetable for the start and completion of each item such as site clearing, grading, excavation, pouring foundations, installing utilities, etc. This should be shown by specific construction areas which minimize areas adjacent to streams, wetlands, and storm drains. This should be consistent with stream buffer requirements.
- Schedule work to minimize the active construction area during the rainy season. Alternatively, smaller active areas can be designated to limit potential erosion and sedimentation impacts.
- Incorporate soil stabilization items in the construction schedule.
- Stabilize nonactive areas as soon as practical within 15 days of grading activities.
- Minimize land-disturbing activities during the rainy season. Schedule major grading operations for the non-winter season when practical.
- Monitor the weather forecast for rainfall. Inform field supervisors and inspectors that additional inspections of erosion and sediment control practices may be needed.

- When rainfall is predicted, adjust the construction schedule to allow the implementation of erosion and sediment controls and sediment treatment controls on all disturbed areas prior to the onset of rain. Where site is cleared, re-inspect prior to and after rain.
- Be prepared year-round to immediately deploy erosion and sediment control and sediment treatment control practices. Erosion may be caused during dry seasons by unseasonable rainfall, wind and vehicle tracking. Keep the site stabilized year-round, and maintain sediment trapping devices.
- Incorporate staged seeding and re-vegetation of graded slopes as work progresses.
- Sequence trenching activities so that most denuded areas are stabilized before new trenching begins.

Maintenance

- Routinely verify that work is progressing in accordance with the schedule. If construction progress deviates, take corrective actions.
- When changes are warranted, amend the sequence scheduling in advance to maintain control. Be sure all field supervisors and inspectors are aware of changes.

Limitations

Site conditions will dictate the extent and detail.

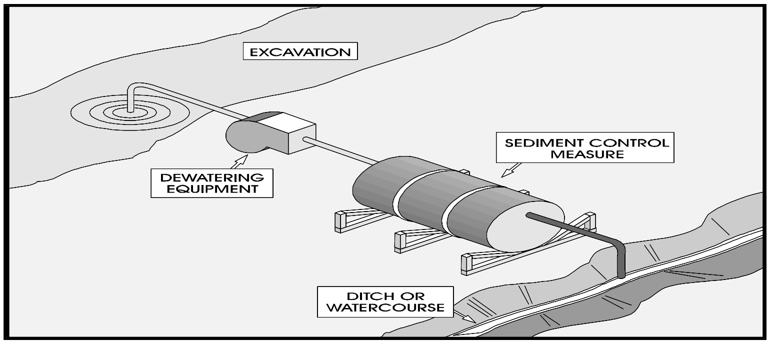
Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

ACTIVITY: Dewatering Operations

CP – 02



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

◗ Capital Costs	◗ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from dewatering operations by using sediment controls and by testing the groundwater for pollutant accumulation. This management practice is likely to create a significant reduction in sediment and a partial reduction in toxic materials.

Approach

There are two general classes of pollutants that may result from dewatering operations: sediment, and toxics and petroleum products. A high sediment content in dewatering discharges is common because of the nature of the operation. On the other hand, toxics and petroleum products are not commonly found in dewatering discharges unless, the site or surrounding area has been used for light or heavy industrial activities, or the area has a history of groundwater contamination. This BMP only addresses capture of sediment. If it is determined that dewatering will result in transfer or accumulation of toxics or petroleum products then the Tennessee Department of Environment and Conservation (TDEC) should be consulted before any dewater activities are performed. The following steps will help reduce stormwater pollution from dewatering discharges:

Sediment

- Use sediment controls to remove sediment from water generated by dewatering. This should include techniques presented in the attached figures and the sediment trap and basin BMP fact sheets.

- Filtration can be achieved with:
  - Sump pit and a perforated or slit standpipe with holes wrapped in filter fabric. The standpipe is surrounded by stones which filters the water as it collects in the pit before being pumped out. Wrapping the standpipe in filter fabric may require an increased suction inlet area to avoid clogging and unacceptable pump operation.

- Floating suction hose to allow cleaner surface water to be pumped out.

- Portable Sediment Tank:
  - Construct with steel drums, sturdy wood or other material suitable for handling the pressure exerted by the water and sediment. The tank should be sturdy enough to enable transfer off-site under fully loaded conditions. A stable access path should be provided for a removal vehicle.

  - Use the following formula to determine the minimum storage volume of the tank:

    Pump discharge (l/s) x 7.3 = m^3 of storage required.
    Note: 1 l/s = 0.001 m^3/s = 15.85 gpm.

  - Design tank to allow for emergency flow over top of tank.
  - Sediment tank minimum depth is 24 in. (600 mm).
  - Locate tank to minimize interference with construction activities.
  - Position tank for easy cleanout and disposal of trapped sediment.
  - Once the water level nears top of tank, shut off pump while the tank drains and additional capacity is made available.
  - Clean-out of the tank is required once one-third of the original capacity is depleted due to sediment accumulation. Clearly mark tank to show the clean-out point.

- Filter Box:
  - The box selected should be made of steel, sturdy wood or other materials suitable to handle the pressure requirements imposed by the water and sediment. 55 gal. (208 l) drums welded top to bottom are normally readily available and, in many cases, will suffice.
  - Use the following formula to determine the minimum storage volume of the filter box:

    Pump discharge (l/s) x 7.3 = m^3 of storage required.
    Note: 1 l/s =0.001 m^3/s = 15.85 gpm.

  - Design box to allow for emergency flow over top of box.
  - Make bottom of the box porous by drilling holes or by other methods.
  - Place aggregate base over holes to a minimum depth of 12 in. (300 mm) (metal hardware cloth may need to be placed between aggregate and the holes if holes are drilled larger than the majority of the stone).
  - Direct effluent over a well vegetated strip of at least 15 m. (50 ft) after leaving base of filter box.
  - Once the water level nears top of box, shut off pump while the box drains and additional capacity is made available.
  - If the stone filter does become clogged with sediment, the stones must be cleared from the inlet, cleaned and replaced.
  - Clean-out of box is required once one-third of the original capacity is depleted due to sediment accumulation. Clearly mark box to show the clean-out point.

- Straw Bale/Silt Fence Pit:
  - Use straw bales, silt fence, a stone outlet and a wet storage pit.

- Use the following formula to determine the minimum storage volume of the pit:

  Pump discharge (l/s) x 7.3 = m^3 of storage required.
  Note: 1 l/s = 0.001 m^3/s = 15.85 gpm.

- The excavated area should be a minimum of 3 ft (1 m) below the base of the straw bales and silt fence.
- Installation guidelines can be found under TCP-13: Silt Fences and TCP-14: Straw Bale Barrier.
- Once the water level nears the crest of stone weir (emergency overflow), shut off pump while the structure drains down to the top of the wet storage pit.
- The wet storage pit may be dewatered only after a minimum of 6 hours of sediment settling time. Pump effluent across a well-vegetated area or through a silt fence prior to discharge.
- Once the wet storage area becomes filled to one-half of the excavated depth, accumulated sediment shall be removed and properly disposed.

■ Sump Pit and Perforated Standpipe Wrapped in Filter Fabric:
- Use filter fabric as required for silt fence fabric, described in TCP-13: Silt Fences, or similar material approved by the Engineer.
- Design pit and size of standpipe according to dewatering discharge requirement.
- The standpipe wrapped in filter fabric shall be surrounded by stones, which filter the water as it collects in the pit before being pumped out.

■ Geotextile/Fabric Filter Bags, Tubes and Packs:

There are increasingly available commercial products that filter pumped slurries. Most products utilize geotextile material or fabric in the form of various sized bags, tubes and packs.

- Design/size the filter bag, tube or pack according to the dewatering discharge requirement and manufactures recommendations.
- If it is determined that the filter bag, tube or pack is not as efficient or there is a higher potential for sediment loss while switching packs then perform this operation within a straw/silt fence pit.
- Direct effluent over a well-vegetated strip of at least 50 ft. (15 m) after leaving the filter.
- The filters must be capable of being removed from the site without tearing or other accidental loss of material. Alternatively, the filter can be placed in a slotted grate or other containment, such as a sloped dumpster, allowing for drainage and easier site removal.
- If it is determined that the sediment is “pollutant free” then the captured material may be used for grading and fill elsewhere on the site. If this is done, then properly dispose of the filter material.

Toxics and Petroleum Products

■ In areas suspected of having groundwater pollution, sample the groundwater near the excavation site and have the water tested for known or suspected pollutants at a certified laboratory. Check with TDEC for their requirements for dewatering, additional water quality tests, and disposal options.

- With a permit from the TDEC, you may be able to recycle/reuse pumped groundwater for landscape irrigation, or discharge to the storm sewer. You may also be able to treat pumped groundwater and discharge it to the municipal wastewater treatment plant via the sanitary sewer with expressed written permission from the local sewer authority.

Requirements

- Costs (Capital, O&M)
  - Sediment controls are low cost measures.
  - Treatment and/or discharge of polluted groundwater can be quite expensive.

Maintenance

- Inspect filtering device frequently and repair or replace once the sediment build-up prevents the structure from functioning as designed.
- Accumulated sediment removed from a dewatering device must be spread on site and stabilized or disposed of at a disposal site.
- Inspect excavated areas daily for signs of contaminated water as evidenced by discoloration, oily sheen, or odors.

Limitations

- The controls discussed in this BMP address sediment only. If the presence of polluted water is identified in the contract, the contractor shall implement dewatering pollution controls as required by the contract documents. If the quality of water to be removed by dewatering is not identified as polluted in the contract documents, but is later determined by observation or testing to be polluted, the contractor shall notify the Engineer.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

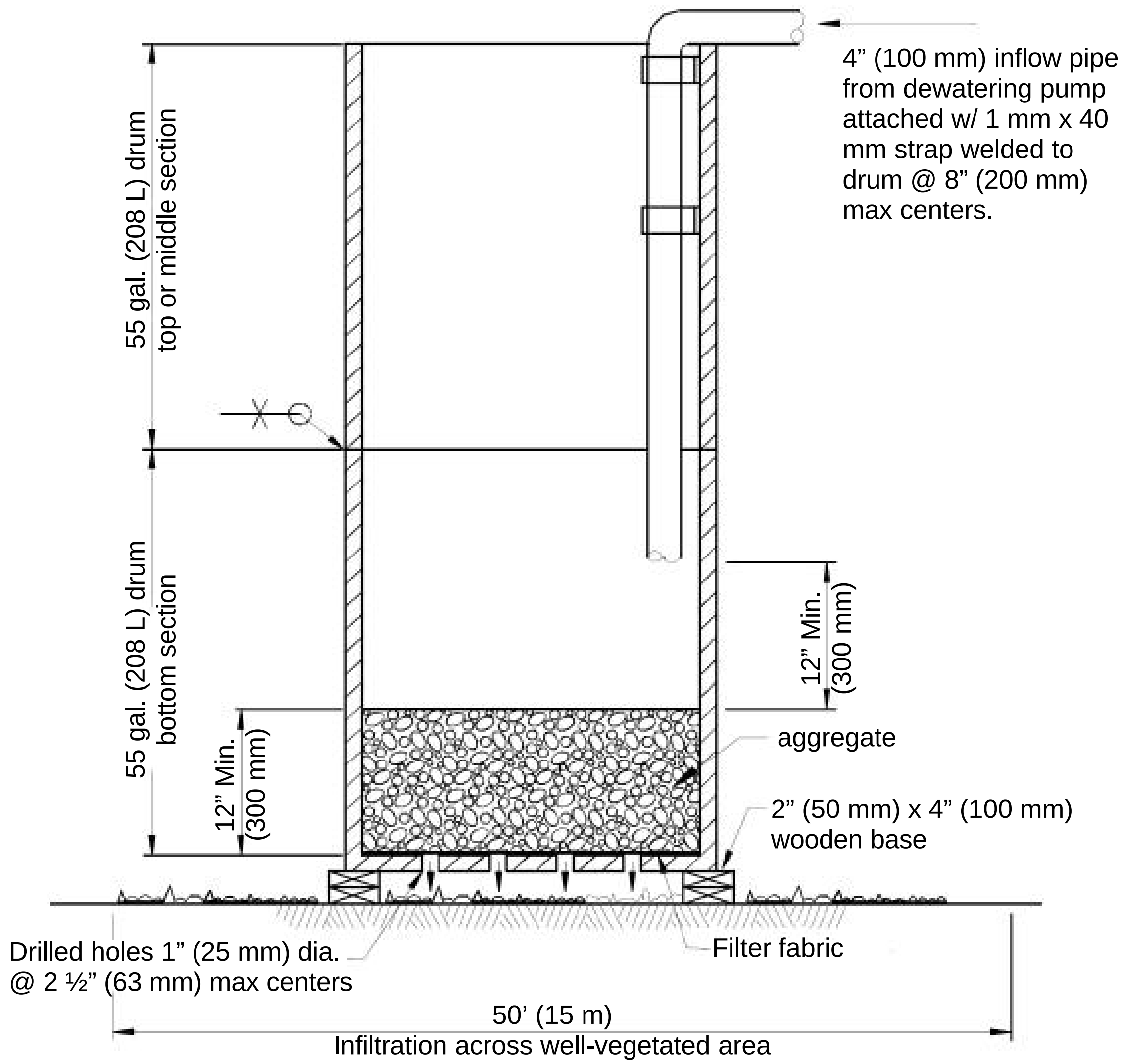
Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

NOTES:
1. Weld shall be designed for the capacity of the tank.
2. For bottom drum, remove top cover only. Remove top & bottom covers for top & middle drums.



TYPICAL FILTER BOX
NOT TO SCALE

Figure CP-02-1
Typical Filter Box

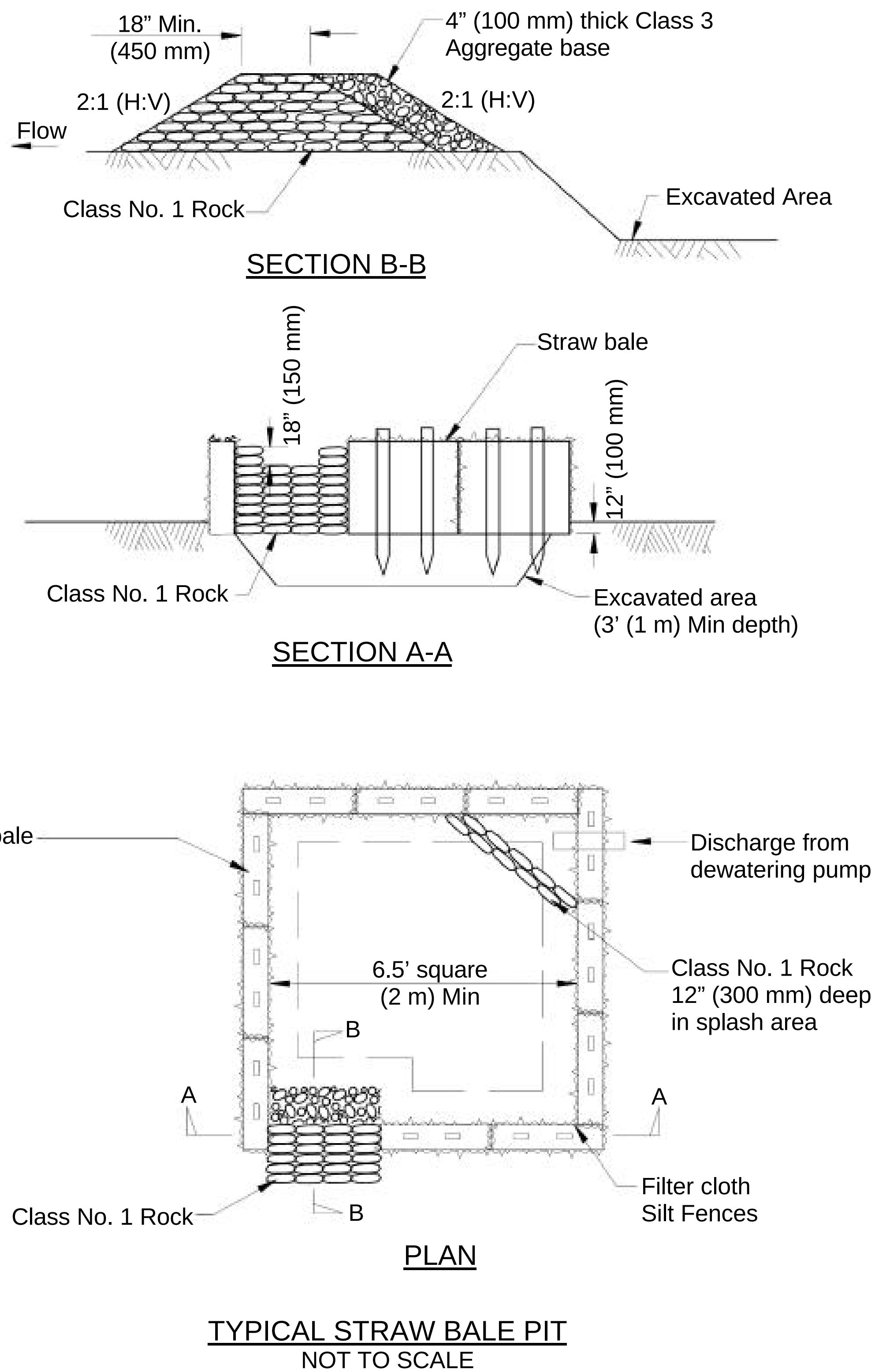


Figure CP-02-2
Typical Straw Bale Pit

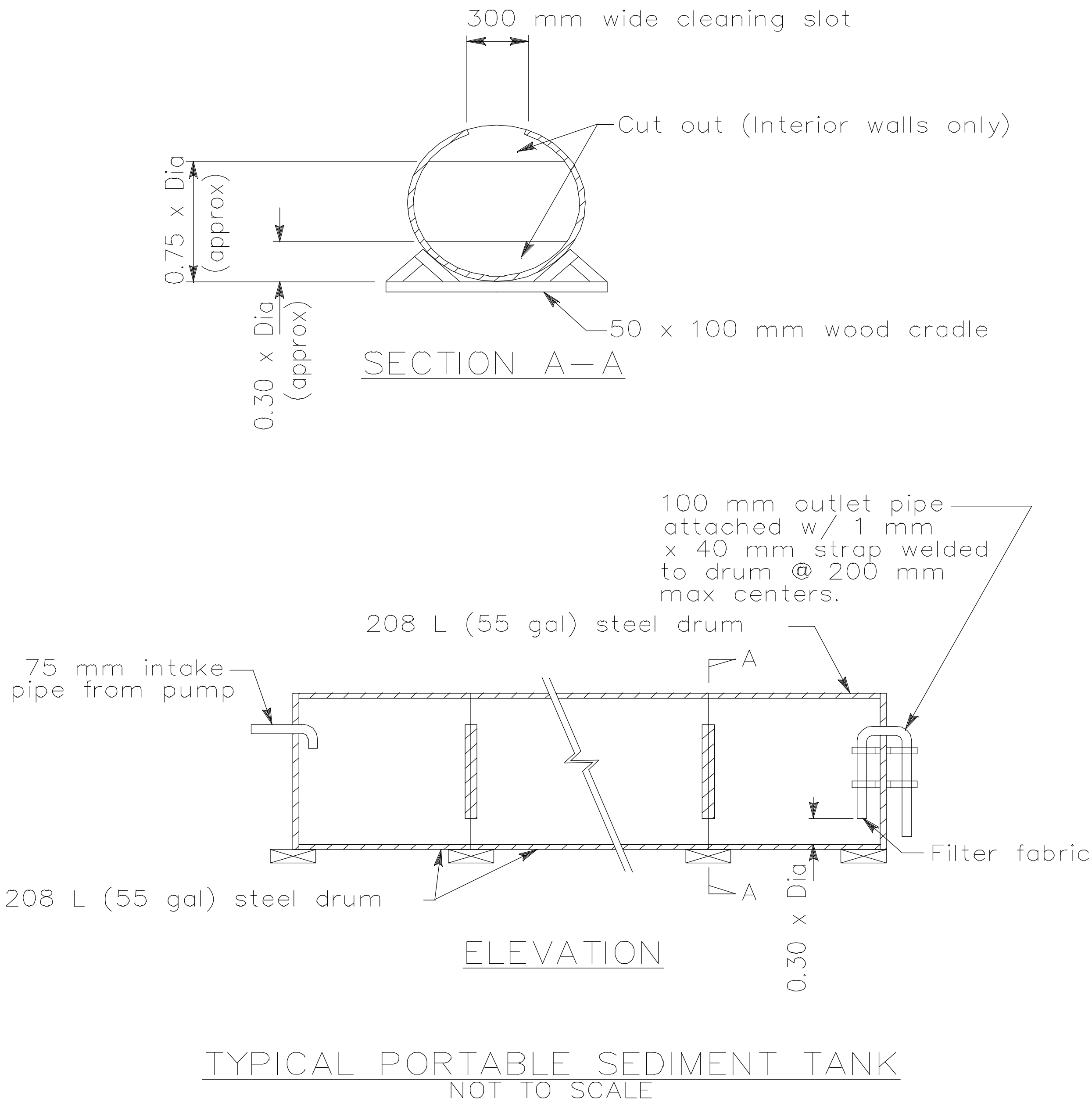
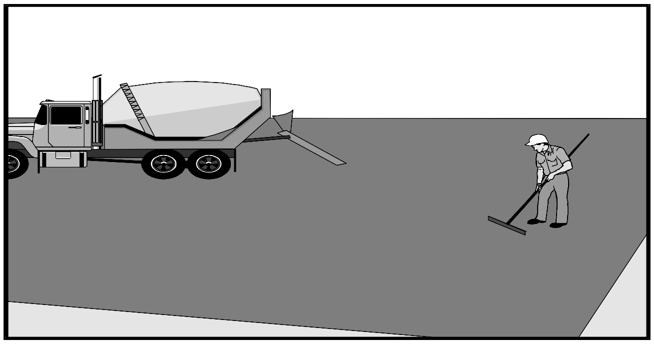


Figure CP-02-3
Typical Portable Sediment Tank

ACTIVITY: Paving Operations	CP – 03



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants from paving operations, using measures to prevent run-on and runoff pollution, properly disposing of wastes, and training of employees and subcontractors. This management practice is likely to create partial reductions in sediment, toxic materials, and oil and grease.

Approach

- Avoid paving during wet weather.
- Store materials away from water courses to prevent stormwater run-on (see CP-5: Material Delivery, Storage, and Use).
- Protect water courses, particularly in areas with a grade, by employing BMPs to divert runoff or trap/filter sediment (see TCP-17, 18, 22, 24, 25).
- Leaks and spills from paving equipment can contain toxic levels of heavy metals and oil and grease. Place drip pans or absorbent materials under paving equipment when not in use. Clean up spills with absorbent materials rather than burying. See CP-13: Vehicle and Equipment Fueling and CP-06: Spill Prevention and Control in this section.
- Cover catch basins and manholes when applying seal coat, tack coat, slurry seal, fog seal, etc.
- There are several commercially available covers that magnetically seal flat catch basins and inlets. Shovel or vacuum saw-cut slurry and remove from site. Cover or barricade storm drains during saw cutting to contain slurry.
- If paving involves portland cement concrete, see CP-10: Concrete Waste Management in this section.

- If paving involves asphaltic concrete, follow these steps:
  - Do not allow sand or gravel placed over new asphalt to wash into storm drains, streets, or creeks by sweeping. Properly dispose of this waste by referring to CP-07: Solid Waste Management in this section.
  - Old asphalt must be disposed of properly. Collect and remove all broken asphalt from the site and recycle whenever possible.
  - If paving involves on-site mixing plant, follow the stormwater permitting requirements for industrial activities.

- Train employees and subcontractors about the importance of these practices.

Requirements

- Costs (Capital, O&M)
  - All of the above are low cost measures.

Maintenance

- Inspect and maintain machinery regularly to minimize leaks and drips.

- Maintain inlet protection so that water is not allowed to back up onto areas subject to traffic. If water begins to backup and flood areas subject to traffic, the protective device must be removed and alternative measures deployed.

- Clean inlet protection measures when sediment reaches the sediment storage capacity. Repair inlet protection measures as needed.

- Inspect employees and subcontractors to ensure that measures are being followed.

- Keep ample supplies of drip pans or absorbent materials on-site.

Limitations

There are no major limitations to this best management practice.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

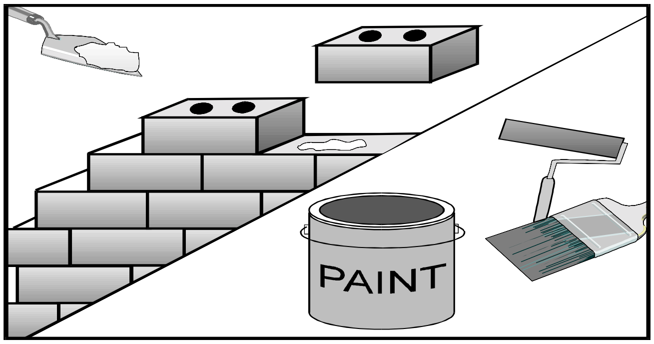
Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Hot-mix Asphalt Paving Handbook, U.S. Army Corps of Engineers, AC 150/5370-14, Appendix I, July 1991.

ACTIVITY: Structure Construction and Painting | CP – 04



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	○ Heavy Metals	● Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	◗ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	● Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from structure construction and painting by enclosing, covering, or berming building material storage areas, using good housekeeping practices, using safer alternative products, and training employees and subcontractors. This management practice is likely to cause a significant reduction in floatable materials and other construction wastes as well as 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 Temporary Construction Site Management 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 CP-05: Material Delivery, Storage and Use in this section.
- Properly store and dispose waste materials generated from the activity. See the waste management BMPs CP-7, 8, 9, 10 and 11 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.

- 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.

Requirements

- Costs (Capital, O&M)
  - These BMPs are generally of low to moderate cost.

Maintenance

- Maintenance should be minimal.

- Spot check employees and subcontractors at least monthly throughout the job to ensure appropriate practices are being employed.

Limitations

- Safer alternative products may not be available, suitable, or effective in every case.

- Hazardous waste that cannot be re-used or recycled must be disposed of by a licensed hazardous waste hauler.

- Be certain that actions to help stormwater quality are consistent with State-and Fed-OSHA and air quality regulations.

Additional Information

Construction and painting activities can generate pollutants that can reach stormwater if proper care is not taken. The sources of these contaminants may be solvents, paints, paint and varnish removers, finishing residues, spent thinners, soap cleaners, kerosene, asphalt and concrete materials, adhesive residues, and old asbestos insulation. For specific information on some of these wastes see the following BMPs in this section:

CP-07 Solid Waste Management,
CP-08 Hazardous Waste Management,
CP-09 Contaminated Soil Management, and
CP-10 Concrete Waste Management.

More specific information on structure construction practices is listed below.

Erosion and Sediment Control

If the work involves exposing large areas of soil or if old buildings are being torn down and not replaced in the near future, employ the appropriate soil erosion and control techniques described in the Temporary Construction Management Practices' (TCP) section.

Storm/Sanitary Sewer Connections

Carefully install all plumbing and stormwater systems. Cross connections between the sanitary and storm drain systems, as well as any other connections into the stormwater system from inside a building, are illegal. Color code or flag pipelines on the project site to prevent such connections, and train construction personnel. See CP-11: Sanitary/Septic Waste Management for additional details.

Painting

Local air pollution regulations may, in many areas of the state, specify painting procedures that if properly carried out are usually sufficient to protect stormwater quality. These regulations may require that painting operations be properly enclosed or covered to avoid drift. Use temporary scaffolding to hang drop cloths or draperies to prevent drift. Application equipment that minimizes overspray also helps. When using sealants on wood, pavement, roofs, etc., quickly clean up spills. Remove excess liquid with absorbent material or rags.

If painting requires scraping or sand blasting of the existing surface, use a drop cloth to collect most of the chips. Dispose the residue properly. If the paint contains lead or tributyl tin, it is considered a hazardous waste. Refer to the waste management BMPs in this section for more information.

Mix paint indoors, in a containment area, or in a flat unpaved area not subject to significant erosion. Do so even during dry weather because cleanup of a spill will never be 100% effective. Dried paint will erode from sloped surfaces and be washed away by storms. If using water based paints, clean the application equipment in a sink that is connected to the sanitary sewer or in a containment area where the dried paint can be readily removed. Properly store leftover paints if they are to be kept for the next job, or dispose of properly.

Roof Work

When working on roofs, if small particles have accumulated in the gutter, either sweep out the gutter or wash the gutter and trap the particles at the outlet of the downspout. A sock or geofabric placed over the outlet may effectively trap the materials. If the downspout is lined tight, place a temporary plug at the first convenient point in the storm drain and pump out the water with a vactor truck, and clean the catch basin sump where you placed the plug.

Primary References

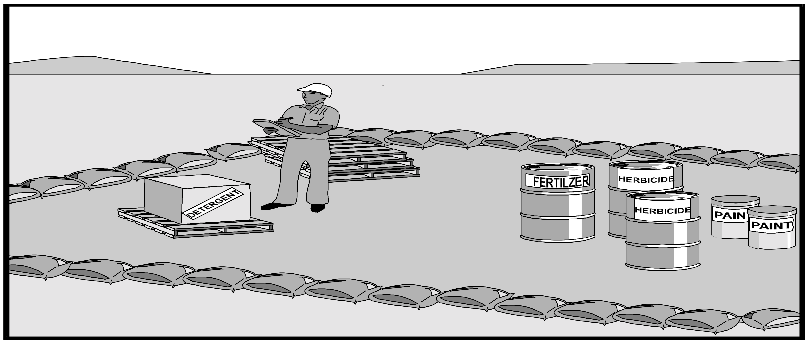
California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

ACTIVITY: Material Delivery, Storage, and Use	CP – 05



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
◗ Sediment	○ Heavy Metals	◗ Floatable Materials	○ Oxygen Demanding Substances	
◗ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from material delivery and storage by minimizing the storage of hazardous materials on-site, storing materials in a designated area, installing secondary containment, conducting regular inspections, and training employees and subcontractors.

This best management practice covers only material delivery and storage. It is likely to partially reduce sediment, nutrients, toxic materials, oil and grease, and floatable materials. For other information on materials, see CP-06: Spill Prevention and Control. For information on wastes, see the waste management BMPs CP-7, 8, 9, 10 and 11 in this section.

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.

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:

- Designate areas of the construction site for material delivery and storage.
  - Place near the construction entrances and away from waterways.
  - Avoid transport near drainage paths or waterways.
  - Surround with earth berms, dikes, swales or other containment practices.
  - Place in an area which will be paved.
- 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.
- Follow manufacturer's instructions regarding uses, protective equipment, ventilation, flammability, and mixing of chemicals.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet.
- Keep an accurate, up-to-date inventory of materials delivered and stored on-site.
- Keep your inventory as close to "when you need it" levels as possible.
- Minimize hazardous materials stored on-site and handle hazardous materials as infrequently as possible.
- 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.
- 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.
- 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.
- Train employees and subcontractors.

- Employees trained in emergency spill cleanup procedures should be present when dangerous materials or liquid chemicals are unloaded.
- Personnel who use pesticides should be trained in their use.
- Do not over-apply fertilizers, herbicides, and pesticides. Prepare only the amount needed. Follow the recommended usage instructions. Over-application is expensive and environmentally harmful. Unless on steep slopes, till fertilizers into the soil rather than hydroseeding. 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.
- If significant residual materials remain on the ground after construction is complete, properly remove materials and any contaminated soil. If the area is to be paved, pave as soon as materials are removed to stabilize the soil.
- Stockpile soil in a central location and protect the stockpile from run-on. Apply suitable controls to remove sediment from runoff from the stockpile by measures such as silt fences, straw bale barriers, sand bag barriers, sediment traps or basins. If the stockpile will be inactive for an extended period, plant temporary vegetation or install long-term perimeter controls. Smaller stockpiles may be protected with tarps.
- Have proper storage instructions posted at all times in an open and conspicuous location. Periodically review this with field supervisors and inspectors.
- Contain and clean up any spill immediately.

Maintenance

- Keep the designated storage area clean and well organized.
- Conduct routine weekly inspections and check for external corrosion of material containers.
- Keep an ample supply of spill cleanup materials near the storage area.
- Inspect storage areas before and after rainfall events, and at least weekly during other times.
- Repair and/or replace perimeter controls, containment structures, and covers as needed to keep them properly functioning.

Limitations

- Space or other construction site limitations may preclude indoor storage.
- Storage sheds often must meet building and fire code requirements.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites; Flood Control District of Maricopa County, AZ, September 1992.

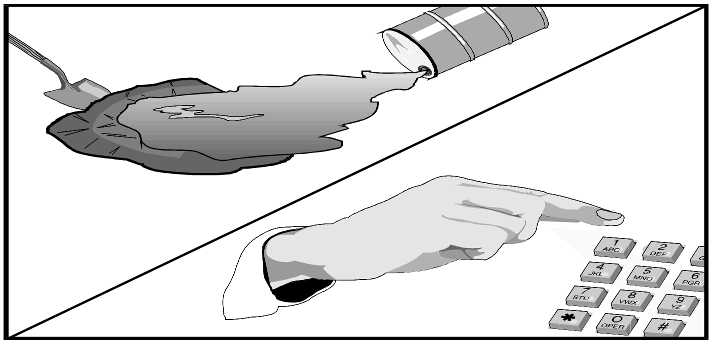
Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance, Working Group Working Paper; USEPA, April 1992.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Spill Prevention and Control

CP – 06



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	◗ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from leaks and spills by reducing the chance for spills, stopping the source of spills, containing and cleaning up spills, properly disposing of spill materials, and training employees. This management practice is likely to create a partial reduction in toxic materials and oil and grease.

This best management practice covers only spill prevention and control. However, CP-05: Material Delivery, Storage, and Use also contains useful information, particularly on spill prevention. For information on wastes, see the waste management BMPs in this section.

Spill prevention and control applies to chemicals and hazardous substances including, but not limited to:

- Soil stabilizers
- Palliatives
- Herbicides
- Growth inhibitors
- Fertilizers
- Deicing/anti-icing chemicals
- Fuels
- Lubricants
- Other Petroleum distillates

This management practice is likely to create a partial reduction in the impacts caused by toxic materials and oil and grease.

Approach

The following steps will help reduce the stormwater impacts of leaks and spills:

Define "Significant Spill"

- Different materials pollute in different amounts. Make sure that each employee knows what a "significant spill" is for each material they use, and what is the appropriate response for "significant" and "insignificant" spills. A significant spill should be defined after review of the Materials Safety Data Sheet or other descriptive documentation that presents the contents and proper handling procedures.

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.
- 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.

  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 TDEC general hotline – environmental assistance at 1-888-891-8332 (TDEC).

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 CP-13 and 14 for details about spill prevention and control while maintaining or fueling vehicles and equipment.

Requirements

- Costs (Capital, O&M)
  - Prevention of leaks and spills is inexpensive. Treatment and/or disposal of contaminated soil or water can be quite expensive.

Maintenance

- Keep ample supplies of spill control and cleanup materials on-site, near storage, unloading, and maintenance areas.
- Update your spill prevention and control plan and stock cleanup materials as changes occur in the types of chemicals on-site.

Limitations

- Use only a reputable, licensed spill clean up company to clean up large spills.
- Procedures and practices presented in this BMP are general. Contractor shall identify appropriate practices for the specific materials used or stored on site.
- If necessary, use a private spill cleanup company.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

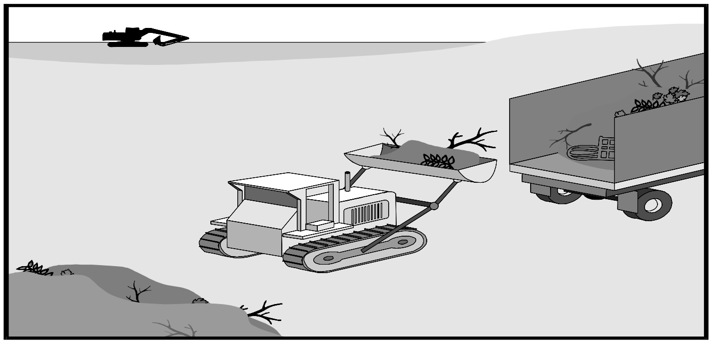
Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Solid Waste Management	CP – 07



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
◗ Sediment	○ Heavy Metals	● Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	● Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from solid or construction waste by providing designated waste collection areas and containers, arranging for regular disposal, and training employees and subcontractors. This management practice is likely to create a significant reduction in floatable materials and other construction wastes as well as a partial reduction in sediment.

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 falsework; 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:

- 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 nonhazardous 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.
- 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.

Limitations

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

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

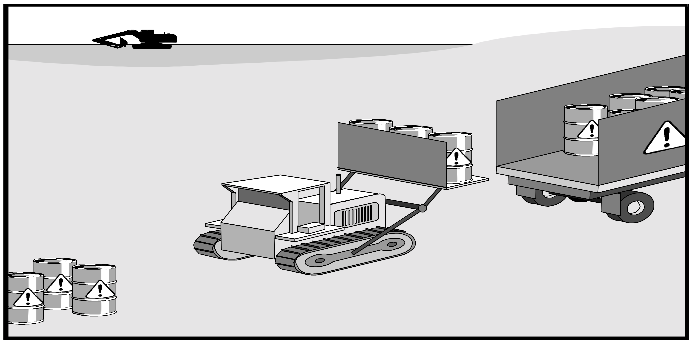
Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites; Flood Control District of Maricopa County, AZ, September 1992.

Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity; USEPA, 430/9-73-007,1973.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Hazardous Waste Management	CP – 08



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
○ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	◗ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
○ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from hazardous waste through proper material use, waste disposal, and training of employees and subcontractors. This management practice is likely to create 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).

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

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.
- Use containment berms in fueling and maintenance areas and where the potential for spills is high.

- Segregate potentially hazardous waste from nonhazardous 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.
- 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.

Limitations

- 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.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

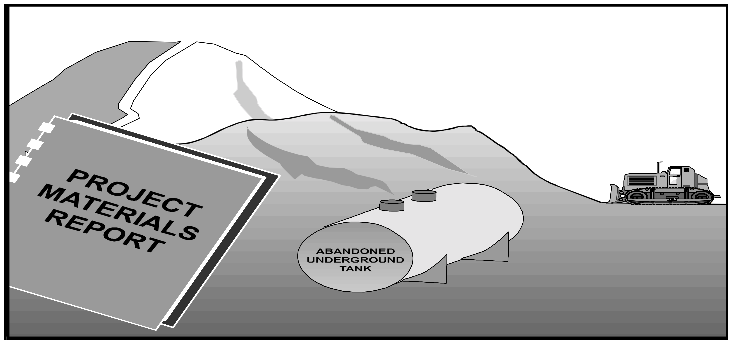
Subordinate References

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity; USEPA, 430/9-73-007, 1973.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Contaminated Soil Management	CP – 09



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
◗ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	● Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	◗ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from contaminated soil and highly acidic or alkaline soils by conducting pre-construction surveys, inspecting excavations regularly, and remediating contaminated soil promptly. This management practice is likely to create a significant reduction in toxic materials as well as a partial reduction in sediment.

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.

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.

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);
- Tennessee Department of Environment and Conservation (TDEC);
- Tennessee Division of Occupation Safety and Health Administration (T-OSHA); and

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).
- 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 TDEC 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 CP-05: 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.
- 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 TDEC, 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 TDEC 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.

Requirements

- Costs (Capital, O&M)
  - Prevention of leaks and spills is inexpensive.
  - Treatment and/or disposal of contaminated soil can be quite expensive.

Maintenance

- Inspect excavated areas daily for indications of contaminated soil.

- Implement CP-06: 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.

Limitations

- 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 CP-02: Dewatering Operations for more information.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

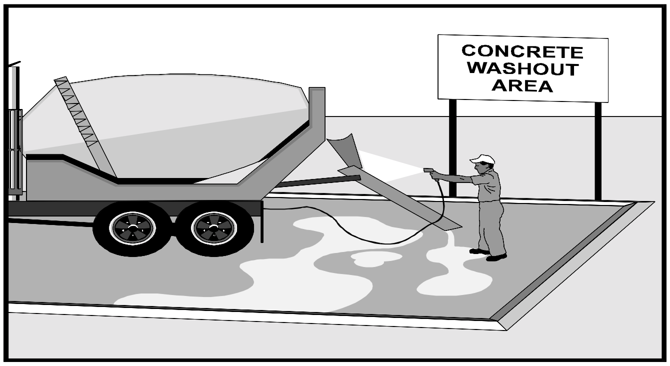
Subordinate References

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity; USEPA, 430/9-73-007, 1973.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Concrete Waste Management — CP – 10



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	◗ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting washout off-site, performing on-site washout in a designated area, and training employees and subcontractors. This management practice is likely to create a partial reduction in construction waste.

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;
  - 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.

Requirements

- Costs (Capital, O&M)
  - All of the above are low cost measures.

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.

Limitations

- Off-site washout of concrete wastes may not always be possible.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

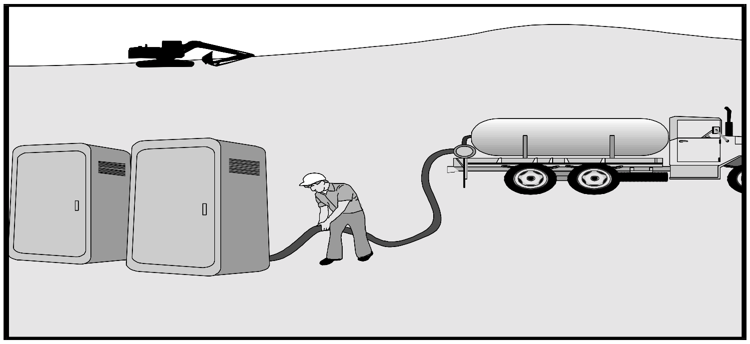
Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites; Flood Control District of Maricopa County, AZ, July 1992.

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Sanitary/Septic Waste Management	CP – 11



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from sanitary/septic waste by providing convenient, well-maintained facilities, and arranging for regular service and disposal. This management practice is likely to cause a partial reduction in construction waste.

Approach

Sanitary or septic wastes should be treated or disposed of in accordance with TDEC 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. TDEC 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. TDEC 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.
- 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.

Requirements

- Costs (Capital, O&M)
  - All of the above are low cost measures.

Maintenance

- Inspect facilities regularly.

- Arrange for regular waste collection.

Limitations

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

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

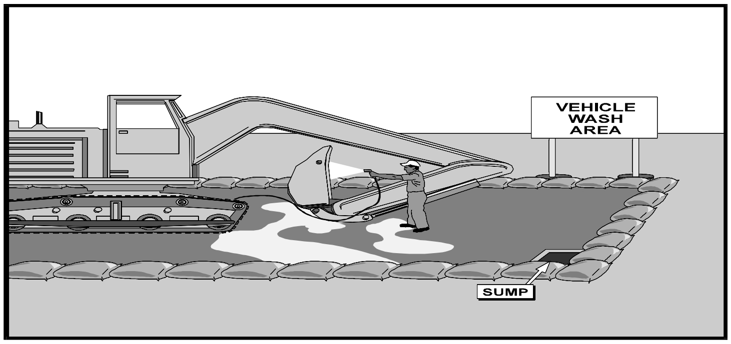
Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites; Flood Control District of Maricopa County, AZ, September 1992.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Vehicle and Equipment Cleaning — CP – 12



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
◗ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from vehicle and equipment cleaning by using off-site facilities, washing in designated, contained areas only, eliminating discharges to the storm drain by infiltrating or recycling the wash water, and training employees and subcontractors. This management practice is likely to cause a partial reduction in toxic materials and oil and grease.

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. Nashville and Davidson County are also bound by permits from TDEC to discourage this practice with actions up to fines and other legal action.

- 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.

- 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.

- For a quick reference on disposal alternatives for specific wastes, see Table CP-21-1.

- 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:

  - Located away from storm drain inlets, drainage facilities, or watercourses;
  - Paved with concrete or asphalt, or stabilized with an aggregate base;
  - Configured wash area with a sump to allow collection and disposal of wash water;
  - 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:

  - 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.
  - Use positive shutoff valve to minimize water usage.

- DO NOT use solvents to clean vehicles/equipment on site.

Requirements

- Costs (Capital, O&M)
  - All of the above are low cost measures.

Maintenance

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

- Service sump regularly.

Limitations/ Additional Information

- Even phosphate-free, biodegradable soaps have been shown to be toxic to fish before the soap degrades.

- 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.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Swisher, R.D., 1987, *Surfactant Biodegradation*, Marcel Decker Corporation.

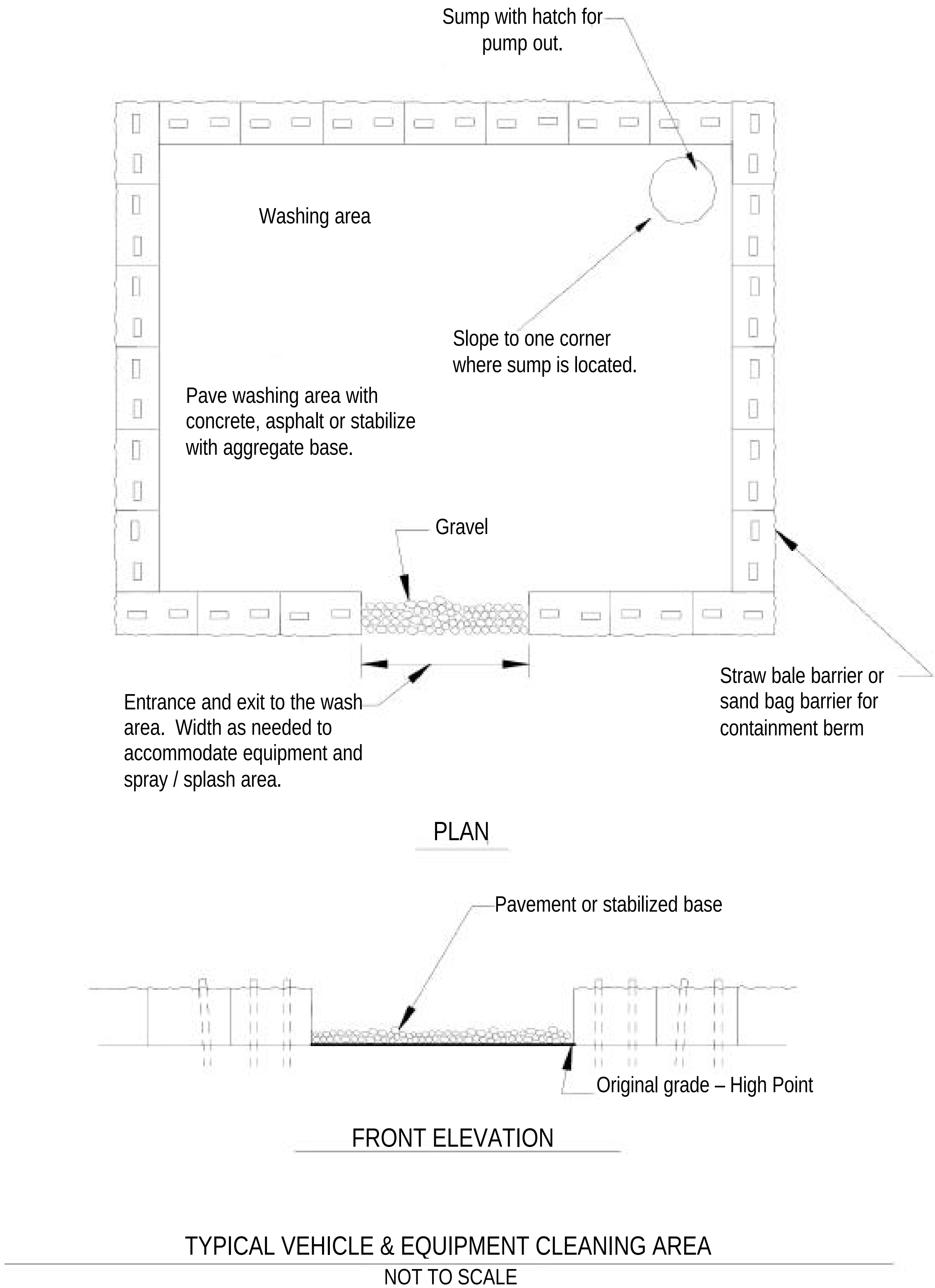
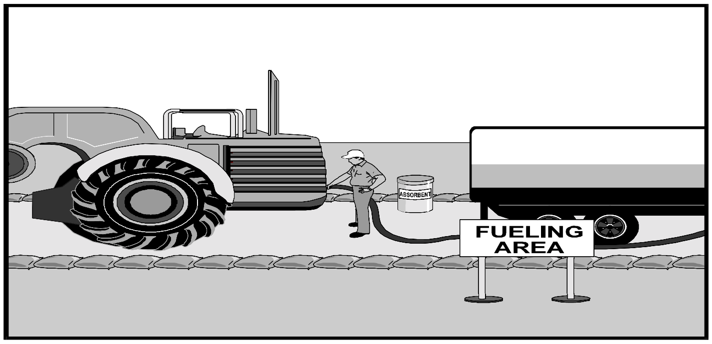


Figure CP-12-1
Typical Vehicle & Equipment Cleaning Area

ACTIVITY: Vehicle and Equipment Fueling	CP – 13



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High		◗ Medium		○ Low
◗ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent fuel spills and leaks, and reduce their impacts 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. This management practice is likely to create a partial reduction in toxic materials and oil and grease.

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.

- 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.

Requirements

- Costs (Capital, O&M)
  - All of the above measures are low cost, except for the capital costs of above ground tanks that meet all local environmental, zoning, and fire codes.

Maintenance

- Keep ample supplies of spill cleanup materials on-site.

- Inspect fueling areas and storage tanks on a regular schedule.

Limitations

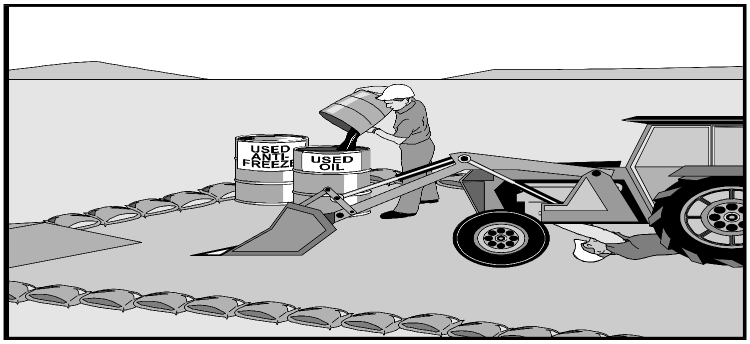
- Sending vehicles/equipment off-site should be done in conjunction with a stabilized construction entrance.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

ACTIVITY: Vehicle and Equipment Maintenance — CP – 14



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from vehicle and equipment maintenance by running a “dry site”. This 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. This management practice is likely to create a significant reduction in toxic materials and oil and grease.

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 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.
- Perform maintenance activities on paved surfaces where practical.
- Use diversion berms to protect maintenance areas from run-on.
- 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.

Limitations

- 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 CP-13: Vehicle and Equipment Fueling.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites; Flood Control District of Maricopa County, AZ, September 1992.

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance, Working Group Working Paper; USEPA, April 1992.

ACTIVITY: Employee/Subcontractor Training

CP – 15

Description

Employee/subcontractor training, like maintenance or a piece of equipment, is not so much a best management practice as it is a method by which to implement BMPs. This fact sheet highlights the importance of training and of integrating the elements of employee/subcontractor training from the individual source controls into a comprehensive training program as a part of a Storm Water Pollution Prevention Plan (SWPPP).

The specific employee/subcontractor training aspects of each of the source controls are highlighted in the individual fact sheets. The focus of this fact sheet is more general, and includes the overall objectives and approach for assuring employee/subcontractor training in stormwater pollution prevention. Accordingly, the organization of this fact sheet differs somewhat from the other fact sheets in this section.

Objective

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).
- 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 CP-15-1) 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.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

TABLE CP-15-1 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 (Metro Nashville-Davidson County-sponsored drop-off site at 941 Dr. Richard Adams Drive)
- POTW — Publicly Owned Treatment Plant – Metro Water Services (MWS)
- MDPW-NPDES — Metropolitan Department of Public Works (DPW) – 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	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.)			

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
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	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. Note: Thoroughly sweep following removal of dirt in all four alternatives.		
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.
Rinsewater 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	1. Recycle/reuse (concrete, wood, etc.).		1. Recycle/reuse (concrete, wood, etc.).

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
debris	2. Dispose as trash.		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 nonhazardous 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 mopwater to sanitary sewer (or collect rinsewater and pump to the sanitary sewer). 3. Same as 2 above, but with rinsewater (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 mopwater 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 rags or adsorbents. b. Sweep (Use dry absorbent as needed). c. Use 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 rinsewater as product. Dispose rinsed containers as trash. 2. Dispose unused pesticide as hazardous waste.		1. Use up. Rinse containers, use rinsewater 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	
Rinsewater 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 mopwater 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 products, 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 if necessary; discharge to sanitary sewer. 3. Treat and discharge to storm drain.	MDPW-NPDES POTW-MWS MDPW-NPDES	
Fire fighting flows	If contamination is present, Fire Dept. will attempt to prevent flow to stream or 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 rinsewater may flow to storm drain).		

TABLE CP-15-1 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 (Metro Nashville-Davidson County-sponsored drop-off site at 941 Dr. Richard Adams Drive)
- POTW — Publicly Owned Treatment Plant – Metro Water Services (MWS)
- MDPW-NPDES — Metropolitan Department of Public Works (DPW) – 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.)			

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
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	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. Note: Thoroughly sweep following removal of dirt in all four alternatives.		
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.
Rinsewater 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	1. Recycle/reuse (concrete, wood, etc.).		1. Recycle/reuse (concrete, wood, etc.).

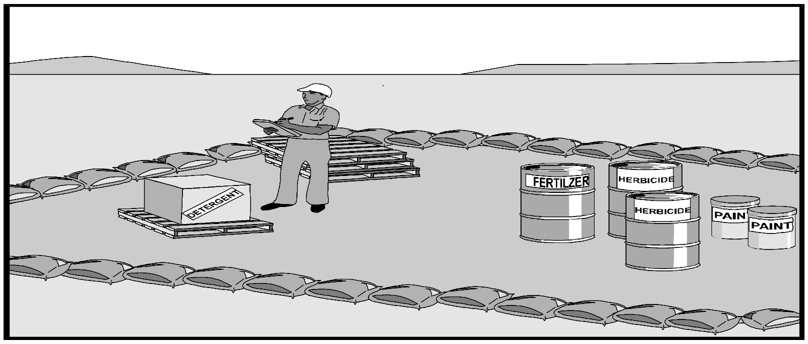
DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
debris	2. Dispose as trash.		2. Dispose as trash.
Hazardous demolition and construction debris (e.g. asbestos)	1. Dispose as hazardous waste.		1. Do not attempt to remove yourself. Contact asbestos removal 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 nonhazardous 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 mopwater to sanitary sewer (or collect rinsewater and pump to the sanitary sewer). 3. Same as 2 above, but with rinsewater (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 mopwater 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 rags or adsorbents. b. Sweep (Use dry absorbent as needed). c. Use 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 rinsewater as product. Dispose rinsed containers as trash. 2. Dispose unused pesticide as hazardous waste.		1. Use up. Rinse containers, use rinsewater 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	
Rinsewater 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 mopwater 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 products, 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 if necessary; discharge to sanitary sewer. 3. Treat and discharge to storm drain.	MDPW-NPDES POTW-MWS MDPW-NPDES	
Fire fighting flows	If contamination is present, Fire Dept. will attempt to prevent flow to stream or 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 rinsewater may flow to storm drain).		

ACTIVITY: Pesticides, Herbicides, and Fertilizer Use	CP – 16



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Promote efficient and safe housekeeping practices (storage, use, and cleanup) when handling potentially harmful materials such as fertilizers, herbicides, and pesticides. This management practice is likely to create a significant reduction in nutrients, toxic materials, and oxygen demanding substances. Related information is provided in CP-06: Spill Prevention and Control.

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.

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:
  - in trash,
  - down storm drains or into creeks,
  - onto the ground, or
  - 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 941 Dr. Richard Adams Drive. For more information call 862-8620.

Requirements

- 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.

Limitations

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

Primary References

California Storm Water Best Management Practice Handbooks, *Municipal Handbook*, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

The Bay Begins at Your Door (Brochure), Santa Clara Valley Nonpoint Source Pollution Control Program, (No date).

Guide to Hazardous Products Around the Home (Booklet), Household Hazardous Waste Project, 1989.

Hazardous Household Products: A guide to the Disposal of Hazardous Household Products and the Use of Non-Hazardous Alternatives, California Department of Toxic Substance Control.

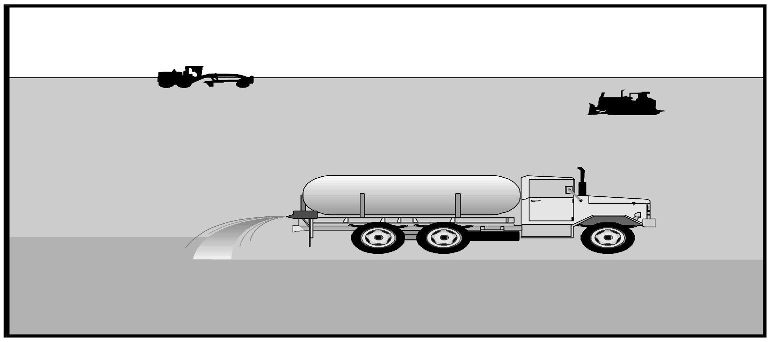
Household Cleaners and Polishes: Chemical Hazards in the Home (Brochure), Golden Empire Health Planning Center, (No date).

Solvents, Chemical Hazards in the Home (Brochure), Golden Empire Health Planning Center, (No date).

Take Me Shopping: A Consumer Guide to Safe Alternatives for Household Hazardous Products (Booklet), Santa Clara County and City of Palo Alto, 1992.

Your Guide to Less Toxic Shopping: Safer Alternatives for Your Home and Life! (Booklet), San Francisco Household Hazardous Waste Program, 1992.

ACTIVITY: Dust Control	CP – 17



Targeted Constituents

● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit

● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances

○ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements

● High	◗ Medium	○ Low

○ Capital Costs	◗ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Dust control measures are used to stabilize soil from wind erosion, and reduce dust generated by construction activities. This thereby reduces the amount of eroded materials available for stormwater runoff. Dust control is considered primarily as a temporary measure-an intermediate treatment between disturbance in either construction, paving, or vegetation. This management practice is likely to create a significant reduction in sediment as well as partial reductions in toxic materials and oil and grease.

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.

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 TCP-01, 02 and 03.
- 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 CP-17-1 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 recommendations for their use are tabulated in Table CP-17-2, 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, subgrade 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:

- Ideally, application should begin in late spring, after seasonal rains - not during or just before heavy rainfall- so that subgrade 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.

Requirements

- Cost
  - Individual installation costs for water/chemical dust suppression are low, but annual costs may be quite high since these measures are effective for only a few hours to a few days.
  - This may warrant selection of other soil stabilization practices.

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.

Limitations

- Watering prevents dust only for a short period and should be applied daily (or more often) to be effective.

- Overwatering may cause erosion. This potential can be limited through use of buffer/filter strips, silt fences, straw bales, vegetation, etc.

- <u>Oil should not be used</u> for dust control because the oil may migrate into drainageways and/or seep into the soil.

- Chemically treated subgrades may make the soil water repellant, interfering with long-term infiltration, and the vegetation/re-vegetation of the site. Some chemical dust suppressants may be subject to freezing and may contain solvents and should be handled properly.

- Asphalt, as a mulch tack or chemical mulch, requires a 24 hour curing time to avoid adherence to equipment, worker shoes, etc. Application should be limited because asphalt surfacing may eventually migrate into the drainage system.

- In compacted areas, watering and other liquid dust control measures may wash sediment or other constituents into the drainage system.

Additional Information

Dust control, as a BMP, is a practice that is already in place for many construction activities.

Many local agencies require dust control in order to comply with local nuisance laws, opacity laws (visibility impairment) and the requirements of the Clean Air Act.

Primary References

California Storm Water Best Management Practice Handbooks, Construction and Industrial Handbooks, CDM et.al. for the California SWQTF, 1993.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

California Air Pollution Control Laws, California Air Resources Board, 1992.

CalTrans, Standard Specifications, Sections 10, "Dust Control"; Section 17, "Watering"; and Section 18, "Dust Palliative".

Prospects for Attaining the State Ambient Air Quality Standards for Suspended Particulate Matter (PM10), Visibility Reducing Particles, Sulfates, Lead, and Hydrogen Sulfide, California Air Resources Board, April 1991.

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USDA Soil Conservation Service, *"Guides for Erosion and Sediment Control"*.

TABLE CP-17-1 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 CP-17-2 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.

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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		

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ACTIVITY: Maintenance of Collection Facilities and Appurtenances	CP – 18

Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	● Heavy Metals	● Floatable Materials	● Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	● Oil & Grease	● Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High	◗ Medium	○ Low		
● Capital Costs	● O & M Costs	● Staff	◗ Admin	◗ Training

Description

Maintain catch basins and stormwater inlets on a regular basis to remove pollutants, reduce high pollutant concentrations during the first flush of storms, prevent clogging of the downstream conveyance system, and restore the catch basins' sediment trapping capacity. A catch basin is distinguished from a stormwater inlet by having at its base a sediment sump designed to catch and retain sediments below the overflow point.

Proper maintenance and siltation removal is required on both a routine and corrective basis to promote effective stormwater pollutant removal efficiencies for wet/dry detention pond and infiltration devices. This management practice is likely to create a significant reduction in sediment, heavy metals, floatable materials, oxygen demanding substances, oil and grease, and bacteria and viruses.

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.

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, TCP-24.
- 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.

Requirements

- Cost Considerations
  - Frequent sediment removal can be labor intensive and costly. However, properly designed ponds allow for easy removal of accumulated sediments at relatively minor cost.
  - Cost of waste material for transport and disposal.
- 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.

- 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, Tennessee Department of Environment and Conservation, and the Tennessee Valley Authority.

Limitations

- Wet detention pond dredging can produce slurried waste that often exceeds the requirements of many landfills. See CP-02: Dewatering Operations.

- Frequent sediment removal is labor and cost intensive.

- If storm channels or basins are recognized as wetlands, many activities, including maintenance, may be subject to regulation by TDEC.

Primary References

California Storm Water Best Management Practice Handbooks, Municipal Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices for Storm Drainage Facilities (Draft), Maintenance Subcommittee, Alameda County Urban Runoff Clean Water Program, 1992.

Environmental Criteria Manual, Design Guidelines for Water Quality Control, City of Austin, Texas, 1989.

Ferguson, B.K. 1991. *Urban Stream Reclamation* p. 324-328, Journal of Soil and Water Conservation.

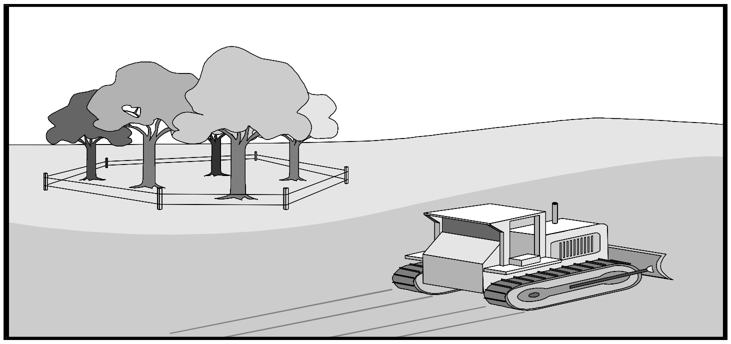
Florida Development Manual: A Guide to Sound Land and Water Management, Storm water and Erosion and Sediment Control BMPs for Developing Areas, Florida Department of Environmental Regulation, 1988.

Protecting Water Quality in Urban Areas: Best Management Practices for Minnesota, Minnesota Pollution Control Agency, 1989.

Stormwater Management Manual for the Puget Sound Basin (The Technical Manual): Volume IV – Urban Land Use BMPs, Washington State Department of Ecology, 1992.

Street Cleaning Practice, American Public Works Association, 1978.

ACTIVITY: Preservation and Maintenance of Existing Vegetation — CP – 19



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

● Sediment	○ Heavy Metals	● Floatable Materials	● Oxygen Demanding Substances

● Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Carefully planned 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 soil or slopes. This management practice is likely to create a significant reduction in sediment, nutrients, floatable materials, and oxygen demanding substances.

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.

Installation/ Application Criteria

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:

  - Life expectancy and present age
  - Health and disease susceptibility
  - Structure
  - Cleanliness
  - Aesthetic values
  - Comfort relative to site temperature variations and wind
  - Wildlife benefits
  - Adaptability to the proposed project
  - Survival needs of the vegetation
  - 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.

- 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.

- 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.

- 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).

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.
- 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.

Requirements

- Costs
  - There is little cost associated with preserving existing vegetation if properly planned during the project design, and may yield aesthetic benefits which enhance property values.
  - Measures to improve the disposition of clippings/cuttings are simple and inexpensive. For the most part, the solution to this problem involves behavior modification through education.

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.

Limitations

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.

Additional Information

The best way to prevent excessive erosion is to minimize the disturbance of the land. On a construction site, where extensive land disturbance is necessary, a reasonable BMP would be to not disturb land in sensitive areas of the site which need not be altered for the project to be viable (e.g., natural watercourses, steep slopes), and to design the site to incorporate particularly unique or desirable existing vegetation into the site landscaping plan. Clearly marking and leaving a buffer area around these unique areas will both help to preserve these areas as well as take advantage of natural erosion prevention and sediment trapping in naturally vegetated areas. Saving existing vegetation and mature trees on-site, beautifies the area and may save money by reducing new landscaping requirements. Mature trees also increase property values and satisfy consumer aesthetic needs.

Existing vegetation to be preserved on the site must be protected from mechanical and other injury while the land is being developed. The purpose of protecting existing vegetation is to ensure the survival of desirable vegetation for shade, beautification, slope and erosion protection. Mature vegetation has extensive root systems that help to hold soil in place, thus reducing erosion and contributing to slope stabilization. Also, vegetation helps to keep soil from drying rapidly and becoming susceptible to erosion. To effectively save existing vegetation, no disturbances of any kind should be allowed within a defined area around the vegetation. For trees, no construction activity should occur within the drip line of the tree.

Preserving and protecting existing vegetation can often result in more stable soil conditions during construction. Careful site planning and identification of plantings to preserve can provide erosion and sedimentation controls during construction, and contribute to the aesthetics of the development.

For new developments in particular, the easiest and least expensive measure is to leave the existing vegetation in place. Native vegetation typically requires much less maintenance than introduced vegetation. Consider mowing or trimming vegetation, both native and introduced, less frequently, thereby generating less waste. If introduced vegetation is necessary, consider planting low maintenance grasses and shrubs. Another advantage to these strategies is considerable water savings.

Once this vegetative waste is generated the main concern is to avoid transport of clippings/cuttings to receiving water bodies. It is necessary to pick up and properly dispose of clippings/cuttings on the slopes and bottom of drainage facilities, including stormwater detention/retention facilities. In addition, the presence of clippings/ cuttings in and around catch basins should be avoided by either using bagging equipment or manually picking the material up. Clippings/cuttings on flat surfaces are generally not transported by stormwater runoff unless the event is particularly intense. Therefore, it is not necessary to pick up or bag clippings/cuttings on flat or nearly flat surfaces. Operators should be trained to use good judgement in determining whether clippings/cuttings should be left in place or collected for disposal or composting.

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

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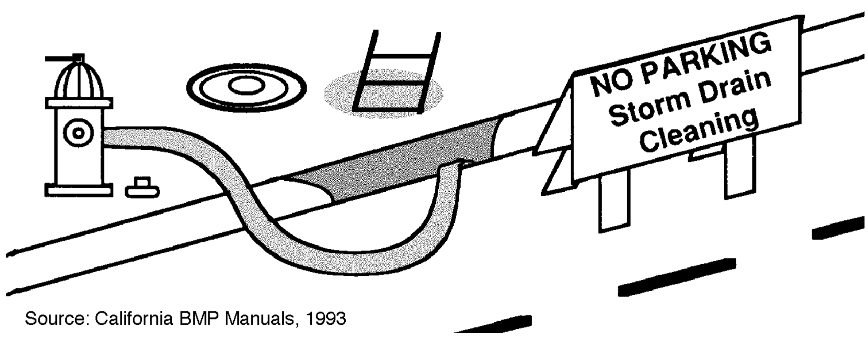
ACTIVITY: System Flushing	CP – 20



Source: California BMP Manuals, 1993

Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

A storm drain is "flushed" with water to suspend and remove deposited materials. Flushing is particularly beneficial for storm drain pipes with grades too flat to be self-cleansing. Flushing helps ensure pipes convey design flow and removes pollutants from the storm drain system. This management practice is likely to create a significant reduction in sediment if flushed effluent is properly collected or treated.

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.

- 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.

Requirements

- Cost Considerations

- Unless flushing to a dry/wet detention pond, the collection of liquid and sediments may be costly in terms of pollutant removal benefits.

■ Regulations

- TDEC 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". TDEC should be consulted if this practice is planned.

■ Equipment

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

Limitations

■ Most effective in small diameter pipes (36-inch (0.91 m) diameter pipe or less, depending on water supply and sediment collection capacity).

■ Available water source.

■ May have difficulty finding downstream area to collect sediments.

■ Requires liquid/sediment disposal.

■ Disposal of flushed effluent to sanitary sewer may be prohibited in some areas.

Additional Information

It has been found that cleansing efficiency of periodic flush waves is dependent upon flush volume, flush discharge rate, sewer slope, sewer length, sewer flow rate, sewer diameter, and population density. As a rule of thumb, the length of line to be flushed should not exceed 700 feet (213.3 m). At this maximum recommended length, the percent removal efficiency from the pipe at the time of flushing ranges between 65-75 percent for organics and 55-65 percent for dry weather grit/inorganic material. The percent removal efficiency drops rapidly beyond that. Water is commonly supplied by a water truck, but fire hydrants can also supply water. To make the best use of water, it is recommended that reclaimed water be used or that fire hydrant line flushing coincide with storm sewer flushing.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Dry Weather Deposition and Flushing for Combined Sewer Overflow Pollution Control, U.S. EPA, EPA-600/2-79-133, August 1979.

SECTION 3
TEMPORARY CONSTRUCTION SITE MANAGEMENT PRACTICES
(TCPs)

Section 3
TEMPORARY CONSTRUCTION SITE MANAGEMENT PRACTICES (TCPs)

3.1 Introduction

This section presents the BMP fact sheets for the Temporary Construction Site Management Practices (TCPs). TCPs predominately focus on practices for Erosion Prevention and Sediment Control (EP&SC).

This section contains the following BMP fact sheets.

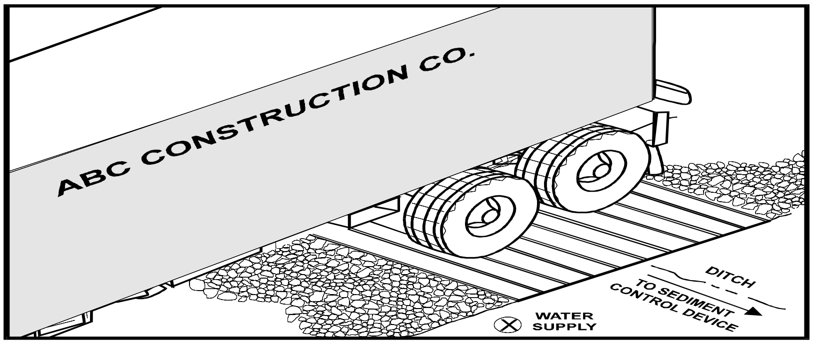
TCP – 01	Tire Washing Facility
TCP – 02	Construction Road Stabilization
TCP – 03	Stabilized Construction Entrance
TCP – 04	Buffer Zones
TCP – 05	Temporary Seeding
TCP – 06	Surface Roughening
TCP – 07	Top Soiling
TCP – 08	Mulching
TCP – 09	Nets and Mats
TCP – 10	Geotextiles
TCP – 11	Terracing
TCP – 12	Check Dams
TCP – 13	Silt Fence
TCP – 14	Weighted Sediment Tube
TCP – 15	Sand Bag Barrier
TCP – 16	Brush or Rock Filters and Continuous Berms
TCP – 17	Sediment Traps
TCP – 18	Temporary Sediment / Detention Basin
TCP – 19	Bank Stabilization
TCP – 20	Rip-rap
TCP – 21	Channel Linings
TCP – 22	Temporary Diversions, Drains and Swales
TCP – 23	Filter Strips
TCP – 24	Temporary Inlet Protection
TCP – 25	Temporary Outlet Protection

Each fact sheet has a quick reference guide indicating what pollutant constituents the BMP is targeting and implementation requirements.

EP&SC is one of the most significant pollution issues for construction sites. Therefore, each fact sheet in this section contains an “Inspection Checklist” to ensure that EP&SC is managed properly. This provides a list of most important items for each of the BMPs. It is not intended to limit the inspection process, but is intended to guide and strengthen the inspection process and maintenance procedures. There may be additional inspection points made by Metro inspectors. However, the “Inspection Checklist” covers a vast majority of the major inspection points.

The BMPs presented in this section are intended to serve as temporary measures (lasting only as long as construction activities). Additional details are provided in sections covering Permanent Erosion Prevention and Sediment Control (PESC) and Permanent Treatment Practices (PTP) for practices that are intended to function on a long-term basis.

ACTIVITY: Tire Washing Facility	TCP – 01



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances

○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

An application that supports a stabilized construction entrance. It is intended to prevent or reduce the discharge of pollutants to the storm drain system or to watercourses as a result of vehicular ingress and egress to the construction site by providing facilities that remove mud and dirt from vehicle tires and undercarriages to prevent these materials from being deposited onto public roads. See TCP-03, for similar discussion on stabilized construction entrance. This management practice is likely to create a significant reduction in sediment.

Approach

- Incorporate with a stabilized construction entrance. See TCP-03.
- Place a layer of 2- to 3-inch (5.1- to 7.6-cm) stone across the full width of the exit.
- Construct on level ground when possible, on a pad of coarse aggregate.
- 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 be of sufficient grade, width, and depth 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.
- It is strongly encouraged that perimeter fencing be installed proximate to the construction entrance that will limit egress to the designated construction exit(s).

Maintenance

- Remove accumulated sediment in wash rack and/or sediment trap to maintain system performance.
- Inspect routinely for damage and repair as needed.

Limitations

- Requires a supply of wash water.
- Requires a turnout or double-wide exit to avoid entering vehicles from having to drive through the wash area.

Primary References

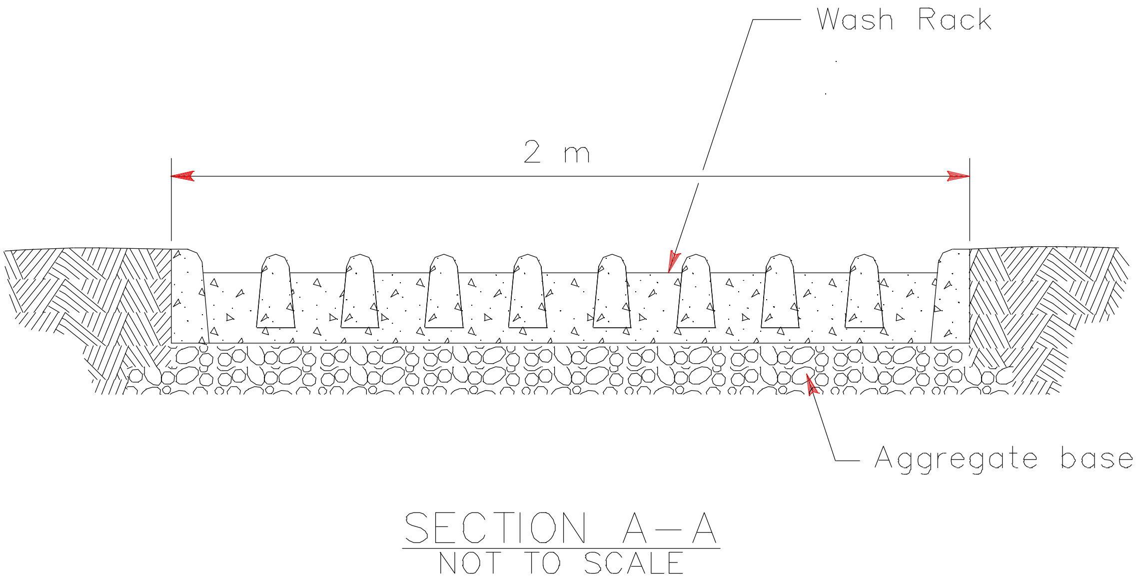
California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Tennessee Erosion and Sediment Control Handbook, Tennessee Department of Environment and Conservation, July 1992.

Inspection Checklist

- Are there indications that vehicles are leaving the site in areas other than the designated construction exit(s)?
- Are there indications that mud, dust or dirt is tracked onto the adjacent road via the construction exit(s)?
- Is the construction exit sufficiently maintained to prevent mud, dirt, and dust from being tracked off-site?



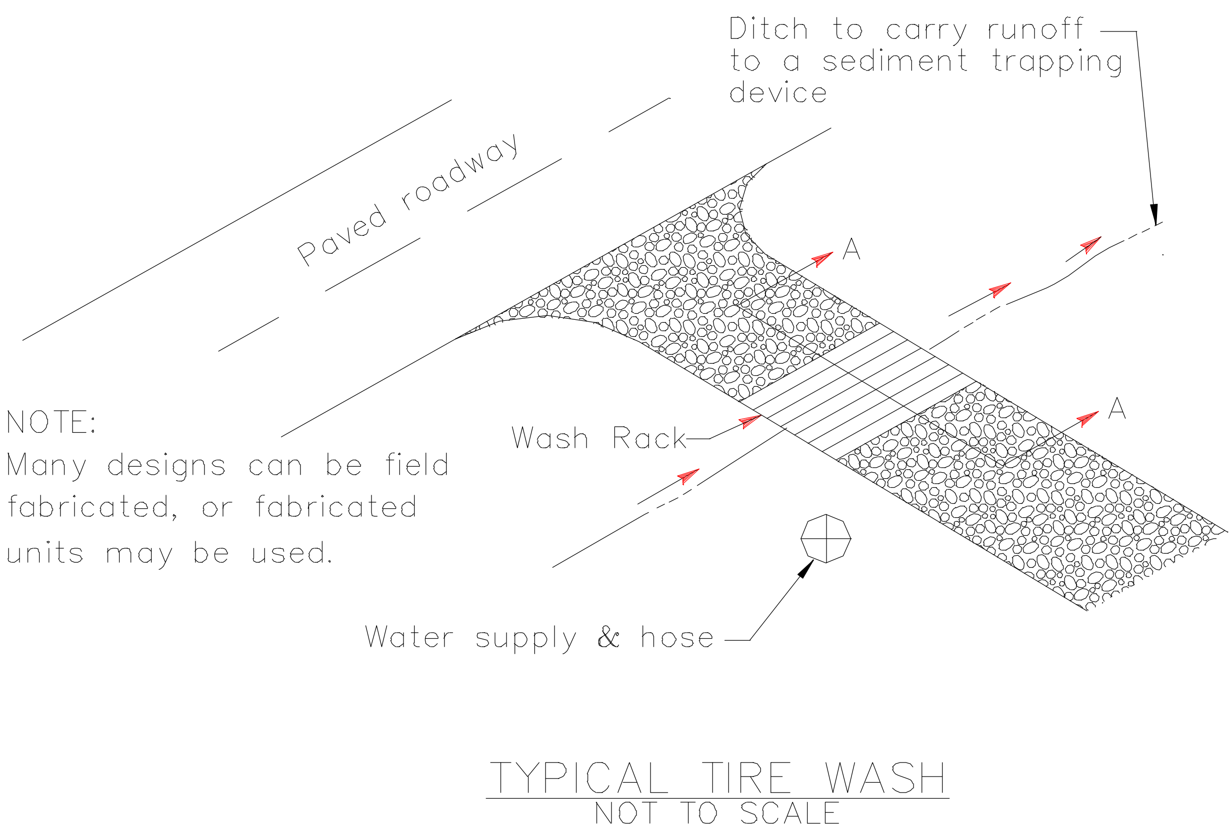
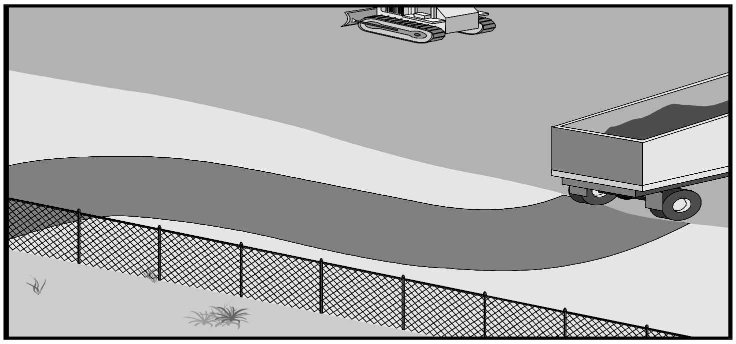


Figure TCP-01-1
Mud Tracking Removal

ACTIVITY: Construction Road Stabilization

TCP – 02



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
◗ Capital Costs	◗ O & M Costs	◗ Maintenance	◗ Suitability for Slopes >5%	○ Training

Description

Access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes should be stabilized immediately after grading and frequently maintained to prevent erosion and control dust. This management practice is likely to create a significant reduction in sediment.

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.
- Any construction roads that utilize a temporary stream crossing must be indicated and approved by the Tennessee Department of Environment and Conservation. Figures TCP-02-1 through 3 present illustrations of common temporary stream crossings.

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-inch (15.2-cm) thick, 2-3 inch (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. (see Dust Control CP-17).

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.

Limitations

- The roadway must be removed or paved when construction is complete.
- Certain chemical stabilization methods may cause stormwater or soil pollution and ARE NOT PERMITTED for use (see Dust Control CP-17).
- Management of construction traffic is subject to air quality control measures. Contact the local air quality management agency.
- Gravel construction roads are moderately expensive, but cost is often balanced by reductions in construction delay.

Additional Information

Areas which are graded for construction vehicle transport and parking purposes are especially susceptible to erosion and dust. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy generating significant quantities of sediment that may eventually pollute nearby streams. Dirt roads can become unstable during wet weather rendering them unusable.

Efficient construction road stabilization not only reduces on-site erosion but can significantly speed on-site transit, avoid instances of immobilized machinery and delivery vehicles, and generally improve site efficiency and working conditions during adverse weather.

Installation/Application Criteria

Where feasible, alternative routes should be made for construction traffic; one for use in dry condition, the other for wet conditions which incorporate the measures listed for this BMP. Permanent roads and parking areas should be paved as soon as possible after grading. As an alternative where construction will be phased, the early application of gravel or chemical stabilization may solve potential erosion and stability problems. Temporary gravel roadway should be considered during the rainy season and/or on slopes greater than 5 percent.

When a gravel road is needed, apply a minimum 4-inch (10.2 cm) course of 2 to 4-inch (5.1- to 10.2-cm) crushed rock, gravel base, or crushed surfacing base course 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 (see the Dust Control BMP CP-17). 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.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication # 91-75.

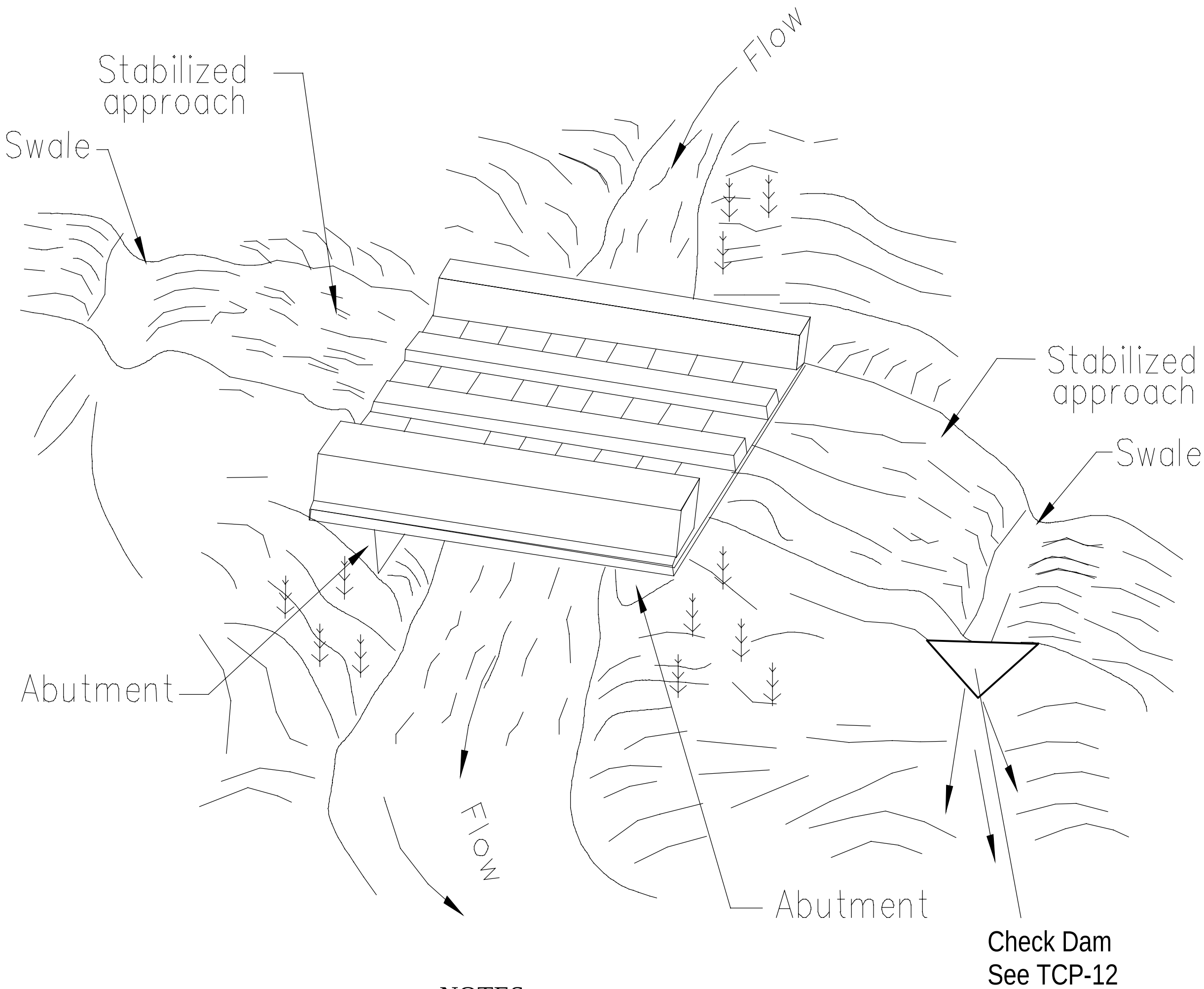
Tennessee Erosion and Sediment Control Handbook, Tennessee Department of Environment and Conservation, July 1992.

Virginia Erosion and Sedimentation Control Handbook, Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, 1991.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

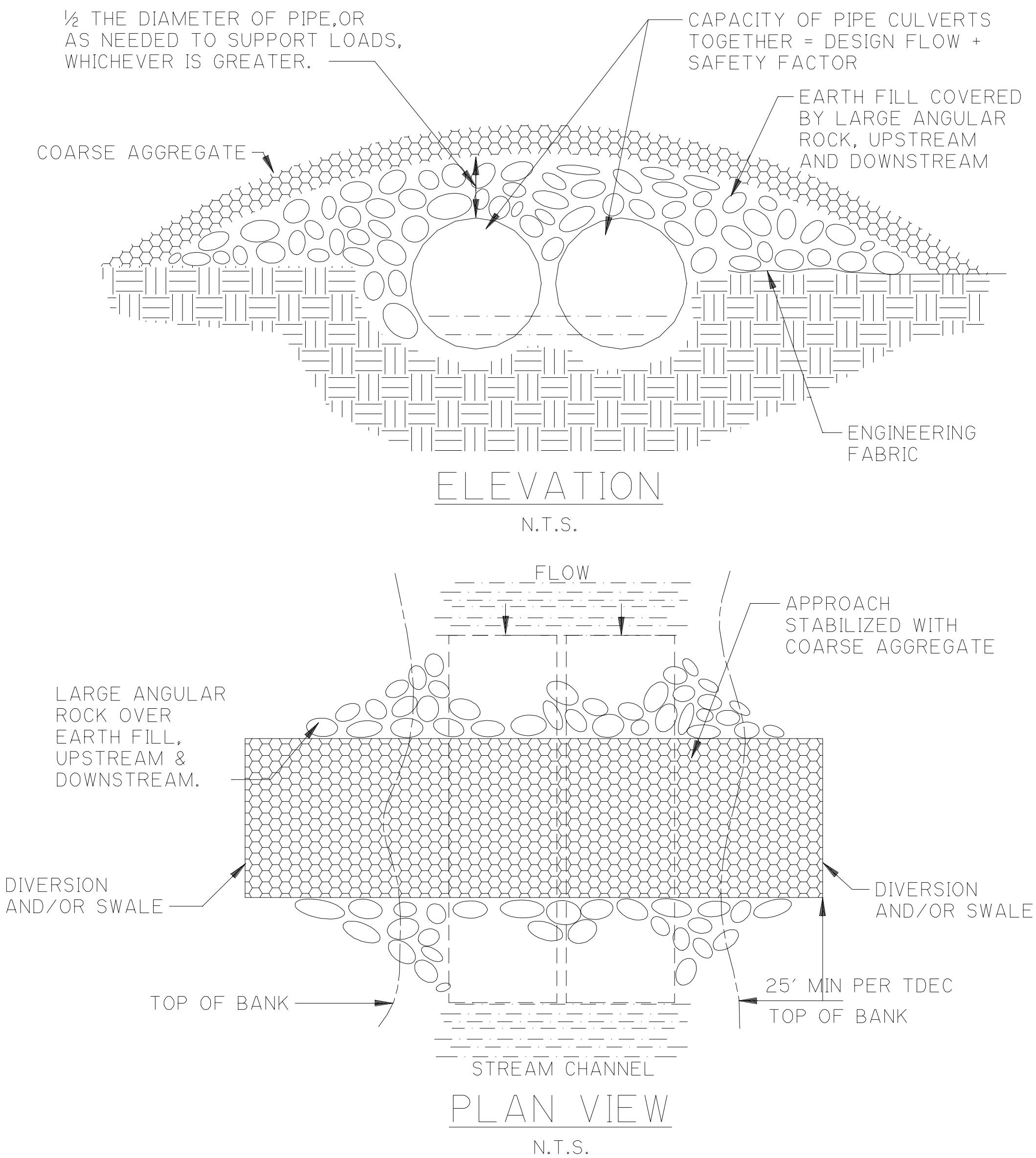
Inspection Checklist

- Gravel roads are maintained so that mud and dirt are not tracked off-site.
- Dirt roads are “treated” to reduce dust problems.
- Dirt and gravel roads do not show signs of erosion including but not limited to rill and gully erosion.
- Any stream crossings were constructed and maintained as mandated by the appropriate general or individual permit from TDEC.



NOTES:
1. Surface flow of road diverted by swale and/or dike.
2. Temporary structure should be designed and inspected by a license structural engineer.
3. Temporary crossings should only be constructed after approval from TDEC.

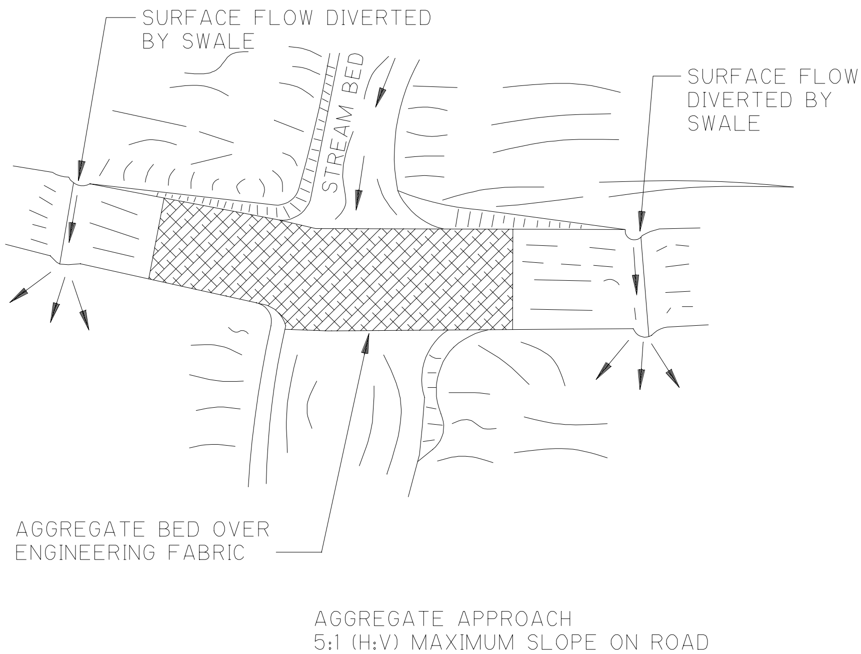
Figure TCP-02-1
Temporary Stream Crossing
N.T.S.

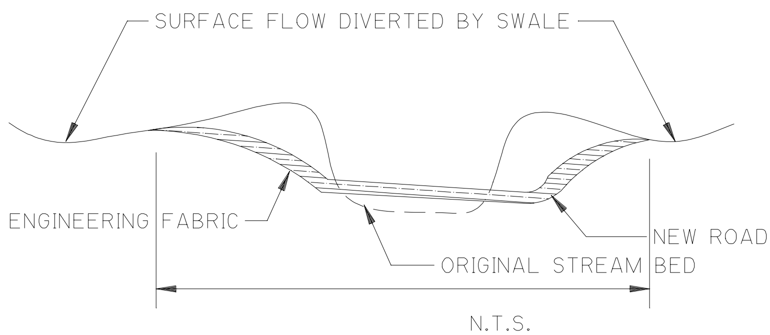


NOTES:

1. SURFACE FLOW OF ROAD DIVERTED BY SWALE AND/OR DIKE.
2. TEMPORARY STRUCTURE SHOULD BE DESIGNED AND INSPECTED BY A LICENSED STRUCTURAL ENGINEER.
3. TEMPORARY CROSSINGS SHOULD ONLY BE CONSTRUCTED AFTER APPROVAL FROM TDEC.

Figure TCP-02-2
Temporary Stream Crossing



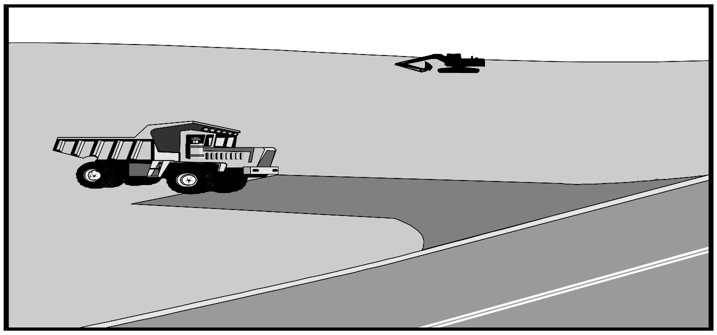


NOTES:

1. SURFACE FLOW OF ROAD DIVERTED BY SWALE AND/OR DIKE.
2. TEMPORARY STRUCTURE SHOULD BE DESIGNED AND INSPECTED BY A LICENSED STRUCTURAL ENGINEER.
3. TEMPORARY CROSSINGS SHOULD ONLY BE CONSTRUCTED AFTER APPROVAL FROM TDEC.

Figure TCP-02-3
Temporary Storm Crossing

ACTIVITY: Stabilized Construction Exit	TCP – 03



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

◗ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

The construction exit practice is a stabilized pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area. Stabilizing the construction exit significantly reduces the amount of sediment (dust, mud) tracked off-site, especially if a washrack is incorporated for removing caked on sediment. If soil and stormwater runoff conditions warrant removal of mud from construction vehicles, see TCP-01. 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 2-4 inch (5.1-10.2 cm) crushed, washed, and well graded rock to at least an 8-inch (20.3 cm) 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 exit.
- Should be used in conjunction with street sweeping on adjacent public right-of-way.
- It is strongly suggested that perimeter fencing be installed proximate to the construction exit that will limit egress to the designated construction exit(s).

Maintenance

- Inspect weekly and after each rainfall.
- Requires periodic top dressing with additional stones; add gravel material when soil subgrade 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.

Limitations

- Stabilized construction exits are rather expensive to construct, especially when a wash rack is included. Most construction sites will already require some measure of sediment trap. A sediment trap of some kind must also be provided to collect wash water runoff. The cost of a sediment trap for a construction exit should be incremental or much less expensive than other BMPs to control sediment from a construction exit.

Additional Information

A stabilized construction exit is a pad of aggregate, that may be enhanced with an underlain filter cloth, located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area. The purpose of a stabilized construction exit is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets. Reducing trackout of sediments and other pollutants onto paved roads helps prevent deposition of sediments into local storm drains and production of airborne dust.

A stabilized construction exit should be used at all points of construction ingress and egress. The NPDES permits administered by TDEC require that appropriate measures be implemented to prevent trackout of sediments onto paved roadways, which is a significant source of sediments derived from mud and dirt carryout from the unpaved roads and construction sites.

Stabilized construction entrances are moderately effective in removing sediment from equipment leaving a construction site. Advantages of the Stabilized Construction Exit is that it does remove some sediment from equipment and serves to channel construction traffic in and out of the site at specified locations. Efficiency is greatly increased when a washing rack is included as part of a stabilized construction exit (See TCP-01).

The exit must be properly graded to prevent runoff from leaving the construction site. When wash areas are provided, washing is done on a reinforced concrete pad (if significant washing is necessary) or in an area stabilized with crushed stone (TCP-03) which drains into a properly constructed sediment trap or basin (TCP-17 and 18). Sediment barriers, such as swales with check dams, must be provided to prevent sediments from entering into the stormwater sewer system, ditch, or waterway.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Tennessee Erosion and Sediment Control Handbook, Tennessee Department of

Environment and Conservation, July 1992.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Work Group Working Paper, USEPA, April, 1992.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication # 91-75.

Virginia Erosion and Sedimentation Control Handbook, Virginia Department of Conservation and Recreation, Division or Soil and Water Conservation, 1991.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

Inspection Checklist

- Are there indications that vehicles are leaving the site in areas other than the designated construction exit(s)?
- Are there indications that mud, dust or dirt is tracked onto the adjacent road via the construction exit(s)?
- Is the construction exit sufficiently maintained to prevent mud, dirt, and dust from being tracked off-site?

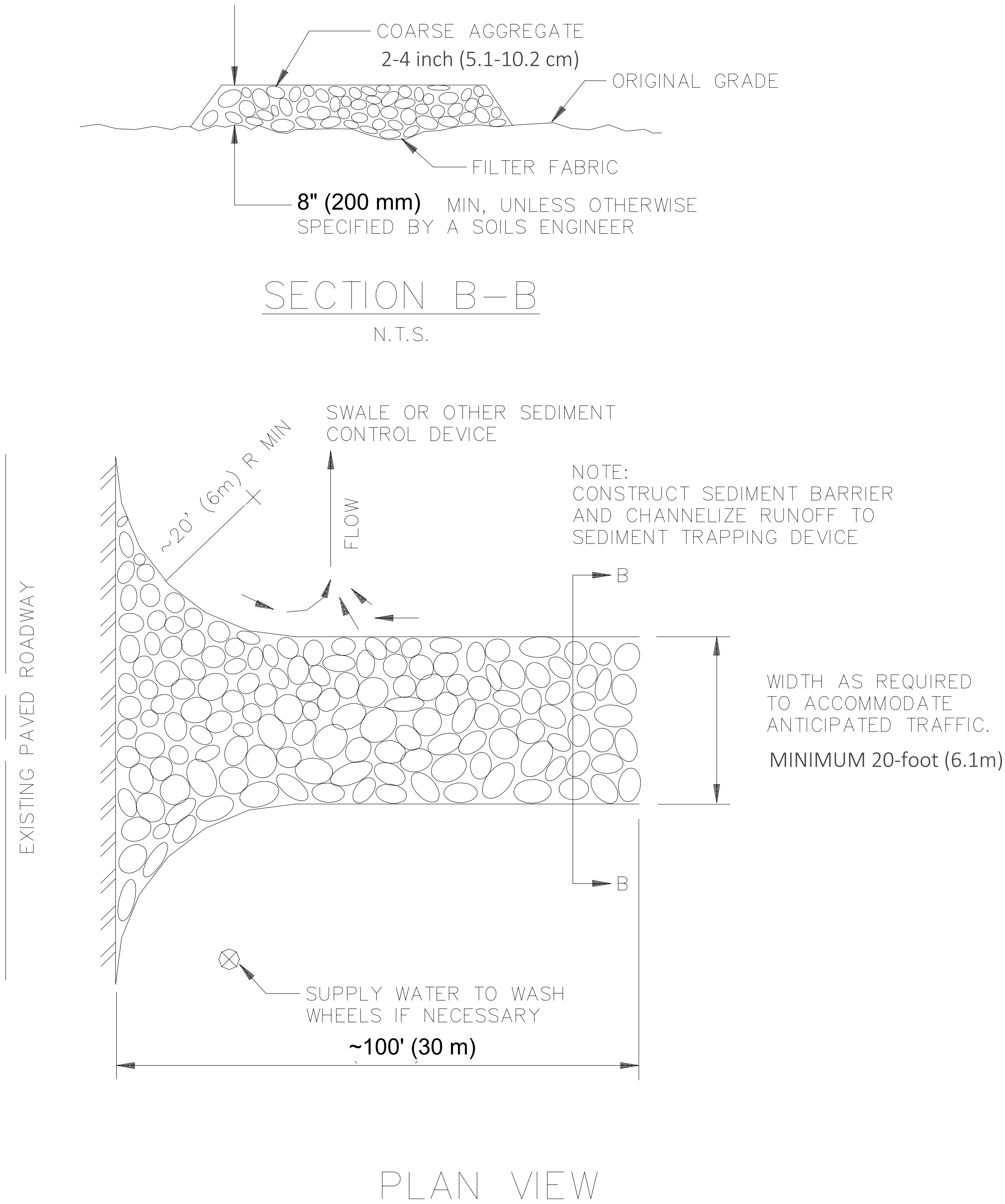
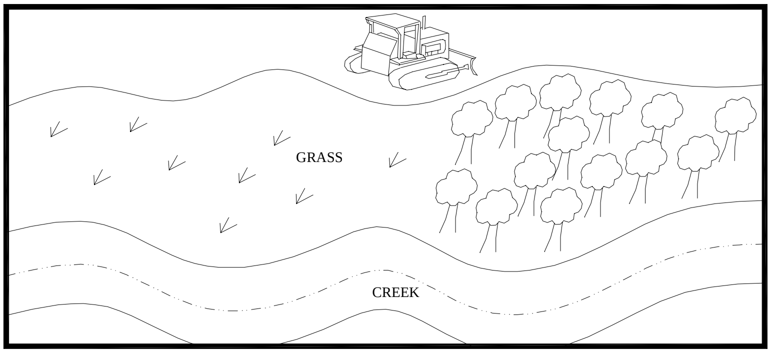


Figure TCP-03-1
Stabilized Construction Exit

ACTIVITY: Buffer Zones

TCP - 04



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

This BMP is intended to prevent or reduce the discharge of pollutants to the storm drain system or to watercourses as a result of construction activity by utilizing vegetation to protect soils from erosion and to slow the velocity of runoff to allow the removal of sediment through filtering and settling. This activity may be performed for temporary benefits, planned for permanent placement (See PESC-04), or may be the required buffer of no construction activity. 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 may be a planned feature and/or a requirement of MDPW. It is preferred that the buffer include all of a floodplain. However, 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.” See Volume 1 Section 5.9 for additional descriptions of the required buffer.

- Any area within a buffer required by the regulation presented in Volume 1 Section 5.9, <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.

- 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.

Approach

The practices set forth in this BMP are for temporary measures and are not to be in conflict with the permanent requirements discussed in Volume 1: Sections 5.3, 5.4 and 5.9.

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

If a vegetative buffer strip will be created from existing vegetation, see CP 22 – Preservation of Existing Vegetation.

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.
- Prepare a good, firm seed bed by adding soil amendments such as fertilizer as needed. After seeding, apply a 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.

Limitations

- The purchase and placement of sod is more expensive than growing vegetation from seed. Additionally, sod is generally more expensive to maintain than other types of vegetation because of the need for irrigation, weeding, and mowing. Sod will not survive unless properly maintained.

- Plugging is more expensive than seed but less expensive than sod. Plugging requires a longer establishment period than for sod before effective control is provided.

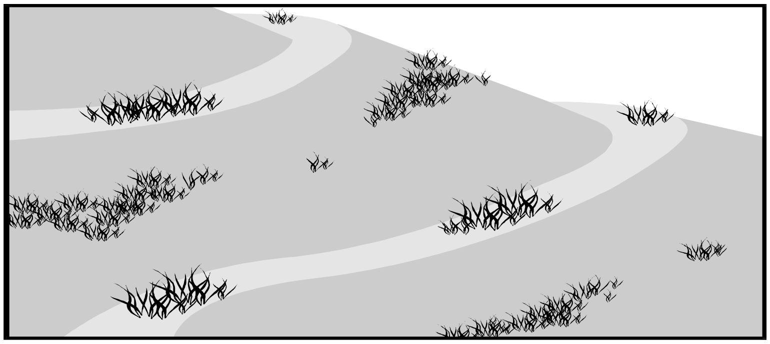
- Site conditions will dictate need and design of vegetative buffer strips. Vegetative buffer strips are most economical when there is existing vegetation that can be retained to serve as the buffer strip; otherwise, vegetation will need to be established.

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, CDM et.al. for the California Department of Transportation, April 1997.

ACTIVITY: Temporary Seeding	TCP - 05



Targeted Constituents

● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit

● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances

◗ Nutrients	◗ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements

● High	◗ Medium	○ Low

◗ Capital Costs	◗ O & M Costs	◗ Maintenance	◗ Suitability for Slopes >5%	◗ Training

Description

Temporary stabilization of soil with rapidly growing annual plants used to prevent erosion on disturbed areas before final grading or in a season not suitable for permanent seeding. This management practice is likely to create a significant reduction in sediment and a partial reduction in nutrients and toxic materials.

Suitable Applications

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

Approach

- To prevent seed wash-out, the area should be protected with such methods as surface roughening diversions and terraces.
- Soil should be analyzed for fertilizer and lime requirements.
- Apply fertilizer and lime per soil requirements or supply fertilizer at a rate of 5 pounds per 1,000 square feet with commercial grade 10-10-10.
- Apply selected seed at a rate of 1 pound per 1,000 square feet. Seed should be sown uniformly as soon as preparation of the seedbed has been completed by means of a rotary seed spreader, hydraulic equipment, or other satisfactory means.
- Straw mulch or chemical stabilization should be applied especially to seedlings in the fall for winter cover or slopes that exceed 3:1 (H:V).
- No seeding shall be done during windy weather or when the ground surface is frozen, wet or otherwise nontillable.

- No seeding shall be performed during December and January unless otherwise permitted.

- Mulching – When the mulching material is hay or straw, it shall be spread evenly over the seeded area at an approximate rate of 100 pounds per 1,000 square feet for straw and 150 pounds per 1,000 square feet for hay immediately following the seeding operations. This rate may be varied by the Engineer depending on the texture and condition of the mulch material and the characteristics of the area seeded.

- Sod shall be Kentucky 31 Fescue, Bluegrass, or Bermuda grass.

- Sod shall be set or reset only when the soil is moist 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

- On steep slopes and channels sod shall be fastened to the ground with wire staples or wood pegs. Where surface water cannot be diverted from flowing over the face of slopes, install a strip of heavy jute or plastic netting and fasten tight along the crown or top of the slope for extra protection against lifting and undercutting of sod.

- The Contractor shall not allow any equipment or material placed on any planted area, and shall erect suitable barricades and guards to prevent his equipment, labor or the public from traveling on or over any area planted with sod.

Maintenance

- Inspect frequently within the first six weeks of planting to see if stands are uniform and dense and to assure that appropriate moisture levels are maintained.

- 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.

Recommended Seed Blends for Tennessee

Blend	*Percent of Blend*
<u>January 1 – May 1</u>	
• Italian Rye	• 33.33%
• Korean Lespedeza	• 33.33%
• Summer Oats	• 33.33%

May 1 – July 15	
• Sudan – Sorghum Crosses	• 100%
or	
• Starr Millet	• 100%
July 15 – January 1	
• Balboa Rye	• 66.66%
• Italian Rye	• 33.33%

Limitations

- Annual rye grass reseeds itself and may make it difficult to establish a good cover of permanent vegetation.
- Uneven seed broadcasting or low application can lead to patchy growth and erosion.
- Misapplication of fertilizer or lime could lead to pollutant runoff.

Additional Information

Sheet erosion, caused by the impact of rain on bare soil, is the source of most fine particles in sediment. To reduce this sediment load in runoff, the soil surface itself should be protected. The most efficient and economical means of controlling sheet and rill erosion is to establish vegetative cover. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover.

Temporary seeding may prevent costly maintenance operations on other erosion control systems. For example, sediment basin clean-outs will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. Perimeter dikes will be more effective if not choked with sediment.

Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

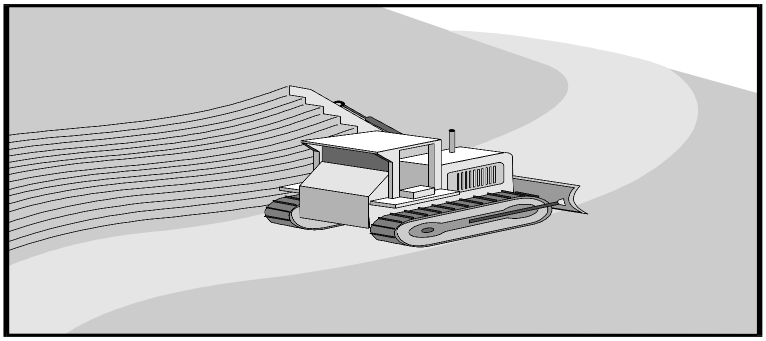
Primary References

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Soil Erosion Prevention and Sediment Control – Reducing Nonpoint Source Water Pollution on Construction Sites, University of Tennessee, Knoxville, Department of Civil and Environmental Engineering, August 1998.

Tennessee Erosion and Sediment Control Handbook, Tennessee Department of Environment and Conservation, July 1992.

ACTIVITY: Surface Roughening	TCP – 06



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High	◗ Medium	○ Low		
○ Capital Costs	○ O & M Costs	○ Maintenance	● Suitability for Slopes >5%	○ Training

Description

Roughening, terracing and rounding are techniques used for creating unevenness on bare soil through the construction of furrows running across a slope, creation of intermediate benches in long slopes, or by utilization of construction equipment to track the soil surface. This management practice is likely to create a significant reduction in sediment.

The primary function of surface roughening (and/or terracing TCP-11) is to reduce erosion potential by decreasing runoff velocities, reducing the length of sheet flow, trapping sediment, and increasing infiltration of water into the soil. It should be used as a permanent measure, to prepare a slope to receive permanent vegetation.

Suitable Applications

- On all construction slopes.
- Where seeding, planting, and mulching to stabilize exposed soils will benefit from surface roughening.
- Graded areas with smooth, hard surfaces, and the potential for erosion of clay, 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 (See TCP-11).

Approach

Roughening methods include stair-step grading or furrowing, which must be done across the slope and along the contour. Tracking, by contrast, must be done up and down the slope. Factors to be considered in choosing a method are slope steepness, mowing requirements, soil type, and whether the slope is formed by cutting or filling.

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 which 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 backblade 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.

Limitations

- Roughening may increase grading costs and result in sloughing in certain soil types.
- Stair-step grading may not be practical for sandy, steep, or shallow soils.
- Roughening alone as a temporary erosion control or surface preparation measure is of limited effectiveness in intense rainfall events. If roughening effects are washed away in a heavy storm, the surface will have to be re-roughened and new seed and mulch applied.

Primary References

Caltrans Storm Water Quality Handbooks, Planning and Design Staff Guide, CDM et.al. for the California Department of Transportation, September 1997.

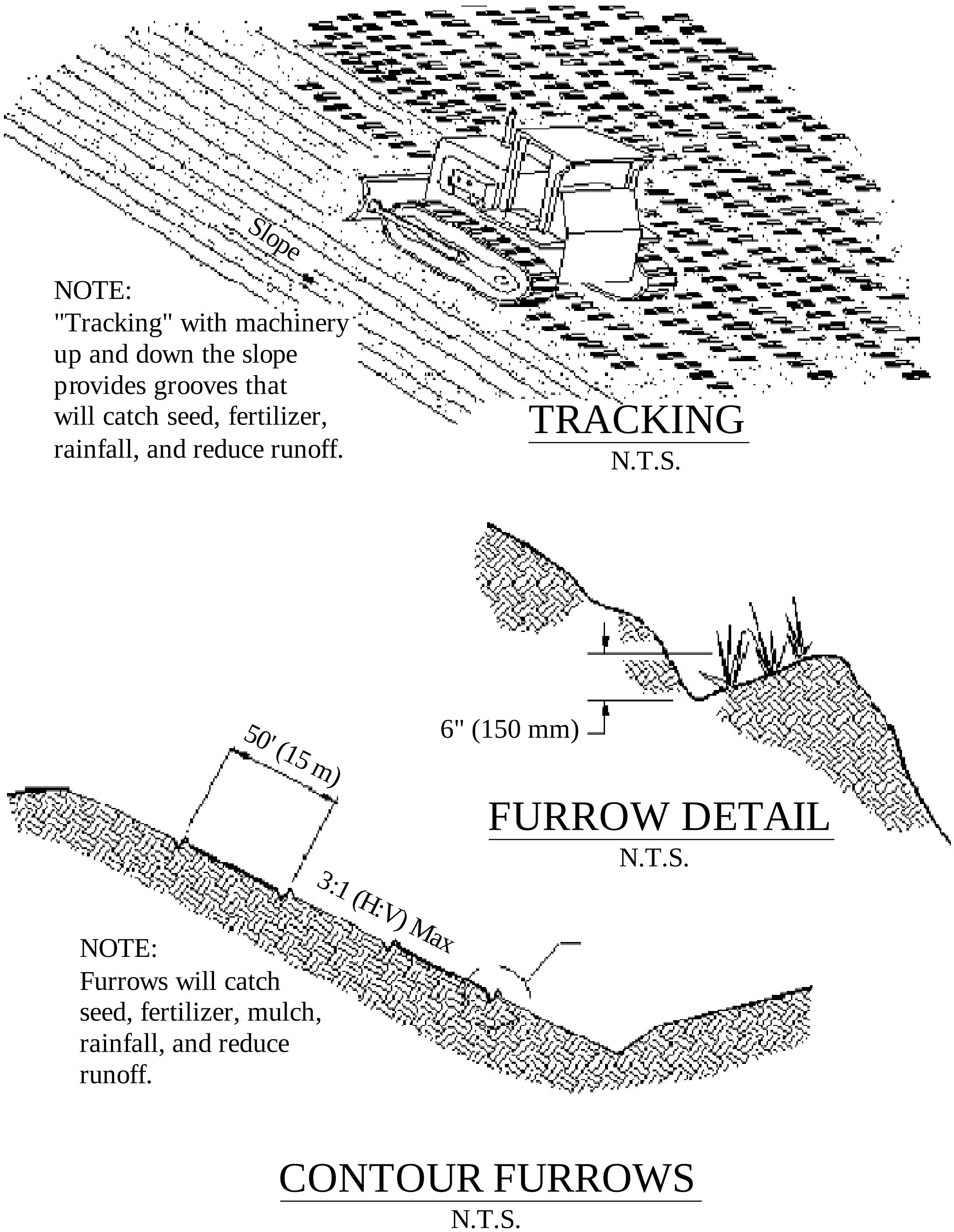
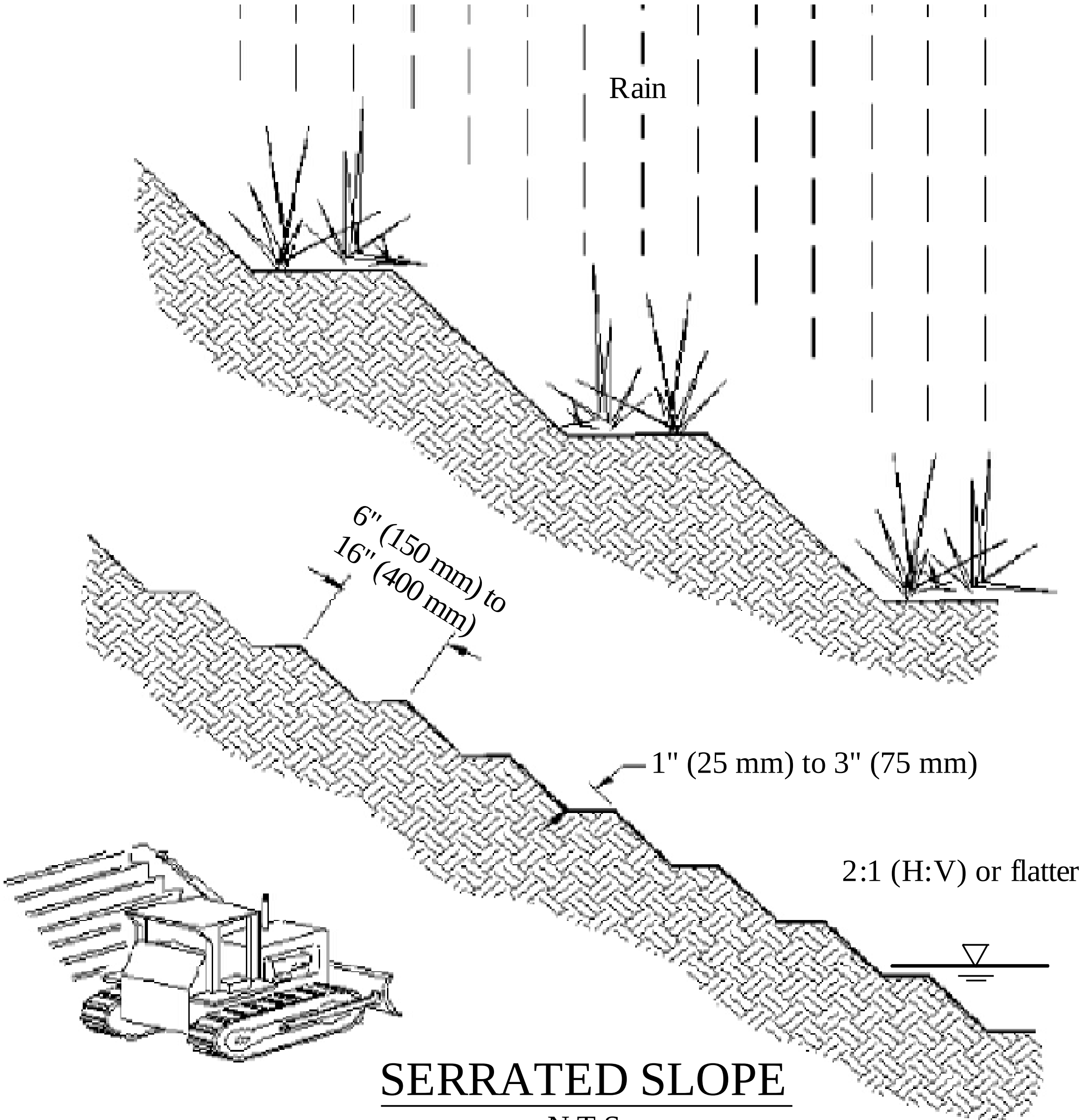


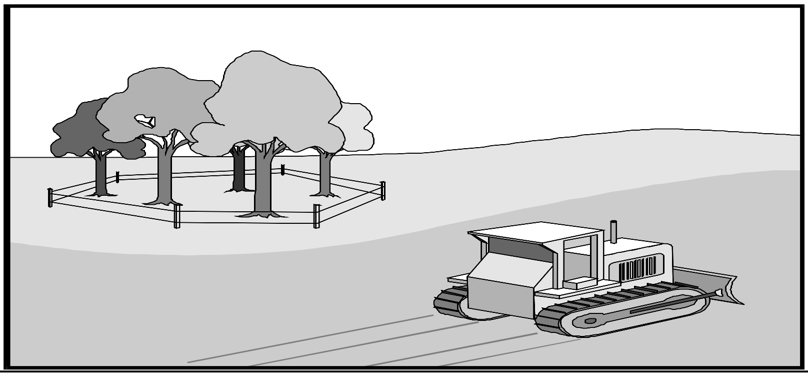
Figure TCP-06-1
Surface Roughening Techniques



NOTE:
Groove by cutting serrations along the contour. Irregularities in the soil surface catch rainwater, seed, mulch and fertilizer.

Figure TCP-06-2
Surface Roughening Techniques

ACTIVITY: Top Soiling	TCP – 07



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Topsoil from the construction site should be preserved and used to enhance the final site stabilization with vegetative cover. This management practice is to be done in support of temporary or permanent seeding and in conjunction with erosion source control practices such as silt fences, mulching, etc. This management practice is likely to create a significant reduction in construction wastes and a partial reduction in sediment.

Suitable Application

- Where earth disturbing activities expose subsoil layers that are poorly suited to support vegetative growth.
- Preservation and reuse of native topsoils helps improve the success rate of new vegetation.

Approach

- Materials cleared during construction can be economically reused as compost on site.
- Prior to stripping away topsoil, make certain that all downslope sediment control practices are in place and operational.
- 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.
- Locate topsoil stockpiles where they will not erode, block drainage, or interfere with work on the site. Use appropriate measure to ensure any eroded material is contained such as silt fences, straw bales, temporary seeding, mats, etc.
- 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.

Maintenance

- Inspect areas of newly applied topsoil frequently until vegetation is reestablished so that erosion and damage or vegetation failure can be quickly remedied.

Limitations

- Topsoil can wash away if erosion control practices are not provided.
- Topsoil should not be applied to slopes steeper than 2:1 (H:V) to avoid slippage.

Primary References

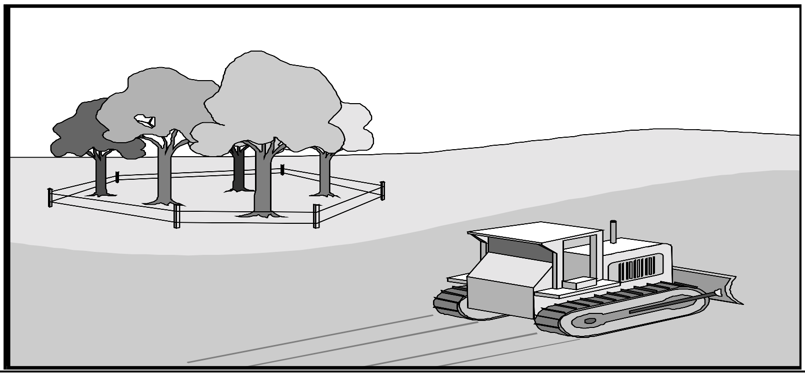
Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Soil Erosion Prevention and Sediment Control Reducing Nonpoint Source Water Pollution on Construction Sites, University of Tennessee, Knoxville, Department of Civil and Environmental Engineering, August 1998.

Inspection Checklist

- If the soil does not have temporary seeding, mulch, or netting, is it stockpiled in an area served by sediment control practices such as silt fencing, straw bales, brush or rock filters, or other equivalent effective management practice.

ACTIVITY: Mulching	TCP – 08



Targeted Constituents

● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit

● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances

◗ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements

● High	◗ Medium	○ Low

◗ Capital Costs	◗ O & M Costs	◗ Maintenance	● Suitability for Slopes >5%	○ Training

Description

Mulching is used to temporarily and permanently stabilize cleared or freshly seeded areas. Types of mulches include organic materials, straw, wood chips, and bark or other wood fibers. This management practice is likely to create a significant reduction in sediment and a partial reduction in nutrients.

Suitable Applications

- Temporary stabilization of freshly seeded and planted areas.
- Temporary stabilization during periods unsuitable for growing vegetation.
- Temporary stabilization of areas that cannot be seeded or planted (e.g., insufficient rain, steep slope, non-growth season).
- Areas which have been permanently seeded to assist in retaining moisture, and to hold seedings.
- On poor or marginal soils to add organic matter and fertility as strategy to speed the establishment and 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 long term, non-vegetative ground cover around established plants, such as trees or shrubs, and on flat to minor slopes not otherwise protected.
- 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 a soil moisture retention aid to avoid cracking of the soil and associated compaction, and require soil temperature

modification.

- As an alternative to nets and mats as presented in TCP-09.

Approach

Mulch prevents erosion by protecting the soil surface from rain and runoff impact and fostering growth of new seedings that do not stabilize by themselves. Organic mulch materials, such as straw, wood chips, bark and wood fiber, have been found to be most effective where re-vegetation will be provided by reseeding. The choice of mulch should be based on the size of the area, site slopes, surface conditions such as hardness and moisture; weed growth and availability of mulch materials.

- May be used with netting to supplement soil stabilization.
- Binders may be required for steep areas, or if wind and runoff is a problem.
- Type of mulch, binders, and application rates should be recommended by manufacturer/contractor.

Mulch Selection

There are many types of mulches, and selection of the appropriate type should be based on the type of application and site conditions. The following criteria should be considered in selection of the appropriate mulch:

- Effectiveness
  - Reduction of erosion
  - Reduction of flow velocity
  - Reduction of runoff
- Vegetation Enhancement
  - Native plant compatibility
  - Germination rate
  - Growth rate
  - Moisture retention
  - Temperature modification
  - Open space/coverage
  - Nutrient uptake
- Operation and Maintenance
  - Maintenance frequency
  - Need for fertilization
  - Need for irrigation

Application Procedures

The construction-application procedures for mulches vary significantly depending upon the type of mulching method specified. Six (6) methods are highlighted here:

Vegetable Fibers (Hay or Straw): Loose hay and/or straw are the most common mulch materials used in conjunction with direct seeding of soil. Straw mulch is a good short-term protection most commonly used with seeding. The mulch should be from the current season's crop. A letter of certification from the supplier should be required to show that the straw was baled less than 12 months from the delivery date. Wheat or oat straw is recommended.

- Mulching is generally the second part of a multi-step process which should be implemented as follows:

  - Apply seed and fertilizer to the bare soil.
  - Immediately apply loose hay or straw over the top of the seed/fertilizer at a rate of 4,500 kg/ha (2 tons/ac) either by machine or by hand distribution.
  - The mulch must be evenly distributed on the soil surface such that 80 to 90% of the ground is covered.
  - Anchor the mulch in place by using a tacking agent, netting, or "punch it" into the soil mechanically. On small areas and/or steepened slopes, straw or hay can also be held in place using plastic netting or jute. The netting should be held in place using 11 gauge wire staples, geotextile pins or wooden stakes (See Geotextiles TCP-10).
  - Where slopes are too steep to support construction equipment or areas of application too large to allow cost-effective use of nettings, straw or hay should be held in place using any number of tacking agents which act to glue the vegetable fibers together and to the soil surface. The tacking agents should be selected on the basis of their longevity and ability to hold the fibers in place until vegetation is established through the mulch.
  - Maximum fiber length shall be maintained and average fiber length should be greater than 6 in. (150 mm).

- "Green" Material: This type of mulch is produced by recycling of vegetation trimmings such as grass, shredded 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 material should be evenly distributed on site to a depth of not more than 4 in. (100 mm).
  - Anchoring green material in place with a tacking agent is necessary on steep slopes and in areas where overland sheet flow is anticipated.

- Wood/Bark Chips: Wood and bark chips are suitable for application in landscaped areas that will not be closely mowed. Wood chips do not require tacking, but do require nitrogen treatment (12 pounds/ton) to prevent nutrient deficiency. Bark chips do not require additional nitrogen fertilizer. When the wood source is near the project site, wood and bark chips can be very inexpensive. Caution must be used in areas of steep slopes, since both wood and bark chips tend to wash down slopes exceeding 6 percent. Suitable for areas that will not be mowed closely or for ground cover in ornamental or landscape plantings.

  - Soils must be tested before application to determine if nitrogen must be added to prevent nutrient deficiency in plants.
  - Wood/bark chips not suitable for steep slopes.
  - Should be distributed by hand (although pneumatic methods are currently being developed).
  - The mulch should be evenly distributed across the soil surface to a depth of 2

in. (50 mm) to 3 in. (75 mm).

- Hydraulic Mulches (made from recycled paper): This mulch is made from recycled newsprint, magazine, or other waste paper sources. This type of mulch is to be mixed in a hydraulic application machine (hydroseeder) and applied as a liquid slurry which contains the recommended rates of seed and fertilizer for the site. It can be specified with or without a tacking agent. The mulch should be mixed with seed and fertilizer as specified and applied at a rate recommended by the manufacturer in order to achieve uniform, effective coverage.

- Hydraulic Mulches (made from wood fiber): This type of mulch is manufactured from wood waste from lumber mills or from urban sources. This type of mulch is mixed in a hydraulic application machine (hydroseeder) and applied as a liquid slurry which contains the recommended rates of seed and fertilizer for the site.

- Wood fiber mulches consist of specially prepared wood fiber processed to contain no growth germination inhibiting factors. The mulch should be from virgin wood, and be manufactured and processed so the fibers will remain in uniform suspension in water under agitation to form a homogenous 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 of 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 fiber mulch can be manufactured containing a tacking agent in each bag or specified without a tacking agent. A typical construction specification and application for wood fiber mulch is as follows:

  - 100 % wood fiber.
  - Moisture content (total weight basis) not to exceed 12% ± 3%.
  - Organic matter content (oven dry weight basis) = 99.3% minimum.
  - Inorganic matter (ash) content (oven dried basis) = 0.7% maximum.
  - pH = 4.9 ± 10% for a 3% water slurry.
  - Water holding capacity (oven dried basis) minimum 1.2 gal/lb. (10 liters/kg) of fiber.
  - The mulch shall be mixed with seed and fertilizer as specified and applied at a rate recommended by the manufacturer in order to achieve uniform, effective coverage and provide adequate distribution of seed.

- Hydraulic Matrices: This mulch category includes hydraulic slurries composed of wood fiber, paper fiber or a combination of the two held together by a binder system. A hydraulic matrix can be formulated using varying quantities of these components. A typical mixture applied on a per hectare basis (per acre) basis is as follows:

  - 500 lbs./ac. (550 kg/ha) wood fiber mulch.
  - 1,000 lbs./ac. (1,100 kg/ha) recycled paper mulch.
  - 55 gal./ac. (500 L/ha) acrylic copolymer w/ minimum 55% solids content.
  - Hydraulic matrix applied as aqueous slurry (with seed) using standard hydroseeding equipment to provide immediate dust control, temporary erosion control, and stabilization until permanent vegetation is reestablished.

Another category of hydraulic matrices is known as a Bonded Fiber Matrix (BFM). Rather than mix components from various manufacturers to create a hydraulic matrix, all fiber and binders are contained in one bag. Typical design guidance for a BFM is as follows:

- The BFM should be a hydraulic matrix which, when applied and upon drying, adheres to the soil to form a 100% cover which is biodegradable, promotes vegetation, and prevents soil erosion.
- The matrix should have no holes > 1 mm (4 x 10^{-3} in.) in size.
- The matrix should have no gaps between the product and the soil.
- The BFM should be comprised of long strand, thermally produced wood fibers passing a freeness test of 760 cc (MLS) level or below (>88% of total volume by weight) held together by organic tacking agents (10%) and mineral bonding agents (<2%) which upon drying becomes insoluble and non-dispersible.
- The material when mixed into a liquid slurry, should pass a free liquid quality control test.
- The binder should not dissolve or disperse upon watering.
- The matrix should have a minimum water holding capacity of 1.2 gal./lb. matrix (10 L/kg matrix).
- The matrix should have no germination or growth inhibiting factors and should not form a water insensitive crust.
- The matrix should be comprised of materials which are 100% biodegradable and 100% beneficial to plant growth.
- The BFM should be installed by an applicator trained in proper mixing and application of the product.
- The BFM should not be applied immediately before, during or immediately after rainfall so that the matrix will have an opportunity to dry for 24 hours after installation.

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 and repair any damaged ground cover and remulch exposed areas of bare soil.

Limitations

- Organic mulches are not permanent erosion control measures.
- Mulches tend to lower the soil surface temperature, and may delay germination of some seeds.
- Vegetable Fibers (Hay or Straw) - A machine and labor intensive practice that requires either proper crimping or use of tacking agents. Hay stays flexible longer than straw, but is more likely to contain weed and other unwanted seed.
- Recycled Paper Hydraulic Mulches - Can be applied rapidly on any large ground surface area. Short fiber length limits erosion control effectiveness unless applied with tackifier and in heavy layers.
- Wood Fiber Based Hydraulic Mulches - Can be applied rapidly on any large

ground surface area. Has longer fiber length than recycled paper-based products, but also has limits on erosion control effectiveness unless applied with tacking agents and in heavy layers.

- Hydraulic Matrices - Behave like erosion control blankets, but can be applied much more rapidly. Need 24 hours to dry before rainfall occurs to be effective.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, September 1992.

Controlling Erosion of Construction Sites, U.S. Department of Agriculture, Soil Conservation Service, Agriculture Information #347.

"Draft-Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April, 1990.

"Environmental Criteria Manual", City of Austin, Texas.

Guides for Erosion & Sediment Control in California, USDA Soils Conservation Service – January 1991.

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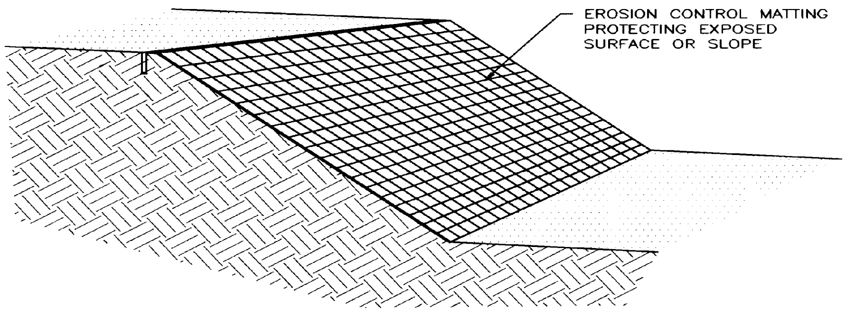
ACTIVITY: Nets and Mats	TCP – 09



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
● Capital Costs	◗ O & M Costs	◗ Maintenance	● Suitability for Slopes >5%	○ Training

Description

To prevent or reduce erosion on previously shaped and seeded swales, channels, slopes, or other critical areas by the placing and securing of either jute mesh, excelsior matting, erosion control fabric, or other approved matting. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- Erosion control matting can be used in any area subjected to erosive actions. Such areas include, but are not limited to: newly graded slopes, detention structures, and stream banks where moving water is likely to wash out new vegetative plantings.
- Mattings are quite effective on steep slopes and ditches where design flow may exceed 3.5 feet per second (1.1 m/s).
- Mattings are advantageous in areas with high soil erosion potential.

Approach

Site Preparation: The areas to receive the erosion control matting should have been previously shaped, fertilized, and seeded as shown on the plans or as specified by the Engineer. A smooth surface free of depressions and eroded areas that would allow water to collect or flow under the matting is required. Unless otherwise specified, the soil should be left with a loose surface after seeding.

Installation: Numerous variations of erosion control mattings currently exist. Basic application of a few most commonly used erosion control mattings are listed below. Erosion control products should always be installed in accordance with the manufacturer's instructions. A basic installation illustration is given in Figures TCP-9-1 and 2.

Erosion Control Fabrics

- Erosion control fabrics, such as nettings, are especially useful when applied over mulch, over sod, and/or in low volume and velocity ditches. Erosion control fabrics may be applied perpendicular or horizontal to the contour lines depending upon the slope characteristics, but should be placed in the direction of the water flow in ditch installation.

- Fabric should be placed approximately horizontal on slopes that are less than 2:1 (H:V) and less than 20 feet (6.1 m) long or in situations where one width of the fabric will cover the entire length.

- Fabric should be placed approximately perpendicular on slopes greater than 2:1 (H:V), if the length of the slope exceeds the width to be covered, or on slopes with excessive runoff from adjacent areas regardless of the degree or length of the slope.

- Prior to netting placement, a 12-inch (0.3 m) deep anchor trench should be dug at the top and toe of the slope with the top trench placed 12-inches (0.3 m) back from the crown, or a berm over which the fabric can be carried should be used.

- For perpendicular application the erosion control fabric should be tucked into the top trench, stapled, and covered with topsoil. The material is then unrolled and stapled as the work proceeds. The vertical strips should have a 4-inch (10.2-cm) overlap. The material should be in the trench at the bottom of the slope.

- For horizontal application, work must proceed from the bottom toward the top of the slope with a 4-inch (10.2-cm) overlap. After cutting, the material should be folded under 3 to 4 inches (7.6 to 10.2 cm) at the end, stapled, and covered with topsoil.

- The netting should not be stretched, but allowed to lay smoothly and loosely on the surface.

- Staples should be placed 9 to 12 inches (22.9 to 30.5 cm) apart in the trenches and along horizontal lap joints. For perpendicular applications, a 3-foot (0.91-m) interval is sufficient along the laps. Staples should be placed in three alternating rows at approximately 3-foot (0.91-m) intervals along the length of the inner portions of the material. Extra staples on 9- to 12-inch (22.9- to 30.5-cm) centers should be used around the mouths of culverts and flumes.

Where extremely erodible soil is anticipated, terracing should be implemented.

Excelsior Matting

- 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.

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 6 inches (15.2 cm) apart.

Maintenance

- Inspect erosion control mattings after rainstorms to check for movement of topsoil, movement of the mulch, or erosion. Continue inspections until vegetation is firmly established.

- In the cases of washout, breakage, or erosion occurring, repair surface, reseed, resod, remulch and/or replace topsoil, and install new netting.

Limitations

- Inadequate coverage or anchoring results in erosion, washout, and poor plant establishment.

- If appropriate staple spacing is not applied or applied in an insufficient amount, then seed, topsoil, and mulch maybe lost to wind and stormwater runoff.

- If the channel grade and liner are not appropriate for the runoff velocity, channel bottom erosion may result.

Primary References

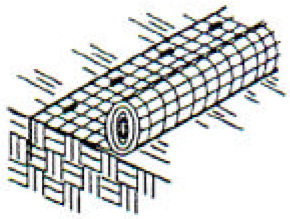
Soil Erosion Prevention and Sediment Control Reducing Nonpoint Source Water Pollution on Construction Sites, University of Tennessee, Knoxville, Department of Civil and Environmental Engineering, August 1998.

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

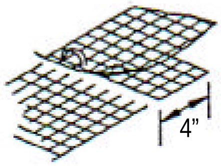
Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Inspection Checklist

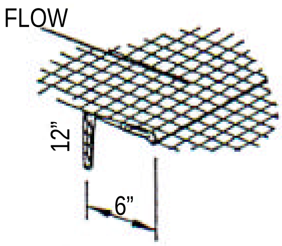
- Are there signs of washout, breakage or erosion?
- Are there areas that require reseeding?
- Are the appropriately sized staples distributed evenly and at the appropriate density?
- Are check slots installed?
- Is there at least a 4-inch (10.2-cm) overlap in parallel strips (running down hill)?
- Are anchor and joining slips at least 12-inches (30.5-cm) deep?



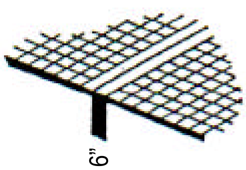
ANCHOR SLOT: BURY THE UP-CHANNEL END OF THE NET IN A 12” DEEP TRENCH. TAMP THE SOIL FIRMLY. STAPLE AT 12” INTERVALS ACROSS THE NET.



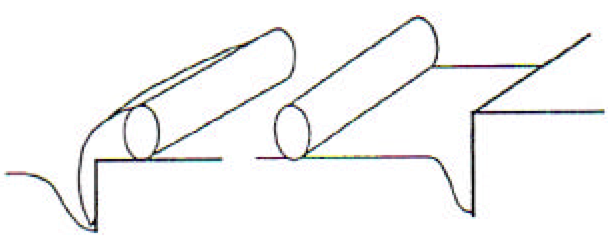
OVERLAP: OVERLAP EDGES OF THE STRIPS AT LEAST 4”. STAPLE EVERY 12” DOWN THE CENTER OF THE STRIP.



JOINING STRIPS: INSERT THE NEW ROLL OR NET IN A TRENCH, AS WITH THE ANCHOR SLOT. OVERLAP THE UP-CHANNEL END OF THE PREVIOUS ROLL 18” AND TURN THE END OF THE PREVIOUS ROLL, JUST BELOW THE ANCHOR SLOT, LEAVING 6” OVERLAP.



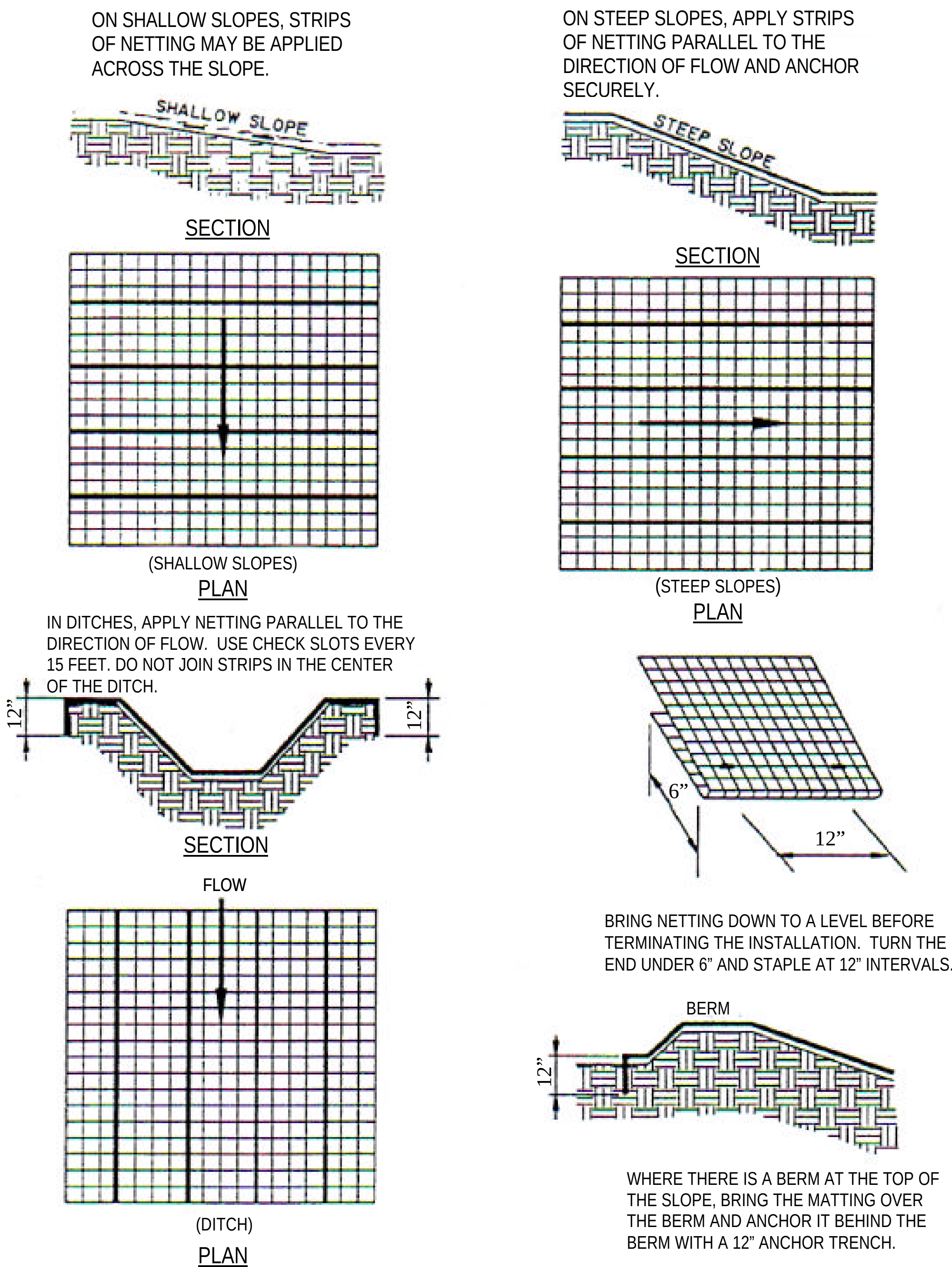
CHECK SLOTS: ON ERODIBLE SOILS OR STEEP SLOPES, CHECK SLOTS SHOULD BE MADE EVERY 15 FEET. INSERT A FOLD OF THE NET INTO A 6” TRENCH AND TAMP FIRMLY. STAPLE AT 12” INTERVALS ACROSS THE NET. LAY THE NET SMOOTHLY ON THE SURFACE OF THE SOIL – DO NOT STRETCH THE NET, AND DO NOT ALLOW WRINKLES.



ANCHORING ENDS AT STRUCTURES: PLACE THE END OF THE NET IN A 12” SLOT ON THE UP-CHANNEL SIDE OF THE STRUCTURE. FILL THE TRENCH AND TAMP FIRMLY. ROLL THE NET UP THE CHANNEL. PLACE STAPLES AT 12” INTERVALS ALONG THE ANCHOR END OF THE NET.

INSTALLATION OF NETTING AND MATTING

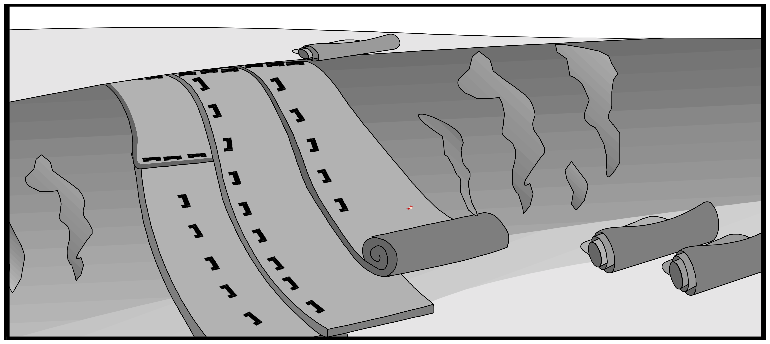
Figure TCP-09-1
Mat Anchoring



ORIENTATION OF NETTING AND MATTING

Figure TCP-09-2
Mat Anchoring and Layout

ACTIVITY: Geotextiles	TCP – 10



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
● Capital Costs	◗ O & M Costs	◗ Maintenance	● Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of pollutants to the storm drain system or to watercourses as a result of construction activity by stabilizing soil utilizing rolled and bound fiber material to reduce erosive impacts from rain, intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide some removal of sediment from runoff. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

Construction sites where disturbed soils must be stabilized. Site conditions that may warrant use of blankets and mats include:

- Slopes and disturbed soils where mulch must be anchored and other methods such as crimping or tacking agents are not cost-effective, feasible or adequate.
- Steep slopes, generally steeper than 3:1 (H:V).
- Slopes where the erosion hazard is high.
- Critical slopes adjacent to sensitive areas, such as streams, wetlands, or other highly valued resources needing protection.
- Disturbed soil areas where plants are slow to develop adequate protective cover.
- Channels with flows exceeding 2 ft/s (0.6 m/s).
- Channels intended to be vegetated and where the design flow exceeds the permissible velocity. The allowable velocity for some turf reinforcement mats after vegetative establishment is up to 10 ft/s (3 m/s).

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

Installation/ Application Criteria

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.

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

Fiber Rolls

- Fiber rolls shall be either prefabricated rolls or tightly rolled tubes of erosion control blanket.
- Assembly of Field Rolled Fiber Roll: Tightly roll length of erosion control blanket into a tube of minimum 8-in. (200-mm) diameter. Then, bind roll at each end and every 6 ft. (1.8 m) along length of roll with jute-type twine.

Installation

- Locate fiber rolls on level contours spaced 8 to 10 ft. (2.4 to 3.0 m) along the face of slope.
- Stake fiber rolls into a 2 to 4 in. (50 to 100 mm) trench.
- Drive stakes at the end of each fiber roll and spaced 4 ft. (1.2 m) maximum on center.
- Use wood stakes with minimum 3/4 by 3/4-in. (19 by 19-mm) cross section, and minimum length of 24 in. (600 mm).
- If more than one fiber roll is placed in a row, the rolls shall be butted; not overlapped.

Removal

- Fiber rolls are typically left in place.
- If fiber rolls are removed, collect and dispose of sediment accumulation, and fill and compact holes, trenches, depressions or any other ground disturbance to blend with adjacent ground.

Maintenance

- All blankets and mats shall be inspected periodically after installation.
- Installation shall be inspected after significant rain storms to check for erosion and undermining. Any failures shall be repaired immediately.

- If washout or breakages occur, re-install the material after repairing the damage to the slope or channel.
- Repair or replace split, torn, unraveling, or slumping fiber rolls.
- Inspect fiber rolls when rain is forecast. Perform required maintenance.
- Inspect fiber rolls following rainfall events and at least daily during prolonged rainfall. Perform required maintenance.

Limitations

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).

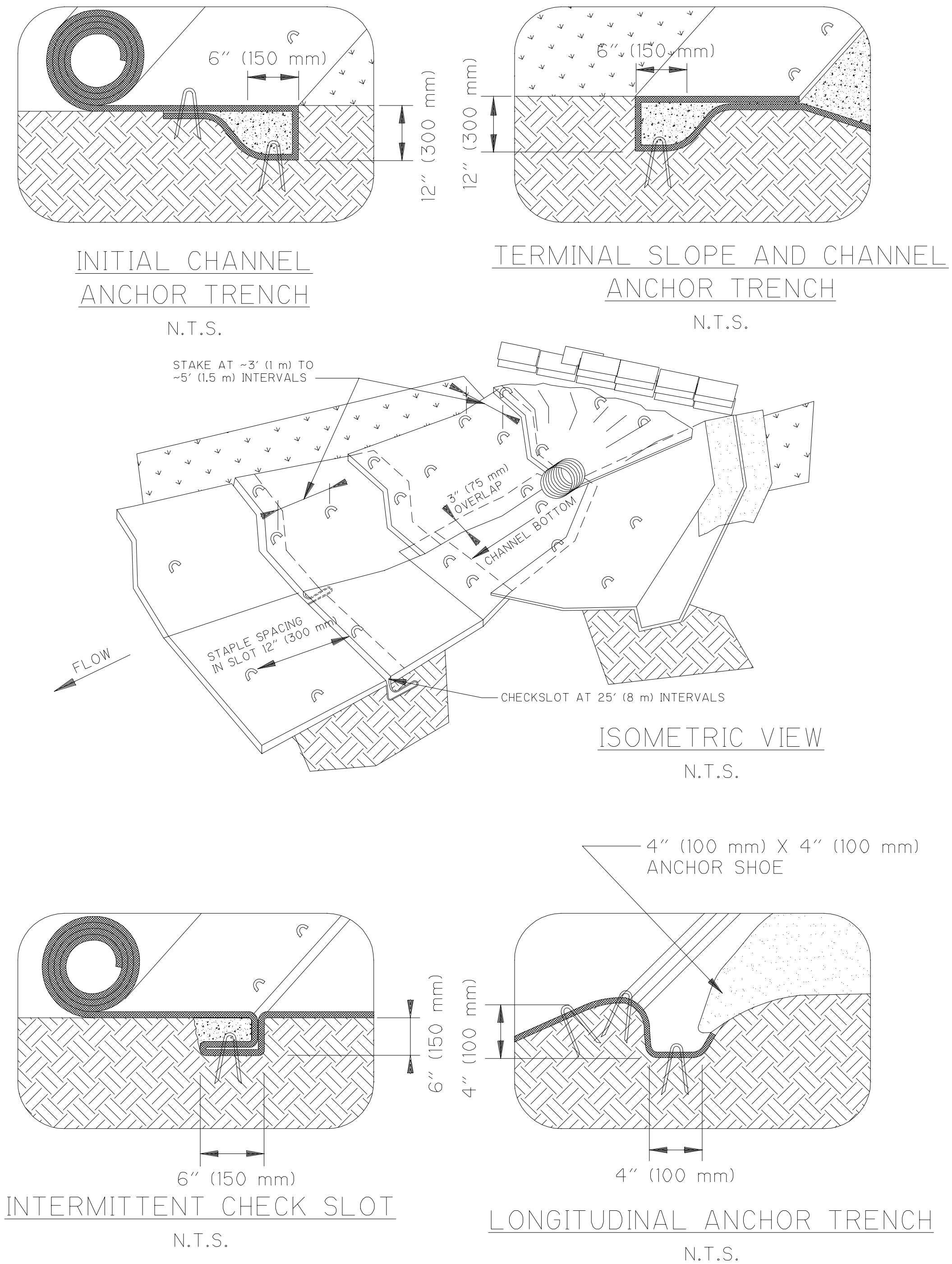
Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

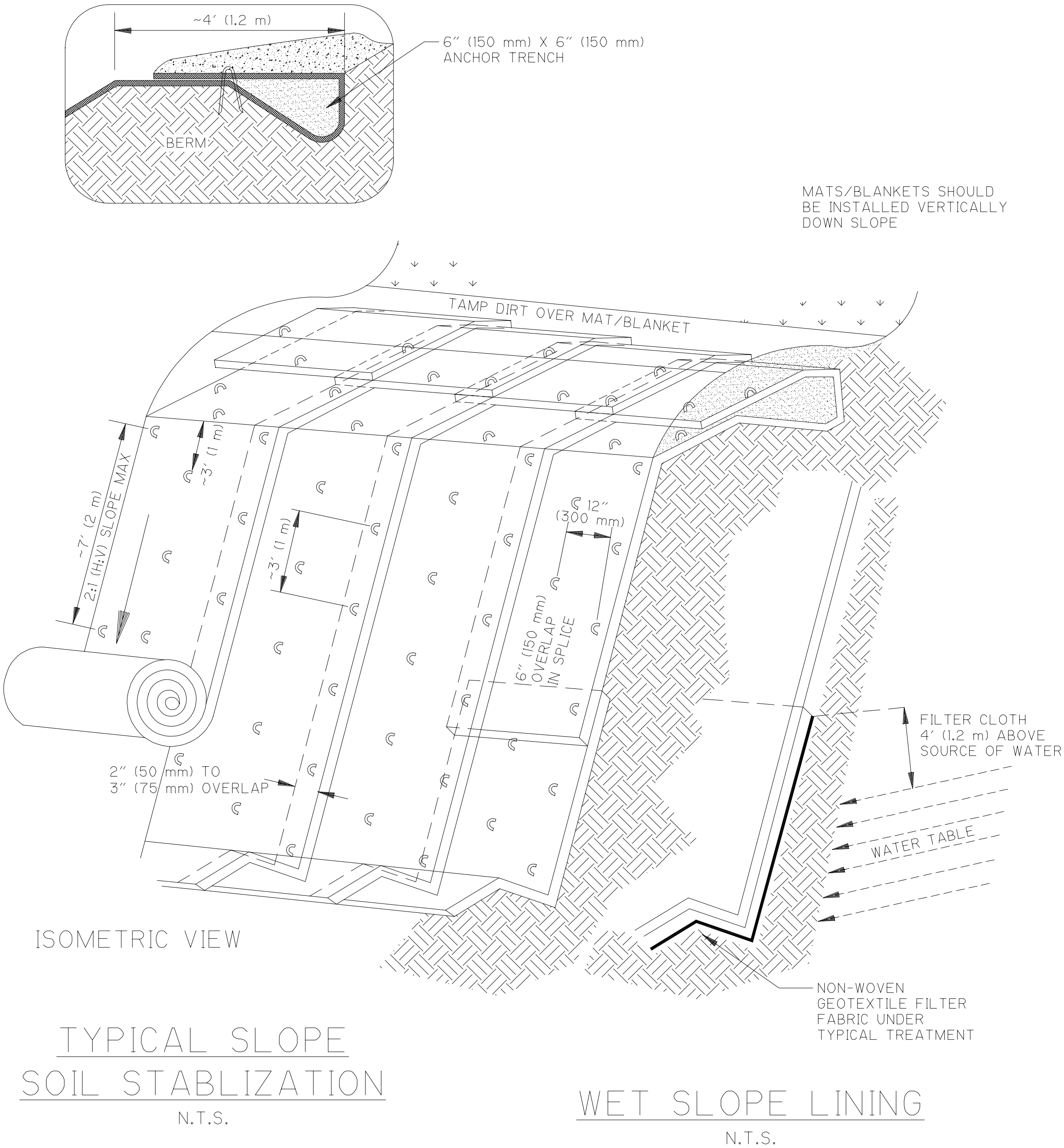
Inspection Checklist

- Are there any indications that additional site preparation is needed? Note areas where: grading or shaping is required, rocks, vegetation or other debris must be removed, and topsoil has not been sufficiently prepared.
- Was seeding performed in a way that meets the requirements of the geotextile used?
- See temporary seeding for other requirements.
- Is there sufficient anchoring?
- Are anchor trenches used at the top and bottom of slopes?
- Are anchor trenches used to start, join and terminate geotextiles placed in channels?
- Are anchor trenches sufficiently deep?
- Is soil filling even and flat?
- Are fiber rolls entrenched and staked?
- Are the fiber rolls tightly wound and/or are there any frays or other damage to the outer most layer?



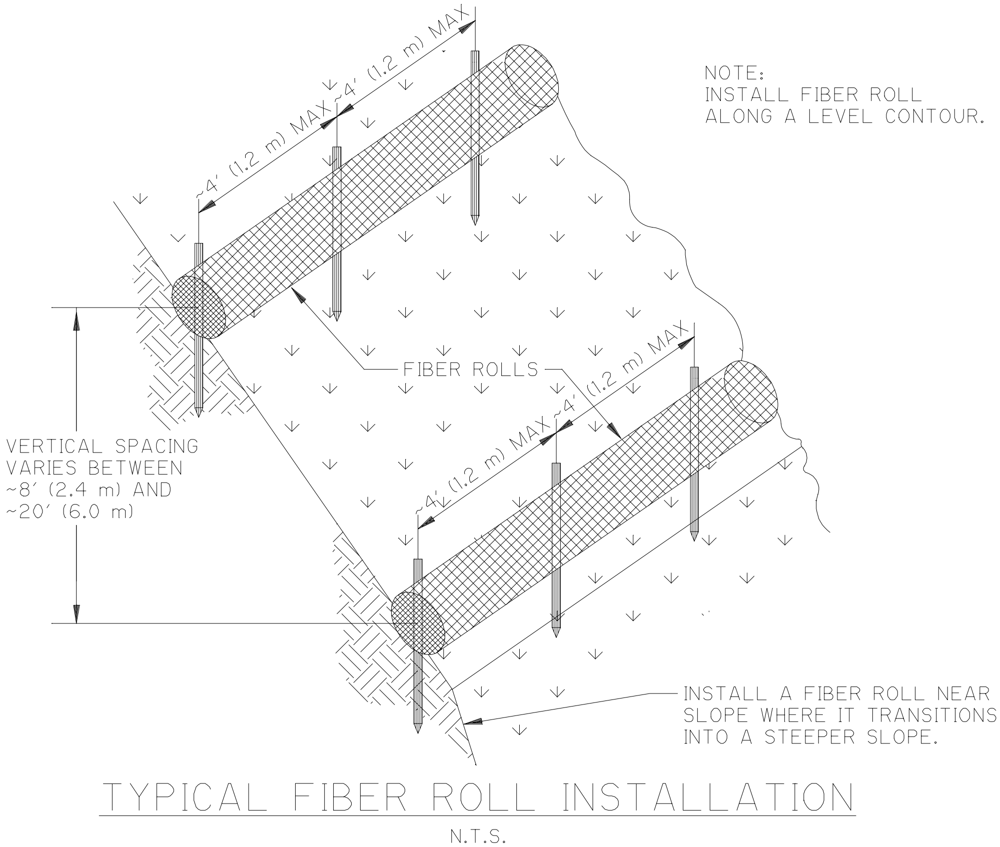
NOTES:
1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURER'S SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURER'S SPECIFICATIONS.

Figure TCP-10-1
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 TCP-10-2
Anchoring Geotextiles on Embankments



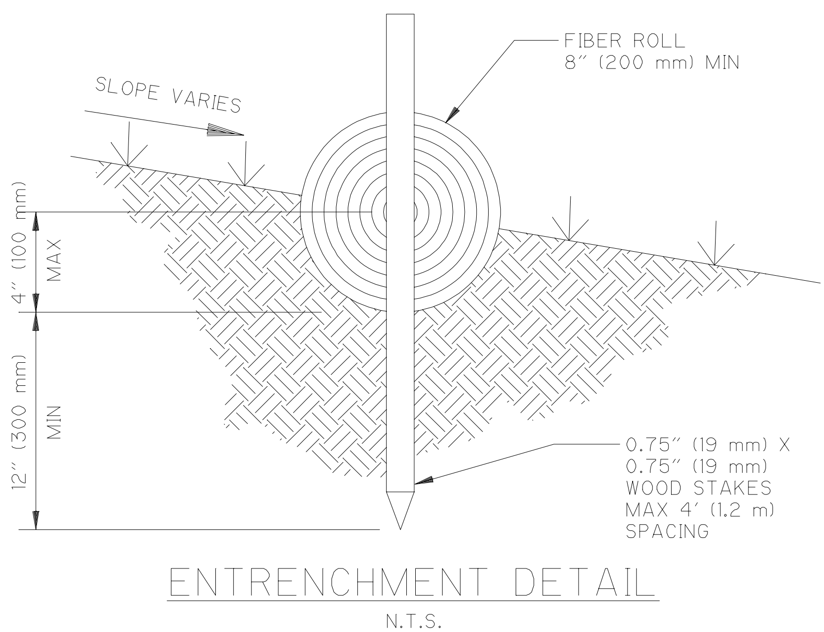
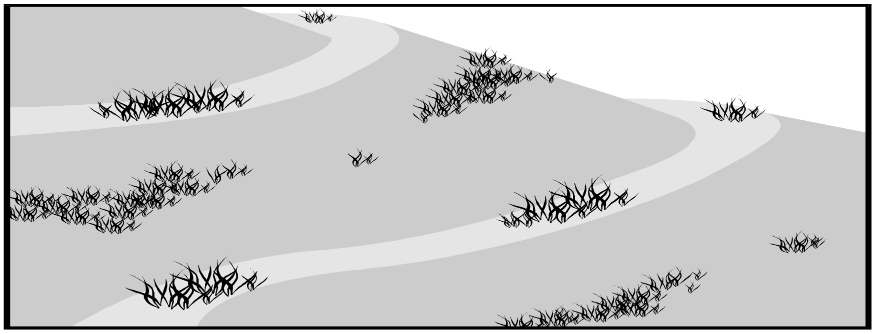


Figure TCP-10-3
Fiber Rolls

ACTIVITY: Terracing	TCP – 11



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	● Suitability for Slopes >5%	○ Training

Description

Terracing creates small but widespread areas for establishing vegetation that reduces runoff velocity, increases infiltration, and provides small depressions for trapping sediment, thereby reducing sediment from leaving the site. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- Any cleared area prior to temporary or permanent seeding and planting.
- Required for cleared, erodible slopes steeper than 3:1 (H:V) and higher than 5 feet (1.5 m) prior to seeding and planting.
- Graded areas with smooth, hard surfaces.
- Where length of slopes needs to be shortened by terracing. Note, 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.
- Terracing can be enhanced by surface roughening as explained in TCP-06.

Application Methods

Slope roughening/terracing is performed in several ways:

- Stair-step grading.
- Grooving.
- Furrowing.
- Tracking.
- Rough grading.

- No grading.

Installation/ Application Criteria

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 (See figure TCP-11-3). 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 TCP-07, 08: Temporary Seeding and Mulching.

- 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 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 reseed and mulch as soon as possible.

- Inspect roughened slopes weekly and after rainfall for excessive erosion.

Limitations

- Roughening may increase grading costs and result in sloughing in certain soil types.
- Stair-step grading may not be practical for sandy soils, very steep, or shallow slopes.
- Roughening alone as a temporary erosion prevention measure is of limited effectiveness in intense rainfall events. If roughening effects are washed away in a heavy storm, the surface will have to be re-roughened and new seed and mulch applied.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

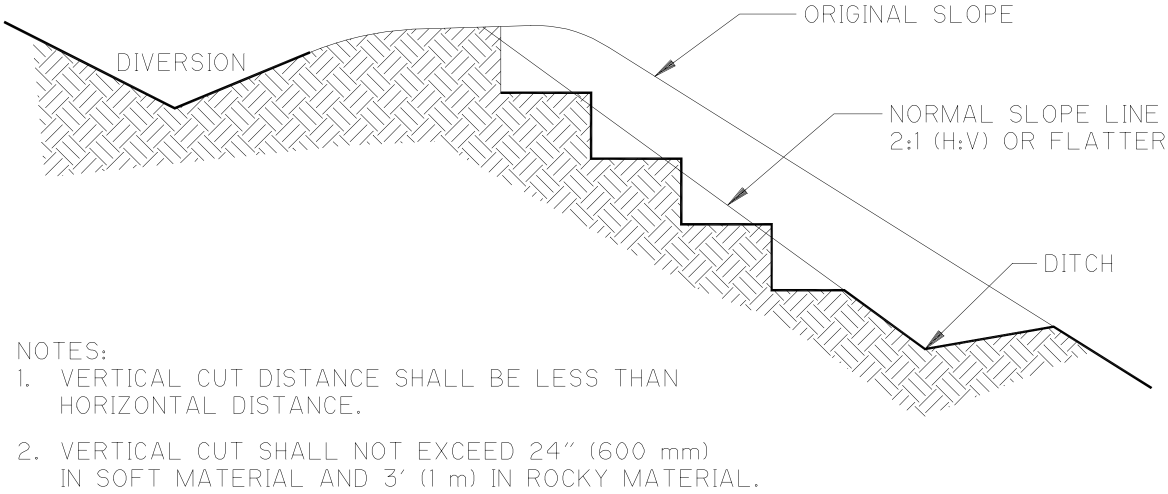
Handbook of Steel, Drainage & Highway Construction, American Iron and Steel Institute, 1983.

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Work Group Working Paper, USEPA, April, 1992.

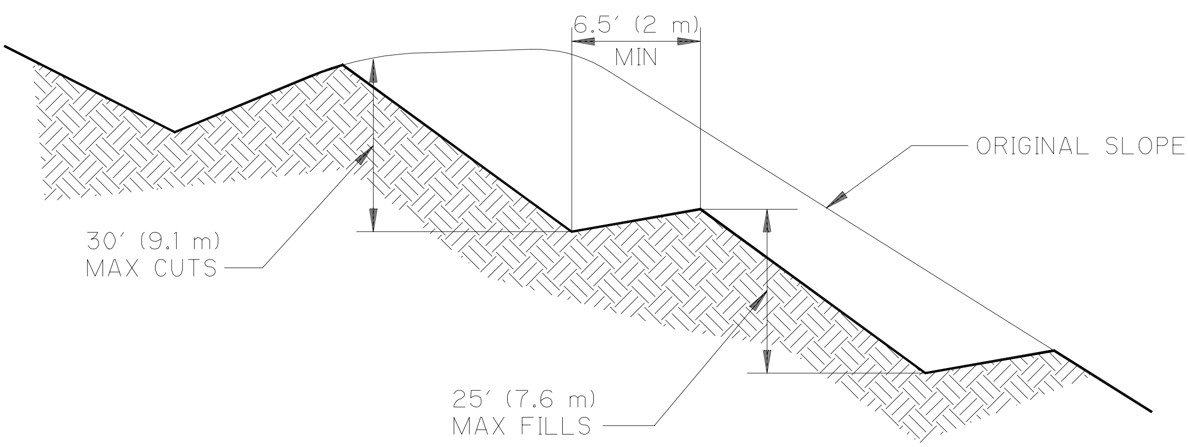
Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Inspection Checklist

- Are furrows at least 6-inches (15.2 cm) deep?
- Are furrows spaced no more than 50-feet (15.2 m) apart?
- What are the groove slopes in serrated slopes?
- Are stepped slopes cut so that the horizontal distance is greater than the vertical?
- Are stepped or terraced slopes cut so that the steps drain in on themselves?



STEPPED SLOPE
N.T.S.

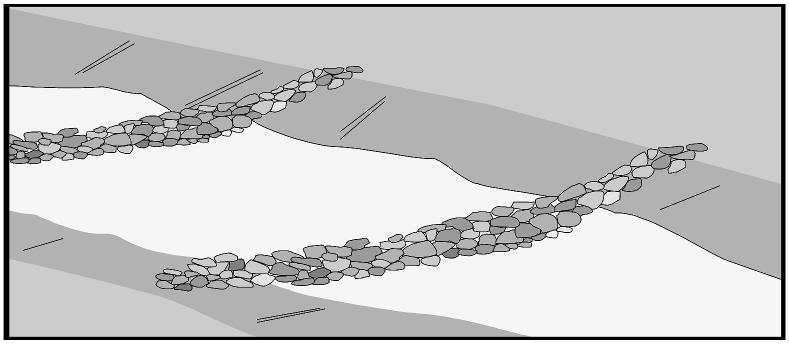


TERRACED SLOPE
N.T.S.

Figure TCP-11-1
Stepped and Terraced Slope Construction

ACTIVITY: Check Dams

TCP – 12



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High	◗ Medium	○ Low		
◗ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Small temporary dams constructed across a swale or drainage ditch. Check dams reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch, and promoting sedimentation behind the dam. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- Used to prevent erosion by reducing the velocity of channel flow in small intermittent channels and temporary swales.
- They will promote sedimentation behind the dam. Maintenance of collected materials is recommended weekly to avoid scour and resuspension.
- Should be used with filter fabric on upstream end.
- In small open channels which drain 10 ac (4 ha) or less.
- In steep channels where stormwater runoff velocities must be reduced to protect against erosion.
- During the establishment of grass linings in drainage ditches or channels.
- In temporary ditches or channels where the short length of service does not allow or warrant erosion-resistant lining installation.

Installation/ Application Criteria

Check dams must be sized and constructed correctly and maintained properly, or they will be either washed out or cause flooding. Check dams can be constructed of either rock or logs. Use of other natural materials available on-site that can withstand the stormwater flow velocities is acceptable, such as sand bags filled with pea gravel. Check dams should not be constructed from straw bales or silt fences, since concentrated flows quickly wash out these materials.

- Check dams should be placed at a distance and height to allow small pools 1 to 2 ft. (0.3 to 0.61 m) deep to form between each one.
- Rock check dams are usually constructed of approximately 1"-3" (2.5-7.6 cm) rock. The rock is placed either by hand or mechanically, but never just dumped into the channel.
- 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).

Maintenance

- Inspect for sediment buildup behind the check dam and signs of erosion around the check dam after each rain.
- Remove accumulated sediment whenever it reaches one half the sump depth by lifting the filter fabric and hand shoveling or backhoeing the silt.

Limitations

- Do not use this BMP for permanent placement unless life-cycle maintenance including sediment removal is guaranteed.
- Not to be used in live or continuously flowing streams.
- Not appropriate in channels which drain areas greater than 10 ac. (4 ha).
- Installation may damage vegetation. Do not place in channels which are already grass lined unless erosion is expected.
- Require extensive maintenance following high velocity flows.

- Promotes sediment trapping which can be resuspended during subsequent storms or removal of the check dam.
- Not to be constructed from straw bales or silt fences.
- Check dams should not be placed in swales/ditches with a base flow during some or all of the year.

Additional Information

Check dams create small detention pools in swales and ditches which drain 10 acres (4 ha) or less. These pools reduce the velocity of stormwater flows, thus reducing erosion of the swale/ditch. Sedimentation also occurs in these small pools.

Maximum velocity reduction is achieved if the toe of the upstream dam is at the same elevation as the top of the downstream dam. The center section of the dam should be lower than the edge sections so that the check dam will act like a weir during major floods. The dam must completely span the ditch or swale to prevent washout. The rock used must be large enough to stay in place given the expected design flow through the channel. Log check dams are usually constructed of 4 to 6-inch (10.2 cm to 15.2 cm) diameter logs. The logs should be embedded into the soil at least 18 inches (45.7 cm).

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

"Draft – Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April, 1990.

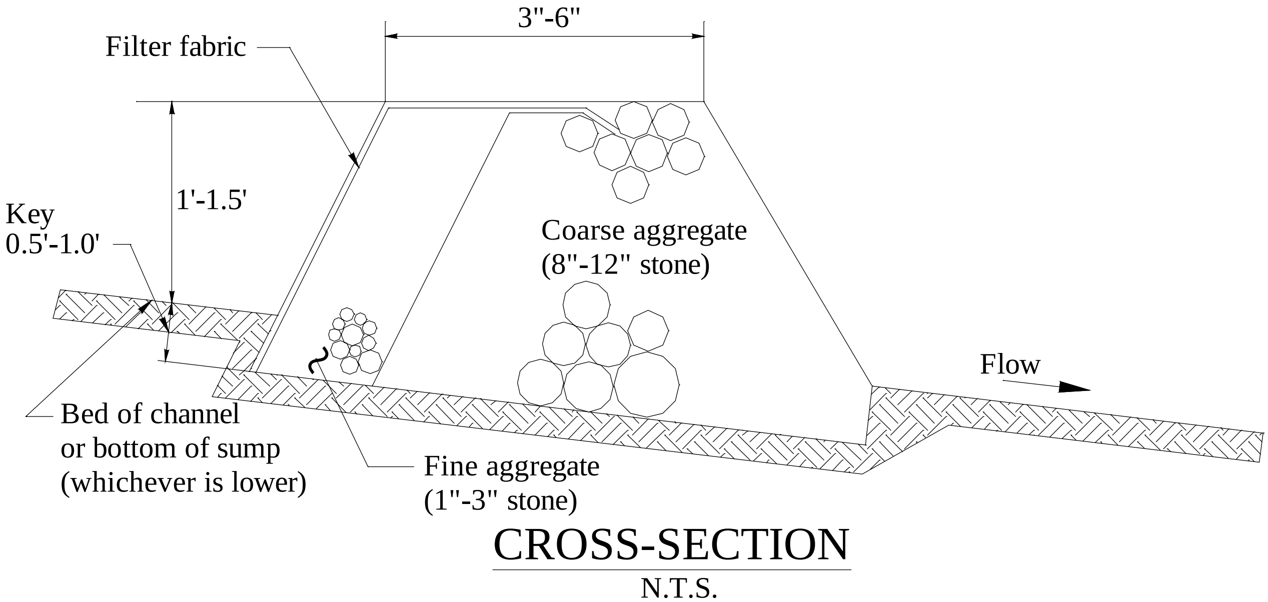
Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

Inspection Checklist

- Is crushed stone used at least 1” to 3” (2.5 cm to 7.6 cm) in diameter?
- Does the check dam span the entire channel width?
- Does this channel contain dry-weather flow?
- Is the sump at least 12-inches (30.5-cm) deep?
- What provisions have been made for sediment removal? Filter fabric?
- Has filter fabric on upstream face been keyed into the bed?
- Are there provisions made to remove the check dam(s)? If no, refer to previous question to check for dam lifecycle.



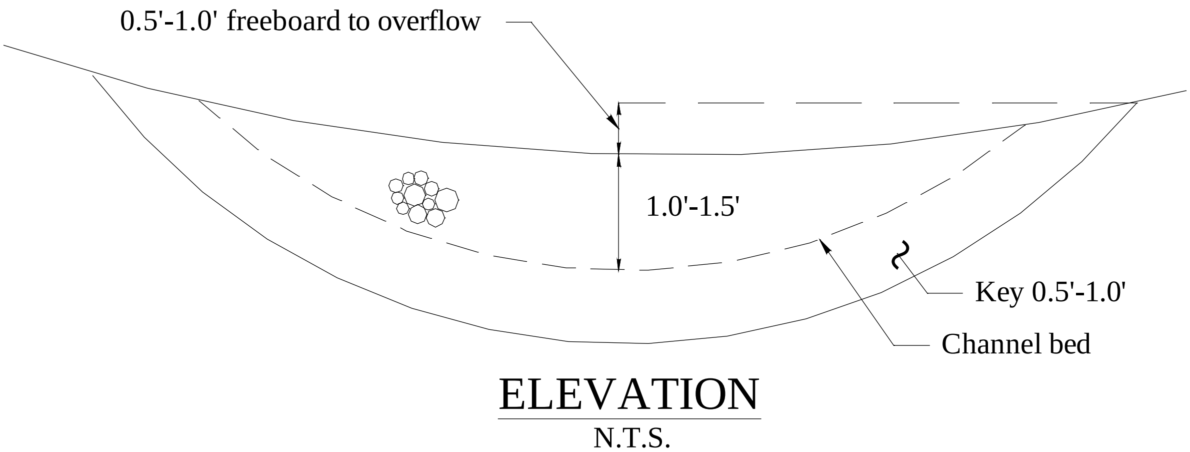


Figure TCP-12-1
Stone Check Dam Construction

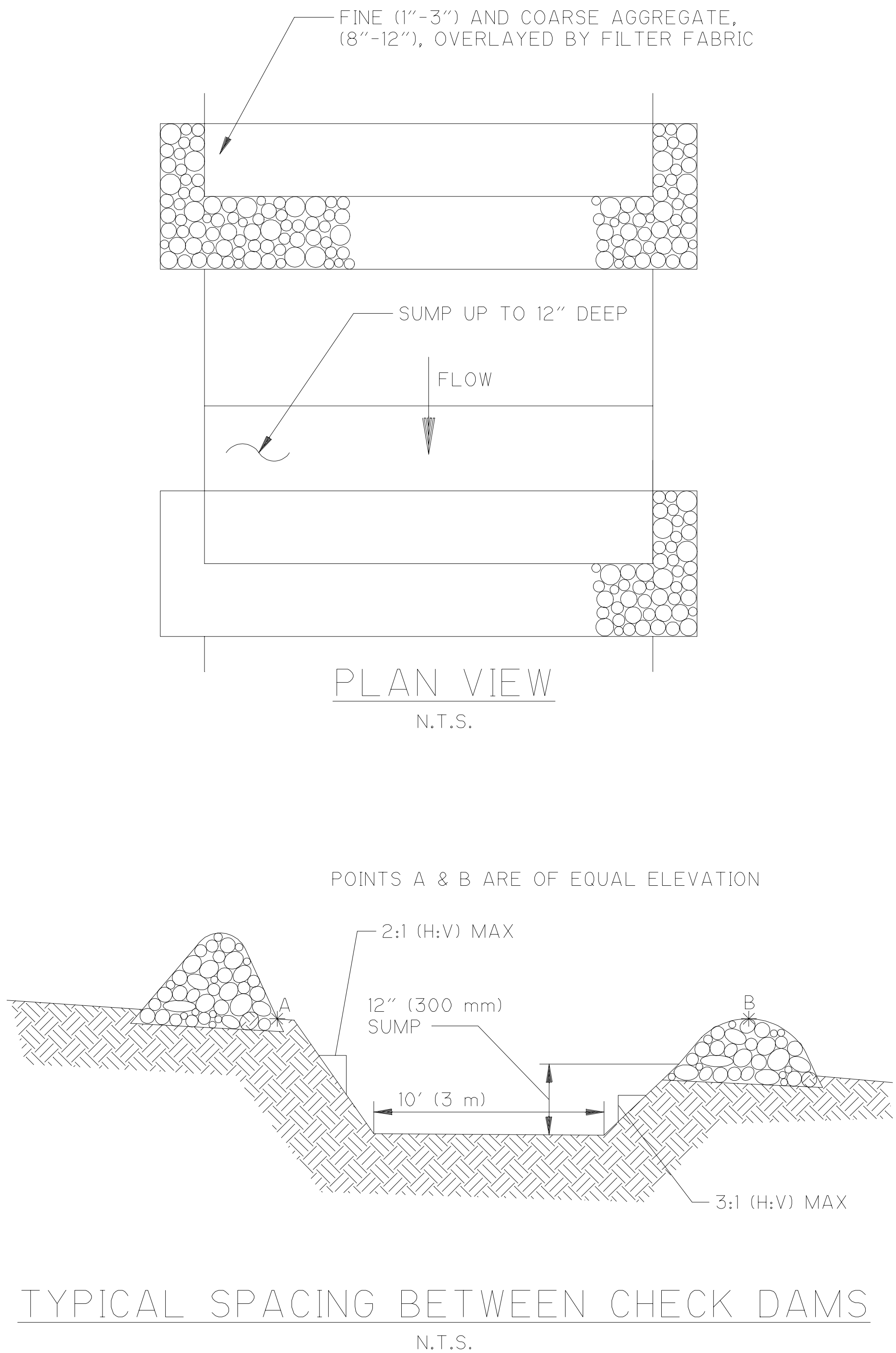
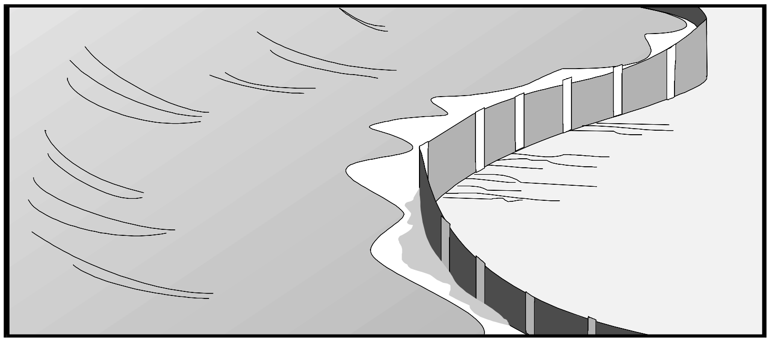


Figure TCP-12-2
Stone Check Dam Spacing



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
◗ Capital Costs	◗ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	◗ Training

Description

A silt fence is made of a filter fabric which has been entrenched, attached to supporting poles, and sometimes backed by a wire fence for support. The silt fence detains sediment-laden water, promoting sedimentation behind the fence.

A silt fence is a temporary sediment barrier consisting of filter fabric stretched across and attached to supporting posts, entrenched, and depending upon the strength of the fabric used, supported with wire fence. Silt fences trap sediment in two ways: (1) by intercepting and detaining small amounts of sediment from disturbed areas during construction operations in order to promote sedimentation behind the fence; and (2) by decreasing the velocity of low flows (up to 0.5 cfs (1.4×10^{-2} m^3/s)) in swales. In simpler terms, a silt fence does not filter the water it slows it down enough for the sediment to settle out of the runoff water. This management practice is likely to create a significant reduction in sediment.

Silt fences, while much more effective than straw bales and brush barriers, are not as effective as sand bag barriers or rock filters (especially continuous berms). The difference in effectiveness is due to the durability and maintenance requirements.

Suitable Applications

- Along the downstream perimeter of the phase construction.
- Below the toe of a cleared slope.
- Upstream of sediment traps or basins.
- Along streams and channels (not across).
- Around temporary spoil areas.
- Across swales with catchments less than 1 acre (0.4 ha) (per 400-feet (125.7 m) of fence) and below other small cleared areas.

Installation/ Application Criteria

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

- 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).

- 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 weekly and after each rainfall.

- Repair wherever fence is damaged.

- Remove sediment when it reaches 1/3 the height of the fence.

- Inspect silt fence when rain is forecast. Perform required maintenance before the storm event.

- Remove silt fence when no longer needed. Fill and compact post holes and anchorage trench, remove sediment accumulation, and grade alignment to blend with adjacent ground.

Limitations

- Do not place fence on a slope, or across any contour line. This may result in worse erosion than not installing the fence at all.

- Do not use in streams, channels, or anywhere flow has concentrated.

- Do not use in locations where ponded water may cause flooding.

- Limit the length of slope draining to any point along the silt fence to 100 ft. (30 m) or less.

- Limit length of any single run of silt fence to 500 ft. (150 m).

- Must be placed along a level contour.

- Don't use below slopes subject to creep, slumping, or landslides.

- Don't use silt fences to divert flow.

Additional Information

Silt fences are preferable to straw barriers in many cases. Laboratory work at the Virginia Highway and Transportation Research Council has shown that silt fences can trap a much higher percentage of suspended sediments than can straw bales. While the failure rate of silt fences is lower than that of straw barriers, there are many instances where silt fences have been improperly installed.

Selection of a filter fabric is based on soil conditions at the construction site (which affect the equivalent opening size (EOS) fabric specifications) and characteristics of the support fence (which affect the choice of tensile strength). The designer should specify a filter fabric that retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging. The following criteria is recommended for selection of the equivalent opening size:

1. If 50 percent or less of the soil, by weight, will pass the U.S. standard sieve No. 200, select the EOS to retain 85 percent of the soil. The EOS should not be finer than EOS 70.
2. For all other soil types, the EOS should be no larger than the openings in the U.S. Standard Sieve No. 70 [0.0083 in. (0.21 mm.)] except where direct discharge to a stream, lake, or wetland will occur, then the EOS should be no larger than Standard Sieve No. 100.

To reduce the chance of clogging, it is preferable to specify a fabric with openings as large as allowed by the criteria. No fabric should be specified with an EOS smaller than U.S. Standard Sieve No. 100 [0.0059 in. (0.15 mm)]. If 85 percent or more of a soil, by weight, passes through the openings in a No. 200 sieve [0.0029 in. (0.074 mm)], filter fabric should not be used. Most of the particles in such a soil would not be retained if the EOS was too large, and they would clog the fabric quickly if the EOS was small enough to capture the soil.

The fence should be supported by a wire mesh if the fabric selected does not have sufficient strength and bursting strength characteristics for the planned application (as recommended by the fabric manufacturer). Filter fabric material should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F to 120°F.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

Environmental Action Manual, City of Austin, Texas, 1989.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Work Group Working Paper, USEPA, April, 1992.

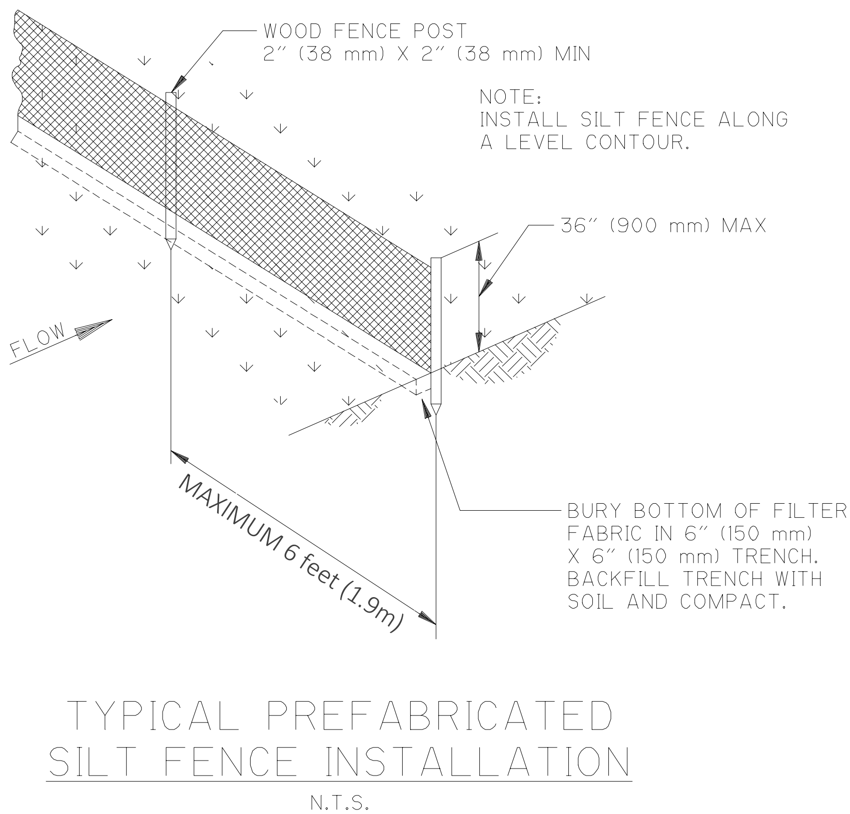
Sedimentation and Erosion Control Practices, An Introductory of Current Practices (Draft), USEPA, 1990.

Stormwater Management Manual for the Puget Sound Basin, Washington State Department of Ecology, Public Review Draft, 1991.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

Inspection Checklist

- Does the silt fence follow a contour?
- Are the ends of the silt fence turned uphill for the last 6 ft. (1.8 m)?
- Is the anchor trench depth color band visible?
- Is the silt fence secure to the posts?
- Has sediment accumulated behind the fence by more than ⅓ the height of the fence? If yes, then clear it.
- Does any 100-foot (30.5 m) of silt fence serve more than ¼ acre (0.1 ha) of exposed area?
- Is there any indication of washaround or underwash? If yes, then reset the fence and determine if it is overloaded (i.e. another fence should be installed upstream).



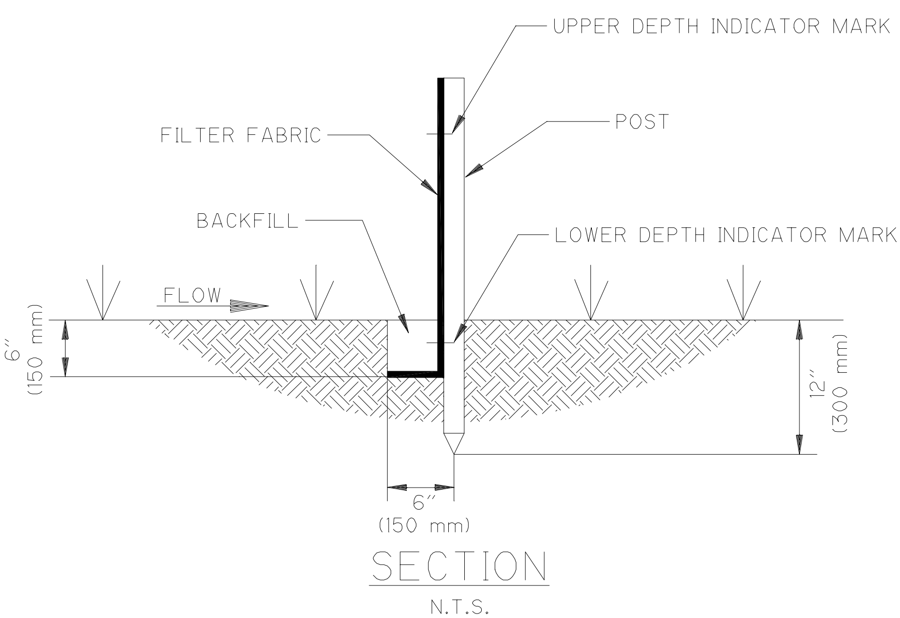


Figure TCP-13-1
Silt Fence Anchoring

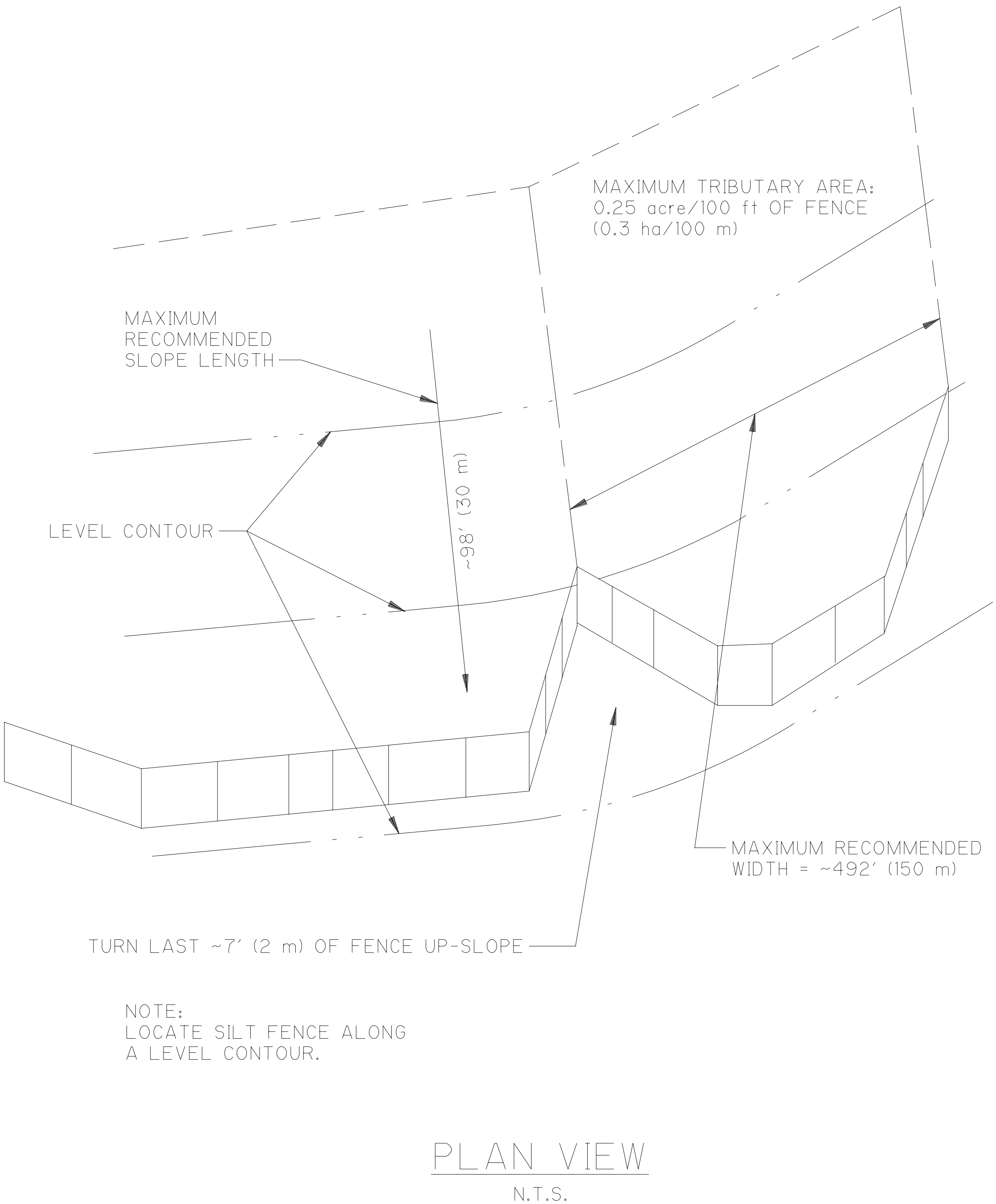
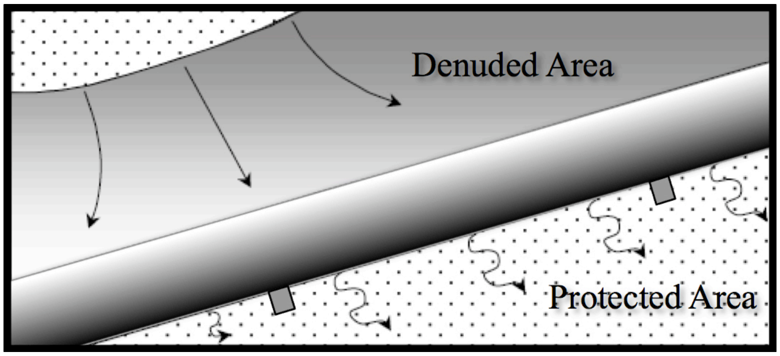


Figure TCP-13-2
Silt Fence End Layout

ACTIVITY: Weighted Sediment Tube	TCP – 14



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
● Capital Costs	● O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

A weighted sediment tube (WST) consists of tubular-shaped filter bags with ballast material designed to reduce suspended solids from runoff.

Sand bag barriers and rock filters (especially continuous berms) are preferred over weighted sediment tubes because sediment removal efficiencies, durability, and maintenance requirements are far less desirable in weighted sediment tubes. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- Along the perimeter of the site.
- Along swales as a temporary erosion control measure (check dams).
- Around temporary spoil areas and other small cleared areas.
- Below the toe of exposed erodible slopes.
- Downslope of exposed soil areas.

Installation/ Application Criteria

Weighted sediment tubes are typically installed with 0.25 acre (0.1 ha) draining to every 100-feet (31.4 m) of barrier. They are designed to function under a 10-year storm event and may be furnished for no longer than three months. The barrier is designed to pond water behind so it is crucial that it is sufficiently anchored and follows contours. Weighted sediment tubes that are not entrenched and do not follow contours can result in worsened erosion.

Generally, weighted sediment tubes are used in conjunction with erosion source controls to provide sufficient control. Weighted sediment tubes are not as effective as silt fences.

- Use primarily in areas where sheet or rill flow occurs.
- No more than 0.25 acre (0.1 ha) per 100 feet (31.4 m) of barrier should drain to the barrier.
- Install along a level contour, turning ends up slope to prevent scour from wash around.
- Tubes should be placed on the contour and in a row with ends tightly abutting the adjacent tube.
- Leave area for runoff to pond upstream of the barrier by locating barrier away from the toe of slopes. This also provides access for maintenance.
- Secure each tube with stakes. Slightly angle stakes with top facing towards direction of flow.
- Tubes should be placed on compacted soils. Hard tamp soft or loose soils.
- Leave enough area (about 1200 sq. ft. (111.5 m2) per acre (0.4 ha)) behind the barrier for runoff to pond (less than 1.5 ft. (0.5 m) depth) and sediment to settle.

Maintenance

- Inspect weekly and within 24 hours after the end of a storm event.
- Replace tubes that have decomposed.
- Repair washouts or other damage as needed.
- Remove sediment when accumulations reach one-half the original height of either a single tube or stacked tubes. Sediments removed shall be disposed of properly.
- Remove tubes when no longer needed. Regrade and stabilize the area.
- Inspect weighted sediment tubes when rain is forecast. Be sure the tubes are overlapped or butted end to end.

Limitations

- Weighted sediment tubes have not been as effective due to improper use. These barriers have been placed in swales and drainageways where runoff volumes and velocities have caused the tubes to wash out. In addition, failure to stake the sediment tube will allow undercutting and end flow.

- Weighted sediment tubes are not to be used for extended periods of time because they tend to rot and fall apart.
- Limit length of any single row of tubes to 500 ft. (157 m).
- Not appropriate for large drainage areas, limit to five acres or less.
- Sediment tubes may lose their effectiveness due to degradation, thus constant maintenance is required.
- Not intended for inlet protection or streams.
- Tube bindings of jute or cotton not recommended as they quickly deteriorate and fail.
- Limit to locations suitable for temporary ponding or deposition of sediment.
- Slopes of 3:1 (H:V) or flatter are preferred. If the slope exceeds 3:1 (H:V), use a different management practice or limit the length of slope upstream of the tube to less than 25 ft (15.7 m).

Additional Information

A weighted sediment tube consists of secured tubes placed to intercept sediment-laden runoff from small drainage areas of disturbed soil. The barrier ponds runoff and allows sediment to settle. Weighted sediment tubes should not be used for extended periods of time because they tend to rot and fall apart.

When installed and maintained according to the guidelines on this fact sheet, sediment tubes can remove some of the sediment transported in construction site runoff. This optimum efficiency can only be achieved through careful maintenance, with special attention to replacing damaged tubes.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

"Draft – Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April, 1990.

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Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

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Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

Inspection Checklist

- Does the barrier follow a contour?
- Are the posts secure?
- Has sediment accumulated behind the fence by more than half the original height of either a sigular tube or stacked tubes? If yes, then clear it.
- Is there any indication of wash around or under wash? If yes, then reset the barrier and determine if it is overloaded (i.e. another barrier should be installed upstream or a silt fence or other practice be implemented).

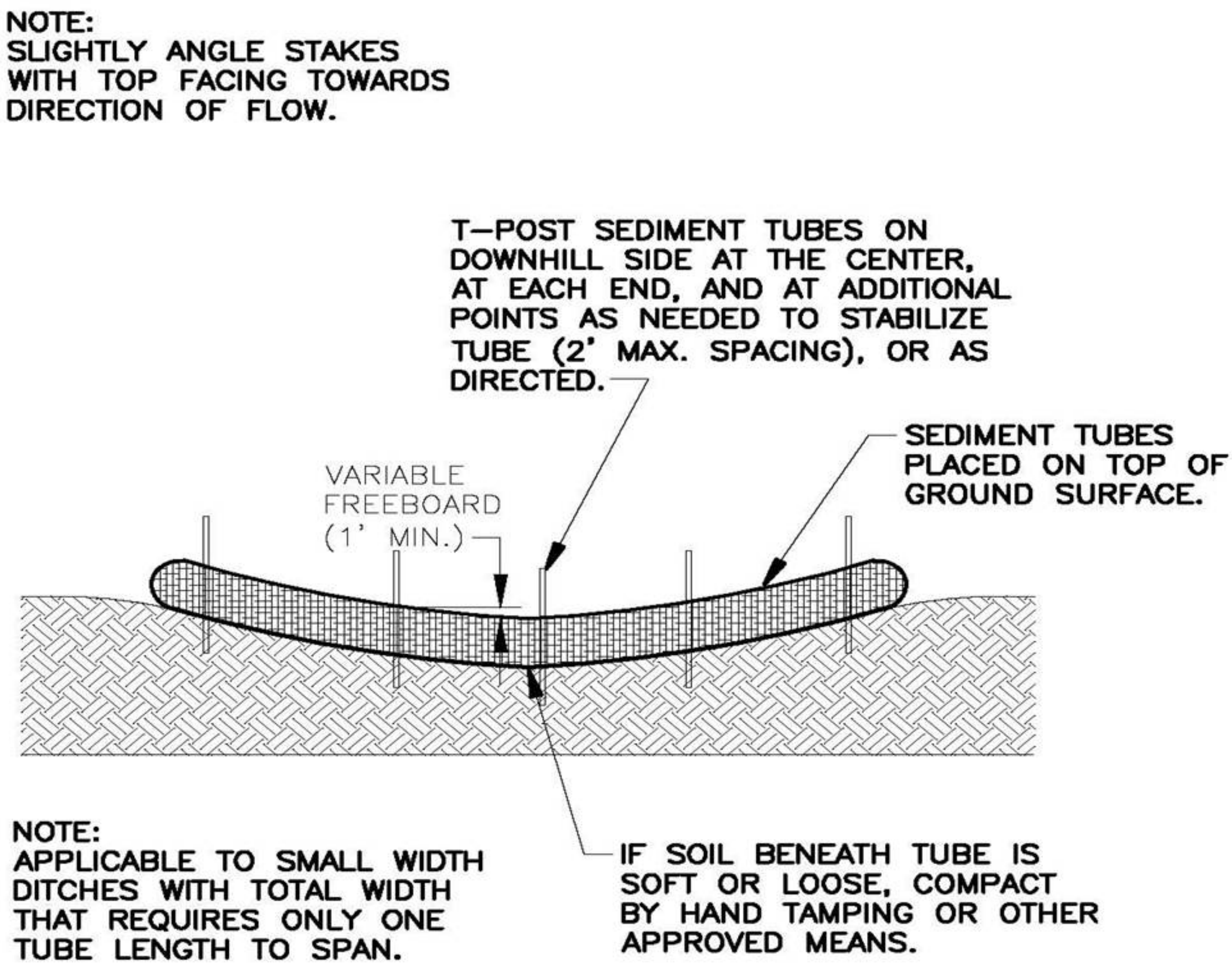


Figure TCP-14-1

Small Ditch Checks for Sediment Tubes

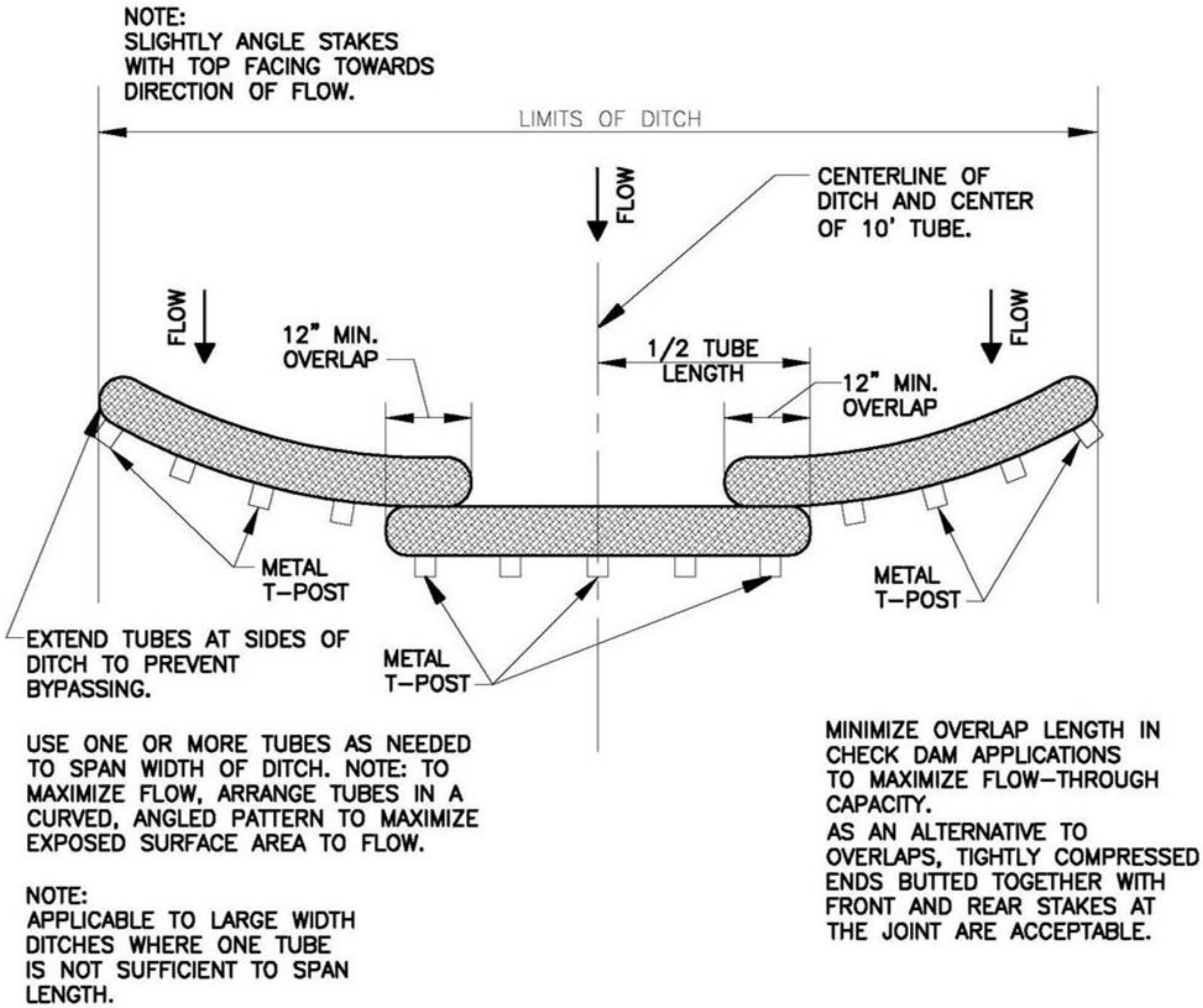
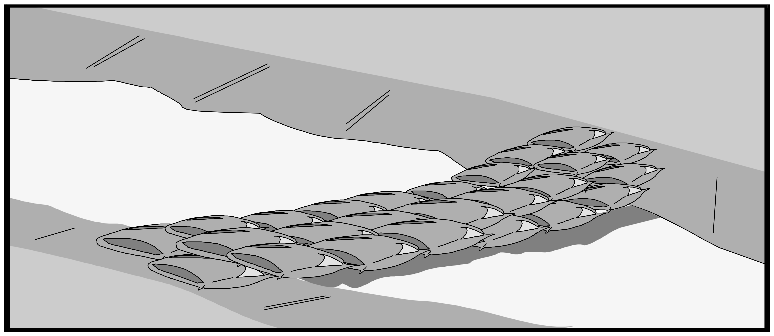


Figure TCP-14-2

Check Dam Arrangement for Larger Width Ditches for Sediment Tubes

ACTIVITY: Sand Bag Barrier	TCP – 15



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
● Capital Costs	○ O & M Costs	○ Maintenance	◗ Suitability for Slopes >5%	○ Training

Description

Stacking sand bags along a level contour creates a barrier which detains sediment-laden water, ponding water upstream of the barrier and promoting sedimentation. A sand bag barrier does not filter the water it slows it down enough for the sediment to settle out of the runoff water. This management practice is likely to create a significant reduction in sediment.

Sand bag barriers, while more effective than straw bales, silt fences and brush barriers are not as effective as rock filters (especially continuous berms). The difference in effectiveness is due to the durability and maintenance requirements.

Suitable Applications

- When extended construction period limits the use of either silt fences or straw bale barriers.
- Along the perimeter of the site.
- Check dams across streams and channels.
- Along streams and channels.
- Across swales with small catchments.
- Division dike or berm.
- Below the toe of a cleared slope.
- Create a temporary sediment trap.
- Around temporary spoil areas.
- Below other small cleared areas.

- May be used in drainage areas up to 5 acres (2 ha).
- Across channels to serve as a barrier for utility trenches or provide a temporary channel crossing for construction equipment, to reduce stream impacts, provided appropriate permits have been received from TDEC.
- Parallel to a roadway to keep sediment off paved areas.
- To divert or direct flow or create a temporary sediment basin.
- When site conditions or construction sequencing require adjustments or relocation of the barrier to meet changing field conditions and needs during construction.

Installation/ Application Criteria

- Install along a level contour with ends angled uphill at least 6 linear feet (1.9 m) to prevent wash around scour.
- Height of Berm – 18 inches (45.7 cm) minimum height, measured from the top of the existing ground at the upslope toe to the top of the barrier.
- Width of Berm – 48 inches (1.3 m) minimum width measured at the bottom of the barrier; 18 inches (45.7 cm) at the top.
- Sand bag Size – Length 24 to 30 inches (70 to 76.2 cm), width 16 to 18 inches (40.6 to 45.7 cm) and thickness 6 to 8 inches (15.2 to 20.3 cm). Weight 90 to 125 pounds (41.5 to 57.6 kg).
- Sand bag Material – Polypropylene, polyethylene or polyamide woven fabric, minimum unit weight four (4) ounces (0.25 lb.) per square yard (0.8 square meter), mullen burst strength exceeding 300 psi and ultraviolet stability exceeding 70 percent. Use of burlap is not intended since it rots and deteriorates easily.
- Grade of Sand – Coarse sand, gravel.
- Runoff water should be allowed to flow over the tops of the sand bags or through 4-inch (10.2-cm) polyvinyl chloride pipes embedded below the top layer of bags.
- Area behind the sand bag barrier should be established according to sizing criteria for sediment trap BMP.
- Provide area behind barrier for runoff to pond and sediment to settle, size according to sediment trap BMP criteria.
- Use sand bags large enough and sturdy enough to withstand major flooding.
- When used as a linear control for sediment removal:
  - Install along a level contour.
  - Turn ends of sand bag row up slope to prevent flow around the Ends
  - Generally, should be used in conjunction with erosion source controls up slope to provide effective control.

- When used for concentrated flows:
  - Stack sand bags to required height using a pyramid approach.
  - Upper rows of sand bags should overlap joints in lower rows.

Maintenance

- Reshape or replace damaged sand bags immediately.
- Inspect sand bag barriers before and after each rainfall event, and weekly throughout the rainy season.
- Repair washouts or other damages as needed.
- Inspect sand bag barriers for sediment accumulations and remove sediments when depth reaches one-third the barrier height. Sediment removed shall be disposed of properly.
- Remove sand bags when no longer needed. Remove sediment accumulation, and clean, regrade, and stabilize the area.

Limitations

- Sand bag barriers are more costly, but typically have a longer useful life than straw bales, silt fences, or brush filters.
- Sand bag barriers may be used for sediment trapping in locations where silt fences and straw bale barriers are not strong enough. In addition, sand bag barriers are appropriate to use when construction of check dams or sumps in a stream is undesirable. The sand bag berms can provide the same function as a check dam without disturbing the stream or vegetation. The sand bag berm will also allow a small sediment retention area to be created prior to construction of final detention basins. They also provide a semi-permeable barrier in potentially wet areas, are more permanent than silt fences or straw bales and allow for easy relocation on site to meet changing needs during construction.
- Burlap should not be used for sand bags.
- Limit the drainage area upstream of the barrier to 5 acres (2 ha).
- Degraded sand bags may rupture when removed, spilling sand.
- Installation can be labor intensive compared to continuous berms or silt fences.
- When used to detain concentrated flows, maintenance requirements significantly increase.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

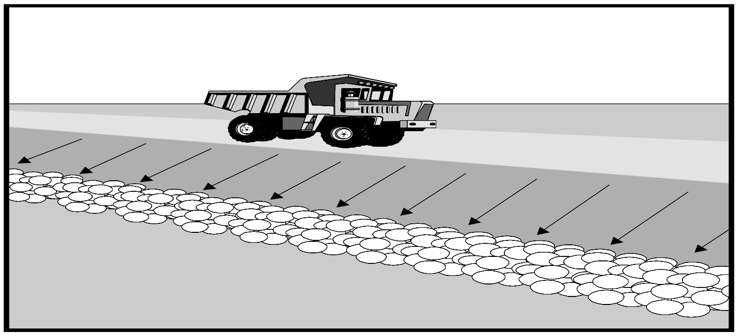
Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

Inspection Checklist

- Does the barrier follow a contour?
- Are the ends of the barrier turned uphill for the last 6 ft. (1.8 m)?
- Has sediment accumulated behind the barrier by more than ⅓ the height of the barrier? If yes, then clear it.
- Does any 100 feet (30.5 m) of barrier serve more than 5 acres (2 ha) of exposed area?
- Is there any indication of wash around or under wash? If yes, then reset the barrier and determine if it is overloaded (i.e. another barrier or type of practice should be installed upstream).



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

◗ Capital Costs	◗ O & M Costs	○ Maintenance	◗ Suitability for Slopes >5%	○ Training

Description

A rock filter berm is made of rock ¾ to 5 inch (1.9 to 12.7 cm) diameter and placed along a level contour where sheet flow may be detained and ponded, promoting sedimentation. A brush barrier is composed of brush (usually obtained during the site clearing) wrapped in filter cloth and anchored to the toe of the slope. A continuous berm is a berm constructed of a continuous role of fabric that encapsulates sand, rock or native soil. It is generally implemented on site through the use of an extruder pulled behind a tractor.

If properly anchored, brush or rock filters and continuous berms may be used for sediment trapping and velocity reduction. In simpler terms brush or rock filters do not filter the water they slow it down enough for the sediment to settle out of the runoff water. See Check Dam BMP for more information. This management practice is likely to create a significant reduction in sediment. Continuous berms are more effective than silt fences, straw bales, brush barriers and sand bag barriers. The difference in effectiveness is due to the durability and maintenance requirements.

Suitable Applications

- Rock filters are appropriate where a temporary measure is needed to prevent sediments from entering right-of-ways of traffic areas such as near the toe of slopes, incorporated into stabilized construction entrances, or at other locations along the construction site perimeter. Rock filters may also be used as check dams across one or more lanes of construction traffic temporary roads, or unsurfaced rights of way subject to construction traffic.
- Across mildly sloped construction roads (rock filter berms, only).
- Below the toe of slopes.
- Along the site perimeter.
- Along streams and channels.

- Around temporary spoil areas.
- Below other small cleared areas.
- At sediment traps at culvert/pipe outlets.
- Construction projects with disturbed areas during wet season.
- Where contributing tributary areas are less than 5 acres (2 ha) to 10 acres (4 ha).

Installation/ Application Criteria

- 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.
- 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).

- In Non-Traffic Areas:

  - Maximum flow-through rate per square foot (0.1 m^2) of filter = 60 gpm (3.8 x 10^{-3} m^3/s)
  - Height = 18 inches (45.7 cm) minimum
  - Top width = 24 inches (61 cm) minimum
  - Side slopes = 2:1 (H:V) or flatter
  - Woven wire sheathing (poultry netting) is recommended in areas of concentrated flow. The wire should be 1-inch (2.5-cm) diameter hexagonal mesh, galvanized 20 gauge.
  - Build the filter on a level contour.
  - Rock: ¾ to 3 inches (1.9 to 7.6 cm) open graded for sheet flow, 3 to 5 inches (7.6 to 12.7 cm) open graded for concentrated flow.

- In construction traffic areas, maximum rock berm heights shall be 12 in. (300 mm). Multiple berms should be constructed every:

  - 300 ft (94.3 m) on slopes less than 100:5 (H:V) (5%)
  - 200 ft (62.9 m) on slopes between 100:5 (H:V) (5%) and 100:10 (H:V) (10%)
  - 100 ft (31.4 m) on slopes greater than 100:10 (H:V) (10%).

Steps in Construction of a Brush Filter:

1. Stack the brush at the toe of a slope or along the perimeter of the site just outside the limits of clearing and grubbing. The brush may be stacked up to 15 ft. (4.7 m) high and 15 ft. (4.7 m) wide.
2. Construct a trench 1 to 3 ft. (0.3 to 0.9 m) deep immediately upslope from the brush.
3. Place filter fabric over the brush filter and in the trench, extending 1 to 2 ft (0.3 to 0.6 m) upslope of the trench.
4. Backfill the trench with aggregate or compacted soil. The trench should be deep enough and backfill material sufficient to hold the barrier in place during a storm.

Maintenance

- Installation in stream beds requires large rock, staking of woven wire sheathing, and daily inspection.

- Inspect berms before and after each significant rainfall event, and weekly throughout the rainy season.

- Reshape berms as needed and replace lost or dislodged rock, brush and/or filter fabric.

- Inspect for sediment accumulation and remove sediments when depth reaches one-fourth of the berm height or 12 in. (300 mm), whichever occurs first.

- Filter berms should be removed upon completion of construction activities.

Limitations

- Cost

  - Brush filter: Low to moderate cost if debris from on-site clearing and grubbing

is used.
- Rock filter: Expensive, since off-site materials, hand construction and demolition/removal are usually required.

- Not appropriate for contributing drainage areas greater than 5 acres (2 ha).
- Requires sufficient space for ponded water.
- Not effective for diverting runoff since filters allow runoff to slowly seep through.
- Performance of brush filters relatively unpredictable.
- Rock filter berms are difficult to remove when construction is complete.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

Handbook of Steel Drainage & Highway Construction, American Iron and Steel Institute, 1983.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Storm Water Pollution Plan Handbook, First Edition, State of California, Department of Transportation Division of New Technology, Materials and Research, October 1992.

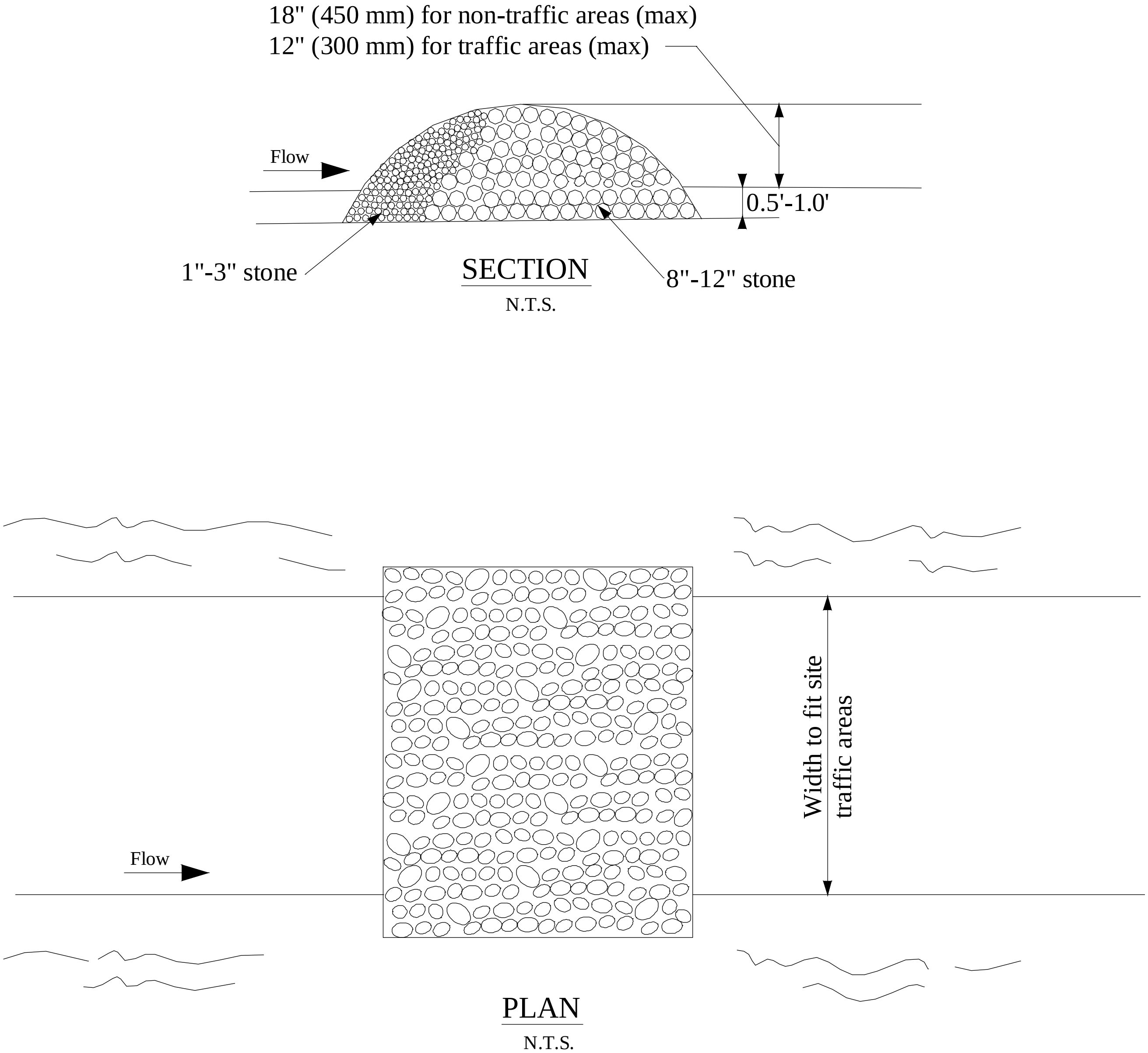
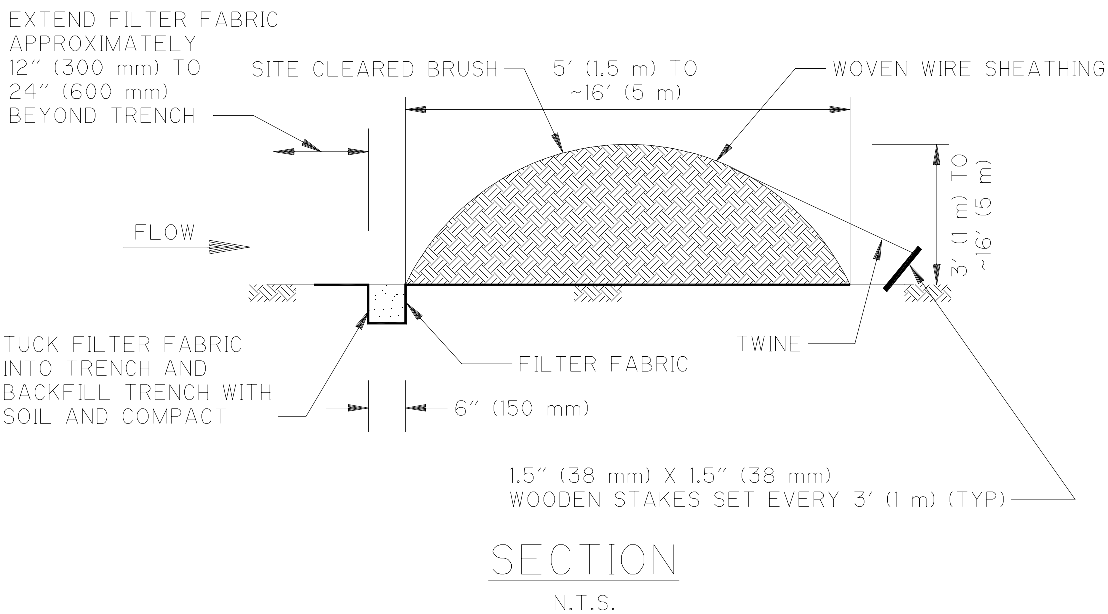


Figure TCP-16-1
Rock Filter Construction



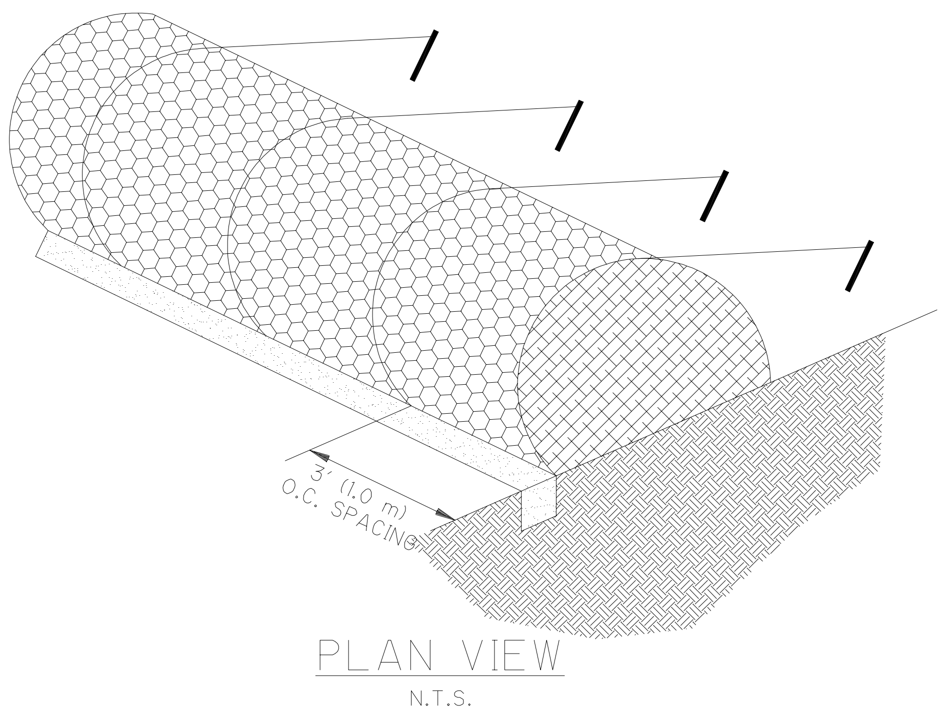
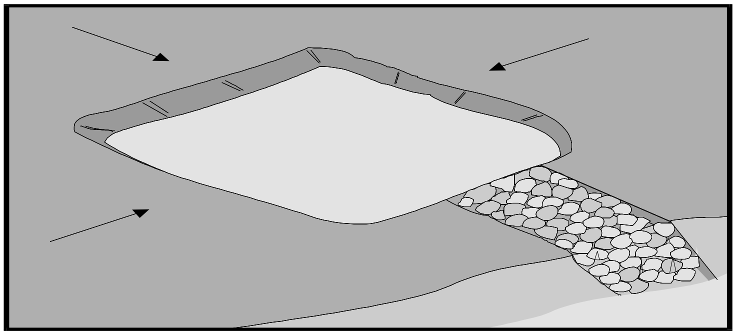


Figure TCP-16-2
Brush Filter Construction

ACTIVITY: Sediment Traps	TCP – 17



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	● Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	◗ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

A sediment trap is a small, excavated or bermed area where runoff from small tributary areas is detained and sediment can settle. This management practice is likely to significantly reduce sediment and floatable materials.

Suitable Applications

- Any disturbed area less than 5 acres (2 ha). (Sediment Basins must be used for drainage areas greater than 5 acres (2 ha)).
- Install detention as first step in site clearing process. Use for temporary construction. Then re-establish and maintain after site is stabilized.
- Along the perimeter of the site at locations where sediment-laden runoff is discharged off-site.
- Around and/or upslope from storm drain inlet protection measures.
- At any point within the site where sediment-laden runoff can exit the site or enter stabilized areas or waterways.
- In place of sediment basins, only when the contributing drainage area is divided into smaller subareas contributing to each trap.

Installation/ Application Criteria

- A sediment trap is a small temporary ponding area, usually with a gravel outlet and filter fabric, formed by excavation and/or by constructing an earthen embankment. Its purpose is to collect and store sediment from sites cleared and/or graded during construction. It is intended for use on small tributary areas, with no unusual drainage features, and projected for a quick build-out time. It should help in removing coarse sediment from runoff. The trap is a temporary measure with a design life of approximately 6 months, and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures.
- Construct sediment traps prior to construction activities. Plan for 100-year, 24-

hour flow from upstream area.

- Trap shall be located: (1) by excavating a suitable area or where a low embankment can be constructed across a swale, (2) where failure would not cause loss of life or property damage, and (3) to provide access for maintenance, including sediment removal and sediment stockpiling in a protected area.

- Build outside the area to be graded before clearing, grubbing, and grading begin.

- Trap size depends on the type of soil, size of the drainage area, and desired sediment removal efficiency.

- Restrict basin side slopes to 4:1 (H:V) or flatter.

- The larger the trap, the less frequently sediment must be removed, but a larger volume will need to be removed.

- The outlet of the trap must be stabilized with rock, geotextile, vegetation, or another suitable material to prevent erosion.

- A stable emergency spillway must be installed to safely convey stormwater runoff for events larger than the 10-year storm event.

- Sediment trap size depends on the type of soil, size of the drainage area, and desired sediment removal efficiency. As a rule of thumb, the larger the basin volume the greater the sediment removal efficiency. The runoff volume from a two-year, 24-hour storm is a common design criterion for a sedimentation trap.

- Traps shall be sized to accommodate a settling zone and sediment storage zone with recommended minimum volumes of at least 134 yd^3/ac and 45 yd^3/ac (256 m^3/ha and 86 m^3/ha) of contributing drainage area, respectively, based on 1.0 in. (2.54 cm) of runoff volume over a 24-hr period. Multiple traps and/or additional volume may be required to accommodate site specific soil conditions.

- Trap inlets should be located to maximize the travel distance to the trap outlet. Trap length to width ratio shall be greater than 3:1 (L:W) or baffles are required to prevent short-circuiting of the inlet flow.

- Two porous baffles shall be provided to reduce the velocity and turbulance of the water in the trap and to divide the trap into three sections as shown in Figure TCP-17-2. The baffles should be made of highly porous materials such as coir or jut netting. Silt fence should not be used.

- To dewater the trap, the outlet should be constructed in one of the following three ways:

  (1) Use a triangular shaped filter dike (see Figure TCP-17-1) or check dam (see TCP-12).

  (2) Use corrugated metal or reinforced concrete riser pipe with dewatering holes encased in gravel to prevent floating debris from flowing out of the

trap or clogging the system. See Figure TCP-17-2. This method is usually applied for larger sediment traps (serving 4 or more acres) or temporary sediment detention basins.

- Top two-thirds of the riser shall be perforated with 0.5 in (1.3 cm) diameter holes spaced 8 in. (20.3 cm) vertically and 10 in. to 12 in. (25.4 cm to 30.5 cm) horizontally.
- Structure shall be placed on a firm, smooth foundation with the base securely anchored with concrete or other means to prevent floatation.
- Securely attach to the riser pipe (watertight connection) a horizontal pipe (barrel) which extends through the embankment to the toe of fill.

(3) Construct a crushed stone outlet section of the embankment at the low point of the trap. The stone section serves as a nonerosive spillway outlet for flood flows and the bottom section provides a means of dewatering the trap between rainfall events. See Figure TCP-17-3.

Maintenance

- Inspect sediment traps weekly, before and after rainfall events. During extended rainfall events, inspect sediment traps daily during construction.
- Examine trap banks for seepage and structural soundness.
- Check outlet structure and spillway for any damage or obstructions. Repair damage and remove obstructions as needed.
- Check outlet area for erosion and stabilize, if required.
- Remove accumulated sediment when the volume has reached one-third the original trap volume. Properly dispose of sediment and debris removed from the trap.

Limitations

- Only use for drainage areas up to 5 acres (2 ha)(see Sediment Detention Basin TCP-18 for larger areas).
- Not to be located in live streams.
- Requires surface areas of 3 to 5 percent of the tributary area to permit settling of sediment.
- Only removes large and medium sized particles and requires upstream erosion control.
- Can be attractive and dangerous to children. Protective fencing for the site is recommended.

Additional Information

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 5 acres (2 ha), use a sediment basin or subdivide the catchment area into smaller drainage basins.

Sediment usually must be removed from the trap after each rainfall event. The Stormwater Pollution Prevention Program for the site should detail how this sediment is to be disposed of, such as for in fill areas on-site, or removal to an approved off-site dump. Sediment traps used as a perimeter control should be installed before any land disturbance takes place in the tributary area.

Sediment traps can be constructed by excavating a depression in the ground or creating an impoundment with a barrier or low-head dam. Sediment traps should be installed outside the area being graded and should be built prior to the start of the grading activities or removal of vegetation. To minimize the area disturbed by them, sediment traps should be installed in natural depressions or in small swales or drainageways. The following are additional typical installation criteria.

1. The area under the embankment must be cleared, grubbed, and stripped of any vegetation and root mat. The pool area should be cleared.
2. The fill material for the embankment must be free of roots or other woody vegetation as well as oversized stones, rocks, organic material, or other objectionable material. The embankment may be compacted by traversing with equipment while it is being constructed.
3. When a riser is used, all pipe joints must be watertight.
4. When an earth or stone outlet is used, the outlet crest elevation should be at least 1 foot below the top of the embankment.
5. When a crushed stone outlet is used, the crushed stone used in the outlet should meet AASHTO M43, size No. 2 or 24, or its equivalent such as MSHA No. 2. Gravel meeting the above gradation may be used if crushed stone is not available.
6. If the trap is to be removed, the area must be properly stabilized including the upslope tributary area. If the trap is to be used as a permanent detention facility, then remove any sediment required to achieve the needed volume and clean or reset the outlet structure.

Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Rough Draft - July 1992.

"Draft – Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April, 1990.

"Environmental Criteria Manual", City of Austin, Texas.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

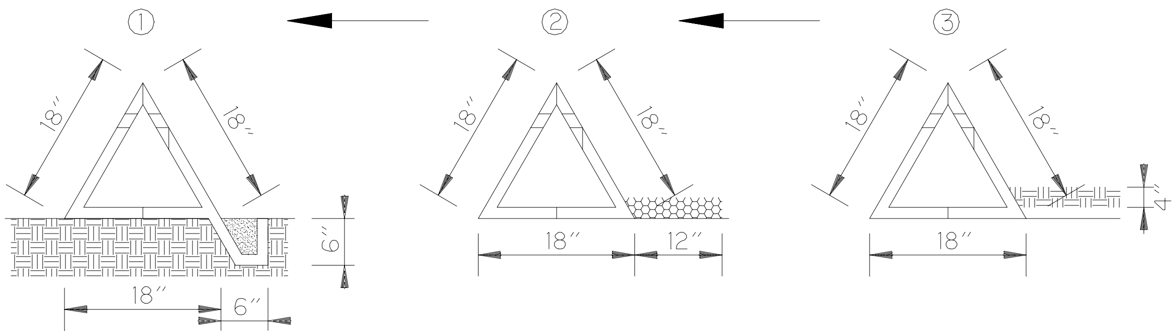
Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Work Group Working Paper, USEPA, April, 1992.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

Inspection Checklist

- Has this management practice been constructed to serve no more than 5 acres (2 ha)?
- Does the outlet structure use a triangular shaped filter dike, riser pipe or stone outlet designed to convey flows up to the 10-year storm event?
- Is the outlet structure stabilized to prevent erosion?
- Is there a gage indicating the depth of the trap?
- Has sediment accumulated beyond ⅓ the depth?
- If the trap failed, would it result in loss of life, damage to home or buildings, or interruption in the use of public roads or utilities?
- Is the trap protected from access by children?
- Is the outlet structure clogged?
- Are there any signs of seeping through or erosion of the low embankment?
- Is an overflow structure present that can convey flows beyond the 10-year storm event?



CROSS SECTION OF INSTALLATION OPTIONS
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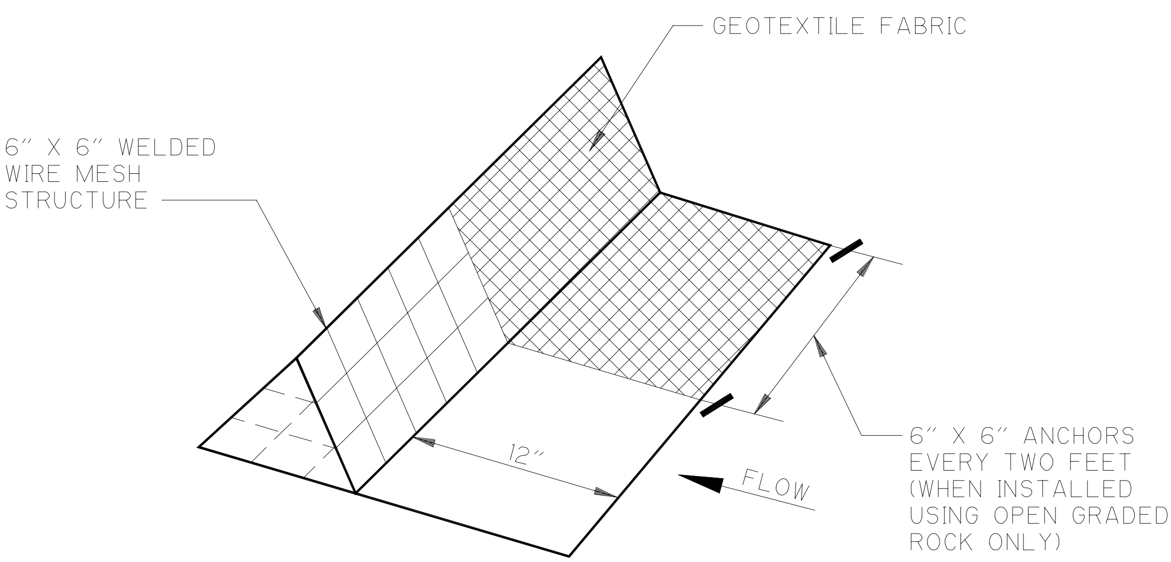
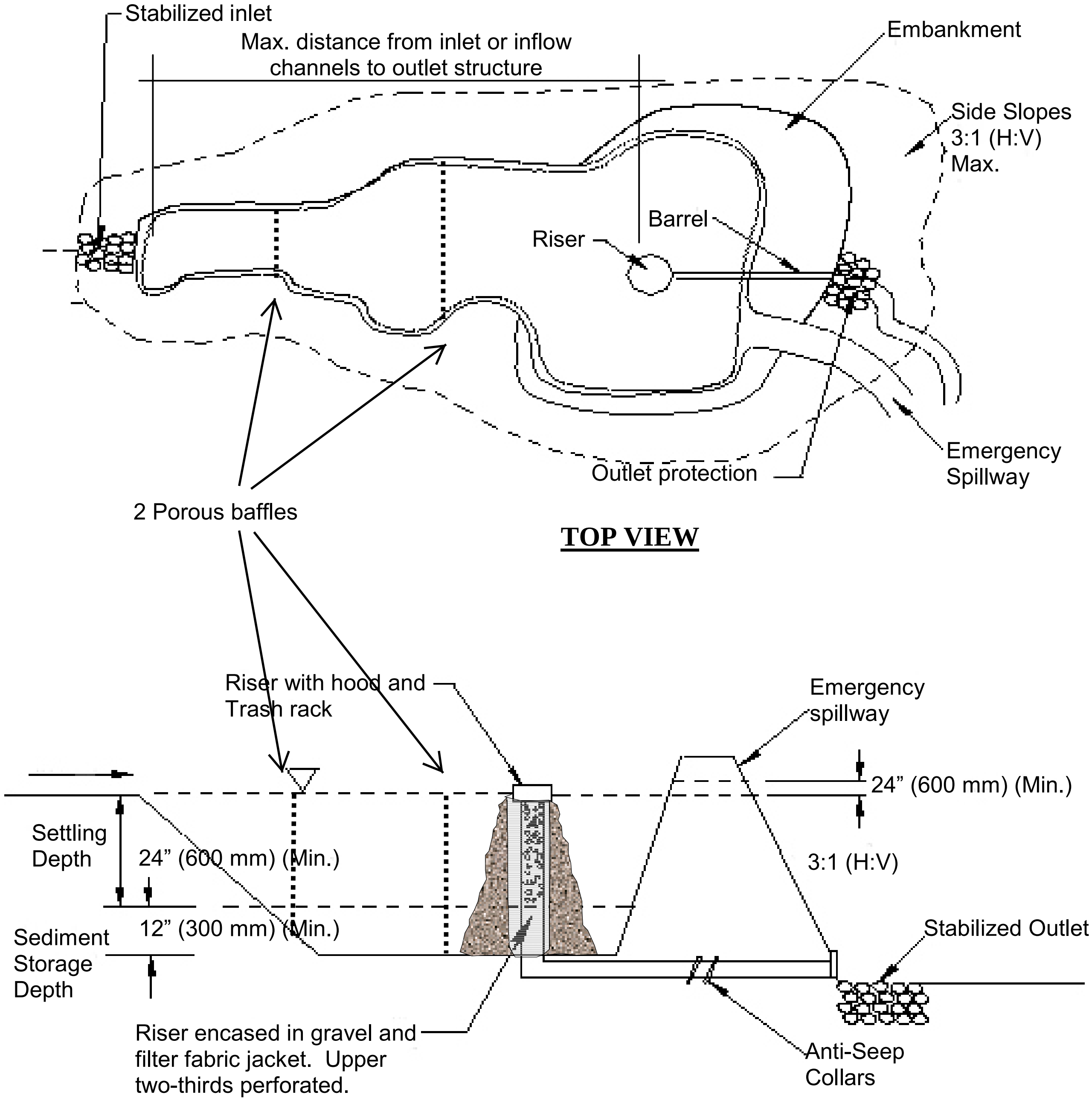


ISOMETRIC PLAN VIEW
N.T.S.

Figure TCP-17-1
Sediment Trap – Filter Dike



NOTES:
1. Typical trap design shown will handle 1.0” (25.4 mm) of runoff over a 24-hour period.
2. Settling volume: at least 134 yd^3 per acre of tributary area.
3. Sediment storage volume: at least 45 yd^3 per acre of tributary area.
4. This outlet provides partial draining of pool. For temporary sediment basins, rock encasement around the riser may not be necessary, however, filter fabric must then be fastened around the riser using either staples or other manufactured fasteners.
5. The mechanism shown in this figure is usually applied to areas of 4 or more acres.

Figure TCP-17-2
Sediment Trap with Riser Pipe Outlet

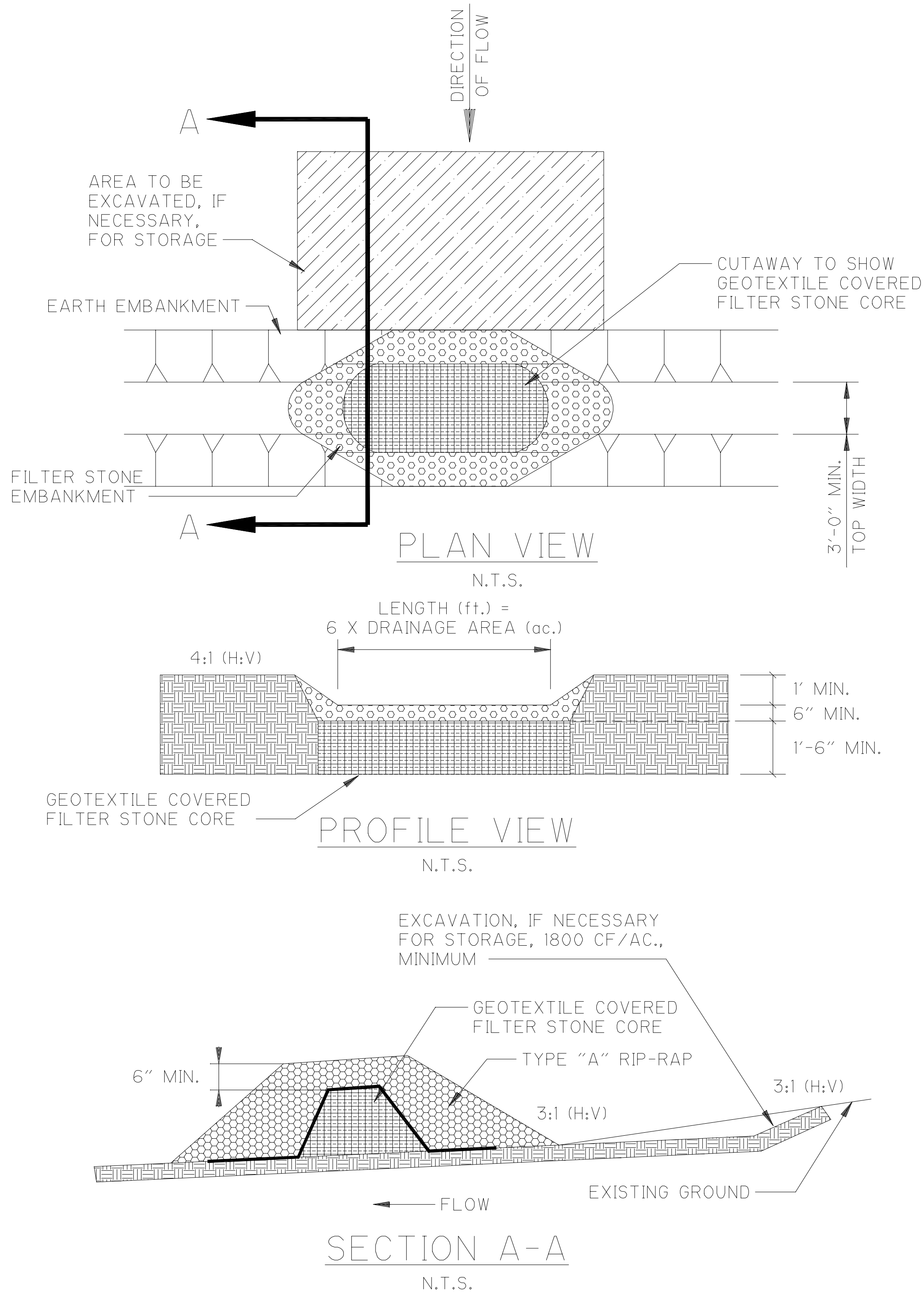
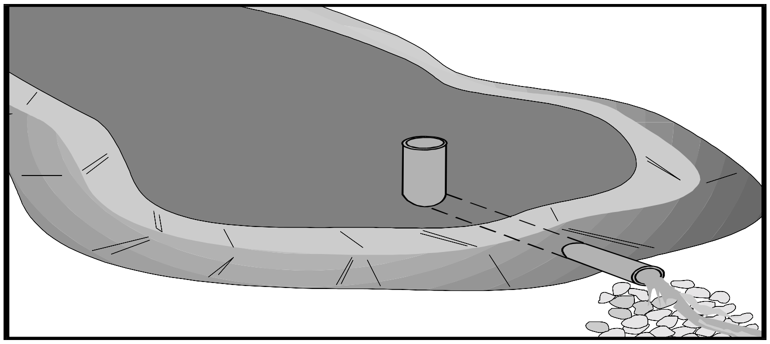


Figure TCP-17-3
Sediment Trap with Stone Outlet

ACTIVITY: Temporary Sediment / Detention Basin

TCP – 18



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	◗ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

An impoundment created by excavating or constructing an embankment. It is designed to detain runoff sufficiently to allow excessive sediment to settle. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- At the outlet of all disturbed watersheds 5 acres (2 ha) or larger.
- At the outlet of smaller severely disturbed watersheds, or where soil conditions suggest severe erosion potential.
- Where permanent detention basins will be located.
- Should be used in association with dikes, temporary or permanent channels, and pipes used to divert disturbed areas into the basin and divert undisturbed areas around the basin.
- Where sediment-laden stormwater may exit the construction site or enter the storm drain system or natural watercourses.

Installation/ Application Criteria

- Shall be designed by a licensed professional civil engineer.
- A sediment basin is a controlled stormwater release structure formed by excavation or by constructing an embankment of compacted soil across a drainageway, or other suitable location. Its purpose is to collect and store sediment from sites cleared and/or graded during construction or for extended periods of time before reestablishment of permanent vegetation and/or construction of permanent drainage structures. It is intended to trap sediment before it leaves the construction site. The basin is a temporary measure (with a design life of 12 to 18 months) and is to be maintained until the site area is permanently protected against erosion or a permanent detention basin is constructed. However, some basins are designed to

serve as permanent facilities that treat stormwater quantity and/or quality. If this is the case, then the facility should be designed to meet both the construction phase sediment control and the permanent quantity and/or quality requirements presented in the Stormwater Management Manual. The completed volume should be surveyed to ensure the permanent facility design requirements have been achieved.

- Sedimentation basins are suitable for nearly all types of construction projects. Whenever possible, construct the sedimentation basins before clearing and grading work begins. Basins should be located at the stormwater outlet from the site, but not in any natural or undisturbed stream. A typical application would include temporary dikes, pipes, and/or channels to divert runoff to the basin inlet.

- Construct before clearing and grading work begins.

- Do not locate in a stream.

- Large basins with either an embankment taller than 20 feet (6.1 m) or a capacity, at maximum water storage elevation, of 30 acre-feet (48,400 y^3) or more, are subject to the Tennessee Safe Dams Act of 1973.

- Securely anchor and install an anti-seep collar on the outlet pipe/riser, and provide an emergency spillway for passing storm events larger than the 2-year storm event. If this pond is to be used as a permanent basin then it may be advisable to install a permanent bypass sized for a 10-year storm and a bypass for a 2-year storm (while site is under construction). See next bullet item.

- The total volume of the sediment basin treatment area shall be at least 134 yd^3/acre (3618 ft^3/acre) of drainage. This total volume is based upon two major components, wet and dry storage. A wet storage volume of 67 yd^3/acre or 1809 ft^3/acre must be provided to establish the permanent pool and sediment storage zone. The volume below the permanent pool shall be measured from the lowest point of the basin up to the bottom elevation of the dewatering device. The dry storage volume should have a minimum volume of 67 yd^3/acre (1809 ft^3/acre) for the settling zone. The top of the dry storage defines the principal spillway riser crest and establishes a minimum volume for treatment in the sediment basin. The dry storage volume is to be dewatered down to the permanent pool in 72 hours.

- The total volume of the sediment basin treatment area should not be confused with detention described in Permanent Treatment Management Practices (PTPs).

- Basin inlets should be located to maximize travel distance to the basin outlet. The length to width ratio should be greater than at least 4:1, or baffles are required to prevent short-circuiting.

- Where practical, contributing areas shall be subdivided into smaller areas, and multiple sediment traps shall be used in lieu of sediment basins. Alternatively, sediment traps can be used as forebays to a sediment basin thereby reducing the required size of the sediment basin. A forebay, constructed upstream of the basin is designed to remove debris and larger particles. See TCP-17: Sediment Traps.

- Basin shall be located: (1) by excavating a suitable area or where a low embankment can be constructed across a swale, (2) where post-construction (permanent) detention basins will be constructed, (3) where failure would not cause loss of life or property damage, and (4) to provide access for maintenance, including sediment removal and sediment stockpiling in a protected area.

- Areas under embankments, structural works, and sediment basin must be cleared, stripped of vegetation.

- Baffles shall be constructed of 4 inch x 4 inch (10.2 cm x 10.2 cm) posts and 4 ft. x 8 ft. x 0.5 inch (1.26 m x 2.51 m x 1.3 cm) exterior plywood. Posts shall be set at least 3 ft. (0.94 m) into the ground, no further apart than 8 ft. (1.26 m) center to center and shall reach a height of 6-inches (15.2 cm) below the riser crest elevation.

- Rock, geotextiles, or vegetation shall be used to protect the basin inlet and slopes against erosion.

- The principal outlet shall consist of a “V” notched weir with a trash rack or a corrugated metal or reinforced concrete riser pipe with dewatering holes and an anti-vortex device and trash rack attached to the top of the riser. The trash rack is intended to prevent floating debris from flowing out of the basin or obstructing the system. This principal structure should be designed to accommodate the inflow design storm.

- The outlet structure shall be placed on a firm, smooth foundation with the base securely anchored with concrete or other means to prevent floatation.

- Attach the riser pipe (watertight connection) to a horizontal pipe (barrel) which extends through the embankment to toe of fill. Provide anti-seep collars on the barrel.

- Cleanout level shall be clearly marked on the riser pipe. This should be at the lowest ⅓ depth.

- One of the following dewatering configurations for the principal outlet shall be used:

  Outlet #1 (Preferred if going to serve as a permanent facility)
  - “V” notch weir.
  - The bottom of the “V” notch should be at the top of the temporary/permanent sediment storage depth as appropriate.
  - See Figure TCP-18-1.
  - See PTP-02 or 03 for sizing criteria.

  Outlet #2 - see following page

Outlet #2

- Perforate the top one-third of the riser with 0.5-inch (1.3-cm) diameter holes spaced 8 inches (20.3 cm) vertically and 10 to 12 inches (25.4 to 30.5 cm) horizontally.
- Wrap with well-secured filter fabric.
- Place 0.75 inches (19 mm) gravel over perforated holes to approximately 2 inches (50 mm) minimum thickness to assist in prevention of clogging of dewatering holes. Gravel will naturally settle into a cone surrounding the riser pipe.
- See Figure TCP-18-2.
- See PTP-02 or 03 for sizing criteria.

■ Spillway control section which is a level portion of the spillway channel at the highest elevation in the channel, shall be a minimum of 20 ft. (6.3 m) in length.

■ Use outlet protection at the pipe outlet.

■ Standing water may cause mosquitoes or other pests to breed. Excavate a 12-inch (0.31-m) shelf at edge of the normal pool to limit this.

■ Safety fence shall be provided to prevent unauthorized entry to the basin.

Maintenance

■ Inspect temporary sediment basins weekly, before and after rainfall events. During extended rainfall events, inspect at least every 24 hours.

■ Examine basin banks for seepage and structural soundness.

■ Check outlet structure and spillway for any damage or obstructions. Repair damage and remove obstructions as needed.

■ Check outlet area for erosion and stabilize, if required.

■ Remove sediments when storage zone is one-third full (by depth).

Limitations

■ Failure of the structure must not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment traps and ponds are attractive to children and can be very dangerous. Local ordinances regarding health and safety must be adhered to. If fencing of the pond is required, the type of fence and its location shall be shown in the construction specifications.

- Generally, temporary sedimentation ponds are limited to drainage of 5 acres (2 ha) or more while sediment traps are intended for drainage of 5 acres or less. Permanent ponds can be designed to serve larger areas of 100 to 150 acres. These facilities can offer more water quality benefits. See PTP-02 and 03 for wet and dry ponds.

- Alternative BMPs must be thoroughly investigated for erosion control before selecting sediment basins.

- Sediment ponds are generally only practically effective in removing sediment down to about the medium silt size fraction. Sediment-laden runoff with smaller size fractions (fine silt and clay) will pass through untreated emphasizing the need to stabilize the soil quickly. Sediment ponds may be capable of trapping smaller sediment particles if additional detention time is provided. However, they are cost effective when used in conjunction with other BMPs such as seeding or mulching.

- Requires large surface areas to permit settling of sediment.

- Generally not appropriate for drainage areas greater than 100 to 150 acres (40.5 to 60.7 ha).

- Not to be located in live streams.

- The basin should have shallow side slopes (minimum 4:1 (H:V)) or be fenced to prevent drowning.

- Ponds may become an “attractive nuisance” and care must be taken to adhere to all safety practices.

- Sites with very fine sediments (fine silt and clay) may require longer detention times for effective sediment removal.

- Basins in excess of certain depth and storage volume criteria must meet State Division of Safety of Dams (DSOD) and local safety requirements.

Additional Information

Sediment basins trap 70-80 percent of the sediment which flows into them if optimally sized. However, they should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, etc., to reduce the amount of sediment flowing into the basin.

The settling zone volume is determined by the following equation:

$$(V) = 1.2\,(SD)Q / V_{SED}$$

Q = design inflow based on the peak discharge from a specified design storm (e.g., a 2-year, 24-hour duration design storm event) from the tributary drainage area. Provide a minimum of 134 cubic yards (103 m^3) of settling volume per acre of drainage if a design storm is not specified.

V_{SED} = the settling velocity of the design soil particle. The design particle chosen is medium silt 7.9 x 10^{-4} in.(0.02 mm). This has a settling velocity (V_{SED}) of

0.00096 ft./sec (3.0×10^{-4} m/s). As a general rule it will not be necessary to design for a particle of size less than 7.9×10^{-4} in. (0.02 mm), especially since the surface area requirement increases dramatically for smaller particle sizes. For example, a design particle of 3.9×10^{-4} in. (0.01 mm) requires about three times the surface area of 7.9×10^{-4} in. (0.02 mm). Note also that choosing V_{SED} of 0.00096 ft./sec (3.0×10^{-4} m/s) equates to a surface area (SA) of 1250 sq. ft. per cfs per of inflow.

SD = settling depth, which should be at least 2 ft. (0.63 m), and no shallower than the average distance from the inlet to the outlet of the pond (L) divided by 200 (i.e., SD>L/200).

Total sediment basin volume and dimension are determined as outlined below:

a. Determine basin geometry for the sediment storage volume calculated above using a minimum of 1 ft. (0.31 m) depth and 4:1 (H:V) side slopes from the bottom of the basin. Note, the basin bottom is level.
b. Extend the basin side slopes (at 4:1 (H:V) max.) as necessary to obtain the settling zone volume as determined above.
c. Adjust the geometry of the basin to effectively combine the settling zone volume and sediment storage volumes while preserving the depth and side slope criteria.
d. Provide an emergency spillway with a crest elevation one foot above the top of the riser pipe.
e. The ratio between the basin length and width of the pond should either be greater than at least 4:1, or baffles should be installed to prevent short-circuiting.

Primary References

California Storm Water Best Management Practice Handbooks, *Construction Handbook*, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

A Current Assessment of Urban Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in the Coastal Zones, Metropolitan Washington Council of Governments, March, 1992.

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Rough Draft - July 1992.

"Draft – Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April, 1990.

"Environmental Criteria Manual", City of Austin, Texas.

Guidelines for the Design and Construction of Small Embankment Dams, Division of Safety of Dams, California Department of Water Resources, March 1986.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Work Group Working Paper, USEPA, April, 1992.

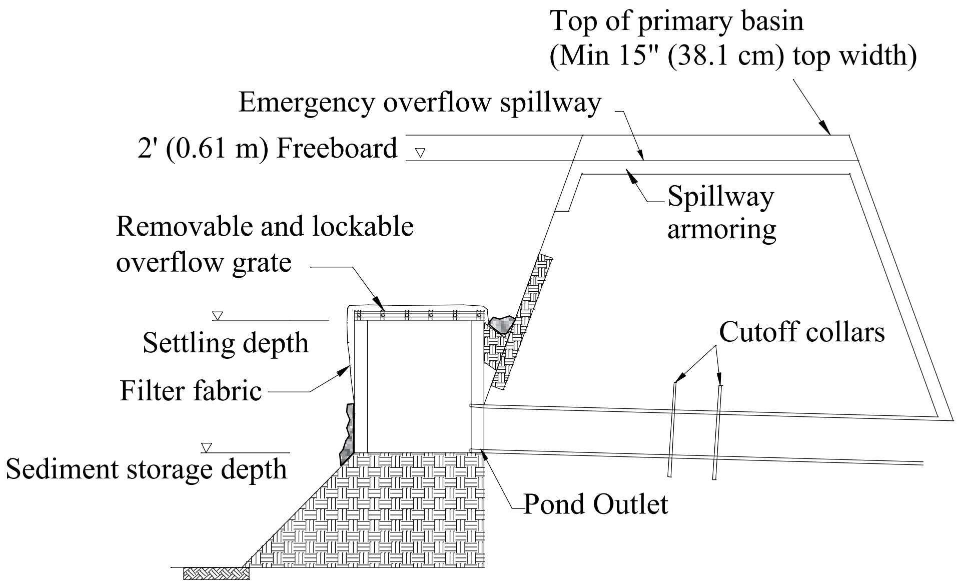
Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Tennessee Erosion & Sediment Control Hand Book - A Stormwater Planning and Design Manual for Construction Activities, Tennessee Department of Environment and Conservation, Fourth Edition, August 2012

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

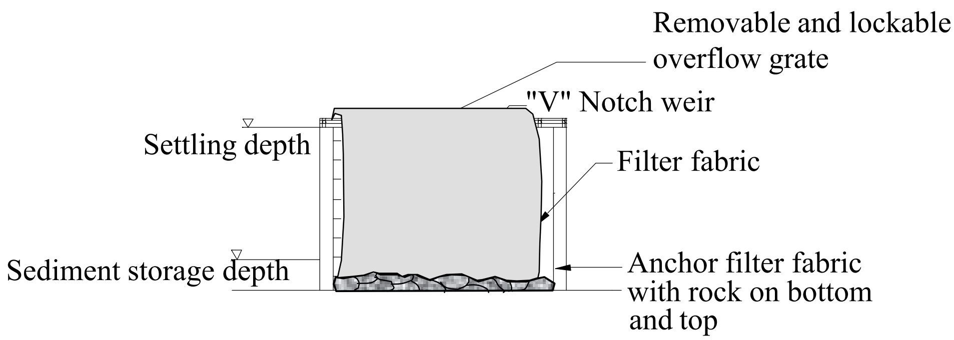
Inspection Checklist

- Does the outlet structure use a triangular-shaped filter dike, riser pipe or stone outlet designed to convey flows up to the 10-year storm event?
- Is the outlet structure stabilized to prevent erosion?
- Is there a gage indicating the depth of the basin?
- Has sediment accumulated beyond ⅓ the depth?
- If the basin failed would it result in loss of life, damage to home or buildings, or interruption in the use of public roads or utilities?
- Is the basin protected from access by children?
- Is the outlet structure clogged?
- Are there any signs of seeping through or erosion of the embankment?
- Were anti-seep collars installed and surrounding soil compacted?
- Is an overflow structure present that can convey flows beyond the 10-year storm event?



SECTION OUTLET STRUCTURE

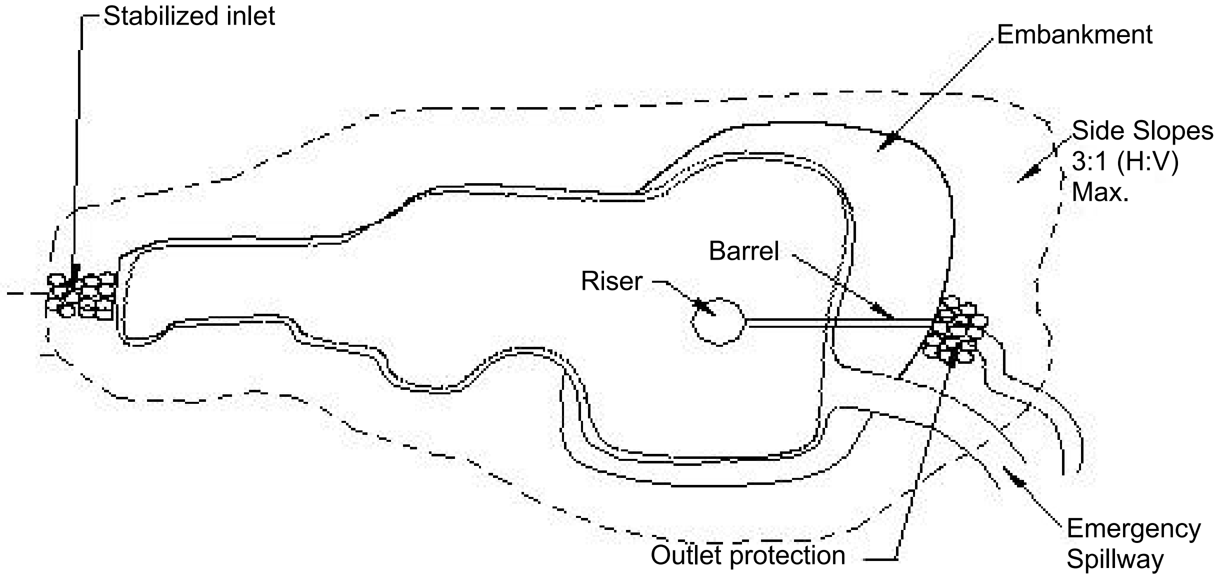
NTS



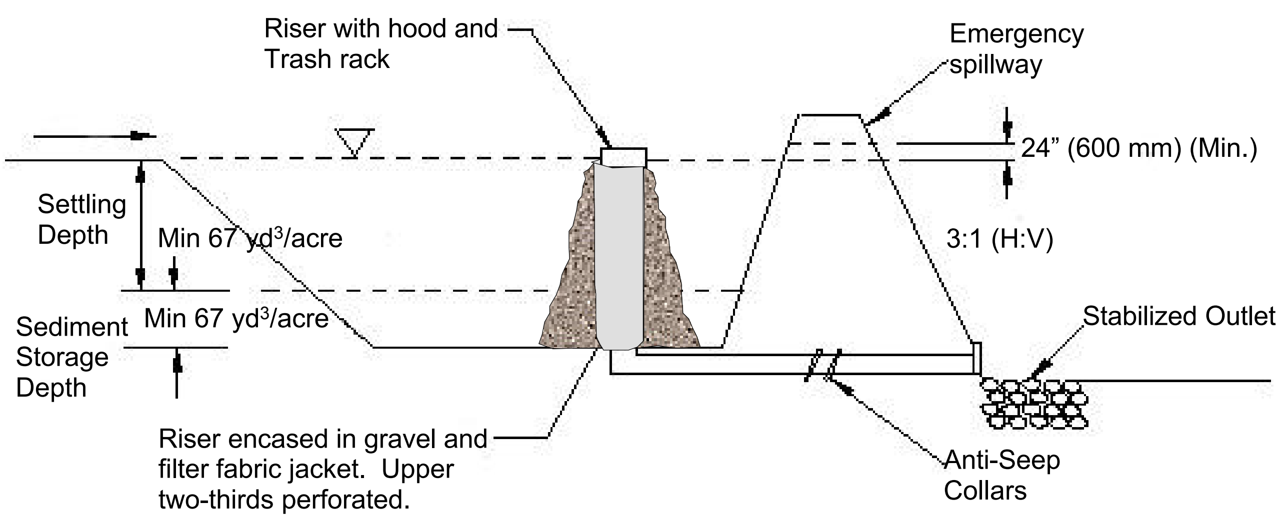
PROFILE OUTLET STRUCTURE

NTS

Figure TCP-18-1
Sediment Basin – “V” Notch Weir Outlet Structure

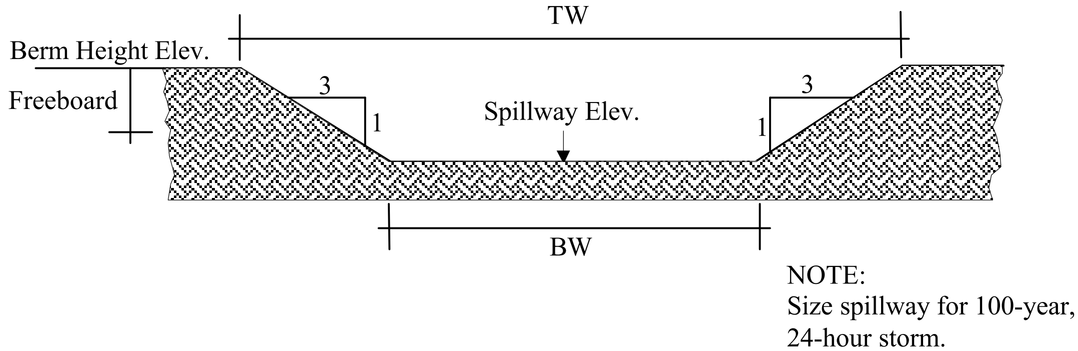


TOP VIEW



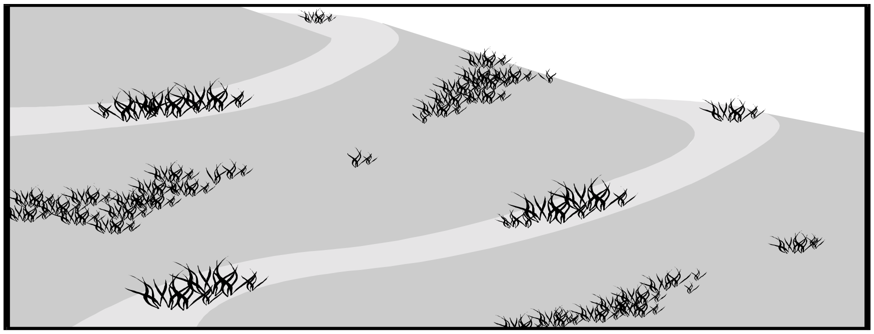
NOTE:
This outlet provides partial draining of pool. For temporary sediment basins, rock encasement around the riser may not be necessary, however, filter fabric must then be fastened around the riser using either staples or other manufactured fasteners.

Figure TCP-18-2
Sediment Basin – Riser Pipe Outlet Structure A



EMERGENCY SPILLWAY

Figure TCP-18-3
Emergency Spillway



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
◗ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of sediment to the stormwater management system or to watercourses by providing slope protection and erosion reduction through the use of vegetation, regrading, and simple retaining structures. This management practice is likely to create a significant reduction in sediment and a partial reduction in nutrients by reducing velocities and erosion.

Suitable Applications

- For immediate protection of slopes against surface erosion, shallow mass wasting, cut and fill slope stabilization, and earth embankment protection (not associated with a pond, impoundment or other water detention device).

Installation/ Application Criteria

- Low retaining structures at the toe of a slope make it possible to grade the slope back to a more stable angle.

- Vegetation measures such as those mentioned in TCP-05 Temporary Seeding should be considered in combination with simple retaining structures for additional erosion control.

- Grade stabilization structures such as simple timber check dams reduce the grade above them and disperse flowing water, limiting rill and gulley erosion.

- On slopes steeper than 3:1 (H:V), stair step or groove cut grading is recommended (TCP-11 Terracing). These practices may be supported by some of the practices presented here.

Standard Earth Retaining Structures

Standard earth retaining structures may be implemented as designed by a licensed professional civil engineer and approved by the engineering department.

A properly designed retaining wall or abutment must satisfy two minimum requirements. First, to make the structure safe against failure by overturning and excessive settlement, the pressure beneath the base must not exceed the allowable soil pressure. Furthermore, the structure as a whole must have an adequate factor of safety with respect to sliding along its base or along some weak structure point below its base. The structure should be proportioned, and its overall stability checked for earth pressures unmodified by load factors. Second, the entire structure as well as each of its parts must possess adequate strength under loaded conditions.

Cribwall

These structures like standard earth retaining structures should be designed by a licensed professional civil engineer. The following briefly describes how a cribwall should be implemented. Vegetative matter can be incorporated into the cribwall creating a "live" cribwall. Depending on soils' conditions and compaction techniques necessary, "live" cribwalls have limited success. However, if the vegetative material can become established it can add to both the structural capacity/stability of the slope through extensive and intertwined root structures; and aid in improving stormwater quality through nutrient uptake.

- 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 reinforced concrete beams, logs or timbers, 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 reinforced concrete beams, 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 cribwall is placed in the same manner and nailed or fastened to the preceding course with nails or reinforcement bars or bands.
- If a "live" cribwall is desired, then 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. Select vegetative matter that has an extensive intertwined root structure at maturity.

Rock Gabions

These structures like standard earth retaining structures should be designed by a licensed professional civil engineer. The following briefly describes how a gabion should be implemented. Vegetative matter can be incorporated into the gabion creating a "live" gabion. Depending on soils conditions and compaction techniques necessary, "live" gabions have limited success. However, if the vegetative material can become established it can add to both the structural capacity/stability of the slope through extensive and intertwined root structures; and aid in improving stormwater quality through nutrient uptake.

- 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. This will provide additional stability to the structure.
- Place the fabricated wire baskets in the bottom of the excavation and fill with rock (by hand).
- Place backfill between and behind the wire baskets.
- Repeat the construction sequence until the structure reaches the required height.
- Vegetation can be added to gabions generally with less success than with cribwalls.

General

- Refer to TCP-20 Rip-rap for use of rock materials for bank stabilization.
- For more permanent stabilization options, refer to the Soil Bioengineering BMP.

Maintenance

- Inspect structures and slopes prior to and after major rainfall events. Make repairs where necessary, consulting/notifying the design engineer.

Limitations

- Stabilization measures can be costly in terms of labor required.

Primary References

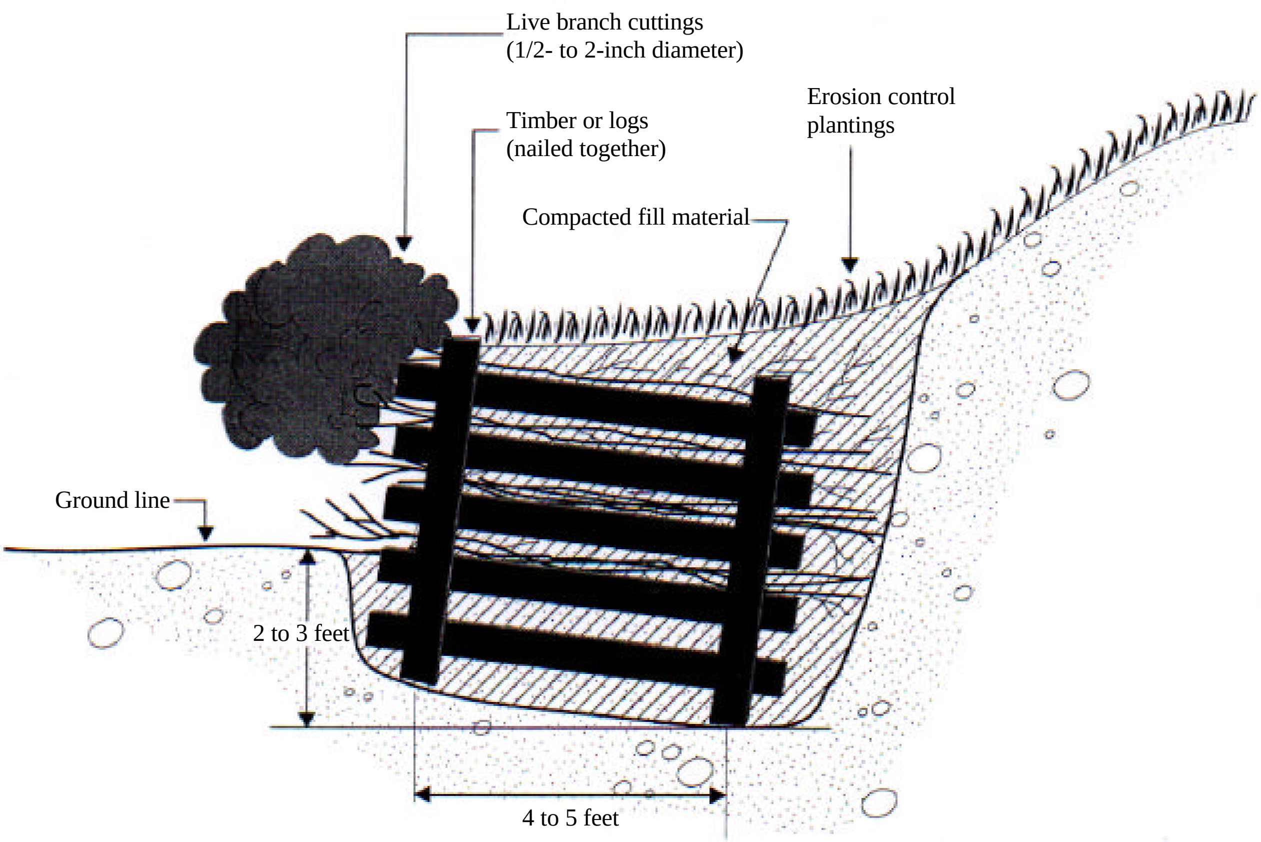
Engineering Field Handbook, Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction, Soil Conservation Service, October 1992.

Foundation Engineers, R.B. Peck, W.E. Hanson, T.H. Thornburn, John Wiley & Sons Publishing, Second Edition, 1976.

Inspection Checklist

Be sure that the earth retention structure is constructed per the plans stamped by a licensed professional civil engineer and that any changes in site conditions are transmitted to the design engineer for review.

Cross section
Not to scale



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

Figure TCP-19-1
Live Cribwall

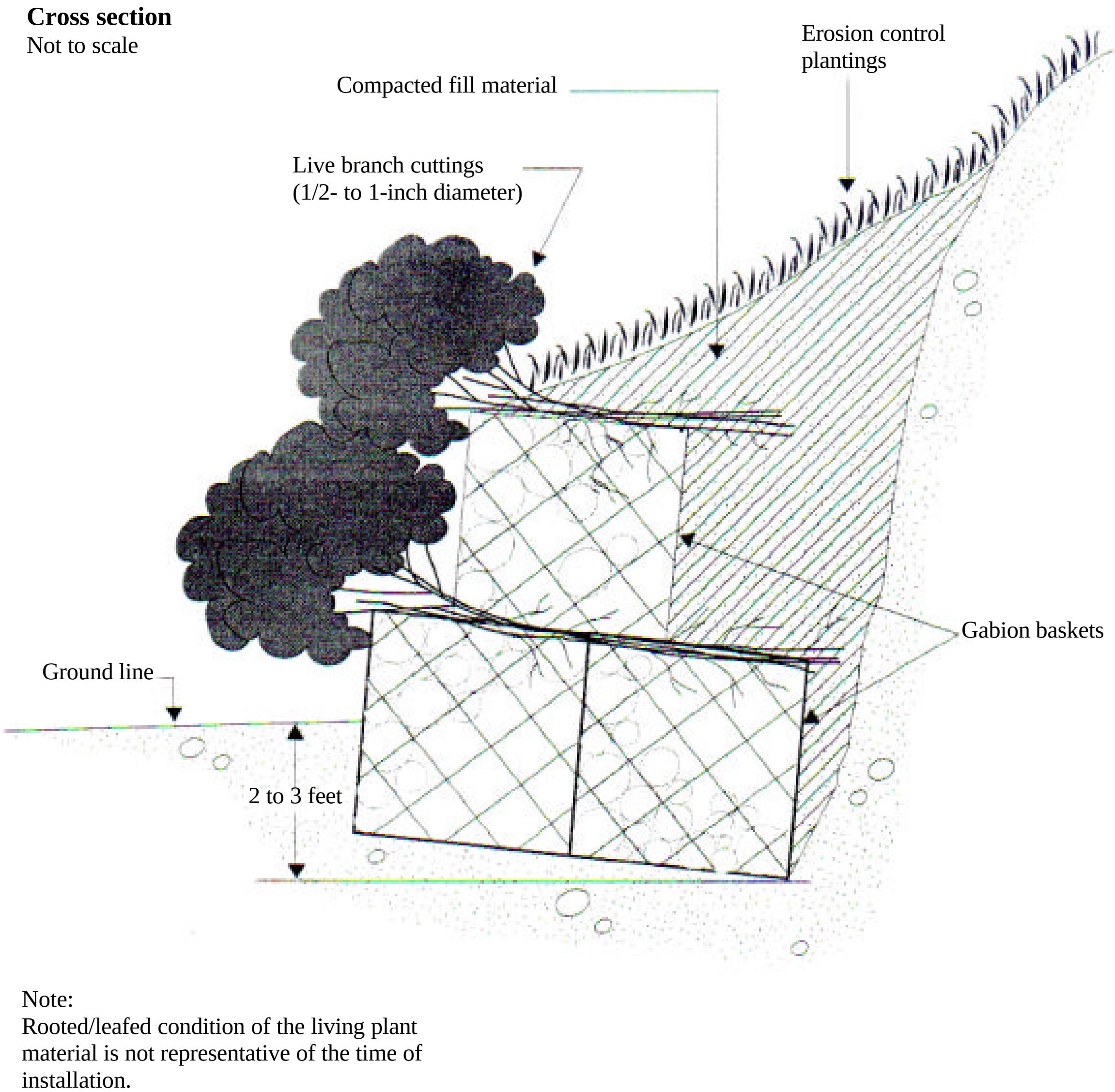
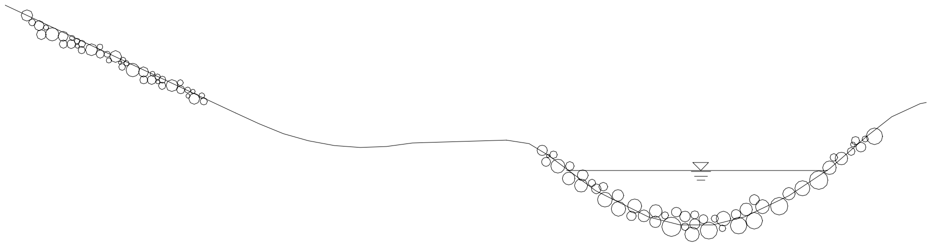


Figure TCP-19-2
Vegetated Rock Gabion

ACTIVITY: Rip-rap	TCP – 20



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Used to protect slopes, streambanks, channels, or other areas subjected to erosion.

This practice is only to be used after alternatives have been explored. These alternatives should include vegetation establishment, surface roughening, mulching, nets, mats, geotextiles, terracing, and earth retention structures or other “green”, aesthetic or environmentally acceptable method. This management practice is likely to create a significant reduction in sediment by protecting against erosion.

Suitable Applications

- On streambanks or other areas subject to wave action.
- In channels where infiltration is desirable, but velocities are too excessive for vegetative or geotextile lining.
- Around outlets and/or inlets to prevent scour and undercutting.

Installation/ Application Criteria

- 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.

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.

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.

Maintenance

- If properly constructed, rip-rap requires minimal maintenance.
- Check after major storm events for slumping, displacement, or scour around or under the rip-rap.
- Periodically check for brush growth and remove.

Limitations

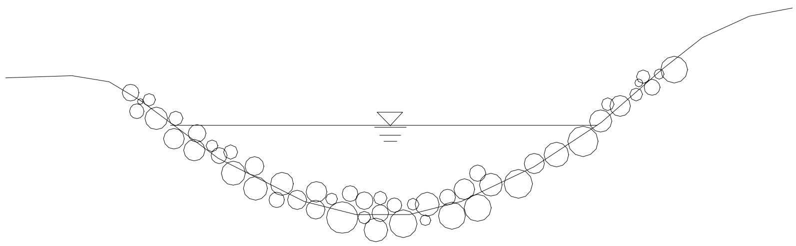
- If the slope is too steep or rip-rap is too small, displacement may occur.
- If an improper type of filter cloth is used, scour may occur.
- Rip-rap may block channel resulting in erosion along the edge.
- Improperly graded rip-rap results in stone movement and erosion of foundation.

Primary References

Soil Erosion Prevention and Sediment Control – Reducing Nonpoint Source Water Pollution on Construction Sites, University of Tennessee, Knoxville, Department of Civil and Environmental Engineering, August 1998.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

ACTIVITY: Channel Linings	TCP – 21



Targeted Constituents				
● Significant Impact		◗ Partial Impact		○ Low or Unknown Impact
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Channel lining is the artificial surfacing of bed, banks, shore or embankments to resist erosion or scour. While similar to rip-rap described in TCP-20: Rip-rap, this fact sheet focuses on the application of rip-rap in channels, creeks, streams, ditches or other waterways. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- Temporary channel lining can be used to promote temporary or permanent vegetative growth in a drainage way or as protection prior to placement of a permanent protective layer.
- Permanent channel lining can be used when an ordinary seeding and mulch application would not be expected to withstand the max shear force of channel flow for 2-year, 24-hour flow.

Approach

- The following materials are applicable for temporary 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

- The following materials are applicable for permanently lining channels.

  - Geosynthetic mats or cells
  - Pre-cast concrete block (“woven” or individually placed)
  - Rip-rap

- Cast-in-place concrete
- Gabions
- Sacked concrete
- Soil cement
- Air blown mortar

Channel linings such as rip-rap, cast-in-place concrete, and pre-cast concrete blocks should only be utilized with expressed permission from the Engineering Department and/or TDEC.

- Application of the net and matting materials above is described in the Nets and Mats (TCP-9), and Geotextiles (TCP-10) BMPs.
- Brushlayering applications are discussed in detail in TCP-16 Brush or Rock Filters and Continuous Berms.
- Rip-rap installation is detailed in TCP-20: Rip-rap.

Maintenance

- Inspect lining before and after rainfall events.
- If net or matting materials are damaged, repair or replace immediately.
- Any spaces left bare in rip-rap or brushlayering applications due to erosion or scouring are to be repaired and replaced with their respective lining materials.

Limitations

- 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 rip-rap is too small, displacement may occur.
- Rip-rap may block channel resulting in erosion along the edge.

Primary References

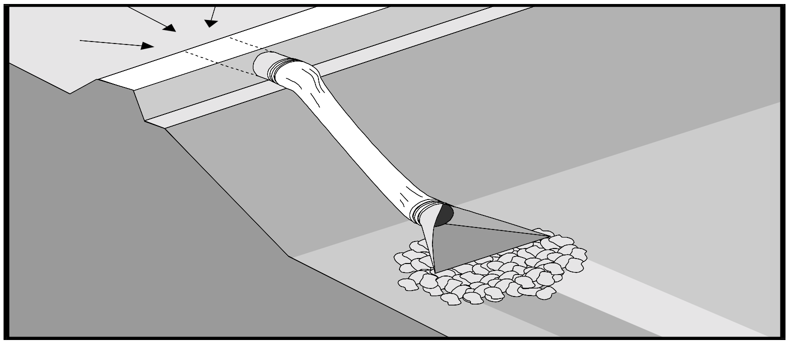
Caltrans Highway Design Manual, 1997.

Soil Erosion Prevention and Sediment Control Reducing Nonpoint Source Water Pollution on Construction Sites, University of Tennessee, Knoxville, Department of Civil and Environmental Engineering, August 1998.

Subordinate References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

ACTIVITY: Temporary Diversions, Drains and Swales	TCP – 22



Targeted Constituents

● Significant Impact ◗ Partial Impact ○ Low or Unknown Impact

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

Implementation Requirements

● High ◗ Medium ○ Low

◗ Capital Costs	○ O & M Costs	○ Maintenance	◗ Suitability for Slopes >5%	○ Training

Description

Temporary drains and swales are used to divert off-site runoff around the construction site, divert runoff from stabilized areas around disturbed areas, and direct runoff into sediment basins or traps. The primary function of a slope drain is to convey runoff down cut or fill slopes, while 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. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

Temporary drains and swales are appropriate for diverting any upslope runoff around unstabilized or disturbed areas of the construction site. In this regard, they divert or bypass disturbed or sensitive areas and convey to stable or protected areas or the permanent infrastructure.

Drains

- Sensitive areas may include material storage areas, equipment fueling and maintenance areas, and any other area where the runoff may become contaminated.
- Prevent slope failures.
- Prevent damage to adjacent property.
- Prevents erosion and sediment transport into waterways.
- Diverts sediment-laden runoff into sediment basins or traps.
- Removes excess water from the soil (subsurface drains).

Diversions

- Where runoff must be intercepted at the bottom of an undisturbed slope prior to entering a denuded area.
- Where needed to direct runoff to a stable conveyance, such as a slope drain.
- Where needed to direct runoff to a sediment trapping device.
- Where needed to intercept runoff and direct it around the site.
- Below steep grades where runoff begins to concentrate, but prior to where there is potential for rill and gulley erosion.
- Where runoff must be prevented from flowing over a disturbed slope.

Installation/ Application Criteria

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 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.

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

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

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

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

Diversions

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

- High flow velocities may require the use of a lined ditch, or other methods of stabilization.
- When installing diversion ditches and berms:
  - Protect outlets from erosion.
  - Utilize planned permanent ditches/berms early in construction phase when practicable.
- All dikes and berms should be compacted by earth-moving equipment.
- All dikes should have positive flow to a stabilized outlet.
- Top width may be wider and side slopes may be flatter at crossings for construction traffic.
- Dikes should direct sediment-laden runoff into a sediment trapping device.
- 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 rainstorm, and weekly until the tributary drainage area has been stabilized. Follow routine inspection procedures for inlets thereafter.
- 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 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.
- Make sure water is not ponding in active or sensitive areas (e.g., active traffic lanes, material storage areas, etc.).
- Inspect temporary diversions weekly and after rainfall events.
- Inspect ditches and berms for washouts. Replace lost rip-rap, damaged linings or soil stabilizers as needed.
- Inspect ditches and berms for accumulation of debris and sediment. Remove debris and sediment as needed.
- Inspect the channel lining, embankments, and bed for erosion and accumulating debris and sediment build up. Remove sediment and debris and repair linings and embankment as required.
- Temporary conveyances should be completely removed as soon as the surrounding area has been stabilized, or at the completion of construction.
- Inspect permanent measures every other week and after rainfall events throughout construction.

Limitations

- Dikes or berms should not be used for drainage areas greater than 5 acres (2 ha), or along slopes greater than 10 percent. For larger areas more permanent structures should be built.
- Earth dikes may create more disturbed area on site and become barriers to construction equipment.
- Earth dikes must be stabilized immediately, which adds cost and maintenance concerns.
- Diverted stormwater may cause downstream flood damage if not properly and evenly distributed.
- Temporary drains and swales or any other diversion of runoff should not adversely impact upstream or downstream properties.
- Temporary drains and swales must conform to local floodplain management requirements.
- Subsurface drains may remove fine soils which can result in collapse of the slope.
- Severe erosion may result when slope drains fail by over topping, piping in surrounding uncompacted soil, or pipe separation.
- Ditches/berms are not sediment trapping devices if they simply divert flow to a sufficiently sized drain. They can trap sediment if flow is permitted to slow

enough for sediment deposition. See TCP-12 Check Dams, TCP-15 Sand Bag Barrier and TCP-16 Brush or Rock Filters and Continuous Berms.

- Dikes should not be constructed of soils which may be easily eroded such as sand, gravels, or loosely consolidated silts or clay.
- Regrading the site to remove the dike may add additional cost.
- Must use a lined ditch for high flow velocities.
- Care must be applied to correctly size and locate earth dikes, swales and lined ditches. Excessively steep, unlined dikes and swales are subject to erosion and gully formation.
- Unstabilized tributary areas will reduce the effectiveness of these measures.
- These measures may cause water to pond onto inappropriate areas (e.g., active traffic lanes, material storage areas, etc.) if not properly sized.
- Altering existing waterways or clearing existing vegetation may require permits from the U.S. Army Corps of Engineers and/or TDEC.

Additional Information

Slopes that are formed during cut and fill operations should be protected from erosion by runoff. A combination of a temporary swale and diversions at the top of a slope can safely divert runoff to a location where it can safely be brought to the bottom of the slope. A combination dike and swale is easily constructed by a single pass of a bulldozer or grader and compacted by a second pass of the tracks or wheels over the ridge. Diversion structures should be installed when the site is initially graded, and remain in place until post-construction BMPs are installed and/or the slopes are stabilized.

Diversion practices concentrate the volume of surface runoff, increasing its velocity and erosive force. Thus, the flow out of the drain or swale must be directed onto a stabilized area or into a grade stabilization structure. A swale should be stabilized using vegetation, chemical treatment, rock rip-rap, matting, or other physical means of stabilization, if significant erosion will occur. Any drain or swale which conveys sediment-laden runoff must be diverted into a sediment basin or trap before it is discharged from the site.

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

"Draft – Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April, 1990.

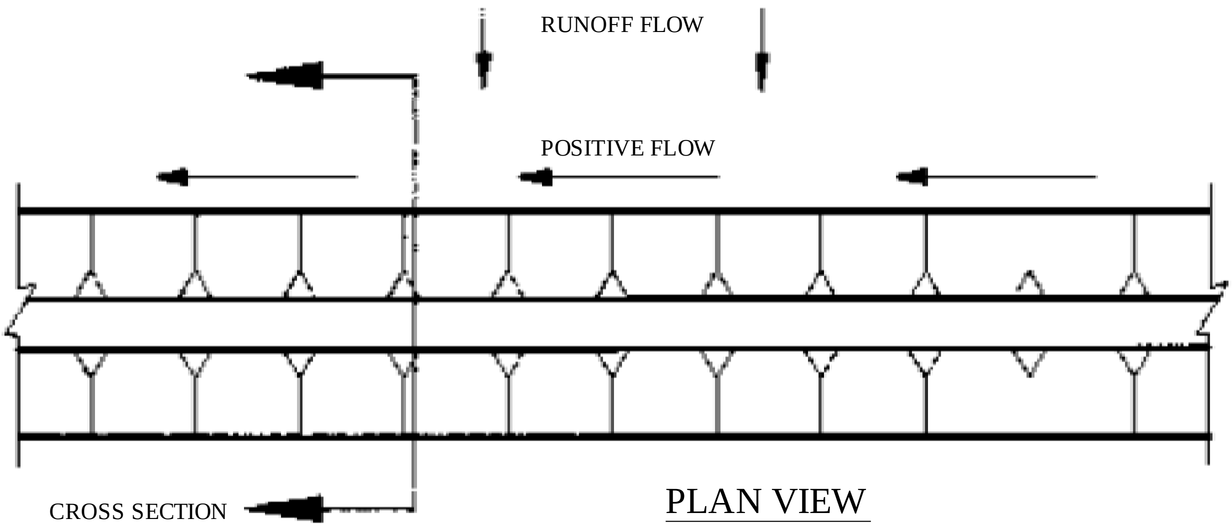
Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

Inspection Checklist

- Are all drain outlets protected from scour and general erosion?
- Is there any evidence of soil piping in any area to be protected by a diversion?
- Are drains sized to handle all the flow from the “diverted” area under a 10-year storm event?
- Are inlets protected and/or flared for pipes larger than 12-inches (30.5 cm)?
- Are all slope drains directed straight down slope (perpendicular to contours)?
- Are all dikes and berms properly compacted?
- Are any level spreaders offering protection or are there downstream energy dissipaters?
- Are all drains securely fastened/anchored to the slope at intervals not greater than every 50 or 100 ft. (15.2 or 30.5 m)?
- Are there any indications of erosion, underwash, or sediment transport that are not expected and treated by a sediment trap or basin?



PLAN VIEW
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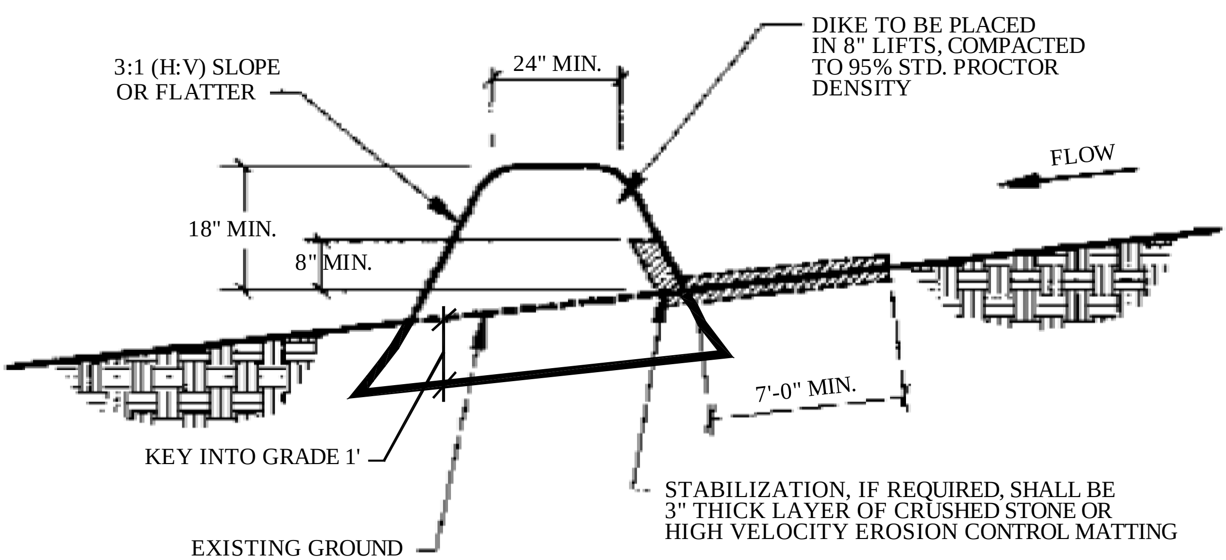

Note: This technique is similar to methods presented in TCP-15: Sand Bag Barrier and TCP-16: Brush or Rock Filters and Continuous Berms.

CROSS SECTION
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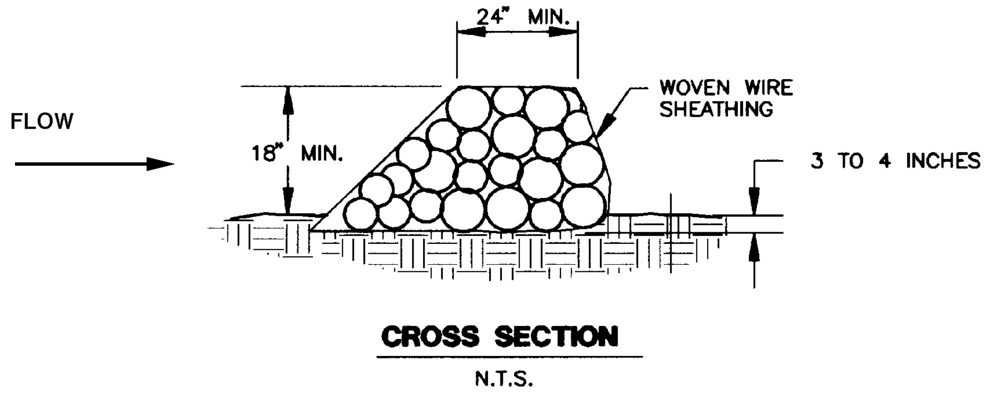
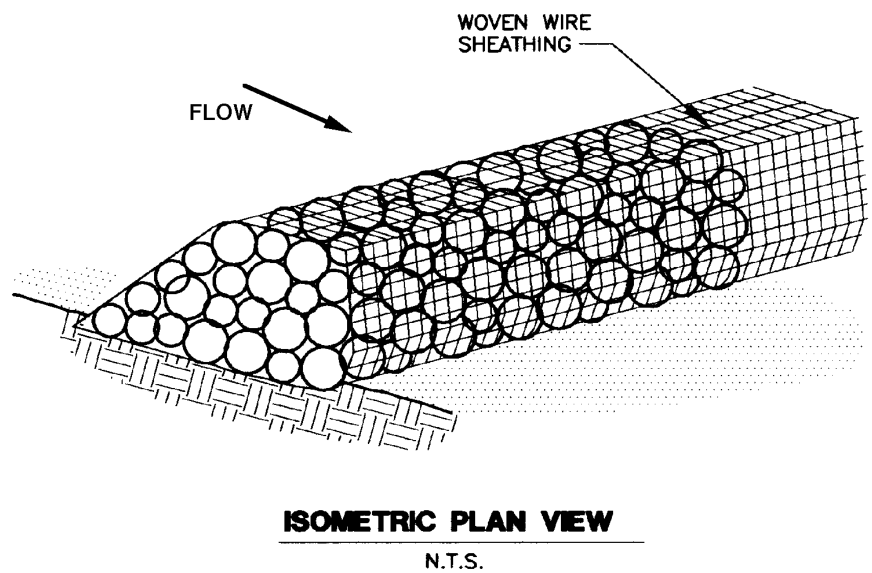
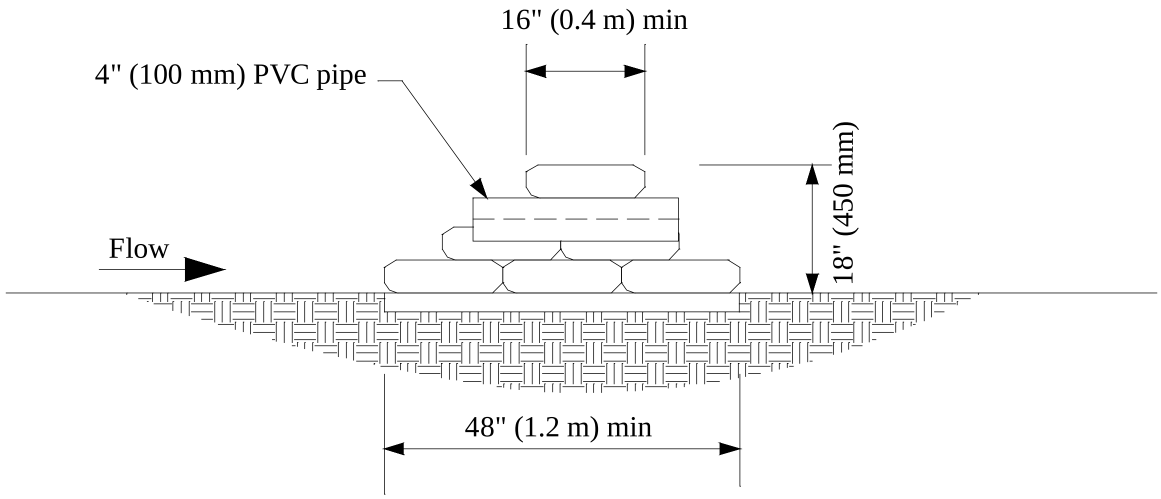
Figure TCP-22-1
Diversion Dike w/o Excavation





Note: This technique is similar to methods presented in TCP-15: Sand Bag Barrier and TCP-16: Brush or Rock Filters and Continuous Berms.

Figure TCP-22-2
Rock Berm



CROSS SECTION

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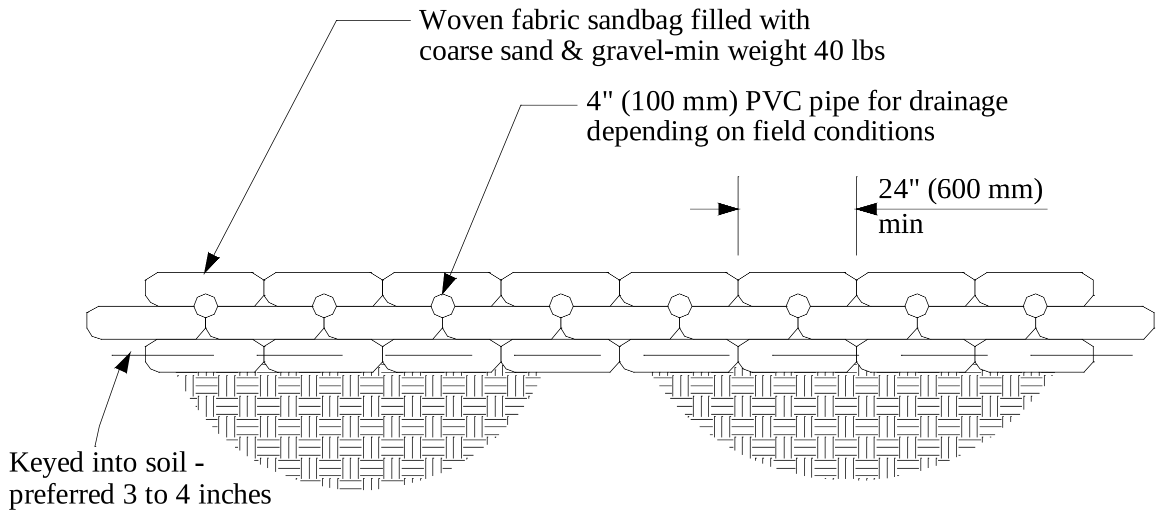

PROFILE VIEW

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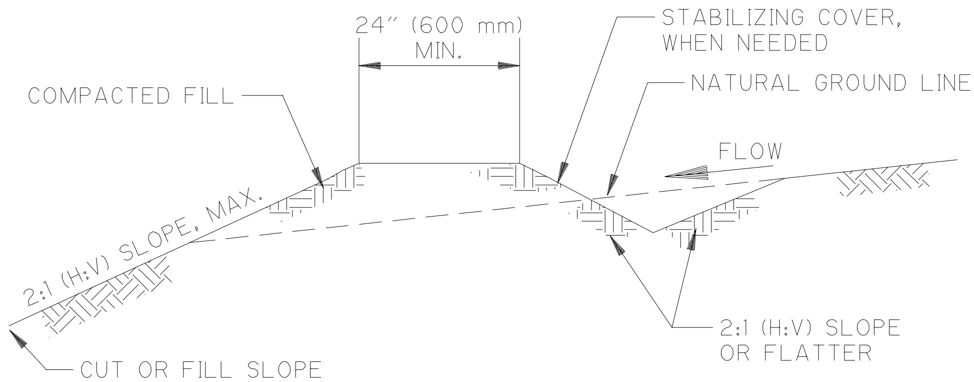
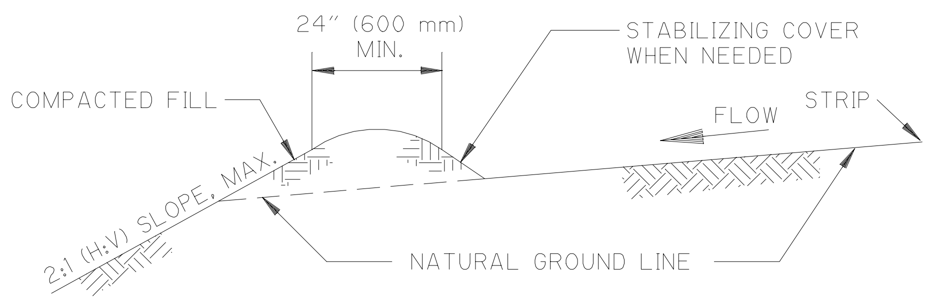
Figure TCP-22-3
Sand Bag Berm



DIVERSION BERM/SWALE

N.T.S.

NOTES:
1. STABILIZE INLET, OUTLETS AND SLOPES.
2. PROPERLY COMPACT THE SUBGRADE.



DIVERSION BERM

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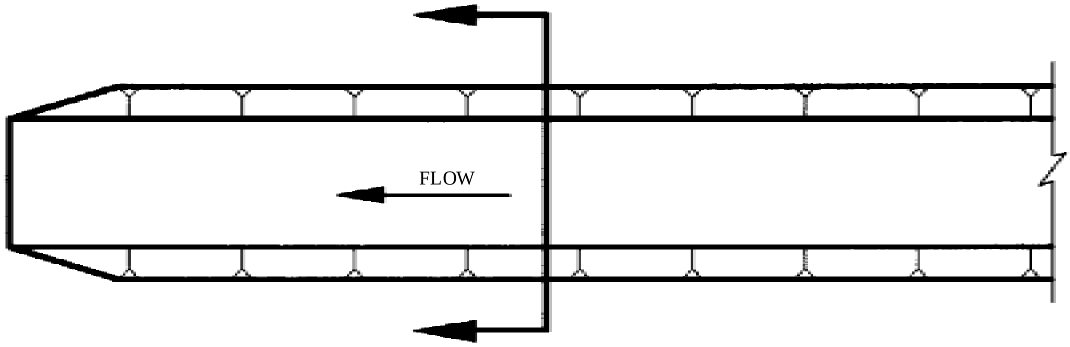
Figure TCP-22-4
Diversion Berm and Berm/Swale



PLAN VIEW
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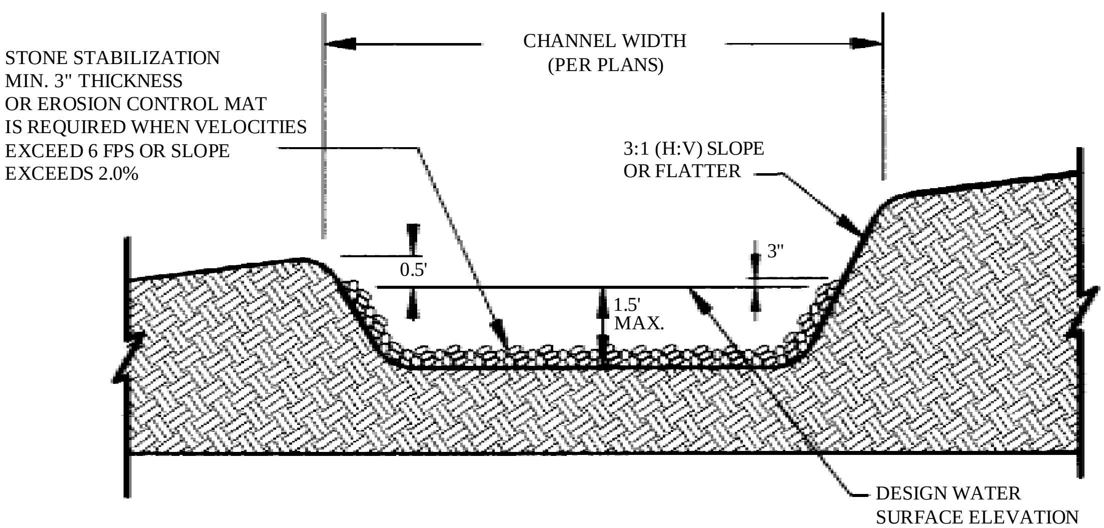

CROSS SECTION
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Figure TCP-22-5
Interceptor swale

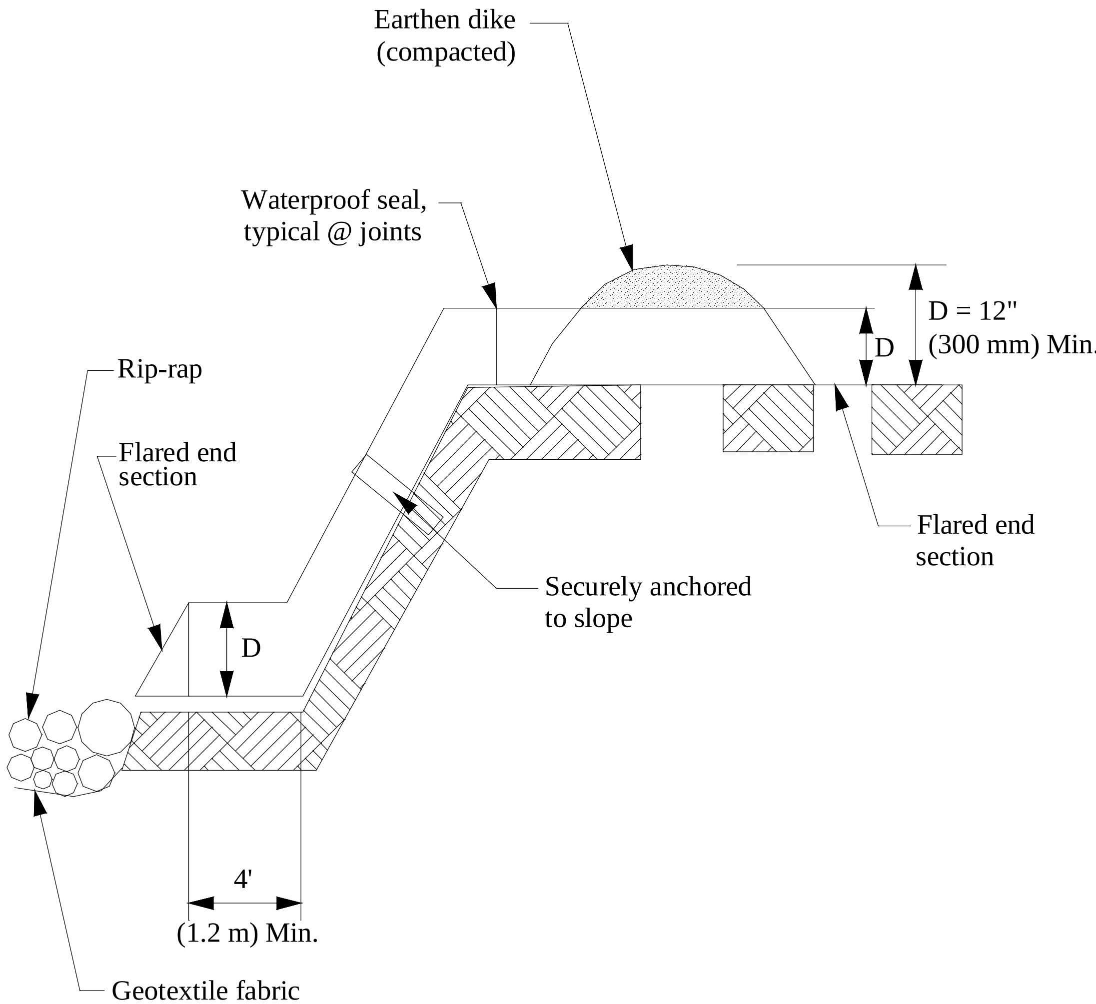
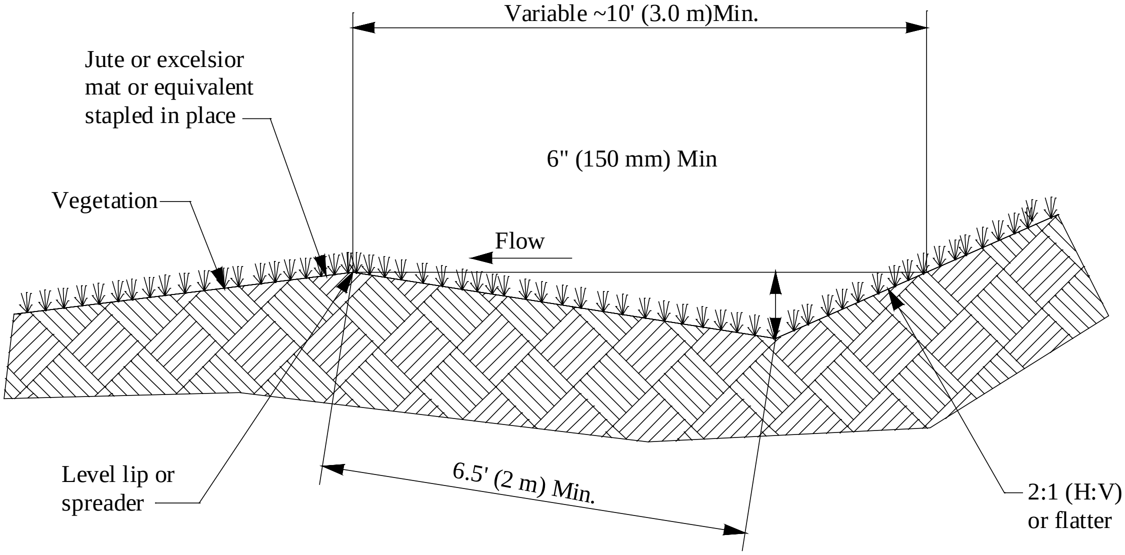


Figure TCP-22-6
Diverted Flow Slope Drain



VEGETATED LIP
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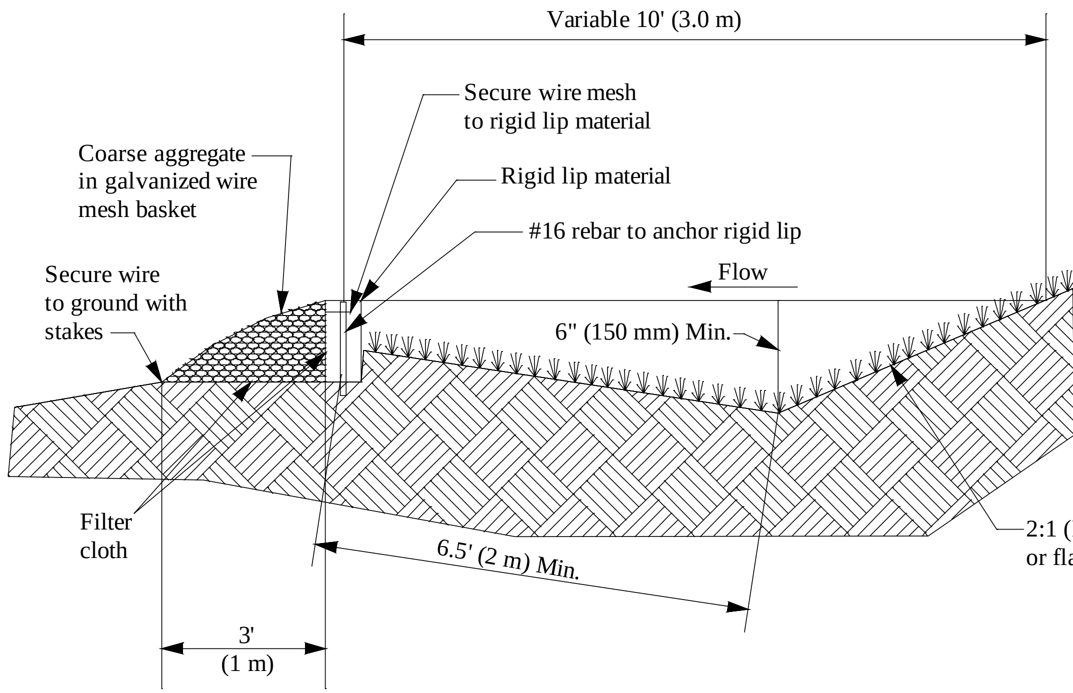

RIGID LIP
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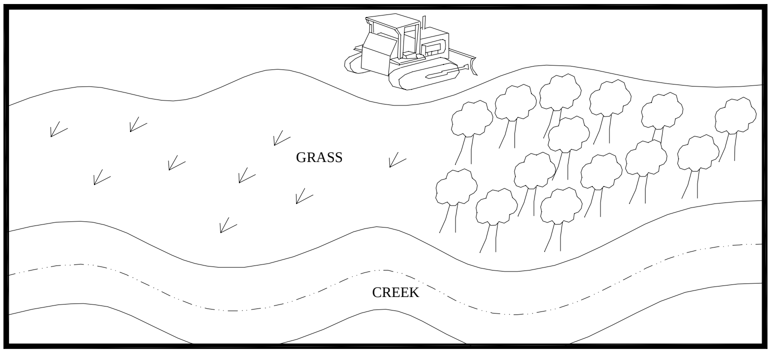
Figure TCP-22-7
Level Spreaders

ACTIVITY: Filter Strips	TCP – 23



Targeted Constituents				
● Significant Impact		◗ Partial Impact		○ Low or Unknown Impact
● Sediment	◗ Heavy Metals	◗ Floatable Materials	◗ Oxygen Demanding Substances	
◗ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of pollutants to the storm system or to watercourses as a result of construction activity by utilizing vegetation to protect soils from erosion and to slow the velocity of runoff to allow the removal of sediment through filtering and settling.

This management practice is likely to create a significant reduction in sediment and a partial reduction in nutrients, heavy metals, toxic materials, floatable materials, oxygen demanding substances, and oil and grease.

Suitable Applications

Sodding and plugging are appropriate for areas that contained turf prior to construction, or for any graded or cleared area that might erode and where a permanent, long-lived plant cover is needed immediately. Filter strips are particularly effective on flood plains, adjacent to wetlands or other sensitive water bodies, and on steep, unstable slopes.

It is strongly encouraged to use filter strips in temporary or permanent buffer areas.

- A buffer may be a planned feature and/or a requirement of MDPW. It is preferred that the buffer include all of a floodplain. However, 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." See Volume 1 Section 5.9 for additional descriptions of the required buffer.

- Any area within a buffer required by the regulation presented in Volume 1 Section 5.9, <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.

Installation/ Application Criteria

Sodding and plugging is the placement of permanent grass cover that has been grown elsewhere and brought to the site. Sodding stabilizes an area by immediately covering the soil surface with grass, thereby protecting the soil from erosion, enhancing infiltration, filtering sediment and removing other pollutants, and slowing runoff velocities. 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.

Sodding and plugging should only be performed if permitted under regulations presented in Volume 1 Section 5.9.2.

A vegetative filter strip is a vegetated strip of land that is either created with new vegetation as part of a project, or may be a strip of existing vegetation left undisturbed or reinforced on a construction site. The purpose of a vegetative filter strip is to achieve temporary or permanent water quality benefits by slowing the velocity and filtering certain pollutants from stormwater runoff.

- 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 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 or length. 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.

- Prepare a good, firm seed bed by adding soil amendments such as fertilizer as needed. After seeding, apply a mulch 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.

- 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.

- 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.
- Avoid using the buffer strip for vehicular traffic as it will damage the vegetation and reduce its effectiveness as a buffer.
- Application of fertilizer, lime, or other soil amendments shall follow state, county, and/or local guidelines and label instructions.

Maintenance

- Inspect sod installations weekly and after significant storm events, until the turf is established.
- Maintenance shall consist of "tall" mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth.
- 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.

Limitations

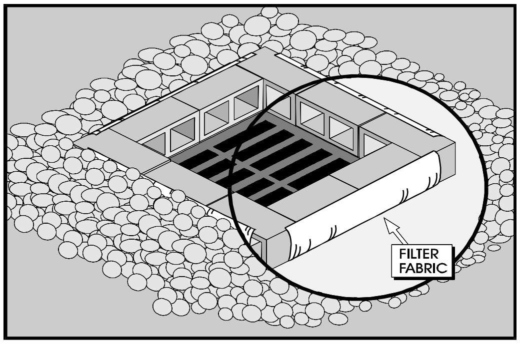
The purchase and placement of sod is more expensive than growing vegetation from seed. Additionally, sod is generally more expensive to maintain than other types of vegetation because of the need for irrigation, weeding, and mowing. Sod will not survive unless properly maintained. Plugging is more expensive than seed but less expensive than sod. Plugging requires a longer establishment period than for sod before effective control is provided.

Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, CDM et.al. for the California Department of Transportation, 1997.

Inspection Checklist

- Is there evidence of vehicular traffic over the filter strip?
- Are there any dead areas that require seeding, plugging, or resodding?
- Is there evidence of under wash that requires turf compaction?
- Is the strip receiving more flow then it can sustain without eroding?



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● Sediment	○ Heavy Metals	◗ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High		◗ Medium		○ Low
◗ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Various devices which detain sediment-laden runoff and allow the sediment to settle prior to discharge into a stormwater inlet or catch basin. This management practice is likely to create a significant reduction in sediment and a partial reduction in floatable materials.

Suitable Applications

- Every storm drain inlet or catch basin receiving sediment-laden runoff should be protected, either by covering the inlet or promoting sedimentation upstream of the inlet.
- Where ponding will not encroach into access road or highway traffic.
- Where disturbed tributary areas have not yet been permanently stabilized.
- Where the drainage area is ½ acre (0.2 ha) or less. Areas draining greater than ½ acre (0.2 ha) must be accompanied by a downstream sediment trap or basin.
- Appropriate during wet and snow-melt seasons.

Installation/ Application

- Storm inlet protection consists of a sediment filter or an impounding area around or upstream of a storm drain, drop inlet, or curb inlet. This erosion and sedimentation control BMP prevents excessive sediment from entering stormwater management systems prior to permanent stabilization of the disturbed area. All on-site storm drain inlets should be protected. Off-site, inlets should be protected in areas where construction activity tracks sediment onto paved areas or where inlets receive runoff from disturbed areas. Different types of inlet protection are appropriate for different applications depending on site conditions and the type of inlet.
- Four types of inlet protection are presented below, however, it is recognized that several other effective methods and proprietary devices exist and may be selected:

- Block and Gravel Filter: Appropriate for flows greater than 0.5 cfs (0.01 m^3/s).
- Gravel and Wire Mesh Filter: Used on curb or drop inlets where construction equipment may drive over the inlet.
- Sand bag barrier: Used to create a small sediment trap upstream of inlets on sloped, paved streets.
- Excavated Drop Inlet Sediment Trap: An excavated area around the inlet to trap sediment (see Sediment Traps TCP-17).

Select the appropriate type of inlet protection and design as referred to or as described in this fact sheet.

■ Grates and spaces around all inlets should be sealed to prevent seepage of sediment-laden water.

■ Excavate sediment sumps (where needed) 1 to 2 feet (0.31 to 0.63 m) with 2:1 (H:V) side slopes around the inlet.

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

Installation Procedure for Block and Gravel Filter:

a. Place hardware cloth or comparable wire mesh with one-half inch (1.3 cm) openings over the drop inlet so that the wire extends a minimum of 1 foot (0.31 m) beyond each side of the inlet structure. If more than one strip is necessary, overlap the strips. Place filter fabric over the wire mesh.
b. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward, not upward. The ends of adjacent blocks should abut. The height of the barrier can be varied, depending on design needs, by stacking combinations of blocks that are 4 inches (10.2 cm), 8 inches (20.3 cm), and 12 inches (30.5 cm) wide. The row of blocks should be at least 12 inches (30.5 cm) but no greater than 24 inches (61 cm) high.
c. Place wire mesh over the outside vertical face (open end) of the concrete blocks to prevent stone from being washed through the blocks. Use hardware cloth or comparable wire mesh with one half-inch (1.3-cm) openings.
d. Pile washed stone against the wire mesh to the top of the blocks. Use ¾- to 3-inch (1.9- to 7.6-cm) gravel.

Installation Procedure for Gravel and Wire Mesh Filters:

a. Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot (0.31 m) beyond each side of the inlet structure. Use hardware cloth or comparable wire mesh with one-half inch (1.3-cm) openings. If more than one strip of mesh is necessary, overlap the strips. Place filter fabric over wire mesh.
b. Place ¾ to 3-inch (1.9- to 7.6-cm) gravel over the filter fabric/wire mesh. The depth of the gravel should be at least 12 inches (30.5 cm) over the entire inlet opening.
c. Excavated Drop Inlet Sediment Trap – Size excavated drop inlet to provide a minimum storage capacity calculated at the rate of 67 yd^3/ac (134 m^3/ha) of tributary area.

Installation Procedure for Sand Bag Barrier:

a. Use sand bag made of geotextile fabric (not burlap), and fill with ¾ in. (1.9 cm) rock or ¼ in. (0.64 cm) pea gravel.
b. Construct on gently sloping street.
c. Leave room upstream of barrier for water to pond and sediment to settle.
d. Place several layers of sand bags—overlapping the bags and packing them tightly together.
e. Leave gap of one bag on the top row to serve as a spillway. Flow from a severe storm (up to a 10-year storm) should not overtop the curb.

Maintenance

- Replace clogged filter fabric or stone filters immediately.
- Remove sediment when depth exceeds half the height of the filter, or half the depth of the sediment trap.
- Inspect all inlet and catch basin protection devices weekly, before and after every rainfall event. During extended rainfall events, inspect inlet protection devices at least once every 24 hours.
- Inspect the storm drain inlet or other infrastructure downstream after severe storms in the rainy season to check for bypassed material.
- Remove all inlet protection devices within thirty days after the site is stabilized, or when the inlet protection is no longer needed.
  - Bring the disturbed area to final grade and smooth and compact it. Appropriately stabilize all bare areas around the inlet.
  - Clean around and inside the storm drain inlet as it must be free of sediment and debris at the time of final inspection.

Limitations

- Use only when ponding will not encroach into access roads, highway traffic, or onto erodible surfaces and slopes.
- Sediment removal may be difficult in high flow conditions or if runoff is heavily sediment laden. If high flow conditions are expected, use other on-site sediment trapping techniques in conjunction with inlet protection.

- Frequent maintenance is required.
- For drainage areas larger than ½ acre (0.2 ha), runoff should be routed to a sediment trap or basin designed for larger flows.
- Runoff will bypass protected inlets on slopes.
- Block and gravel filter and sand bag barriers for inlet protection are applicable when sheet flows or concentrated flows exceed 0.5 cfs (0.014 m^3/s), and it is necessary to allow for overtopping to prevent flooding.
- Excavated drop inlet sediment traps are appropriate where relatively heavy flows are expected and overflow capability is needed.

Additional Information

Large amounts of sediment may enter the storm drain system when storm drains are installed before the upslope tributary area is stabilized, or where construction is adjacent to an existing storm drain. In cases of extreme sediment loading, the storm drain itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, Arizona, September 1992.

"Draft – Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April 1990.

Erosion and Sediment Control Handbook, S.J. Goldman, K. Jackson, T.A. Bursetynsky, P.E., McGraw Hill Book Company.

Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Work Group Working Paper, USEPA, April 1992.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

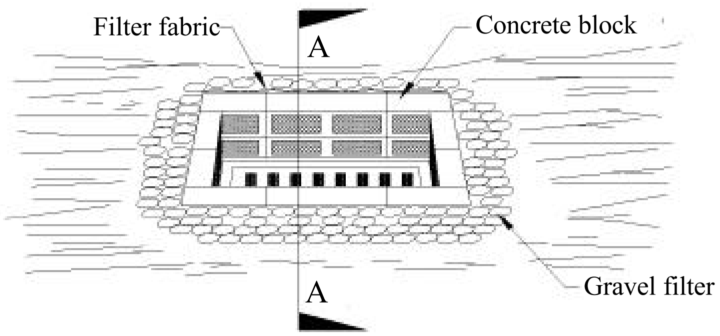
Storm Water Pollution Prevention Handbook, First Edition, State of California, Department of Transportation Division of New Technology, Materials, and Research, October 1992.

Inspection Checklist

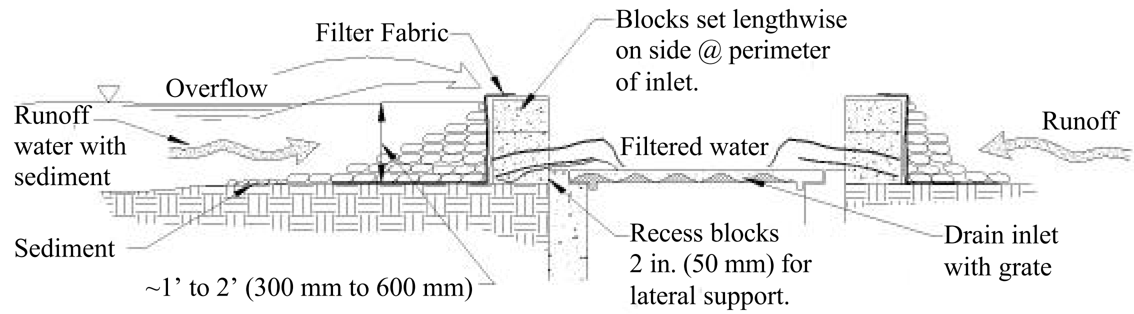
- Block and Gravel Filter
  - Make sure the blocks are in good shape and not displaced.
  - Check the gravel piled around the blocks to make sure gravel is not washing through the fabric and blocks.
  - Do not clean gravel adjacent to any inlet or waterway.
  - Remove sediment behind the gravel pack when it reaches one-third the block height

- Sand Bag Barrier
  - Inspect bags for holes, gashes, and snags.
  - Check sand bags for proper arrangement and displacement. Remove the sediment behind the barrier when it reaches one-third the height of the barrier.

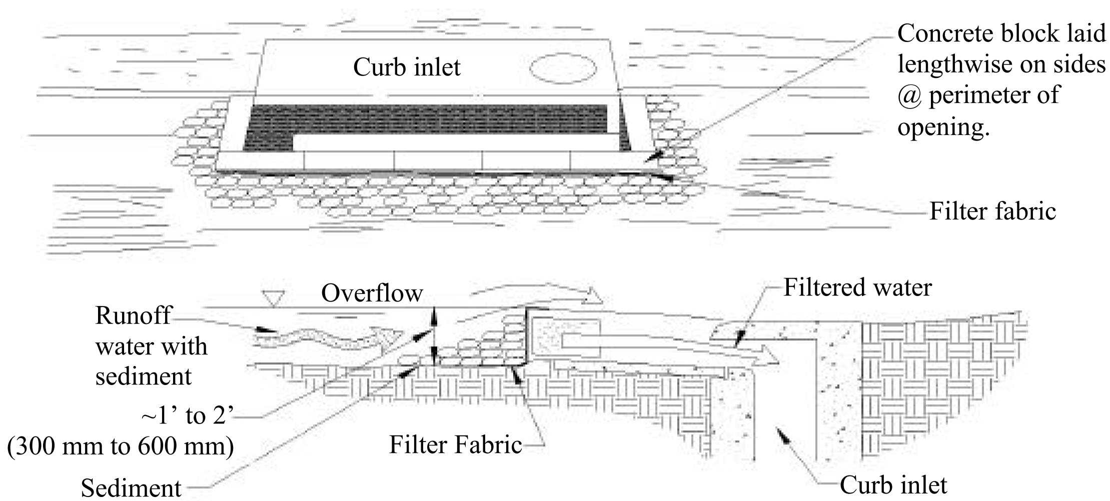
- Excavated Drop Inlet Sediment Trap
  - Remove sediment from basin when the volume of the basin has been reduced by one-half.



NOTES:
1. Use clean ¾ in. (19 mm) gravel or approved equal.
2. Periodically change gravel with new, clean gravel. Old gravel may be used as backfill material if approved by Engineer.

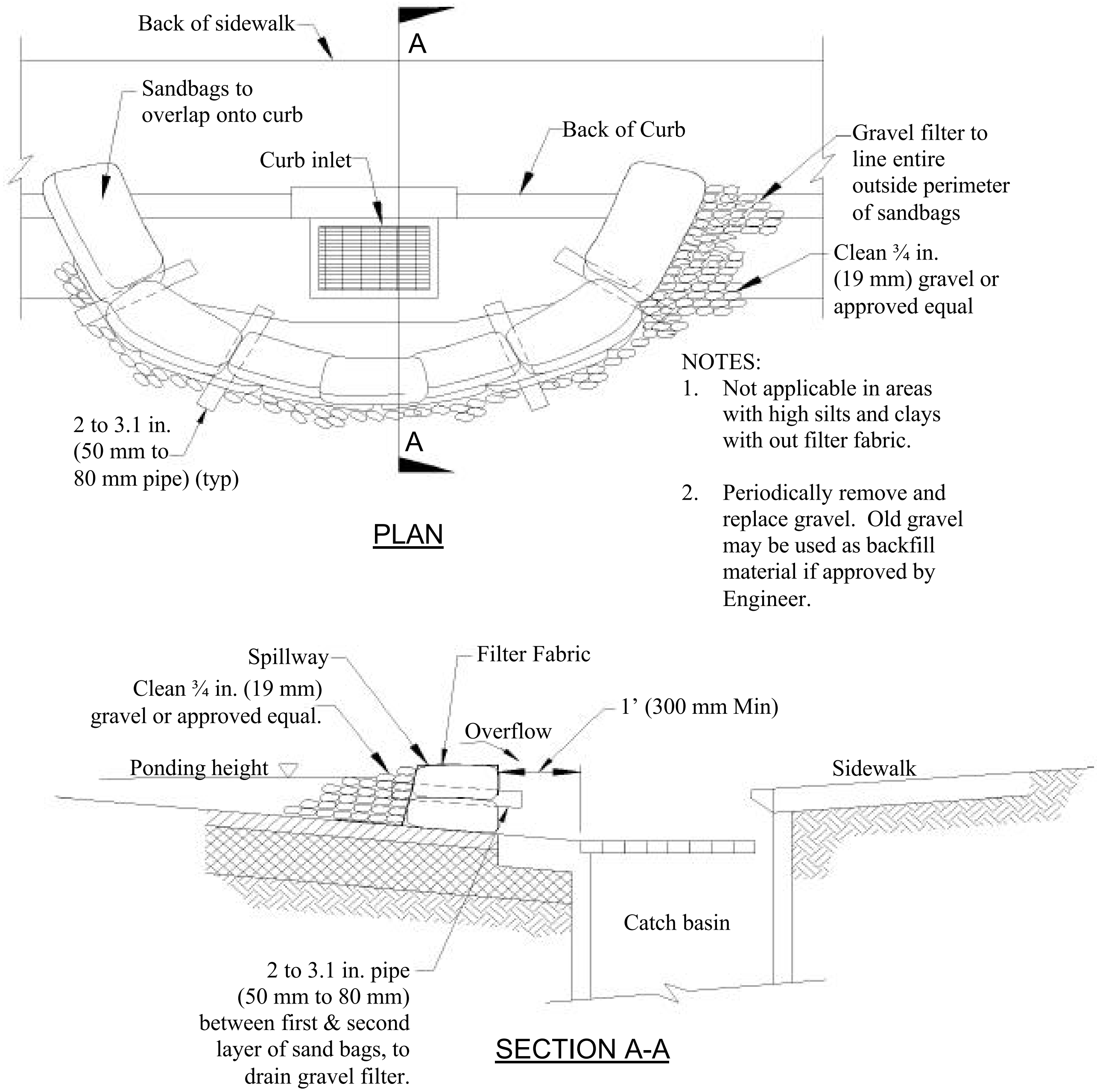


WITHOUT CURB



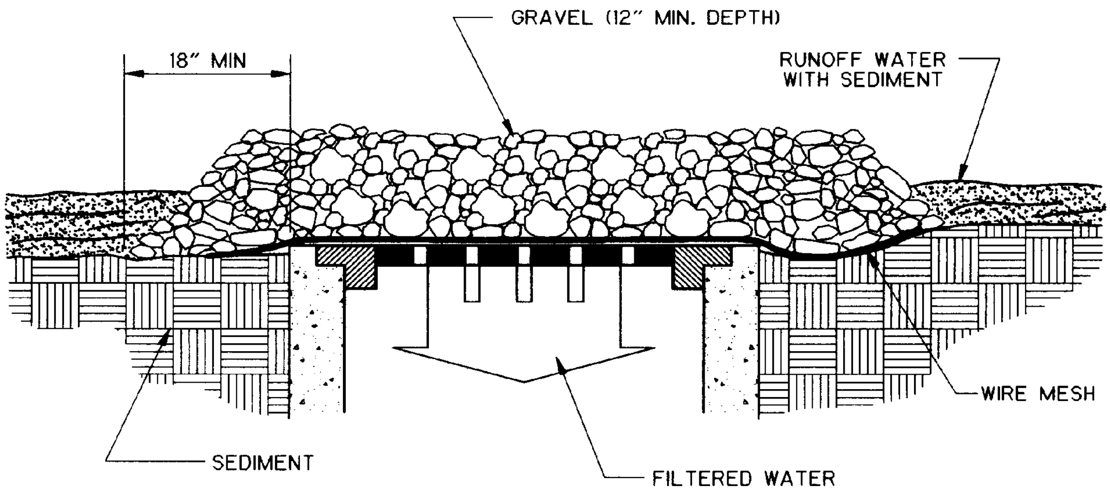
WITH CURB

Figure TCP-24-2
Block and Gravel Catch Basin Filter



NOTES:
1. Not applicable in areas with high silts and clays with out filter fabric.
2. Periodically remove and replace gravel. Old gravel may be used as backfill material if approved by Engineer.

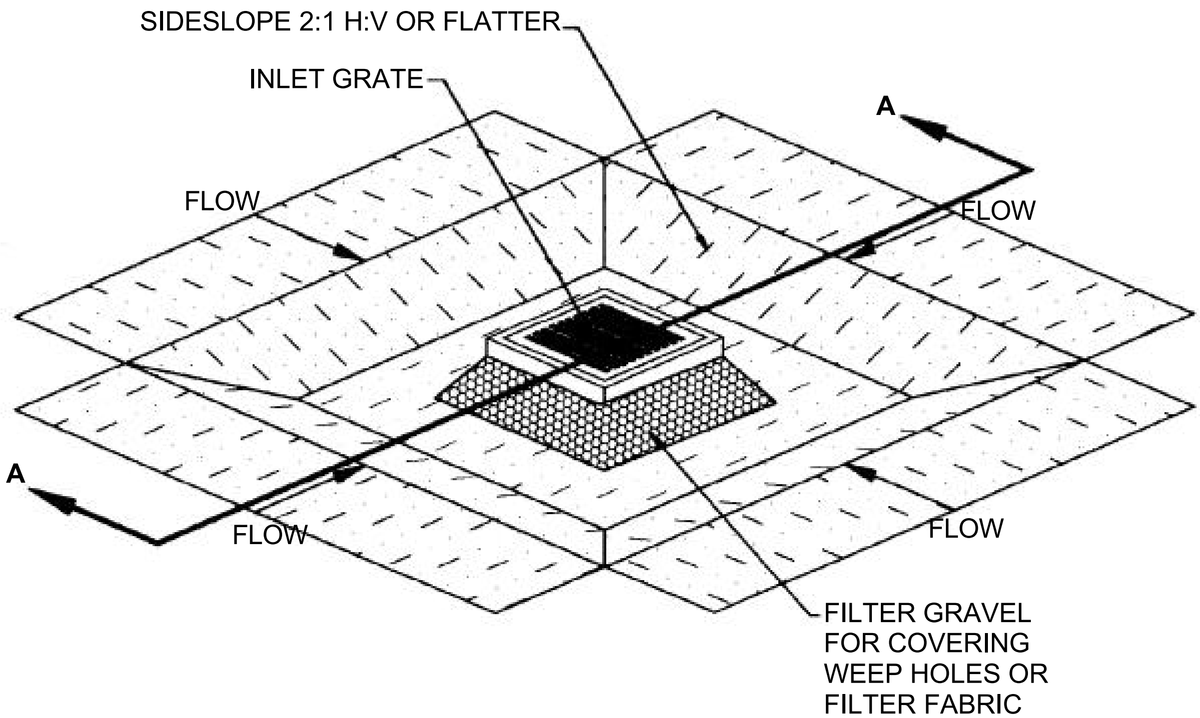
Figure TCP-24-3
Sand Bag Barrier



SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY CONCENTRATION FLOWS ARE EXPECTED, BUT NOT WHERE PONDING AROUND THE STRUCTURE MIGHT CAUSE EXCESSIVE AND UNPROTECTED AREAS.

Figure TCP-24-4
Wire Mesh and Gravel Inlet Filter



ISOMETRIC PLAN VIEW
N.T.S.

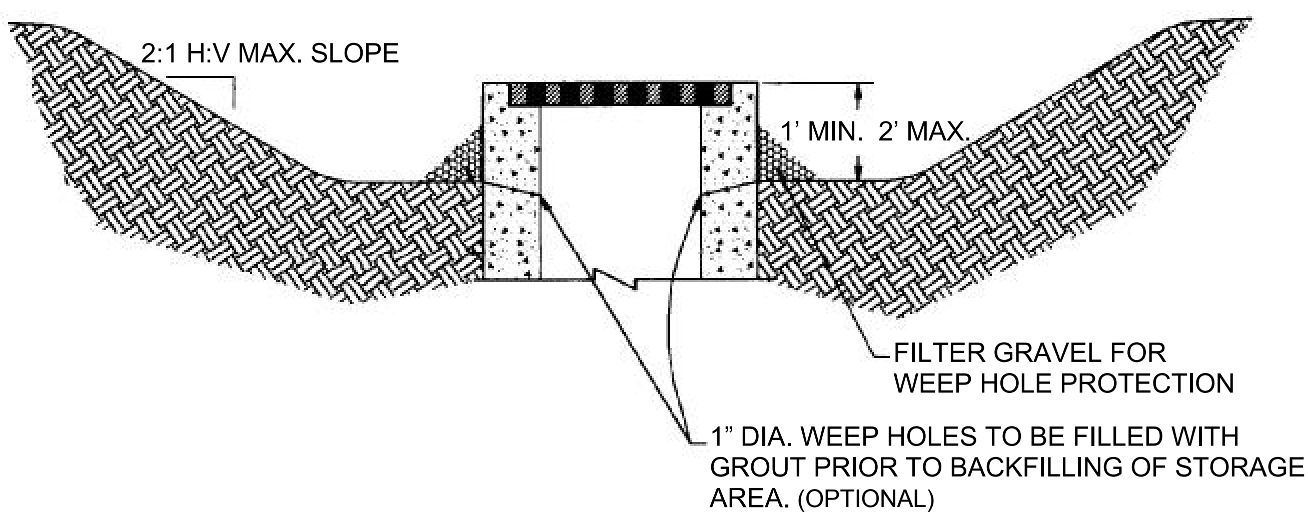


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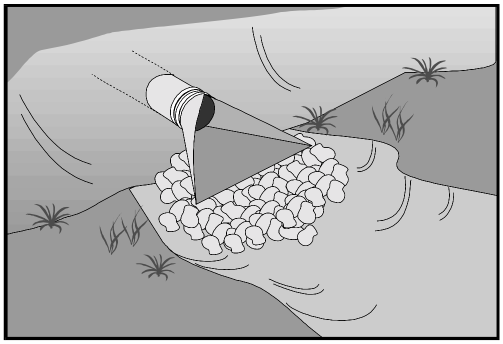
Figure TCP-24-5
Inlet Impoundment/Trap

ACTIVITY: Temporary Outlet Protection	TCP – 25
	

Targeted Constituents				
● Significant Impact	◗ Partial Impact	○ Low or Unknown Impact		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
◗ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Rock outlet protection is a physical device composed of rock, grouted rip-rap, or concrete rubble which is placed at the outlet of a pipe to prevent scour of the soil caused by high pipe flow velocities, and to dissipate flow energy to produce non-erosive velocities. This management practice is likely to create a significant reduction in sediment by reducing velocities.

Suitable Applications

- Outlet protection is needed where discharge velocities and energies at the outlets of culverts, conduits or channels are sufficient to erode the immediate downstream reach (>3 ft/s). This practice protects the inlet or outlet from developing small eroded pools (3 plunge pools), and protects against gully erosion resulting from scouring at a culvert mouth.
- Outlets of pipes, drains, culverts, conduits or channels.
- Outlets located at the bottom of mild to steep slopes (greater than 4:1 (H:V)).
- Outlets of channels which carry continuous flows of water.
- Outlets subject to short, intense flows of water.
- Where lined conveyances discharge to unlined conveyances.
- Rock outlet protection is best suited for temporary use during construction because it is usually less expensive and easier to install than concrete aprons or other energy dissipaters.
- A sediment trap below the pipe outlet is recommended if runoff is sediment laden.
- Grouted rip-rap should be avoided in areas of freeze and thaw because the grout will break up.

Installation/ Application Criteria

Permanent rip-rap protection should be designed and sized by a licensed professional civil engineer as part of the culvert, conduit or channel design. Rock outlet protection is effective when the rock is sized and placed properly. When this is accomplished, rock outlets significantly limit erosion at pipe outlets. Rock size should be increased for high velocity flows. Best results are obtained when sound, durable, angular or crushed rock is used.

- Rip-rap aprons are best suited for temporary use during construction.
- Carefully place rip-rap to avoid damaging the underlain 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 the upper section of the apron, placing additional bank reinforcement in the curved section and immediately downstream.
- See figure TCP-25-1 for proper sizing of rip-rap.

Maintenance

- Grouted or wire-tied rock rip-rap can minimize maintenance requirements.
- Inspect temporary measures weekly, before and after rainfall events.
- 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.
- Temporary devices should be completely removed as soon as the tributary area has been stabilized, or at the completion of construction.

Limitations

- 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.
- Grouted rip-rap may break up in areas of freeze and thaw.
- Grouted rip-rap may break up from hydrostatic pressure without adequate drainage.

Additional Information

Rock outlet protection is usually less expensive and easier to install than concrete aprons or energy dissipaters. It also serves to trap sediment and reduce flow velocities.

As with most channel design projects, depth of flow, roughness, gradient, side slopes, discharge rate and velocity should be considered in the outlet design. Compliance to local and state regulations should also be considered while working in environmentally sensitive streambeds. General recommendations for rock size and length of outlet protection mat is shown in the rock outlet protection figure. Best results are obtained when sound, durable, angular or crushed rock is used. Rock depth and outlet protection lengths are governed by the discharge pipe size, but hydraulic calculations and velocities should be used to determine length.

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Mariposa County, Arizona, September 1992.

County of Sacramento Improvement Standards, Sacramento County – May 1989.

Environmental Criteria Manual, City of Austin, TX, 1989.

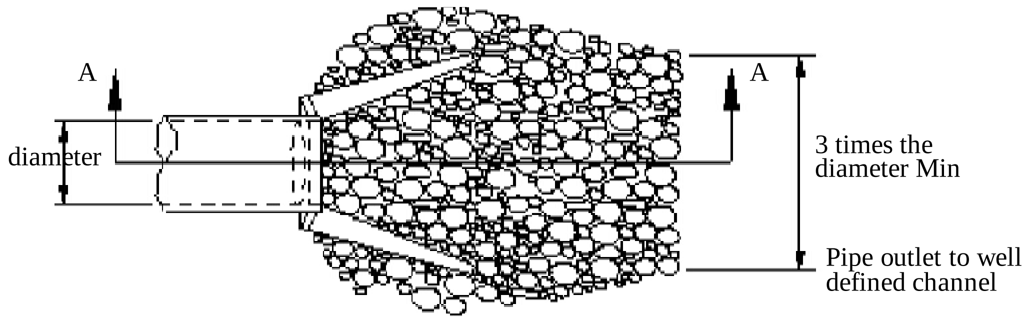
Erosion and Sediment Control Handbook, S.J. Goldman, K. Jackson, T.A. Bursztynsky, P.E., McGraw Hill Book Company, 1986.

Handbook of Steel Drainage & Highway Construction, American Iron and Steel Institute, 1983.

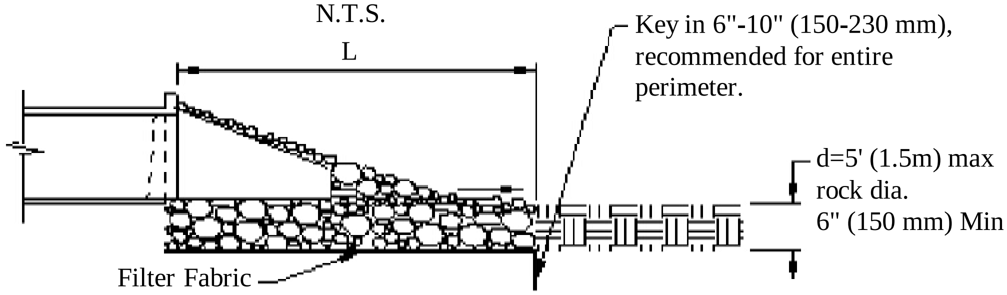
Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Water Quality Management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.



PLAN VIEW
N.T.S.



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Adapted from: Virginia Erosion & Sediment Control Handbook, 1992

Pipe Diameter in (mm)	Discharge $ft^3/s(m^3/s)$	Apron Length, L ft (m)	Rip-Rap D_{50} Diameter Min in (mm)
12 (300)	4.9 (0.14)	10 (3)	4 (100)
	9.89 (0.28)	13 (4)	6 (150)
18 (450)	9.89 (0.28)	10 (3)	6 (150)
	20.13 (0.57)	16 (5)	8 (200)
	30.01 (0.85)	23 (7)	12 (300)
	39.90 (1.13)	26 (8)	16 (400)
24 (600)	30.01 (0.85)	16 (5)	8 (200)
	39.90 (1.13)	26 (8)	8 (200)
	50.14 (1.42)	26 (8)	12 (300)
	60.03 (1.70)	30 (9)	16 (400)
For larger or higher flows, consult a registered civil engineer			

Source: USDA-SCS

Figure TCP-25-1
Outlet Protection Sizing

SECTION 4
INDUSTRIAL / COMMERCIAL MANAGEMENT PRACTICES (ICPs)

Section 4
INDUSTRIAL / COMMERCIAL MANAGEMENT PRACTICES (ICPs)

4.1 Introduction

This section presents the BMP fact sheets for the Industrial / Commercial Management Practices (ICPs). ICPs predominately focus on practices relating to manufacturing facility "Good Housekeeping" measures with special emphasis on hazardous materials. Other frequently used practices that address containing or capturing pollutants for minor repairs, renovation, minor construction and other activities are also included.

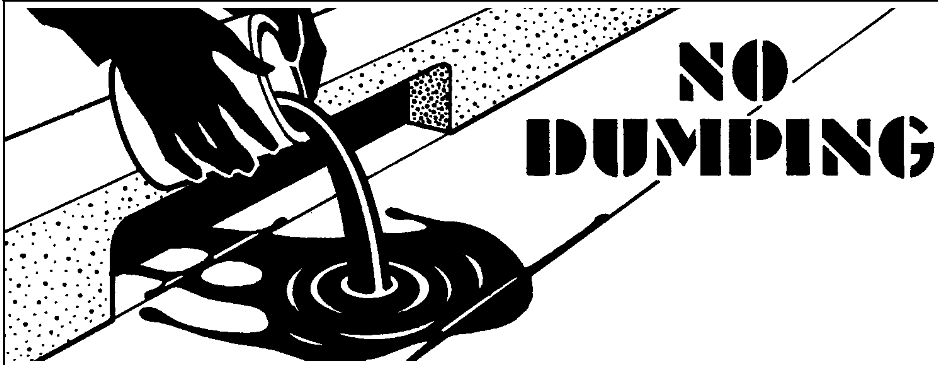
This section contains the following BMP fact sheets.

ICP – 01	Non-Stormwater Discharges to Storm Drains
ICP – 02	Vehicle and Equipment Fueling
ICP – 03	Vehicle and Equipment Washing and Cleaning
ICP – 04	Vehicle and Equipment Maintenance and Repair
ICP – 05	Outdoor Loading/Unloading and Storage of Materials
ICP – 06	Outdoor Container Storage of Liquids
ICP – 07	Outdoor Process Equipment Operations and Maintenance
ICP – 08	Waste Handling and Disposal
ICP – 09	Contaminated or Erodible Surface Areas
ICP – 10	Building and Grounds Construction and Maintenance
ICP – 11	Over-Water Activities
ICP – 12	Employee Training

Each fact sheet has a quick reference guide indicating what pollutant constituents the BMP is targeting and implementation requirements.

The BMPs presented in this section are intended to coincide with non-construction activity. Additional details are provided in sections covering Contractor Management Practices (CP) for practices that are intended to be used for construction activities.

ACTIVITY: Non-Stormwater Discharges to Storm Drains	ICP – 01



Targeted Constituents			
● Likely to Have Significant Benefit		○ Probable Low or Unknown Benefit	
○ Sediment ● Nutrients	● Heavy Metals ● Toxic Materials	◗ Floatable Materials ● Oxygen Demanding Substances	● Oil & Grease ● Bacteria & Viruses
Implementation Requirements			
● High		○ Low	
◗ Capital Costs	○ O & M Costs	○ Maintenance	◗ Training

Description

Eliminate non-stormwater discharges to the stormwater collection system. Non-stormwater discharges may include oils, paints, acids, solvents, process wastewaters, cooling waters, wash waters, and sanitary wastewater. This task is intended to eliminate nutrients, heavy metals, toxic materials, floatable debris, oxygen demand substances, oil and grease, bacteria and virus.

Approach

To ensure that the stormwater system discharge contains only stormwater, industry should:

- Locate discharges to the municipal storm sewer system or "Waters of the State" from the industrial storm sewer system from:
  - "as-built" pipeline schematics, and
  - visual observation (walk boundary of plant site).
- Locate and evaluate all discharges to the industrial storm sewer system (including wet weather flows) from:
  - "as-built" pipeline schematics,
  - visual observation,
  - dye tests,
  - TV camera,
  - chemical field test kits, and
  - smoke tests.
- Develop plan to eliminate illicit connections:
  - replumb sewer lines,
  - isolate problem areas, and
  - plug illicit discharge points

- Develop disposal options.

- Document that non-stormwater discharges have been eliminated by recording tests performed, methods used, dates of testing, and any on-site drainage points observed.

The following approaches may be used to identify non-stormwater discharges:

- Visual Inspection
  - The easiest method is to inspect each discharge point during dry weather.
  - Keep in mind that flow from a storm event can continue for three days or more and groundwater often infiltrates the underground stormwater collection system.

- Piping Schematic
  - The piping schematic is a map of pipes and stormwater systems used to carry wastewater, cooling water, sanitary wastes, etc.
  - A review of the "as-built" piping schematic is a way to determine if there are any connections to the stormwater collection system.
  - Inspect the path of floor drains in older buildings. It is not uncommon to find cross-connections in older buildings.

- Smoke Testing
  - Smoke testing of wastewater and stormwater collection systems is used to detect connections between the two systems.
  - During dry weather the stormwater collection system is filled with smoke and then traced to sources. The appearance of smoke at the base of a toilet indicates that there may be a connection between the sanitary and the stormwater system.

- Dye Testing
  - A dye test can be performed by simply releasing a dye into either your sanitary or process wastewater system and examining the discharge points from the stormwater collection system for discoloration.

Limitations

- It can be difficult to locate illicit connections especially if there is groundwater infiltration.

- Many facilities do not have accurate, up-to-date schematic drawings. Mistakes in construction may not be reflected in the schematics.

- TV and visual inspections can identify illicit connections to the storm sewer, but further testing is sometimes required (e.g., dye, smoke) to identify sources.

Non-stormwater discharges to the stormwater collection system may include any water used directly in the manufacturing process (process wastewater), air conditioning condensate and coolant, non-contact cooling water, cooling equipment condensate, outdoor secondary containment water, vehicle and equipment wash water, sink and drinking fountain wastewater, sanitary wastes, or other wastewaters. Table ICP-15-01 in the Employee/Subcontractor training BMP fact sheet presents disposal alternatives information for specific types of wastewaters.

Additional Information

Substances illegally dumped on the street and into the storm drain system and creeks include paints, used oil and other automotive fluids, construction debris, chemicals, fresh concrete, leaves, grass clippings, and pet wastes. All of these wastes can cause stormwater and receiving water quality problems as well as clog the storm drain system itself.

Primary References

California Storm Water Best Management Practice Handbooks, Industrial Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

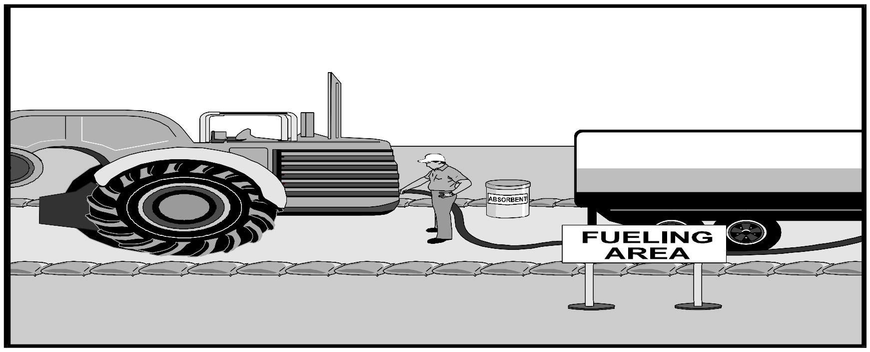
Subordinate References

General Industrial Storm Water Permit, SWRCB, 1992.

*NPDES General Permit for Discharges of Storm Water Associated with Industrial Activity in Santa Clara County to South San Francisco Bay or its Tribu*taries, SFBRWQCB, 1992.

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832-R-92-006, USEPA, 1992.

ACTIVITY: Vehicle and Equipment Fueling	ICP – 02



Targeted Constituents			
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit	
○ Sediment	● Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances

○ Nutrients	● Toxic Materials	● Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium	○ Low	
◗ Capital Costs	○ O & M Costs	◗ Maintenance	◗ Training

Description

Prevent fuel spills and leaks, and reduce their impacts to stormwater. This management practice is likely to create a significant reduction in VOCs, heavy metals, toxic materials, and oil and grease.

Approach

Spills from fueling or from the transfer of fuels to the storage tank can be a significant source of pollution. Fuels carry contaminants of particular concern to humans and wildlife, such as heavy metals, toxic materials, and oil and grease, which are not easily removed by stormwater treatment devices. Consequently, control at the source is particularly important. Adequate control can be achieved with careful design of the initial installation, retrofitting of existing installations, and proper spill control and cleanup procedures, as described below.

- Design the fueling area to prevent the run-on of stormwater and the runoff of spills:
  - Cover fueling area if possible.
  - If it is not possible to cover the fueling area, then route all stormwater runoff from the area to an oil/water separator. For permanent fueling areas, use coalescent plate oil/water separators (see PTP-07).
  - Use a perimeter drain or slope pavement inward with drainage to sump.
  - Pave fueling area with concrete rather than asphalt.
- Where covering is infeasible and the fuel island is surrounded by pavement, apply a suitable sealant that protects the asphalt from spilled fuels.
- If a dead-end sump is not used to collect spills, install an oil/water separator.
- Install vapor recovery nozzles to help control drips as well as air pollution.
- Discourage “topping-off” of fuel tanks.

- Place secondary containment around the fuel truck when it is transferring fuel to the storage tank. The truck operator should remain with the truck while the transfer is in progress.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Use dry methods to clean the fueling area whenever possible. If you periodically clean by pressure washing, place a temporary plug in the downstream drain and pump out the accumulated water. Properly dispose of the water through the sanitary sewer system only after gaining permission from Metro Water Services (MWS).
- Use adsorbent materials on small spills and general cleaning rather than hosing down the area. Remove the adsorbent materials promptly.
- Carry out all Federal and State requirements regarding underground storage tanks, or install above ground tanks.
- Do not use mobile fueling of mobile industrial equipment around the facility; rather, transport the equipment to designated fueling areas.
- The Spill Prevention Control and Countermeasure (SPCC) Plan, which is required by law for some facilities, is an effective program to reduce the number of accidental spills. Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.
- Train employees in proper fueling and cleanup procedures including periodic review of the SPCC.
- For a quick reference on disposal alternatives for specific wastes see Table CP-15-1 in the Employee/Subcontractor Training BMP fact sheet.

Maintenance

- Clean/empty oil/water separators at the appropriate intervals. Generally this is inspected monthly.
- Keep ample supplies of spill cleanup materials on-site.
- Inspect fueling areas and storage tanks on a regular schedule. Special attention should be given to detecting leaks to/from any underground storage tanks.

Limitations

- Oil/water separators are only as effective as their maintenance program.
- The retrofitting of existing fueling areas to minimize stormwater exposure or spill runoff can be expensive. Good design must occur during the initial installation.
- Installing extruded curb along the “upstream” side of the fueling area to prevent stormwater run-on is a modest cost.

Additional Information

Design

With new installations, design the fueling area to prevent the run-on of stormwater and the runoff of spills. This can be achieved by contouring the site in the appropriate fashion. Covering the site is the best approach but may not be feasible if very large mobile equipment is being fueled. Stormwater run-on can be diverted around the fueling area by an extruded curb, berm, swale, or with a "speed bump", if vehicle access is needed from this direction. Spills can be contained within the fueling area either by using a perimeter drain or by sloping the pavement inward with drainage to a sump. In both cases the drain can be connected to the storm drain with a valve that is only closed during fueling operations and left open at all other times. Pave the fueling area with Portland cement concrete rather than asphalt, since the latter will gradually disintegrate and be washed from the site.

Mobile Fueling

If your facility has large numbers of mobile equipment working throughout the site and you currently fuel them with a mobile fuel truck, consider establishing a designated area for fueling. With the exception of tracked equipment such as bulldozers and perhaps small forklifts, most vehicles should be able to travel to a designated area with little lost time. Place temporary "caps" over nearby catch basins or manhole covers so that if a spill occurs it is prevented from entering the storm drain.

Primary References

California Storm Water Best Management Practice Handbooks, Industrial Handbook, CDM et.al. for the California SWQTF, 1993.

Subordinate References

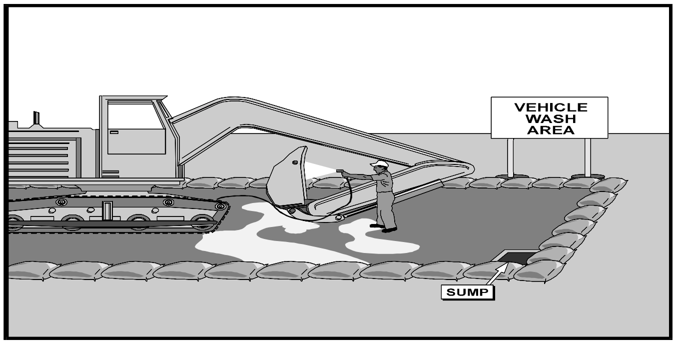
Best Management Practices for Automotive-Related Industries, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832-R-92-006, USEPA, 1992.

Water Quality Best Management Practices Manual, City of Seattle, 1989.

ACTIVITY: Vehicle and Equipment Washing and Cleaning	ICP – 03



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	● Heavy Metals	○ Floatable Materials	● Oxygen Demanding Substances	
● Nutrients	● Toxic Materials	● Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium	○ Low	
◗ Capital Costs	○ O & M Costs	○ Maintenance	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from vehicle and equipment washing and steam cleaning. This practice is designed to address permanent washing and cleaning operations. This management practice is likely to create a significant reduction in sediment, nutrients, heavy metals, toxic materials, and oil and grease. For discussion of on-site or temporary washing and cleaning, see CP-12.

Approach

- Use designated wash areas, preferably covered to prevent contact with stormwater and bermed with a continuous berm, double layered straw or sand bag barrier, or diversion swale to contain wash water.

- Discharge wash water to sanitary sewer, after contacting local sewer authority to find out if pretreatment (oil/water separators or other means) is required.

- Educate employees on pollution prevention measures including review of the Spill Prevention Control and Countermeasures (SPCC) plan.

- When cleaning vehicles/equipment with water:

  - Use as little water as possible. High pressure sprayers may use less water than a hose, and should be considered.
  - Use positive shutoff valve to minimize water usage.

- Consider filtering and recycling wash water.

- For a quick reference on disposal alternatives for specific wastes see Table CP-15-1 in the Employee/Subcontractor Training BMP fact sheet.

- When the vehicle/equipment washing/cleaning operation cannot be located within a structure or building equipped with sanitary sewer facilities, the outside cleaning area should have the following characteristics:

- Perimeter diversion swale or containment berm or barrier.
- Located away from storm drain inlets, drainage facilities, or watercourses,
- Paved with concrete or asphalt, or stabilized with an aggregate base,
- Bermed to contain wash waters and to prevent run-on and runoff,
- Configure wash area with a sump to allow collection and disposal of wash water,
- Discharge wash water to a sanitary or process waste sewer (where permitted), or to a dead end sump. Wash waters should not be discharged to storm drains or watercourses,
- Sloped for wash water collection to swale and/or diverted to sump.
- Discharge pipe should have a positive control valve that allows switching between the storm drain and sanitary or process sewer,
- Clearly designated, and
- Equipped with media infiltration or oil/water separator (see PTP-06 Media Filtration or PTP-07 Oil/Water Separators and Water Quality Inlets).

Maintenance

- Inspect berms for necessary repair and patching weekly.
- Inspection and maintenance of sumps, oil/water separators, and on-site treatment/recycling units.

Limitations

- Steam cleaning can generate significant pollutant concentrations requiring permitting, monitoring, pretreatment, and inspections. The measures outlined in this fact sheet are insufficient to address all the environmental impacts and compliance issues related to steam cleaning.
- Do not use solvents to clean vehicles/equipment on site.
- Do not permit steam cleaning on site.

Additional Information

Washing vehicles and equipment outdoors or in areas where wash water flows onto the ground can pollute stormwater. If your facility washes or steam cleans a large number of vehicles or pieces of equipment in an outdoor or uncovered facility, consider contracting out this work to a commercial business. These businesses are better equipped to handle and dispose of the wash waters properly. Contracting out this work can also be economical by eliminating the need for a separate washing/cleaning operation at your facility.

Primary References

California Storm Water Best Management Practice Handbooks, Industrial Handbook, CDM et.al. for the California SWQTF, 1993.

Subordinate References

Best Management Practices for Automotive-Related Industries, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832OR-92-006, USEPA, 1992.

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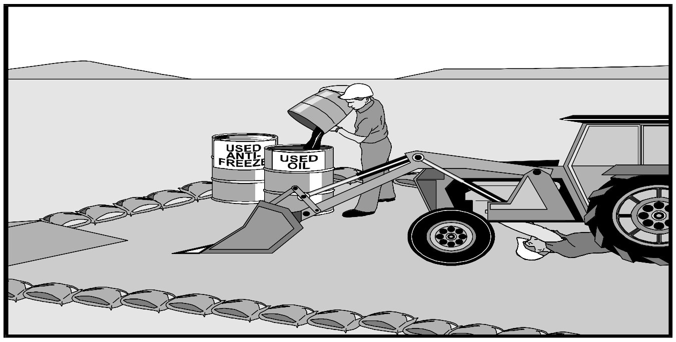
ACTIVITY: Vehicle and Equipment Maintenance and Repair

ICP – 04



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
○ Sediment	● Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	● Toxic Materials	● Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium	○ Low	
○ Capital Costs	◗ O & M Costs	◗ Maintenance	◗ Training

Description

Procedures and practices to reduce the discharge of pollutants to the storm drain system or to watercourses as a result of vehicle and equipment maintenance by conducting these activities off-site or in a designated area designed to contain spills and prevent run-on or runoff. This management practice is likely to create a significant reduction in heavy metals, toxic materials, and oil and grease.

Approach

Vehicle or equipment maintenance is a potentially significant source of stormwater pollution. Activities that can contaminate stormwater include engine repair and service (parts cleaning, spilled fuel, oil, etc.), replacement of fluids, and outdoor equipment storage and parking (dripping engines). For further information on vehicle or equipment servicing, see ICP-02, Vehicle and Equipment Fueling, and ICP-03, Vehicle and Equipment Washing and Cleaning.

- Use centralized, covered, off-site maintenance facilities whenever practical.
- Locate on paved surfaces where practical (Preferably paved with concrete rather than asphalt).
- Use berms to protect maintenance areas from run-on.
- Always use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.
- Do not dump fuels and lubricants onto the ground.
- Do not place used oil in a dumpster.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Do not bury used tires.

- Repair leaks of fluids and oil immediately as soon as possible.
- Clean leaks, drips, and other spills with as little water as possible. Use rags for small spills, a damp mop for general cleanup, and dry absorbent material for larger spills. Use the following three-step method for cleaning floors:

1. Clean spills with rags or other absorbent materials.
2. Sweep floor using dry absorbent material.
3. Mop floor. Mop water may be discharged to the sanitary sewer via a toilet or sink.

- Provide spill containment dikes or secondary containment (swales, berms, walls, etc.) around stored oil and chemical drums.
- Maintain an adequate supply of spill cleanup materials in designated areas.
- Inspect equipment for damaged hoses and leaky gaskets routinely. Repair or replace as needed.
- Keep equipment clean, don't allow excessive build-up of oil and grease.
- Keep drip pans or containers under the areas that might drip.
- Do not change motor oil or perform equipment maintenance in non-appropriate areas. Use a vehicle maintenance area designed to prevent stormwater pollution.
- Inspect stored equipment for leaks on a regular basis.
- Segregate liquid, solid and hazardous wastes for easier recycling and may reduce treatment 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). Many products made of recycled (i.e., refined or purified) materials are available. Engine oil, transmission fluid, antifreeze, and hydraulic fluid are available in recycled form. Buying recycled products supports the market for recycled materials.
- If possible, eliminate or reduce the amount of hazardous materials and waste by substituting non-hazardous or less hazardous materials. For example:
  - Use non-caustic detergents instead of caustic cleaning agents for parts cleaning (ask your supplier about alternative cleaning agents).
  - Use detergent-based or water-based cleaning systems in place of organic solvent degreasers. Wash water may require treatment before it can be discharged to the sewer. Contact your local sewer authority for more information.
  - 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.

   - Choose cleaning agents that can be recycled.
   - Contact your supplier or refer to trade journals for more waste minimization ideas.

- Make sure incoming vehicles are checked for leaking oil and fluids.

- Clean yard storm drain inlet(s) regularly and especially after large storms.

- Do not pour materials down drains or hose down work areas; use dry sweeping. Infrequent steam or pressure wash is appropriate if wash water is collected and/or treated.

- Store idle equipment under cover.

- Drain all fluids from wrecked vehicles into pans or other containers instead of letting them drain on the ground.

- Recycle greases, used oil or oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic, and transmission fluids.

- Minimize use of solvents. Switch to non-toxic chemicals for maintenance when possible.

- Parts are often cleaned using solvents such as trichloroethylene, 1,1,1-trichloroethane or methylene chloride. Many of these cleaners are harmful and must be disposed of as a hazardous waste. Cleaning without using liquid cleaners (e.g. wire brush) whenever possible reduces waste. Prevent spills and drips of solvents and cleansers to the shop floor. Do all liquid cleaning at a centralized station so the solvents and residues stay in one area. Locate drip pans, drain boards, and drying racks to direct drips back into a solvent sink or fluid holding tank for re-use.

- 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.

- Be especially careful with <u>wrecked vehicles</u>, whether you keep them indoors or out, as well as vehicles kept on-site for scrap or salvage. Wrecked or damaged vehicles often drip oil and other fluids for several days.
   - As the vehicles arrive, place drip pans under them immediately, even if you believe that the fluids have leaked out before the car reaches your shop.
   - Build a shed or temporary roof over areas where you park cars awaiting repair or salvage, especially if you handle wrecked vehicles. Build a roof over vehicles you keep for parts.
   - Drain all fluids, including air conditioner coolant, from wrecked vehicles and “part” cars. Also drain engines, transmission, and other used parts.

- Paint signs on storm drain inlets to indicate that they are not to receive liquid or solid wastes.

- Oil filters disposed of in trashcans or dumpsters can leak oil and contaminate stormwater. Most municipalities prohibit or discourage disposal of these items in solid waste facilities. Place the oil filter in a funnel over the waste oil recycling or disposal collection tank to drain excess oil before disposal. Oil filters can be crushed and recycled. Ask your oil supplier or recycler about recycling oil filters.

- If the vehicle or equipment is to be stored outdoors, oil and other fluids should be drained first.
- There are several commercial available materials and devices that can temporarily seal (some magnetically) storm or sanitary drains. Place these in conspicuous locations proximate to the drains and train personnel in their use for spills and leaks.
- 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.
- For a quick reference on disposal alternatives for specific wastes see Table CP-15 in the Employee/Subcontractor Training BMP fact sheet.
- Collect leaking or dripping fluids in fluid specific drip pans or containers. Fluids are easier to recycle if kept separate.
- Keep a drip pan under the vehicle while you unclip hoses, unscrew filters, or remove other parts. Use a drip pan under any vehicle that might leak while you work on it to keep splatters or drips off the shop floor.
- Promptly transfer used fluids to the proper waste or recycling drums. Don’t leave full drip pans or other open containers lying around.
- Train employees and subcontractors in proper maintenance and spill procedures. This should include periodic review of the Spill Prevention Control and Countermeasures (SPCC) Plan.

Maintenance

- Maintain waste fluid containers in leak proof condition.
- Vehicle and equipment maintenance areas shall be inspected regularly.

Limitations

- Space and time limitations may preclude all work being conducted indoors.
- It may not be possible to contain and clean up spills from vehicles/equipment brought on-site after working hours.
- <u>Drain</u> pans (usually 1 ft. (0.3 m) x 1 ft. (0.3 m)) are generally too small to contain antifreeze, which may gush from some vehicles, so <u>drip</u> pans (3 ft. (0.91 m) x 3 ft. (0.91 m)) may have to be purchased or fabricated.
- Dry floor cleaning methods may not be sufficient for some spills. Use three-step method instead.

- Identification of engine leaks may require some use of solvents.

Primary References

California Storm Water Best Management Practice Handbooks, Industrial Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices for Automotive-Related Industries, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Best Management Practices for Controlling Oil and Grease in Urban Storm Water Runoff, G.S. Silverman, et. al, 1986 Environmental Professional, Vol. 8, pp 351-362.

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Fact Sheet – *Waste Reduction for Automotive Repair Shops*; DTSC, 1989.

Hazardous Waste Reduction Assessment Handbook – Automotive Repair Shops; DTSC, 1988.

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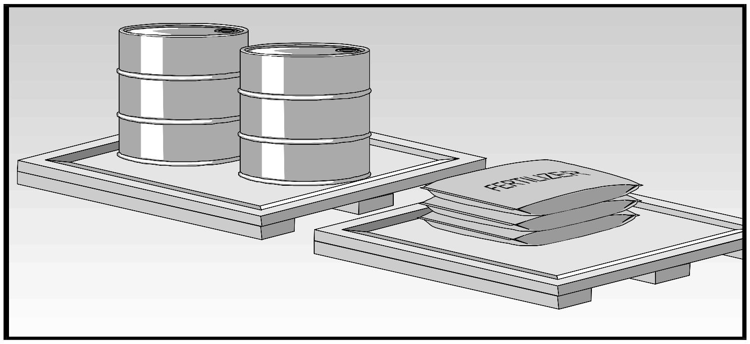
ACTIVITY: Outdoor Loading/Unloading and Storage of Materials	ICP – 05



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
○ Sediment	● Heavy Metals	● Floatable Materials	● Oxygen Demanding Substances	
● Nutrients	● Toxic Materials	● Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium	○ Low	
◗ Capital Costs	○ O & M Costs	○ Maintenance	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from outdoor loading/ unloading and storage of materials by enclosing or covering materials, installing secondary containment, and preventing stormwater run-on. This management practice is likely to create a significant reduction in nutrients, heavy metals, toxic materials, oxygen demanding substances, and oil and grease.

Approach

- The loading/unloading of materials usually takes place outside. Loading or unloading of materials occurs in two ways: materials in containers or direct liquid transfer. Materials spilled, leaked or lost during loading/unloading may collect in the soil or on other surfaces and be carried away by runoff or when the area is cleaned. Rainfall may wash pollutants from machinery used to unload or move materials. The loading or unloading may involve rail or truck transfer.

- The most important factors in preventing these constituents from entering stormwater is:

  - Limit exposure of material to rainfall.
  - Prevent stormwater run-on.
  - Check equipment regularly for leaks.
  - Contain spills during transfer operations.

- Loading or unloading of liquids should occur in the manufacturing building so that any spills that are not completely retained can be discharged to the sanitary sewer, treatment plant, or treated in a manner consistent with permit requirements.

Training

- Train employees and subcontractors on the proper material delivery and storage practices including review of the Spills Prevention, Control and Countermeasures (SPCC) Plan.

- Make sure fork lift operators are properly trained to limit spills or damaged containers.
- Employees should be periodically trained to be well acquainted with the Material Safety Data Sheets. They should be aware of material content, potential hazards to mixing with other materials stored on-site, and safety procedures required in the event of a spill or leak.

Material Delivery Practices

- Keep an accurate, up-to-date inventory of material delivered and stored on site.
- Train all “exposed” employees in emergency spill clean-up procedures should they be present when dangerous materials or liquid chemicals are unloaded.
- Park tank trucks or delivery vehicles so that spills or leaks can be contained with drip pans under hoses or other secondary containment.
- Cover the loading/unloading docks to reduce exposure of materials to rain.
- Place a seal or door skirt between trailer and building to prevent exposure to rain.
- Design loading/unloading area to prevent stormwater run-on:
    - With diversion grading, berming or swales, and
    - Position roof downspouts to direct stormwater away from loading/unloading areas.
- Look for dust or fumes during loading or unloading operations.
- When loading and unloading tank trucks to above and below ground storage tanks, the following procedures should be used:
    - The area where the transfer takes place should be paved. If the liquid is reactive with the asphalt, Portland cement concrete should be used to pave the area.
    - Transfer area should be designed to prevent run-on of stormwater from adjacent areas. Sloping the pad and using a curb, like a speed bump, around the uphill side of the transfer area should reduce run-on.
    - Transfer area should be designed to prevent runoff of spilled liquids from the area. Sloping the area to a drain should prevent runoff. The drain should be connected to a dead-end sump or to the sanitary sewer if given approval by the local sewer authority. A positive control valve should be installed on the drain.
- For transfer from rail cars to storage tanks that must occur outside, use the following procedures:
    - Drip pans should be placed at locations where spillage may occur, such as hose connections, hose reels, and filler nozzles. Use drip pans when making and

breaking connections.
- Drip pan systems should be installed between the rails to collect spillage from tank cars.

Material Storage Areas and Practices

- Designate storage areas at the project site with conspicuous signs and employee training.
- Store materials indoors within existing structures or sheds when available.
- Have proper storage instructions posted at all times in an open and conspicuous location.
- Locate the storage area away from the storm drain system and watercourses.
- Prevent spills or leakage of liquid materials from contaminating soil or soaking into the ground by placing storage areas on impervious surfaces.
- Provide curbs or dikes around the perimeter of material storage areas to prevent run-on from adjacent areas as well as runoff of stormwater from the material storage areas.
- Minimize the hazardous material inventory stored on site. Attempt to store only the volume of materials needed before another delivery is possible. Schedule more frequent deliveries of less material.
- Do not store hazardous chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet under cover and when possible, in secondary containment.
- Parking lots or other surfaces near bulk materials storage areas should be swept periodically to remove debris blown or washed from storage area.
- Install pellet traps at stormwater discharge points where plastic pellets are loaded and unloaded.
- Keep hazardous chemicals in their original containers and keep them well labeled.
- Keep ample supply of storm drain seals near drains and inlets.
- Keep ample supply of appropriate spill clean up material near storage areas.

Spill Clean-up

- Contain and clean up any spill immediately according to the SPCC Plan.
- Different materials pollute in different amounts. Make sure that each employee knows what a “significant spill” is for each material they use, and what is the appropriate response for “significant” and “insignificant” spills. A significant spill should be defined after review of the Materials Safety Data Sheet or other

descriptive documentation that presents the contents and proper handling procedures.

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.
- 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.

- 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 City 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 TDEC – Department of Water Pollution Control at (615) 532-0625.
    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 CP-13 and 14 for details about spill prevention and control while maintaining or fueling vehicles and equipment.

Maintenance

- Inspect storage areas before and after rainfall events, and at least weekly during other times.
- Inspect to ensure that designated storage areas are kept clean and well organized.
- Repair and/or replace perimeter controls, containment structures, and covers as needed to keep them properly functioning.
- Conduct regular inspections to identify repairs necessary. The frequency of repairs will depend on the age of the facility.
- Check loading and unloading equipment regularly for leaks:
  - valves,
  - pumps,
  - flanges, and
  - connections.

Limitations

- Space limitation may preclude indoor storage.
- Storage sheds must meet building & fire code requirements.
- Space and time limitations may preclude all transfers from being performed

indoors or under cover.

- It may not be possible to conduct transfers only during dry weather.

Primary References

California Storm Water Best Management Practice Handbooks, Industrial Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

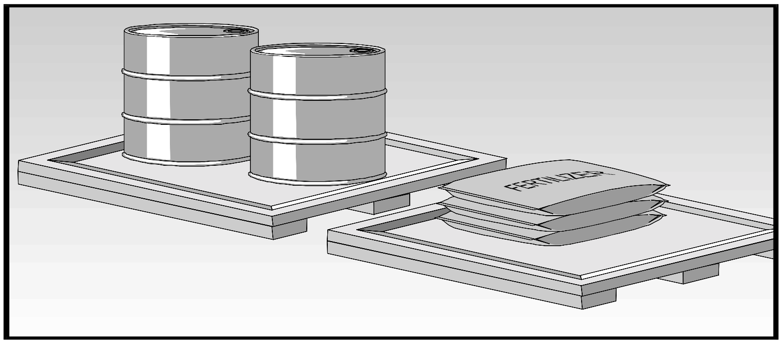
Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832-R-92-006, EPA, 1992.

Water Quality Best Management Practices Manual, City of Seattle, 1989.

Blueprint for a Clean Bay-Construction-Related Industries: Best Management Practices for Storm Water Pollution Prevention; Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices, EPA 832-R-92005; USEPA, April 1992.

ACTIVITY: Outdoor Container Storage of Liquids	ICP – 06



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	● Heavy Metals	○ Floatable Materials	● Oxygen Demanding Substances	
○ Nutrients	● Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium		○ Low
◗ Capital Costs	◗ O & M Costs	◗ Maintenance	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from outdoor container storage areas by installing safeguards against accidental releases, installing secondary containment, conducting regular inspections, and training employees in standard operating procedures and spill cleanup techniques. This management practice is likely to create a significant reduction in heavy metals, toxic materials, and oxygen demanding substances.

Approach

- All approaches mentioned in ICP-05 Outdoor Loading/Unloading of Materials are applicable to ICP-06 Outdoor Container Storage of Liquids. This fact sheet provides additional detail for storage of liquids.

- Accidental releases of materials from aboveground liquid storage tanks, drums, and dumpsters present the potential for contaminating stormwater with many different pollutants. Materials spilled, leaked or lost from storage containers and dumpsters may accumulate in soils or on the surfaces and be carried away by stormwater runoff. These source controls apply to containers located outside of a building used to temporarily store liquid materials. It should be noted that the storage of reactive, ignitable, or flammable liquids must comply with fire codes.

The most common causes of unintentional releases:

- External corrosion and structural failure,

- Installation problems,

- Spills and overfills due to operator error,

- Failure of piping systems (pipes, pumps, flanges, couplings, hoses, and valves),

- Leaks during pumping of liquids or gases from truck or railcar to a storage facility or vice versa.

- Protect materials from rainfall, run-on, runoff, and wind dispersal:
  - Store materials indoors.
  - Cover the storage area with a roof.
  - Minimize stormwater run-on by enclosing the area or building with a berm.
  - Use "doghouse" for storage of liquid containers.
  - Use covered dumpsters for waste product containers.
- Storage of oil and hazardous materials must meet specific Federal and State standards including:
  - Spill Prevention Control and Countermeasure Plan (SPCC),
  - secondary containment,
  - integrity and leak detection monitoring, and
  - emergency preparedness plans.
- Train operator on proper storage.
- Safeguards against accidental releases:
  - overflow protection devices to warn operator or automatic shut down transfer pumps,
  - protection guards (bollards) around tanks and piping to prevent vehicle or fork lift damage, and
  - clear tagging or labeling, and restricting access to valves to reduce human error.
- Berm or surround tank or container with secondary containment system:
  - dikes, liners, vaults, or double walled tanks.
- Facilities with "spill ponds" designed to intercept, treat, and/or divert spills should contact the TDEC regarding environmental compliance.

Maintenance

- Inspect storage areas before and after rainfall events, and at least weekly during other times.
- Inspect to ensure that designated storage areas are kept clean and well organized.
- Repair and/or replace perimeter controls, containment structures, and covers as needed to keep them properly functioning.
- Conduct routine weekly inspections.
- Weekly inspection should be considered and include:
  - Check for external corrosion and structural failure,
  - Check for spills and overfills due to operator error,
  - Check for failure of piping system (pipes, pumps, flanges, coupling, hoses, and valves),

- Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa,
- Visually inspect new tank or container installation loose fittings, poor welding, and improper or poorly fitted gaskets, and
- Inspect tank foundations, connections, coatings, and tank walls and piping system. Look for corrosion, leaks, cracks, scratches, and other physical damage that may weaken the tank or container system.

Limitations

- Space limitation may preclude indoor storage.
- Storage sheds must meet building & fire code requirements.
- Space and time limitations may preclude all transfers from being performed indoors or under cover.
- It may not be possible to conduct transfers only during dry weather.
- Costs may be prohibitive when covering a large loading/unloading area.

Additional Information

<u>Container Management</u>

- To limit the possibility of stormwater pollution, containers used to store dangerous waste or other liquids should be kept inside the building unless this is impractical due to site constraints. If the containers are placed outside, the following procedures should be employed:

  - Dumpsters used to store items awaiting transfer to a landfill should be placed in a lean-to structure or otherwise covered. Dumpsters shall be kept in good condition without corrosion or leaky seams. All drain valves should be closed.
  - Garbage dumpsters shall be replaced if they are deteriorating to the point where leakage is occurring. It should be kept undercover to prevent the entry of stormwater. Employees should be made aware of the importance of keeping the dumpsters covered and free from leaks.
  - A fillet should be placed on both sides of the curb to facilitate moving the dumpster.
  - Waste container drums should be kept in an area such as a service bay. If drums are kept outside, they must be stored in a lean-to type structure, shed or walk-in container to keep rainfall from reaching the drums.

- Storage of reactive, ignitable, or flammable liquids must comply with the fire codes of your area. Practices listed below should be employed to enhance the fire code requirements.

  - Containers should be placed in a designated area.
  - Designated areas should be paved, free of cracks and gaps, and impervious in order to contain leaks and spills.
  - Liquid waste should be surrounded by a curb or dike to provide the volume to contain 10 percent of the volume of all of the containers or 110 percent of the volume of the largest container, whichever is greater.
  - The area inside the curb should slope to a drain.
  - For used oil or dangerous waste, a dead-end sump should be installed in the

drain.
- All other liquids should be drained to the sanitary sewer if available. The drain must have a positive control such as a lock, valve, or plug to prevent release of contaminated liquids.

- The designated storage area should be covered.
- Containers used for liquid removal by employees must be placed in a containment area.
  - A drip pan should be used at all times.
- Drums stored in an area where unauthorized persons may gain access must be secured to prevent accidental spillage, pilferage, or any unauthorized use.
- Employees trained in emergency spill cleanup procedures should be present when dangerous waste, liquid chemicals, or other wastes are loaded or unloaded.

Operator Training/Safeguards

Well-trained employees can reduce human errors that lead to accidental releases or spills. Employees should be familiar with the Spill Prevention Control and Countermeasure (SPCC) Plan. The employee should have the tools and knowledge to immediately begin cleaning up a spill if one should occur. Operator errors can be prevented by using engineering safeguards and thus reducing accidental releases of pollutant.

Tank systems should be inspected and tank integrity tested regularly. Problem areas can often be detected by visually inspecting the tanks frequently. Problems or potential problems should be corrected as soon as possible. Registered and specifically trained professional engineers can identify and correct potential problems such as loose fittings, poor welding, and improper or poorly fitted gaskets for newly installed tank systems. The tank foundations, connections, coatings, and tank walls and piping systems also should be inspected. Inspection for corrosion, leaks, cracks, scratches in protective coatings, or other physical damage that may weaken the tank system should be a part of regular integrity testing.

Secondary Containment

Tanks should be bermed or surrounded by a secondary containment system. Leaks can be detected more easily and spills can be contained when secondary containment systems are installed. Berms, dikes, liners, vaults, and double-wall tanks are examples of secondary containment systems.

One of the best protective measures against contamination of stormwater is diking. Containment dikes are berms or retaining walls that are designed to hold spills. Diking is an effective pollution prevention measure for above ground storage tanks and railcar or tank truck loading and unloading areas. The dike surrounds the area of concern and holds the spill, keeping spill materials separated from the stormwater side of the dike area. Diking can be used in any industrial facility, but it is most commonly used for controlling large spills or releases from liquid storage areas and liquid transfer areas.

For single-wall tanks, containment dikes should be large enough to hold the contents of the storage tank for the facility plus rain water. For trucks, diked areas should be capable of holding an amount equal to the volume of the tank truck compartment.

Diked construction material should be strong enough to safely hold spilled materials. Dike materials can consist of earth, concrete, synthetic materials, metal, or other impervious materials. Strong acids or bases may react with metal containers, concrete, and some plastics. Where strong acids or bases are stored, alternative dike materials should be considered. More active organic chemicals may need certain special liners for dikes. Dikes may also be designed with impermeable materials to increase containment capabilities. Dikes should be inspected during or after significant storms or spills to check for washouts or overflows. Regular checks of containment dikes to insure the dikes are capable of holding spills should be conducted. Inability of a structure to retain stormwater, dike erosion, soggy areas or changes in vegetation indicates problems with dike structures. Damaged areas should be patched and stabilized immediately. Earthen dikes may require special maintenance of vegetation such as mulching and irrigation.

Curbing is a barrier that surrounds an area of concern. Curbing is similar to containment diking in the way that it prevents spills and leaks from being released into the environment. The curbing is usually small scaled and can not contain large spills like diking. Curbing is common at many facilities in small areas where handling and transferring liquid materials occur. Curbing can redirect contaminated stormwater away from the storage area. It is useful in areas where liquid materials are transferred from one container to another. Asphalt is a common material used for curbing; however, curbing materials include earth, concrete, synthetic materials, metal, or other impenetrable materials. Spilled materials should be removed immediately from curbed areas to allow space for future spills. Curbs should have manually-controlled pump systems rather than common drainage systems for collection of spilled materials. The curbed area should be inspected regularly to clear clogging debris. Maintenance should also be conducted frequently to prevent overflow of any spilled materials as curbed areas are designed only for smaller spills. Curbing has the following advantages:

- Excellent run-on control,
- Inexpensive,
- Ease of installment,
- Provides option to recycle materials spilled in curbed areas, and
- Common industry practice.

Primary References

California Storm Water Best Management Practice Handbooks, Industrial Handbook, CDM et.al. for the California SWQTF, 1993.

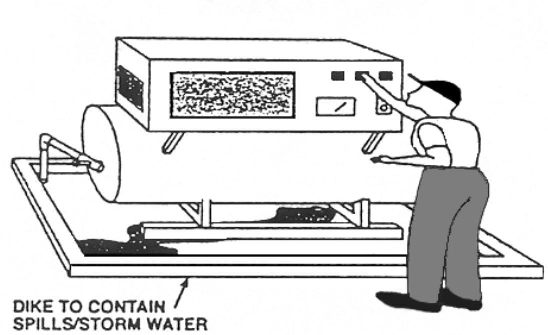
Subordinate References

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832-R-92-006, USEPA, 1992.

Water Quality Best Management Practices Manual, City of Seattle, 1989.

ACTIVITY: Outdoor Process Equipment Operations & Maintenance	ICP – 07



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

● Capital Costs	◗ O & M Costs	◗ Maintenance	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from outdoor process equipment operations and maintenance by reducing the amount of waste created, enclosing or covering all or some of the equipment, installing secondary containment, and training employees. This management practice is likely to create significant reductions in sediment, heavy metals, toxic materials, and oil and grease.

Approach

Outside process equipment operations can contaminate stormwater runoff. Activities, such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, landfills, waste piles, wastewater and solid waste treatment and disposal, and land application are process operations that use hazardous materials and that can lead to contamination of stormwater runoff. Pollutants from the wastewater and solid waste treatment and disposal areas result from waste pumping, additions of treatment chemicals, mixing, aeration, clarification, and solids dewatering.

- Alter the activity to prevent exposure of pollutants to stormwater.
- Move activity indoors.
- Cover the area with a permanent roof.
- Minimize contact of stormwater with outside manufacturing operations through berming and drainage routing (run-on prevention).
- Connect process equipment area to public sewer or facility wastewater treatment system.
- Clean regularly the stormwater system.
- Use catch basin filtration inserts (PTP-06: Media Filtration) as a means to capture particulate pollutants.

- Some municipalities require that secondary containment areas (regardless of size) be connected to the sanitary sewer, prohibiting any hard connections to the storm drain.
- The preferred (and possibly the most economical) action to reduce stormwater pollution is to alter the nature of activity such that pollutants are not exposed to stormwater. This may mean performing the activity during dry periods only or substituting benign materials for more toxic ones.
- Actions other than altering the activity include enclosing the activity in a building and connecting the floor drains to the sanitary sewer.
- The area used by the activity may be so great as to make enclosure prohibitively expensive. Building cost can be reduced by not covering the sides, and thus eliminating the need for ventilating and lighting systems.
- When certain parts of the activity are the worst source of pollutants, those parts can be segregated and enclosed or covered.
- Curbs can be placed around the immediate boundaries of the process equipment. The storm drains from these interior areas can be connected to the facility's process wastewater system.
- Reducing the amount of waste that is created and consequently the amount that must be stored or treated is another way to reduce the potential for stormwater contamination from outside manufacturing activities.

Treatment

If stormwater becomes polluted, used in a mechanical process, or as a cooling or cleaning solution, it should be captured and treated. If you do not have your own process wastewater treatment system, consider discharging to the public sewer system. Use of the public sewer might be allowed under the following conditions:

- It may be possible under unusual circumstances to connect a much larger area to the public sewer, as long as the rate of stormwater discharges do not exceed the capacity of the wastewater treatment plant. The stormwater could be stored during the storm and then transferred to the public sewer when the normal flow is low, such as at night.
- The majority of the pollutants in stormwater are discharged over time by the small, high frequency storms. Less polluted runoff from the infrequent large storms can be bypassed to the storm drain. To implement this BMP, a hydraulic evaluation of the downstream sewer system should occur in consultation with the local sewer authority.

Maintenance

- Routine preventive maintenance, including checking process equipment for leaks.

Limitations

- Providing cover may be expensive.

- Space limitations may preclude enclosing some equipment
- Storage sheds often must meet building and fire code requirements.

Additional Information

Possible stormwater contaminants from operation and maintenance described above include heavy metals, toxic materials, and oil and grease. Waste spilled, leaked, or lost from outdoor process equipment operations may build up in soils or on other surfaces and be carried away by stormwater runoff. There is also a potential for liquid waste from lagoons or surface impoundments, associated with outdoor equipment operations, to overflow to surface waters or soak the soil, which eventually can be picked up by stormwater runoff.

Industries that generate large volumes of process wastewater typically have their own treatment system that discharges directly to the nearest receiving water. These industries have the discretion to use their wastewater treatment system to treat stormwater within the constraints of their permit requirements for process treatment. It may also be possible for the industry to discharge the stormwater directly to its effluent outfall without treatment as long as the total loading or concentration of the discharged process water and stormwater does not exceed the loading or concentration had a stormwater treatment device been used. This could be achieved by reducing the loading from the process wastewater treatment system. Check with the local sewer authority, as this option would be subject to permit constraints and potentially regular monitoring.

Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

Subordinate References

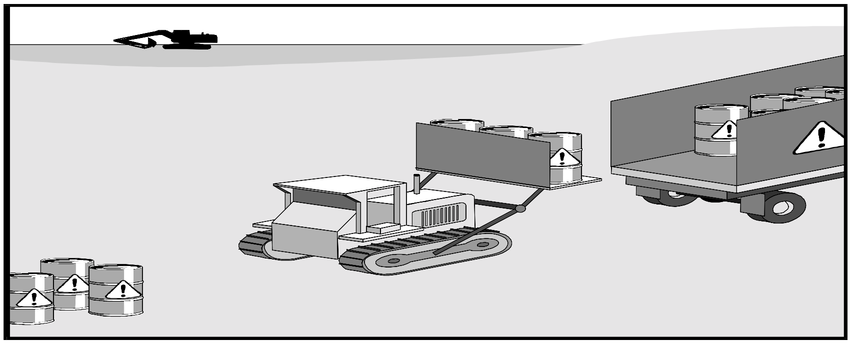
Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

Publications That Can Work For You!; California Department of Toxic Substances Control, Sacramento, CA, 1991 (A list and order form for waste minimization publications from the State).

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832-R-92-006, USEPA, 1992.

Water Quality Best Management Practices Manual, City of Seattle, 1989.

ACTIVITY: Waste Handling and Disposal	ICP – 08



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
○ Sediment	● Heavy Metals	● Floatable Materials	● Oxygen Demanding Substances	
○ Nutrients	● Toxic Materials	● Oil & Grease	● Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium		○ Low
○ Capital Costs	◗ O & M Costs	○ Maintenance	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from waste handling and disposal by tracking waste generation, storage, and disposal; reducing waste generation and disposal through source reduction, re-use, and recycling; and preventing run-on and runoff from waste management areas. This management practice is likely to create a significant reduction in heavy metals, toxic materials, floatable materials, oxygen demanding substances, oil and grease, bacteria and viruses.

Approach

Many of the approaches presented in BMPs CP-06: Spill Prevention and Control, CP-07: Solid Waste Management, CP-08: Hazardous Waste Management, ICP-05: Outdoor Loading/Unloading and Storage of Materials, and ICP-06: Outdoor Container Storage of Liquids are applicable to ICP-08: Waste Handling and Disposal.

- Maintain usage inventory to limit waste generation.

- SARA Title III, Section 313 requires reporting for over 300 listed chemicals and chemical compounds. This requirement should be used to track these chemicals although this is not as accurate a means of tracking as other approaches.

- Track waste generated:

  - Characterize waste stream.
  - Evaluate the process generating the waste.
  - Prioritize waste streams using: manifests, biennial reports, permits, environmental audits, SARA Title III reports, emission reports, NPDES monitoring reports.
  - Inventory reports.
  - Data on chemical spills.
  - Emissions.
  - Shelf life expiration.

- Use raw material and production data and review: composition sheets, materials safety data sheets (MSDS), batch sheets, product or raw material inventory records, production schedule, operator data log.
- To eliminate or substitute some raw materials to reduce waste generation.
- Use design data and review: process flow diagram, materials and applications diagram, piping and instructions, equipment list, plot plan.
- Modify the process or equipment to reduce waste generation or contain waste more safely there by limiting potential stormwater impacts.
- Production planning and sequencing to limit exposure of hazardous or other waste to rainfall during transfer or disposal.
- Recycle materials whenever possible.
- Maintain list of and the amounts of materials disposed. This is also required for all SARA Title II listed materials.
- Segregate and separate waste to facilitate recycling.
- Check industrial waste management areas for spills and leaks.
- Cover, enclose, or berm industrial wastewater management areas whenever possible to prevent contact with run-on or runoff.
- Equip waste transport vehicles with spill containment equipment.
- Minimize spills and fugitive losses such as dust or mist from loading systems.
- Ensure that sediments or wastes are prevented from being tracked off-site.
- Stencil storm drains on the facility’s property with prohibitive message regarding waste disposal limitations. Messages may include notice that the drain is a “separate storm sewer system” or that it goes to the facility pre-treatment plant.
- For a quick reference on disposal alternatives for specific wastes see Table ICP-12-1 presented in the Employee/Subcontractor Training BMP fact sheet.

Education

- Thoroughly train employees in proper handling and disposal of wastes at the site/facility. This should include periodic review of the material safety data sheets.
- 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.
- 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.

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.
- Use containment berms in fueling and maintenance areas and where the potential for spills is high.
- 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 chemical reactions, make recycling impossible, and complicate disposal.

Disposal Procedures

- Regularly schedule hazardous waste removal to minimize on-site storage.
- Arrange for regular waste collection before containers overflow.
- Use only reputable, licensed hazardous waste haulers.

- 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.
- Recycle any useful material such as used oil or water-based paint.

Maintenance

- None except for maintaining equipment for material tracking program and permanent oil/water separators.
- Foreman and/or construction supervisor should monitor on-site hazardous waste storage and disposal procedure.

Limitations

- Hazardous waste that cannot be re-used or recycled must be disposed of by a licensed hazardous waste hauler.
- 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.

Primary References

California Storm Water Best Management Practice Handbooks, Industrial Handbook, CDM et.al. for the California SWQTF, 1993.

Subordinate References

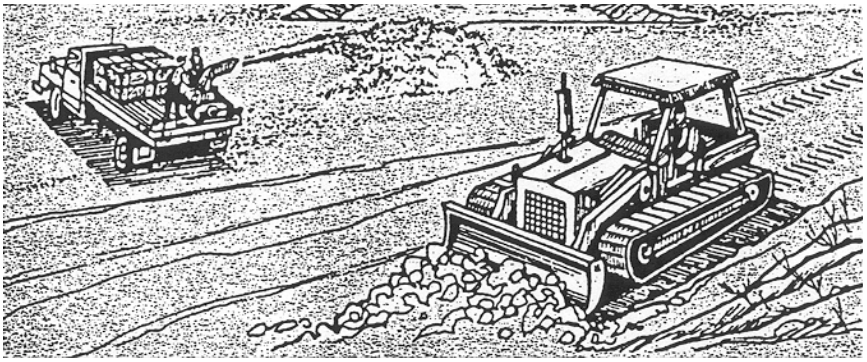
Publications That Can Work For You!; California Department of Toxic Substances Control, Sacramento, CA, 1991 (A list and order form for waste minimization publications from the State).

Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans, and Best Management Practices, EPA 832-R-92-006, USEPA, 1992.

Distribution List - Pollution Prevention Information Clearinghouse, USEPA, 1992.

ACTIVITY: Contaminated or Erodible Surface Areas

ICP – 09



Targeted Constituents			
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit	
● Sediment	● Heavy Metals	● Floatable Materials	● Oxygen Demanding Substances

● Nutrients	● Toxic Materials	● Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium	○ Low	
◗ Capital Costs	◗ O & M Costs	○ Maintenance	○ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from contaminated or erodible surface areas by leaving as much vegetation on-site as possible, minimizing soil exposure time, stabilizing exposed soils, and preventing stormwater run-on into or controlling/treating run-off from contaminated areas. This management practice is likely to create significant reductions in sediment, nutrients, heavy metals, toxic materials, floatable materials, oxygen demanding substances, and oil and grease.

Approach

- The most effective way to control erosion is to preserve existing vegetation. Preservation of natural vegetation provides a natural buffer zone and an opportunity for infiltration of stormwater and capture of pollutants in the soil matrix. By preserving stabilized areas, it minimizes erosion potential, protects water quality, and provides aesthetic benefits. This practice is used as a permanent control measure.

- Contaminated or erodible surface areas can be controlled by:

  - Removal of contaminated soils,
  - Preservation of natural vegetation,
  - Re-vegetation,
  - Chemical stabilization,
  - Geosynthetics, or
  - Run-on diversion and/or Runoff control/treatment with sediment cups/basins or dry/wt detention ponds.

- Vegetation preservation on-site should be planned before disturbing the site. Preservation requires good site management to minimize the impact of construction when construction is underway.

- Proper maintenance is important to ensure healthy vegetation that can control erosion. Maintenance should be performed regularly especially during construction phases.

- Different species, soil types, and climatic conditions will require different maintenance activities such as mulching, fertilizing, liming, irrigation, pruning and weed and pest control.

Advantages of preservation of natural vegetation are:

- Vegetated areas can handle higher quantities of stormwater runoff than newly seeded areas.
- Removal of contaminated soils is a last resort , unless regulated by TDEC, and quite expensive. The level and extent of the contamination must be determined. This determination and removal must comply with State and Federal regulations, permits must be acquired, and fees paid.
- For a quick reference on disposal alternatives for specific wastes see ICP-12-1 presented in the Employee/Subcontractor Training BMP fact sheet.

Maintenance

- Maintenance should be minimal, except possibly if irrigation of vegetation is necessary.

Limitations

- Except for preservation of natural vegetation, each of the above solutions can be quite expensive depending upon the size of the area.
- Requires some planning to preserve and maintain the existing vegetation.
- May not be cost-effective with high land or contaminated soil disposal costs.
- Poor soils may limit the success of re-vegetated areas.
- Disadvantages of chemical stabilization include:
  - Creation of impervious surfaces.
  - May reduce erosion but cause different harmful effects on stormwater quality.
  - Is usually more expensive than vegetative cover.

Suitable Applications

This BMP addresses soils which are not so contaminated as to exceed criteria requiring a permit from the Tennessee Department of Environment and Conservation (TDEC), but the soil is eroding or carrying pollutants off in the stormwater. Much of the information presented in CP-09: Contaminated Soil Management can also be applied to this practice.

Of interest here are areas within the industrial site that are bare of vegetation and therefore subject to erosion. They may or may not be contaminated from past or current activities. Activity may or may not be occurring in the area of interest.

Contaminated or erodible surfaces can result from the human activities such as vegetation removal, compacting or disturbing soil, and changing natural drainage patterns. Industries must identify the areas of contaminated or erodible surfaces. The areas may include:

- Heavy activity where plants cannot grow.
- Soil stockpiles.
- Steep slopes.
- Construction areas.
- Demolition areas.

Any area where soil is disturbed.

Additional Information

- Natural vegetation increases the filtering capacity because surface growth and root systems are usually dense in preserved natural vegetation.
- It provides areas for infiltration and “rougher” flow paths, thus reducing the quantity and velocity of stormwater runoff.
- It allows areas where wildlife can remain undisturbed or stressed.
- Tall and dense vegetation can provide noise buffers and screens for on-site operations/processes.
- It usually requires less maintenance than planting new vegetation.
- Geosynthetics include those materials that are designed as an impermeable barrier to contain or control large amounts of liquid or solid matter. Some geosynthetics have been developed primarily for use in landfills and surface impoundments, and the technology is well established. There are two general types of geosynthetics: geomembranes (impermeable) and geotextiles (permeable).
  - Geomembranes are composed of one of three types of impermeable materials: elastomers (rubbers), thermoplastics (plastics), or a combination of these two types of materials. The advantages of these materials include: 1) the variety of compounds available, 2) sheeting is produced in a factory environment, 3) polymeric membranes are flexible, and 4) simple installation. The disadvantages include: 1) chemical resistance must be determined for each application, 2) seaming systems may be a weak link in the system, and 3) many materials are subject to attack from biotic, mechanical, or environmental sources.
  - Geotextiles are uncoated synthetic textile products that are not watertight. They are composed of a variety of materials, most commonly polypropylene and polyester. Geotextiles serve five basic functions: 1) filtration, 2) drainage, 3) separation, 4) reinforcement, and 5) armoring.

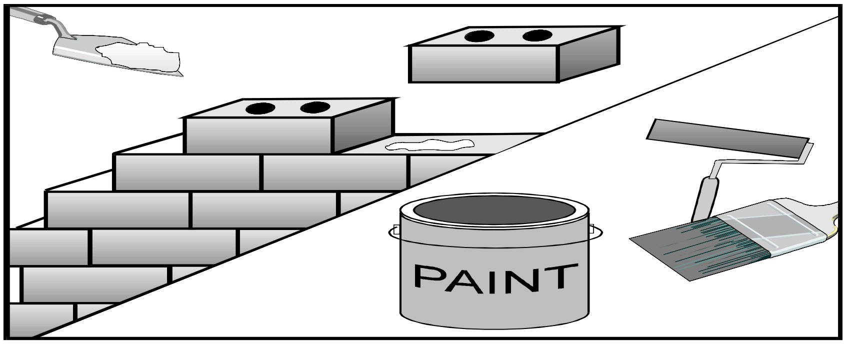
Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor’s Guide and Specifications, April 1997.

Subordinate References

Covers for Uncontrolled Hazardous Waste Sites, USEPA, EPA/540/2-85/002, PB87-119483, 1985.

ACTIVITY: Building and Grounds Construction and Maintenance	ICP – 10



Targeted Constituents			
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit	
● Sediment	● Heavy Metals	● Floatable Materials	● Oxygen Demanding Substances

● Nutrients	● Toxic Materials	● Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements			
● High	◗ Medium	○ Low	
○ Capital Costs	◗ O & M Costs	◗ Maintenance	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater from buildings and grounds construction and maintenance by using soil erosion controls, enclosing or covering building material storage areas, using good housekeeping practices, using safer alternative products, training employees, washing and cleaning up with as little water as possible, preventing and cleaning up spills immediately, keeping debris from entering the storm drains, and maintaining the stormwater collection system. This management practice is likely to create a significant reduction in sediment, nutrients, heavy metals, toxic materials, floatable materials, oxygen demanding substances, and oil and grease.

Approach

Modifications are a common occurrence particularly at large industrial sites. The activity may vary from landscaping maintenance to minor and normal building repair to major remodeling, or the installation of new facilities on currently open space. These activities can generate pollutants that can reach stormwater if proper care is not taken. The sources of these contaminants may be pesticides, herbicides, fertilizers, solvents, paints, and varnish removers, finishing residues, spent thinners, soap cleaners, kerosene, asphalt and concrete materials, adhesive residues, and old asbestos installation.

- Leaving or planting native vegetation to reduce water, fertilizer, and pesticide needs.
- Careful use of pesticides and fertilizers in landscaping.
- Integrated pest management where appropriate.
- Sweeping of paved surfaces.
- Cleaning of the stormwater system at appropriate intervals.

- Proper disposal of wash water, sweepings, and sediments.
- Remove debris in a timely fashion to keep the work site clean and orderly.
- Collect and properly dispose of roofing debris prior to rainfall and upon completion of work to prevent entry of debris and materials into gutter downspouts.
- Inform employees and subcontractors of acceptable housekeeping, disposal and other stormwater management practices and include appropriate provisions in subcontracts to make certain proper housekeeping disposal and other stormwater management practices are implemented.
- Do not remove original product labels, they contain important safety and disposal information.
- Make Material Safety Data Sheets (MSDSs) available to all employees and review in periodic safety training.
- Use soil erosion control techniques if bare ground is temporarily exposed. See the Temporary Construction Site Management Practice (TCP) and Contractor Management Practices (CP) sections of this manual.
- Use permanent soil erosion control techniques if the remodeling clears buildings from an area that is not to be replaced. See the Permanent Erosion and Sediment Control Management Practices (PESC) section of this manual.
- Enclose painting operations, consistent with local air quality regulations and OSHA.
- Properly store materials that are normally used in repair and remodeling such as paints and solvents.
- Properly store and dispose waste materials generated from the activity. ICP-8: Waste Handling and Disposal BMP fact sheet.
- Mix paint indoors, or in a containment area.
- Use all the product before disposing of the container.
- For water-based paints, paint out brushes to the extent practical, and rinse to a drain leading to a sanitary sewer where permitted, or into a concrete washout pit or temporary sediment trap.
- 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.
- For a quick reference on disposal alternatives for specific wastes see Table ICP-12-

1 presented in Employee/Subcontractor Training BMP fact sheet. Dispose of any paint, thinners, residue, and sludges that cannot be recycled as hazardous waste.

- 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.

- Recycle residual paints, solvents, lumber, and other materials to the maximum extent practical. Buy recycled products to the maximum extent practical.

Requirements

- Costs (Capital, O&M)
  - Cost will vary depending on the type and size of facility.
  - Overall costs should be low in comparison to structural BMPs.

Maintenance

- The BMPs themselves relate to training, maintenance and construction activities that do not require maintenance as they do not involve structures. However, regular inspection and refresher training is warranted.

- Spot check employees and subcontractors at least monthly throughout the job to ensure appropriate practices are being employed.

Limitations

- Alternative pest/weed controls may not be available, suitable, or effective in every case.

- Safer alternative building and construction products may not be available or suitable in every instance.

- This BMP is for minor construction only.

- Hazardous waste that cannot be re-used or recycled must be disposed of by a licensed hazardous waste hauler.

- Be certain that actions to help stormwater quality are consistent with TDEC and Fed-OSHA and air quality regulations.

Additional Information

Pesticide/Fertilizer Management

Landscape maintenance involves the use of pesticides and fertilizers. Proper use of these materials will reduce the risk of loss to stormwater. In particular, do not apply these materials during rain as they may be carried from the site by the runoff. When irrigating the landscaped areas, avoid over-watering not only to conserve water but to avoid the discharge of water, which may have become contaminated with excess nutrients and pesticides.

It is important to properly store pesticides and application equipment, and to dispose the used containers in a responsible manner, consistent with TDEC regulations. Personnel who use pesticides should be trained in their use.

Written procedures for the use of pesticides and fertilizers relevant to your facility would help maintenance staff understand the “do’s” and don’ts”. If you have large vegetated areas, consider the use of integrated pest management (IPM) techniques to reduce the use of pesticides.

Good Housekeeping

Proper care involves a variety of mostly common sense, housekeeping actions such as:

- Keep the work site clean and orderly. Removing debris in a timely fashion. Sweep the area.
- Cover materials of particular concern that must be left outside.
- Educate employees who are doing the work about the importance of keeping pollutants out of the stormwater system including review of the Spill Prevention, Control and Countermeasures (SPCC) Plan.
- Inform on-site contractors of company policy on these matters and include appropriate provisions in their contract to make certain proper housekeeping and disposal practices are implemented.
- Make sure that nearby storm drains are well marked to minimize the chance of inadvertent disposal of residual paints and other liquids.
- Advise concrete truck drivers to not wash their truck over the storm drain. Have a designated area that does not drain to the storm drain. See CP-10: Concrete Waste Management.
- Clean the storm drain system in the immediate vicinity after the construction activity is completed.

Proper education of off-site contractors is often overlooked. The conscientious efforts of well trained employees can be lost by unknowing off-site contractors, so make sure they are well informed about what they are expected to do. See ICP-12: Employee/ Subcontractor Training.

Painting operations should be properly enclosed or covered to avoid drift. Use temporary scaffolding to hang drop cloths or draperies to prevent drift. Application equipment that minimizes overspray also helps. Air pollution regulations may, specify painting procedures which if properly carried out are usually sufficient to protect water quality. If painting requires scraping or sand blasting of the existing surface, use a ground cloth to collect the chips. Dispose the residue properly. If the paint contains lead or tributyl tin, it is considered a hazardous waste.

Mix paint indoors before using so that any spill will not be exposed to rain. Do so even during dry weather because cleanup of a spill will never be 100% effective. Dried paint will erode from a surface and be washed away by storms. If using water based paints, clean the application equipment in a sink that is connected to the sanitary sewer. Properly store leftover paints if they are to be kept for the next job, or dispose properly.

When using sealants on wood, pavement, roofs, etc. quickly clean up spills. Remove excess liquid with absorbent material or rags. If when repairing roofs, small particles have accumulated in the gutter, either sweep out the gutter or wash the gutter and trap the particles at the outlet of the downspout. A sock or geofabric placed over the outlet may effectively trap the materials. If the downspout is tight lined, place a temporary plug at the first convenient point in the storm drain and pump out the water with a vacuum truck, and clean the catch basin sump where you placed the plug.

Parking/Storm Sewer Maintenance

A parking area that drains to the same stormwater system as the industrial activity that is to be permitted must also be evaluated for suitable BMPs. Stormwater from parking lots may contain undesirable concentrations of oil, grease, suspended particulates, and metals such as copper, lead, cadmium, and zinc, as well as the petroleum byproducts of engine combustion. Deposition of air particulates, generated by the facility or by adjacent industries, may contribute significant amounts of pollutants.

The two most appropriate maintenance BMPs are periodic sweeping and cleaning catch basins if they are part of the stormwater system. A vacuum sweeper is the best method of sweeping, rather than mechanical brush sweeping which is not as effective at removing the fine particulates.

Catch basins in parking lots generally need to be cleaned every 6 to 12 months, or whenever the sump is half full. A sump that is more than half full is not effective at removing additional particulate pollutants from the stormwater. If the storm drain lines have a low gradient, less than about 0.5 feet in elevation drop per 100 feet of line, it is likely that material is settling in the lines during the small, frequent storms. If you have not cleaned the storm drain system for some time, check the lines as well. If they are not cleaned, the catch basins will likely be filled during the next significant storm by material that is washed from the lines. Also, install skimmers, “turn-down” elbows or similar devices on the outlets of the catch basins; they serve to retain floatables, oil and grease.

Clearly mark the storm drain inlets, either with a color code (to distinguish from pretreatment-process water inlets if you have them) or with the painted stencil. This will minimize inadvertent dumping of liquid wastes.

Sweepings and sediments from these maintenance activities are generally low in metals and other pollutants and therefore can be disposed on-site or to a construction debris landfill. Test the material if there is a reasonable doubt whether metals or other pollutants are present. If concentrations of contaminants are high, it indicates that other BMPs may be needed to eliminate or reduce emissions from the source. If a vactor truck is used to clean the storm drainage system, dirty water will be generated. This water should not be discharged to the storm drainage system as it is silt laden and contains much of the pollutants that were removed by the catch basins. The water should be disposed to the process wastewater system, if you have one, or to the public sewer if permission is granted by the local sewer authority. Alternatively, the water can be placed somewhere on the site where it can evaporate such as a sediment trap or basin.

If some employees have cars that are leaking abnormal amounts of engine fluids, encourage them to have the problem corrected.

Older Buildings and Sewers

If a building is to be placed over an open area with a storm drainage system, make sure that storm inlets within the building are covered or removed, or the storm line is connected to the sanitary sewer. If because of the remodeling a new drainage system is to be installed or the existing system is to be modified, consider installing catch basins as they serve as effective "in-line" treatment devices. Include in the catch basin a "turn-down" elbow or similar device to trap floatables.

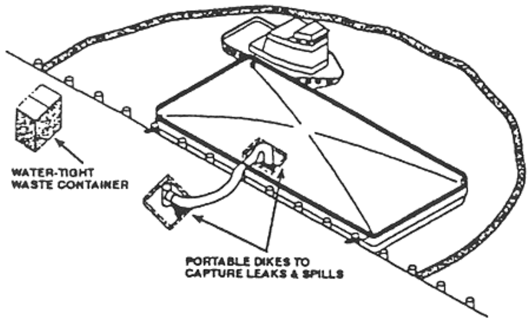
Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

Subordinate References

Best Management Practices for Industrial Storm Water Pollution Control, Santa Clara Valley Nonpoint Source Pollution Control Program, 1992.

ACTIVITY: Over-Water Activities	ICP – 11



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	◗ O & M Costs	◗ Maintenance	◗ Training

Description

Prevent or reduce the discharge of pollutants to stormwater and receiving waters from over-water activities by minimizing over-water maintenance, keeping wastes out of the water, cleaning up spills and wastes immediately, and educating tenants and employees. This management practice is likely to create a significant reduction in heavy metals, toxic materials, floatable materials, oil and grease, oxygen demanding substances, and bacteria and viruses.

Suitable Applications

Over-water activities occur at boat and ship repair yards, marinas, and yacht clubs, although the latter are not required to obtain a permit. Activities of concern include chipping and painting of hulls, on board maintenance of engines, and the disposal of domestic wastewater and ballast water. With few exceptions, BMPs to protect water quality are common sense, low cost changes to normal day-to-day procedures.

Approach

- Properly dispose of domestic wastewater and ballast water.
- Limit over-water hull surface maintenance to sanding and minor painting.
- Use phosphate-free and biodegradable detergents for hull washing.
- Use secondary containment on paint cans.
- Have available spill containment and cleanup materials.
- Use ground cloths when painting boats on land.
- Use tarps, plastic sheeting, etc. to contain spray paint and blasting sand.
- Properly dispose of surface chips, used blasting sand, residual paints, and other materials. Use temporary storage containment that is not exposed to rain.

- Immediately clean up spills on docks or boats.
- Sweep drydocks before flooding.
- Clean catch basins and the storm drains at regular intervals.
- Post signs to indicate proper use and disposal of residual paints, rags, used oil, and other engine fluids.
- Educate tenants and employees on spill prevention and cleanup including review of the Spill Prevention, Control and Countermeasures (SPCC) Plan.
- Include appropriate language in tenant contracts indicating their responsibilities to guard against spills, properly dispose solid, liquid and hazardous waste, and limit practices that may pollute stormwater.
- Marinas should provide wastewater disposal facilities.

Over-Water Activity Minimization

Work on boats in the water should be kept to a minimum. Major hull resurfacing should occur on land. Surface preparation over water should be limited to sanding. Painting should be limited to spot work. In marinas, tenant maintenance over water should be such as to not require opening more than a pint size paint can. Paint mixing should not occur on the dock.

Good Housekeeping

When conducting on board maintenance, used antifreeze should be stored in a separate, labeled drum and recycled. Fuel tank vents should have valves to prevent fuel overflows or spills. Boats with inboard engines should have oil absorption pads in bilge areas and should be changed when no longer useful or at least once a year.

Marina owners should provide temporary storage stations for used engine fluids, paint cans, and other maintenance materials. Signs should be posted at the head of each dock indicating maintenance rules. Marina owners should install a wastewater disposal system, either dockside lines or a pumpout station.

When painting on shore, place paint cans in a tray or comparable device that collects spills and drips. Use spray guns that minimize overspray; also enclose the area with plastic tarps. Identify a designated area for washing boats. Vacuum sweep work areas frequently.

Large boat repair yards can implement the above BMPs. There are several additional measures. With regard to dry dock operations: sweep the accessible areas of the dry dock before flooding; and pick up other debris that appears after the ship is floated. Remove floatable debris such as wood. Shipboard cooling and process water discharges should be directed to minimize contact with spent abrasives, paints, and other debris. Look for and repair leaking valves, pipes, hoses, or soil shutes carrying either water or wastewater. Plastic sheeting or other suitable materials should be installed when sandblasting and spray painting.

Use drip pans or comparable devices when transferring oils, solvents, and paints. Regularly clean the shoreside work areas of debris, sandblasting material, etc. Clean catch basins or other parts of the stormwater system that might accumulate these materials.

Fish Wastes

Fish wastes must also be managed properly. Recycling fish wastes back to the water is encouraged when disposal will not result in water quality or public nuisance problems, such as wastes washing up onshore or causing odors or bacteria problems. Fish wastes should not be recycled in any dead end lagoons or other poorly flushed areas. Marina owners should provide fish cleaning stations where waste recycling can occur without adversely affecting water quality.

Maintenance

- Keep ample supply of spill cleanup materials on hand and conspicuously marked.

Limitations

- Private tenants at marinas may resist restrictions on shipboard painting and maintenance.
- Existing contracts with tenants may not allow the owner to require that tenants abide by new rules that benefit water quality.
- Even biodegradable cleaning agents have been found to be toxic to fish, therefore they should only be disposed of through the sanitary sewer.

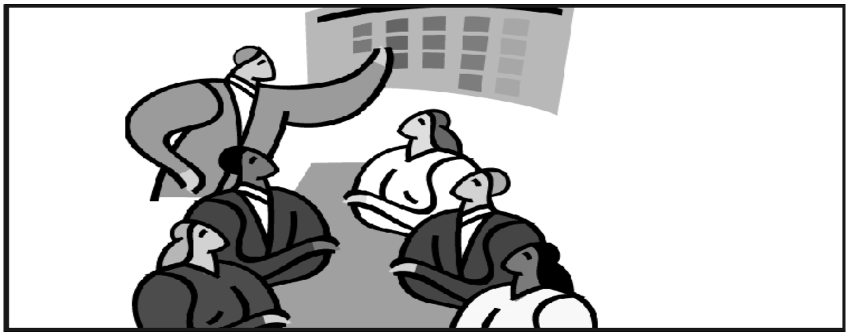
Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

Subordinate References

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, USEPA, 1992.

General NPDES Permit for Discharges of Storm Water from Boat Repair Facilities, SFBRWQCB, 1992.



Description

Employee/subcontractor training, like maintenance or a piece of equipment, is not so much a best management practice as it is a method by which to implement BMPs. This fact sheet highlights the importance of training and of integrating the elements of employee/subcontractor training from the individual source controls into a comprehensive training program as part of a company's Storm Water Pollution Prevention Plan (SWPPP).

The specific employee/subcontractor training aspects of each of the source controls are highlighted in the individual fact sheets. The focus of this fact sheet is more general, and includes the overall objectives and approach for assuring employee/subcontractor training in stormwater pollution prevention. Accordingly, the organization of this fact sheet differs somewhat from the other fact sheets in this section.

Objectives

Employee/subcontractor training should be based on five objectives:

- Promote a clear identification and understanding of the problem, including facility/plant specific activities with the potential to drain to the stormwater and/or facility/plant pretreatment system;
- Identify locations with higher potential for spills and leaks;
- 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).
- Identify locations with higher potential for spills and leaks. This should include indoor and outdoor unloading/board and storage of materials, plant/facility processes, and disposal of solid, liquid, and hazardous wastes. Examples of leaks or spills at the site or facilities/plants of similar type should be discussed to review

controllable and uncontrollable processes that lead to the spill or leak, actions that were taken by staff and actions that should have been taken by staff. Various similar case studies should be incorporated into regular periodic safety training.

- Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, may use the information in this Handbook to develop a training program to reduce their potential to pollute stormwater.
- Use the quick reference on disposal alternatives (Table ICP-12-1) 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, herbicides, fertilizers, etc. 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.

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

TABLE ICP-12-1 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 (Metro Nashville-Davidson County-sponsored drop-off site at 941 Dr. Richard Adams Drive)
- POTW — Publicly Owned Treatment Plant – Metro Water Services (MWS)
- MDPW-NPDES — Metropolitan Department of Public Works (DPW) – 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	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).		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
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	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. Note: Thoroughly sweep following removal of dirt in all four alternatives.		
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.
Rinsewater 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.		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
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 nonhazardous 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 mopwater to sanitary sewer (or collect rinsewater and pump to the sanitary sewer). 3. Same as 2 above, but with rinsewater (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 mopwater 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 rags or adsorbents. b. Sweep (Use dry absorbent as needed). c. Use 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 rinsewater as product. Dispose rinsed containers as trash. 2. Dispose unused pesticide as hazardous waste.		1. Use up. Rinse containers, use rinsewater 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	
Rinsewater 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 mopwater 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 products, 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 if necessary; discharge to sanitary sewer. 3. Treat and discharge to storm drain.	MDPW-NPDES POTW-MWS MDPW-NPDES	
Fire fighting flows	If contamination is present, Fire Dept. will attempt to prevent flow to stream or 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 rinsewater may flow to storm drain).		

TABLE ICP-12-1 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:
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"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	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).		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
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	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. Note: Thoroughly sweep following removal of dirt in all four alternatives.		
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.
Rinsewater 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.		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
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 nonhazardous 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 mopwater to sanitary sewer (or collect rinsewater and pump to the sanitary sewer). 3. Same as 2 above, but with rinsewater (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 mopwater 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 rags or adsorbents. b. Sweep (Use dry absorbent as needed). c. Use 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 rinsewater as product. Dispose rinsed containers as trash. 2. Dispose unused pesticide as hazardous waste.		1. Use up. Rinse containers, use rinsewater 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	BUSINESS/COMMERCIAL 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	
Rinsewater 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 mopwater 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 products, 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 if necessary; discharge to sanitary sewer. 3. Treat and discharge to storm drain.	MDPW-NPDES POTW-MWS MDPW-NPDES	
Fire fighting flows	If contamination is present, Fire Dept. will attempt to prevent flow to stream or 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 rinsewater may flow to storm drain).		

SECTION 5
PERMANENT EROSION PREVENTION AND SEDIMENT CONTROL
(PESC)

Section 5
PERMANENT EROSION PREVENTION AND SEDIMENT CONTROL (PESC)

5.1 Introduction

This section presents the BMP fact sheets for Permanent Erosion Prevention and Sediment Control (PESC). PESCs focus on practices for Erosion Prevention and Sediment Control (EP&SC).

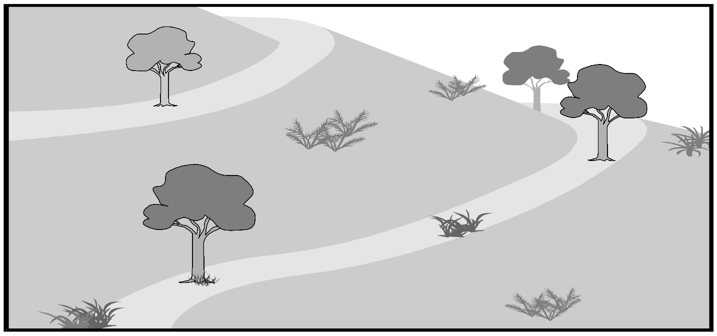
This section contains the following BMP fact sheets.

PESC – 01	Permanent Grass, Vines and Other Vegetation
PESC – 02	Geotextiles
PESC – 03	Buffer Zones
PESC – 04	Soil Bioengineering and Bank Stabilization
PESC – 05	Gradient Terraces and Slope Roughening
PESC – 06	Flow Diversions, Drains and Swales
PESC – 07	Outlet Protection
PESC – 08	Channel Linings

Each fact sheet has a quick reference guide indicating what pollutant constituents the BMP is targeting and implementation requirements.

The BMPs presented in this section are intended to serve as permanent measures. Additional details are provided in sections covering Temporary Construction Site Management Practices (TCPs) for practices that are intended to function on a short-term basis (lasting only as long as construction activities) and Permanent Treatment Practices (PTP) for practices that are intended to function on a long-term basis.

ACTIVITY: Permanent Grass, Vines and Other Vegetation	PESC – 01



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
◗ Nutrients	◗ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
○ Capital Costs	○ O & M Costs	○ Maintenance	● Suitability for Slopes >5%	○ Training

Description

Seeding of grasses and plantings of trees, shrubs, vines and ground covers provide long-term stabilization of soil. The primary function of permanent seeding and planting is to: improve long-term aesthetics, reduce erosion by slowing runoff velocities, enhance infiltration and transpiration, trap sediment and other particulates, protect soil from raindrop impact, and provide habitat for wildlife. This management practice is likely to create a significant reduction in sediment as well as partial reductions in the impacts caused by nutrients and toxic materials.

Suitable Applications

- Appropriate 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 most storm conditions.

Installation/ Application Criteria

These systems should be designed by a licensed professional civil engineer. Many of the measures presented in TCP-05: Temporary Seeding, TCP-09: Nets and Mats, and TCP-10: Geotextiles are applicable for establishing, stabilizing and maintaining permanent vegetation.

Application of appropriate vegetation must consider: the seedbed or plantbed, 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.

- 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 soilbed 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.

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.

The sites for new plantings should be evaluated. Consider the prior use of the land: adverse soil conditions such as poor drainage or acidity; exposure to wind; temperature extremes; location of utilities; paved areas, and security lighting and traffic problems.

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.).
- 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 varietal 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 rototilled 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 ⅓ 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 ⅓ 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.

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 is 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 CP-16: Pesticides, Herbicides and Fertilizer Use.

Limitations

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.

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.

Subordinate References

Best Management Practices and Erosion Control Manual for Construction Sites, Flood Control District of Maricopa County, September 1992.

"Draft-Sedimentation and Erosion Control, An Inventory of Current Practices", U.S.E.P.A., April, 1990.

Guides for Erosion and Sediment Controls in California, USDA Soils Conservation Service – January 1991.

Kiowa Engineering, Interim Erosion and Sedimentation Control for Construction Activities, Urban Drainage and Flood Control District, Denver, Colorado.

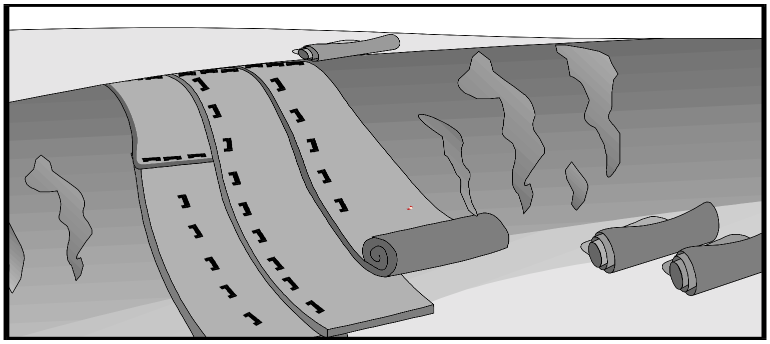
Manual of Standards of Erosion and Sediment Control Measures, Association of Bay Area Governments, June 1981.

Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Work Group Working Paper, USEPA, April, 1992.

Stormwater Management Water for the Puget Sound Basin, Washington State Department of Ecology, The Technical Manual – February 1992, Publication #91-75.

Water Quality management Plan for the Lake Tahoe Region, Volume II, Handbook of Management Practices, Tahoe Regional Planning Agency – November 1988.

ACTIVITY: Geotextiles	PESC – 02



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
● Capital Costs	◗ O & M Costs	◗ Maintenance	● Suitability for Slopes >5%	○ Training

Description

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. This will be accomplished by stabilizing soil utilizing 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, generally steeper than 3:1 (H:V).
- Slopes where the 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 (3 m/s).

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

Application Criteria

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

Refer to TCP-10: Geotextiles for discussion of material selection, site preparation, seeding, anchoring, installation on slopes, installation in channels, soil filling, and fiber roles. Figures PESC-02-01 through 3 have 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 effected 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.

Limitations

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).

Primary References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

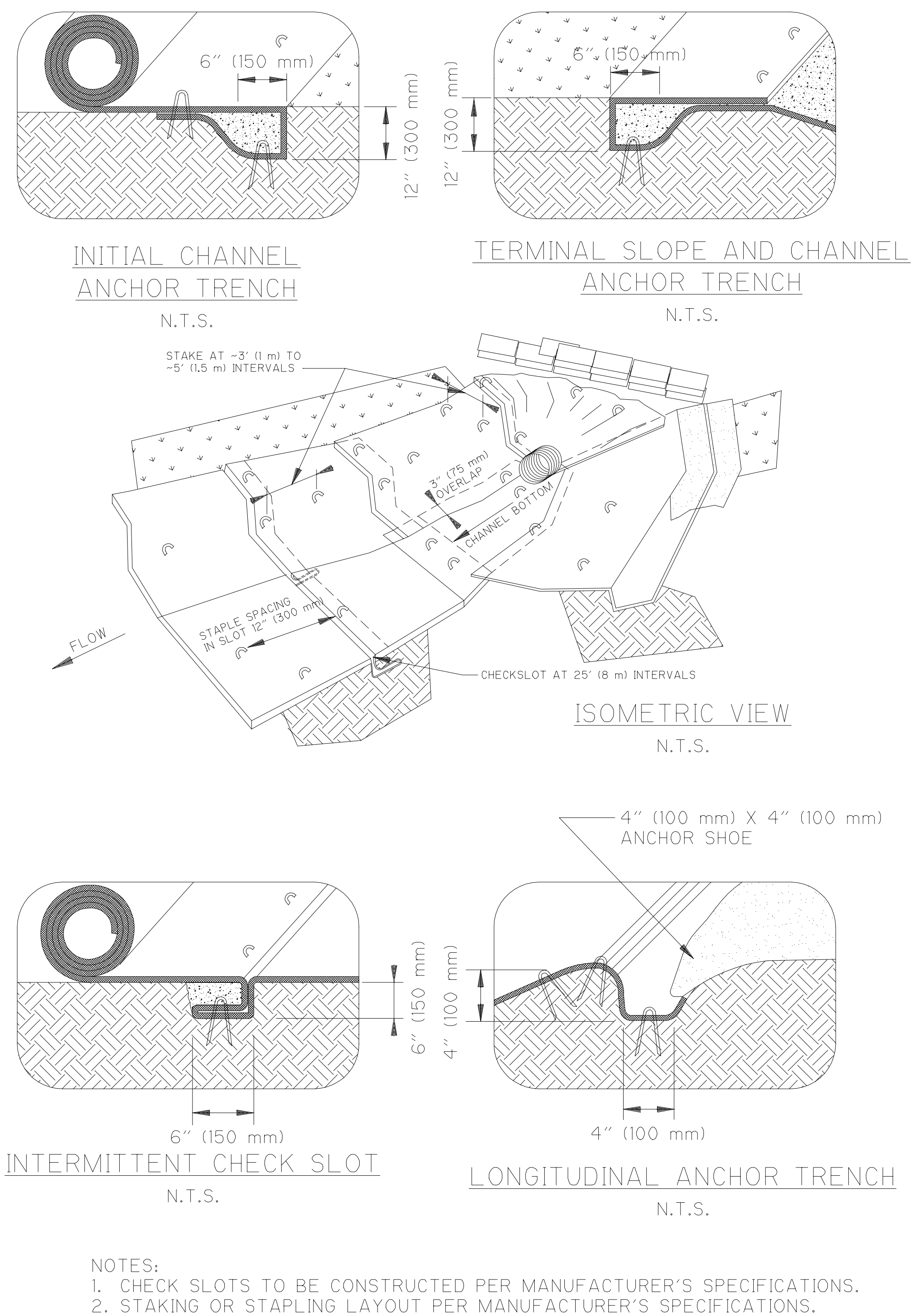
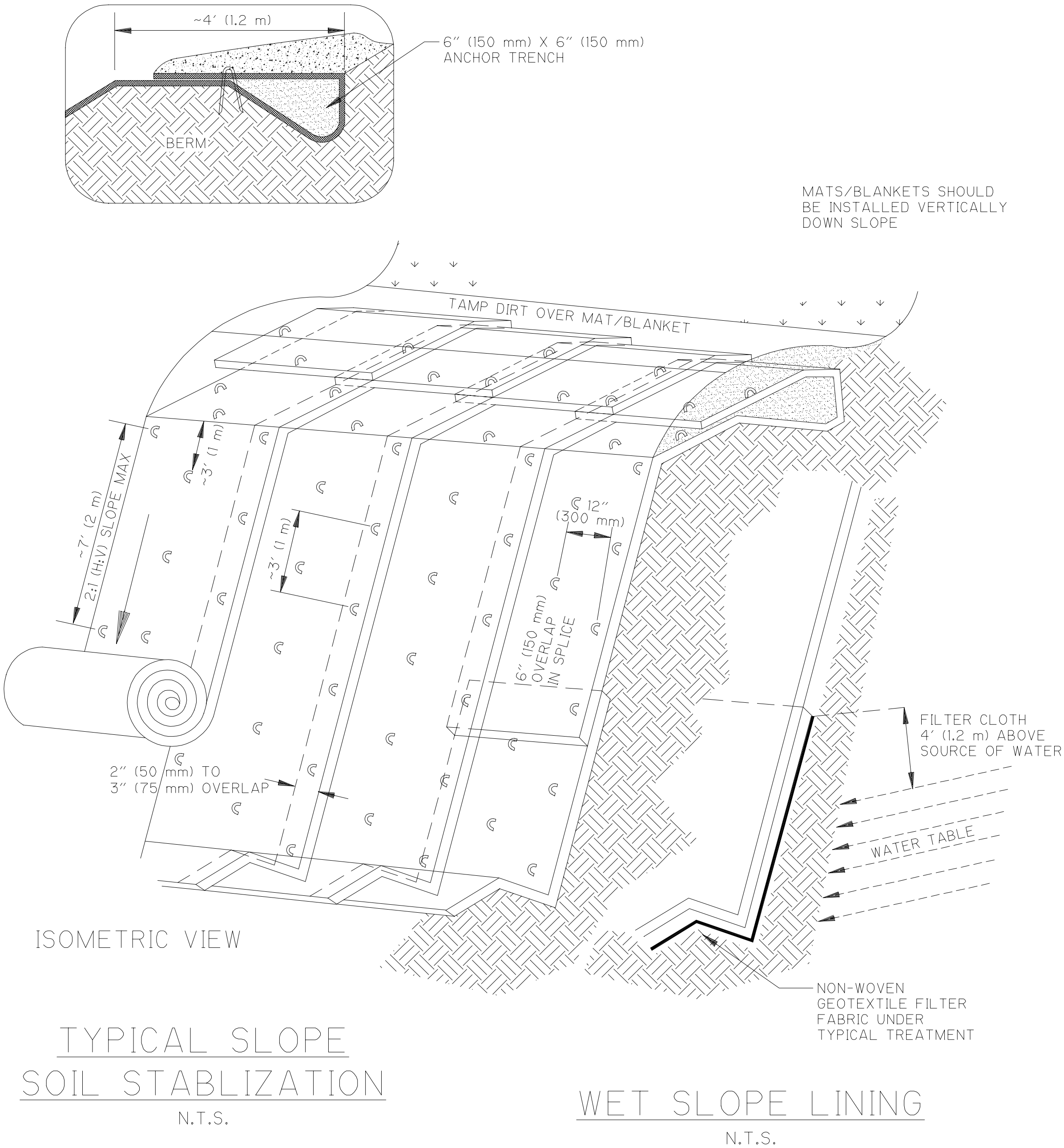
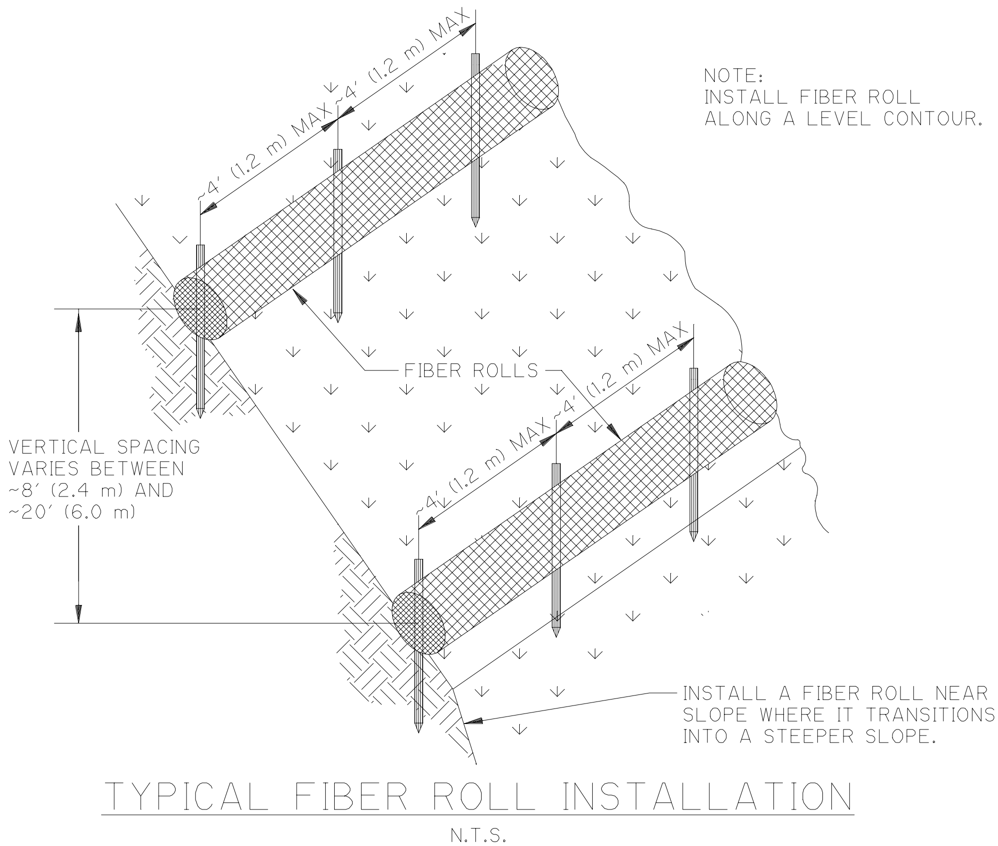


Figure PESC-02-1
Anchoring Geotextiles in Channels



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 PESC-02-2
Anchoring Geotextiles on Embankments



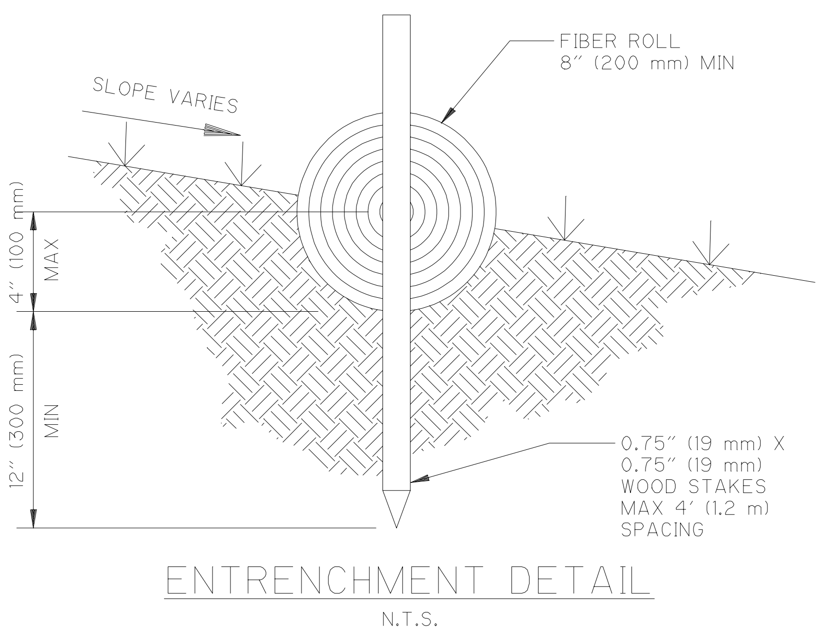
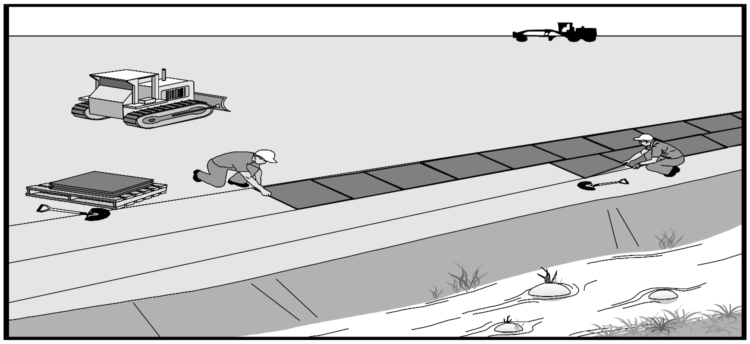


Figure PESC-02-3
Fiber Rolls

ACTIVITY: Buffer Zones

PESC – 03



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

● Sediment	◗ Heavy Metals	◗ Floatable Materials	◗ Oxygen Demanding Substances

◗ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of pollutants to the storm drain system or to watercourses as a result of construction activity by utilizing vegetation to protect soils from erosion and to slow the velocity of runoff to allow the removal of sediment and other pollutants through filtering and settling. This management practice is likely to create a significant reduction in sediment as well as partial reductions in the impacts due to nutrients, heavy metals, toxic materials, floatable materials, oxygen demanding substances, and oil and grease.

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.

Installation/ Application Criteria

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

Many of the measures presented in TCP-04: Buffer Zones and TCP-23: 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.

Additional Information

- Sodding and plugging is the placement of permanent grass cover that has been grown elsewhere and brought to the site. Sodding stabilizes an area by immediately covering the soil surface with grass, thereby protecting the soil from erosion, enhancing infiltration, filtering sediment and other pollutants, and slowing runoff velocities.

- 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.

Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

ACTIVITY: Soil Bioengineering and Bank Stabilization | PESC – 04

Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	◗ Floatable Materials	○ Oxygen Demanding Substances	
◗ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of sediment to the storm drain system or to watercourses by providing slope stabilization, protection and erosion reduction through the use of woody vegetative structures alone or in combination with simple retaining structures. This management practice is likely to create a significant reduction in sediment as well as a partial reduction in nutrients and floatable materials. Many of the measures presented in TCP-19: 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/ Application Criteria

- 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.
- 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 temporary erosion and sediment control practices (TCP).

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 feet (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).
  - See PESC-04-1 and 6.

- Live facine-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.
  - Cuttings tied together to form live fascine bundles vary in length from 5 to 30 feet (1.6 to 9.4 m) or longer, depending on site conditions and limitations in handling.
  - The completed bundles should be 6 to 8 inches (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 feet (0.8 m) long in cut slopes and 3 feet (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-inch (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 inches (30.5 to 45.7 cm), depending on the angle of the slope to be treated. The depth will be 6 to 8 inches (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 feet (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 downslope 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 inches (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 PESC-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 PESC-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.

Table PESC-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)

- Brushlayering – 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 inches (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 feet (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 feet (0.94 to 1.57 m) apart, depending upon the slope angle and stability (Table PESC-04-2).

Table PESC-04-2
Brushlayer Installation Guidelines

Slope (H:V)	Slope distance between benches Wet slopes (ft)	Dry slopes (ft)	Maximum slope 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)

- 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 inch 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 trench and extend slightly from the rebuilt slope face.
  - Wooden stakes should be 5 to 8 feet (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 feet (0.94 to 1.26 m) into the ground. Set them 1 to 1 ½ feet (0.31 to 0.47 m) apart.
  - A layer of living branches 4 to 6 inches (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 PESC-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 feet (0.63 m) wide, 1 foot deep (0.31 m), and 15 feet (4.71 m) long.
- Live branch cuttings may range from ½ inch 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-inch (7.6- to 10.2-cm) layer of branches at lowest end of the rill or gully and perpendicular to the slope (Figure PESC-04-3).
- Cover with a 6- to 8- inch (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.
- 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 PESC-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.
  - 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 PESC-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 PESC-04-6).

Limitations

- 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.

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.

Primary References

Engineering Field Handbook, Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction, Soil Conservation Service, October 1992.

Subordinate References

California Storm Water Best Management Practice Handbooks, Construction Handbook, CDM et.al. for the California SWQTF, 1993.

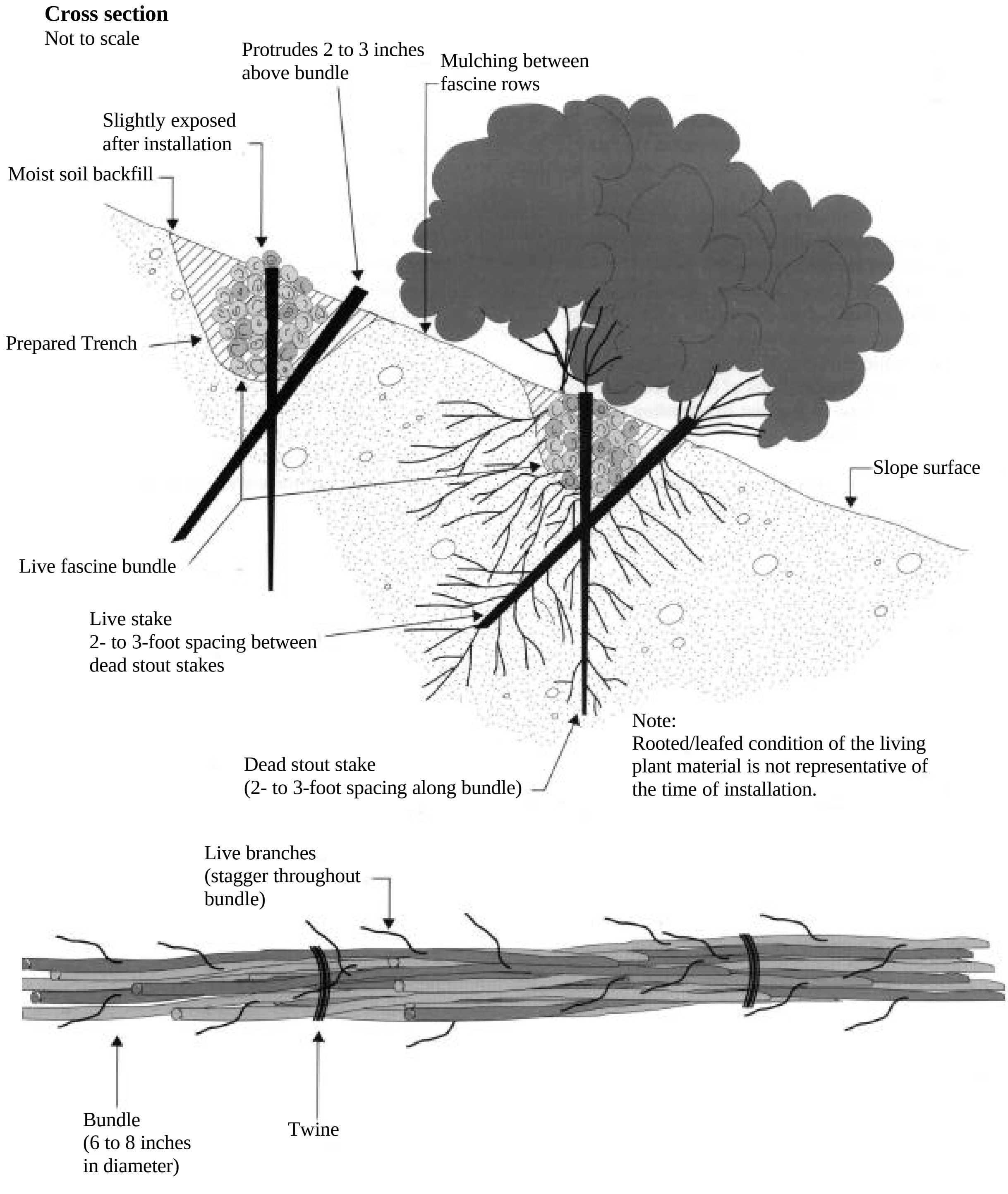


Figure PESC-04-1
Live Fascine Details

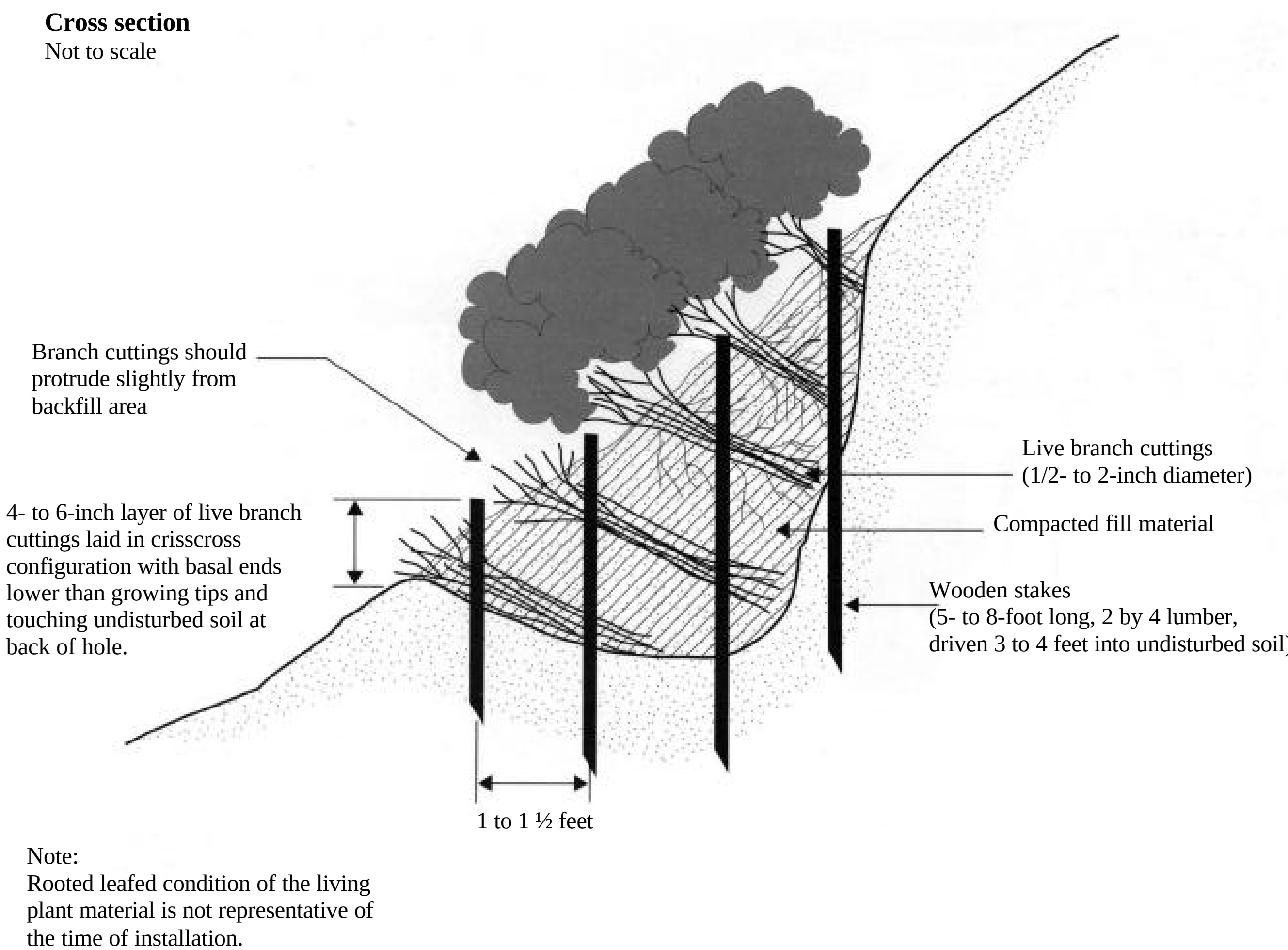


Figure PESC-04-2
Branchpacking Details

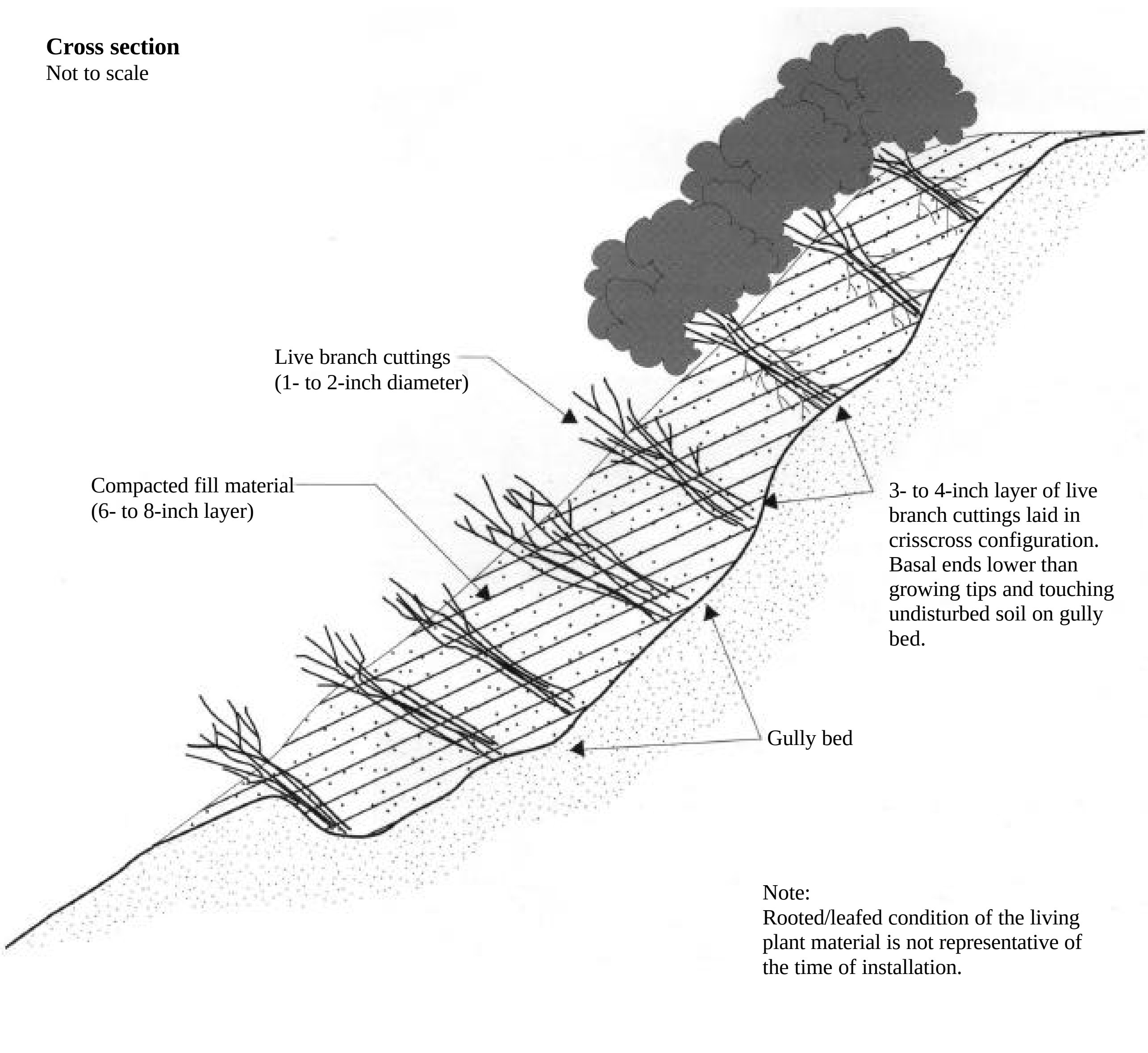
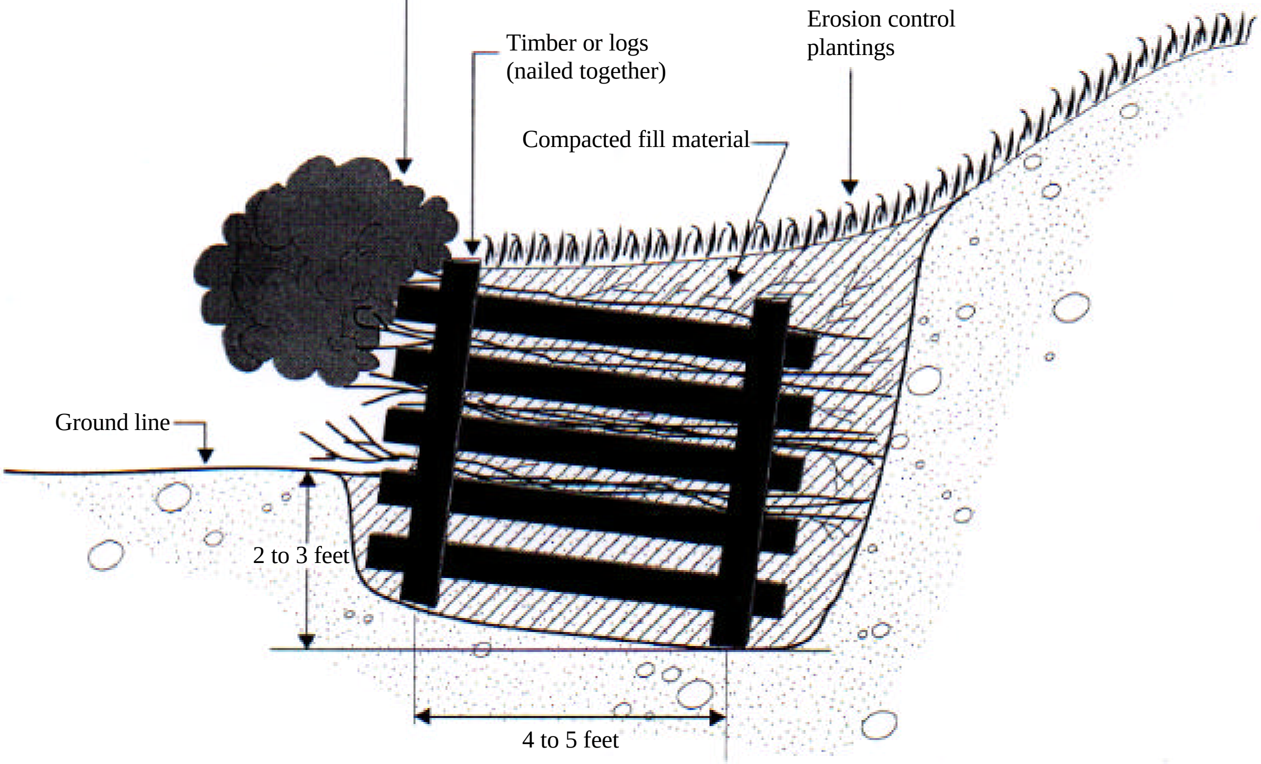


Figure PESC-04-3
Live Gully Repair Details

Cross section
Not to scale



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

Figure PESC-04-4
Live Cribwall

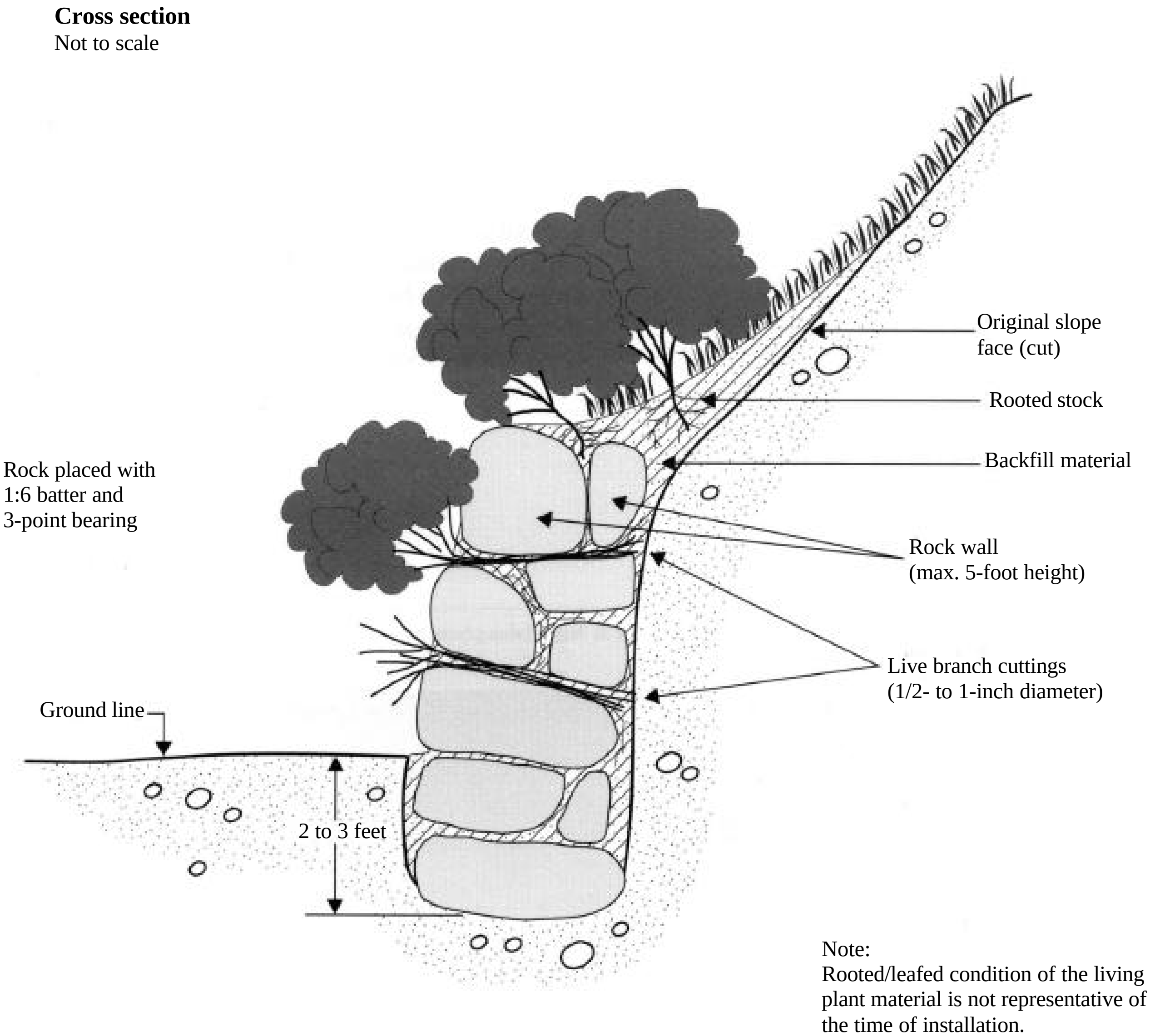


Figure PESC-04-5
Vegetated Rock Wall Details

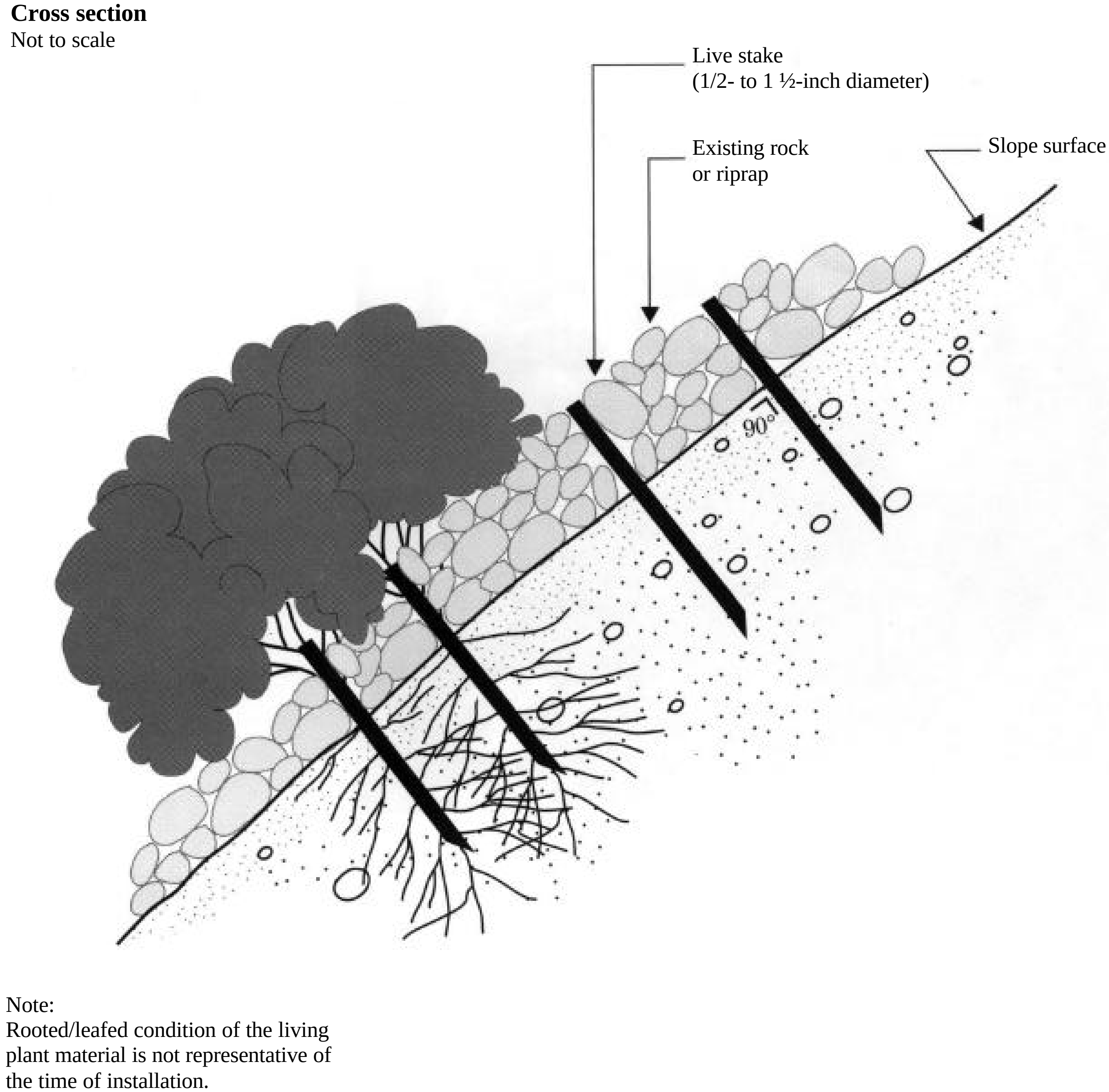
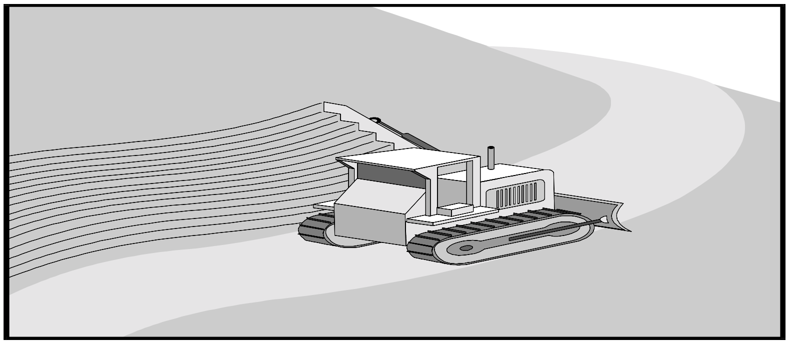


Figure PESC-04-6
Joint Planting Details

ACTIVITY: Gradient Terraces and Slope Roughening	PESC – 05



Targeted Constituents

● Significant Benefit ◗ Partial Benefit ○ Low or Unknown Benefit

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

Implementation Requirements

● High ◗ Medium ○ Low

○ Capital Costs	○ O & M Costs	○ Maintenance	● Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of pollutants to the storm drain system or to watercourses as a result of construction activity by terracing slopes to reduce erosion by decreasing runoff velocities, trapping sediment, increasing infiltration, and aiding in supporting vegetative cover. This management practice is likely to create a significant reduction in sediment.

Suitable Applications

- Slopes steeper than 3:1 (H:V), and greater than 5 ft. (1.5 m) in height.
- Graded areas with smooth, hard surfaces.
- Where length of slopes needs to be shortened by terracing. Note: 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.

Installation/ Application Criteria

- These systems should be designed by a licensed professional civil engineer.
- Terracing installation techniques are presented in TCP-11: Terracing.
- 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 TCP section. These measures should be designed to consider the permanent structure/slope and other site conditions.

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.

Limitations

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

Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

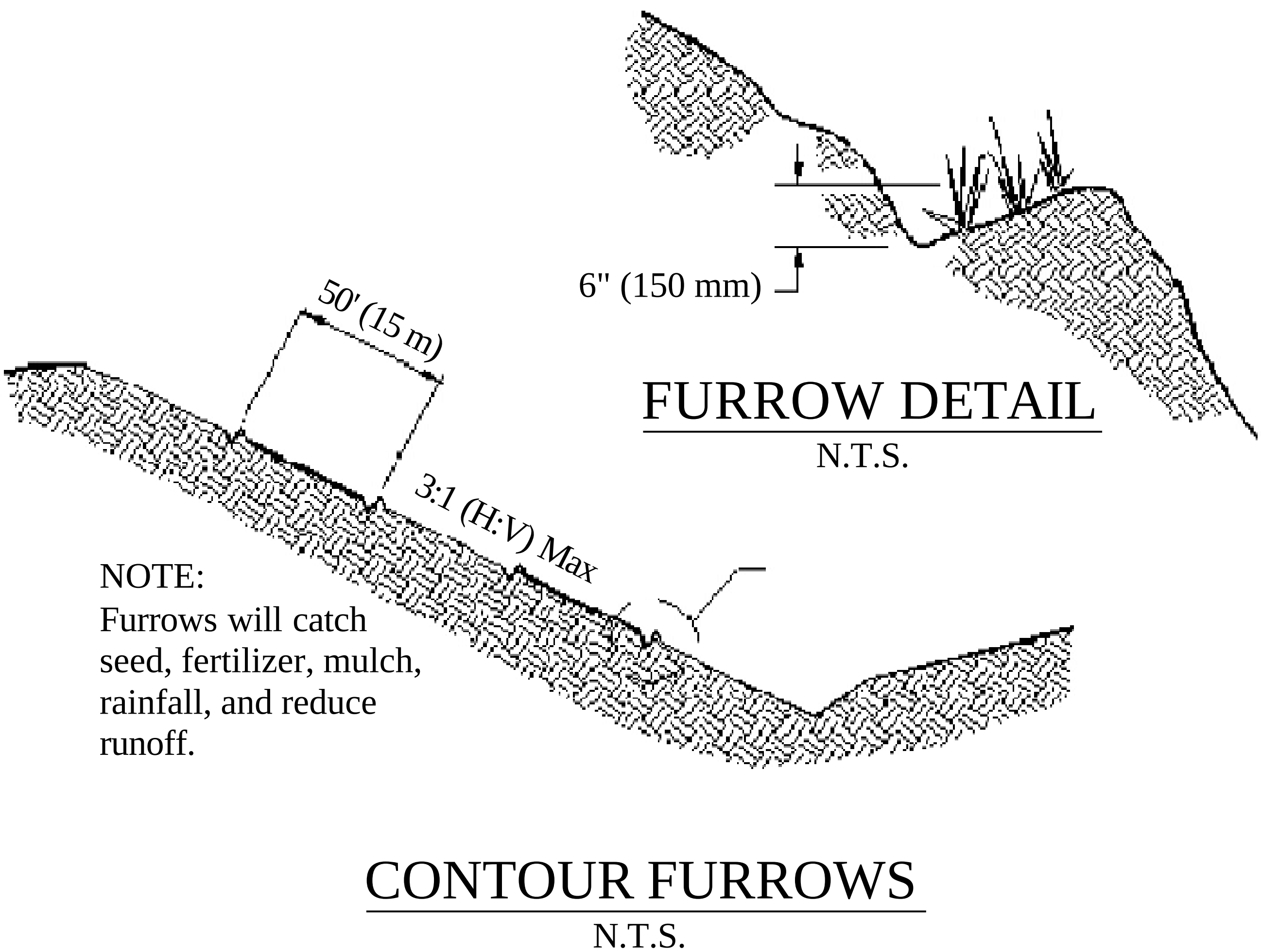
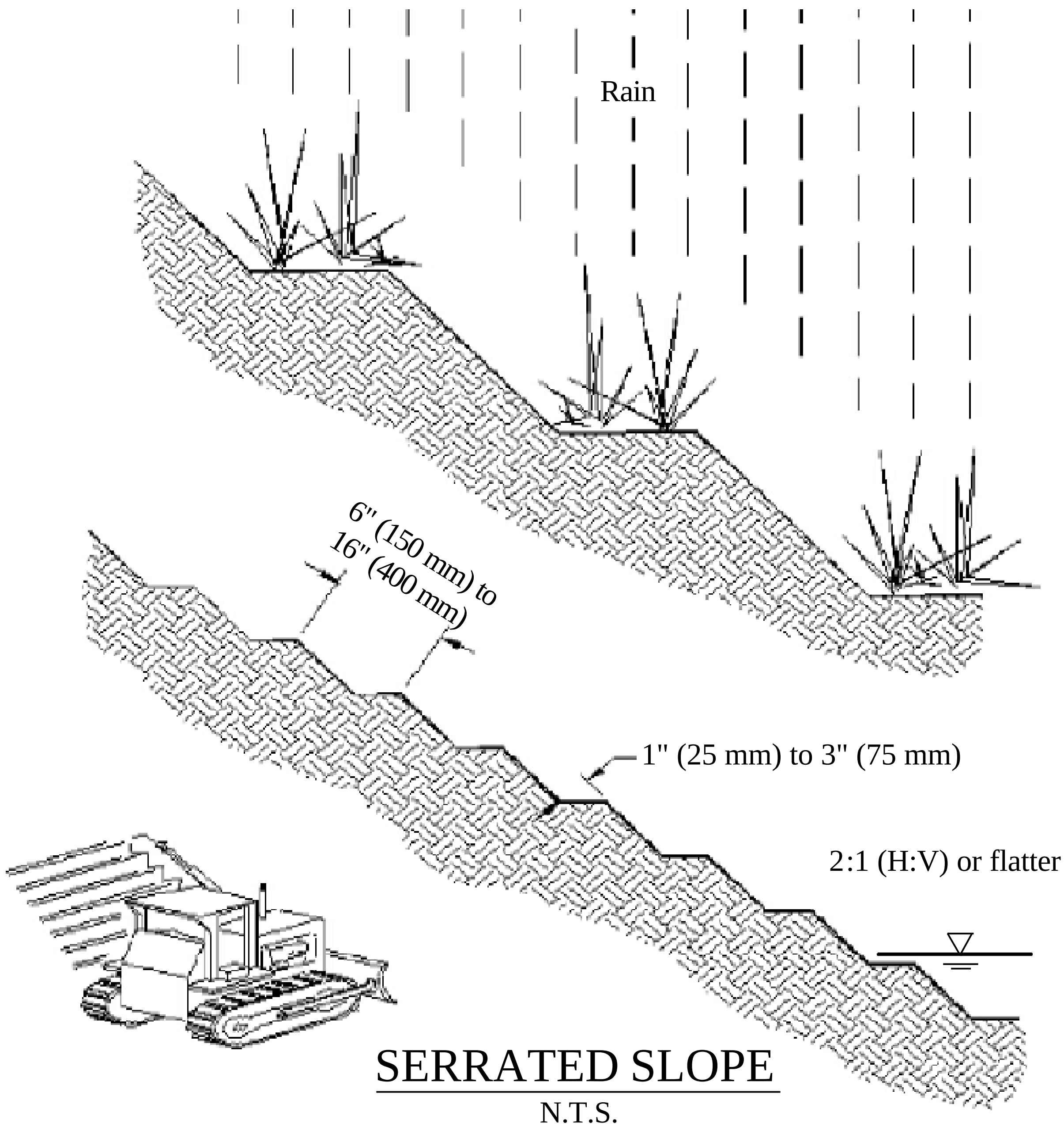
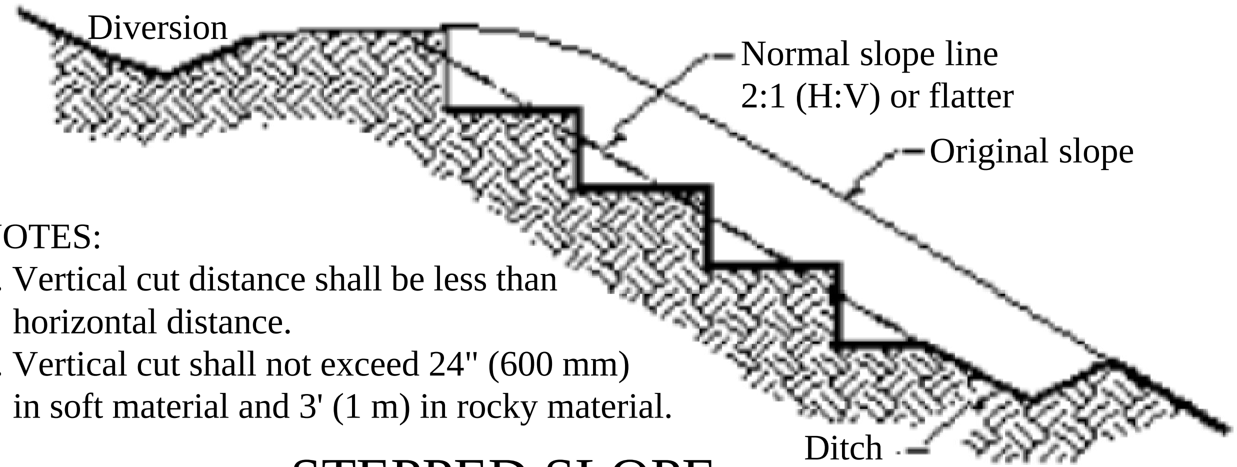


Figure PESC-05-1
Furrow Layout



NOTE:
Groove by cutting serrations along the contour. Irregularities in the soil surface catch rainwater, seed, mulch and fertilizer.

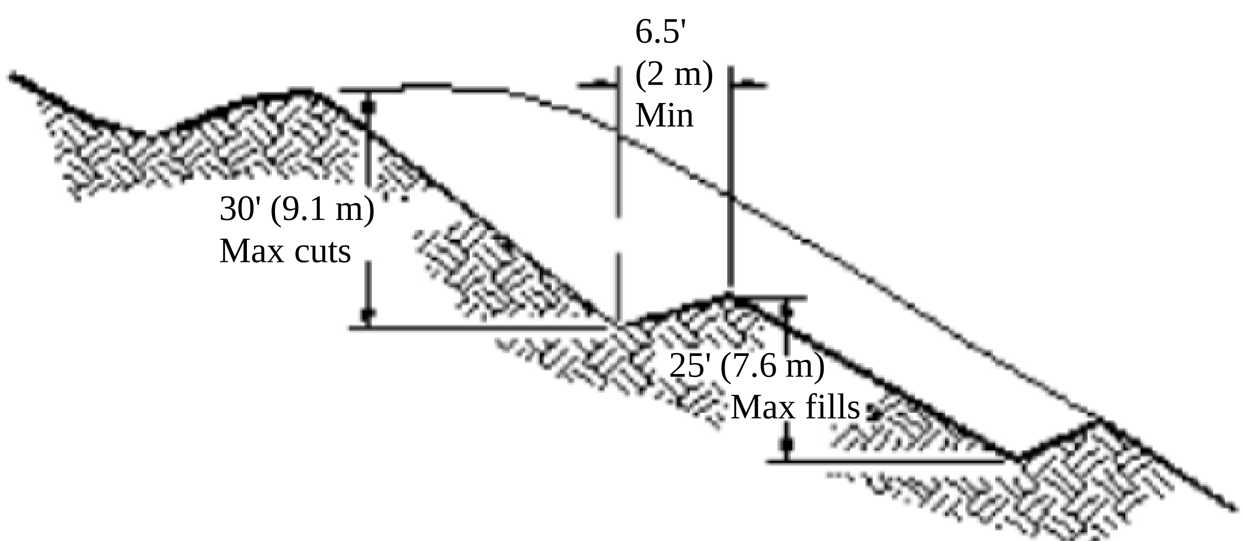
Figure PESC-05-2
Serrated Slope Layout



NOTES:
1. Vertical cut distance shall be less than horizontal distance.
2. Vertical cut shall not exceed 24" (600 mm) in soft material and 3' (1 m) in rocky material.

STEPPED SLOPE

N.T.S.

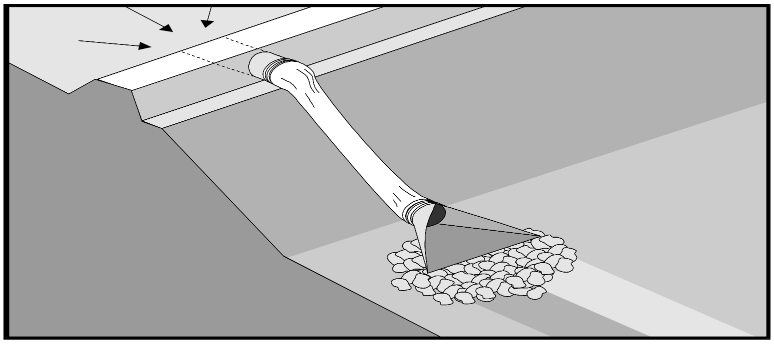


TERRACED SLOPE

N.T.S.

Figure PESC-05-3
Stepped and Terraced Slope Construction

ACTIVITY: Flow Diversions, Drains and Swales	PESC – 06



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High	◗ Medium	○ Low		
◗ Capital Costs	○ O & M Costs	○ Maintenance	◗ Suitability for Slopes >5%	○ Training

Description and Suitable Applications

Permanent drains and swales are used to divert runoff from stabilized areas around disturbed areas, and direct runoff into sediment basins or detention ponds. The primary function of a slope drain is to convey runoff down cut or fill slopes, while 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. This management practice is likely to create a significant reduction in sediment.

Installation/ Application Criteria

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

Installation/Application criteria for permanent flow diversions, drains and swales are presented in TCP-22: Temporary Diversions, Drains and Swales. The principal difference 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.
- 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.

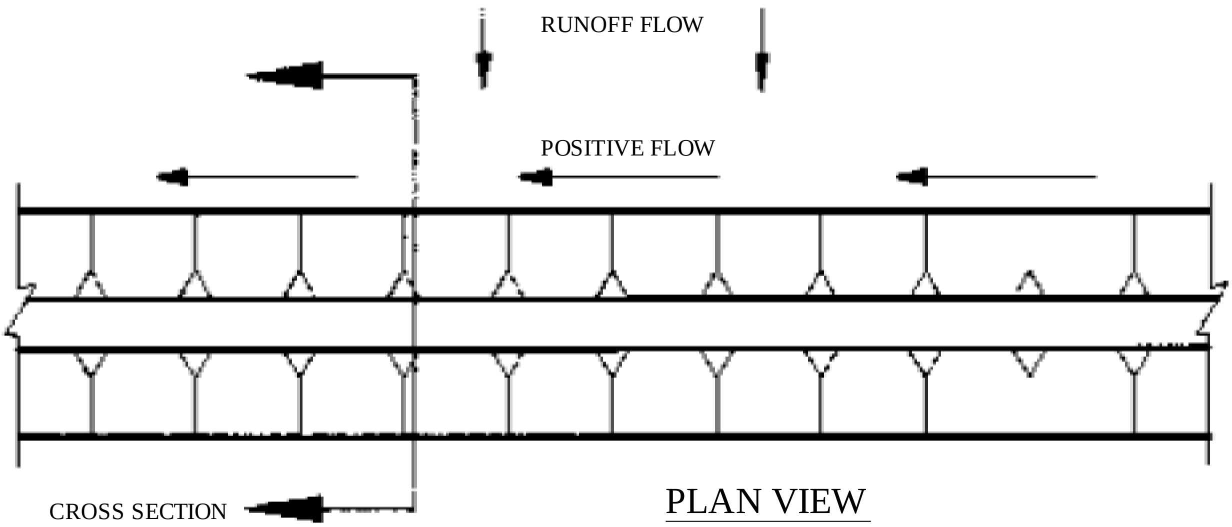
Limitations

- 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.

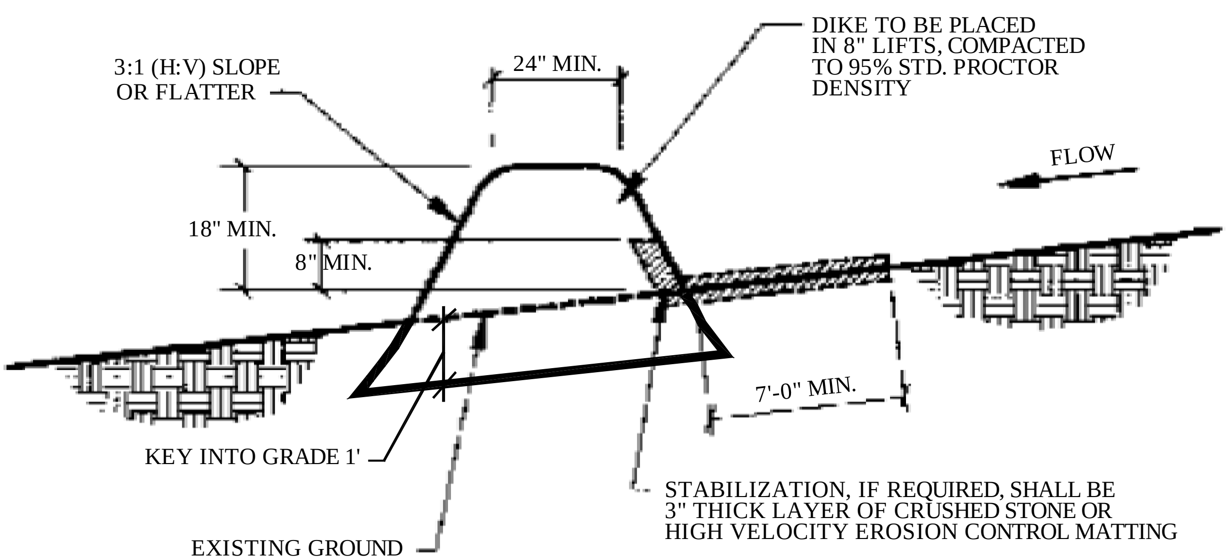
Primary References

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, CDM et.al. for the California Department of Transportation, 1997.



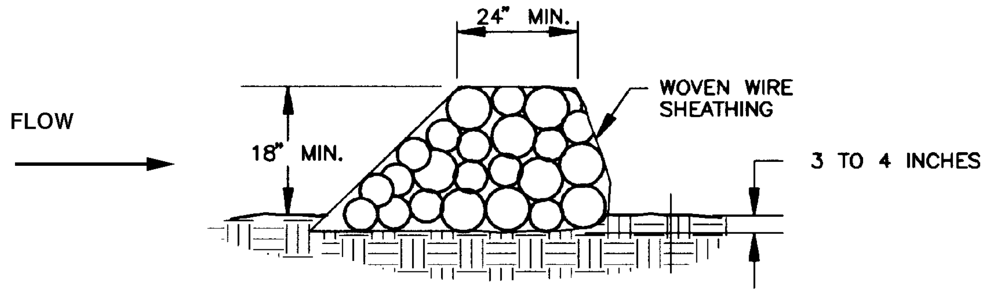
PLAN VIEW
N.T.S.



Note: This technique is similar to methods presented in TCP-15: Sand Bag Barrier and TCP-16: Brush or Rock Filters and Continuous Berms.

CROSS SECTION
N.T.S.

Figure PESC-06-1
Diversion Dike w/o Excavation



CROSS SECTION

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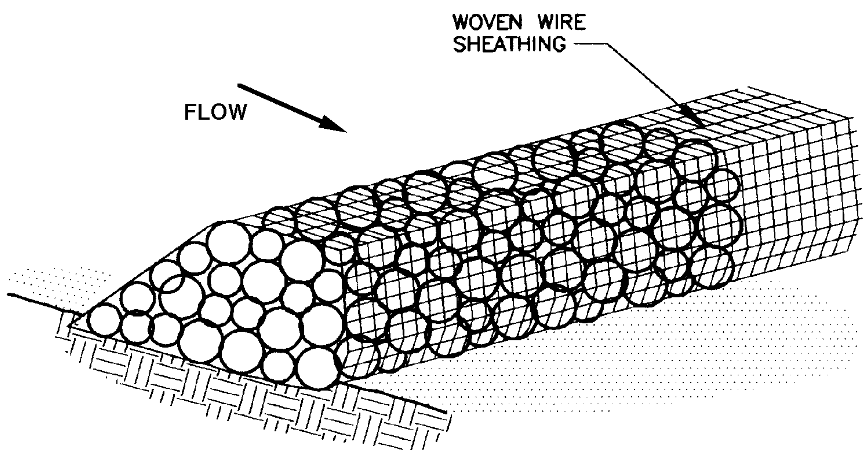
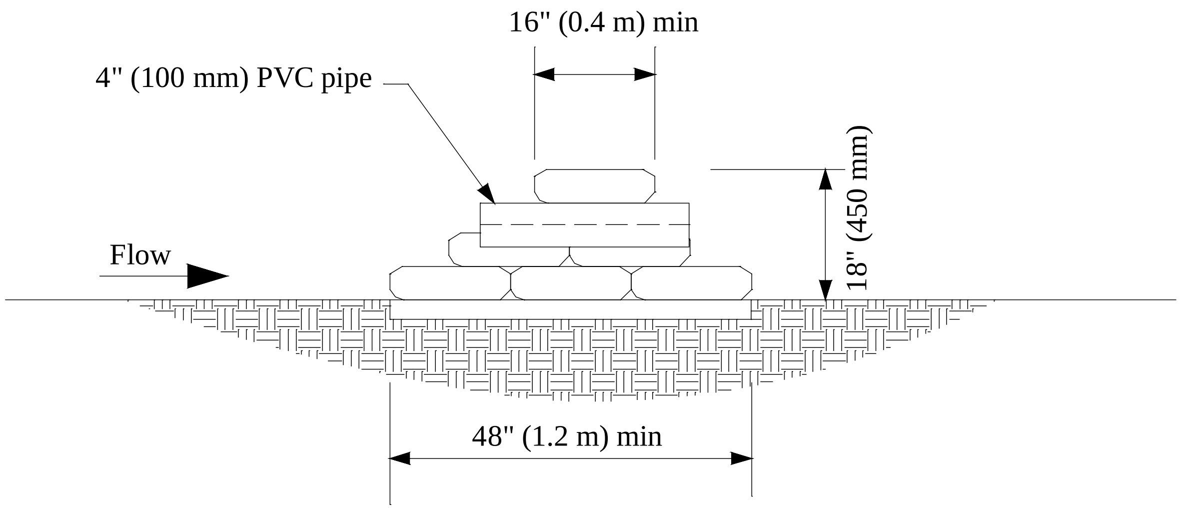


ISOMETRIC PLAN VIEW

N.T.S.

Note: This technique is similar to methods presented in TCP-15: Sand Bag Barrier and TCP-16: Brush or Rock Filters and Continuous Berms.

Figure PESC-06-2
Rock Berm



CROSS SECTION

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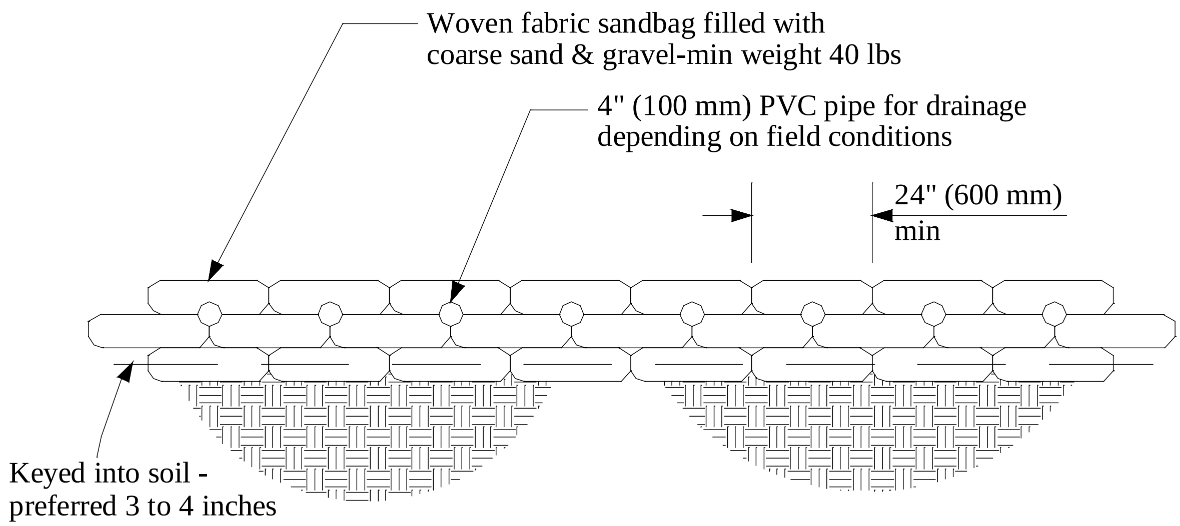

PROFILE VIEW

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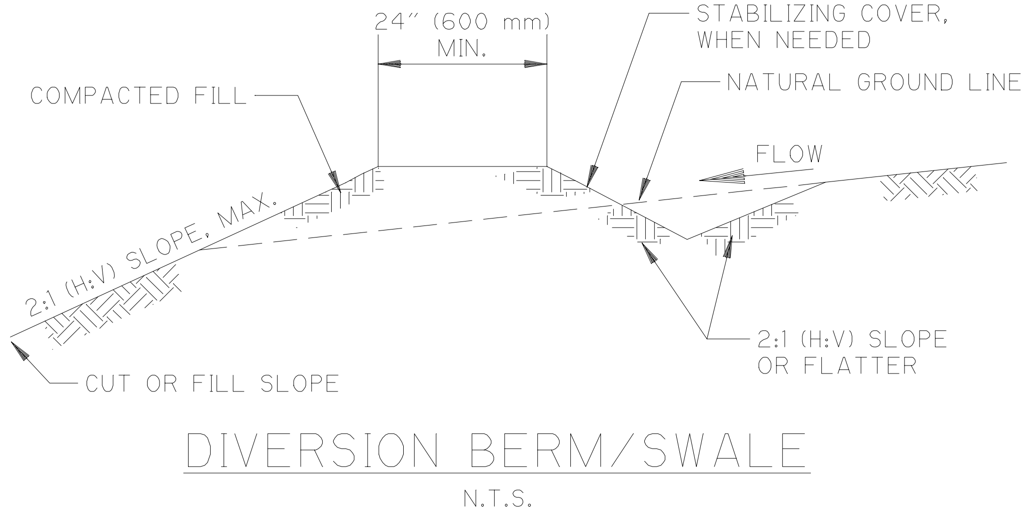
Figure PESC-06-3
Sand Bag Berm



NOTES:
1. STABILIZE INLET, OUTLETS AND SLOPES.
2. PROPERLY COMPACT THE SUBGRADE.

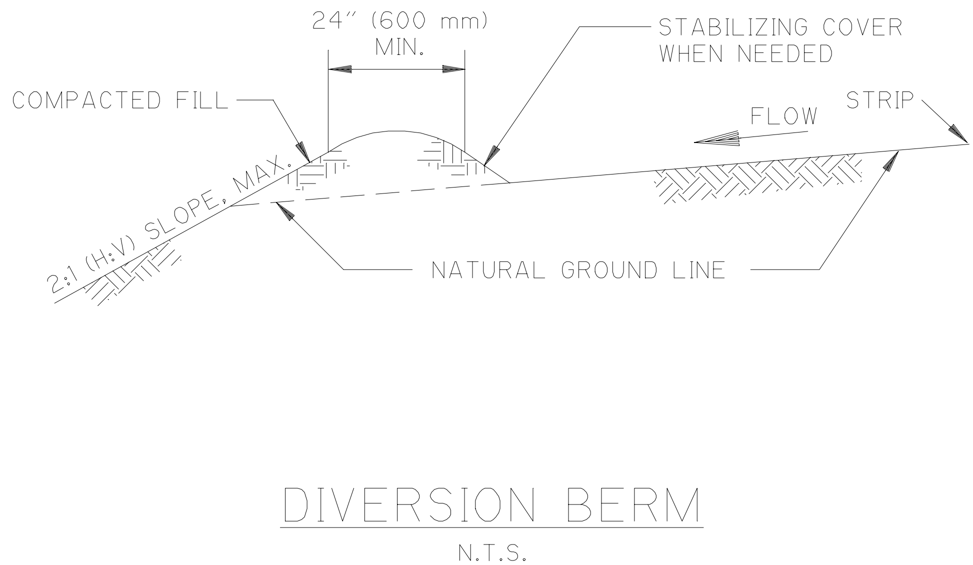


Figure PESC-06-4
Diversion Berm and Berm/Swale

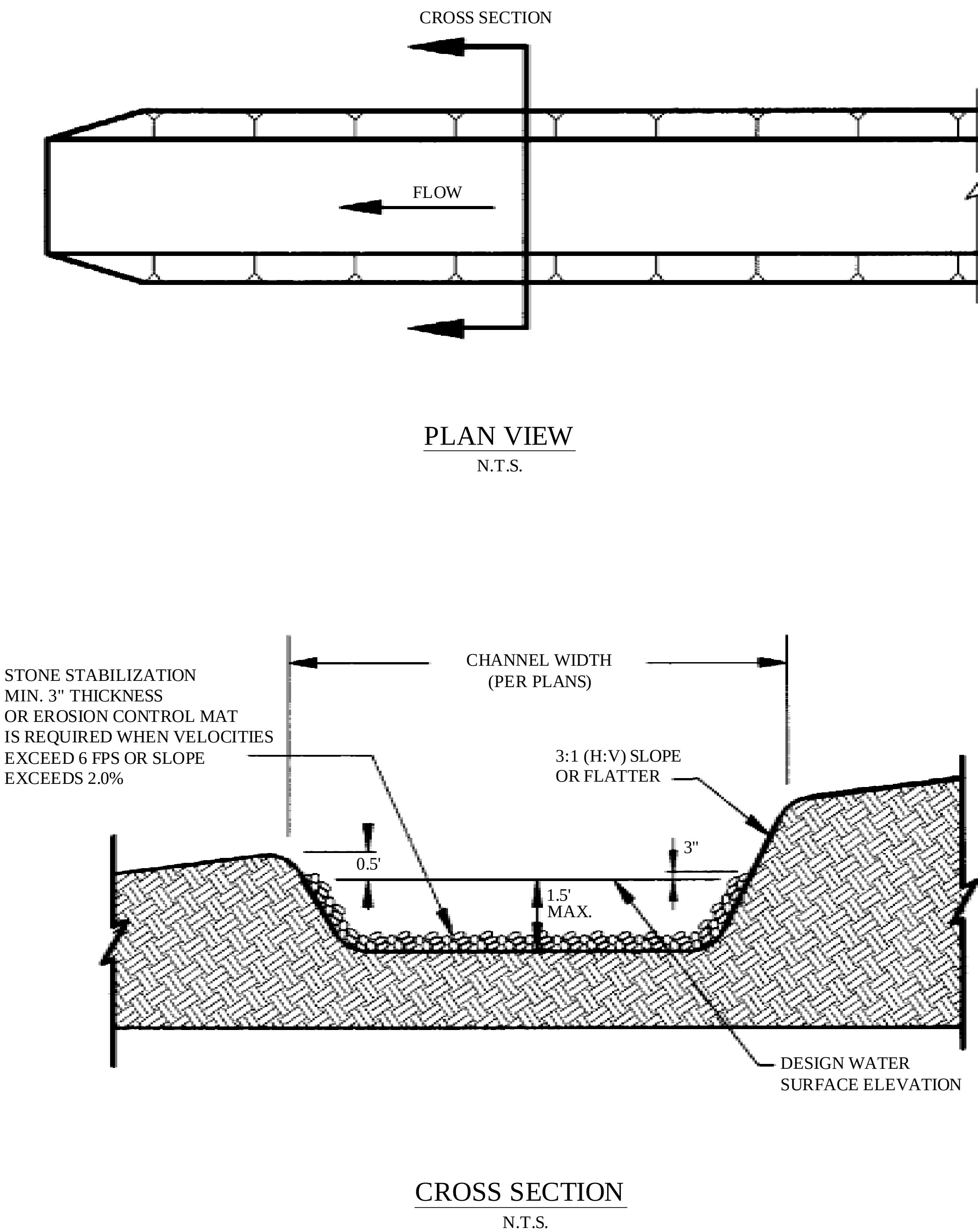


Figure PESC-06-5
Interceptor swale

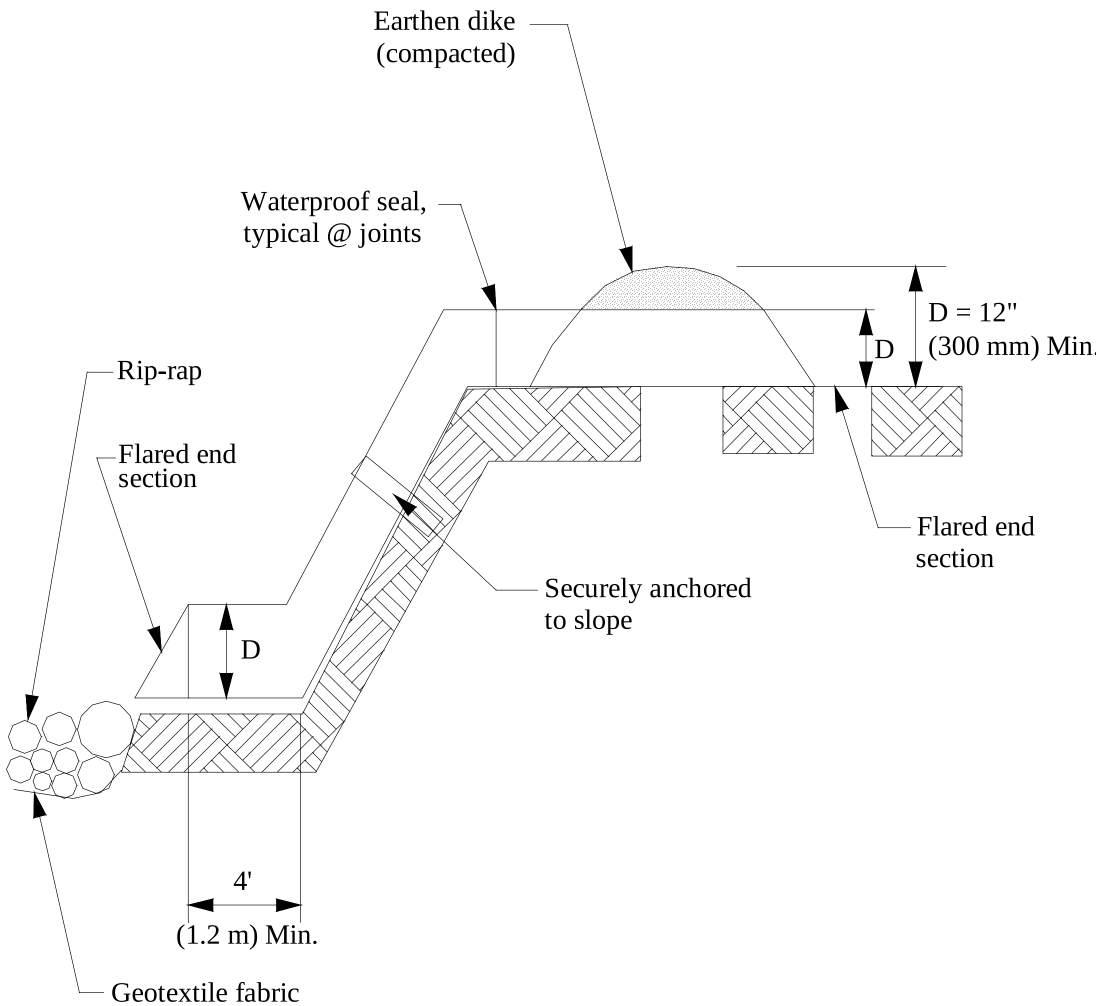
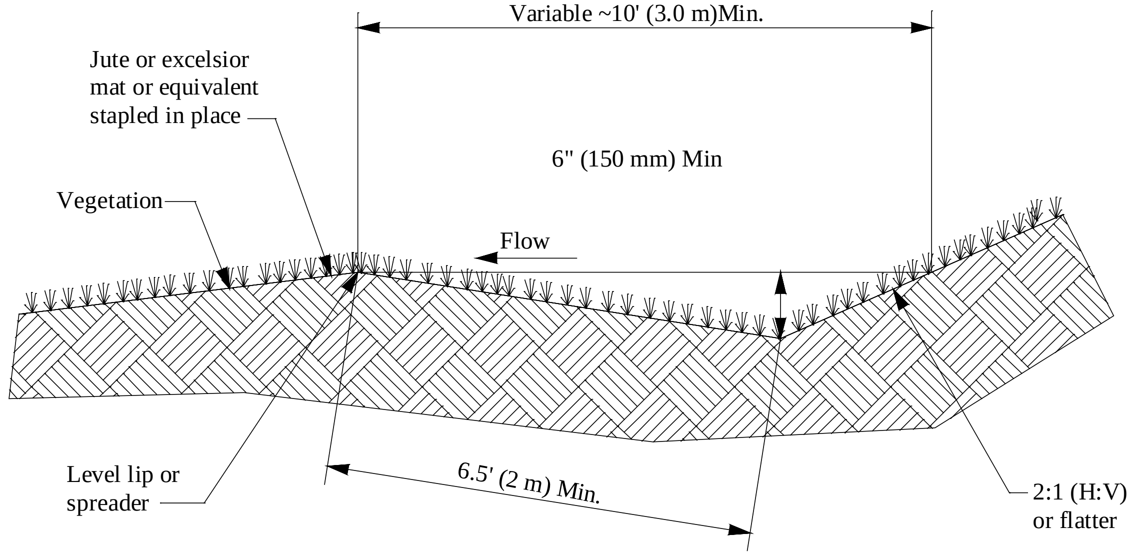
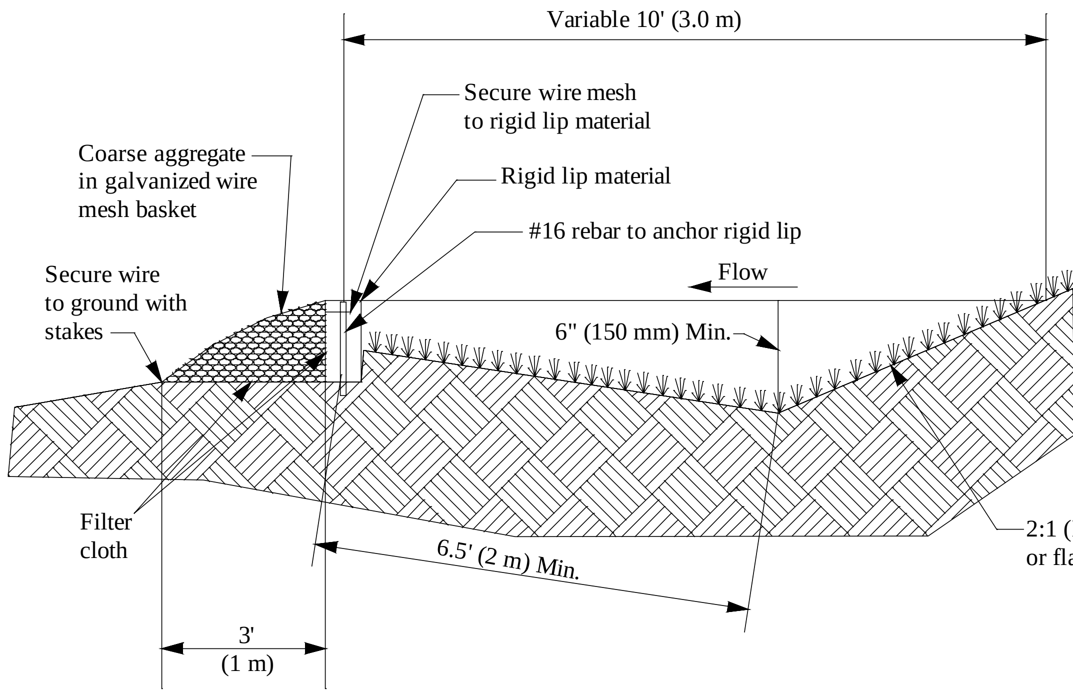


Figure PESC-06-6
Diverted Flow Slope Drain



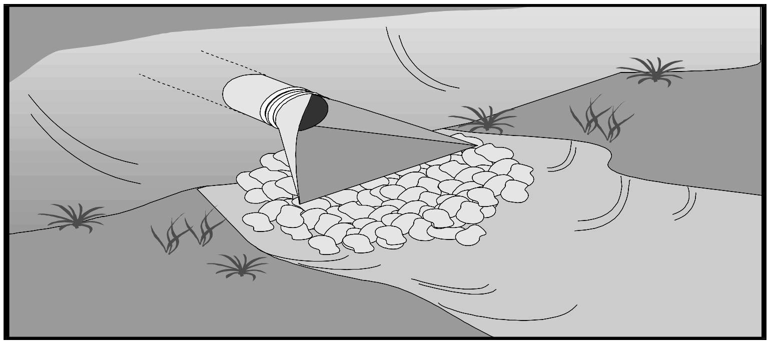
VEGETATED LIP
N.T.S.



RIGID LIP
N.T.S.

Figure PESC-06-7
Level Spreaders

ACTIVITY: Outlet Protection	PESC – 07



Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Implementation Requirements				
● High	◗ Medium	○ Low		
◗ Capital Costs	○ O & M Costs	◗ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Prevent or reduce the discharge of pollutants to the storm drain system or to watercourses by utilizing devices placed at outlets to pipes and channels to reduce the velocity and/or energy of exiting water as a means of controlling erosion and scour. This management practice is likely to create a significant reduction in sediment.

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/ Application Criteria

- 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 percent 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.

Maintenance

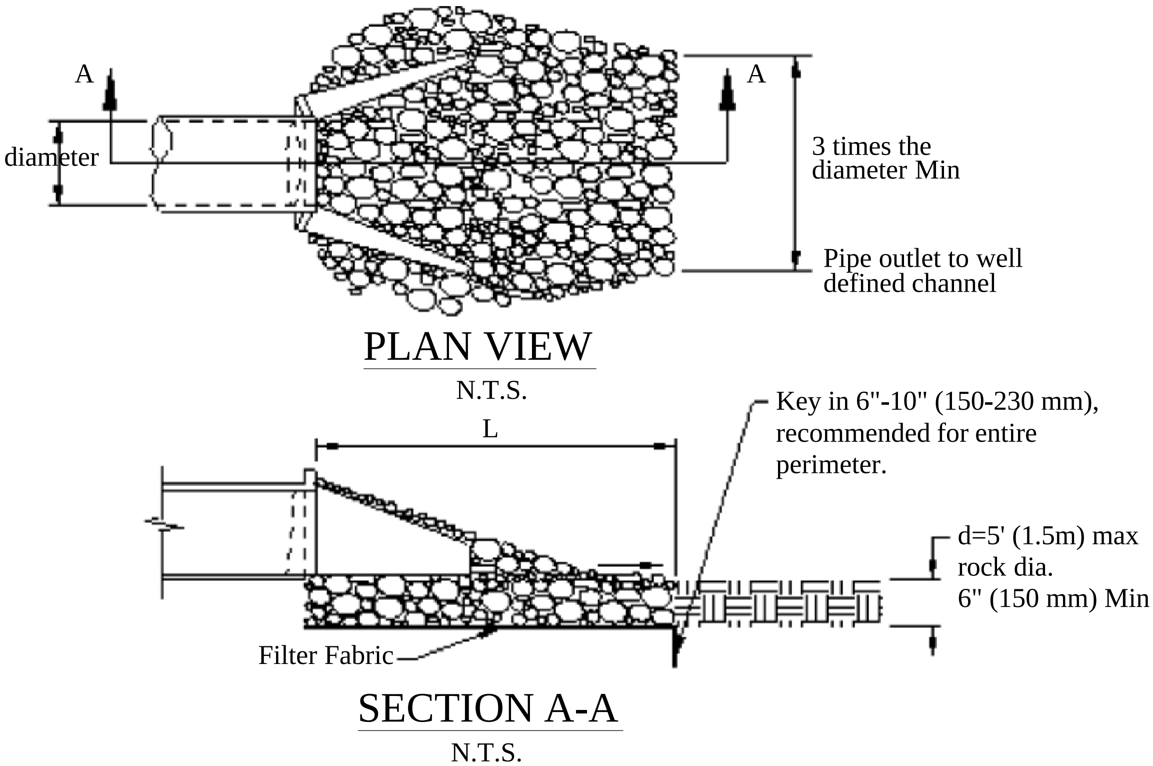
- Permanent outlet protection should be inspected monthly through the first year after construction and annually thereafter.
- Permanent outlet protection should be inspected after any storm events equal to or larger than a 10-year storm event.
- Inspect apron for displacement of the rip-rap and/or damage 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.

Limitations

- 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.

Primary References

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.



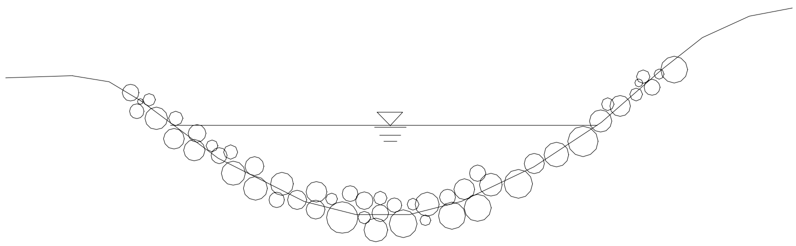
Adapted from: Virginia Erosion & Sediment Control Handbook, 1992

Pipe Diameter in (mm)	Discharge ft^3/s (m^3/s)	Apron Length, L ft (m)	Rip-Rap D_{50} Diameter Min in (mm)
12 (300)	4.9 (0.14)	10 (3)	4 (100)
	9.89 (0.28)	13 (4)	6 (150)
18 (450)	9.89 (0.28)	10 (3)	6 (150)
	20.13 (0.57)	16 (5)	8 (200)
	30.01 (0.85)	23 (7)	12 (300)
	39.90 (1.13)	26 (8)	16 (400)
24 (600)	30.01 (0.85)	16 (5)	8 (200)
	39.90 (1.13)	26 (8)	8 (200)
	50.14 (1.42)	26 (8)	12 (300)
	60.03 (1.70)	30 (9)	16 (400)
For larger or higher flows, consult a registered civil engineer			

Source: Adapted from USDA-SCS

Figure PESC-07-1
Outlet Protection Sizing

ACTIVITY: Channel Linings | PESC – 08



Targeted Constituents				
● Significant Benefit		◗ Partial Benefit		○ Low or Unknown Benefit
● Sediment	○ Heavy Metals	○ Floatable Materials	○ Oxygen Demanding Substances	
○ Nutrients	○ Toxic Materials	○ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes
Implementation Requirements				
● High		◗ Medium		○ Low
○ Capital Costs	○ O & M Costs	○ Maintenance	○ Suitability for Slopes >5%	○ Training

Description

Channel lining is the artificial surfacing of bed, banks, shore or embankments to resist erosion or scour. This management practice is likely to create a significant reduction in sediment.

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 TDEC.

Approach

- 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
- 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 (TCP-9), and Geotextiles (TCP-10) BMPs.
- Brushlayering applications are discussed in detail in TCP-16: Brush or Rock Filter.
- Riprap installation is detailed in TCP-20: 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 therafter.
- 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.

Limitations

- 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.

Primary References

Soil Erosion Prevention and Sediment Control Reducing Nonpoint Source Water Pollution on Construction Sites, University of Tennessee, Knoxville, Department of Civil and Environmental Engineering, August 1998.

California Storm Water Best Management Practice Handbooks, CDM et.al. for the California SWQTF, 1993.

Caltrans Storm Water Quality Handbooks, Construction Contractor's Guide and Specifications, April 1997.

Subordinate References

Caltrans Highway Design Manual, 1997.

SECTION 6
PERMANENT TREATMENT PRACTICES (PTP)

Section 6
PERMANENT TREATMENT PRACTICES
(PTP)

6.1 Introduction

This section presents the Stormwater Control Measure (SCM) specifications for Permanent Treatment Practices (PTP). PTPs are intended to treat stormwater runoff in the long-term. PTPs are designed for pollutant removal and are rated by their ability to remove Total Suspended Solids (TSS). Table 1 presents a pre-approved listing of PTPs and their assigned TSS removal capabilities. Some of these PTPs can be designed to achieve both stormwater quantity and quality management objectives.

Structural Control		TSS Removal %
PTP – 01	Stormwater Wet Ponds	80
PTP – 02	Constructed Wetlands	80
PTP – 03	Bioretention Area	80
PTP – 04	Surface Sand Filters	80
PTP – 05	Water Quality Swales	80
PTP – 06	Dry Ponds	60
PTP – 07	Filter Strips	50
PTP – 08	Grass Channels	50
PTP – 09	Greenroofs	*
PTP – 10	Underground Sand Filters	80
PTP – 11	Perimeter Sand Filters	80
PTP – 12	Organic Filters	80
PTP – 13	Gravity (Oil-Grit) Separators	40
PTP – 14	Infiltration Trenches	80
PTP – 15	Permeable Pavements	*

*For the purposes of water quality volume calculations, the area of the green roof or pervious pavement is subtracted from the site's impervious area and only the area of the practice is considered to receive 80% TSS Removal.

Each specification has a quick reference guide outlining selection, design, and implementation requirements.

The PTPs presented in this section are intended to serve as permanent treatment measures. Additional details are provided in sections covering Temporary Construction Site Management Practices (TCPs) for practices that are intended to function on a short-term basis (lasting only as long as construction activities) and covering Permanent Erosion Prevention and Sediment Control (PESC) that are intended to function on a long-term basis.

6.2 Water Quality Volume Overview

Metro's water quality treatment standard is designed to capture 85% of the annual stormwater runoff. Water quality systems must be designed to treat the runoff from the first 1.1 inches of rainfall. Each site's water quality treatment volume is also based upon its percent impervious cover. The treatment standard is the same for all sites throughout the community unless other secondary pollutant reduction goals are established, for instance, through the establishment of Total Maximum Daily Loads (TMDLs). Metro's water quality treatment methodology is as follows:

$$WQv = P \times Rv \times \frac{A}{12}$$

Where:

WQv = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = drainage area, ac

$$Rv = 0.015 + 0.0092I$$

Where:

I = drainage area impervious cover, % (50% imperviousness would be 50)

6.3. Calculations for SCMs in a Series

SCMs that do not individually meet Metro's pollutant reduction goal may be used with another SCM to meet the 80 percent TSS removal requirement. That is, water may pass through one treatment device, into another in a "treatment train" to achieve added treatment. It is necessary to calculate the cumulative pollutant removal from SCMs in a series with an equation that accounts for the fact that the majority of the heavy (easily removed) suspended pollutants and particulate matter are removed by the first structural control in a series. The runoff that enters the second and subsequent controls contains sediment with much smaller particles, which are more difficult for the control to remove. Thus, the second control has a pollutant removal efficiency that is less than it would ordinarily have. The following equation accounts for the cumulative pollutant removal of SCMs in a series.

$$TR = A + (1 - A) * B$$

Where:

TR = Total Removal
A = 1st structural control in series
B = 2nd structural control in series

Notes:
1) When runoff flows from a more efficient structure (one with a higher removal rate) to a less efficient structure (one with a lower removal rate), the cumulative pollutant removal of a structure does not increase. The reason is that a structure with a lower removal efficiency that follows a structure with a higher removal efficiency does not have an appreciable affect on cumulative pollutant reduction.

6.2.1 Example Calculation

A site is planned to have a manufactured pretreatment device that is approved for a 50% TSS removal credit, followed by a dry detention basin designed, built, and maintained as required by Metro regulations to achieve a 60% removal credit. The calculation is as follows:

$$\boldsymbol{TR} = A_{MD} + (1 - A_{MD}) * B_{DD}$$

Where:

TR = Total Removal
A_{MD} = 1st structural control—manufactured device
B_{DD} = 2nd structural control—dry detention basin

TR = 0.5 + (1-0.5)*0.6
TR = 0.5 + (0.5)*0.6
TR = 0.5 + 0.3
TR = 0.8

Total Removal equals 80%.

Wet Ponds

Description: Constructed stormwater detention basin that has a permanent pool (or micropool). Runoff from each rain event is captured and treated in the pool primarily through settling and biological uptake mechanisms.

Variations: Wet extended detention, micropool extended detention, multiple pond system.

Components:
- Permanent pool – prevents resuspension of solids
- Live storage above permanent pool – sized for a percentage of water quality volume and flow attenuation. Percentage depends on type of wet pond chosen
- Forebay – settles out larger sediments in an area where sediment removal will be easier
- Spillway system – spillway system(s) provides outlet for stormwater runoff when large storm events occur and maintains the permanent pool

Advantages/Benefits:
- Moderate to high pollutant removal
- Can be designed as a multi-functional BMP
- C ost effective
- Can be designed as an amenity within a development
- Wildlife habitat potential
- High community acceptance when integrated into a development

Disadvantages/Limitations:
- Potential for thermal impacts downstream
- May require additional permitting through TDEC for ARAP or Safe Dams
- Community perceived concerns with mosquitoes and safety

Design considerations:
- Minimum contributing drainage area of 25 acres; 10 acres for micropool extended detention (Unless water balance calculations show support of permanent pool by a smaller drainage area)
- Sediment forebay or equivalent pretreatment must be provided
- Minimum length to width ratio = 3:1
- Maximum depth of permanent pool = 8’
- 3:1 side slopes or flatter around pond perimeter

Selection Criteria:

- ✓ **Water Quality 80 % TSS Removal**
- ✓ **Quantity Control**

Land Use Considerations:

- ✓ **Residential**
- ✓ **Commercial**
- ✓ **Industrial**

Maintenance:

- Remove debris from inlet and outlet structures
- Maintain side slopes/remove invasive vegetation
- Monitor sediment accumulation and remove periodically

M **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Stormwater ponds are constructed stormwater basins that can be designed to serve multiple functions, including stormwater quality treatment, peak flow attenuation, and wildlife habitat creation. Stormwater quality treatment is achieved in the storage provided both within the permanent pool and the live pool volume, depending on the type of wet pond design. The permanent pool (or micropool for micropool extended detention design) provides the majority of the volume used for settling particulates. A well-designed and landscaped pond can be an aesthetic feature when planned and located properly.

Figure 1.1 illustrates a typical wet pond, showing the components found in the pond variations, described in the next section. Figures 1.2, 1.3, and 1.4 are schematics for wet pond variations that are allowed in Metro.

Stormwater wet ponds must be designed by a licensed professional engineer.

Components

Sediment forebay. The forebay is a pretreatment BMP that allows heavier sediments to settle out before they reach the permanent pool. Often, the floor of the forebay is concrete or other hardened surface so that periodic sediment removal is easier. The forebay treatment area can provide for a portion of the required water quality treatment volume for a site.

Permanent pool. The permanent pool, or dead storage, provides the mechanism for settling out solids from stormwater runoff, as well as providing the setting for biological uptake of some pollutants. As new stormwater runoff enters the permanent pool, stormwater stored in the permanent pool is replaced. A micropool is a type of permanent pool

Live storage. The storage area provided above the permanent pool is used to capture and slowly release the first flush volume. In some pond variations, such as the wet extended detention pond, the water quality treatment volume is split between the permanent pool and the live storage area. Larger storm events can also be treated for peak flow attenuation within the live storage volume.

Spillway systems. Spillway systems are typically made up of emergency spillways and primary spillway systems, designed as channels, riser and barrel structures, or a combination of the two. Spillway systems for wet ponds typically have multiple outlets to control different design storms. The spillway system must also include an emergency drain to allow complete draining of the pond within 24 hours.

Design Variations

The following design variations are allowed as stormwater quality treatment BMPs in Metro:

Design Variations (continued)

Wet pond. Stormwater wet ponds are built with a permanent pool, or dead storage, equal to the water quality volume. Stormwater runoff displaces the water already in the pool. Temporary storage is provided above the permanent pool elevation for attenuation of larger storm events.

Wet extended detention (ED) pond. In a wet extended detention (ED) pond, the water quality volume is split evenly between the permanent pool and extended detention (ED) storage provided above the permanent pool. During storm events, water is detained above the permanent pool elevation for 24-48 hours. This design provides the same pollutant reduction but consumes less space.

Micropool extended detention pond. Variation of the ED pond, where a micropool is maintained below the outlet of the pond. The micropool volume is calculated as 0.1 inch per impervious acre or 20% of the water quality volume (WQ_v), whichever is greater. The remainder of the required water quality volume is stored above the micropool in the live pool storage. The micropool prevents resuspension of solids and prevents clogging of low flow orifices. The live pool storage above the micropool is also used for the attenuation of larger storm events. The water quality volume stored in the live pool area must be detained for 24 hours. This pond most resembles the “dry pond” design. The difference in this style pond and the wet ED pond is the storage location of the water quality volume (WQ_v).

Multiple pond systems. Multiple ponds in series, that provide longer flow paths and two or more storage cells for water quality and quantity treatment. Pollutant reduction of ponds in series provides more than 80% TSS removal (see Volume 4, Section 6 Introduction, section 6.2 for guidance on pollutant removal reductions for BMPs in series).

Site and Design Considerations

The following design and site considerations must be incorporated into the BMP plan:

General design

1. A licensed professional engineer must design all types of wet ponds.
2. Ponds must not be constructed in or located on a stream.
3. All components of a stormwater wet pond, including access, must be located in a drainage easement.
4. Access to the forebay, permanent pool and spillways must be considered in the planning and design. Permanent access must be provided from a public road and maintained throughout the life of the structure.
5. A minimum drainage area of 25 acres is needed for wet ponds and wet ED ponds to maintain the permanent pool. The minimum drainage area for micropool ED ponds is 10 acres. A smaller drainage area may be acceptable with an adequate water balance (refer to PTP-02 *Constructed Wetlands*

Site and Design Considerations (continued)

Design Procedures Step #2 for water balance calculations) and an anti-clogging pond outlet.

6. The space required to construct a wet pond is approximately 2-3% of the tributary drainage area.
7. Stormwater ponds should be located to provide for maximum runoff storage at a minimal construction cost.
8. Stormwater ponds should not be located on slopes that are equal to or greater than 15%.

Pretreatment

9. All stormwater ponds must incorporate a sediment forebay or pretreatment device at the point or points of inflow. The purpose of the pretreatment is to settle out heavier solids in an area that is easier to clean out than the permanent pool.
10. The forebay must consist of a separate cell from the permanent pool, separated by an acceptable barrier.
    a. For maintenance purposes in larger ponds, the bottom of the forebay should be hardened (e.g., concrete lined) to make sediment removal easier and width of the forebay should accommodate a small piece of equipment, such as a Bobcat.
    b. The forebay must be sized to contain 0.1 inches per impervious acre contributing drainage and should be a minimum of 4-6 feet deep. The forebay storage volume counts toward the total WQ_v requirement and may be subtracted from the WQ_v for subsequent calculations.
    c. A fixed vertical sediment depth marker must be installed in the forebay to visually indicate sediment depth over time.
    d. Exit velocities from the forebay must be non-erosive.
11. Although forebays are preferred for pretreatment because they require less maintenance, other acceptable pretreatment devices include baffle boxes or stormwater quality inlets.

Permanent Pool

12. The maximum depth of the permanent pool is 8 feet. The objective is to avoid thermal stratification that could result in odor problems associated with anaerobic conditions.
13. In general, stormwater pond designs will be unique for each site. However, the following should be observed to meet the pollutant removal goals:
    a. Permanent pool:
        - Standard wet ponds: 100% of the water quality treatment volume (1.0 WQ_v).
        - Wet ED pond: 50% of the water quality treatment volume (0.5 WQ_v), the other 50% is accounted for in the live pool volume.
        - Micropool pond: Approximately 0.1 inch per impervious acre or 20% of the water quality treatment volume (0.1 IA) or (0.2 WQ_v), whichever is greater.

Site and Design Considerations (continued)

b. Short-circuiting of the pond should be avoided by designing stormwater ponds with a length to width ratio of 3:1 or greater. Baffles, pond shaping, or islands can be added to the permanent pool area to create a longer flow path.

c. Side slopes of the pond should not exceed 3H:1V, or additional safety precautions must be provided, and should terminate on a safety bench (see Figure 1.5). The safety bench requirement may be waived if the side slopes are 4H:1V or flatter.

14. The perimeter of all pool areas that are 6 feet or deeper must be surrounded by two benches: a safety bench and an aquatic bench. The safety bench extends at least 15 feet outward from the permanent pool water edge to the toe of the pond slope. The maximum slope of the safety bench is 6%. The aquatic bench should extend inward from the permanent pool edge a minimum of 15 feet and should have a maximum depth of 18 inches below the permanent pool surface elevation.
15. Bedrock must be considered in the Nashville area because excavation may be required for a permanent pool. If there is highly fractured bedrock or karst topography, then the feasibility of a wet pond should be carefully considered because it may not hold water and the additional water flow and/or weight could intensify karst activity.
16. To maintain a permanent pool, excessive losses through infiltration must be avoided. Depending on the soils, infiltration losses can be minimized through compaction, the addition of a clay liner or an artificial liner.

Live Pool

17. Live pool volumes are dependent upon the need for storm attenuation. Hydrograph routing must be completed for the 2- through 100-year events to determine the required volume and to demonstrate that post-construction flow rates are equal to or smaller than pre-construction rates for each event. Wet ED ponds and micropool ED ponds require that a percentage of the WQ_v be treated in the live-pool volume. This volume can also be included as volume required for storm attenuation.

Outlet Structures

18. Flow control from a stormwater pond is typically accomplished with the use of a concrete or corrugated metal riser and barrel. The riser should be located within the stormwater pond embankment for maintenance access, safety, floatation prevention, and aesthetics. See Figures 1.6 through 1.8 for typical pond outlet structures.
19. To control different storm events, outlets at varying elevations on the riser pipe should be used. The number of orifices varies and is usually a function of the pond design parameters. Additional information for outlet design is provided in Volume 2, Chapter 8.

Site and Design Considerations (continued)

For example, a wet pond riser configuration is typically comprised of multiple small storm outlets (usually orifices) and the 25- and 100- year outlets (often slots or weirs).

20. Water quality outlet designs require additional outlet configurations, separate from the storm attenuation/flood control outlet. For wet ponds, the water quality volume is fully contained in the permanent pool, no additional orifice sizing is necessary for this volume. For larger volumes, orifice sizing guidance is included in the Design Procedures and Figures 1.8 and 1.9. As runoff from a water quality event enters the wet pond, it simply displaces that same volume through a smaller storm event orifice. Thus an off-line wet pond providing *only* water quality treatment can use a simple overflow weir as the outlet structure. On-line wet ponds may or may not require multi-stage riser configurations, depending on the need for storm attenuation. In the case of wet ED ponds and micropool ED ponds, there is an additional outlet (usually an orifice) that is sized to pass the extended detention water quality volume on top of the permanent pool. Flow will first pass through this orifice, which is sized to release the water quality ED volume in 24-48 hours. The preferred design is a reverse slope pipe attached to the riser, with its inlet submerged 1 foot below the elevation of the permanent pool to prevent floatables from clogging the pipe and to avoid discharging warmer water at the surface of the pond. The next outlet is sized for the release of other smaller storm events (2- or 10-yr). The primary outlet (often an orifice) invert is located at the maximum elevation associated with the extended detention water quality volume and is sized through routing to release flow at or below the pre-100-yr levels.

    The following types of orifices that may be encountered in a typical pond design are as follows:
    1. Pond drain (to allow maintenance and construction)
    2. Permanent pool orifice (to control volume and allow drawdown)
    3. WQ_v orifice (for ED and MicroPool to control live pool elevation)
    4. Outlets at required flow attenuation levels to control peaks.

    Alternative hydraulic control methods to an orifice can be used and include the use of a broad-crested rectangular, V-notch, or proportional weir, or an outlet pipe protected by a hood that extends at least 12 inches below the permanent pool.
21. The water quality outlet (if designed for a wet ED or micropool ED pond) must be fitted with adjustable gate valves or other mechanism that can be used to adjust detention time.
22. Higher flows pass through openings or slots protected by trash racks further up the riser.
23. Anti-seep collars must be installed on the outlet barrel and an anti-vortex device must be incorporated into the outlet barrel. An energy dissipater must be installed at the stormwater pond pipe outlet to prevent scour at the outlet.

Site and Design Considerations (Continued)

24. Stormwater ponds must have a bottom drain with an adjustable valve that can completely drain the pond within 24 hours. The pond drain should be sized one pipe size larger than the calculated design diameter. The drain valve is typically a handwheel activated knife or gate valve. Valve controls must be located inside of the riser at a point where they will not likely be inundated and can be operated in a safe manner.
25. Access to the riser must be provided by lockable manhole covers and manhole steps within easy reach of valves and other controls.

Outlet Design Considerations

26. Proper hydraulic design of the outlet is critical to achieving good performance of the stormwater pond. 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 the intended 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) Notched weir and 2) perforated riser. The notched weir will not clog as easily, and is therefore preferred. Details for designing outlets/orifices are found in the Design Procedures Step # 6 and in Volume 2, Chapter 8.

Emergency spillway

27. An emergency spillway must be included in the stormwater pond design to safely pass large storm events. The spillway prevents overtopping of the embankment in large storm events and causing structural damage. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.
28. A minimum of 1 foot of freeboard must be provided, measured from the top of the water surface elevation for the 100-year storm event to the lowest point on the top of berm. The emergency spillway crest elevation will be slightly below the 100-year storm elevation, determined by the amount of flow calculated over the weir to match post- to pre-conditions.

Landscaping

29. Aquatic vegetation can play an important role in pollutant removal in a stormwater pond. In addition, vegetation can enhance the appearance of the pond, stabilize the side slopes and serve as wildlife habitat. Therefore, wetland plants are encouraged in a pond design, along with the aquatic bench (fringe wetlands), the safety bench and side slopes, and within shallow areas of the pool itself. The best elevations for establishing wetland plants, either by transplantation or volunteer colonization, are within 6 inches (plus or minus) of the permanent pool elevation. Information about wetland plants can be found at TVA's Native Plant Selector that can be found at: http://www.tva.gov/river/landandshore/stabilization/plantsearch.htm.
30. Woody vegetation must not be planted on the embankment or allowed to grow within 15 feet of the toe of the embankment and within 25 feet from the principle spillway.

Site and Design Considerations (Continued)

31. Fish such as *Gambusia affinis* can be stocked for mosquito control if necessary.
32. A fountain or aerator may be beneficial for oxygenating water in the permanent pool. Considerations must be given in the design of this fountain or aerator not to disturb settling within the pond or prevent settling. Use of such fountains is discouraged during storm events.

As-Built Certification

An as-built certification of the pond by a registered professional engineer, must be submitted to Metro prior to the release of the site's bond or issuance of a Use and Occupancy permit. The as-built certification must verify that the BMP was installed as designed and approved. If components of the stormwater pond constructed in the field differ from the design approved by Metro, the as-built certification must:

1. Note any differences between the measure in the field and the design approved by Metro;
2. Demonstrate that the design meets the requirements of Metro's stormwater program; and/or
3. Propose additional measures to be included on the site to mitigate the differences.

The following components should be addressed in the as-built certification:

- Sediment forebay of sufficient size to pretreat runoff.
- Access to all components of the pond.
- Sufficient water depth to prevent the creation of stagnant water.
- Depth of treatment area.
- Side slopes and benches created as noted in the plans.
- Properly functioning spillway systems.

Operation and Maintenance

Each BMP on a site must be addressed in the overall Operations and Maintenance (O&M) Agreement (refer to Volume 1, Appendix C) for the development and submitted to Metro for approval with the plans submittal. This information should be included in the O&M Agreement for the development.

The O&M Agreement is to be used by the BMP owner or owners in performing routine inspections. The owner is responsible for the cost of maintenance and annual inspections, and maintaining and updating the BMP operations and maintenance plan at least annually. At a minimum, the operations and maintenance plan must address:

1. The inspection of the embankment and spillway components;
2. The removal of sediment deposits from the forebay and permanent pool area;
3. The removal of spillway blockages or dead vegetation.

Design Procedures

Design Procedures for standard wet pond, extended detention, and micropool extended detention ponds are described separately below. Some of the steps for extended detention and micropool extended detention ponds are the same as for a standard wet pond and these common steps will refer back to the standard wet pond design steps.

Design Procedures for Wet Pond

Wet Pond

Step 1. Compute the Water Quality Volume.

Calculate (WQ_v).

$$\mathbf{WQ_v = P \times Rv \times A/12}$$

Where:

WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$\mathbf{Rv = 0.015 + 0.0092I}$$

Where:

I = site impervious cover, % (for example, 50% imperviousness is 50)

Step 2. Determine if the development site and conditions are appropriate for the use of the wet pond.

Consider the Site and Design Considerations discussed previously in this section. Available land area and drainage area are key components.

Step 3. Determine pretreatment volume.

A sediment forebay is sized for each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4-6 feet deep. The forebay storage volume (F_v) counts toward the total WQ_v requirement and may be subtracted from the WQ_v for subsequent calculations.

$$\mathbf{F_v = 0\ .1\ inches \times A_I\ acres \times .0833}$$

Where:

F_v = Forebay volume (ac-ft)
A_I = Impervious area of drainage basin, acres
0.0833 = conversion factor of acre inches to acre feet

Design Procedures for Wet Pond (Continued)

Often, it is more manageable to work with forebay volumes in cubic feet rather than acre feet, because they are small volumes. To convert F_v in acre feet to cubic feet, multiply F_v by 43560 square feet.

Step 4. Determine permanent pool volume.

Size permanent pool volume to 1.0 WQ_v.

Step 5. Determine pond preliminary geometry and storage available for pool areas.

Establish contours and determine the stage-storage relationship for the pond. Include safety and aquatic benches. Any live pool volume is dependent on the necessity for flow attenuation only. If no flow attenuation is necessary, no live pool is necessary.

Step 6. Size the outlet system for other storm events.

If the pond is to serve as a multifunctional pond addressing flow attenuation, the downstream impacts must be considered for the 2- through 100-year storm events. Determine the downstream point in the watershed where the proposed site makes up 10% or less of the total drainage area to the point in question (considered the 10% point). Check the peak discharge for pre- and post-development runoff rates at the 10% point and at major junctions within the downstream watershed. Where an increase is realized, the stormwater pond can be designed for flow attenuation to the pre-development runoff rate or less through the use of multiple orifices in the primary spillway structure. (See Volume 2, Chapter 8).

Establish a stage-storage-discharge relationship for the design storms of interest, based upon the downstream analysis (see Section 6.6.1 in Volume 1).

Step 7. Design embankment and spillway.

Size emergency spillway for any overtopping of pond in case of rain event in excess of 100-year and for instances of malfunction/clogging of primary outlet structure.

Step 8. Investigate potential dam hazard classification.

The design and construction of ponds in Tennessee must follow the requirements of the Safe Dams Act. Contact the Tennessee Department of Environment and Conservation, Division of Water Supply for more information about building dams in Tennessee.

Design Procedures for Wet Pond (Continued)

Step 9. Design inlets, sediment forebays, outlet structures, maintenance access and safety features.

See the *Site and Design Considerations* section for information on design.

Step 10. Prepare the vegetation and landscaping plan.

See the Landscaping section of *Site and Design Considerations* section.

Design Procedures for Wet Extended Detention (ED) Pond

Wet Extended Detention (ED) Pond

Step 1. Compute the Water Quality Volume.

Calculate (WQ_v).

$$WQ_v = P \times Rv \times A/12$$

Where:

WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$Rv = 0.015 + 0.0092I$$

Where:

I = site impervious cover, % (for example, 50% imperviousness is 50)

Step 2. Determine if the development site and conditions are appropriate for the use of the wet ED pond.

See standard Wet Pond Design Procedures Step 2.

Step 3. Determine pretreatment volume.

See standard Wet Pond Design Procedures Step 3.

Step 4. Determine permanent pool volume.

Size permanent pool volume to 0.5 WQ_v. Size extended detention volume to 0.5 WQ_v.

Design Procedures for Wet Extended Detention (ED) Pond (Continued)

Step 5. Determine pond preliminary geometry and storage available for pool areas.

Establish contours and determine the stage-storage relationship for the pond. Include safety and aquatic benches.

Set permanent pool elevation and live pool elevation based on volume calculated previously.

Step 6. Compute extended detention orifice release rate(s).

Based on the elevations established in Step 5 for the extended portion of the water quality volume, the water quality orifice is sized to release this extended detention volume in 24-48 hours. The water quality orifice should have a minimum diameter of 3 inches or use the perforated riser pipe and should be adequately protected from clogging by an acceptable external trash rack. A reverse slope pipe attached to the riser, with its inlet submerged 1 foot below the elevation of the permanent pool, is a recommended design. Adjustable gate valves can also be used to achieve this equivalent diameter.

Three different types of control structures are listed below. More information can be found on the design of outlet structures in Volume 2, Chapter 8.

Flow Control Using a "V" Notch Weir
The outlet control "V" notch weir should be sized using the following formula (Metro, 2000). See Figure 1.8

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

Where

θ = notch angle, in degrees
H = head or elevation of water over the weir, ft
C_1 = discharge coefficient (see Figure 1.9)

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 (Metro, 2000).

$$a = \frac{2A(H - H_o)^{0.5}}{3600CT(2g)^{0.5}}$$

Design Procedures for Wet Extended Detention (ED) Pond (Continued)

Where:
a = area of orifice (ft^2)
A = average surface area of the pond (ft^2)
C = orifice coefficient, 0.66 or 0.80
T = drawdown time of pond (hrs)(must be greater than 24 hours)
g = gravity (32.2 ft/sec^2)
H = elevation when pond in full (ft)
H_o= final elevation when pond is at permanent pool elevation (ft)

With a drawdown time of 40 hours the equation becomes:

$$a = \frac{(1.75x10^{-5})A(H-H_o)^{0.5}}{CT}$$

Care must be taken in the selection of "C": 0.60 is most often recommended and used. However, based on actual tests the following is recommended:

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.

Flow Control Using the Perforated Riser
For outlet control using the perforated riser as the outflow control, incorporate flow control for the small storms in the perforated riser but also provide an overflow outlet for large storms, as illustrated in Figure 1.10. If properly designed, see Table 1.1, the facility can be used for both water quality and quantity 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. 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.

Table 1.1 Perforated Riser Sizing Guidance *(Metro, 2000)*

Riser Pipe Diameter	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 per row	1 in. (2.54 cm)
10 in. (25.4 cm)	2.5 in. (6.4 cm)	16 per row	1 in. (2.54 cm)

Design Procedures for Wet Extended Detention (ED) Pond (Continued)

Step 7. Size the primary spillway system for other storm events.

See standard Wet Pond Design Procedures Step 6.

Step 8. Design embankment and spillway.

Size emergency spillway for any overtopping of pond in case of rain event in excess of 100-year and for instances of malfunction/clogging of primary outlet structure.

Step 9. Investigate potential dam hazard classification.

The design and construction of ponds in Tennessee must follow the requirements of the Safe Dams Act. Contact the Tennessee Department of Environment and Conservation, Division of Water Supply for more information about building dams in Tennessee.

Step 10. Design inlets, sediment forebays, outlet structures, maintenance access and safety features.

See the *Site and Design Considerations* section for information on designing these features

Step 11. Prepare the vegetation and landscaping plan.

See the Landscaping section of *Site and Design Considerations* section.

Design Procedures for Micropool ED Pond

Micropool ED Pond

Step 1. Compute the Water Quality Volume.

Calculate (WQ_v).

$$\mathbf{WQ_v = P \times Rv \times A/12}$$

Where:

WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$Rv = 0.015 + 0.0092I$$

Where:

I = site impervious cover, % (for example, 50% imperviousness is 50)

Design Procedures for Micropool ED Pond (Continued)

Step 2. Determine if the development site and conditions are appropriate for the use of the wet pond.

See standard Wet Pond Design Procedures Step 2.

Step 3. Determine pretreatment volume.

See standard Wet Pond Design Procedures Step 3.

Step 4. Determine permanent pool volume.

Size permanent pool volume to minimum of either 20% of WQ_v or 0.1 inch per impervious acre. Size extended detention volume (live pool) to remainder of WQ_v.

Step 5. Determine pond preliminary geometry and storage available for pool areas.

Establish contours and determine the stage-storage relationship for the pond. Include safety and aquatic benches.

Set micropool permanent pool elevation and live pool elevation based on volume calculated previously.

Step 6. Compute extended detention orifice release rate(s).

See standard Wet ED Design Procedures Step 6.

Step 7. Size the primary spillway system for other storm events.

See standard Wet Pond Design Procedures Step 6.

Step 8. Design embankment and spillway.

Size emergency spillway for any overtopping of pond in case of rain event in excess of 100-year and for instances of malfunction/clogging of primary outlet structure.

Step 8. Design embankment and spillway.

Size emergency spillway for any overtopping of pond in case of rain event in excess of 100-year and for instances of malfunction/clogging of primary outlet structure.

Design Procedures for Micropool ED Pond (continued)

Step 9. Investigate potential dam hazard classification.

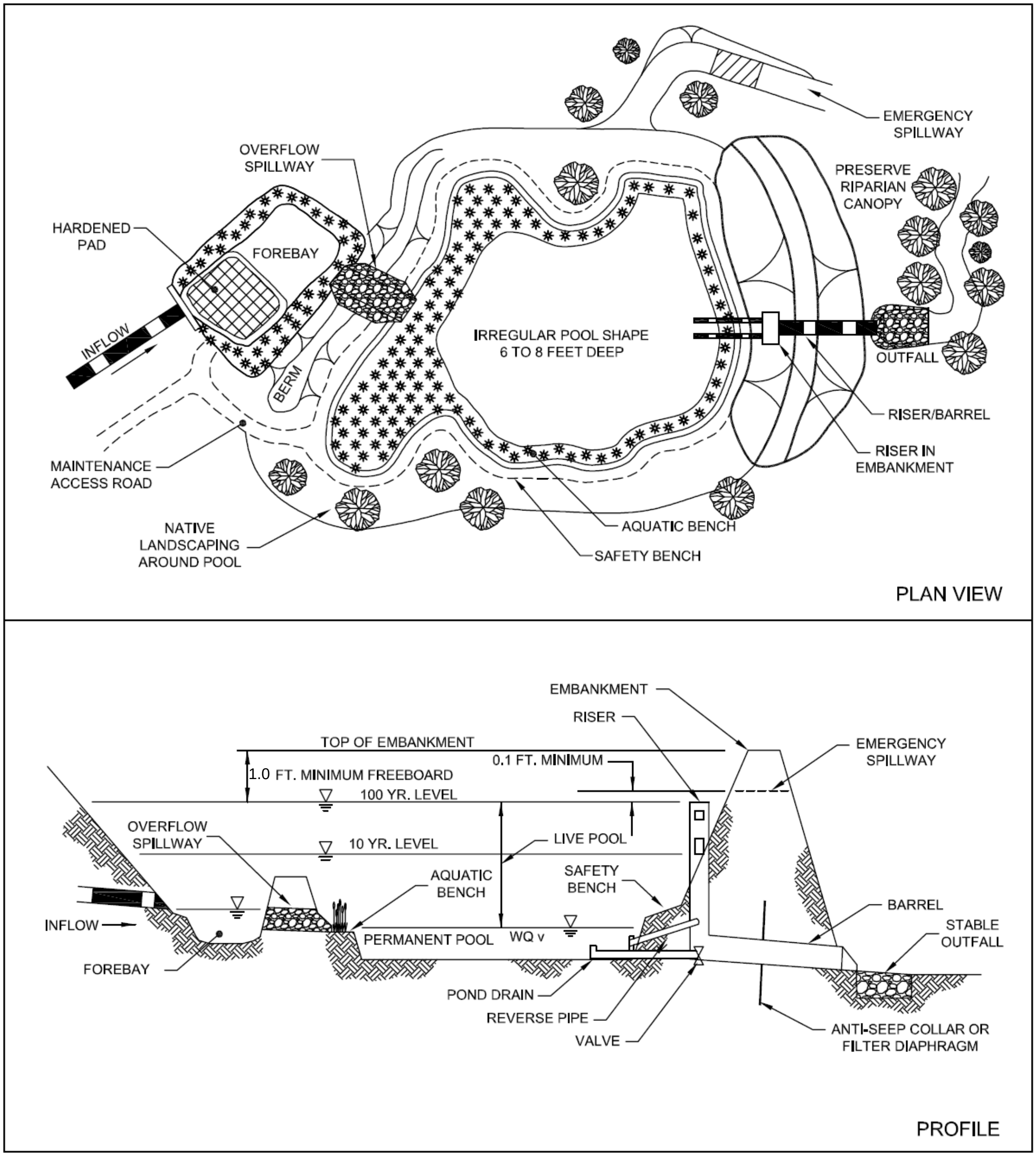
The design and construction of ponds in Tennessee must follow the requirements of the Safe Dams Act. Contact the Tennessee Department of Environment and Conservation, Division of Water Supply for more information about building dams in Tennessee.

Step 10. Design inlets, sediment forebays, outlet structures, maintenance access and safety features.

See the *Site and Design Considerations* section for information on designing these features.

Step 11. Prepare the vegetation and landscaping plan.

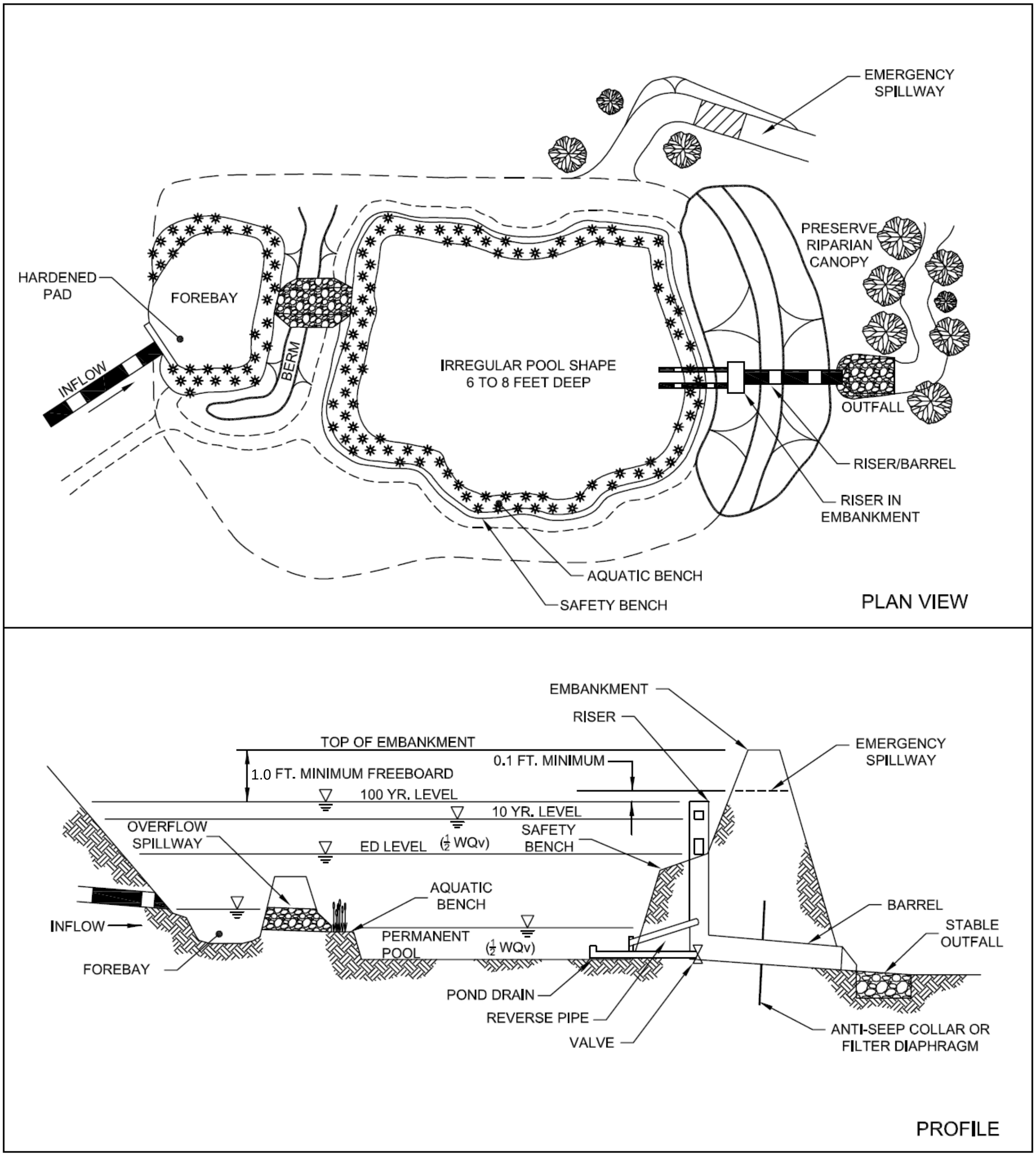
See the Landscaping section of *Site and Design Considerations* section.



Note: Storm attenuation levels vary depending on site detention requirements.

(Adapted from the Center for Watershed Protection)

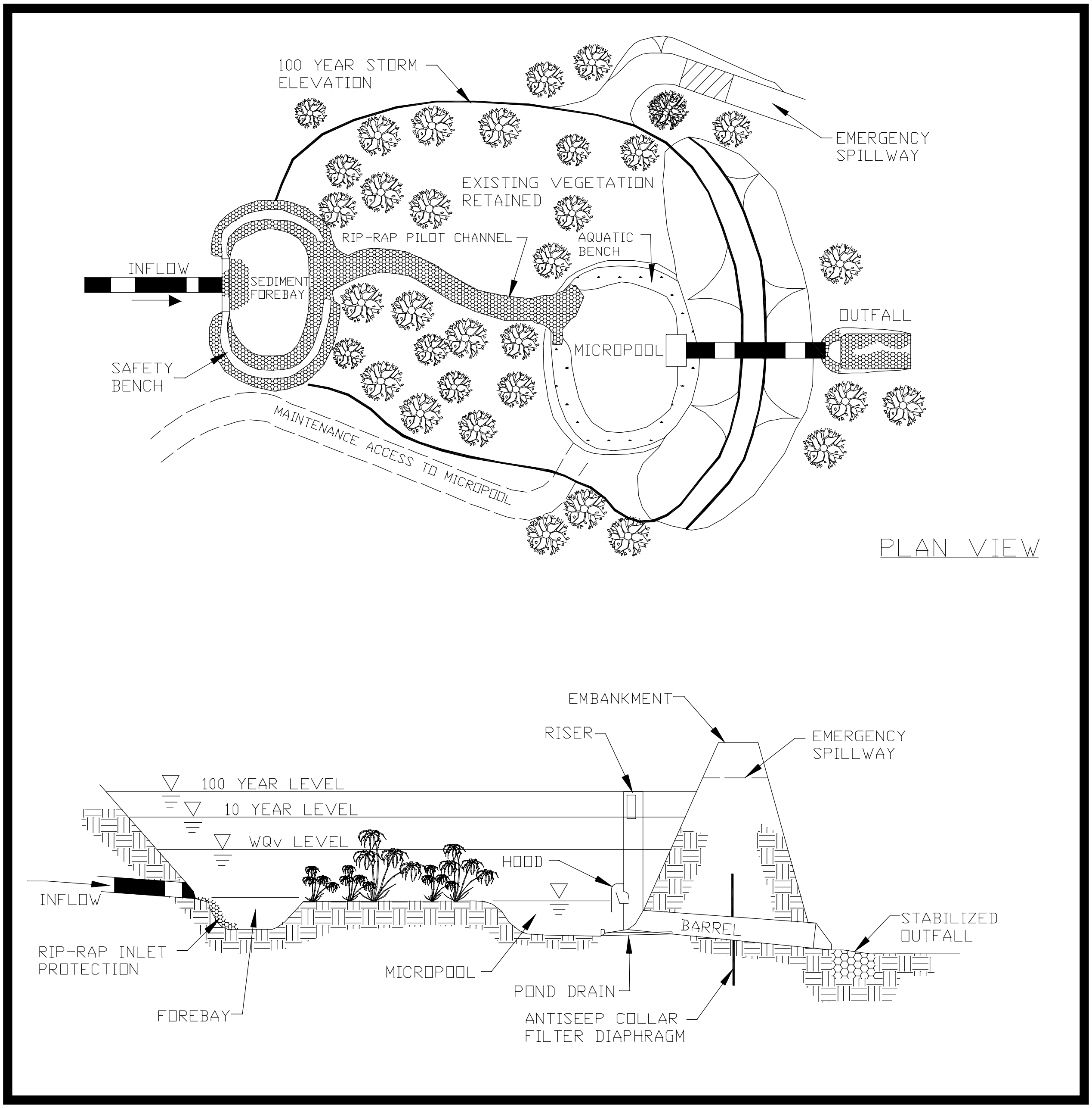
Figure 1.1 Typical Schematic for a Wet Pond



Note: Storm attenuation levels vary depending on site detention requirements.

(Adapted from the Center for Watershed Protection)

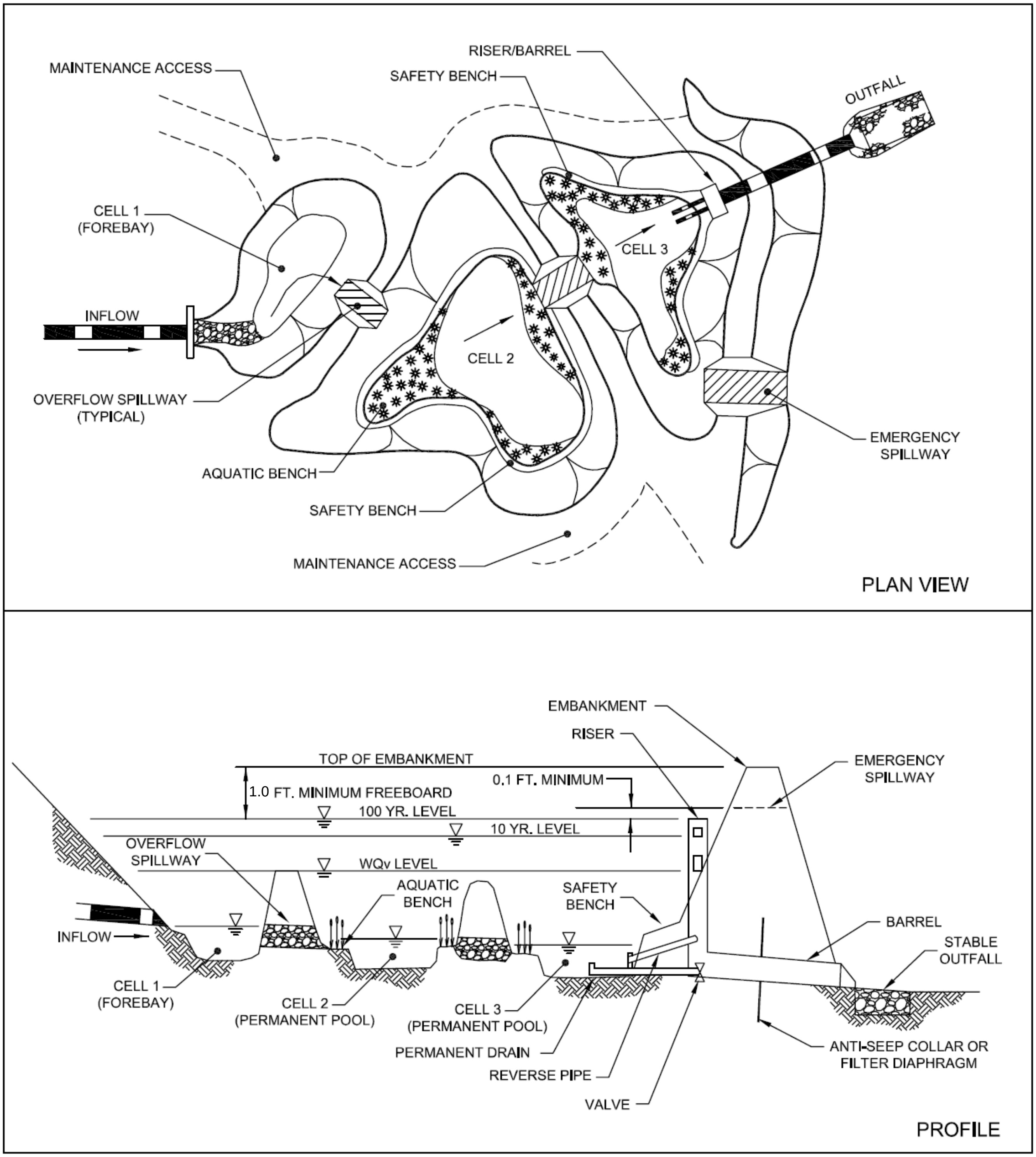
Figure 1.2 Wet Extended Detention Pond



Note: Storm attenuation levels vary depending on site detention requirements.

(Source: Center for Watershed Protection)

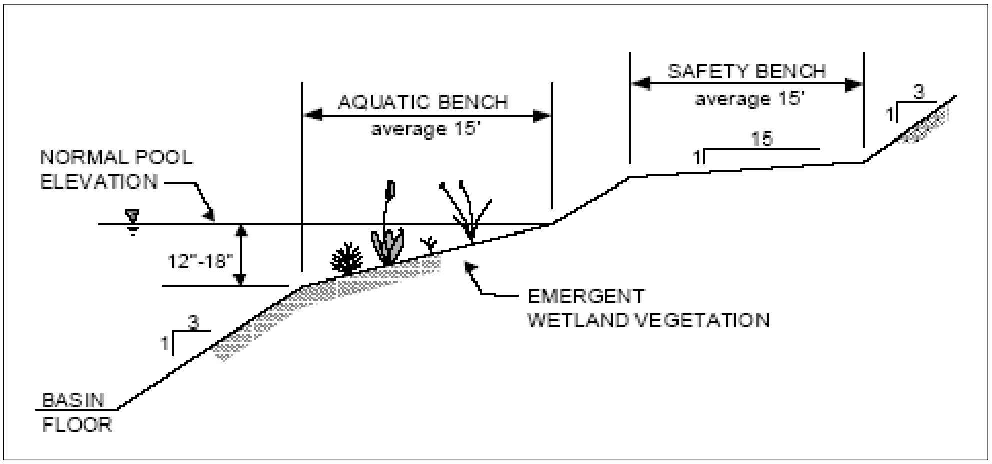
Figure 1.3 Micropool Extended Detention Pond



Note: Storm attenuation levels vary depending on site detention requirements.

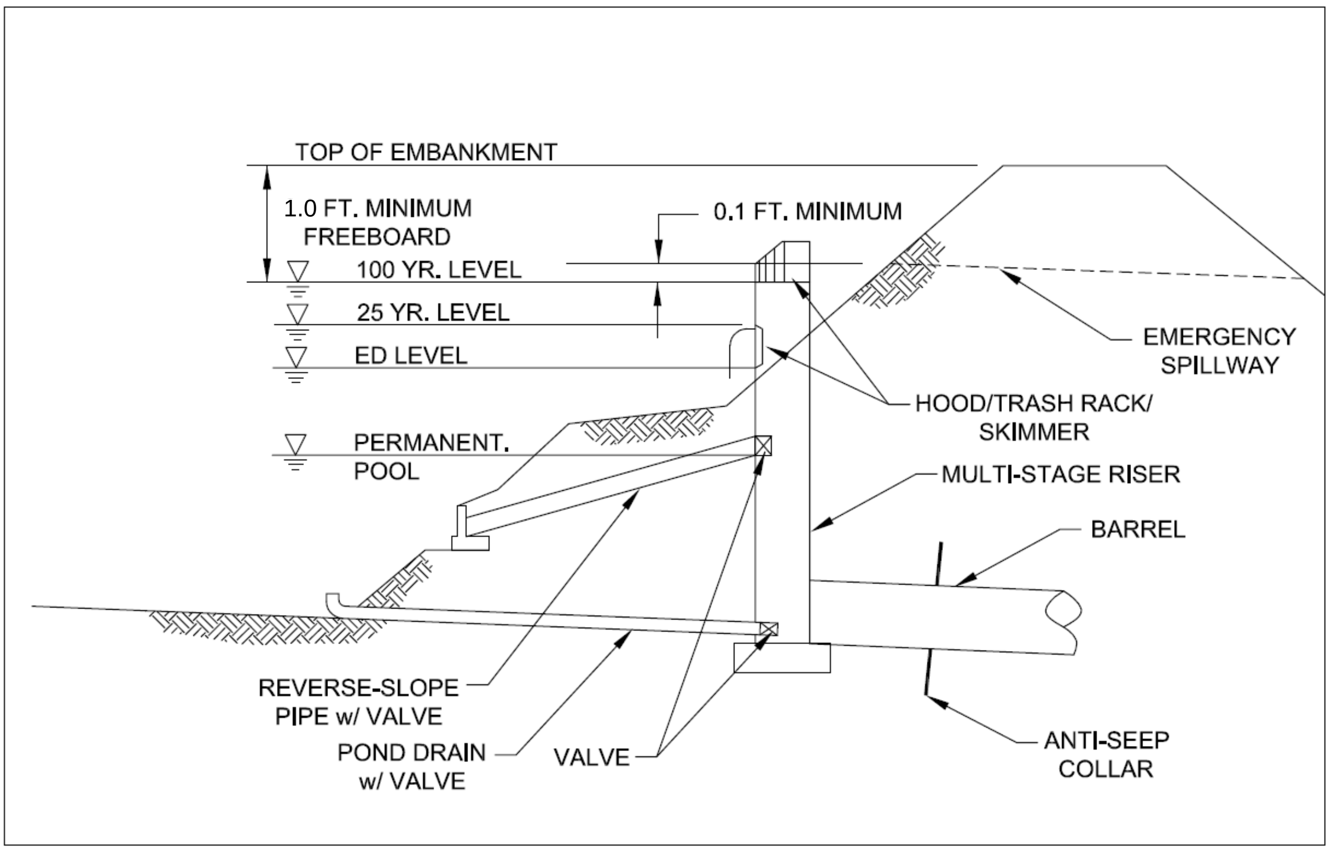
(Adapted from the Center for Watershed Protection)

Figure 1.4 Multiple Pond System



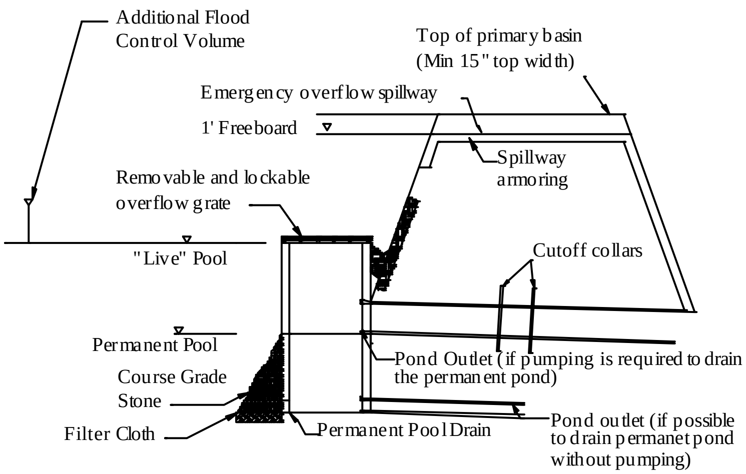
(Adapted from the Center for Watershed Protection)

Figure 1.5 Stormwater Pond Cross-Section with Benches

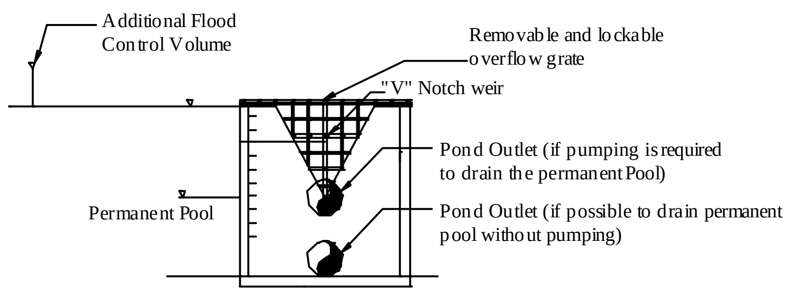


(Adapted from the Center for Watershed Protection)

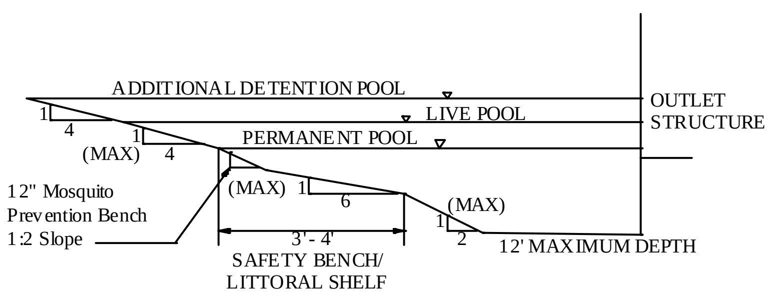
Figure 1.6 Outlet Configuration (Includes Extended Detention Level)



SECTION OUTLET STRUCTURE
NTS



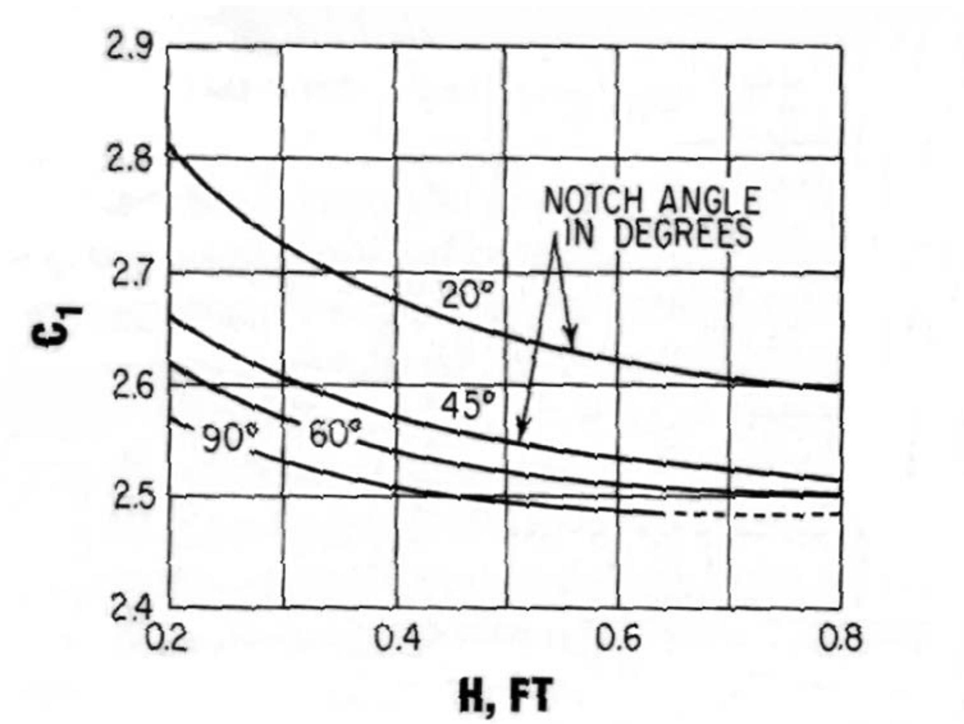
PROFILE OUTLET STRUCTURE
NTS



POND GRADING
NTS

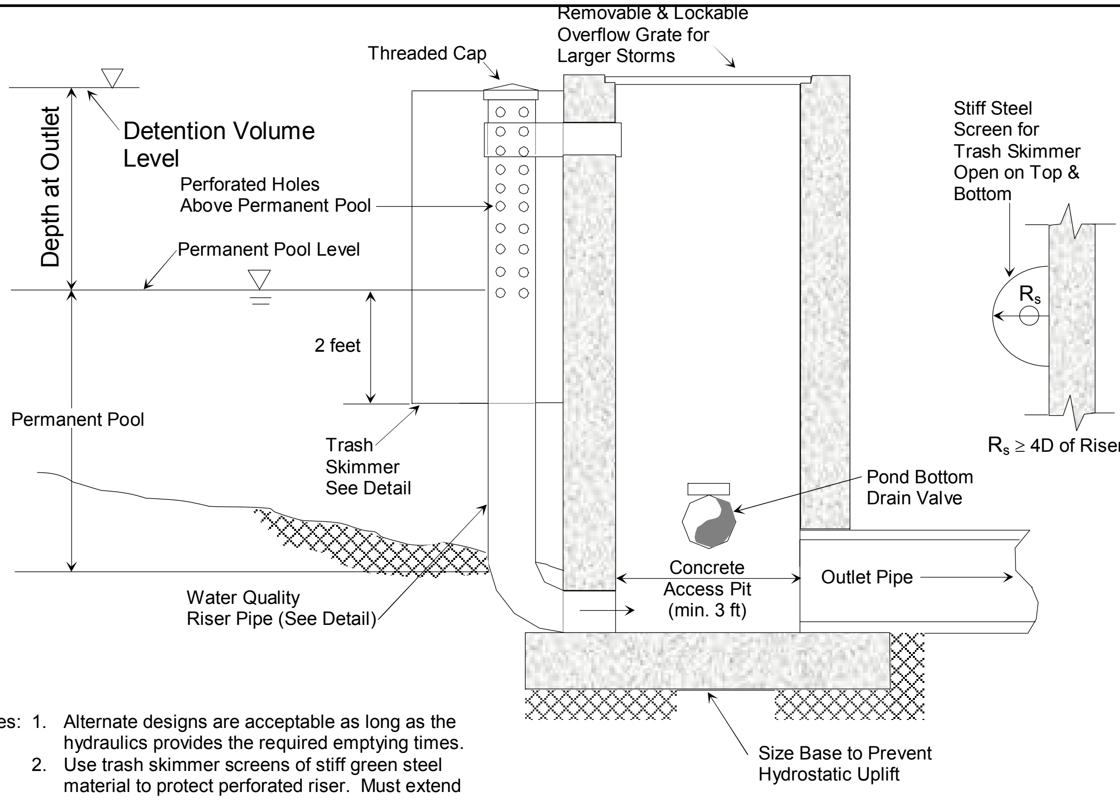
(Source: Metro, 2000)

Figure 1.7 V-Notch Weir Outlet Structure



(Source: Metro, 2000)

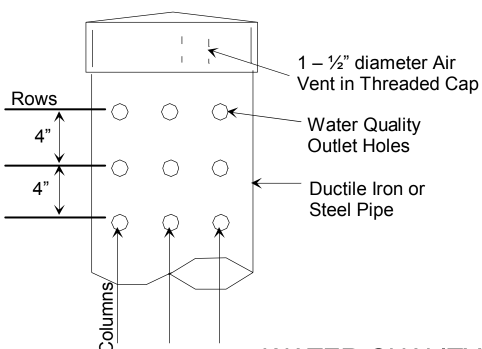
Figure 1.8 Sharp-Crested V-Notch Weir Discharge Coefficients



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.



WATER QUALITY
RISER

See Table 1.1, page 13 for perforated riser design guidance.

(Adapted from Metro, 2000)

Figure 1.9 Perforated Riser Outlet Structure

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Suggested Reading

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Walker, W., 1987, "Phosphorus Removal by Urban Runoff Detention Basins", in Lake and Reservoir Management, North American Society for Lake Management, 314.

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Constructed Wetlands

Description: Constructed wetland systems that are designed specifically for the purpose of managing stormwater. Runoff volume is stored and pollutants are removed in the wetland facility.

Variations: Pocket wetland, pond/wetland system, shallow wetland, extended detention shallow wetland.

Components:
- Ponding area – for water quality treatment through settling, biological, and chemical processes
- Marsh area – for water quality treatment through plant uptake; provides some filtering as well
- Forebay – settles larger sediments before entering pond; aids maintenance
- Spillway system(s) – provides control of pond discharge

Advantages/Benefits:
- High removal of typical urban stormwater pollutants
- Provides habitat for wildlife
- Can be designed for multi-objective use, including water quantity control
- Can be designed to treat stormwater from multiple developments

Disadvantages/Limitations:
- Requires a large amount of land to construct
- Can cause nuisance problems if not properly designed, installed and maintained
- Needs constant source of water to maintain function
- Wetland area can quickly become filled with sediment, causing the wetland to fail
- Warm water discharged from wetland can cause habitat degradation downstream

Design considerations:
- Minimum drainage area is 25 acres; 5 acres for pocket wetland
- Flow path through the wetland system should be 2:1 (length: width); may need serpentine system to be created internally
- Must design marsh area and ponding area through a water balance to ensure wetland does not fail in droughts

Selection Criteria:

- ✓ **Water Quality 80 % TSS Removal**
- ✓ **Accepts Hotspot Runoff**
- ✓ **Residential Subdivision**
- ✓ **High Density / Ultra Urban Use**

Maintenance:
- Remove accumulated sediments
- Remove invasive vegetation
- Harvest vegetation every 5 years to prevent overgrowth of plants and a reduced water storage

Maintenance Burden

M	Shallow Wetland
M	ED Shallow Wetland
H	Pocket Wetland
M	Pond/Wetland

L = Low M = Moderate H = High

General Description

Constructed wetlands, or stormwater wetlands, are constructed basin marsh systems that are designed to both treat urban stormwater for pollutants and control runoff volumes. The basin has a sediment forebay for coarse sediments. Runoff then flows through shallow marsh (also called, high marsh) and deep marsh (also called, low marsh) areas (see Figure 2.1). As stormwater runoff flows through the wetland facility, pollutant removal is achieved through settling and uptake by marsh vegetation. Wetlands are among the most effective stormwater practices for pollutant removal and they offer aesthetic value and wildlife habitat. Constructed stormwater wetlands differ from natural wetland systems because they are engineered facilities designed specifically for the purpose of treating stormwater runoff and typically have less biodiversity than natural wetlands both in terms of plant and animal life. However, as with natural wetlands, stormwater wetlands require a continuous base flow or a high water table to support aquatic vegetation.

There are several design variations of the stormwater wetland. Each design differs in the relative amounts of shallow and deep water, and dry storage above the wetland. These include the shallow wetland, the extended detention shallow wetland, pond/wetland system and pocket wetland. Below are descriptions of each design variant.

Shallow Wetland – In the shallow wetland design, most of the water quality treatment volume is in high marsh or relatively shallow low marsh depths. The only deep portions of the shallow wetland design are the forebay at the inlet to the wetland, and the micropool at the outlet. One disadvantage of this design is that, since the marsh area is very shallow, a relatively large amount of land is typically needed to store the water quality volume.

Extended Detention (ED) Shallow Wetland – The extended detention (ED) shallow wetland design is the same as the shallow wetland; however, part of the water quality treatment volume is provided as extended detention above the surface of the marsh and released over a period of 24 hours. This design can treat a greater volume of stormwater in a smaller space than the shallow wetland design. In the extended detention wetland option, plants that can tolerate both wet and dry periods need to be specified in the ED zone, since plants this zone is sometimes dry.

Pond/Wetland Systems – The pond/wetland system has two separate cells: a wet pond and a shallow marsh. The wet pond traps sediments and reduces runoff velocities prior to entry into the wetland, where stormwater flows receive additional treatment. Information on designing wet ponds is found in PTP-01. Less land is required for a pond/wetland system than for the shallow wetland or the ED shallow wetland systems.

Pocket Wetland – A pocket wetland is intended for smaller drainage areas of 5 to 10 acres and typically requires excavation down to the water table

Site and Design Considerations

for a reliable water source to support the wetland system.

Location and Siting

1. Stormwater wetlands should normally have a minimum contributing drainage area of 25 acres or more. For a pocket wetland, the minimum drainage area is 5 acres.
2. A continuous base flow or high water table is required to support wetland vegetation. A water balance must be performed to demonstrate that a stormwater wetland can withstand a 30-day drought at summer evaporation rates without completely drawing down. (See Step #2 of Design Procedure for water balance calculation).
3. Wetland siting should also take into account the location and use of other site features such as natural depressions, buffers, and undisturbed natural areas, and should attempt to aesthetically "fit" the facility into the landscape. Bedrock close to the surface may prevent excavation.
4. Stormwater wetlands cannot be located within navigable waters of the U.S., including wetlands, without obtaining a Section 404 permit under the Clean Water Act, and any other applicable State permit. In some isolated cases, a wetlands permit may be granted to convert an existing degraded wetland in the context of local watershed restoration efforts.
5. A wetland facility may be designed as either an on-line or off-line system. It is recommended that higher flows be slowed to prevent erosion and wetland vegetation mortality.
6. For various reasons, it is suggested that wetlands be setback from certain areas. Some suggested minimum setbacks for stormwater wetland facilities are as follows:
   1. From a property line – 10 feet
   2. From a private well – 100 feet; if well is down gradient from a hotspot land use then the minimum setback is 250 feet
   3. From a septic system tank/leach field – 50 feet
7. All utilities should be located outside of the wetland site.

General Design

8. A well-designed stormwater wetland consists of:
   1) Shallow marsh areas, which vary in depth, with wetland vegetation,
   2) Permanent micropool, and
   3) Overlying zone in which runoff control volumes are stored.
9. Pond/wetland systems include a stormwater pond (see PTP-01 for design information).
10. In addition, **all wetland designs must include a sediment forebay at the inflow** to the facility to allow heavier sediments to drop out of suspension before the runoff enters the wetland marsh. (See sediment forebay design information in PTP-01).
11. Additional pond design features include an **emergency spillway, maintenance access, safety bench, wetland buffer, and appropriate wetland vegetation and native landscaping**.

Site and Design Considerations (Continued)

12. Figures 2.2 through 2.5 provide plan view and profile schematics for the designs of shallow, ED shallow, pond/wetland, and pocket wetlands.

Physical Specifications/Geometry

13. In general, wetland designs are unique for each site and application. However, there are number of geometric ratios and limiting depths for the design of a stormwater wetland that must be observed for adequate pollutant removal, ease of maintenance, and improved safety. Table 2.1 provides the recommended physical specifications and geometry for the various stormwater wetland design variants.

Table 2.1 Recommended Design Criteria for Stormwater Wetlands

Modified from Massachusetts DEP, 1997; Schueler, 1992

Design Criteria	Shallow Wetland	ED Shallow Wetland	Pond/ Wetland	Pocket Wetland
Length to Width Ratio (minimum)	2:1	2:1	2:1	2:1
Extended Detention (ED)	No	Yes	Optional	Optional
Allocation of WQ_v Volume (pool/marsh/ED) in %	25/75/0	25/25/50	70/30/0 (includes pond volume)	25/75/0
Allocation of Surface Area (deepwater/low marsh/high marsh/semi-wet) in %	20/35/40/5	10/35/45/10	45/25/25/5 (includes pond surface area)	10/45/40/5
Forebay	Required	Required	Required	Optional
Micropool	Required	Required	Required	Required
Outlet Configuration	Reverse-slope pipe or hooded broad-crested weir	Reverse-slope pipe or hooded broad-crested weir	Reverse-slope pipe or hooded broad-crested weir	Hooded broad-crested weir

Depth:
Deepwater: 1.5 to 6 feet below permanent pool elevation
Low marsh: 6 to 8 inches below permanent pool elevation
High marsh: 6 inches or less below permanent pool elevation
Semi-wet zone: Above permanent pool elevation

Site and Design Considerations (Continued)

14. The stormwater wetland should be designed with the recommended proportion of "depth zones." Each of the four wetland design variants has depth zone allocations which are given as a percentage of the stormwater wetland surface area. Target allocations are found in Table 2.1. The four basic depth zones are:
    - **Semi-wet zone** Those areas above the permanent pool that are inundated during larger storm events. This zone supports a number of species that can survive flooding
    - **High marsh zone** From the permanent pool to 6 inches below the permanent pool. This zone will support a greater density and diversity of wetland species than the low marsh zone. The high marsh zone should have a higher surface area to volume ratio than the low marsh zone.
    - **Low marsh zone** From 6 to 18 inches below the permanent pool or water surface elevation. This zone is suitable for the growth of several emergent wetland plant species.
    - **Deepwater zone** From 1.5 to 6 feet deep to the top of the permanent pool elevation. Includes the outlet micropool and deepwater channels through the wetland facility. This zone supports little emergent wetland vegetation, but may support submerged or floating vegetation.

    .
15. A minimum dry weather flow path of 2:1 (length to width) is required from inflow to outlet across the stormwater wetland and should ideally be greater than 3:1. This path may be achieved by constructing internal dikes or berms, using marsh plantings, and by using multiple cells. Finger dikes are commonly used in surface flow systems to create serpentine configurations and prevent short-circuiting. Microtopography (contours along the bottom of a wetland or marsh that provide a variety of conditions for different species needs and increases the surface area to volume ratio) is encouraged to enhance wetland diversity.
16. A 4 to 6 foot deep micropool must be included in the design at the outlet to prevent the outlet from clogging and resuspension of sediments, and to mitigate thermal effects.
17. Maximum depth of any permanent pool areas should generally not exceed 6 feet.
18. The volume of the extended detention must not comprise more than 50% of the total WQ_v, and its maximum water surface elevation must not extend more than 3 feet above the permanent pool. Storage for larger storms can be provided above the WQ_v elevation.
19. The perimeter of all deep pool areas (4 feet or greater in depth) should be surrounded by safety and aquatic benches similar to those for stormwater ponds (see Stormwater Ponds, PTP-01).
20. The perimeter of the wetland should be irregular to provide a more natural landscaping effect.

Site and Design Considerations (Continued)

Pretreatment/Inlets

21. Sediment regulation is critical to sustain stormwater wetlands. A wetland facility should have a sediment forebay or equivalent upstream pretreatment. A sediment forebay is designed to remove incoming sediment from the stormwater flow prior to dispersal into the wetland. The forebay should consist of a separate cell, formed by an acceptable barrier. A forebay is to be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the wetland facility.
22. The forebay is sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The pretreatment storage volume is part of the total WQ_v requirement and may be subtracted from WQ_v for wetland storage sizing.
23. A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time. The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.
24. Inflow channels are to be stabilized with flared riprap aprons, or the equivalent. Inlet pipes to the pond can be partially submerged. Exit velocities from the forebay must be nonerosive.

Outlet Structures

25. Flow control from a stormwater wetland is typically accomplished with the use of a concrete or corrugated metal riser and barrel. The riser is a vertical pipe or inlet structure that is attached to the base of the micropool with a watertight connection. The outlet barrel is a horizontal pipe attached to the riser that conveys flow under the embankment. The riser should be located within the embankment for maintenance access, safety and aesthetics.
26. A number of outlets at varying depths in the riser provide internal flow control for routing runoff volumes. The number of orifices can vary and is usually a function of the pond design.
27. For shallow and pocket wetlands, the riser configuration is typically comprised of a flood protection outlet (often a slot or weir).

    Since the water quality volume is fully contained in the permanent pool, no orifice sizing is necessary for this volume. An off-line shallow or pocket wetland providing _only_ water quality treatment (not ED) can use a simple overflow weir as the outlet structure.

    In the case of an extended detention (ED) shallow wetland, there is generally a need for an additional outlet (usually an orifice) that is sized to pass the extended detention water quality volume that is surcharged on top of the permanent pool. Flow will first pass through this orifice, which is sized to release the water quality ED volume in 24 hours. The

Site and Design Considerations (Continued)

preferred design is a reverse slope pipe attached to the riser, with its inlet submerged 1 foot below the elevation of the permanent pool to prevent floatables from clogging the pipe and to avoid discharging warmer water at the surface of the pond. The outlet (often an orifice) invert is located at the maximum elevation associated with the extended detention water quality volume.

Alternative hydraulic control methods to an orifice can be used and include the use of a broad-crested rectangular, V-notch, or proportional weir, or an outlet pipe protected by a hood that extends at least 12 inches below the normal pool. (Refer to Stormwater Ponds, PTP-01 for orifice equations.)

28. The water quality outlet (if design is for an ED shallow wetland) should be fitted with adjustable gate valves or other mechanism that can be used to adjust detention time.
29. Higher flows pass through openings or slots protected by trash racks further up on the riser.
30. After entering the riser, flow is conveyed through the barrel and is discharged downstream. Anti-seep collars should be installed on the outlet barrel to reduce the potential for pipe failure.
31. Riprap, plunge pools or pads, or other energy dissipaters are to be placed at the outlet of the barrel to prevent scouring and erosion. If a wetland facility daylights to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance.
32. The wetland facility must have a bottom drain pipe located in the micropool with an adjustable valve that can completely or partially dewater the wetland within 24 hours.
33. The wetland drain should be sized one pipe size greater than the calculated design diameter. The drain valve is typically a handwheel activated knife or gate valve. Valve controls shall be located inside of the riser at a point where they will not normally be inundated and can be operated in a safe manner.
34. See the design procedures in Volume 2 – Procedures of the Stormwater Management Manual for additional information and specifications on pond routing and outlet hydraulics. Orifice sizing is also presented in Stormwater Ponds, PTP-01.

Site and Design Considerations (Continued)

Emergency Spillway

35. An emergency spillway is to be included in the stormwater wetland design to safely pass flows that exceed the design storm flows. The spillway prevents the wetland's water levels from overtopping the embankment and causing structural damage. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.
36. A minimum of 1 foot of freeboard must be provided, measured from the top of the maximum design storm elevation to the lowest point of the dam embankment, not counting the emergency spillway.

Maintenance Access

37. A maintenance right of way or easement must be provided to the wetland facility from a public or private road. Maintenance access should be at least 12 feet wide, have a maximum slope of no more than 15 percent, and be appropriately stabilized to withstand maintenance equipment and vehicles.
38. The maintenance access must extend to the forebay, safety bench, riser, and outlet and, to the extent feasible, be designed to allow vehicles to turn around.
39. Access to the riser is to be provided by lockable manhole covers, and manhole steps within easy reach of valves and other controls.

Safety Features

40. All embankments and spillways must be designed to State of Tennessee guidelines for dam safety.
41. Fencing of wetlands is not generally desirable, but it may be infeasible to leave them unfenced because of community concerns. A preferred method is to manage the contours of deep pool areas through the inclusion of a safety bench (see above) to eliminate drop-offs and reduce the potential for accidental drowning.
42. The principal spillway opening should not permit access by small children, and endwalls above pipe outfalls greater than 48 inches in diameter should be fenced to prevent a hazard.

Landscaping

A landscaping plan should be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of landscaping zones, selection of corresponding plant species, planting plan, sequence for preparing wetland bed (including soil amendments, if needed) and sources of plant material. Landscaping zones include low marsh, high marsh, and semi-wet zones. The low marsh zone ranges from 6 to 18 inches below the permanent pool. This zone is suitable for the growth of several emergent plant species. The high marsh zone ranges from 6 inches below the permanent pool up to the permanent pool.

Site and Design Considerations (Continued)

This zone will support greater density and diversity of emergent wetland plant species. The high marsh zone should have a higher surface area to volume ratio than the low marsh zone. The semi-wet zone refers to those areas above the permanent pool that are inundated on an irregular basis and can be expected to support wetland plants.

43. The landscaping plan should provide elements that promote greater wildlife and waterfowl use within the wetland and buffers.
44. Woody vegetation may not be planted on the embankment or allowed to grow within 15 feet of the toe of the embankment and 25 feet from the principal spillway structure.
45. The wetland shall have a 15-foot setback to structures.
46. To discourage resident geese populations, the area surrounding the constructed wetland can be planted with trees, shrubs and native ground covers. The soils of a wetland buffer are often severely compacted during the construction process to ensure stability. The density of these compacted soils is so great that it effectively prevents root penetration and therefore may lead to premature mortality or loss of vigor. Consequently, it is advisable to excavate large and deep holes around the proposed planting sites and backfill these with uncompacted topsoil.

Other Constraints

- Karst – Requires poly or clay liner to sustain a permanent pool of water and protect aquifers; limits on ponding depth; geotechnical tests may be required
- Hydrologic group "A" soils and some group "B" soils may require liner (not relevant for pocket wetland)

Design Procedures

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v).

$$WQ_v = P \times Rv \times A/12$$

Where: WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$Rv = 0.05 + 0.0092I$$

Where: I = site impervious cover, % (i.e., 50% imperviousness = 50)

Step 2. Determine if the development site and conditions are appropriate for the constructed wetland.

See the *Site and Design Considerations* in the section, above.
Perform Water Balance calculations to ensure that drainage basin has characteristics to support permanent pool. See Volume 2, Section 8.8.1 for an example water balance calculation.

Step 3. Confirm design criteria and applicability to site.

Check with Metro and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 4. Determine pretreatment volume.

A sediment forebay is to be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The forebay storage volume counts toward the total WQ_v requirement and may be subtracted from the WQ_v for subsequent calculations.

$$F_v = 0\ .1 \text{ inches} \times A_I \text{ acres} \times .0833$$

Where:
F_v = Forebay volume (ac-ft)
A_I = Impervious area of drainage basin, acres
0.0833 = conversion factor of acre inches to acre feet

Design Procedures (Continued)

Often, it is more manageable to work with forebay volumes in cubic feet rather than acre feet, because they are small volumes. To convert F_v in acre feet to cubic feet, multiply F_v by 43560 square feet.

<u>Step 5. Allocate the WQ_v among marsh, micropool, and ED volumes.</u>

Use recommended criteria from Table 2.1

<u>Step 6. Determine wetland location and preliminary geometry, including distribution of wetland depth zones.</u>

This step involves initially laying out the wetland design and determining the distribution of wetland surface area among the various depth zones (high marsh, low marsh, and deepwater). Set WQ_v permanent pool elevation (and WQ_v-ED elevation for ED shallow wetland) based on volumes calculated earlier.

Determine if constructed wetland is on-line or off-line. Off-line wetlands require a diversion structure to divert low flows towards wetland and high flows away from wetlands. See Figure 2.6 for example diversion structure and Figure 2.7 for an example of an off-line system.

See the Physical Specifications/Geometry section (pages 4 to 6) of *Site and Design Considerations* for more details.

<u>Step 7. Compute extended detention orifice release rate(s) and size(s), and establish WQ_v elevation.</u>

Shallow Wetland, Pocket Wetland and ED Shallow Wetland: Based on the elevations established in Step 6 for the extended detention portion of the water quality volume, the water quality orifice is sized to release this extended detention volume in 24 hours. The water quality orifice should have a minimum diameter of 3 inches or use a perforated riser, and should be adequately protected from clogging by an acceptable external trash rack. A reverse slope pipe attached to the riser, with its inlet submerged one foot below the elevation of the permanent pool, is a recommended design. Adjustable gate valves can also be used to achieve this equivalent diameter.

*An off-line shallow or pocket wetland providing only water quality treatment can employ a simple overflow weir.

<u>Step 8. Calculate 100-year storm release rate and water surface elevation.</u>

Set up a stage-storage-discharge relationship for the control structure for the extended detention orifice(s) and the 100-year storm.

Design Procedures (Continued)

Step 9. Design embankment(s) and spillway(s).

Size emergency spillway to pass flows larger than the maximum design storm and to pass flows when the inlet bypass (for off-line systems) or outlet structures malfunction. Attenuation may not be required.

Step 10. Design safe design velocity for on-line systems.

For on-line systems, scour and erosion and wetland vegetation mortality may be of concern. Flow velocities must be minims to prevent these conditions. Limit in-flow velocities to less that five feet per second into the wetland area. Energy dissipaters should be used to reduce flow velocities.

Step 11. Investigate potential pond/wetland hazard classification.

The design and construction of ponds in Tennessee must follow the requirements of the Safe Dams Act. Contact the Tennessee Department of Environment and Conservation, Division of Water Supply for more information about building dams in Tennessee.

Step 12. Design inlets, sediment forebay(s), outlet structures, maintenance access, and safety features.

See the *Site and Design Considerations* section for information on design.

Step 13. Prepare Vegetation and Landscaping Plan.

A landscaping plan for the wetland facility should be prepared to indicate how aquatic and terrestrial areas will be stabilized and established with vegetation.

Operations and Maintenance

Each BMP must have an Operations and Maintenance agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for wetlands, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The O&M Agreement is to be used by the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Clean and remove debris from inlet and outlet structures.
2. Mow side slopes. Periodic mowing of the wetland buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year) or forest.
3. Monitor wetland vegetation and perform replacement planting as necessary.
4. Replace wetland vegetation to maintain at least 50% surface area coverage in wetland plants after the second growing season.

Maintenance (Continued)

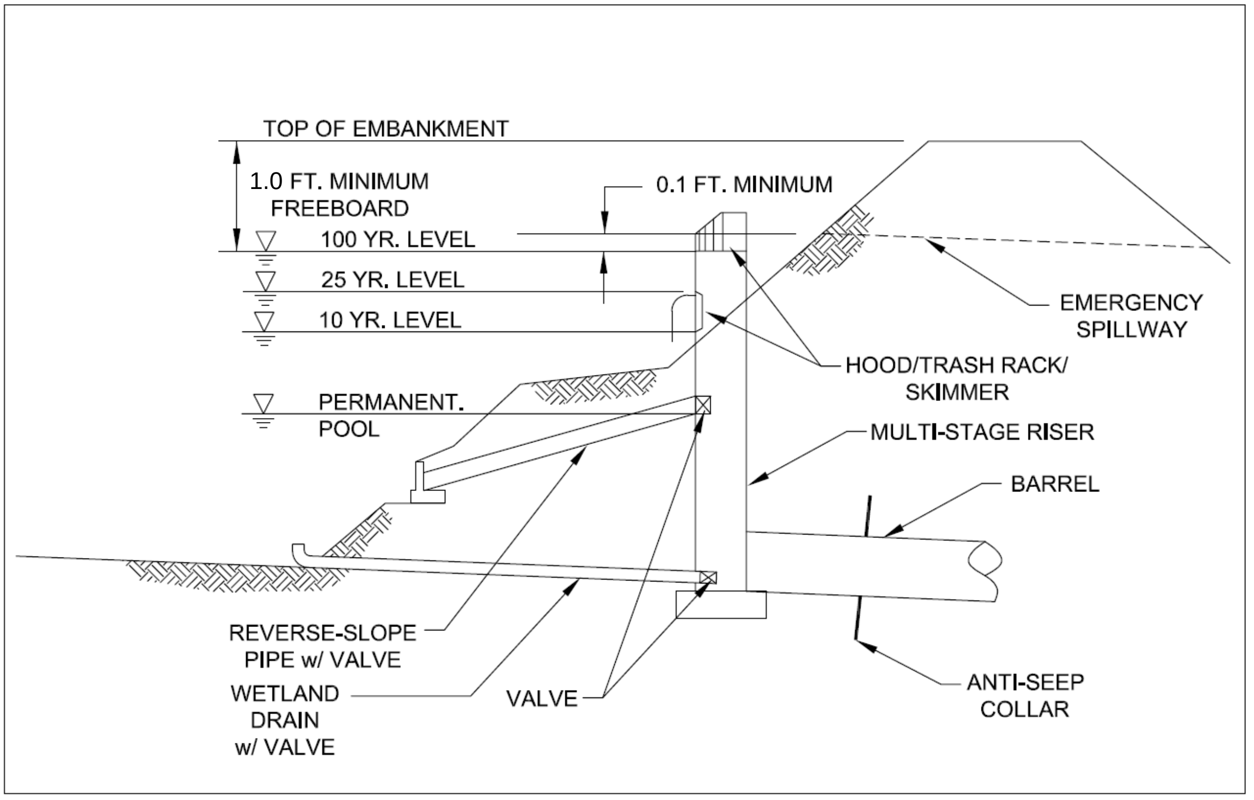
5. Examine stability of the original depth zones and microtopographical features. Inspect for invasive vegetation, and remove where possible.
6. Inspect for damage to the embankment and inlet/outlet structures. Repair as necessary. Note signs of hydrocarbon build-up, and remove appropriately.
7. Monitor for sediment accumulation in the facility and forebay.
8. Examine to ensure that inlet and outlet devices are free of debris and operational.
9. Repair undercut or eroded areas.
10. Harvest wetland plants that have been "choked out" by sediment build-up. A sediment marker should be located in the forebay to determine when sediment removal is required. Monitor sediment accumulations, and remove sediment when the pool volume has become reduced significantly, plants are "choked" with sediment, or the wetland becomes eutrophic.
11. Maintenance requirements for constructed wetlands are particularly high while vegetation is being established. Monitoring during these first years is crucial to the future success of the wetland as a stormwater structural control. Wetland facilities should be inspected after major storms (greater than 2 inches of rainfall) during the first year of establishment to assess bank stability, erosion damage, flow channelization, and sediment accumulation within the wetland. For the first 3 years, inspections should be conducted at least twice a year.
12. Sediments excavated from stormwater wetlands that do not receive runoff from designated hotspots are not considered toxic or hazardous material and can be safely disposed of by either land application or landfilling. Sediment testing may be required prior to sediment disposal when a hotspot land use is present.

As-Built Certification

An as-built certification of the constructed wetland performed by a registered Professional Engineer must be submitted to Metro prior to the release of the site's bond or issuance of a Use and Occupancy permit. The as-built certification verifies that the BMP was installed as designed and approved. If components of the stormwater wetland constructed in the field differ from the design approved by Metro, the as-built certification must: (1) Note the differences between the measure in the field and the design approved by Metro; (2) Demonstrate that the design meets the requirements of Metro's stormwater program; and/or (3) Propose additional measures to be included on the site to mitigate the differences.

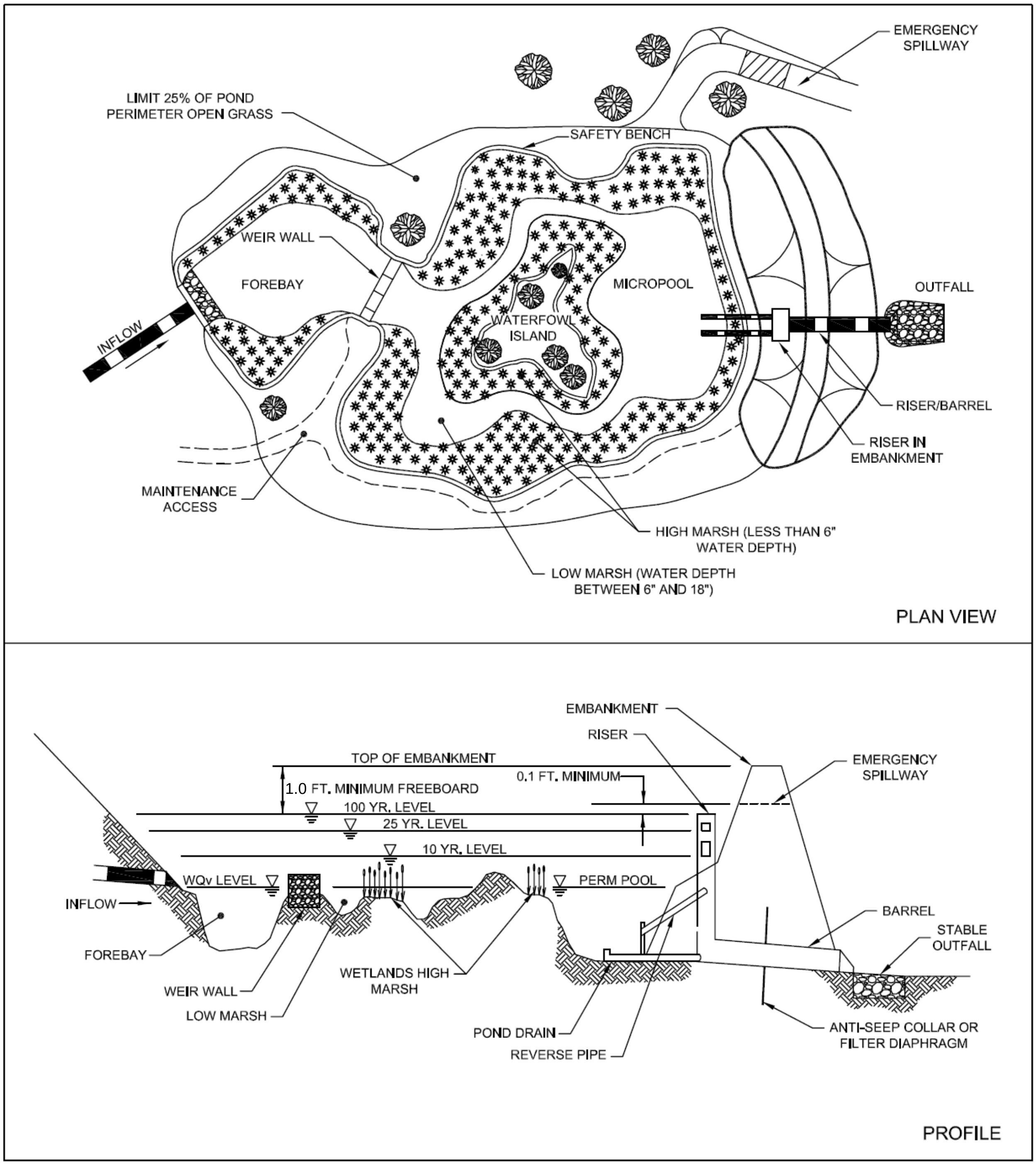
The following components should be addressed in the as-built certification:

- Sediment forebay of sufficient size to pretreat runoff.
- Access to all components of the wetland for maintenance
- Sufficient water depth to prevent the creation of stagnant water.
- Depth of treatment area.
- Side slopes and benches created as noted in the plans.
- Properly functioning spillway systems.



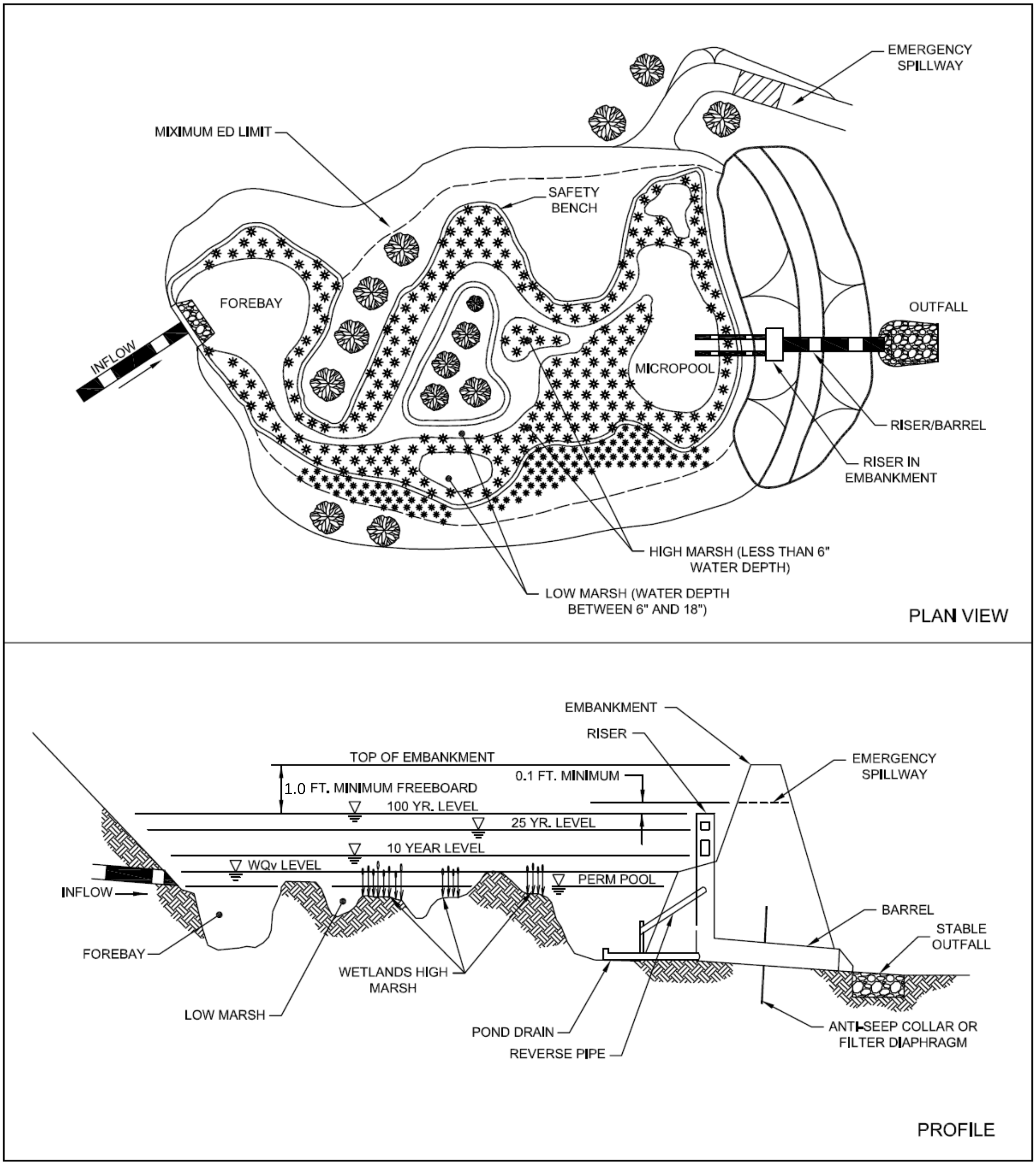
(Adapted from Center for Watershed Protection)

Figure 2.1 Typical Wetland Facility Outlet Structure



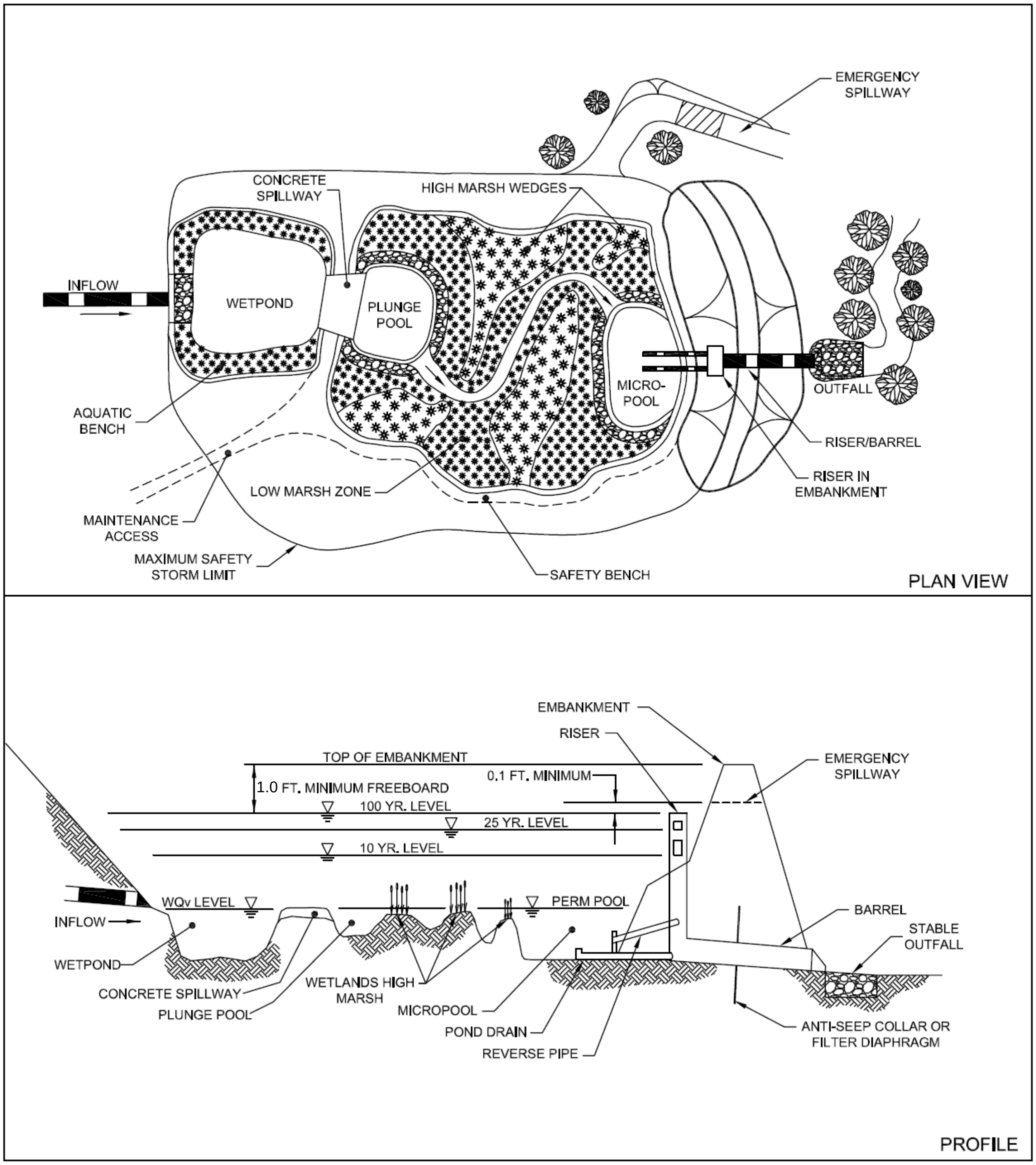
(*Source: Center for Watershed Protection*)

Figure 2.2 Schematic of Shallow Wetland



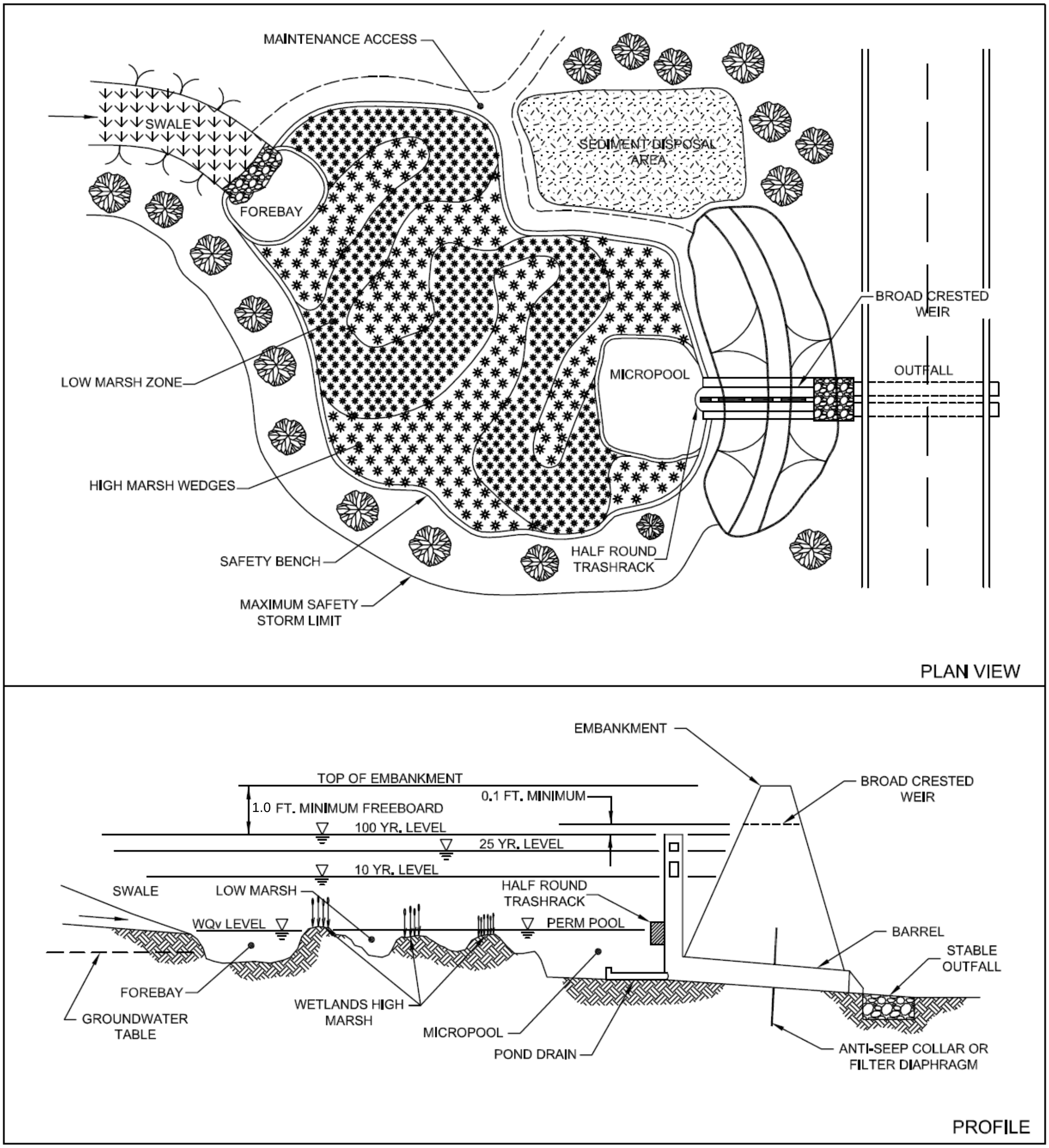
(Adapted from Center for Watershed Protection)

Figure 2.3 Schematic of Extended Detention Shallow Wetland



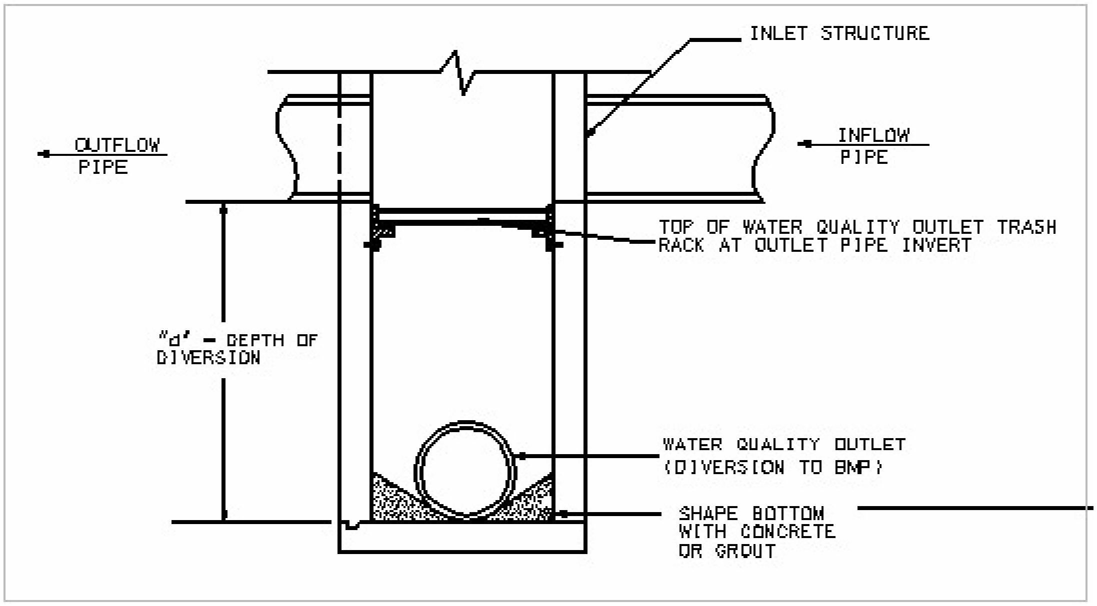
(Adapted from Center for Watershed Protection)

Figure 2.4 Schematic of Pond/Wetland System



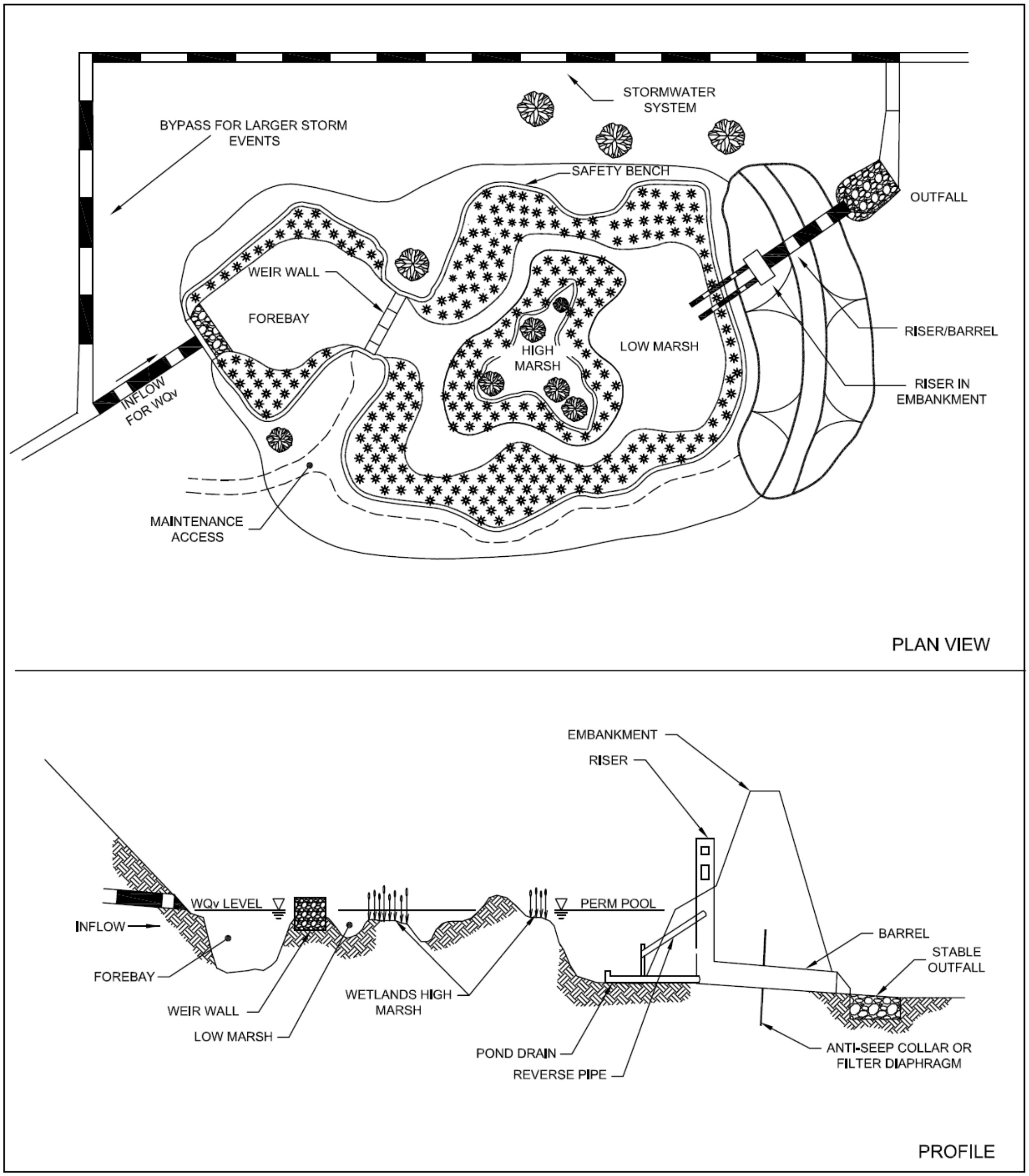
(Source: Center for Watershed Protection)

Figure 2.5 Schematic of Pocket Wetland System



(Source: AMEC)

Figure 2.6 Example Diversion Structure



(Adapted from the Center for Watershed Protection)

Figure 2.7 Example of Off-line Constructed Wetland

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Bioretention Areas

Description: Shallow detention area that employs engineered soils and plants to capture and treat runoff.

Variations: Bioretention areas can be designed as "raingardens," small bioretention areas that serve individual lots or that can be installed in parking lot planting areas or in depressed areas receiving runoff from paved areas.

Components:
- Pretreatment - for coarse sediments that would quickly clog area.
- Ponding area – for water quality treatment through settling and chemical processes
- Soils – water quality treatment through chemical processes and filtering; supports plants
- Mulch – water quality treatment through biological processes; conserves soil moisture between rain events to support plants
- Plants – water quality treatment through biological treatment, plant up-take and filtering
- Spillway system – provides outlet for stormwater runoff when large storm events occur and prevents long-term ponding in planting area

Advantages/Benefits:
- Easily incorporated into new development
- High community acceptance
- Good for highly paved areas such as parking lots
- Good for small drainage areas

Disadvantages/Limitations:
- Sediment-laden runoff can clog soils in bioretention area
- Requires detailed landscape planning
- Not appropriate for steep slopes
- Relatively expensive

Design considerations:
- Maximum drainage area of 5 acres, 2 acres maximum impervious
- Typically requires 5 feet of head
- Underlying soils must have good infiltration or must be replaced
- Underdrain system may be needed to keep planting area from ponding water too long

Selection Criteria:

☑ **Water Quality 80 % TSS Removal**

☑ **Accepts Hotspot Runoff**

☑ **Residential Subdivision**

☑ **High Density / Ultra Urban Use**

Maintenance:
- Replace mulch as needed to maintain depth of mulch
- Replace plant material as needed
- Replace soil if it becomes clogged
- Clean spillway system(s)

M **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Bioretention areas, sometimes known as rain gardens, are structural stormwater controls that capture and temporarily store the WQ_v while using soils and vegetation in landscaped areas to remove pollutants from stormwater runoff. Bioretention areas are engineered facilities in which runoff is conveyed as sheet flow to the "treatment area," consisting of a grass buffer strip, ponding area, organic or mulch layer, planting soil, and vegetation. An optional sand bed can be included in the design to provide aeration and drainage of the planting soil. The filtered runoff is typically collected and returned to the conveyance system, though it can be exfiltrated into the surrounding soil in areas with porous soils.

There are numerous design applications, both on- and off-line, for bioretention areas. These include use on single-family residential lots (rain gardens), as off-line facilities adjacent to parking lots, along highways and road drainage swales, within larger landscaped pervious areas, and as landscaped islands in impervious or high-density environments. However, the structures are not designed to serve as regional stormwater BMPs.

Bioretention facilities can provide a limited amount of water quantity control, with the storage provided by the facility included in the design of any downstream detention structures. However, bioretention areas should be designed so that larger flows bypass them.

Bioretention areas are designed for intermittent flow and to drain and aerate between rainfall events. Sites with continuous flow from groundwater, sump pumps or other areas are not acceptable for bioretention areas.

Components

Figure 3.1 illustrates a bioretention area. Bioretention areas consist of:

1. Grass filter strip between the contributing drainage area and the ponding area;
2. Ponding areas containing vegetation with a planting soil bed,
3. Organic/mulch layer,
4. Planting soil and vegetation, and
5. Gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layers (bioretention areas can optionally be designed to infiltrate into the soil).

Optional design components include:

1. Sand filter layer to spread flow, filter runoff and aid in aeration and drainage of the planting soil;
2. Stone diaphragm at the beginning of the grass filter strip to reduce velocities and spread flow into the grass filter;
3. Inflow diversion or an overflow structure.

Site and Design Considerations

The following design and site considerations must be incorporated into the BMP plan including bioretention areas:

1. The drainage area (contributing or effective) must be 5 acres or less, though 0.5 to 2 acres is preferred.
2. The minimum size for facility is 200 ft^2, with a length to width ratio of 2:1. Slope of the area immediately adjacent to the facility must be no more than 20%, but must be more than 2% to ensure proper drainage.
3. The planting soil filter bed is sized using a Darcy's Law equation with a filter bed drain time of 48 hours and a coefficient of permeability (k) of 0.5 ft/day. The planting soil bed must be at least 2 feet deep. Planting soils must be sandy loam, loamy sand or loam texture per USDA textural triangle with a clay content rating from 10 to 25 percent. The soil must have an infiltration rate of at least 0.5 inches per hour and a pH between 5.5 and 6.5. In addition, the planting soil should have a 1.5 to 3 percent organic content and a maximum 500-ppm concentration of soluble salts. For bioretention areas using in situ soils, the depth criteria does not apply.
4. The maximum ponding depth in bioretention areas is 6 inches.
5. The mulch layer must consist of 2-4 inches of commercially available fine shredded hardwood mulch or shredded hardwood chips.
6. The sand bed, if used, must be 12-18 inches thick. Sand must be clean and have less than 15% silt or clay content.
7. Pea gravel for the diaphragm and curtain, where used, must be ASTM D 448 size No. 6 (1/8 inches to 1/4 inches).
8. The underdrain collection system must be equipped with 6-inch perforated pipe in an 8-inch gravel layer. The pipe must have 3/8-inch perforations, spaced on 6-inch centers with a minimum of 4 holes per row. The pipe is spaced at a maximum of 10 feet on center, and a minimum grade of 0.5 percent must be maintained. A permeable filter fabric can be placed between the gravel layer and the planting soil bed.
9. The required elevation difference needed from the inflow to the outflow is 5 feet.
10. The depth from the bottom of the bioretention facility to the seasonally high water table must be a minimum of 2 feet.
11. Runoff captured by facility must enter as sheet flow to prevent erosion of the organic or mulch layer. Velocities entering the mulch layer must be between 1 and 2 feet per second.
12. Continuous flow from groundwater, sump pumps or other areas to the bioretention area is prohibited.
13. An overflow structure and a non-erosive overflow channel must be provided to safely pass the flow from the bioretention area that exceeds the storage capacity to a stabilized downstream area. The high flow structure within the bioretention area can consist of a yard drain catchbasin, with the throat of the catchbasin inlet typically 6 inches above the elevation of the shallow ponding area.
14. All components of the BMP must be located within an easement. Access to the BMP must be located within the easement.
15. The area that will house bioretention must not be used as sediment control measure during active construction.

Landscaping Bioretention Areas

Landscaping is critical to the performance and function of the bioretention area. A dense and vigorous groundcover must be established over the contributing pervious drainage area before runoff can be diverted into the facility.

1. The bioretention area should be vegetated like a terrestrial forest ecosystem, with an eventual tree canopy, subcanopy of understory trees, scrub layer and herbaceous ground cover. Three species of each tree and shrub type should be planted.
2. The tree-to-shrub ratio should be 2:1 to 3:1. On average, trees should be spaced 8 feet apart. Plants should be placed at regular intervals to replicate a natural forest. Woody vegetation should not be planted at inflow locations.
3. After the trees and shrubs are established, the ground cover and mulch should be established.

Use native plants, selected based upon hardiness and hydric tolerance.

As-Built Certification Considerations

After the bioretention area has been constructed, the developer must have an as-built certification of the bioretention area conducted by a registered Professional Engineer. The as-built certification verifies that the BMP was installed as designed and approved.

The following components are vital to ensure that the bioretention area works properly and they must be addressed in the as-built certification:

1. Pretreatment, such as a grass filter strip, for coarser sediments must be provided to prevent premature clogging of the system. Design guidance for grass filter strips used as pretreatment is provided in PTP-07 Filter Strip.
2. Surrounding drainage areas must be stabilized to prevent sediment from clogging the filter media.
3. Correct ponding depths and infiltration rates must be maintained to prevent killing vegetation.

A mechanism for overflow for large storm events must be provided.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the O&M Agreement for bioretention areas, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The O&M Agreement is to be used by the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP O&M plan. At a minimum, the operations and maintenance plan must require:

1. Inspect and repair/replace treatment components.
2. Perform annual verification of infiltration rates.
3. Remove debris or dead vegetation.

Design Procedures

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v).

$$WQ_v = P \times Rv \times A/12$$

Where:
WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85^{th} percentile storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$Rv = 0.015 + 0.0092I$$

Where:
I = site impervious cover, % (for example, 50% imperviousness = 50)

Step 2. Determine if the development site and conditions are appropriate for the use of bioretention area.

See the *Site and Design Considerations* in this section, above.

Step 3. Confirm additional requirements and watershed applicability.

Check with Metro Water Services and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply to the site.

Step 4. Compute WQ_v flow rate.

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures.

$$Q = C * I * A$$

Where:
Q =Peak discharge (cfs) for the 3 month storm
C = Runoff coefficient
I = 2.45 in/hour
A = site area, acres

Design Procedures (Continued)

Step 5. Size flow regulator, if needed.

A flow regulator (or flow splitter diversion structure) must be used to divert the WQ_v to the bioretention area.

Size flow regulator to pass the water quality flow rate, computed in Step 4.

Step 6. Determine size of bioretention ponding/filter area.

The required planting soil filter bed area is computed using the following equation (based on Darcy's Law):

$$Af = (WQ_v)\ (df) / [(k)\ (hf + df)\ (tf)]$$ where:

Af = surface area of ponding area (ft^2)

WQ_v = water quality volume in cubic feet (or total volume to be captured)
df = filter bed depth (2 feet minimum)
k = coefficient of permeability of filter media (ft/day) (must be at least 0.5 ft/day)
hf = average height of water above filter bed (ft)
(typically 3 inches, which is half of the 6-inch ponding depth)
tf = design filter bed drain time (days)
(2.0 days or 48 hours is recommended maximum)

Step 7. Set design elevations and dimensions of facility.

See *Site and Design Considerations* section.

Step 8. Design conveyances to bioretention area.

See Figure 3.2 for examples of conveyance types for different applications.

Step 9. Design pretreatment.

Pretreat with a grass filter strip (on-line configuration) or grass channel (off-line), and stone diaphragm.

Design Procedures (Continued)

Step 10. Size underdrain system

See *Site and Design Considerations*.

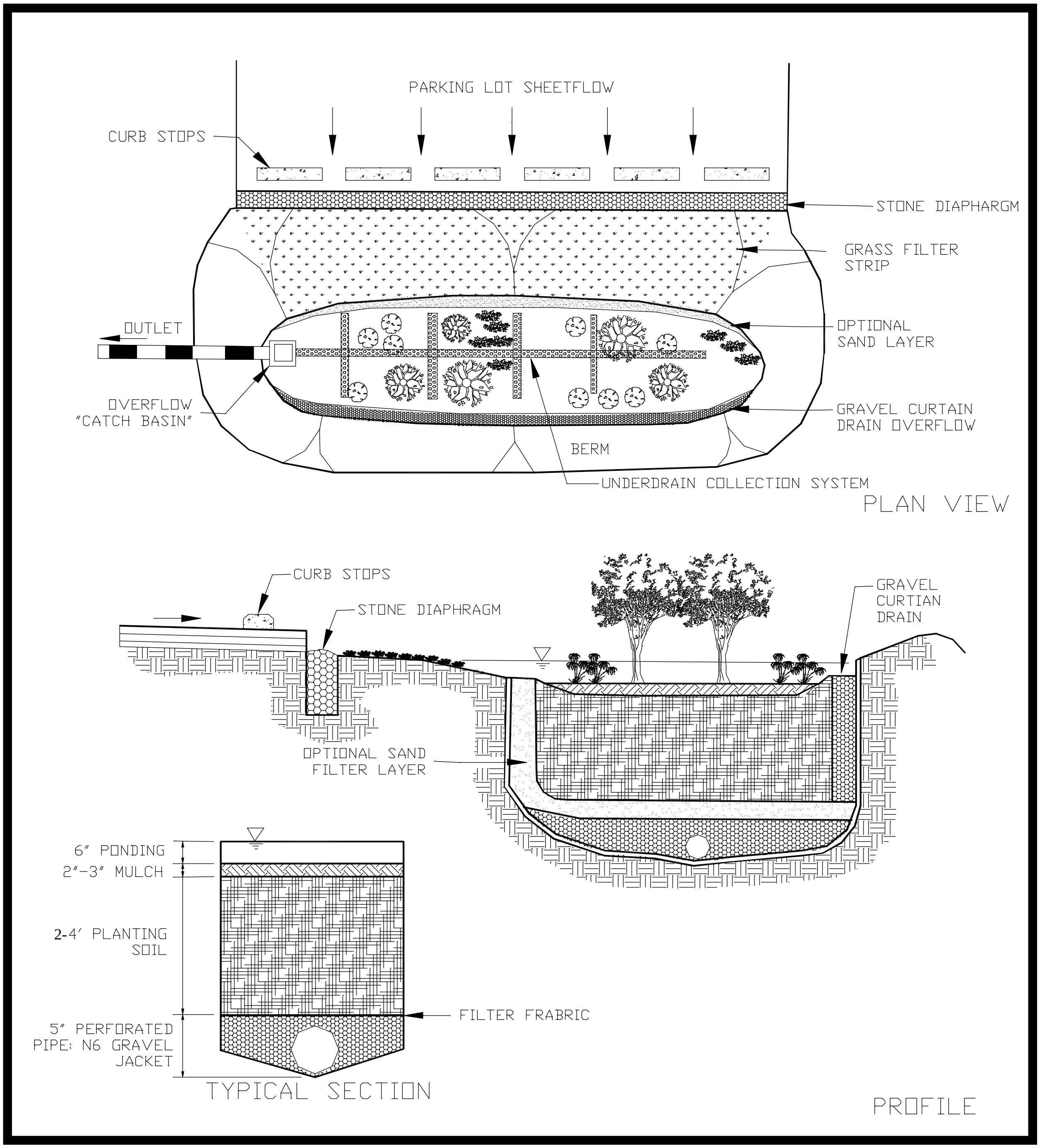
Step 11. Design emergency overflow.

An overflow must be provided to bypass and/or convey larger flows to the downstream drainage system or stabilized watercourse. Non-erosive velocities need to be ensured at the outlet point.

Step 12. Prepare Vegetation and Landscaping Plan.

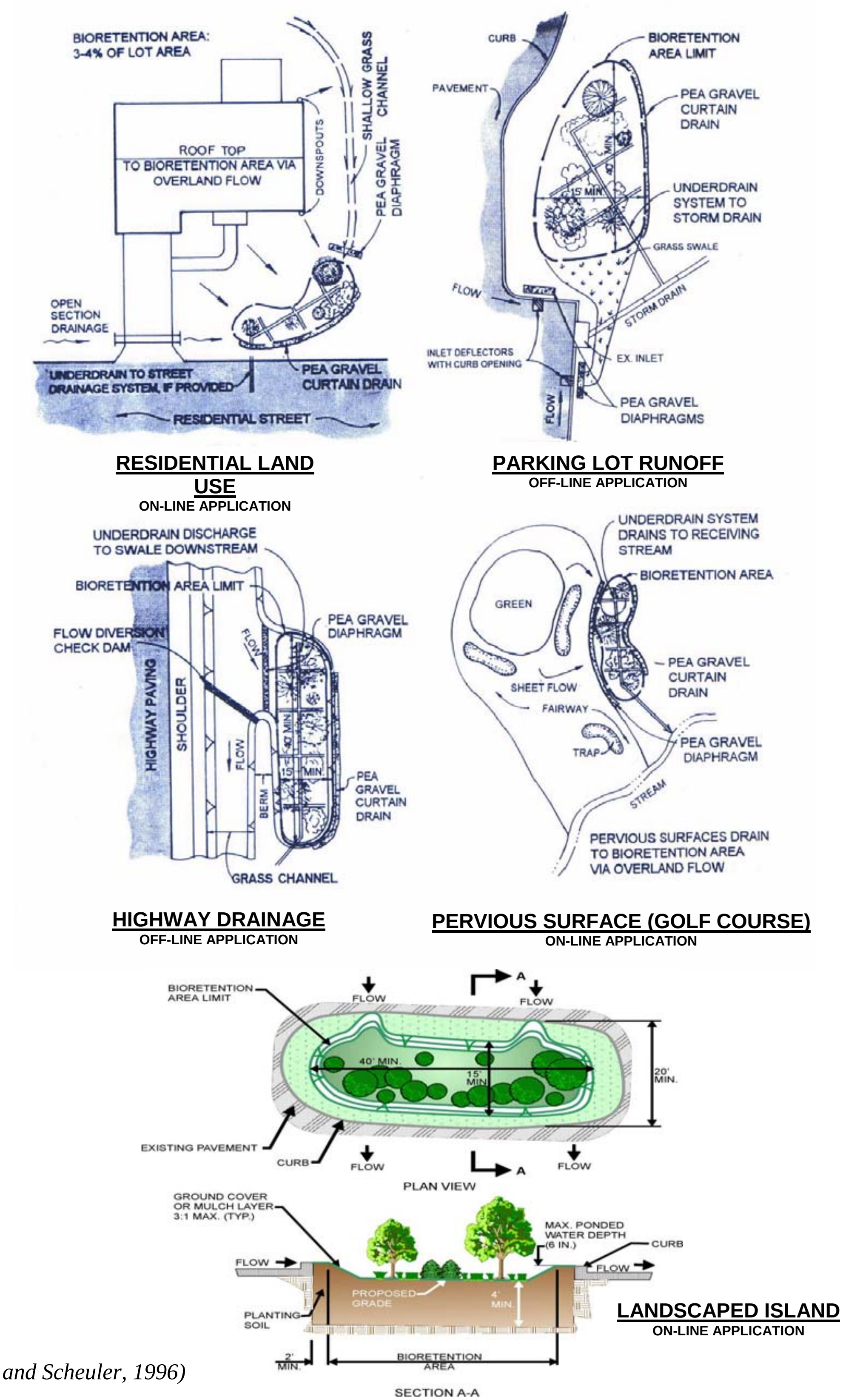
A landscaping plan for the bioretention area should be prepared to indicate how it will be established with vegetation.

See the *Landscaping Bioretention Areas* section for more details.



(Source: Center for Watershed Protection)

Figure 3.1 Bioretention Area



(Adapted from Claytor and Scheuler, 1996)

Figure 3.2 Applications of Bioretention Areas

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Sand Filters

Description: Multi-chamber structure designed to treat stormwater runoff through filtration, using a sediment forebay, a sand bed as its primary filter media and an underdrain collection system (typically).

Variations: Underground Sand Filter (see PTP-10), Perimeter Sand Filter (see PTP-11), and Organic Filter (PTP-12)

Components:
- Forebay (or sedimentation chamber)—settles coarse particles and trash
- Sand bed (or Filtration) chamber—provides water quality treatment by filtering other pollutants
- Spillway system(s)— provide discharge control

Advantages/Benefits:
- Applicable to small drainage areas
- Good for highly impervious areas
- Good for water quality retrofits to existing developments

Disadvantages/Limitations:
- High maintenance burden
- Not recommended for areas with high sediment content in stormwater or clay/silt runoff areas
- Relatively costly
- Possible odor problems
- Typically needs to be combined with other controls to provide water quantity control

Design considerations:
- Typically requires 2 to 6 feet of head
- Maximum contributing drainage area of 10 acres
- In karst areas use polyliner or impermeable membrane to seal bottom of earthen surface sand filter or use watertight structure

Selection Criteria:

- [x] **Water Quality 80 % TSS Removal**
- [x] **Accepts Hotspot Runoff**
- [ ] **Residential Subdivision**
- [x] **High Density / Ultra Urban Use**

Maintenance:
- Inspect for clogging—rake first inch of sand
- Remove sediment from forebay-chamber
- Replace sand filter media as needed
- Clean spillway system(s)

H — **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Sand filters (also referred to as *filtration basins*) are structural stormwater controls that capture and temporarily store stormwater runoff and treat it by filtering it through a bed of sand. The surface sand filter is a ground-level open air structure that consists of a pretreatment sediment forebay and a sand bed chamber. This system can treat drainage areas up to 10 acres in size and is an off-line device in which flows larger than the water quality volume by-pass the system. Surface sand filters can be designed as an excavation with earthen embankments or as a concrete or block structure. The filtered runoff is collected and returned to the conveyance system, or it can also be partially or fully exfiltrated into the surrounding soil in areas with porous soils. A schematic of a surface sand filter is shown in Figure 4.1.

Because they have few site constraints beside head requirements, sand filters can be used on development sites where the use of other structural controls may be precluded. However, sand filter systems can be relatively expensive to construct and install and they have high maintenance requirements.

A design variant, the *underground sand filter*, is intended primarily for extremely space limited and high density areas and is thus considered a limited application structural control. See PTP-10 for more details. Another design variant is the *perimeter sand filter*, which is an enclosed filter system typically constructed just below grade in a vault along the edge of an impervious area such as a parking lot. See PTP-16 for information on the perimeter sand filter.

In surface sand filter systems, stormwater pollutants are removed through a combination of gravitational settling, filtration, and adsorption. The filtration process effectively traps suspended solids and particulates. As solids are trapped in the sand bed, some reduction of associated pollutants such as biochemical oxygen demand (BOD), fecal coliform bacteria, and other pollutants may be achieved.

Site and Design Considerations

Location and Siting

1. Surface sand filters should have a contributing drainage area of 10 acres or less.
2. Surface sand filter systems are generally applied to land uses with a high percentage of impervious surfaces. Sites with less than 50% imperviousness or with high clay/silt sediment loads must not use sand filters without adequate pretreatment because the sediment causes clogging and failure of the filter bed. Any disturbed areas within the sand filter facility drainage area should be identified and stabilized. Filtration controls should only be constructed after the construction site is stabilized.

Site and Design Considerations (Continued)

3. Surface sand filters are used in an off-line configuration where the water quality volume (WQ_v) is diverted to the filter facility. Stormwater flows greater than the WQ_v are diverted to other controls or downstream using a diversion structure or flow splitter.
4. Sand filter systems are designed for intermittent flow and must be allowed to drain and aerate between rainfall events. They should not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

General Design

5. A surface sand filter facility consists of a two-chamber open-air structure, which is located at ground-level. The first chamber is the sediment forebay (sedimentation chamber) while the second chamber houses the sand filter bed. Flow enters the forebay chamber where settling of larger sediment particles occurs. Discharge from the forebay chamber flows through a perforated standpipe into the sand bed chamber. The flow is then uniformly distributed across the sand bed chamber via distribution vault or weir. After passing though the filter bed, runoff is collected by a perforated pipe and gravel underdrain system. Figure 4.1 provides plan view and profile schematics of a surface sand filter.

Physical Specifications/Geometry

6. The entire treatment system (including the forebay) must temporarily hold the WQ_v prior to filtration. Table 4.1 presents the design parameters and values for the perimeter sand filter. Figure 4.2 illustrates these design parameters.
7. The forebay chamber must be sized to at least 50% of the computed $WQ_{v,}$ hold this volume for 24 hours, and have a length-to-width ratio of at least 2:1. Inlet and outlet structures should be located at opposite ends of the chamber.
8. The filter area is sized based on the principles of Darcy's Law. A coefficient of permeability (k) of 3.5 ft/day for sand should be used. The filter bed is typically designed to completely drain in 24 hours or fewer.
9. The filter media consists of an 18 to 24 inch layer of clean washed medium sand (meeting ASTM C-33 concrete sand) on top of the underdrain system. Permeable filter fabric is placed both above and below the sand bed to prevent clogging of the sand filter and the underdrain system. Figure 4.3 illustrates a typical media cross section.
10. The filter bed is equipped with a 6-inch perforated pipe (ASTM Schedule 40) underdrain in a gravel layer. The underdrain must have a minimum grade of 1/8-inch per foot (1% slope). Holes should be 3/8-inch diameter and spaced approximately 6 inches on center. Gravel should be clean washed aggregate with a maximum diameter of 3.5

Site and Design Considerations (Continued)

inches and a minimum diameter of 1.5 inches with a void space of about 30%. Do not use aggregate contaminated with soil.

11. The structure of the surface sand filter may be constructed of impermeable media such as concrete, or through the use of excavations and earthen embankments. When constructed with earthen walls/embankments, filter fabric should be used to line the bottom and side slopes of the structures before installation of the underdrain system and filter media. The structure should include an access ramp at 4:1 (H:V) or less for maintenance.

Table 4.1 Surface Sand Filter Design Parameters

Parameter Description	Parameter	Parameter Value
Total Temporary Volume in Forebay and Sand Bed Chamber	WQ_v	WQ_v; See Design Step #1
Approximate Temporary Sand Bed Volume[1]	V_{ST}	(0.5) WQ_v
Minimum Sand Bed Thickness	T_S	18 inches
Sand Bed Design Porosity	n	0.3
Sand Bed Design Permeability	k	3.5 feet/day
Sand Bed Design Drain Time	t_d	1.5 days, 36 hours max
Minimum Sand Bed Chamber Area	A_S	See Design Step #6
Approximate Temporary Forebay Volume[2]	V_{FT}	(0.5) WQ_v
Minimum Forebay Surface Area	A_F	(0.05) WQ_v
Maximum Temporary Sand Bed Depth[3]	D_{ST}	See Design Step #3
Minimum Temporary Forebay Depth	D_{FT}	2 feet
Overall Minimum Length to Width Ratio	L/W	2

1. Includes temporary storage volume in sand.
2. Includes temporary storage volume in sand.
3. Excludes storage volume in forebay permanent pool.
4. Measured from top of sand bed.

(Adapted from the New Jersey Stormwater Best Management Practices Manual)

Site and Design Considerations (Continued)

Pretreatment/Inlets

12. Pretreatment of runoff in a sand filter system is provided by the forebay chamber.
13. Inlets to surface sand filters are to be provided with energy dissipaters. Exit velocities from the forebay chamber must be nonerosive.
14. Figure 4.4 shows a typical inlet pipe from the forebay to the sand bed chamber where the flow is then evenly distributed across the filtration area.

Outlet Structures

Outlet pipe is to be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary (except for emergency overflows and spillways).

Emergency Spillway

Surface sand filters are off-line devices and the emergency spillway is provided in case diversion structure fails. The spillway prevents filter water levels from overtopping the embankment and causing structural damage. The emergency spillway should be located so that downstream buildings and structures will not be impacted by spillway discharges.

Maintenance Access

Adequate access through maintenance easements must be provided for all sand filter systems for inspection and maintenance, including the appropriate equipment and vehicles. Facility designs must enable maintenance personnel to easily replace the upper layers of the filter media. Maintenance access ramps at a 4:1 slope or flatter must be provided.

Safety Features

Surface sand filter facilities can be fenced to prevent unauthorized access.

Design Procedures

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v), which must be temporarily stored within the perimeter sand filter's entire treatment system.

$$WQ_v = P \times Rv \times A/12$$

Where:
WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$Rv = 0.015 + 0.0092*I$$

Where:
I = site impervious cover, % (for example 50% equals 50)

Step 2. Determine approximate required volumes of the forebay and sand bed.

Each should be equal to approximately 0.5 WQ_v, as shown in Table 4.1.

Step 3. Determine approximate temporary depths in sand bed (D_{ST}) and forebay (D_{FT}) for the WQ_v.

The estimate will depend on and be based on analysis of site conditions including the difference between the invert elevation of the downstream conveyance system and the maximum ground elevation at filter facility. Make sure to include the minimum sand bed thickness (T_{HS}) into the consideration for these temporary depths. Note that the maximum temporary depth in the sand bed zone (D_{ST}) is measured from the top of the sand bed, while the maximum temporary forebay depth (D_{FT}) is measured the bottom of the forebay.

Step 4. Compute minimum forebay surface area (A_F).

The minimum surface area is

$$A_F = 0.05\ (WQ_v)$$

Where:
A_F = forebay area
0.05 = a multiplier in units per area of volume (L^2/L^3)

Design Procedures Continued

Step 5. Compute total temporary storage volume in the forebay (V_{FT}).

From the maximum temporary depth in the forebay (D_{FT}) from Step 3 and the minimum forebay area (A_F) from Step 4, compute the total temporary storage volume in the forebay (V_{FT}). *Compare* this volume with the approximate required forebay volume computed in Step 2. *Adjust* the maximum temporary forebay depth (D_{FT}) and/or forebay area (A_F) as necessary to achieve a total temporary forebay storage volume (V_{FT}) as close as practical to the required forebay volume from Step 2. While adjusting the forebay surface area (A_F) by varying its length and width, remember that the forebay will be located immediately adjacent to the sand bed zone and that the minimum overall length to width ratio of the combined zone is two to one.

Step 6. Compute **sand bed** chamber area (A_S).

The filter area is sized using the following equation (based on Darcy's Law):

$$\mathbf{A_S = (WQ_v)\ (T_S / [(k)\ (D_{ST}/2 + T_S)\ (T_D)]}$$

Where:

A_S = Sand Bed Surface Area (in square feet)
T_S = Thickness of Sand in Sand Bed (typically 18 inches, no more than 24 inches)
k = Coefficient of permeability of filter media (ft/day) (use 3.5 ft/day for sand)
D_{ST} = Maximum Temporary Sand Bed Depth (ft)
t_d = Sand Bed Design Drain Time (1.5 days or 36 hours is recommended maximum)

See the Physical Specifications/Geometry section of the *Site and Design Considerations* for filter media specifications.

Step 7. Compute total temporary storage volume in sand bed.

$$\mathbf{V_{ST} = (A_S)(D_{ST}) + (A_S)(T_S)(n)}$$

Where:
V_{ST} = Temporary Sand Bed Storage Volume (in cubic feet)
A_S = Sand Bed Surface Area (in square feet)
D_{ST} = Maximum Temporary Sand Bed Depth (ft)
T_S = Thickness of Sand in Sand Bed, recommended 18 inches (in feet)
n = Sand Bed Design Porosity, recommended 0.3

Design Procedures (Continued)

Step 8. Compare and adjust areas and volumes to achieve storage of WQ_v within the entire facility.

Compare the total temporary sand bed storage volume (V_{ST}) with the approximate required sand bed zone volume computed in Step 2. As shown on Table 16.1, this temporary sand bed storage volume should be approximately one half of the stormwater quality design storm runoff volume (WQ_v). In addition, add the total temporary sand bed volume (V_{ST}) to the total temporary forebay storage volume (V_{FT}) to determine the total temporary storage volume in the sand filter. As shown in Table 16.1, this total temporary storage volume must equal the stormwater quality design storm runoff volume (WQ_v). Adjust the maximum temporary sand bed depth (D_{ST}) and/or sand bed area (A_S) as necessary to achieve a total temporary sand bed storage volume (V_{ST}) as close as practical to the required sand bed volume from Step 2 and a total filter volume equal to WQ_v. Remember, while adjusting width and length that forebay will be located immediately adjacent to the sand bed zone and that the minimum overall length to width ratio of the combined zone is two to one.

Step 9. Design flow diversion structure.

A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQ_v to the sand filter.

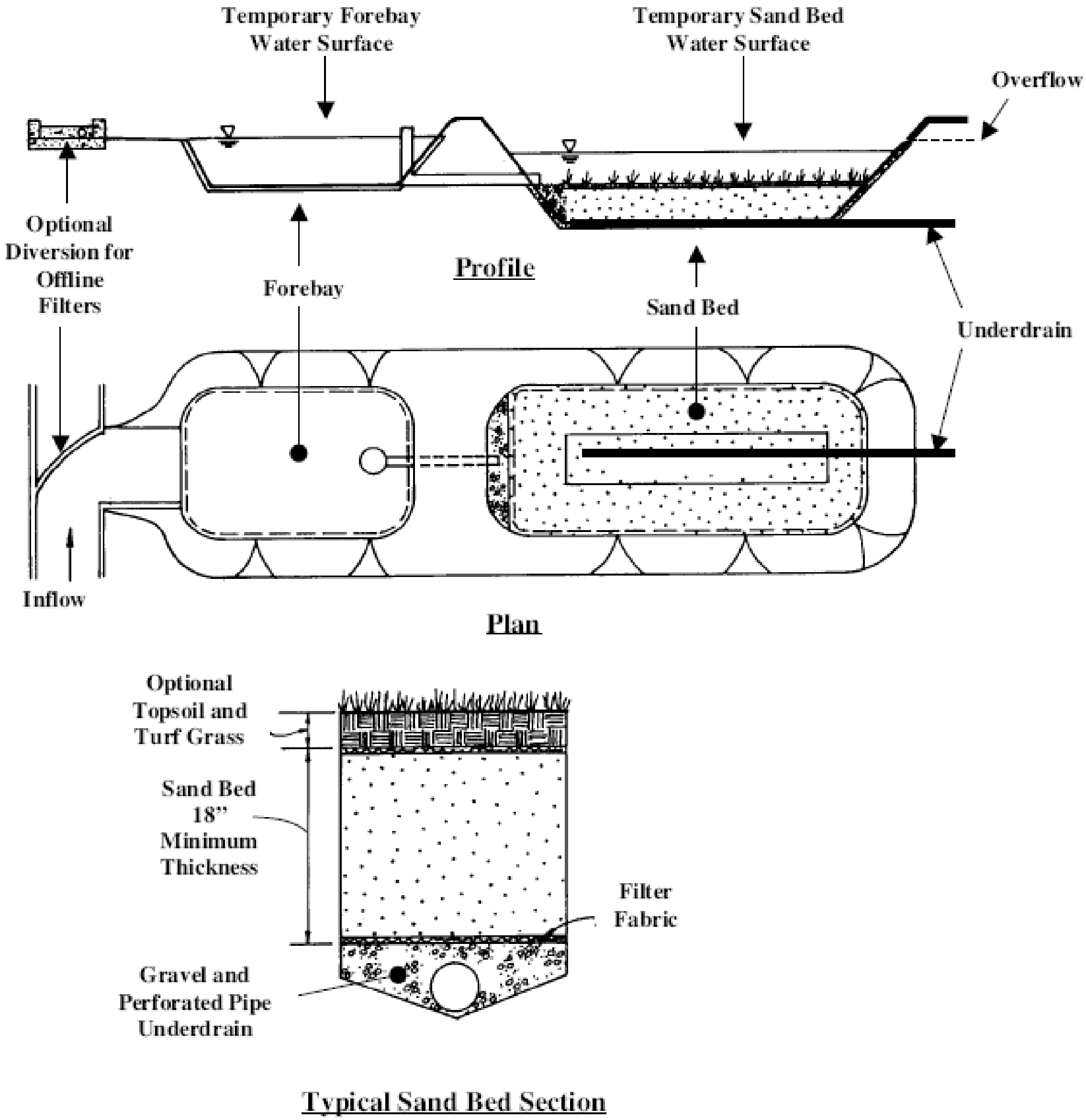
Size low flow orifice, weir, or other device to bypass the 100-year flood.

Step 10. Design inlets, underdrain system, overflow weirs, and outlet structures.

See *Site and Design Considerations* for more information on underdrain specifications and outlet structures. PTP-01 provides more information on sizing orifices, weirs, and outlets.

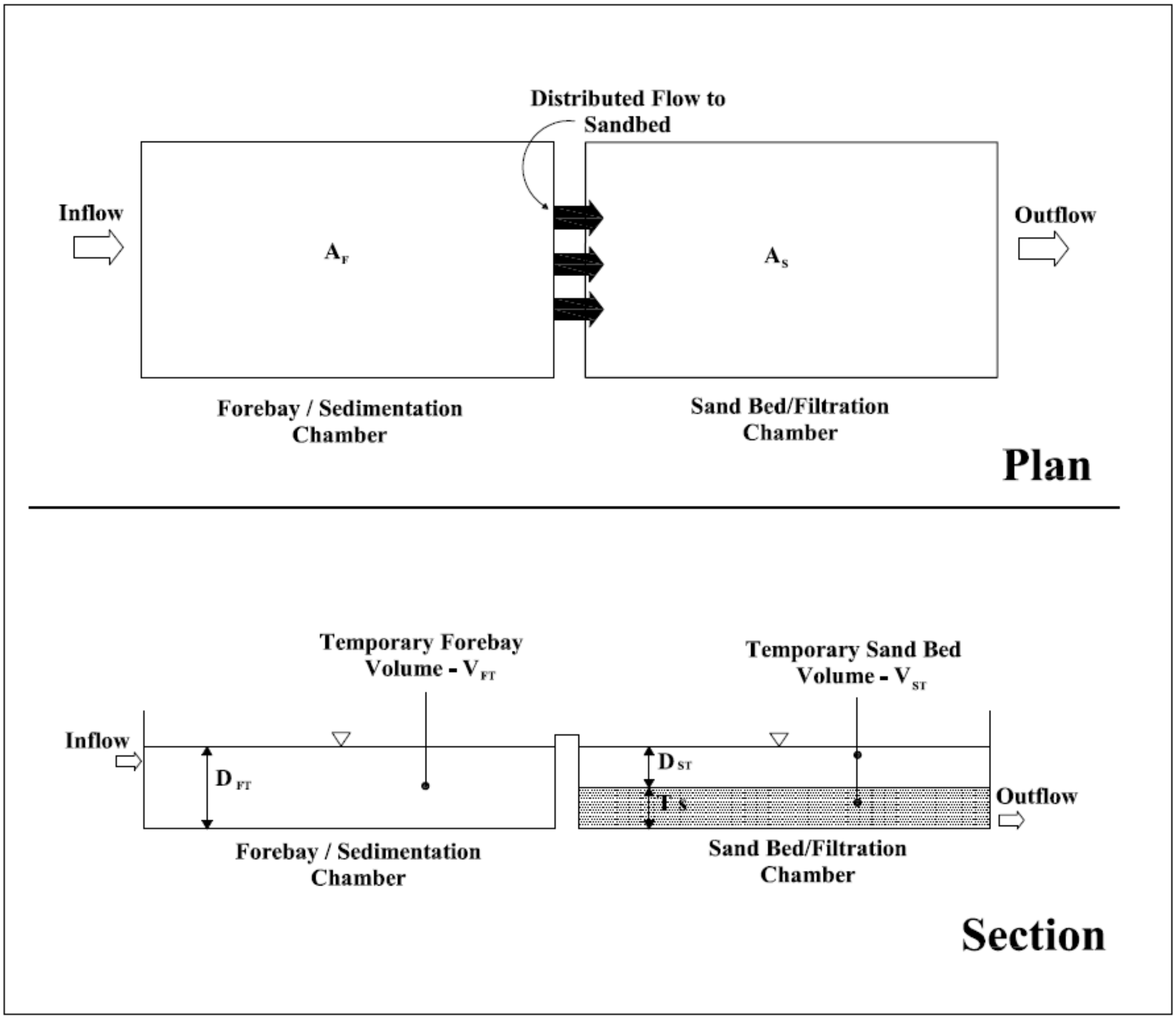
Step 11. Design emergency overflow.

An overflow must be provided in case of a failure in the diversion structure. Non-erosive velocities need to be ensured at the outlet point.



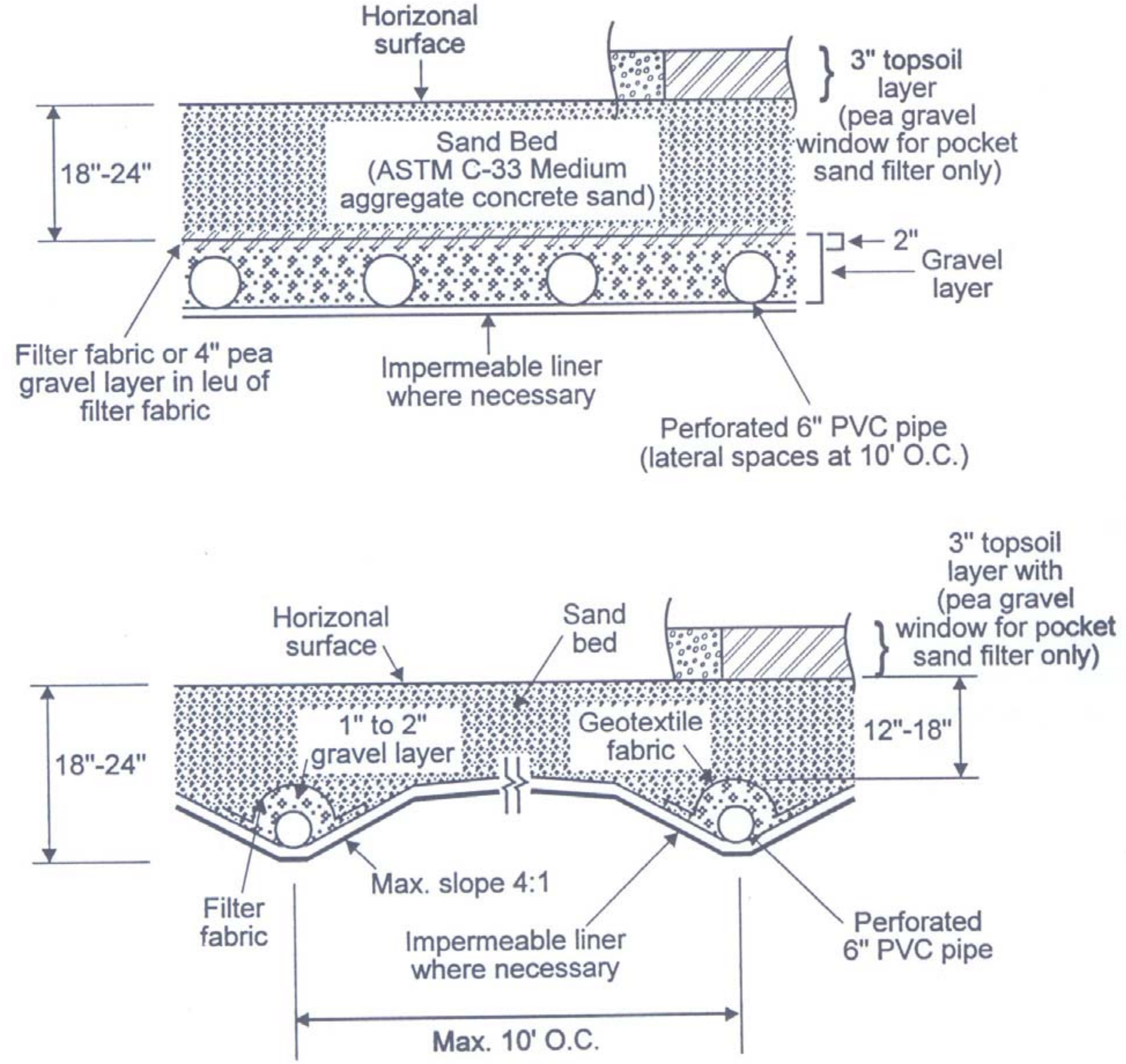
(Source: New Jersey Stormwater Best Management Practices Manual, 2003)

Figure 4.1 Surface Sand Filter Schematic



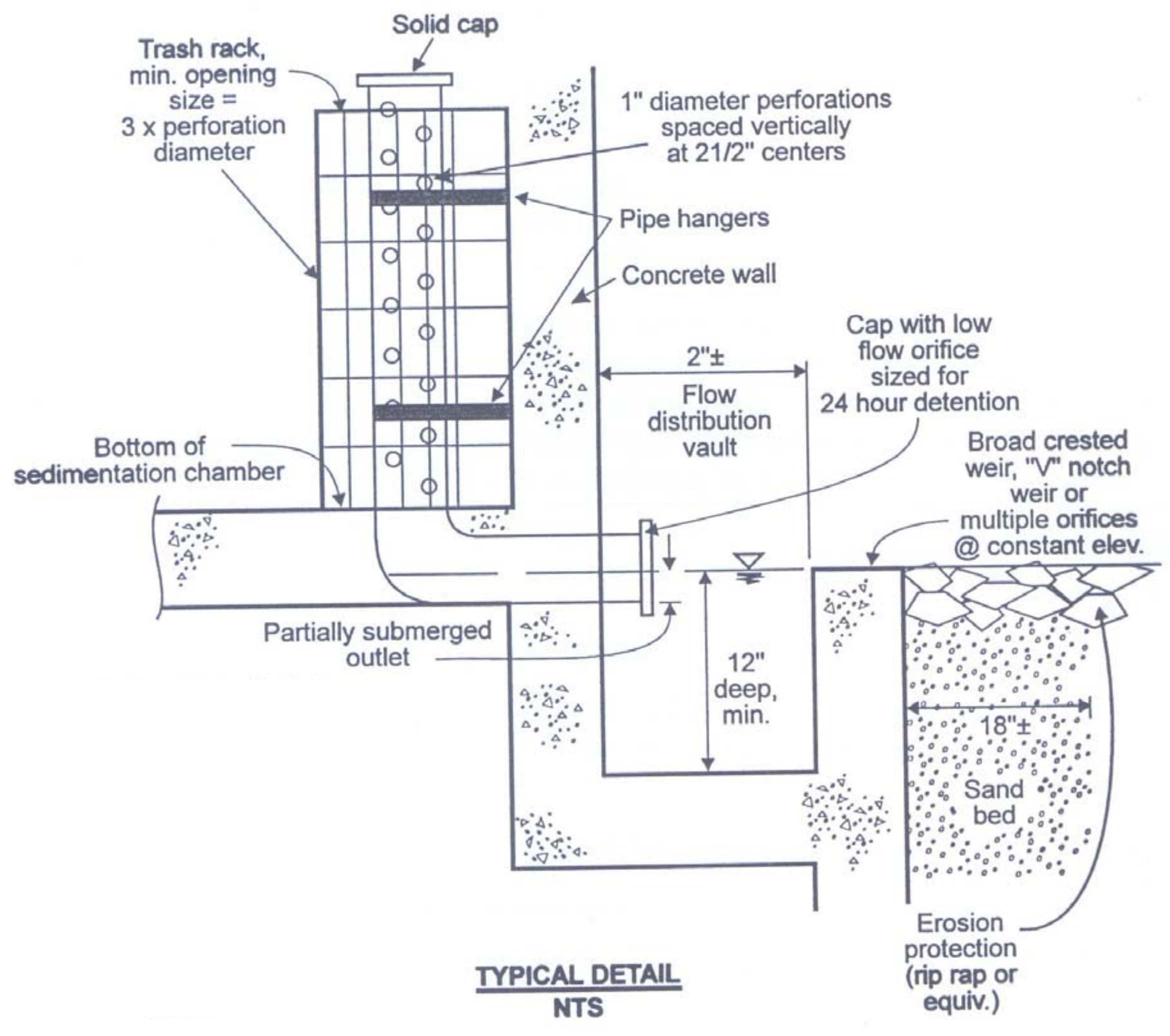
(Source: New Jersey Stormwater Best Management Practices Manual, 2003)

Figure 4.2 Schematic of Surface Sand Filter Showing Design Parameters



(Source: Claytor and Schueler, 1996)

Figure 4.3 Typical Sand Filter Media Cross Sections



(Source: Claytor and Schueler, 1996)

Figure 4.4 Surface Sand Filter Perforated Stand-Pipe

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Water Quality Swales

Description: Vegetated open channels that are designed to capture and treat stormwater runoff within dry or wet cells formed by check dams or other methods.

Variations: Swales can be wet or dry.

Components:

- Open trapezoidal or parabolic channel sized to store entire WQ_V. Dry swale infiltrates full WQ_V and wet swale retains WQ_V.
- Filter bed of permeable, engineered soils
- Underdrain system for impermeable soils (dry swale only)
- Wet cells created by check dams (wet swale only)
- Level spreaders every 50 feet, if length exceeds 100 feet.

Advantages/Benefits:

- Stormwater treatment combined with runoff conveyance
- Less expensive than curb and gutter
- Reduces runoff velocity
- Promotes infiltration

Disadvantages/Limitations:

- Higher maintenance than curb and gutter
- Cannot be used on steep slopes
- High land requirement
- Vector concerns (wet water quality swale)
- Requires ≈ 3 feet of head

Design considerations:

- Longitudinal slopes less than 4%
- Bottom channel width of 2 to 8 feet
- Underlying soils must have good infiltration or must be replaced (dry swale)
- Side slopes of 3:1 or flatter; 4:1 recommended
- Convey the 10-year storm event with minimum 6 inches of freeboard.

Selection Criteria:

- ✓ **Water Quality 80 % TSS Removal**
- ✓ **Accepts Hotspot Runoff (impermeable liner required)**
- ✓ **Residential Subdivision**
- ☐ **High Density / Ultra Urban Use**

Maintenance:

- Maintain grass heights
- Remove sediment from forebay and channel
- Remove accumulated trash
- Re-establish plants as needed

M — **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Water quality swales, also known as "enhanced swales" or vegetated open channels, are channels that capture and treat the water quality volume for a site. They are specifically engineered to perform pollutant removal functions. Water quality swales have specific features that allow them to treat the Water Quality Volume (WQ_v). Water quality swales are designed with gradual longitudinal slopes that force runoff to slow down, which allow sediment to settle out while limiting channel erosion. Check dams or other mechanisms are installed perpendicular to the flow to further allow sediment to settle out and runoff to infiltrate.

There are two types of water quality swales, dry and wet:

<u>Dry water quality swales:</u> The dry swale is a vegetated channel that includes a filtering bed of permeable soils overlying an underdrain system. Dry swales are designed to filter or infiltrate the entire WQ_v through this filter bed and underdrain system. Dry swales rely primarily on the filtration mechanism to remove stormwater pollutants. *If it can be demonstrated that the swale can infiltrate the WQ_v within 24 to 48 hours (24 hours is preferred) without an underdrain, the swale may be designed without the underdrain.*

<u>Wet water quality swale:</u> The wet swale is a vegetated channel, also called a wetland channel that acts as a shallow wetland system that retains the WQ_v. The channel supports wetland vegetation in shallow marshy conditions. Usually impermeable or poorly drained soils are necessary to support the sufficient retention of water. Wet swales remove pollutants through sediment settling and biological removal. A wet swale does not require an underdrain.

Enhanced swales can be used in a variety of development types; however, they are primarily applicable to residential and institutional areas of low to moderate density where the impervious cover in the contributing drainage area is relatively low. They can also be used along roads and highways. Dry swales are mainly used in moderate to large lot residential developments, small impervious areas (parking lots and rooftops), and along rural highways. Wet swales tend to be used for highway runoff applications, small parking areas, and in commercial developments as part of a landscaped area. Because of their relatively large land requirement, enhanced swales are generally not used in higher density areas. In addition, wet swales may not be desirable for some residential applications, due to the presence of standing water, which may create nuisance odor or mosquito problems.

The topography and soils of a site will determine the applicability of the use of one of the two enhanced swale designs. Overall, the topography should allow for the design of a swale with sufficient slope and cross-sectional area to maintain nonerosive velocities. The following criteria should be evaluated to ensure the suitability of a water quality swale for meeting stormwater management objectives on a site or development.

Site and Design Considerations

The following design and site considerations must be incorporated into the design for a water quality swale:

Location:

1. Channels must be sited so that the longitudinal slope is less than 4%. *Drop structures*, which disrupt flow by producing a pool of water behind them and a short drop in the surface gradient for water flowing over the structure, may be used to reduce the velocity of water in areas with greater slopes. Drop structures include check dams.
2. The water quality swale should have a contributing drainage area of five acres or less to prevent problems with distributing flow evenly across the swale.
3. Wet swales may be used where the water table is very high (at or near the surface of the soil) *or* where the water balance in poorly drained soils will support wetland vegetation.

General Design:

4. Both wet and dry water quality swales are designed to treat for water quality, but also to pass larger storms. Runoff enters the channel through a pretreatment forebay. In addition, distributed flow can enter along the sides of the channel after passing through a flow spreader such as a pea gravel diaphragm, level 2 x 12 timbers, or other level spreader along the bank of the channel.
5. <u>Dry water quality swale:</u> consists of an open channel with a filter bed of permeable soils overlaying an underdrain system. Water flows into the channel where it is filtered through the permeable bed. After being filtered, the runoff is conveyed through a perforated pipe and underdrain system to the outlet. A schematic is found in Figure 5.1.
6. <u>Wet water quality swale:</u> consists of an open channel excavated to the water table or to poorly drained soils. Check dams divide the channel into cells. A schematic is found in Figure 5.2.

Physical Specifications*:*

7. Swales can incorporate raised inlets (4 to 6 inches) to allow for the retention of initial runoff volume.
8. Channel slopes of 1% to 2% and no greater than 4% are recommended. If steeper slopes are necessary, 6 to 12 inch drop structures (see #1 above) can be used to limit runoff energy. Energy dissipators must be installed below drop structures and drop structures must be no closer than 50 feet. The depth of the water at the downstream end of the swale must not exceed 18 inches.
9. Both dry and wet water quality swales must have a bottom channel width of 2 to 8 feet. Wider channels may be installed if designed with berms, walls, or a multi-level cross-section that prevent the channel from meandering and eroding.
10. Cross-sections of dry and wet swales are to be parabolic or trapezoidal with moderate slopes of no greater than 3:1. More gentle slopes of 4:1 are recommended.

Site and Design Considerations (Continued)

11. Minimum width should be determined using Manning's equation, with an n of 0.2 to 0.24.
12. Maximum length of the swale shall be 100 feet unless level spreaders are used. Level spreaders shall be placed at least every 50 feet. Maximum length without a level spreader is 80 feet.
13. The maximum ponding depth of the WQ_v must be no greater than 18 inches at the downstream end of the swale. The average ponding depth should be 12 inches.
14. The maximum velocity should be no more than 0.9 feet per second.

Physical Specifications—Dry Swale:

15. Dry swale channels are sized to store and infiltrate the entire water quality volume (WQ_v) with less than 18 inches of ponding and allow for full filtering through the permeable soil layer. The maximum ponding time is 48 hours, though a 24-hour ponding time is more desirable. Refer to PTP-01 for orifice sizing.
16. The bed of the dry swale consists of a permeable soil layer of at least 30 inches in depth, above a 4-inch diameter perforated pipe (AASHTO Schedule 40) longitudinal underdrain in a 6-inch gravel layer. The soil media should have an infiltration rate of at least 0.5 inches/hour (maximum 0.75 inches/hour) and contain a high level of organic material to facilitate pollutant removal. A permeable filter fabric is placed between the gravel layer and the overlying soil.

Table 5.1 Infiltration Rates of Common Soil Types

Common Soil Types	Infiltration Rates (inches/hour)
Coarse Sand	¾ to 2
Fine Sand	½ to 1
Fine Sandy Loam	1/3 to ¾
Silt Loam	¼ to 4/10
Clay Loam	1/10 to ¼

(Source: NRCS, USDA www.soils.usda.gov)

17. The channel and underdrain excavation should be limited to the width and depth specified in the design. The bottom of the excavated trench shall not be loaded in a way that causes soil compaction, and scarified prior to placement of gravel and permeable soil. The sides of the channel shall be trimmed of all large roots. The sidewalls shall be uniform with no voids and scarified prior to backfilling.

Physical Specifications—Wet Swale:

18. Wet swale channels are sized to retain the entire water quality volume (WQ_v) with less than 18 inches of ponding at the maximum depth point.
19. Check dams can be used to achieve multiple wetland cells. V-notch weirs in the check dams can be utilized to direct low flow volumes.

Site and Design Considerations (Continued)

Pretreatment/Inlets

20. Inlets to enhanced swales must be provided with energy dissipators such as riprap.
21. Pretreatment of runoff in both a dry and wet swale system is typically provided by a sediment forebay located at the inlet. The pretreatment volume should be equal to 0.1 inches per impervious acre. This storage is usually obtained by providing check dams at pipe inlets and/or driveway crossings.
22. Enhanced swale systems that receive direct concentrated runoff may have a 6-inch drop to a flow spreader at the upstream end of the control.
23. A flow spreader and gentle side slopes should be provided along the top of channels to provide pretreatment for lateral sheet flows.

Outlet Structures

24. *Dry water quality swale* underdrain system must discharge to the storm drainage infrastructure or a stable outfall.
25. *Wet water quality swales* must have outlet protection at any outlet so that scour and downstream erosion do not occur.

Other Considerations

26. Water quality swales must be designed to safely pass flows that exceed the design storm flows.
27. Maintenance access must be provided for all swales.
28. Landscaping must specify grass species and/or wetland plants that will thrive under the hydric and soils conditions at the particular site.

As-Built Certification Considerations

After the water quality swale has been constructed, the developer must have an as-built certification of the swale prepared by a registered Professional Engineer and submit it to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

The following components must be addressed in the as-built certification:

1. Appropriate underdrain system for dry swales.
2. Correctly sized treatment volume.
3. Poor soils or groundwater table interface for wet swales.
4. Adequate vegetation in place.
5. Overflow system in place for high flows.

Maintenance

Each BMP must have an Operations and Maintenance agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for swales areas, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

Maintenance (Continued)

1. Inspection and repair/replacement of treatment components.
2. Maintain vegetation at heights of 8 inches or less to prevent thinning of vegetative cover, which lessens swale effectiveness.
3. Removal of debris or dead vegetation.

Landscaping

Dry Swale: Turf grass species appropriate for Metro conditions should be used for dry swale vegetation.

Wet Swale: Emergent vegetation should be planted or wetland soils can be spread on the swale bottom for seeding. Where wetland swales do not intercept the groundwater table, a water balance calculation should be performed to ensure that the swale has a water budget adequate to support wetland species. The water balance calculation is found in the stormwater Constructed Wetland BMP, PTP-02.

Design Procedures

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v), which is the volume that must be stored in the swale.

$$\mathbf{WQ_v = P \times Rv \times A/12}$$

Where:
WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85th percentile storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$\mathbf{Rv = 0.015 + 0.0092I}$$

Where:
I = site impervious cover, % (for example, 50% equals 50)

Step 2. Determine if the development site and conditions are appropriate for the use of an enhanced swale system (dry or wet swale).

See the *Site and Design considerations*, above.

Step 3. Determine pretreatment volume.

The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage. The forebay storage volume (F_v) counts toward the total WQ_v requirement and may be subtracted from the WQ_v for subsequent calculations.

$$\mathbf{F_v = 0\ .1\ inches \times A_I\ acres \times .0833}$$

Design Procedures (Continued)

Where:
F_v = Forebay volume (ac-ft)
A_I = Impervious area of drainage basin, acres
0.0833 = conversion factor of acre inches to acre feet

Often, it is more manageable to work with forebay volumes in cubic feet rather than acre feet, because they are small volumes. To convert F_v in acre feet to cubic feet, multiply F_v by 43560 square feet.

Step 4. Determine swale dimensions.

Size bottom width, depth, length, and slope necessary to store WQ_v with less than 18 inches of ponding at the downstream end.

Channel slope cannot exceed 4% (1% to 2% recommended). For more steeply sloped areas, swale must be "stepped" with check dams or similar structures to maintain slope.

Bottom width should range from 2 to 8 feet

Length to width ratio of 5:1 is suggested.

Ensure that side slopes are no greater than 3:1 (4:1 recommended)

See *Site and Design Considerations*, above.

Step 5. Compute number of check dams or similar structures required to detain WQ_v.

Step 6 Calculate drawdown time in the swale.

Dry Swale: Planting soil, 30 inches, should pass a maximum rate of 1.5 feet/day and must completely filter WQ_v in 48 hours.

Wet Swale: Must hold WQ_v.

Step 7 Check 2-year velocity erosion potential and provide 6 inches of freeboard above 10-year storm.

Step 8 Design low flow orifice at downstream headwalls and checkdams.

Design orifice to pass WQ_v in six hours. See PTP-01 Stormwater Ponds for information on orifice sizing.

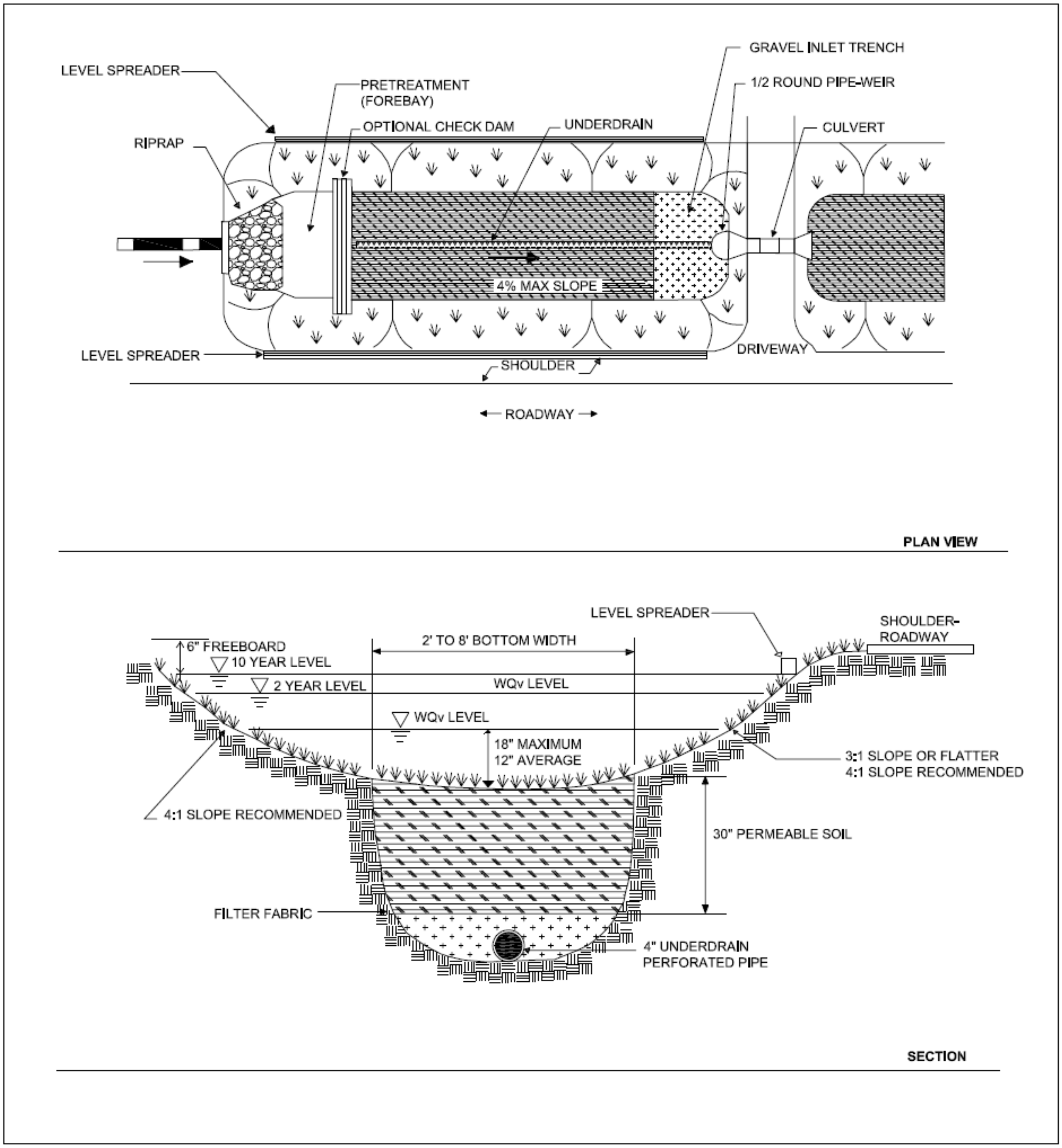
Design Procedures (Continued)

Step 9. Design inlets, sediment forebays and underdrain system (dry swale).

See *Site and Design Considerations,* above.

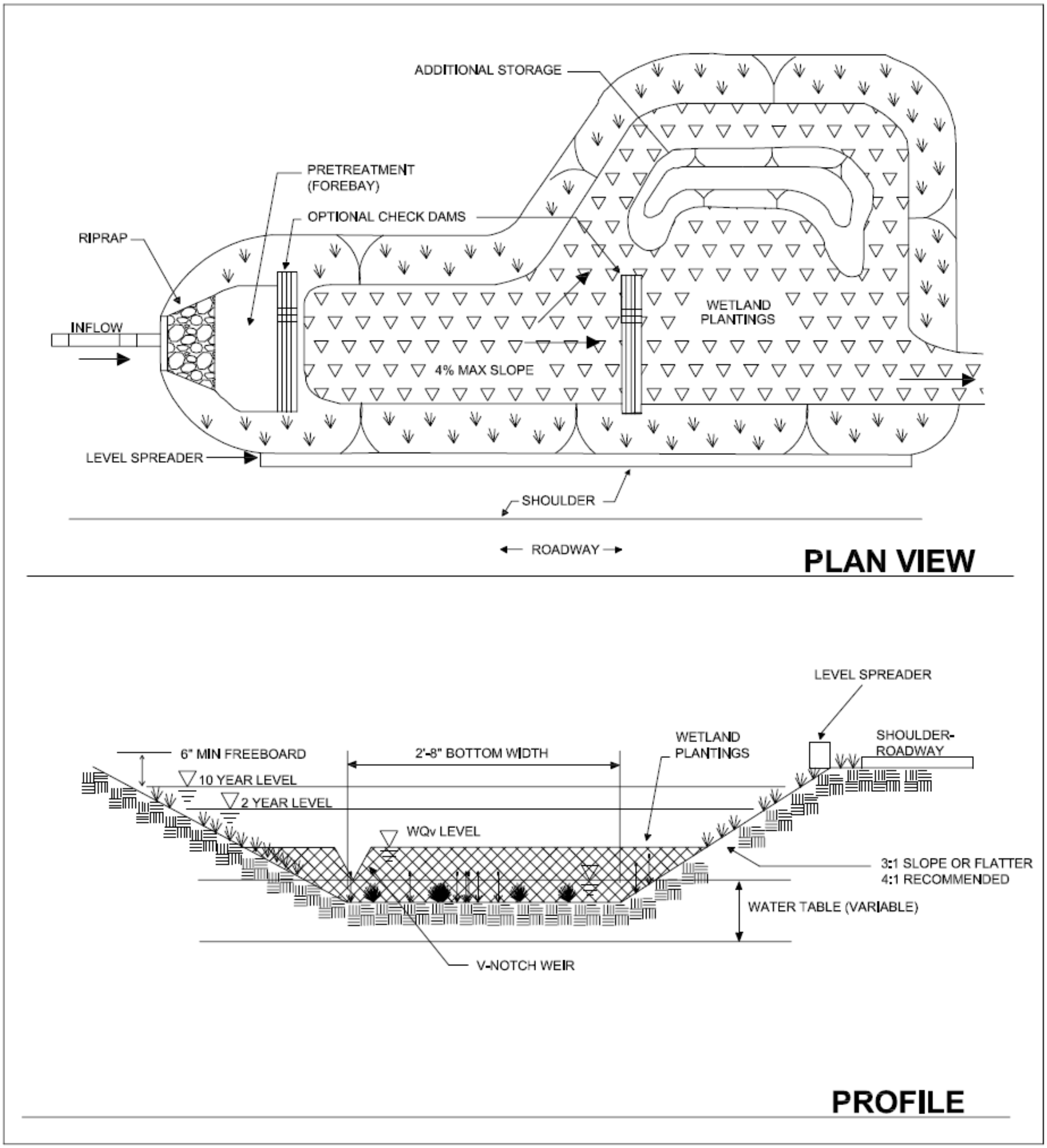
Step 10 Prepare Vegetation and Landscaping Plan.

A landscaping plan for a dry or wet swale should indicate how the enhanced swale system will be stabilized and established with vegetation.



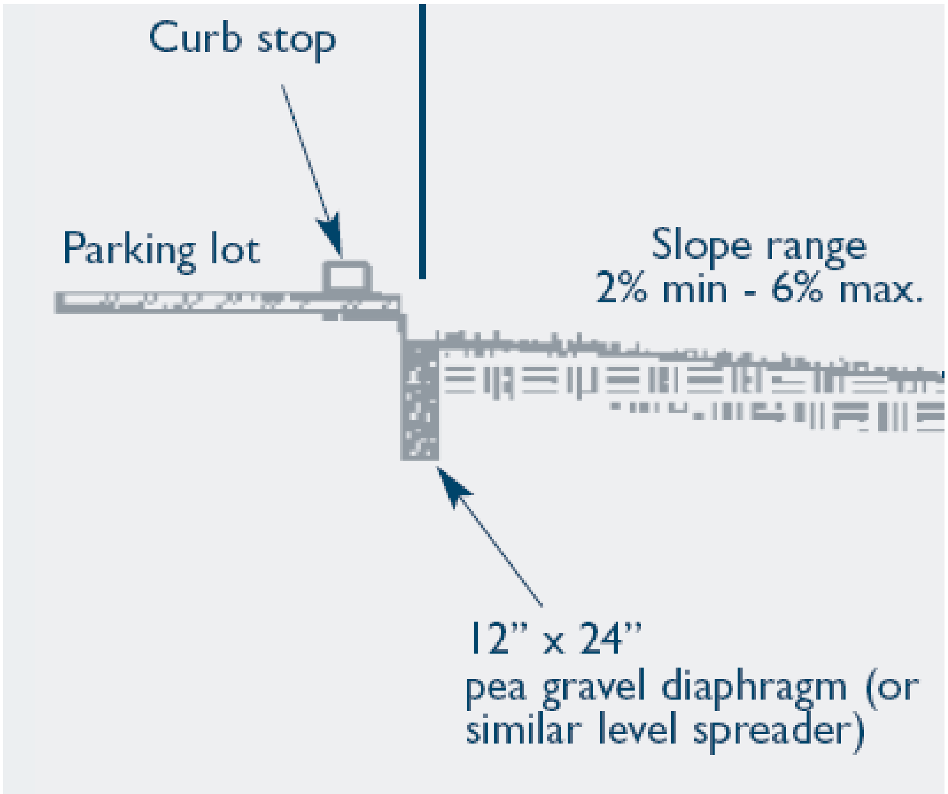
(Adapted from the Center for Watershed Protection)

Figure 5.1 Dry Water Quality Swale

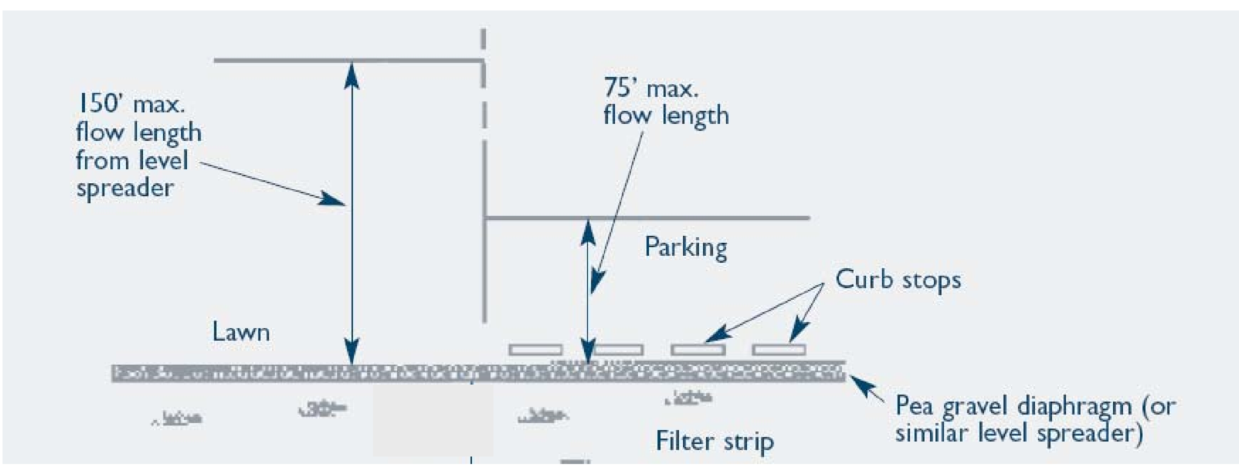


(Adapted from the Center for Watershed Protection)

Figure 5.2 Wet Water Quality Swale



PLAN VIEW



PROFILE

(Source: Connecticut Stormwater Management Manual)

Figure 5.3 Example of Level Spreader
(for Swales Receiving Directly Connected Runoff)

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Dry Ponds

Description: A surface storage basin or facility designed to provide water quantity control and limited water quality benefits through detention and/or extended detention of stormwater runoff.

Components:
- Pool area –fills during a storm and releases water slowly through bottom outlet
- Forebay – settles out larger sediments in an area where sediment removal (maintenance) will be easier
- Spillway system – provides outlet for stormwater runoff when large storm events occur

Advantages/Benefits:
- Typically less costly than stormwater (wet) ponds for equivalent flood storage, as less excavation is required
- Provides recreational and other open space opportunities between storm runoff events

Disadvantages/Limitations:
- Controls for stormwater quantity—not intended to provide for total water quality treatment; assumed to achieve 60% TSS removal
- Must be used in conjunction with other water quality controls
- Tends to re-suspend sediment

Design considerations:
- Applicable for drainage areas up to 75 acres
- Drawdown of 24 to 48 hours
- Shallow pond with large surface area performs better than deep pond of same volume
- Assumed to provide 60% TSS removal

Selection Criteria:

☐ **Water Quality 80 % TSS Removal**

☐ **Accepts Hotspot Runoff**

☑ **Residential Subdivision**

☑ **High Density / Ultra Urban Use**

Maintenance:
- Remove debris from basin surface
- Remove sediment buildup
- Repair and revegetate eroded areas.
- Perform structural repairs to inlet and outlets.
- Mow unwanted vegetation

L **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Dry extended detention (ED) basins, as shown in Figure 6.1, are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts. These facilities temporarily detain stormwater runoff, releasing the flow over a period of time. They are designed to completely drain following a storm event and are normally dry between rain events. For the purposes of this application, dry detention and dry extended detention are considered the same treatment.

Dry detention basins, when used for flow attenuation, can be designed to control the 100-year storm event, the detention requirement for Metro.

Dry detention basins provide limited pollutant removal benefits and are not intended for sole water quality treatment. Detention-only facilities must be used in a treatment train approach with other structural controls that provide treatment of the WQ_v. This type of facility is assumed to provide 60% TSS removal. While the ponds may be providing peak flow attenuation in addition to water quality treatment (in-line ponds), the other water quality treatment controls in the treatment train must be off-line.

Compatible multi-objective use of dry detention facilities is strongly encouraged.

Site and Design Considerations

Location

1. Dry detention basins are to be located downstream of other structural stormwater controls providing treatment of the water quality volume (WQ_v). See Volume 4, PTP Section 6 Introduction, sub-section 6.2 for more information on the use of multiple structural controls in a treatment train.
2. The maximum contributing drainage area to be served by a single dry detention basin is 75 acres.

General Design

3. Dry detention basins can be sized to hold the WQ_v or, if used for flow attenuation, they can be sized to temporarily store the 100-year storm. Routing calculations must be used to demonstrate that the storage volume is adequate for flow attenuation. See Volume 2 for procedures on the design of detention storage.
4. Tennessee Safe Dams Act may apply to ponds with storage volumes and embankment heights large enough to fall under the regulation.
5. Vegetated embankments shall be less than 20 feet in height and shall have side slopes no steeper than 3:1 (horizontal to vertical). Riprap-protected embankments shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for embankments greater than 10 feet in height and is mandatory for embankment slopes steeper than those given above. All embankments must be designed to Tennessee state

Site and Design Considerations (Continued)

guidelines for dam safety, as applicable.

6. The maximum depth of the basin should not exceed 10 feet.
7. Areas above the normal high water elevations of the detention facility (that is, the largest event for which the facility is sized) should be sloped toward the basin to allow drainage and to prevent standing water. Careful finish grading is required to avoid creation of upland surface depressions that may retain runoff. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with riprap) is recommended to convey low flows and prevent standing water conditions.
8. Adequate maintenance access must be provided for all dry basins.

Inlet and Outlet Structures

9. Inflow channels are to be stabilized with flared riprap aprons, or the equivalent. A sediment forebay sized to 0.1 inches per impervious acre of contributing drainage should be provided for dry detention basins.
10. For a dry detention basin used for flow attenuation, the outlet structure is sized for 100-year peak flow control (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure. Small outlets that will be subject to clogging or are difficult to maintain are not acceptable. A low flow orifice capable of releasing the WQ_v over 24 hours must be provided.
11. Seepage control or anti-seep collars should be provided for all outlet pipes.
12. Riprap, plunge pools or pads, or other energy dissipaters are to be placed at the end of the outlet to prevent scouring and erosion. If the basin discharges to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance.
13. An emergency spillway is to be included in the stormwater pond design to safely pass the extreme flood flow. The spillway prevents pond water levels from overtopping the embankment and causing structural damage. The emergency spillway must be designed to State of Tennessee dam safety requirements and must be located so that downstream structures will not be affected by spillway discharges.
14. A minimum of one foot of freeboard must be provided, measured from the top of the water surface elevation for the 100-year storm, to the lowest point of the dam embankment not counting the emergency spillway.

As-Built Certification Considerations

After the pond is constructed, an as-built certification of the pond, performed by a registered Professional Engineer, must be submitted to Metro. The as-built certification verifies that the BMP was installed as designed and approved. The following components must be addressed in the as-built certification:

1. Pretreatment for coarse sediments must be provided.
2. Surrounding drainage areas must be stabilized to prevent sediment from clogging the filter media.
3. Correct ponding depths and infiltration rates must be maintained to prevent killing vegetation.
4. A mechanism for overflow for large storm events must be provided.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) Agreement submitted to Metro for approval and maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for dry detention ponds, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plan. The O&M agreement is for the use of the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Inspect and repair/replace treatment components.
2. Perform annual verification of infiltration rates.
3. Remove debris or dead vegetation.

Design Procedures

Refer to PTP-01 Wet Ponds for further information on pond design.

Step 1. Compute the Water Quality Volume to Receive 60% TSS Credit.

Calculate (WQ_v). *If flow attenuation is not required, the pond can be sized for the WQ_v only.*

$$WQ_v = P \times Rv \times A/12$$

Where:

- WQ_v = water quality treatment volume, ac-ft
- P = rainfall for the 85% storm event (1.1 in)
- Rv = runoff coefficient (see below)
- A = site area, acres

$$Rv = 0.015 + 0.0092I$$

Where:
I = site impervious cover, % where 50% is 50

Step 2. Determine if the development site and conditions are appropriate for the use of a dry pond.

Consider the *Site and Design Considerations* previously in this section. This type of treatment must be used in conjunction with another water quality measure in order to achieve 80% TSS removal.

Step 3. Determine pretreatment volume.

A sediment forebay is sized for each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4-6 feet deep. The forebay storage volume counts toward the total WQ_v requirement and may be subtracted from the WQ_v for subsequent calculations.

$$F_v = 0 .1 \times A_I \times 3630$$

Where:
F_v = Forebay volume (ft^3)
A_I = Impervious area of drainage basin, acres
3630 = conversion factor from Ac/in to cubic feet

Step 4. Size the outlets for storm events.

If the pond is to serve as a multifunctional pond addressing peak flow attenuation, the downstream impacts must be considered for the 2- through 100-year events.

Design Procedures (Continued)

Establish a stage-storage-discharge relationship for the design storms of interest, based upon the downstream analysis (see Section 6.8.1 in Volume 1).

Refer to PTP-01 Stormwater Ponds and Volume 2, Chapter 8 for more information on design of outlet orifices and weirs.

Step 5. Size the low flow outlet for the water quality volume.

Size low flow orifice using the following equation. If different equation is used or different type of low flow orifice is used, provide supporting calculations.

$$a = \frac{2A(H - H_o)^{0.5}}{3600CT(2g)^{0.5}}$$

a = area of orifice (ft^2)
A = average surface area of the pond (ft^2)
C = orifice coefficient, 0.66 for thin, 0.80 for materials thicker than orifice diameter
T = drawdown time of pond (hrs), must be greater than 24 hours
g = gravity (32.2 ft/sec^2)
H = elevation when pond in full (ft)
H_o= final elevation when pond is empty (ft)

Step 6. Design embankment and emergency spillway.

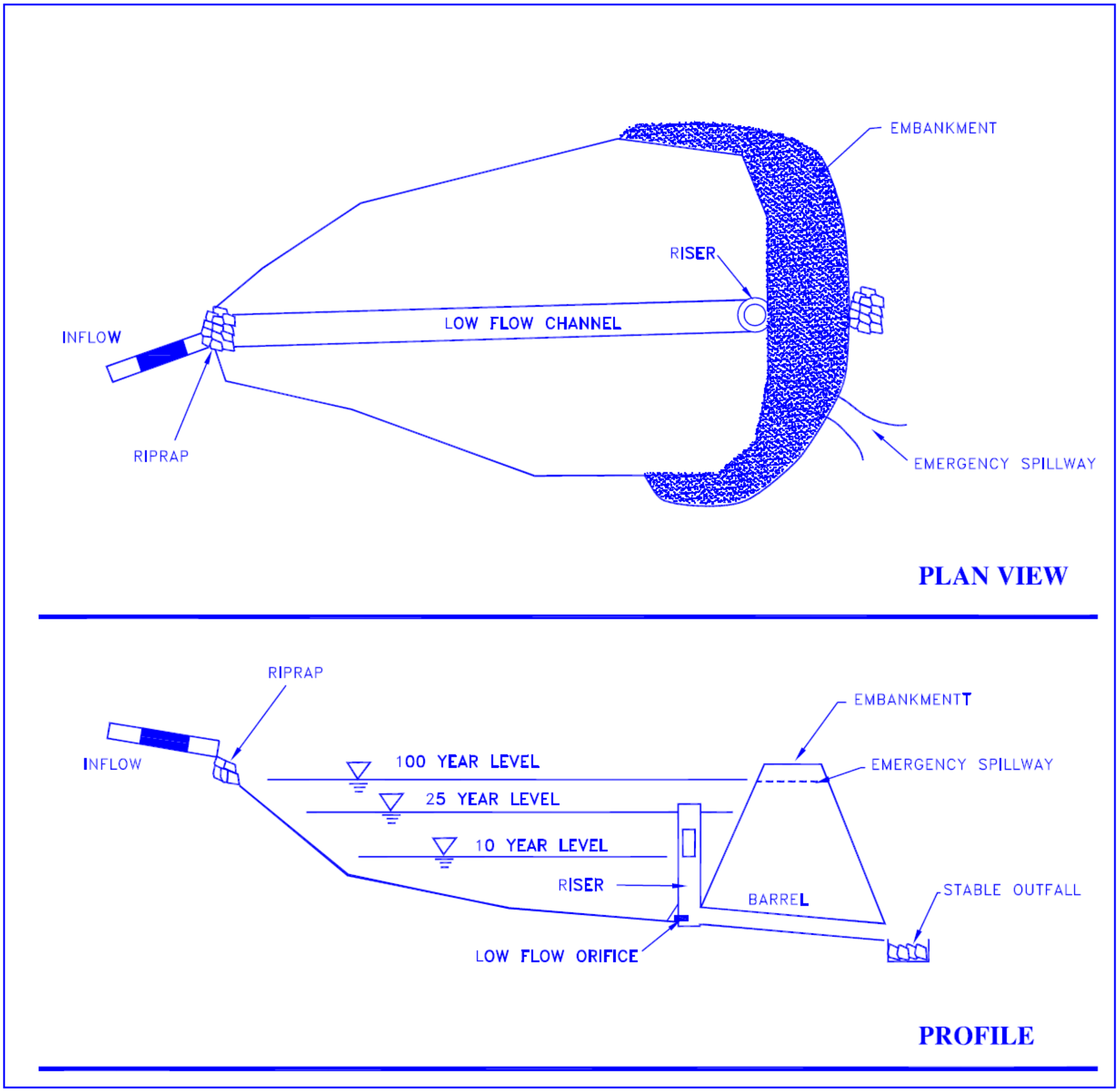
Size emergency spillway for any overtopping of pond in case of rain event in excess of 100-year storm and for instances of malfunction or clogging of primary outlet structure.

Step 7. Investigate potential dam hazard classification.

The design and construction of ponds in Tennessee must follow the requirements of the Safe Dams Act. Contact the Tennessee Department of Environment and Conservation, Division of Water Supply for more information about building dams in Tennessee.

Step 8. Design inlets, sediment forebays, outlet structures, maintenance access and safety features.

See the *Site and Design Considerations* section for information on design.



Note: Storm attenuation levels vary depending on site detention requirements.

(Adapted from the Center for Watershed Protection)

Figure 6.1 Schematic of Dry Extended Detention Basin

References

ARC, 2001. Georgia Stormwater Management Manual Volume 2 Technical Handbook.

CDM, 2000. Metropolitan Nashville and Davidson County Stormwater Management Manual Volume 4 Best Management Practices.

Suggested Reading

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Filter Strip

Description: Uniformly graded section of land that is densely vegetated and is designed to treat runoff through vegetative filtering and infiltration. Water enters the filter strip along its width and runs across the length of the filter strip.

Components:

- Vegetation – provides water quality treatment through filtering and plant uptake; vegetation can be grasses or other deep-rooted plants
- Land with gradual slope – minimal slopes allow for some amount of water quality treatment through infiltration
- Level spreader – ensures runoff over the vegetated filter is in sheet flow (shallow, uniform flow length) as opposed to concentrated (channelized) flow

Advantages/Benefits:

- High community acceptance in any type of setting
- Easy to maintain once ground cover and/or trees established
- Can be used as pre-treatment for other BMPs, similar to sediment forebay
- Filter strips are easily incorporated into new construction/ development designs

Disadvantages/Limitations:

- Cannot meet the 80% total suspended solids goal without another BMP in a treatment train. Fifty foot strip is assumed to achieve 50% TSS removal, while 25 foot strip used as a pretreatment control is assumed to achieve 10% TSS removal
- Filter strip and level spreaders have limited drainage areas
- It can be difficult to construct a level lip on level spreaders

Design considerations:

- Must have slopes between 2% and 6%
- Must maintain sheet flow across entire filter strip
- Minimum 25 foot flow length; the longer the flow length, the higher the pollutant removal, if sheet flow is maintained.

Selection Criteria:

- [ ] **Water Quality 80% TSS Removal**
- [x] **Accepts Hotspot Runoff**
- [x] **Residential Subdivision**
- [ ] **High Density / Ultra Urban Use**

Maintenance:

- Maintain a dense, healthy stand of grass and other vegetation
- Repair erosion
- Periodic sediment removal
- Revegetate as needed

L	**Maintenance Burden**

L = Low M = Moderate H = High

General Description

Filter strips are uniformly graded, densely vegetated areas of land that are designed to remove pollutants from runoff through vegetative filtration and infiltration. Filter strips are suited for treating runoff from roads and highways, small parking lots, pervious areas, and roof downspouts. They are also well-suited as the outer zone of a stream buffer and as pretreatment for other structural controls. Filter strips that fulfill Metro requirements can be used as credits against the stormwater quality volume for a site (see Volume 1, Chapter 7.8).

The vegetation can be grassed or a combination of grass and woody plants. Pollutant removal efficiencies are based upon a 50-foot long strip. Filter strips with shorter flow lengths are considered to have lower removal efficiencies and should be used as coarse sediment settling areas for other structural controls. Filter strips are and considered to be an integral component of those controls, similar to sediment forebays for stormwater wet ponds (see PTP-01). Uniform sheet flow must be maintained through the filter strip to provide pollutant reduction and to avoid erosion. To obtain sheet flow when discharging runoff from a developed area, a level spreader may be required.

Components

Figure 7.1 illustrates a filter strip. Filter strips consist of the following components:

1. Sheet flow spreader that allows flow to enter the filter strip as sheet flow.
2. Uniformly graded area with 2 to 6 percent slopes, with a minimum width of 15 feet, and a minimum length (flow path) of 50 feet for a 50% TSS removal credit (Volume 4, Section 6.1) and 25 feet for a settling or pretreatment control, with a lesser credit of 10% TSS removal.
3. Dense vegetation that can withstand relatively high velocity flows.
4. Optional berm.

Site and Design Considerations

The following design and site considerations must be incorporated into the filter strip design:

1. Filter strips should be used to treat small drainage areas, ordinarily with a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces (CWP, 1996). For longer flow paths, special provision must be made to ensure design flows spread evenly across the filter strip. .
2. Flow must enter the filter strip as sheet flow spread out over the width of the strip, generally no deeper than 1 to 2 inches.
3. Filter strips should be integrated into site designs.
4. Filter strips should be constructed outside the natural stream buffer area whenever possible to maintain a more natural buffer along the streambank.
5. Filter strips should be designed for slopes between 2% and 6%. Greater slopes than this would encourage the formation of concentrated flow. Flatter slopes would encourage standing water.
6. Filter strips should not be used on soils that cannot sustain a dense grass cover with high retardance. Designers should choose a grass that can withstand relatively high velocity flows at the entrances, and both wet and dry periods.
7. The filter strip should be at least 15 feet long to provide filtration and contact time for water quality treatment. 25 feet is preferred, though length will normally be dictated by design method. 50 feet is necessary to achieve the 50% TSS removal credit.
8. Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion.
9. An effective flow spreader a pea gravel diaphragm located at the top of the slope (ASTM D 448 size no. 6, 1/8” to 3/8”). The pea gravel diaphragm is a small trench running along the top of the filter strip. It serves two purposes. First, it acts as a pretreatment device, settling out sediment particles before they reach the filter strip. Second, it acts as a level spreader, maintaining sheet flow as runoff flows over the filter strip. Other types of flow spreaders include long timbers, a concrete sill, curb stops, or curb and gutter with “sawteeth” cut into it.
10. Ensure that flows in excess of design flow move across or around the strip without damaging it. Often a bypass channel or overflow spillway with protected channel section is designed to handle higher flows.
11. Maximum discharge loading per foot of filter strip width (perpendicular to flow path) is found using the Manning’s equation:

$$q = \frac{0.00236}{n} Y^{\frac{5}{3}} S^{\frac{1}{2}}$$

Where: q = discharge per foot of width of filter strip (cfs/ft)
Y = allowable depth of flow (inches)
S = slope of filter strip (percent)
n = Manning’s “n” roughness coefficient
(Use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

Site and Design Considerations (Continued)

12. Using *q*, computed above, The minimum width of a filter strip is:

$$W_{fMIN} = \frac{Q}{q}$$

Where: W_{fMIN} = minimum filter strip width perpendicular to flow (feet)
Q = water quality flow rate (see PTP-03 Bioretention, page 5, Design Step #4).

Filter Strips without Berm

13. Size filter strip (parallel to flow path) for a contact time of 5 minutes minimum.
14. Equation for filter length is based on the SCS TR-55 travel time equation (SCS, 1986):

$$L_f = \frac{(T_t)^{1.25}(P_{2-24})^{0.625}(S)^{0.5}}{3.34n}$$

Where: L_f = length of filter strip parallel to flow path (25 ft minimum)
T_t = travel time through filter strip (5 minutes minimum)
P2-24 = 2-year, 24-hour rainfall depth (3.39 inches)
S = slope of filter strip (2-6 percent preferred)
n = Manning's "n" roughness coefficient
(Use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

(Source for equations in items 11 through 14: Georgia Stormwater Management Manual)

Filter Strips with Berm

15. Size outlet pipes to ensure that the bermed area drains within 24 hours. Refer to PTP-01 Stormwater Wet Ponds for orifice sizing equations.
16. Specify grasses resistant to frequent inundation within the shallow ponding limit.
17. Berm material should consist of sand, gravel and sandy loam to encourage grass cover (Sand: ASTM C-33 fine aggregate concrete sand 0.02"-0.04", Gravel: AASHTO M-43 ½" to 1").
18. Size filter strip to contain the WQ_v within the wedge of water backed up behind the berm.
19. Maximum berm height is 12 inches.

Filter Strips for Pretreatment

20. A number of other structural controls, including bioretention areas and infiltration trenches, may utilize a filter strip as a pretreatment measure. The required length of the filter strip depends on the drainage area, imperviousness, and the filter strip slope. Table 7.1 provides sizing guidance for using filter strips for pretreatment. Filter strips used as pretreatment for coarse sediment for bioretention areas and infiltration trenches are not credited with removing TSS above and beyond the main treatment BMP.

Site and Design Considerations (Continued)

Table 7.1 Sizing of Filter Strips for Pretreatment Only

Parameter	Impervious Areas*				Pervious Areas (Lawns, etc)**			
Maximum inflow approach length (feet)	35		75		75		150	
Filter strip slope (max = 6%)	< 2%	> 2%	< 2%	> 2%	< 2%	> 2%	< 2%	> 2%
Filter strip minimum length (feet)***	10	15	20	25	10	12	30	36

* 75 feet maximum impervious area flow length to filter strip.
** 150 feet maximum pervious area draining to filter strip.
***At least 25 feet is *required* for minimum pretreatment credit of 10% TSS removal. Fifty feet is required for obtaining 50% TSS removal credit.
(*Adapted from Georgia Stormwater Management Manual)*

As-Built Certification Considerations

After the filter strip has been constructed, the developer must have an as-built certification of the filter strip conducted by a registered Professional Engineer. The as-built certification verifies that the BMP was installed as designed and approved.

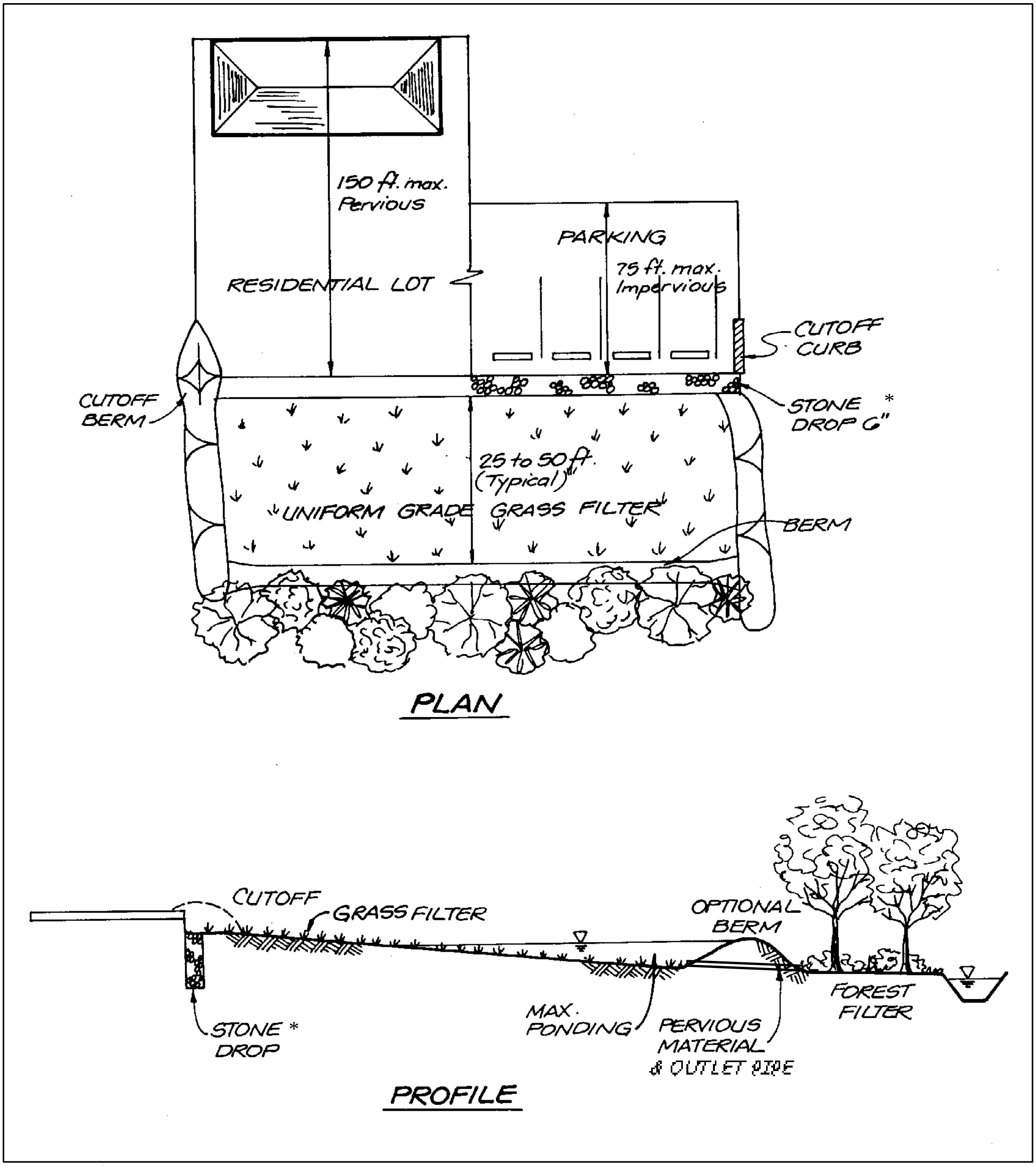
The following components must be addressed in the as-built certification:

1. Ensure design flows spread evenly across filter strip.
2. Ensure design slope is between 2% and 6%.
3. Verify dimensions of filter strip.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) Agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for filter strips, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The O&M Agreement is to be used by the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Maintain a dense, healthy stand of grass and other vegetation by frequent mowing: grass heights of 3 to 5 inches should be maintained, with a maximum grass height of 8 inches;
2. Repair erosion;
3. Periodic sediment removal; and
4. Revegetate as needed.



(Adapted from Georgia Stormwater Manual)

* Stone drop or some other acceptable type of level spreader to achieve sheet flow.

Figure 7.1 Filter Strip

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Grass Channels

Description: Limited application structural control. Open channels that are vegetated and are designed to filter stormwater runoff, as well as slow water for treatment by another structural control.

Components:
- Broad bottom channel on gentle slope (4% or less)
- Gentle side slopes (3:1 (H:V) or less)
- Dense vegetation that assists in stormwater filtration
- Check dams can be installed to maximize treatment

Advantages/Benefits:
- Provides pretreatment if used as part of runoff conveyance system
- Provides partial infiltration of runoff in pervious soils
- Less expensive than curb and gutter
- Good for small drainage areas
- Relatively low maintenance requirements

Reasons for Limited Use:
- Cannot alone achieve 80% removal of TSS; Fifty foot long channel is assumed to achieve 50% removal of TSS
- Must be carefully designed to achieve low flow rates in the channel (< 1.0 ft/s)
- May re-suspend sediment
- May not be acceptable for some areas because of standing water in channel

Design considerations:
- Maximum drainage area of 5 acres
- Require slopes of 4% or flatter
- Runoff velocities must be non-erosive
- Appropriate for all but the most impermeable soils
- Requires vegetation that can withstand both relatively high velocity flows and wet and dry periods.

Selection Criteria:

☐ **Water Quality 80% TSS Removal**

☑ **Pretreatment**

☑ **Residential Subdivision**

☑ **High Density / Ultra Urban Use**

Other: Replaces curb and gutter

Maintenance:
- Mow grass to 3 or 4 inches high
- Clean out sediment accumulation in channel
- Inspect for and correct formation of rills and gullies
- Ensure that vegetation is well-established

L **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Grass channels, sometimes called biofilters, are conveyance channels that are designed to provide some treatment of runoff, as well as to slow down runoff velocities for treatment in other structural controls. Grass channels are appropriate for a number of applications including treating runoff from paved roads and from pervious areas.

Grass channels do not provide full water quality treatment because they are not designed with engineered filtration areas, as water quality swales (PTP-06) are. Because they are not enhanced for increased filtration and infiltration, they provide a lower TSS removal and are appropriate for limited application in combination with other structural controls.

Grass channels are able to infiltrate some runoff from small storms when situated in pervious soils. They provide other ancillary benefits such as reduction of impervious cover, accenting natural features, and reduced cost when compared with traditional curb and gutter.

The most important considerations when designing a grass channel are the channel capacity and erosion prevention. Runoff velocities must not exceed 1.0 foot per second during the peak discharge associated with the 2-year design storm. In addition, the vegetation height should provide 5 minutes of residence time in the channel.

Figure 8.1 illustrates a grass channel. A grass channel consists of the following elements:

1. A broad bottomed, trapezoidal or parabolic channel on a gentle slope (4% or less);
2. Gently sloping sides (3:1 (H:V) or less);
3. Hardy vegetation that can withstand relatively high velocities as well as a range of moisture conditions from very wet to dry; and
4. Optional check dams to increase residence time.

Site and Design Considerations

The following design and site considerations must be incorporated into the grass channel design:

General Considerations

1. The drainage area (contributing or effective) must be 5 acres or less. Runoff flows and volumes from larger drainage areas prevent proper filtration and infiltration of stormwater.
2. Grass channels should be designed on areas with slope of less than 4%. Slopes of 1% to 2% are recommended.
3. Grass channels can be used on most soils with some restrictions on the most impermeable soils. Grass channels should not be used on soils with infiltration rates less than 0.27 inches per hour if infiltration of small runoff flows is intended.
4. A grass channel should be designed to accommodate the water quality flow. Calculations for the water quality flow are as follows:

   $$Qp = C * I * A$$

   Where:
   Qp = the peak flow through the grass channel in cfs
   C = runoff coefficient
   I = rainfall intensity, 2.45 in/hr
   A = the contributing drainage area for the grass channel in acres

   Larger flows should be accommodated by the channel if dictated by the surrounding conditions. For instance, Metro requires site drainage to accommodate the 10-year design storm.
5. The channel should accommodate the 2-year, 24-hour storm without eroding.
6. Grass channels should have a trapezoidal or parabolic cross section with relatively flat side slopes (generally 3:1 or flatter).
7. The bottom of the channel should be between 2 and 6 feet wide. The minimum width ensures a minimum filtering surface for water quality treatment, and the maximum width prevents braiding, which is the formation of small channels within the swale bottom. The bottom width is a dependent variable in the calculation of velocity based on Manning's equation. If a larger channel is needed, the use of a compound cross section is recommended.
8. Runoff velocities must be nonerosive. The full-channel design velocity will typically govern.
9. A 5-minute residence time is recommended for the water quality peak flow. Residence time may be increased by check dams, reducing the slope of the channel, increasing the wetted perimeter, or planting a denser grass (raising the Manning’s n).
10. The depth from the bottom of the channel to the groundwater should be at least 2 feet to prevent a moist swale bottom, or contamination of the groundwater.

Site and Design Considerations (Continued)

11. Incorporation of check dams within the channel will maximize retention time.
12. Designers should choose a grass that can withstand relatively high velocity flows at the entrances, and both wet and dry periods.
13. A forebay is recommended in order to minimize the volume of sediment in the channel. (Refer to PTP-01 for forebay design.)
14. Provide an overflow for larger storm events.
15. Refer to Volume 2, Chapter 3 for design of open channel hydraulics.

Grass Channel as Pretreatment

A number of structural controls such as bioretention areas and infiltration trenches may be supplemented by a grass channel that serves as pretreatment for runoff flowing to the device. The lengths of grass channels vary based on the drainage area imperviousness and slope. Channels must be no less than 20 feet long. Table 8.1 below gives the minimum lengths for grass channels based on slope and percent imperviousness:

Table 8.1 Grass Channel Length Guidance
(Source: Georgia Stormwater Management Manual)

Parameter	<= 33% Impervious		Between 34% and 66% Impervious		>= 67% Impervious	
Slope (max = 4%)	< 2%	> 2%	< 2%	> 2%	< 2%	> 2%
Grass channel minimum length* (feet) *assumes 2-foot wide bottom width	25	40	30	45	35	50

As-Built Certification Considerations

After the grass channel has been constructed, an as-built certification of the grass channel must be prepared by a registered Professional Engineer and submitted to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

The following components must be addressed in the as-built certification:

1. The channel must be adequately vegetated.
2. The channel flow velocities must not exceed 1.0 foot per second.
3. A mechanism for overflow for large storm events must be provided.

Maintenance

Each BMP must be addressed in the overall Operations and Maintenance (O&M) Agreement (refer to Volume 1, Appendix C) for the development and submitted to Metro for approval with site plans.

Maintenance requirements for grass channels include the following:

1. Maintain grass height of 3 to 4 inches.
2. Remove sediment build up in channel bottom when it accumulates to 25% of original total channel volume.
3. Ensure that rills and gullies have not formed on side slopes. Correct if necessary.
4. Remove trash and debris build up.
5. Replant areas where vegetation has not been successfully established.

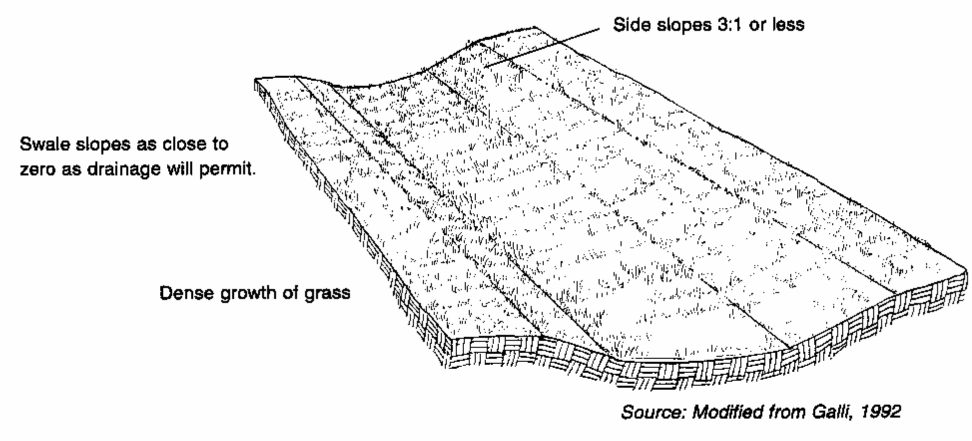
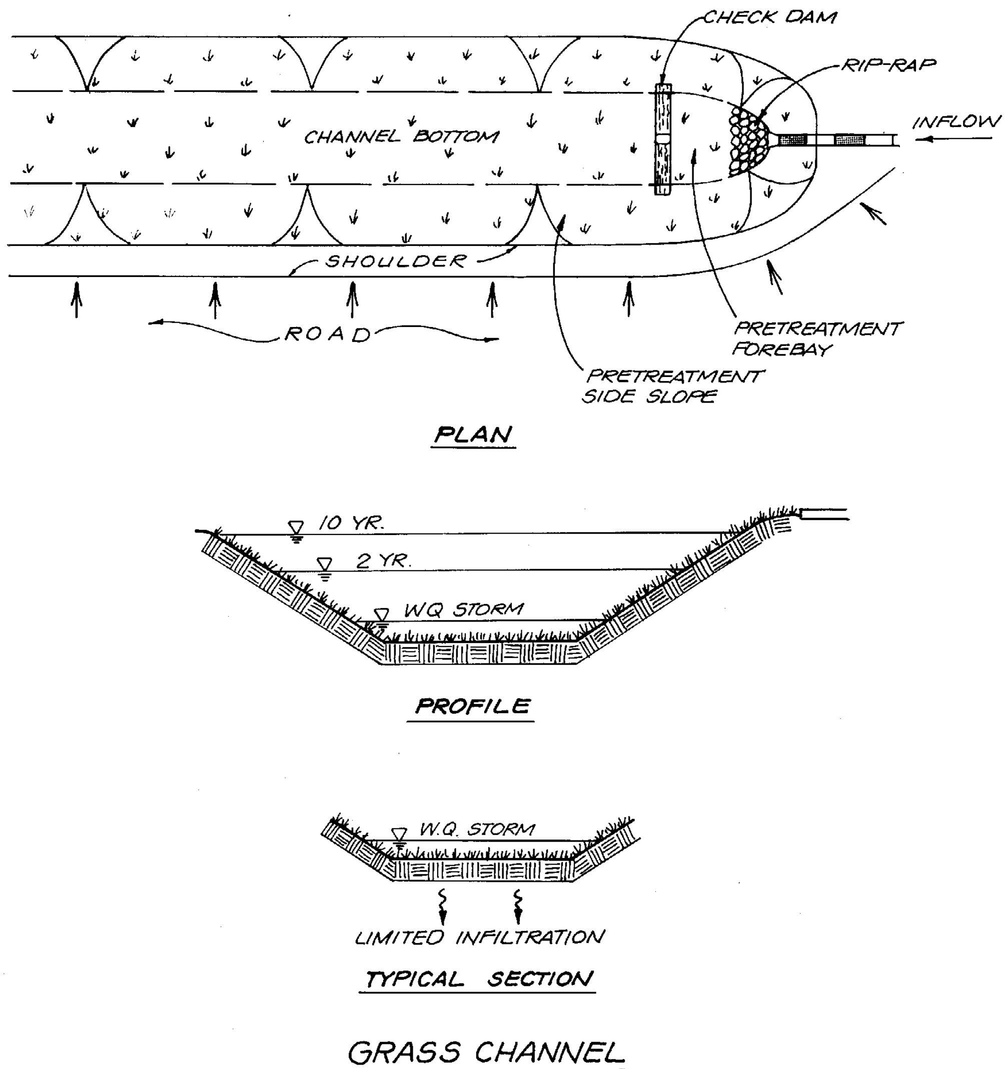


Figure 8.1 Typical Grass Channel



(Source: Center for Watershed Protection)

Figure 8.2 Grass Channel Schematic

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Claytor, R.A., and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. The Center for Watershed Protection, Silver Spring, MD.

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Green Roofs

Description: A vegetated roof cover composed of hardy plants growing in an engineered plant medium, filter cloth, drainage layer, and waterproofing membrane. Green roofs provide benefits such as reducing runoff volume and peak discharge rate, reducing building cooling costs, and prolonging roof life.

Variations: Lightweight extensive roof covers and heavier-weight intensive roof covers, or "roof gardens." Can be accessible or inaccessible.

Components:

- Vegetation selected for its ability to thrive in rooftop climate.
- Engineered planting medium, not soil, typically composed of expanded clay or a mixture of clay and other materials.
- Filter layer.
- Containment (in modular systems refers to plant containers; in non-modular systems refers to barriers at roof perimeter and drainage structures).
- Drain layer, sometimes with built-in water reservoirs.
- Water proofing layer or roof membrane with root repellant.

Advantages/Benefits:

- Reduces site imperviousness for water quality treatment calculation
- Reduces Rational C number for overall site
- Energy savings: green roofs keep buildings cool
- Stormwater retention and water quality treatment
- Possible amenity space for public or users
- Prolongs roof life
- Sound absorption
- Life cycle costs comparable to traditional roof

Disadvantages/Limitations:

- For retrofits, strengthening structure may be required
- If leaks occur, may be harder to trace
- Design and installation require specialized knowledge
- Installation costs higher than for traditional roof

Design considerations:

- Good waterproofing material and installation are essential.
- Materials used must be lightweight.
- Building structure must be able to support saturated weight.
- Roofs with moderate to flat slopes are most appropriate. Maximum roof slope of 15%.

Selection Criteria:

✓	**Water Quality 80 % TSS Removal**
NA	**Accepts Hotspot Runoff**
✓	**Residential Subdivision**
✓	**High Density / Ultra Urban Use**

Maintenance:

- Watering and fertilization until well-established
- Occasional weeding
- Inspection for proper drainage
- Ordinary life cycle roof replacement

L	**Maintenance Burden**

L = Low M = Moderate H = High

General Description

A green roof is a vegetated roof cover that allows the roof to provide several environmental benefits. Although modern green roofs have only recently been embraced in urban American design, they have been used for centuries both as functional elements (to provide insulation to homes) and as amenities (to provide enjoyable “roof garden” space for city residents).

There are two classes of roof top vegetation systems: extensive and intensive. Each of these types can be further classified as accessible or inaccessible green roofs. Extensive systems, also known as low-profile, performance, or eco-roofs, are composed of a waterproof membrane covered with a shallow layer (4-6 inches) of growing medium and low growing vegetation. Intensive systems, also known as high profile or roof gardens are heavier weight systems that consist of a waterproof membrane covered with a deeper layer (6 to 24 inches) of growing medium and a variety of vegetation including some deeper-rooted vegetation (even trees). Either of these types of green roofs can be made accessible to the residents or users of a building or the general public and provide a green space and amenity to the users. However, it is more common for intensive green roofs to be designed as accessible space, while extensive green roofs are often only accessed for inspections and maintenance.

Green roofs provide numerous economic and environmental benefits. Green roofs prolong roof life by reducing temperature fluctuations on rooftops, thus reducing the stress caused by expansion and contraction of roofing materials and supports in variable temperatures. In addition, green roofs provide insulation to buildings, which reduces heating and cooling costs. The vegetation itself cools the rooftop as well. An accessible green roof can increase the unit value of apartments, condominiums, or office space.

While green roofs provide environmental benefits such as cleaning fine, airborne particles from the air (improving air quality), cooling buildings (reducing the urban heat island effect), and providing habitat for various types of plants and animals, the main focus of their use in Metro is the benefit to stormwater. The vegetated roof covers provide various stormwater benefits. Because green roofs are permeable surfaces, they slow runoff, attenuating the peak runoff rate. In addition, green roofs retain water, reducing runoff volumes from the roof. Finally, water quality off of green roofs is improved through the filtering of stormwater.

Key design considerations include structural capacity and the waterproofing layer.

The components of a green roof are as follows:

1. Structural roof support sufficient to hold green roof weight. For retrofit projects, an architect, structural engineer, or roof consultant must determine if added support to the building structure is needed.

General Description (Continued)

2. Waterproof membrane appropriate for green roof. These impermeable materials come in a number of forms, such as large sheets, rolls, or liquid form; and materials, such as bituminous membranes and liquid polymer-modified asphalt products, synthetic thermoset, hypalon, and reinforced thermoplastic resin. During construction, protective material for the waterproof membrane is necessary so that it is not punctured or damaged during the green roof installation stage. The protective layer also prevents breakdown from UV rays.
3. Root barrier, if not integral to membrane. Some waterproof membranes are equipped with an integral root barrier, which prevents the membrane from being compromised. However, other membrane products need an added root barrier.
4. Drainage layer. The drainage layer prevents damage to the waterproof membrane by draining excess rainfall off the roof through roof drains. In addition, it keeps the vegetation from drowning or rotting. The drainage can consist of a manufactured mat or a layer of gravel.
5. Filter fabric between the drainage layer and the growing medium prevents clogging.
6. Growing medium. A lightweight, well-drained engineered medium in which the vegetation grows. Typical components include: pumice perlite, expanded clay, sand, shale, compost, and coir.
7. Vegetation. Extensive green roofs must have hardy drought-tolerant plants such as succulents. These perennial plants should require little maintenance except while they are being established. Intensive green roofs that are used as amenity spaces can support a wider variety of plants, even shrubs and trees, since they are maintained areas, but hardy species are advisable.

Design and Implementation Considerations

The following design and implementation considerations must be incorporated into green roofs:

Structure
The structural capacity of the building must be sufficient to support the saturated weight of the green roof system. On new construction, it is relatively inexpensive to incorporate the structural requirements of the green roof at the outset. An existing building should be able to hold an additional 10 to 30 psf (for an extensive green roof). Structural retrofits to existing buildings can be costly.

Slope
The maximum slope for a roof with a vegetated system should be 15 percent. Studies have shown that gently sloping or flat roofs retain more runoff and thus fulfill the intended stormwater functions better. Note that steeper roofs require that the planting medium and vegetation layers do not slump or slip under their own weight, especially when wet, through the use of strapping or other methods.

Use
The intended function of the green roof affects design. Green roofs in Metro should be designed to perform stormwater functions of retention, peak flow attenuation, and filtration. It may also be desired that green roofs serve as green space, in which case accessibility and aesthetics will also be important design considerations.

Roof Climate
The microclimate on the roof, which is affected by the height of the roof, wind exposure, orientation to the sun, shading by other buildings, rainfall, temperatures, and humidity are important factors in green roof design, particularly in vegetation selection.

Waterproof Membrane
The waterproof membrane is a crucial component of the green roof system. Membranes come in various materials: bitumens, synthetic thermoset, hypalon and reinforced thermoplastic resin. If the membrane contains any organic material (bitumen is most common), a root barrier is necessary to prevent root penetration and destructive micro-organic activity. Many roof membranes are manufactured with root repellant as an integral component. Membranes with pesticides as an integral component are not permitted.

Drainage
Although green roofs retain a great deal of stormwater, drainage from the entire system is still a necessary design component so that the roofing membrane is not compromised and so that the vegetation does not drown or rot. Proper drainage can be provided in a number of ways. Commonly, drainage mat systems with pockets for water storage are used. The drainage layer must be protected by filter

Design and Implementation Considerations (Continued)

fabric. The drainage layer directs excess rainfall off of the roof through roof drains and downspouts. When impervious areas drain to the roof, flow directed to the green roof from these areas must be distributed evenly to prevent scour.

Protection

Parapets, edges, flashing, skylights, vents, chimneys, and mechanical systems must be well protected with a gravel skirt, and sometimes with a weep hole.

Growing Medium

Growing medium should be a lightweight mineral-based mix. Common components include pumice perlite, expanded clay, sand, shale, compost, and coir.

Vegetation

Vegetation must be suitable for harsh rooftop climates unless shading, irrigation, and fertilization will be provided. Plants must thoroughly cover the soil, at least 90% coverage. On extensive roofs, it is most practical to install hardy and indigenous plants such as succulents, sedums, mosses, semperviviums, and festucas that can survive with little maintenance aside from watering and fertilization in the short term, while the plants establish themselves. On intensive green roofs, a wide variety of plants, bushes, and even trees can make up the vegetation. Intensive green roofs require more maintenance than extensive green roofs.

Vegetation Installation

There are common methods of establishing vegetation on green roofs:

Method	Description/Advantages	Disadvantages
Vegetation Mats	Sod-like mats with pregerminated seeds. Provide full coverage, erosion control, with little maintenance or weeding requirements.	Little flexibility in design.
Plugs or potted plants	Well-rooted seedlings raised in a nursery and then planted on the green roof.	Take longer to achieve coverage, erosion control, need more watering and weeding.
Sprigs	Cuttings that are hand broadcast.	More maintenance than mats.
Seeds	Can be handbroadcast or hydroseeded.	More maintenance than mats.

Access

Access to the green roof is important, not only for maintenance but for the initial installation of the green roof. Materials including the membrane, drainage materials, growing medium, and plants will need to be brought up to the roof. This will be easiest if there is an elevator that goes to the roof. Otherwise,

Design and Implementation Considerations (Continued)

material must be hauled up via stairs, utility ladders, or even a crane. New buildings should be designed with easy access to the roof.

If the green roof is designed to be accessible, the access must not only be convenient for installation and maintenance purposes but also must adhere to Metro Building Codes and other regulations for access and safety.

Construction and Installation
It is best to choose a roof installer who has experience in working with green roof systems. Because an industry has built up around green roofs, it is possible to find companies that specialize in green roofing. Some companies specialize in handling the whole green roofing process from re-roofing to installation and initial maintenance, some have experience with design of green roofs, while others have created special components for use on green roofs.

As-Built Certification Considerations

After the green roof has been constructed, the developer must have an as-built certification of the green roof conducted by a registered professional engineer. The as-built certification verifies that the BMP was installed as designed and approved.

The following components are vital components of a properly working green roof and must be addressed in the as-built certification:

1. Protection of vulnerable areas (abutting vertical walls, roof vent pipes, outlets, air conditioning units, and perimeter areas) from leakage;
2. Profile view of facility including typical cross-sections with dimensions;
3. Growing medium specification including dry and saturated weight;
4. Filter fabric specification;
5. Drainage layer specification;
6. Waterproof membrane specification, including root barriers;
7. Stormwater piping associated with the site, including pipe materials, sizes, slopes, invert elevations at bends and connections; and
8. Planting and irrigation plan.

Operation and Maintenance

Each BMP on a site must be addressed in the overall Operations and Maintenance (O&M) Agreement (refer to Volume 1, Appendix C) for the development and submitted to Metro for approval with the plans submittal. The components of the O&M Agreement can be found in Section 6.7.1 of Volume 1. This section generally outlines the inspection and maintenance needs specific to green roofs. More detailed inspection and maintenance information can be found in Appendix C of Volume 1 in the form of an inspection and maintenance checklist. This information should be included in the O&M Agreement for the development.

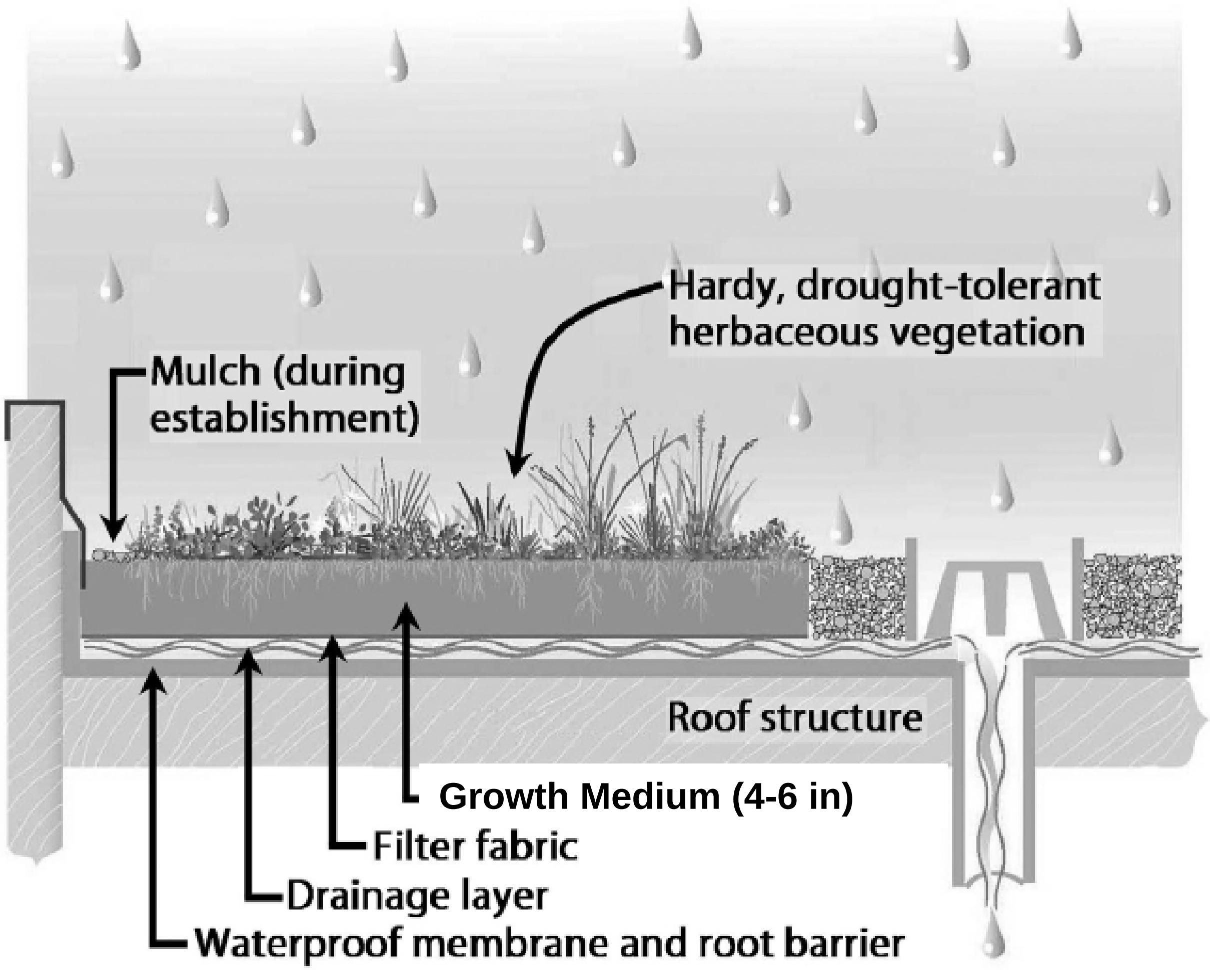
The O&M Agreement is to be used by the BMP owner or owners in performing routine inspections. The owner is responsible for the cost of maintenance and annual inspections, and the BMP owner must maintain and update the BMP operations and maintenance plan at least annually. At a minimum, the operations and maintenance plan must address:

1. Inspect and repair/replace green roof system components.
2. Ensure survival of vegetation.
3. Remove debris or dead vegetation.

Design Procedures

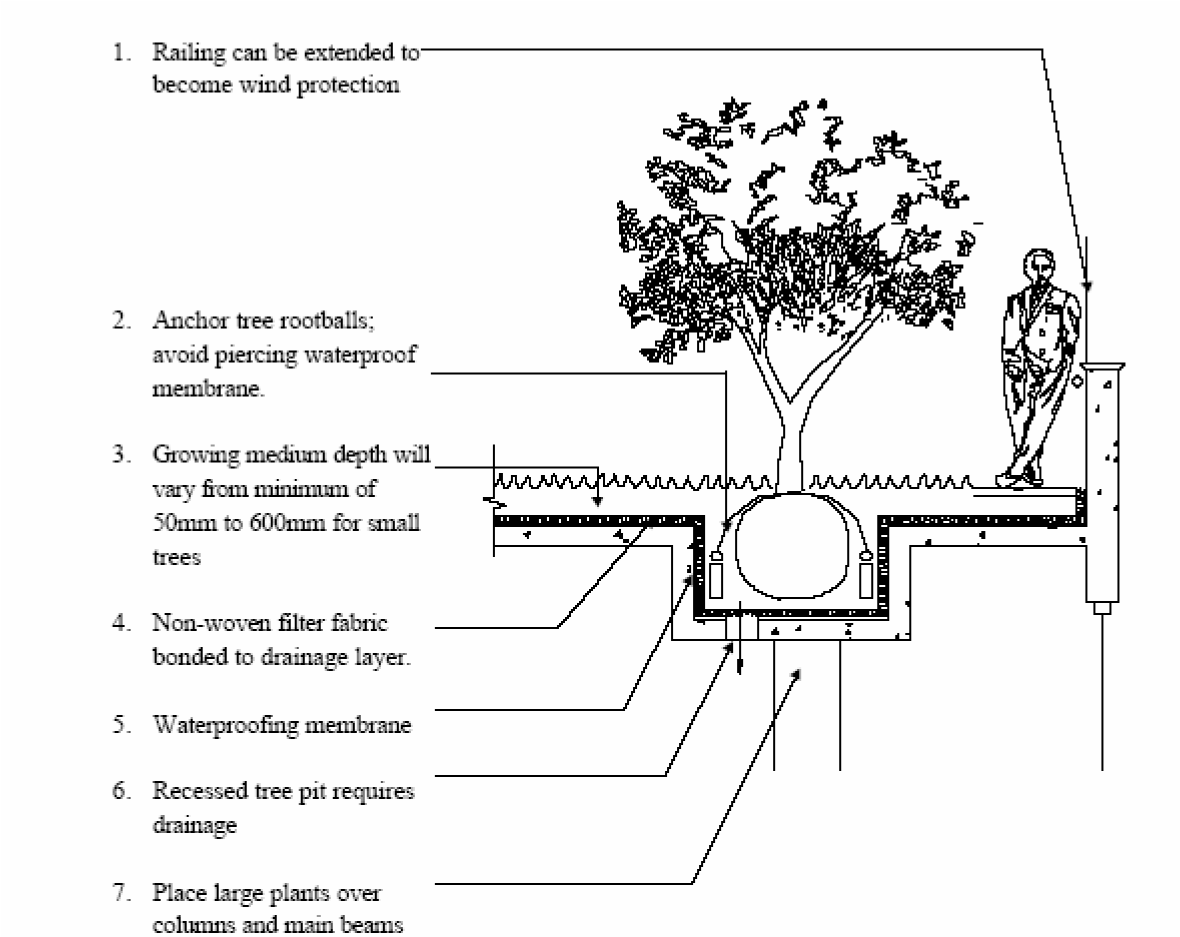
Specialized design and installation companies should be consulted for the design of the green roof.

For the purposes of water quality volume calculations, the area of the building(s)'s roof that is covered with the green roof structure is subtracted from the site's impervious area. Thus, the advantage of a green roof, from a water quality treatment volume standpoint is that the green roof reduces the WQ_v *through the reduction in site's imperviousness percentage.*



(*Source: Massachusetts Low Impact Development Toolkit)*

Figure 9.1 Extensive Green Roof (4 to 6 inches of growth medium)



Source: Public Works and Government Services Canada, 2002

Figure 9.2 Intensive Green Roof (6 to 24 inches of growth medium)

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Suggested Reading

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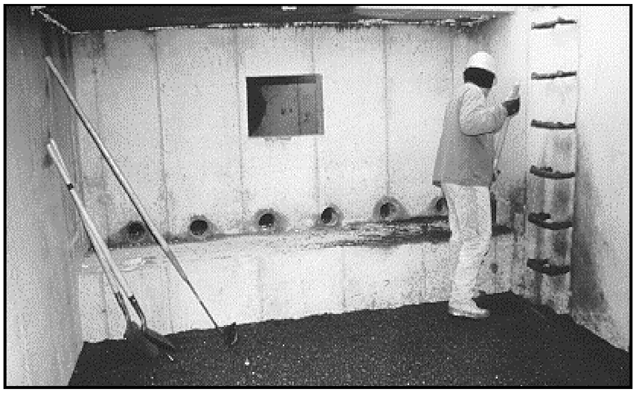
Greenroofs for Healthy Cities. http://www.greenroofs.net/index.php

Underground Sand Filter



Description: Design variant of the sand filter, located in an underground vault.

Variations: Surface Sand filter (PTP-04), Perimeter Sand filter (PTP-11)

Components:
Underground vault with three chambers
(1) Sedimentation chamber
(2) Filter chamber with protective screen and perforated drain system to third chamber
(3) Overflow/outlet chamber

Advantages/Benefits:
- High sediment trapping capability
- Additional pollutant removal as a result of sediment removal
- Precast concrete shells available, which decrease construction costs

Disadvantages/Limitations:
- Intended for space-limited applications
- High maintenance requirements

Design considerations:
- Drains highly impervious areas, usually 1 acre or less
- Provide maintenance access to chambers
- Underground chamber must be water tight. Openings must be $1/16^{th}$ inch or smaller to prevent mosquito intrusion

Selection Criteria:
- [✓] **Water Quality 80 % TSS Removal**
- [✓] **Accepts Hotspot Runoff**
- [ ] **Residential Subdivision**
- [✓] **High Density / Ultra Urban Use**

Maintenance:
- Monitor water level in sand filter chamber.
- Sedimentation chamber should be cleaned out when the sediment depth reaches 12 inches.
- Remove accumulated oil and floatables in sedimentation chamber.

Maintenance Burden: **H**

L = Low M = Moderate H = High

General Description

The underground sand filter is a variant of the sand filter located in an underground vault designed for high-density land use or ultra-urban applications where there is not enough space for a surface sand filter or other structural stormwater controls.

The underground sand filter is a three-chamber system (See Figure 10.1). The initial chamber is a sedimentation chamber that temporarily stores runoff and utilizes a wet pool to capture sediment. The sedimentation chamber is connected to the sand filter chamber by a submerged wall that protects the filter bed from floating oil and trash. The filter bed is 18 to 24 inches deep and may have a protective screen of gravel or permeable geotextile to limit clogging. The sand filter chamber also includes an underdrain system with capped inspection and clean out wells. Perforated drain pipes under the sand filter bed extend into a third chamber that collects filtered runoff. The WQ_v displaces part of the permanent pool as it flows into the facility and creates a temporary pool above the permanent pool. Flows beyond the filter capacity are diverted through an overflow weir.

Due to its location below the surface, underground sand filters have a high maintenance burden and should only be used where adequate inspection and maintenance can be ensured.

Site and Design Considerations

1. Underground sand filters are typically used on highly impervious sites of 1 acre or less. The maximum drainage area that should be treated by an underground sand filter is 5 acres.
2. Underground sand filters are typically constructed on-line, but can be constructed off-line. For off-line construction, the overflow between the second and third chambers is not included.
3. The underground vault should be tested for water tightness prior to placement of filter layers.
4. Adequate maintenance access must be provided to the sedimentation and filter bed chambers.
5. Compute the minimum permanent pool volume required in the sedimentation chamber as:

   $\mathbf{V_w = A_s * 3}$ **feet minimum**

   Where: A_s = Surface Area, from PTP-04

6. Consult the design criteria for the perimeter sand filter (see PTP-11 for the underground filter sizing and design steps.)

As-Built Certification Considerations

An as-built certification conducted by a registered Professional Engineer must be performed and submitted to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

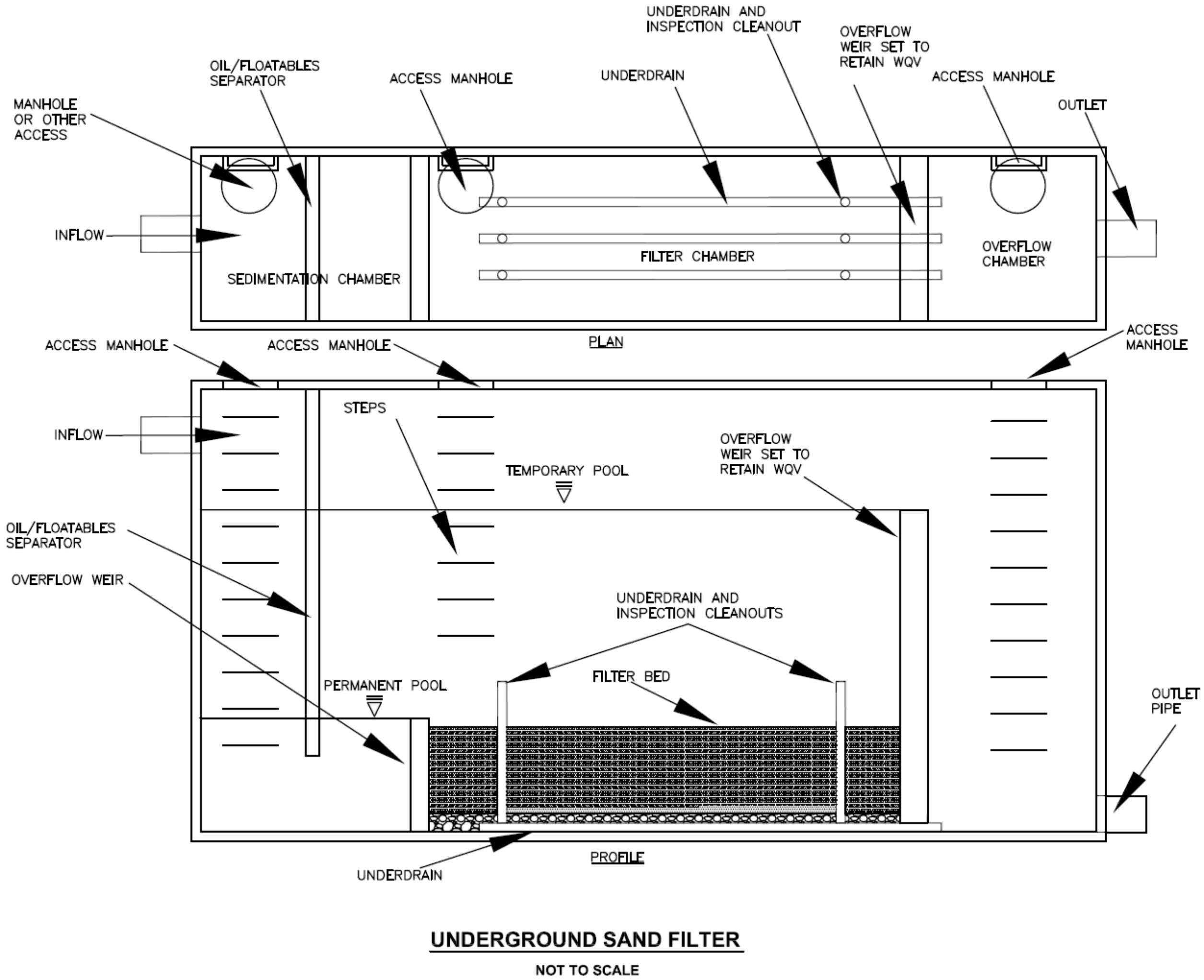
Maintenance

Each BMP must have an Operations and Maintenance (O&M) Agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for sand filters, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

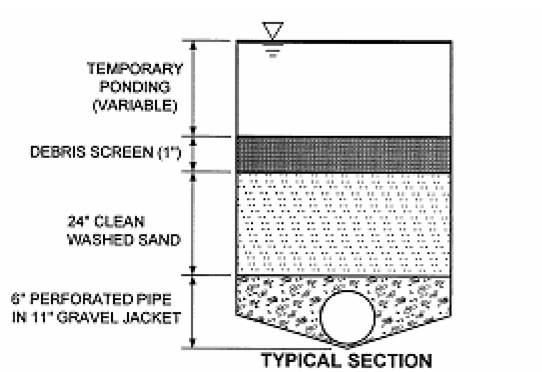
1. Monitor water level in sand filter chamber.
2. Sedimentation chamber should be cleaned out when the sediment depth reaches 12 inches.
3. Remove accumulated oil and floatables in sedimentation chamber.
4. Replace filter media when temporary pool is maintained for 40 hours following design storm (FHWA).

Design Procedures

Consult design criteria for perimeter sand filter (PTP-11) for sizing and design steps.



(Adapted from the Minnesota Stormwater Manual)



(Source: Center for Watershed Protection)

Figure 10.1 Schematic of Underground Sand Filter

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Perimeter Sand Filters

Description: Multi-chamber structure designed to treat stormwater runoff through filtration, using a sediment forebay, a sand bed as its primary filter media and an underdrain collection system (usually). Perimeter sand filters are located along the edge of impervious areas.

Variations: Surface Sand Filter (see PTP-04) and Underground Sand Filter (see PTP-10).

Components:
- Forebay—settles coarse particles and trash
- Sand bed chamber—provides water quality treatment through sand filtration.
- Overflow chamber to outlet for larger storm flows

Advantages/Benefits:
- Applicable to small drainage areas
- Good for highly impervious areas
- Good for water quality retrofits to existing developments

Disadvantages/Limitations:
- Standing water raises mosquito concerns
- High maintenance burden
- Not recommended for areas with high sediment content in stormwater or clay/silt runoff areas
- Relatively costly
- Possible odor problems
- Typically needs to be combined with other controls to provide water quantity control

Design considerations:
- Typically requires 2 to 6 feet of head
- Maximum contributing drainage area of 2 acres

Selection Criteria:

- [x] **Water Quality 80 % TSS Removal**
- [x] **Accepts Hotspot Runoff**
- [ ] **Residential Subdivision**
- [x] **High Density / Ultra Urban Use**

Maintenance:

- Inspect for clogging—rake first inch of sand
- Remove sediment from forebay-chamber
- Replace sand filter media as needed
- Clean spillway system(s)

H — **Maintenance Burden**

L = Low M = Moderate H = High

General Description

The perimeter sand filter is an enclosed filter system typically constructed just below grade in a vault along the edge of an impervious area such as a parking lot. The filter captures and temporarily stores stormwater runoff, filtering it through a bed of sand. Runoff flows into the structure through a series of inlet grates located along the top of the filter. The system consists of a forebay (sedimentation chamber) and a sand bed (filtration) chamber. The first chamber is a forebay or sedimentation chamber, which removes floatables and heavy sediments. The second is the sand bed or filtration chamber, which removes additional pollutants by filtering the runoff through a sand bed. The filtered runoff is collected and returned to the conveyance system. In addition, since perimeter sand filters receive all runoff, as on-line controls, they include an overflow for flows larger than the water quality volume. A schematic of a perimeter sand filter is shown in Figure 16.1.

Because they have few site constraints beside head requirements, perimeter sand filters can be used on development sites where the use of other structural controls may be precluded. However, perimeter sand filter systems can be relatively expensive to construct and install and they have high maintenance requirements. Because perimeter sand filters have a permanent pool of standing water, they present vector concerns. Their use is limited to situations in which they can be inspected and maintained frequently enough to control mosquito breeding. In addition, although perimeter sand filter systems are designed as on-line systems, they do not control water quantity.

In perimeter sand filter systems, stormwater pollutants are removed through a combination of gravitational settling, filtration and adsorption. The filtration process effectively traps suspended solids and particulates. As solids are trapped in the sand bed, some reduction of associated pollutants such as biochemical oxygen demand (BOD), fecal coliform bacteria, and other pollutants may be achieved.

Site and Design Considerations

Two design variants of perimeter sand filters are the surface sand filter (PTP-04) and the underground sand filter (PTP-10).

Location and Siting

1. The maximum drainage area for a perimeter sand filter is 2 acres.
2. Perimeter sand filter systems are generally applied to land uses with a high percentage of impervious surfaces. Sites with less than 50% imperviousness or with high clay/silt sediment loads must not use sand filters without adequate pretreatment because the sediment causes clogging and failure of the filter bed. Any disturbed areas within the sand filter facility drainage area should be identified and stabilized. Filtration controls should only be constructed after the construction site is stabilized.

Site and Design Considerations (Continued)

3. Perimeter sand filters are typically sited along the edge, or perimeter, of an impervious area such as a parking lot.
4. Perimeter and filter systems are designed for intermittent flow and must be allowed to drain and aerate between rainfall events. They should not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

General Design

5. A perimeter sand filter facility is a vault structure located just below grade level. Runoff enters the device through inlet grates along the top of the structure into the sediment forebay (or sedimentation chamber). Unlike the surface sand filter, the perimeter sand filter sediment forebay contains a permanent forebay volume. Runoff is discharged from the forebay through a weir into the sand bed chamber. After passing though the filter bed, runoff is collected by a perforated pipe and gravel underdrain system. An overflow must be provided for flows larger than the design storm.

Physical Specifications/Geometry

6. The entire treatment system (excluding the permanent pool in the forebay) must temporarily hold the WQ_v prior to filtration. Table 16.1 presents the design parameters and values for the perimeter sand filter. Figure 16.2 illustrates these design parameters.
7. The forebay must be sized to at least 50% of the computed WQ_v.
8. The filter area is sized based on the principles of Darcy's Law. A coefficient of permeability (k) of 3.5 ft/day for sand should be used. The filter bed is typically designed to completely drain in ≤ 36 hours.
9. The filter media should consist of a 12- to 18-inch layer of clean washed medium sand (meeting ASTM C-33 concrete sand) on top of the underdrain system. See PTP-04, Figure 4.3 for a typical filter section.
10. The perimeter sand filter is equipped with a 6-inch perforated pipe (ASTM Schedule 40) underdrain in a gravel layer. The underdrain must have a minimum grade of 1/8 inch per foot (1% slope). Holes should be 3/8-inch diameter and spaced approximately 10 inches on center. A permeable filter fabric should be placed between the gravel layer and the filter media. Gravel should be clean washed aggregate with a maximum diameter of 3.5 inches and a minimum diameter of 1.5 inches with a void space of about 30%. Aggregate contaminated with soil shall not be used. Gravel layer and perforated underdrain piping must have infiltration rates at least twice as fast as the design infiltration rate of the sand bed.

Pretreatment/Inlets

11. Pretreatment of runoff in a sand filter system is provided by the forebay.
12. Inlets to surface sand filters are to be provided with energy dissipaters.

Site and Design Considerations (Continued)

Outlet Structures

13. Outlet pipe is to be provided from the underdrain system to the facility discharge. Due to the slow rate of filtration, outlet protection is generally unnecessary (except for emergency overflows and spillways).
14. All flows enter the perimeter sand filter. However, flows larger than the water quality volume are not treated. They pass to an overflow chamber and outlet.

Maintenance Access

15. Adequate access through maintenance easements must be provided for all sand filter systems for inspection and maintenance. Access grates to the filter bed need to be included in a perimeter sand filter design. Facility designs must enable maintenance personnel to easily replace the upper layers of the filter media.

Table 16.1 Perimeter Sand Filter Design Parameters

Parameter Description	*Parameter*	*Parameter Value*
Total Temporary Volume in Forebay and Sand Bed Chamber[1]	WQ_v	WQ_v; See Design Step #1
Approximate Temporary Sand Bed Volume[2]	V_{ST}	(0.5) WQ_v
Minimum Sand Bed Thickness	T_S	18 inches
Sand Bed Design Porosity	n	0.3
Sand Bed Design Permeability	k	3.5 feet/day
Sand Bed Design Drain Time	t_d	1.5 days, 36 hours max
Minimum Sand Bed Chamber Area	A_S	See Design Step #6
Approximate Temporary Forebay and Sand Bed Chamber Volume[3]	V_{FT}	(0.5) WQ_v
Minimum Forebay Surface Area	A_F	(0.05) WQ_v
Maximum Temporary Sand Bed Depth[4]	D_{ST}	See Design Step #3
Maximum Temporary Forebay Depth	D_{FT}	See Design Step #3
Minimum Permanent Forebay Depth	D_{FP}	2 feet

1. Includes temporary storage volume in sand, but excludes storage volume in forebay permanent pool.
2. Includes temporary storage volume in sand.
3. Excludes storage volume in forebay permanent pool.
4. Measured from top of sand bed.

(Adapted from the New Jersey Stormwater Best Management Practices Manual)

Design Procedures

Design of a sand filter is usually a trial and error process because of the number of variables involved.

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v), which must be temporarily stored within the perimeter sand filter's entire treatment system, excluding the forebay permanent pool.

$$WQ_v = P \times Rv \times A/12$$

Where:
WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$$Rv = 0.015 + 0.0092*I$$

Where:
I = site impervious cover, % (for example 50% equals 50)

Step 2. Determine approximate required volumes of the forebay and sand bed chambers.

Each should be equal to approximately 0.5 WQ_v, as shown in Table 16.1.

Step 3. Determine approximate temporary depths in sand bed (D_{ST}) and forebay (D_{FT}) for the WQ_v.

The estimate will depend on and be based on analysis of site conditions including the difference between the invert elevation of the downstream conveyance system and the maximum ground elevation at filter facility. Make sure to include the minimum sand bed thickness (T_S) and the permanent forebay depth (D_{FP}) into the consideration for these temporary depths. Note that the maximum temporary depth in the sand bed zone (D_{ST}) is measured from the top of the sand bed, while the maximum temporary forebay depth (D_{FT}) is measured from the permanent forebay water surface.

Step 4. Compute minimum forebay surface area (A_F).

The minimum surface area is
$$A_F = 0.05 (WQ_v)$$

Where:

Design Procedures (Continued)

A_F = forebay area
0.05 = a multiplier in units per area of volume (L^2/L^3)

Step 5. Compute total temporary storage volume in the forebay (V_{FT}).

From the maximum temporary depth in the forebay (D_{FT}) from Step 3 and the minimum forebay area (A_F) from Step 4, compute the total temporary storage volume in the forebay (V_{FT}). *Compare* this volume with the approximate required forebay volume computed in Step 2. *Adjust* the maximum temporary forebay depth (D_{FT}) and/or forebay area (A_F) as necessary to achieve a total temporary forebay storage volume (V_{FT}) as close as practical to the required forebay volume from Step 2. While adjusting the forebay surface area (A_F) by varying its length and width, remember that the forebay will be located immediately adjacent to the sand bed zone.

Step 6. Compute sand bed chamber area (A_S).

The filter area is sized using the following equation (based on Darcy's Law):

$$\mathbf{A_S = (WQ_v)\ (T_S / [(k)\ (D_{ST}/2 + T_S)\ (T_D)]}$$

Where:
A_S = Sand Bed Surface Area (in square feet)
T_S = Thickness of Sand in Sand Bed (typically 18 inches, no more than 24 inches)
k = Coefficient of permeability of filter media (ft/day) (use 3.5 ft/day for sand)
D_{ST} = Maximum Temporary Sand Bed Depth (ft)
t_d = Sand Bed Design Drain Time (1.5 days or 36 hours is recommended maximum)

See the Physical Specifications/Geometry section of the *Site and Design Considerations* for filter media specifications.

Step 7. Compute total temporary storage volume in sand bed.

$$\mathbf{V_{ST} = (A_S)(D_{ST}) + (A_S)(T_S)(n)}$$

Where:
V_{ST} = Temporary Sand Bed Storage Volume (in cubic feet)
A_S = Sand Bed Surface Area (in square feet)
D_{ST} = Maximum Temporary Sand Bed Depth (ft)
T_S = Thickness of Sand in Sand Bed, recommended 18 inches (in feet)

Design Procedures (Continued)

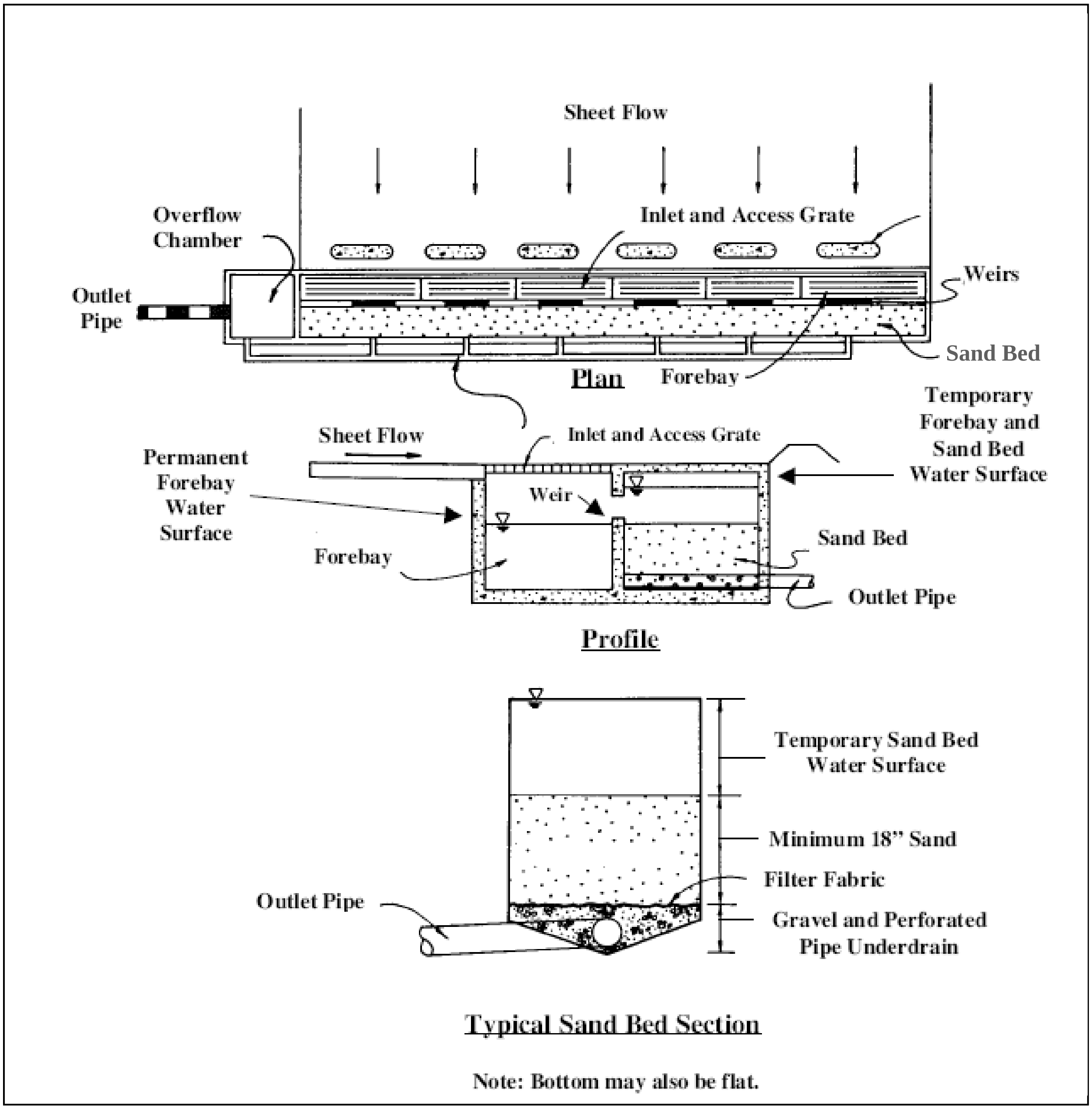
n = Sand Bed Design Porosity, recommended 0.3

Step 8. Compare and adjust areas and volumes to achieve storage of WQ_v within the entire facility.

Compare the total temporary sand bed storage volume (V_{ST}) with the approximate required sand bed zone volume computed in Step 2. As shown on Table 16.1, this temporary sand bed storage volume should be approximately one half of the stormwater quality design storm runoff volume (WQ_v). In addition, add the total temporary sand bed volume (V_{ST}) to the total temporary forebay storage volume (V_{FT}) to determine the total temporary storage volume in the sand filter. As shown in Table 16.1, this total temporary storage volume must equal the stormwater quality design storm runoff volume (WQ_v). Adjust the maximum temporary sand bed depth (D_{ST}) and/or sand bed area (A_S) as necessary to achieve a total temporary sand bed storage volume (V_{ST}) as close as practical to the required sand bed volume from Step 2 and a total filter volume equal to WQ_v.

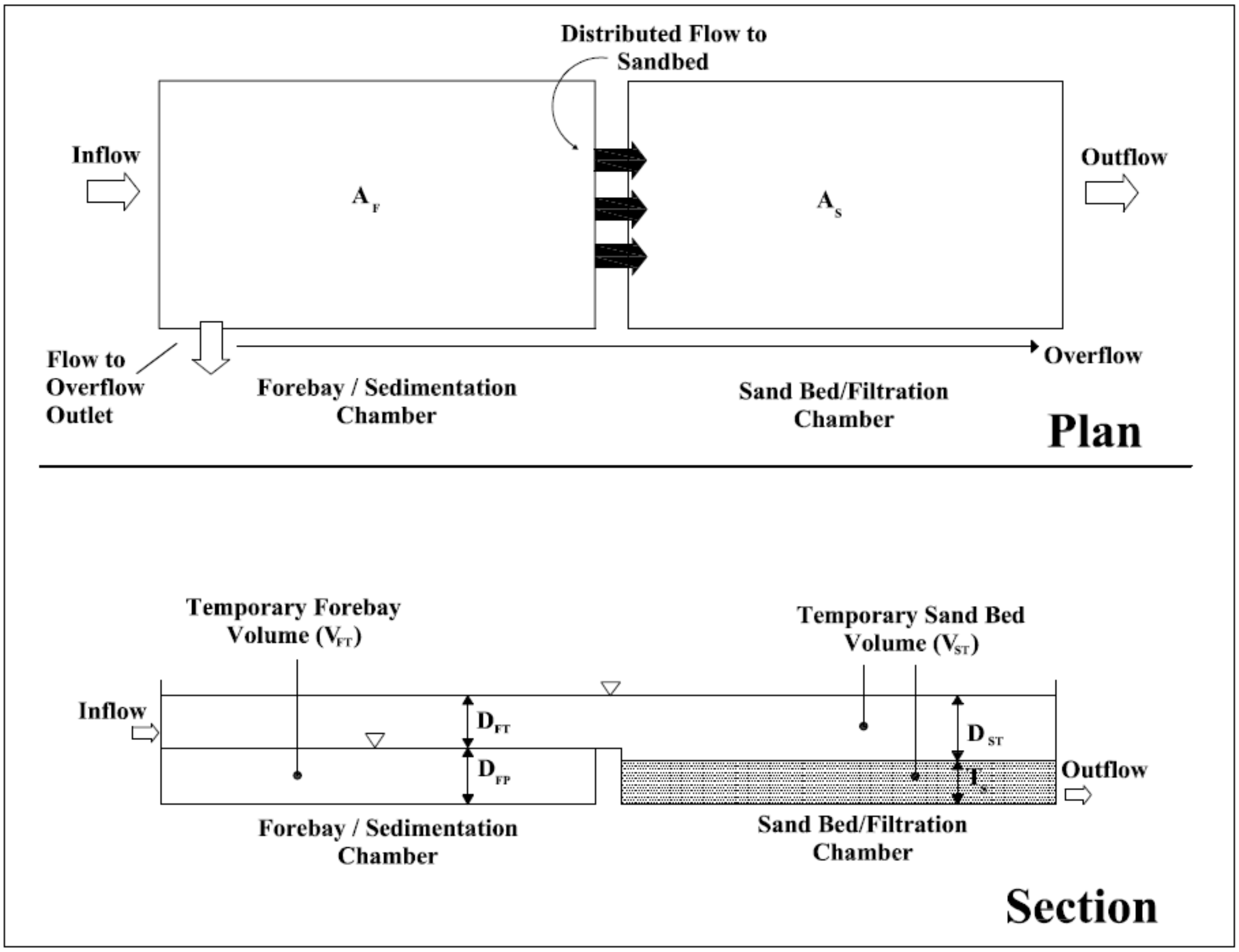
Step 9. Design inlets, underdrain system, overflow weirs, and outlet structures.

See *Site and Design Considerations* for more information on underdrain specifications and outlet structures. PTP-01 provides more information on sizing orifices, weirs, and outlets.



(Source: New Jersey Stormwater Best Management Practices Manual, 2003)

Figure 16.1 Perimeter Sand Filter



(Source: New Jersey Stormwater Best Management Practices Manual, 2003)

Figure 16.2 Schematic of Perimeter Sand Filter Showing Design Parameters

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Organic Filter

Description: Usually a two chambered stormwater treatment practice and variant on a sand filter. The first chamber is for settling and the second is a filter bed of organic media. Large particles settle out in the first chamber and finer particles and other pollutants are removed in the second chamber.

Variations: Surface Sand Filter (PTP-04), a general application BMP.

Components:
- Settling chamber—settles coarse particles and trash
- Filter chamber—provides water quality treatment by filtering other pollutants
- Spillway system(s) provide discharge control

Advantages/Benefits:
- High pollutant removal capability
- Removal of dissolved pollutants is greater than sand filters due to cation exchange capacity until exchange capacity is exhausted

Disadvantages/Limitations:
- Intended for hotspot or space-limited applications or for areas requiring enhanced pollutant removal capability
- Filter may require more frequent maintenance than most of the other stormwater controls
- Severe clogging potential if exposed soil surfaces exist upstream

Design considerations:
- Minimum head requirement of 5 to 8 feet
- Contributing drainage area of up to 10 acres for organic filter
- Organic filter media with underdrain system
- In karst areas, use polyliner or impermeable membrane to seal bottom of earthen surface sand filter or use watertight structure

Selection Criteria:

- [ ] **Water Quality 80 % TSS Removal**
- [x] **Accepts Hotspot Runoff**
- [ ] **Residential Subdivision**
- [x] **High Density / Ultra Urban Use**

Maintenance:

- Ensure that inlets and outlets are free from debris and not clogged.
- Check for sediment buildup in gravel bed.
- Remove gravel and sediment from cell; replace gravel and replant vegetation.

H — **Maintenance Burden**

L = Low M = Moderate H = High

General Description

The organic filter is a design variant of the surface sand filter that uses organic materials such as leaf compost or a peat/sand mixture as the filter media. The organic material enhances pollutant removal by providing adsorption of contaminants such as soluble metals, hydrocarbons, and other organic chemicals until the adsorptive capacity is exhausted.

As with the surface sand filter, an organic filter consists of a pretreatment chamber, and one or more filter cells. Each filter cell is a layer of leaf compost or a peat/sand mixture, followed by filter fabric and a gravel/perforated pipe underdrain system. The filter bed and subsoils can be separated by an impermeable polyliner or concrete structure to prevent movement into groundwater.

Organic filters are typically used in densely developed areas, or in areas that require an enhanced pollutant removal ability. Maintenance is typically higher than the surface sand filter facility due to the potential for clogging. In addition, organic filter systems have a higher head requirement than sand filters.

Site and Design Considerations

1. Organic filters are typically used on relatively small sites (up to 10 acres), to minimize potential clogging.
2. The minimum head requirement (elevation difference needed at a site from the inflow to the outflow) for an organic filter is 5 to 8 feet.
3. Organic filters can utilize a variety of organic materials as the filtering media. Two typical media bed configurations are the peat/sand filter and compost filter (see Figure 12.1). The peat filter includes an 18-inch 50/50 peat/sand mix over a 6-inch sand layer and can be optionally covered by 3 inches of topsoil and vegetation. The compost filter has an 18-inch compost layer. Both variants utilize a gravel underdrain system.
4. The type of peat used in a peat/sand filter is critically important. Fibric peat in which undecomposed fibrous organic material is readily identifiable is the preferred type. Hemic peat containing more decomposed material may also be used. Sapric peat made up of largely decomposed matter should *not* be used in an organic filter.
5. Typically, organic filters are designed as "off-line" systems, meaning that the water volume (WQ_v) is diverted to the filter facility through the use of a flow diversion structure or flow splitter. Stormwater flows greater than the WQ_v are diverted to other controls or downstream using a diversion structure or flow splitter.
6. Consult the design criteria for the surface sand filter (PTP-04, *Sand Filters*) for the organic filter sizing and design steps. The coefficient of permeability for a peat/sand mix is 2.75 feet/day and compost is 8.7 feet/day, while pure sand is 3.5 feet/day (CWP, 1996).

As-Built Certification Considerations

After the organic filter has been constructed, an as-built certification by a registered Professional Engineer must be submitted to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

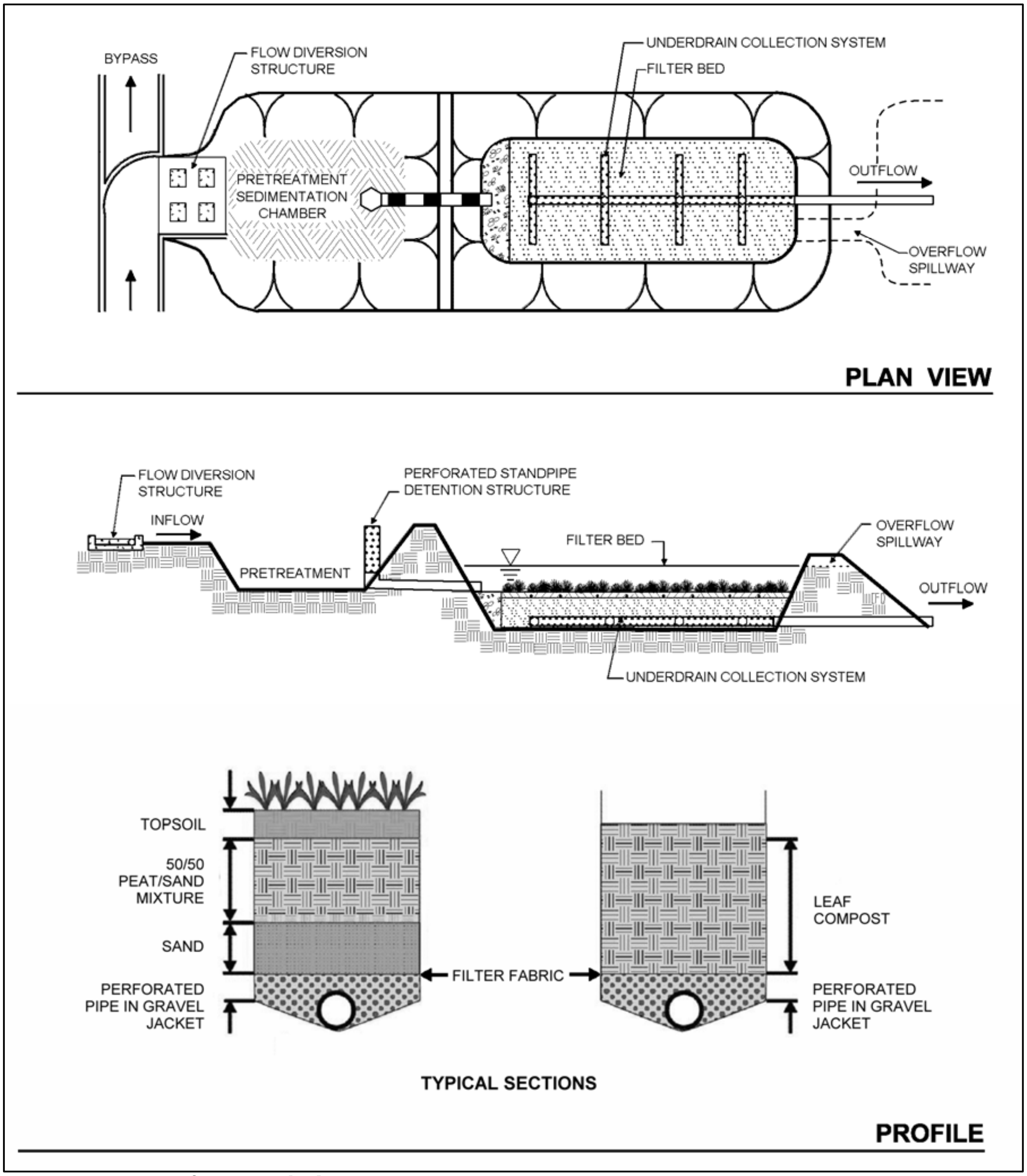
Maintenance

Each BMP must have an Operations and Maintenance (O&M) Agreement submitted to Metro for approval and maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with grading permit application. The O&M agreement is for the use of the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Inspect for clogging—rake upper stratum of media as needed.
2. Remove sediment from forebay-chamber.
3. Replace organic filter media as needed.
4. Clean spillway system(s).

Design Procedures

See PTP-04 *Sand Filter*, surface sand filter sections, for additional guidance.



(Source: Center for Watershed Protection)

Figure 12.1 Schematic of Organic Filter

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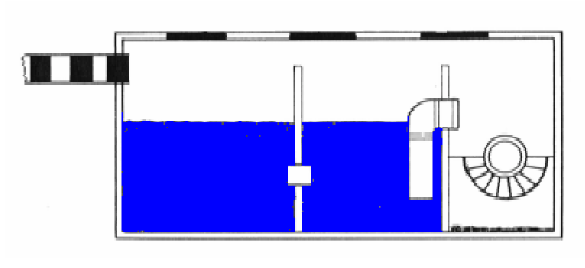
Gravity (Oil-Grit) Separator



Description: Hydrodynamic separation device designed to remove settleable solids, oil and grease, debris and floatables from stormwater runoff through gravitational settling and trapping of pollutants. Facilities with fueling and parking lots containing over 400 spaces require a more advanced separator with coalescing tubes/plates designed to provide a surface that minute oil globules are attracted to and can agglomerate upon. The coalesced oil then rises to the surface to be skimmed.

Components:

- Inlet chamber
- Separation and oil storage chamber
- Enhanced components such as swirl concentrator chamber and Coalescing filter (in high-risk areas)
- Outlet chamber

Advantages/Benefits:

- Good for land uses that are hotspots for hydrocarbons
- Pretreatment for water quality
- Coalescing systems can remove oil particles down to the 20 micron range, while conventional device removes down to the 150 micron level.

Disadvantages/Limitations:

- Cannot alone achieve the 80% TSS removal target
- Intended for hotspot, space-limited or pretreatment applications
- Limited performance data
- Dissolved pollutants are not removed
- Frequent maintenance required

Design considerations:

- Intended for the removal of settleable solids (grit and sediment) and floatable matter, including oil and grease
- Access point for maintenance required
- Performance dependent on design and frequency of inspection and cleanout of unit
- Openings to device must be 1/16 inch or less to prevent mosquito intrusion and breeding.
- Install as an off-line device unless size of separator can be matched to smaller drainage area
- Install inspection/collection manhole on downstream side to provide easy access for sampling of effluent.

Selection Criteria:

- [ ] **Water Quality 80 % TSS Removal**
- [x] **Accepts Hotspot Runoff**
- [ ] **Residential Subdivision**
- [x] **High Density / Ultra Urban Use**

Maintenance:

- Inspect the gravity separator unit
- Clean out sediment, oil and grease, and floatables, using catch basin cleaning equipment (vacuum pumps). Manual removal may be necessary

H — **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Gravity separators (also known as oil-grit separators) are hydrodynamic separation devices that are designed to remove grit and heavy sediments, oil and grease, debris and floatable matter from stormwater runoff through gravitational settling and trapping. Gravity separator units contain a permanent pool of water and typically consist of an inlet chamber, separation/storage chamber, and an access port for maintenance purposes. Runoff enters the inlet chamber where heavy sediments and solids drop out. The flow moves into the main gravity separation chamber, where further settling of suspended solids takes place. Oil and grease are skimmed and stored in a waste oil storage compartment for future removal. After moving into the outlet chamber, the clarified runoff is then discharged.

In "hot-spot" areas (fueling areas and large parking lots with over 400 spaces), separators are required to be equipped with coalescing tubes/plates. These tubes/plates provide a media in which minute oil globules can agglomerate to aid in the separation process. Oil that agglomerates around the coalescing tubes/plates can easily be skimmed through the gravity process.

When used for oil removal, the performance of these systems is based primarily on the relatively low solubility of petroleum products in water and the difference between the specific gravity of water and the specific gravities of petroleum compounds. Gravity separators are not designed to separate other products such as solvents, detergents, or dissolved pollutants. The typical gravity separator unit may be enhanced with a pretreatment swirl concentrator chamber, coalescing tubes/plates, oil draw-off devices that continuously remove the accumulated light liquids, and flow control valves regulating the flow rate into the unit.

Gravity separators are best used in commercial, industrial and transportation land uses and are intended primarily as a pretreatment measure for high-density or ultra urban sites or for use in hydrocarbon hotspots such as gas stations and areas with high vehicular traffic. However, gravity separators cannot be used for the removal of dissolved or emulsified oils and pollutants such as coolants, soluble lubricants, glycols and alcohols, or in waste streams that contain detergents or other chemical-laden wastes.

Since resuspension of accumulated sediments is possible during heavy storm events, gravity separator units are typically installed off-line. Gravity separators are available as prefabricated proprietary systems from a number of commercial vendors.

Site and Design Considerations

1. The use of gravity (oil-grit) separators should be limited to the following applications:
   - Pretreatment for other structural stormwater controls

Site and Design Considerations (Continued)

- High-density, ultra urban or other space-limited development sites
- Hotspot areas where the control of grit, floatables, and/or oil and grease are required

2. Gravity separators are typically used for areas less than 5 acres. It is recommended that the contributing area to any individual gravity separator be limited to 1 acre or less of impervious cover.
3. Gravity separator systems can be installed in almost any soil or terrain. Since these devices are underground, appearance is not an issue and public safety risks are low.
4. Gravity separators are flowrate-based devices. This contrasts with most other stormwater structural controls, which are sized based on capturing and treating a specific volume.
5. Gravity separator units are typically designed to bypass runoff flows in excess of the design flow rate. Some designs have built-in high flow bypass mechanisms. Other designs require a diversion structure or flow splitter ahead of the device in the drainage system. An adequate outfall must be provided.
6. The separation chamber should provide for three separate storage volumes:

   (1) A volume for separated oil storage

   (2) A volume for settleable solids accumulation at the bottom of the chamber

   (3) A volume required to give adequate flow-through detention time for separation of oil and sediment from the stormwater flow
7. The total wet storage of the gravity separator unit should be at least 400 cubic feet per contributing impervious acre.
8. The minimum depth of the permanent pools should be 4 feet.
9. Horizontal velocity through the separation chamber should be 1 to 3 ft/min or less. No velocities in the device should exceed the entrance velocity.
10. A trash rack should be included in the design to capture floating debris, preferably near the inlet chamber to prevent debris from becoming oil impregnated.
11. Ideally, a gravity separator design will provide an oil draw-off mechanism to a separate chamber or storage area.
12. Adequate maintenance access to each chamber must be provided for inspection and cleanout of a gravity separator unit.
13. Gravity separator units should be watertight to prevent possible groundwater contamination.
14. The design criteria and specifications of a proprietary gravity separator unit should be obtained from the manufacturer.

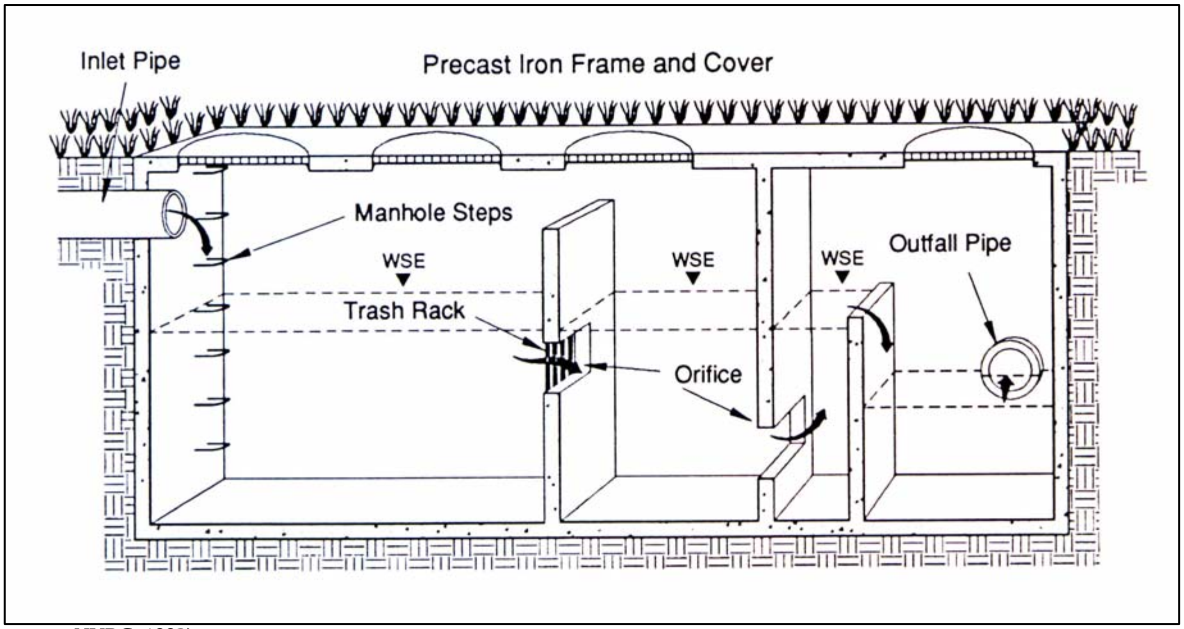
As-Built Certification Considerations

After the hydrodynamic device has been constructed, an as-built certification must be performed by a registered Professional Engineer and submitted to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) Agreement which is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the O&M Agreement for separators, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with grading permit application. The O&M agreement is for the use of the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Additional maintenance requirements for a proprietary system should be obtained from the manufacturer.
2. Proper disposal of oil, solids and floatables removed from the gravity separator must be ensured.



(Sources: NVRC, 1992)

Figure 13.1 Schematics of Gravity (Oil-Grit) Separator

References

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CDM, 2000. Metropolitan Nashville and Davidson County Stormwater Management Manual Volume 4 Best Management Practices.

Suggested Reading

California Storm Water Quality Task Force, 1993. California Storm Water Best Management Practice Handbooks.

Infiltration Trenches

Description: Excavated trench filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the trench.

Components:
- Soil infiltration rate of 0.5 in/hr or greater required
- Excavated trench (3 to 8 foot depth) filled with stone media (1.5- to 2.5-inch diameter); pea gravel and sand filter layers
- A sediment forebay and grass channel, or equivalent upstream pretreatment, must be provided
- Observation well to monitor percolation

Advantages/Benefits:
- Provides for groundwater recharge
- Good for small sites with porous soils

Disadvantages/Limitations:
- Potential for groundwater contamination
- High clogging potential; should not be used on sites with fine-particled soils (clays or silts) in drainage area
- Cannot be used in karst soils
- Geotechnical testing required, two borings per facility

Design considerations:
- 5 acres maximum drainage area
- Space Required – Will vary depending on the depth of the facility
- Site Slope – No more than 6% slope (for pre-construction facility footprint)
- Minimum Head – Elevation difference needed at a site from the inflow to the outflow: 1 foot
- Minimum Depth to Water Table – 4 feet recommended between the bottom of the infiltration trench and the elevation of the seasonally high water table.
- Soils – Infiltration rate of 0.5 inches per hour or greater required (typically hydrologic group “A”, some group “B” soils)

Selection Criteria:

- [x] **Water Quality 80 % TSS Removal**
- [ ] **Accepts Hotspot Runoff**
- [x] **Residential Subdivision**
- [x] **High Density / Ultra Urban Use**

Maintenance:

- Inspect for clogging
- Remove sediment from forebay
- Replace pea gravel layer as needed

H — **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Infiltration trenches are excavations typically filled with stone to create an underground reservoir for stormwater runoff (see Figure 14.1). The runoff volume gradually exfiltrates through the bottom and sides of the trench into the subsoil over a 2-day period and eventually reaches the water table. By diverting runoff into the soil, an infiltration trench not only treats the water quality volume, but also helps to preserve the natural water balance on a site and can recharge groundwater and preserve baseflow. Due to this fact, infiltration systems are limited to areas with highly porous soils where the water table and/or bedrock are located well below the bottom of the trench. In addition, infiltration trenches must be carefully sited to avoid the potential of groundwater contamination.

Infiltration trenches are not intended to trap sediment and must always be designed with a sediment forebay and grass channel or filter strip or other appropriate pretreatment measures to prevent clogging and failure. Due to their high potential for failure, these facilities must only be considered for sites where upstream sediment control can be ensured.

Using the natural filtering properties of soil, infiltration trenches can remove a wide variety of pollutants from stormwater through sorption, precipitation, filtering, and bacterial and chemical degradation. Sediment load and other suspended solids should be removed from runoff by pretreatment measures on-site before they reach the trench surface.

Site and Design Considerations

Infiltration trenches are generally suited for medium-to-high density residential, commercial and institutional developments where the subsoil is sufficiently permeable to provide a reasonable infiltration rate and the water table is low enough to prevent groundwater contamination. They are applicable primarily for impervious areas where there are not high levels of fine particulates (clay/silt soils) in the runoff and should only be considered for sites where the sediment load is relatively low.

Infiltration trenches can either be used to capture sheet flow from a drainage area or function as an off-line device. Due to the relatively narrow shape, infiltration trenches can be adapted to many different types of sites and can be utilized in retrofit situations. Unlike some other structural stormwater controls, they can easily fit into the margin, perimeter, or other unused areas of developed sites.

To protect groundwater from potential contamination, runoff from designated hotspot land uses or activities must not be infiltrated. Infiltration trenches should not be used for manufacturing and industrial sites, where there is a potential for high concentrations of soluble pollutants and heavy metals. In addition, infiltration should not be considered for areas with a high pesticide concentration. Infiltration trenches are also not suitable in

Site and Design Considerations (Continued)

areas with karst geology without adequate geotechnical testing by qualified individuals and in accordance with local requirements.

1. To be suitable for infiltration, underlying soils should have an infiltration rate (f_c) of 0.5 inches per hour or greater, as initially determined from NRCS soil textural classification and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5,000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility). Infiltration trenches cannot be used in fill soils.
2. Infiltration trenches should have a contributing drainage area of 5 acres or less.
3. Soils in the drainage area tributary to an infiltration trench should have a clay content of less than 20% and a silt/clay content of less than 40% to prevent clogging and failure.
4. There should be at least 4 feet between the bottom of the infiltration trench and the elevation of the seasonally high water table.
5. Clay lenses, bedrock or other restrictive layers below the bottom of the trench will reduce infiltration rates unless excavated.
6. Suggested minimum setback requirements for infiltration trench facilities:
   - From a property line – 10 feet
   - From a building foundation – 25 feet
   - From a private well – 100 feet
   - From a public water supply well – 1,200 feet
   - From a septic system tank/leach field – 100 feet
   - From surface waters – 100 feet
   - From surface drinking water sources – 400 feet (100 feet for a tributary)
7. When used in an off-line configuration, the water quality volume (WQ_v) is diverted to the infiltration trench through the use of a flow splitter. Stormwater flows greater than the WQ_v are diverted to other controls or downstream using a diversion structure or flow splitter.
8. To reduce the potential for costly maintenance and/or system reconstruction, it is strongly recommended that the trench be located in an open or lawn area, with the top of the structure as close to the ground surface as possible. Infiltration trenches shall not be located beneath paved surfaces, such as parking lots.
9. Infiltration trenches are designed for intermittent flow and must be allowed to drain and allow aeration of the surrounding soil between rainfall events. They must not be used on sites with a continuous flow from groundwater, sump pumps, or other sources.

Site and Design Considerations (Continued)

General Design
A well-designed infiltration trench consists of:

(1) Excavated shallow trench backfilled with sand, coarse stone, and pea gravel, and lined with a filter fabric;
(2) Appropriate pretreatment measures; and
(3) One or more observation wells to show how quickly the trench dewaters or to determine if the device is clogged.

An example of an on-line infiltration trench is shown in Figure 14.1. Figure 14.2 provides a plan view and profile schematic for the design of an off-line infiltration trench facility.

Physical Specifications/Geometry

10. The required storage volume in the gravel trench is equal to the water quality volume (WQ_v).
11. A trench must be designed to fully dewater the entire WQ_v within 24 to 48 hours after a rainfall event. The slowest infiltration rate obtained from tests performed at the site should be used in the design calculations.
12. Trench depths should be between 3 and 8 feet, to provide for easier maintenance. The width of a trench must be less than 25 feet.
13. Broader, shallow trenches reduce the risk of clogging by spreading the flow over a larger area for infiltration.
14. The surface area required is calculated based on the trench depth, soil infiltration rate, aggregate void space, and fill time (assume a fill time of 2 hours for most designs).
15. The bottom slope of a trench should be flat across its length and width to evenly distribute flows, encourage uniform infiltration through the bottom, and reduce the risk of clogging.
16. The stone aggregate used in the trench should be washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40%. Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.32 should be used in calculations, unless aggregate specific data exist.
17. A 6-inch layer of clean, washed sand is placed on the bottom of the trench to encourage drainage and prevent compaction of the native soil while the stone aggregate is added.
18. The infiltration trench is lined on the sides and top by an appropriate geotextile filter fabric that prevents soil piping but has greater permeability than the parent soil. The top layer of filter fabric is located 2 to 6 inches from the top of the trench and serves to prevent sediment from passing into the stone aggregate. Since this top layer serves as a sediment barrier, it will need to be replaced more frequently and must be readily separated from the side sections.

Site and Design Considerations (Continued)

19. The top surface of the infiltration trench above the filter fabric is typically covered with pea gravel. The pea gravel layer improves sediment filtering and maximizes the pollutant removal in the top of the trench. In addition, it can easily be removed and replaced should the device begin to clog. Alternatively, the trench can be covered with permeable topsoil and planted with grass in a landscaped area.
20. An observation well must be installed in every infiltration trench and should consist of a perforated PVC pipe, 4 to 6 inches in diameter, extending to the bottom of the trench (see Figure 14.3 for a schematic of an observation well). The observation well will show the rate of dewatering after a storm, as well as provide a means of determining sediment levels at the bottom and when the filter fabric at the top is clogged and maintenance is needed. It should be installed along the centerline of the structure, flush with the ground elevation of the trench. A visible floating marker should be provided to indicate the water level. The top of the well should be capped and locked to discourage vandalism and tampering.
21. The trench excavation should be limited to the width and depth specified in the design. Excavated material should be placed away from the open trench so as not to jeopardize the stability of the trench sidewalls. The bottom of the excavated trench shall not be loaded in a way that causes soil compaction, and should be scarified prior to placement of sand. The sides of the trench shall be trimmed of all large roots. The sidewalls shall be uniform with no voids and scarified prior to backfilling. All infiltration trench facilities should be protected during site construction and should be constructed after upstream areas have been stabilized.

Pretreatment/Inlets

22. Pretreatment facilities must always be used in conjunction with an infiltration trench to prevent clogging and failure
23. For a trench receiving sheet flow from an adjacent drainage area, the pretreatment system should consist of a vegetated filter strip with a minimum 25-foot length. A vegetated buffer strip around the entire trench is required if the facility is receiving runoff from both directions. If the infiltration rate for the underlying soils is greater than 2 inches per hour, 50% of the WQ_v should be pretreated by another method prior to reaching the infiltration trench.
24. For an off-line configuration, pretreatment should consist of a sediment forebay, vault, plunge pool, or similar sedimentation chamber (with energy dissipaters) sized to 25% of the water quality volume (WQ_v). Exit velocities from the pretreatment chamber must be nonerosive for the 2-year design storm.

Site and Design Considerations Continued

Outlet Structures
Outlet structures are not required for infiltration trenches.

Emergency Spillway
Typically for off-line designs, there is no need for an emergency spillway. However, a nonerosive overflow channel should be provided to safely pass flows that exceed the storage capacity of the trench to a stabilized downstream area or watercourse.

Maintenance Access
Adequate access in an easement should be provided to an infiltration trench facility for inspection and maintenance.

Safety Features
In general, infiltration trenches are not likely to pose a physical threat to the public and do not need to be fenced.

Landscaping
Vegetated filter strips and buffers should fit into and blend with surrounding area. Native grasses are preferable, if compatible. The trench may be covered with permeable topsoil and planted with grass in a landscaped area.

Additional Site-Specific Design Criteria and Issues
Not suitable for karst areas without adequate geotechnical testing.

As-Built Certification Considerations

After the infiltration trench has been constructed, an as-built certification must be performed by a registered Professional Engineer and submitted to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

The following components must be addressed in the as-built certification:

1. The infiltration trench cannot be located in a sinkhole area or in karst soils.
2. Infiltration rates must be verified.
3. Proper dimensions for the trench must be verified.
4. A mechanism for overflow for large storm events must be provided.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) Agreement submitted to Metro for approval and maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for infiltration trenches, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with grading permit application. The O&M agreement is for the use of the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Ensure that contributing area, facility and inlets are clear of debris.
2. Ensure that the contributing area is stabilized.
3. Remove sediment and oil/grease from pretreatment devices, as well as overflow structures.
4. Check observation wells following 3 days of dry weather. Failure to percolate within this time period indicates clogging.
5. Inspect pretreatment devices and diversion structures for sediment build-up and structural damage.
6. Remove trees that start to grow in the vicinity of the trench.
7. Replace pea gravel/topsoil and top surface filter fabric (when clogged).
8. Perform total rehabilitation of the trench to maintain design storage capacity.
9. Excavate trench walls to expose clean soil.

Design Procedures

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v). This volume must be contained in the gravel trench.

WQ_v = P x Rv x A/12

Where:
WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

Rv = 0.015 + 0.0092I

Where:
I = site impervious cover, % (for example, 50% would be 50)

Step 2. Determine if the development site and conditions are appropriate for the use of infiltration trench.

Consider the *Site and Design Considerations* in this section, above.

Step 3. Divert flows above the WQ_v flow rate (Q_{wq}).

Flows exceeding the WQ_v flow are to be diverted from the trench.

$$Qwq = C * I * A$$

Where:
Q_{wq} = the WQ_v flow rate
C = runoff coefficient
I = rainfall intensity, 2.45 inches/hour for Metro for design storm associated with WQ_v
A = the contributing drainage area for the BMP, in acres

Step 4. Size flow diversion structure, if needed.

A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQ_v to the infiltration trench.

Size low flow orifice, weir, or other device to pass Q_{wq}.

Design Procedures (Continued)

Step 5. Size infiltration trench.

The area of the trench can be determined from the following equation:

$$A = \frac{WQ_v}{(nd + kT/12)}$$

Where:

A = Surface Area (acres)
WQ_v = Water Quality Volume (or total volume to be infiltrated)
n = porosity
d = trench depth (feet)
k = percolation (inches/hour)
T= Fill Time (time for the trench to fill with water), in hours

A porosity value *n* = 0.32 should be used.

All infiltration systems should be designed to fully dewater the entire WQ_v within 24 to 48 hours after the rainfall event.

A fill time T=2 hours can be used for most designs.

See the Physical Specifications/Geometry section of *Site and Design Considerations* for more details.

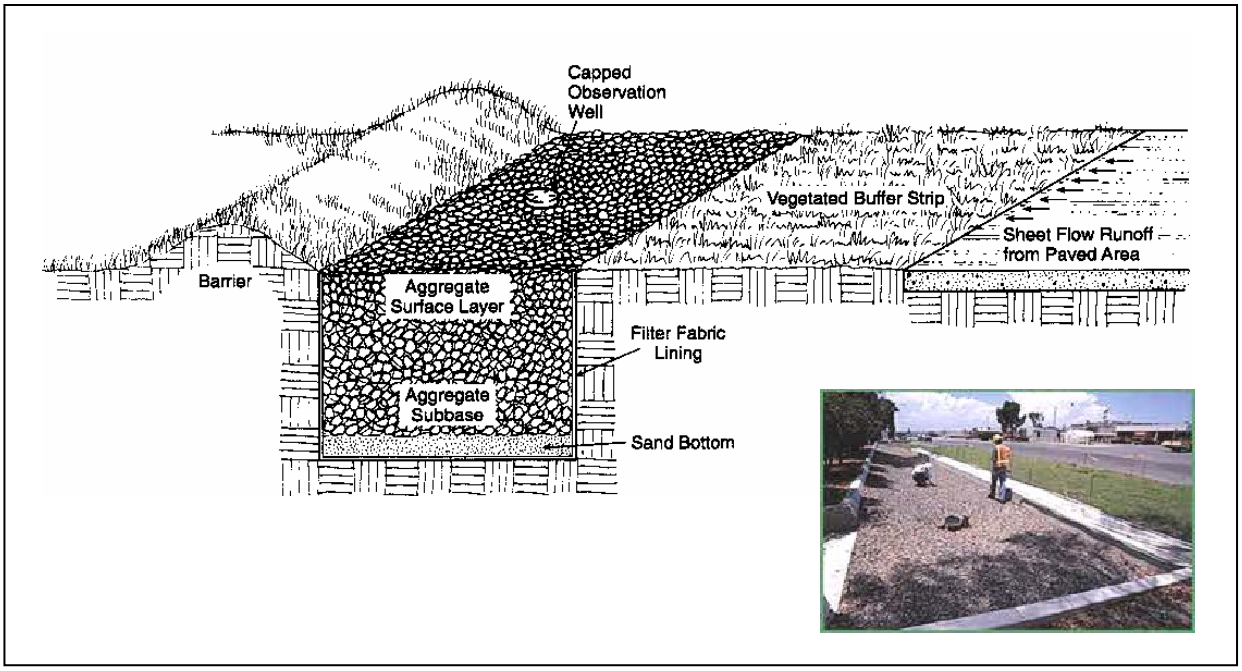
Step 6. Determine pretreatment volume and design pretreatment measures.

Size pretreatment facility to treat 25% of the water quality volume (WQ_v) for off-line configurations.

See the Pretreatment / Inlets section of *Site and Design Considerations* for more details.

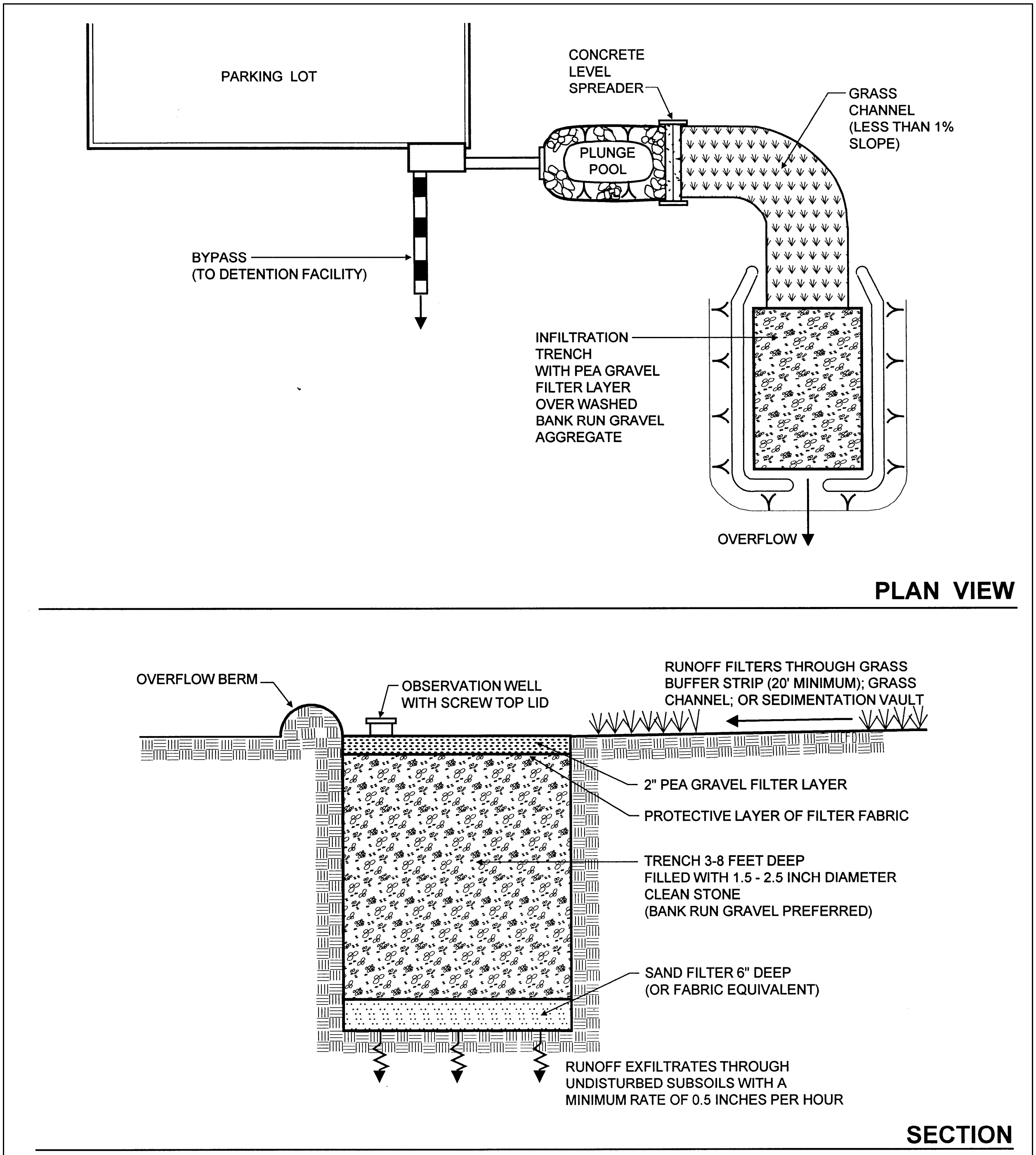
Step 7. Design spillway(s).

Adequate stormwater outfalls should be provided for the overflow exceeding the capacity of the trench, ensuring nonerosive velocities on the down-slope.



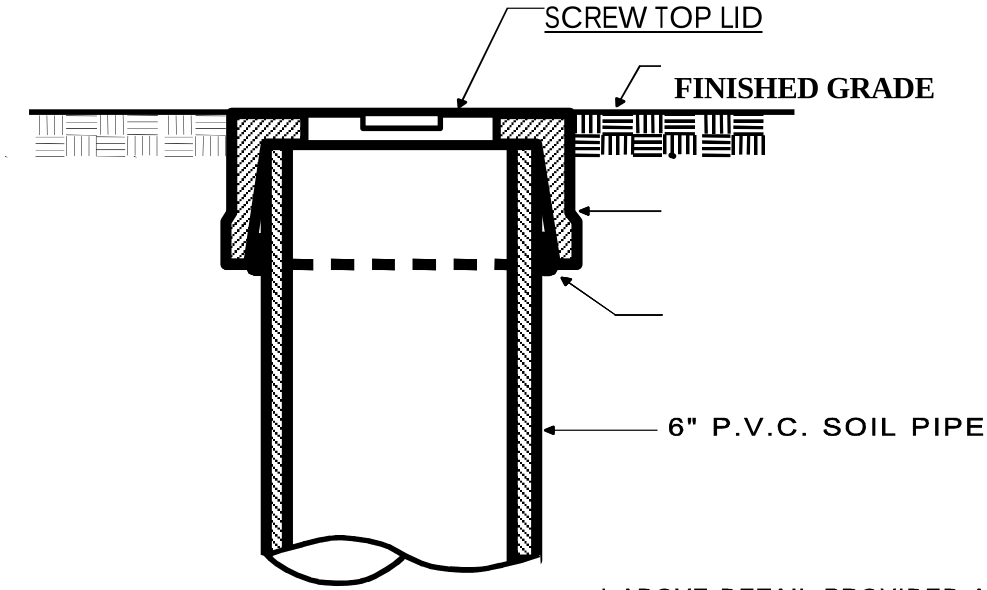
(Source: Georgia Stormwater Management Manual)

Figure 14.1 Infiltration Trench Example



(Source: Center for Watershed Protection)

Figure 14.2 Schematic of Infiltration Trench



* ABOVE DETAIL PROVIDED AS SCHEMATIC
SCREW TOP P.V.C. WELL CAP ONLY

EACH OBSERVATION WELL / CLEANOUT SHALL INCLUDE THE FOLLOWING:

1. FOR AN UNDERGROUND FLUSH MOUNTED OBSERVATION WELL / CLEANOUT, PROVIDE A TUBE MADE OF NON-CORROSIVE MATERIAL, SCHEDULE 40 OR EQUAL, AT LEAST THREE FEET LONG WITH AN INSIDE DIAMETER OF AT LEAST 6 INCHES.

2. THE TUBE SHALL HAVE A FACTORY ATTACHED CAST IRON OR HIGH IMPACT PLASTIC COLLAR WITH RIBS TO PREVENT ROTATION WHEN REMOVING SCREW TOP LID. THE SCREW TOP LID SHALL BE CAST IRON OR HIGH OMPACT PLASTIC THAT WILL WITHSTAND ULTRA-VIOLET RAYS.

OBSERVATION WELL DETAIL

(Source: Metro Stormwater Management Manual, 2000)

Figure 14.3 Observation Well Detail

References

ARC, 2001. Georgia Stormwater Management Manual Volume 2 Technical Handbook.

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Permeable Pavements

Description: Infiltration practices that are alternatives to traditional asphalt and concrete surfaces. Stormwater runoff is infiltrated into the ground through a permeable layer of pavement or other stabilized permeable surface.

Variations: Options range from poured-in-place, specially formulated concrete and asphalt that have greater void space than ordinary pavement to systems of interlocking modular pavers cast with void spaces.

Components:
- Open graded pavement mix or pavers with open surfaces
- Settling layer
- Open-graded base material
- Filter fabric
- Underdrain (where required)
- Subgrade with *minimal* compaction

Advantages/Benefits:
- Reduces runoff volume, attenuates peak runoff rate and outflow
- Reduces slick surfaces during rain
- Water quality enhancement from filtration of stormwater

Disadvantages/Limitations:
- Sediment-laden runoff can clog pervious pavement, causing it to fail
- Constant pressure in the same spot (constant vehicle braking) can collapse pores, causing pavement to fail
- Incorrect installation practices can clog pores

Design considerations:
- Same basic considerations as any paved area (soil properties, load-bearing design, hydrologic design of pavement & subgrade)
- Infiltration rate of native soil determines appropriateness and need for underdrain
- Not appropriate for heavy or high traffic areas
- Accessibility, aesthetics, maintainability

Installation considerations:
- Proper installation is crucial to ensure proper functioning
- Subgrade **cannot** be overly compacted
- Construction must be sequenced to avoid compaction and clogging pavement

Selection Criteria:

☐	**Water Quality 80 % TSS Removal**
☐	**Accepts Hotspot Runoff**
✓	**Residential Subdivision**
✓	**High Density / Ultra Urban Use**

Maintenance:
- Vacuum or jet wash to increase pavement life and avoid clogging
- Ensure that contributing area is clear of debris and sediment.

M — **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Permeable pavements are surfaces that can be driven over while permitting rapid infiltration of water into the underlying soil. Constructed of alternative paving materials, permeable pavements are used to locally infiltrate rainwater and reduce the runoff leaving a site. This can decrease downstream flooding, the frequency of combined sewer overflow (CSO) events, and the thermal pollution of sensitive waters. Use of these materials can also eliminate problems with standing water, provide for groundwater recharge, control erosion of streambeds and riverbanks, facilitate pollutant removal, and provide for a more aesthetically pleasing site.

Permeable pavements can be applied in areas that experience low vehicular traffic including parking lots and overflow parking areas; portions of streets such as residential parking lanes; driveways; plazas; and pedestrian or golf cart paths. There are several different forms of permeable pavements, varying from a permeable layer of paving material to grid systems. Four different types of permeable surfaces are discussed below.

Porous Asphalt: Porous asphalt differs from dense asphalt in its use of open-graded aggregate. Because no fine aggregate fills the voids between the single-sized particles, the material is porous and permeable. Porous asphalt can have a porosity of 15%-20%. A surface of porous asphalt is typically placed over a layer of open-graded gravel and crushed stone, with an underlying layer of permeable soil. There are several modifications to the standard design that can be used to increase storage capacity or pass larger flows, including the installation of a perforated pipe in the gravel sublayer, adding a layer of sand, etc.

Porous Concrete: Considered to be more durable than porous asphalt, porous concrete is a mixture of open-graded aggregate, which creates the voids in the structure, and Portland cement. The void space in porous concrete is in the 15%-22% range compared to 3%-5% for conventional pavements. Porous concrete is thought to have a greater ability than porous asphalt to maintain its porosity in hot weather. The permeable surface of porous concrete is typically installed as the top of several permeable layers, similar to the installation of porous asphalt described above.

General Description (Continued)

Plastic Grid Systems: These systems are often referred to as *geocells* and are defined by manufactured plastic lattices or mattresses that form networks of box-like cells that are filled with earth material. The lattice is typically 1-2 inches thick and the cells are a few inches wide. Porosity and permeability of these systems is entirely dependent on the cells' fill and vegetation. Like any other pavement surface, geocells require a firm gravel base that provides strength and storage capacity as runoff infiltrates. Geocells are lightweight and easy to transport and install. However, they may similarly be jarred easily by moving traffic.

Open-Celled Paving Grids: Commonly called *block pavers or grid pavers*, these grids are structural units, such as concrete blocks or bricks with regularly interdispersed voids that penetrate their entire thickness. Grids are made of concrete or brick and the open cells are filled with porous aggregate or vegetated soil. Block pavers are more rigid and therefore can bear larger traffic loads than plastic grid systems.

Pollutant Removal Capabilities

As they provide for the infiltration of stormwater runoff, permeable pavements trap particulate pollutants and absorb some soluble pollutants. Due to the potential for clogging, porous pavements must not be used for the removal of sediment or other coarse particulate pollutants.

Components

Several options exist for the top layer or surface of permeable pavements and should be chosen depending on strength required due to traffic loads, infiltration needs, and the manufacturers' recommendations. However, the sub layers are generally similar, consisting of four to five layers as shown in Figure 15.1. The aggregate reservoir layer can sometimes be avoided or minimized if the sub-grade is sandy and there is adequate time to infiltrate the necessary runoff volume into the sandy soil without by-passing the water quality volume. Descriptions of each of the layers are presented below:

Permeable Pavement Layer – This layer consists of a porous mixture of concrete or asphalt or a modular pavement grid of plastic, concrete, or brick and an aggregate or a vegetation medium. This layer is usually 2 to 4 inches deep depending on required bearing strength, pavement design requirements, and manufacturer's specifications.

Settling Layer – This layer consists of a 0.5-inch diameter crushed stone to a depth of 1 to 2 inches. This layer serves to stabilize the porous asphalt or concrete layer. Can be combined with reservoir layer using suitable stone.

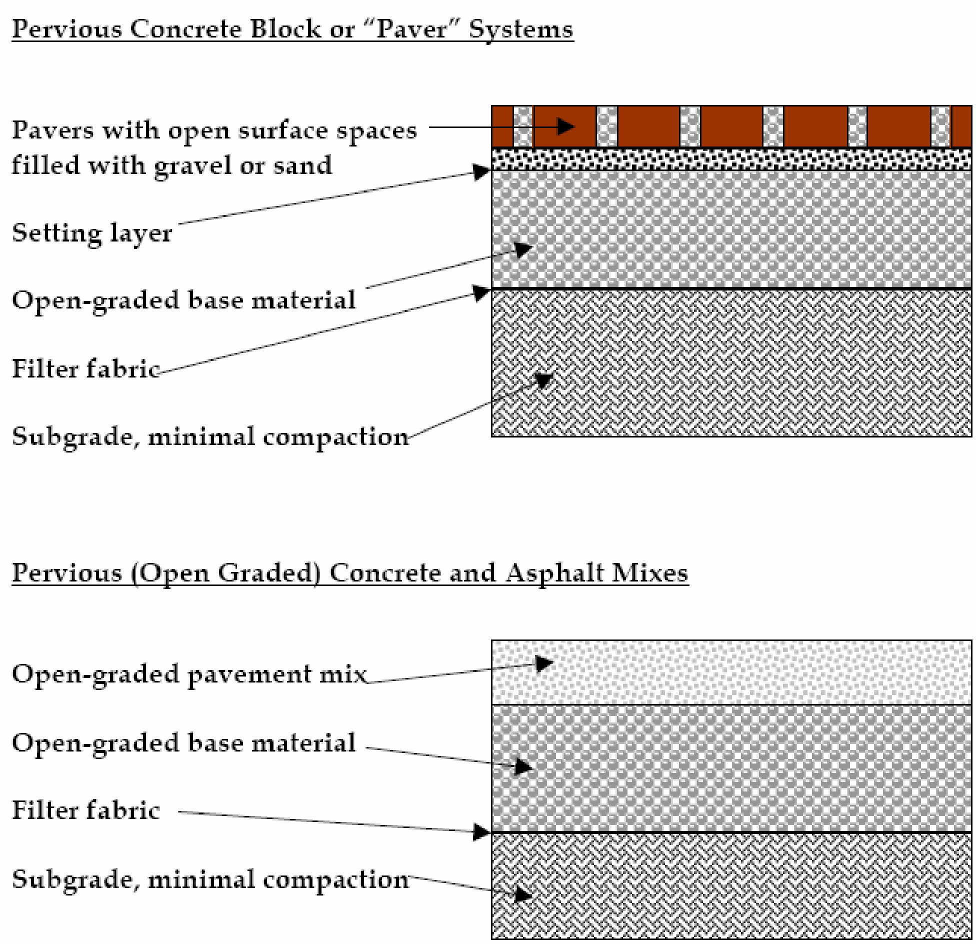
Reservoir Layer or Open Graded Base Material – The reservoir gravel base layer consists of washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40%. The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate and void spaces, but typically ranges from two to four feet. The layer must have a minimum depth of nine inches. The layer should be designed to drain completely in 48 hours and should be designed to store, at a minimum, the water quality volume (WQ_v). Aggregate contaminated with soil must not be used.

Bottom Filter Layer (not shown in diagram) – In cases where infiltration needs to be increased, a 6 inch layer of sand or a 2 inch thick layer of 0.5 inch crushed stone can be installed. The layer should be completely flat to promote infiltration across the entire surface. This layer serves to stabilize the reservoir layer, to protect the underlying soil from compaction, and act as the interface between the reservoir layer and the filter fabric covering the underlying soil.

Components (Continued)

Filter Fabric – It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the aggregate. The filter fabric serves to inhibit soil from migrating into the reservoir and reducing storage capacity.

Underlying Soil – The underlying soil should have an infiltration capacity of at least 0.5-inches/hour but preferably greater than 0.5-inches/hour. Soils at the lower end of this range may not be suited for a full infiltration system or may require additional infiltration measures such as a perforated pipe or additional sand layer. Test borings are recommended to determine the soil classification, seasonal high ground water table elevation, and impervious substrata, and an initial estimate of permeability.



(Source: City of Portland, Oregon, Stormwater Management Manual)

Figure 15.1 Permeable Pavement Layers

Site and Design Considerations

When designing permeable pavement systems, the infiltration rate of the native soil is a key element in determining the depth of base rock for the storage of stormwater, or for determining whether an underdrain system is appropriate. Traffic loading and design speed are important considerations in determining which type of pervious pavement surface is applicable. Pedestrian ADA accessibility, aesthetics, and maintainability are also important considerations.

The following design and site considerations must be incorporated into sites using permeable pavements:

1. The in-situ subsoils should have a high infiltration rate. Permeable pavements are appropriate for all soil types, but will require underdrain systems for soils that do not infiltrate well - hydrologic soil group D or most group C soils, or soils with a high (>30%) clay content. During construction and preparation of the subgrade, special care must be taken to avoid compaction of the soils.
2. Because even infiltration is important, the slope of the site should be less than 10% in all cases, but are not recommended to be more than 2%. Specifications are product-specific and shall comply with manufacturer's recommendations. Barriers perpendicular to the direction of drainage should be installed in sub-grade material to keep it from washing away, or filter fabric should be placed at the bottom and sides of the aggregate to keep soil from migrating into the aggregate and reducing porosity.
3. Porous pavements should only receive runoff from impervious areas. Runoff containing sediment will clog the porous paver surface.
4. Permeable pavements should not be used on sites with a likelihood of high oil or grease concentrations.
5. Not for use in drinking water aquifer recharge areas.

During construction, **do not** overly compact the soil, and avoid installing pavement during extremely high or low temperatures.

Porous paver system designs must use some method to convey larger storm event flows to the conveyance system. One option is to use storm drain inlets set slightly above the elevation of the pavement. This would allow for some ponding above the surface, but would accept bypass flows that are too large to be infiltrated by the porous pavement or if the system clogs.

As-Built Certification Considerations

After the porous pavement has been installed, an as-built inspection and certification must be performed by a Professional Engineer. The as-built certification must include verification of the infiltration rates of the porous pavement in addition to other design components that ensure the proper performance of the BMPs.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) agreement submitted to Metro for approval and maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with the grading permit application. The O&M agreement is for the use of the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan.

The burden of maintenance is fairly low for permeable pavements. However, failure to maintain and to abide by design and construction standards often results in failure of the measure.

Permeable pavements should be inspected regularly to ensure that the porous surface is free of sediment and that the surrounding area does not have the potential to contribute sediment-laden runoff. The surface should be vacuum swept, followed by high-pressure hosing to keep pores free of sediment. The adjacent, contributing area should be inspected to ensure that it is free of debris and litter, stabilized and mowed, and that clippings have been removed. It would be beneficial to inspect the system during a rain event to ensure that it is dewatering appropriately.

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Suggested Reading

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