

Construction Stormwater Best Management Practices Manual

1200-C NPDES General Permit

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Water Quality Permitting

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State of Oregon
Department of
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Chapter 1: Introduction

2.11 Regulatory Overview

The NPDES program was established by federal legislation as part of the Clean Water Act to improve the quality of stormwater from industries, or industrial type activities. Discharges to waters of the State may not contain pollutants or characteristics in levels that would cause the receiving water body to fail to meet water quality standards. The Oregon water quality standard for turbidity (Oregon Administrative Rule 340-041-0036) includes the requirement that “No more than a ten percent cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity.”

All point source discharges of pollutants from non-point sources, including those from construction sites, to federal waters (such as lakes, rivers and wetlands) must be authorized by a permit. In Oregon, a permit is required for construction activities with one acre or more of disturbed soil or that are part of a larger common plan of development or sale and has the potential to discharge to surface waters. Operators must obtain a National Pollutant Discharge Elimination System (NPDES) 1200C General Stormwater Discharge Permit for construction activities unless they can be covered under a local code or permit from a limited number of local government agencies and are under five disturbed acres.

Best Management Practices (BMPs) are a key component of the Erosion Sediment Control Plans (ESCPs) required by the 1200-C permit. BMPs are stormwater controls or measures that reduce pollutants at the source to prevent the pollution of stormwater runoff discharged from the site. These practices can also be used to divert stormwater runoff from areas of exposure to pollutants, or to treat stormwater runoff before discharge to receiving waters. BMPs are designed to address the quality of a site’s practices with respect to stormwater leaving the site, and to meet environmental water quality standards or benchmarks. BMPs are most effective when organized into a comprehensive Erosion and Sediment Control Plan.

Rather than delineate particular practices that all sites should adhere to, the 1200-C sets narrative criteria that allow the permittee to select technologies to meet those standards. The stormwater discharge permit does not generally require specific BMPs because the practices should be selected on a case-by-case basis depending on the particular conditions at the site, such as the quantity of rainfall reaching the site, the area of land available for constructing management practices, costs in implementing the practices, site slope and soil type.

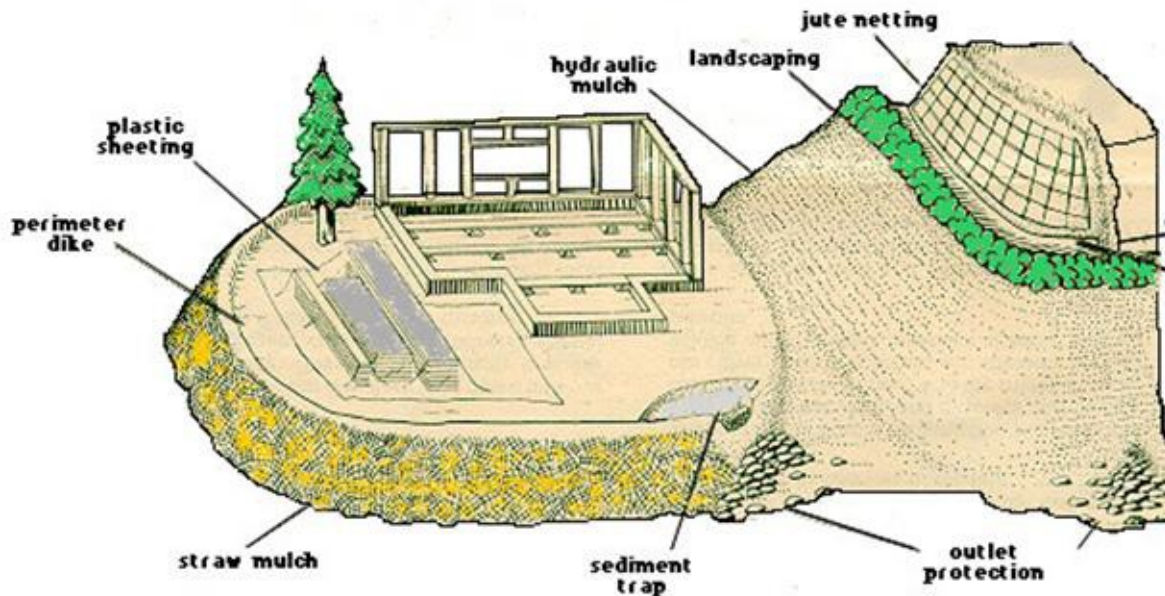
The best way to use this guide is to assess your site and your stormwater discharge(s). Determine the best BMPs for the site conditions that will have the most impact on the discharge(s). Select BMPs that will be most effective in controlling pollution in the stormwater discharges for the resources and costs that will be required to implement those BMPs (Refer to DEQ’s *Construction Stormwater Erosion and Sediment Control Manual* for detailed information on selecting BMPs). Implement the BMPs selected and check the stormwater discharges to verify the anticipated results of the BMP implementation and determine if more BMPs will be required in order to meet the benchmarks or water quality standards for the various pollutants of concern.

The BMPs included in this document are a work-in-progress and are by no means to be considered a complete list of appropriate erosion control measures. New technologies are continually being developed and refined. Additional BMPs will be added periodically to this

document as they are found to be reliable and effective. Some BMPs may be removed from the document if field use shows that they are not reliable, effective, or cost effective.

2.12 Construction Stormwater BMPs

The BMPs included in this guidance document are related to source reduction and treatment methods for specific processes and activities at construction sites. In addition, the preventive measures mentioned may assist the facility in achieving stormwater discharge benchmarks and limitations or water quality standards through pollution prevention. All of the BMPs recommended in this guidance are intended to complement, not conflict with, existing state and federal regulations regarding the handling, containment, or treatment of any material or waste.



Flagging

Flagged poles or stakes can be used to mark storm drains, catch basins, curb inlets, and so on. This helps protect sediment controls from being hit by cars and street cleaners, buried under mounds of soil, or lost in fields of high grasses.



BMP Removal

Temporary sediment and erosion control BMPs must be removed. At the conclusion of the construction project, after vegetation is reestablished, temporary erosion and sediment controls such as sediment fences, catch basin insert bags, and biobags should be removed from the construction site. Prior to their removal, the up-gradient sediment trapped by the erosion control should be removed by a vacuum truck, shovel, sweeping, or other method. Failure to remove the retained sediment will result in sediment being released to the receiving stream and negate the reason for installing the controls.

Chapter 2: Best Management Practices

2.1 Preserve Existing Vegetation

Description



Preserving the existing vegetation on a construction site is frequently the best preventative measure for erosion - and the least expensive. Vegetation limits the capacity of flowing water to detach soil particles and transport sediment by decreasing the velocity of raindrops as they hit the ground and by decreasing runoff volume. Native or existing vegetation is adapted to local climate and soil conditions and typically has fewer pests, minimizing the amount of maintenance, and therefore is usually a better cover species than introduced species.

Basic Design and Construction:

- Do not remove existing vegetation unless absolutely necessary.
- Preserve existing vegetation on all steep, unstable slopes whenever possible.
- Preserve mature trees when at all possible. With their extensive root systems and large canopies, mature trees serve important erosion control functions.
- Avoid compaction and grading of soils close to trees. Compaction (for example, from parking or driving too close to the tree) restricts the movement of gases and water. Grading of soils close to trees often will damage roots and cause existing trees to decline and die.
- Do not pile soil on top of roots, because this cuts off the air supply and suffocates the tree.
- Establish "do not disturb" zones on your site by marking off areas with stakes and tape or fencing. Extend do not disturb zones at least to the dripline of preserved trees.
- When lowering the grade of the site, terrace around the tree and the support the soil with a retaining wall so that tree roots are not exposed.
- Where trenches may cut through the root system, minimize damage by tunneling under the roots rather than trenching through them.

Maintenance:

- Minimize the impact of construction activities on existing vegetation.
- Irrigate in dry months.
- Monitor for the presence of pests or disease that will weaken the plant population.
- Inspect and repair boundary tape or fencing.

2.2 Vegetated Filter Strip

Description

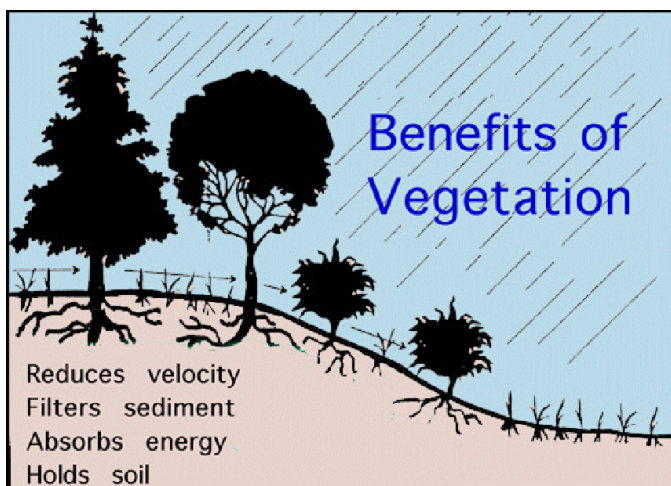
Vegetated filter strips are land areas of either indigenous or planted vegetation, adjacent to a disturbed area. They reduce flow and remove sediment and other pollutants from runoff and wastewater by infiltration, deposition, absorption, adsorption, and decomposition. The longer the flow path of stormwater through vegetation, the better the pollutant removal.

Design Considerations:

- Vegetated filter strips are designed to be used under conditions in which runoff passes over the vegetation in a uniform sheet flow. Such a flow is critical to the success of the filter strip. If runoff is allowed to concentrate, vegetation will be easily inundated and will not perform to its fullest capability.
- A filter strip is an edge-of-the-site BMP. Therefore, other BMPs that are designed to reduce soil loss are usually needed in conjunction with vegetated strips.
- Quality of vegetation in the filter strip is an important factor in determining effectiveness. Poor quality vegetation may result in increased amounts of sediment leaving the filter.
- If pollutants other than soil are to be targeted, then select the vegetation for the pollutant of concern.

Design and Construction Specifications:

- Limit the contributing area to 10 acres.
- The appropriate size and shape of the filter strip is dependent on a number of factors, including the type and quantity of pollutants, soil characteristics, infiltration rate, permeability, and slope.
- Keep slopes moderate to prevent channelized flow from forming. Length and width should be at least 50 feet and 20 feet (EPA, 1996) but width (flow direction) may be as little as 5 feet, depending on slope and loading.
- Regrading may be necessary to ensure a gentle slope of no more than 5 percent for short width strips or to roughen the soil.
- Remove trees, brush, stumps, rocks and similar materials that could interfere with installing the filter strip.
- For planted filter strips, a roughened surface (cat tracked) is preferred to slow surface runoff and thus increase infiltration. (Image courtesy of Clean Water Services; adapted)
- When constructing a filter strip, use a device such as a level spreader to ensure that runoff passes through as sheet flow.
- Select plants that have dense top-growth and provide good, uniform soil cover, and a fibrous root system for stability. Use vegetation adapted to local soil and climatic conditions and that has good regrowth following dormancy and cutting.
- Grasses are more effective than broadleaf plants for erosion control since they form a dense sod, have a fibrous root system and a more



- complete ground cover.
- Mark filter strips with stakes and tape or fencing.

Maintenance:

- Frequent inspections are necessary the first few years until vegetation is well established.
- Periodic regrading and sediment removal may be necessary.
- Encourage high plant density by fertilizing and weeding periodically. Reseeding may also be necessary.
- Minimize the development of erosion channels within the filter. Even small channels may allow runoff to bypass the filter.
- Inspect and repair boundary tape or fencing.

2.3 Reestablish Vegetative Cover

Description

Vegetative cover acts as either a permanent cover or as a temporary measure prior to permanently stabilizing an area. Vegetation shields the soil from the direct impact of rainfall or runoff, increases soil porosity and water storage capacity of the soil, reduces the energy of the runoff, and physically holds the soil in place with the root system of the vegetation. The most effective practice is to establish vegetation on an area as work as completed on that area, rather than waiting until all project work is complete. Reestablishing vegetation can be accomplished by seeding, seeding and mulching, seeding and matting, or sodding. Maintenance may be required to successfully replant an area. This practice is not suited for areas that carry heavy traffic.

Design Considerations

Apply mulch to areas which cannot be seeded due to the season or other issues, or to exposed soils that need immediate cover and protection. Mulch can also be applied to newly seeded areas to provide protection and cover until seed is established. Suitable mulch materials include tackified or blown straw, corn stalks, compost, and bonded fiber mix mulch. Use material that is dry and free of weeds and seeds (except that compost and bonded fiber mix mulch are applied moist). In dry weather the mulch may need to be anchored with netting or a fiber and tackifier to prevent it from blowing away. Check all mulched areas should be checked for spots where mulch has blown away or been pushed together.

Design and Construction Specifications:

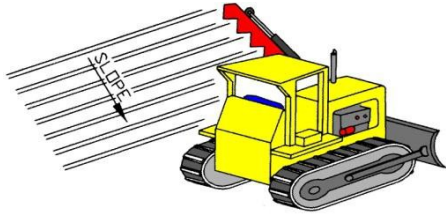
- Spread 4-6" of topsoil or compost over the site before seeding or planting.
- Fertilize according to soil test recommendations. Use a time release fertilizer.
- Use seed mix recommendations from local suppliers. Base seed mixes upon the time of year seeding is taking place. Use low maintenance, native grasses.
- Plant shrubs 2'-5' apart; trees 6'-10' for wooded areas.
- Mulch with tackified loose straw, or blown straw, or provide close knit matting.
- Water as needed to keep soil moist.
- If planting is done in July through September, irrigation may be necessary.

Maintenance:

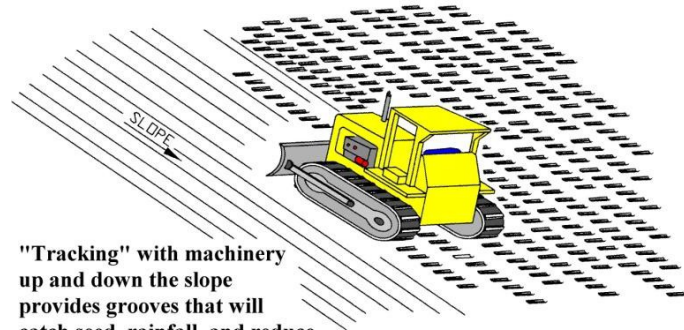
- Fertilize and water as recommended by supplier.
- Re-seed areas where adequate cover has not been established.

2.4 Hydroseeding, Mulching and Tackifiers

Hydroseeding



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



"Tracking" with machinery up and down the slope provides grooves that will catch seed, rainfall, and reduce runoff.

Hydroseeding is the application of a mulch, seed and fertilizer slurry to establish vegetation and prevent erosion. This is a very economical option that can stabilize slopes until grasses and plants are able to sprout. Most hydroseeding using just the blue green mulch will not provide sufficient vegetation to stabilize the site. A second or third hydroseeding may be necessary in order to establish at least a 90% coverage level. A wide variety of seed mixes are commercially available to suit each site's needs. Mulch provides water retention, soil retention, and protection for germinating seeds away from direct sun and wind. The mulch can reduce the tendency of the seeds to wash away and depending on the type of mulch can retain up to 10 times its weight in water to keep the seeds moist. Mulch can also add a carbon source and adds nutrients to the soil as it decomposes. This is especially true if compost or bonded wood fiber is used with the seed mix. A carbon source and long term nutrients are necessary for long term vegetation establishment.

Grading and minimal compaction of slopes should occur prior to hydroseeding. Ensure that the caterpillar tracks on slopes run perpendicular to the slope in order to provide a damming or mini-terracing effect rather than a channeling of the runoff (see Surface Roughening).



Mulching

Mulching is the application of plant material such as compost or straw to the soil surface, and can be used alone, or as part of a hydroseeding mixture as discussed above. It provides immediate temporary protection from erosion. Mulching also improves seed growth by conserving moisture; holding fertilizer, seed and topsoil in place; and moderating soil temperatures. Apply straw and mulch at a rate of at least 1½ -2 tons per acre, until the soil surface is not visible through the mulch. Mulch may need to be held in place by sprayed-on tackifiers or netting.

Straw mulch will need a tackifier if it is spread loose from bales. Use straw that is sterile or contains no straw seeds, wheat, rye, grass seed, etc. other than what is being grown on purpose. If it is blown, shorter straw strands do not appear to be as affected by wind as the longer loose straw, and usually will not require a tackifier.

Tackifiers

A tackifier is a biodegradable adhesive that can be applied directly to the soil, or over a layer of mulch. It acts as a glue to hold the soil in place or increase the holding power of the mulch. One tackifier used by a local company is a vegetable based adhesive made of guar gum which they import from India. Coagulants and flocculants (polymers) can be used. An interesting product call DriWater^{tm(1)} actually releases water as it biodegrades which may be an advantage when hydroseeding in late summer. Tackifiers or netting are necessary in high or frequent wind areas to hold down straw.

Maintenance:

- As with reestablishing vegetation, regular watering of the seed in the first two weeks is critical for healthy growth. Less watering is needed with use of a compost blanket cover and to some extent a complete straw cover.
- Monitor for the presence of pests or disease that will weaken the plant population.
- Reapply if necessary.

2.5 Compost Cover

Description

The use of compost cover over newly graded soil can greatly reduce erosion and minimize sediment loss and turbid discharges of stormwater from a construction site. The added benefit of having an excellent vegetative growth media in place when landscape vegetation is installed will greatly enhance the construction site.

Properly installed, the use of a compost cover can eliminate turbid runoff from construction sites for all but the most intense storms. When grading and compacting of a site occurs during construction, the infiltration rate of the resulting soil is greatly reduced (depending on the soil type by as much as twenty percent or more). By tilling in the compost towards the end of the construction just prior to landscaping, the infiltration rate of the soil immediately is enhanced and quickly approaches that of native undisturbed soil. Without some type of soil enhancement such as compost, it may be many years before the infiltration rate for vegetated areas of the site approaches that of the site's natural infiltration rate.

¹ Use of trade names is for illustrative purposes only and should not be construed as a DEQ endorsement of a particular product.

Design and Construction Specifications

Prepare underlain soil by grading it smooth; ensure that the finished grades and slopes minimize the potential concentrating of any water runoff. Use of at least three inches of less than 50% moisture content three quarter minus compost on 50 % or less slopes has been shown to greatly reduce turbid runoff and enhance vegetation growth. Extend the compost at least 6 feet up onto the flat portion of a site or into the vegetated undisturbed area.

2.6 Erosion Control Blankets and Geotextiles

Description

Erosion control blankets are mats of organic fibers or inorganic materials held by synthetic or biodegradable netting. Most blankets are rolled products, but some may be sprayed onto exposed soils. Rolled erosion control products (such as netting, meshes, erosion control blankets, and turf reinforcement mats) come in a variety of materials, including jute, coconut fiber, straw, synthetic materials, plastics or combinations thereof. Geotextiles are permeable fabrics used to separate, filter, reinforce, protect or drain. Because of the versatility of the product, this technology has developed to include geogrids, meshes and cells with a wide range of applications. Geotextiles are commonly made from polypropylene, polyester or from natural material like coir, jute or straw.

Depending on the desired use, they can be purchased with increasing degrees of porosity and permeability.

This is a short term measure designed to provide immediate protection until a more permanent stabilization measure can be implemented. Heavy traffic areas are not well suited to this type of protection. Some types of products are manufactured with seed incorporated into the matting, providing protection and moisture to the germinating seeds. This option requires close attention to installation procedures, and may be expensive in large scale applications. It can be very effective, however, if an appropriate medium is selected for the site. Erosion from rain impact is generally prevented if the underlying soil cannot be observed through the matting. With proper installation and maintenance this practice can stabilize the slope and greatly reduce if not eliminate the potential erosion and associated soil in the runoff.



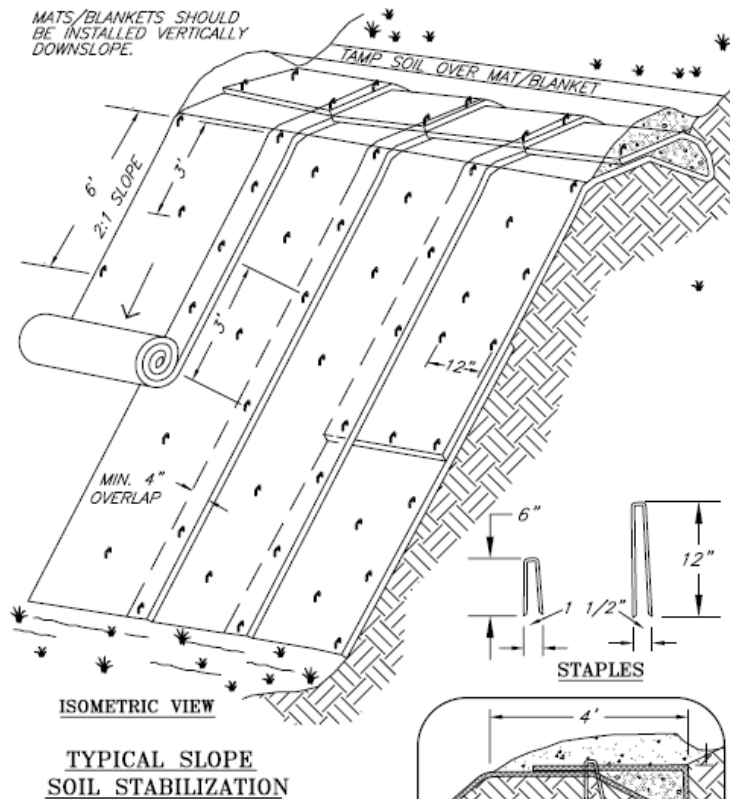
Straw Matting (photo courtesy of Clean Water Services)



Coconut Matting

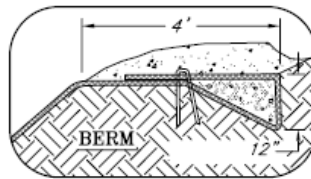
Design Considerations

Where water infiltration is not desirable, for example on extremely unstable or steep slopes, an



NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.
4. STAKING OR STAPLING LAYOUT PER MANUFACTURERS SPECIFICATIONS.



NOT TO SCALE

(image courtesy of Clean Water Services)

2.7 Plastic Sheeting

Description

Plastic sheets (such as black UV resistant visqueen) may be used to temporarily cover soil stockpiles or bare slopes until a more permanent stabilization can occur or until the stockpile is removed. For sites that develop erosion problem areas in the middle of the wet season and it is not possible to make a permanent repair or placement of other BMPs (for example, equipment can't access the area due to the soft soil conditions), consider a temporary placement of plastic sheeting to protect the area and divert runoff away from the area of concern until a more permanent solution can be applied.

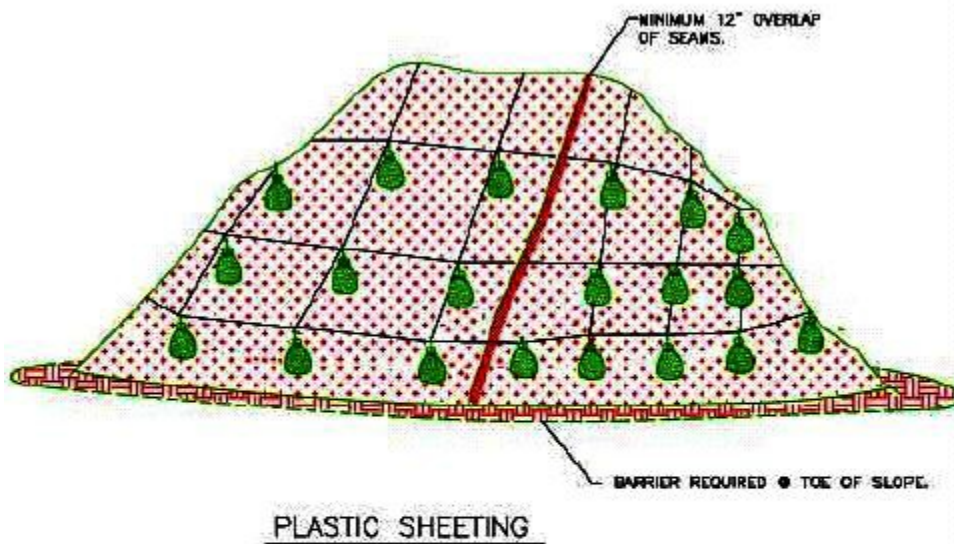
Design Considerations

Some method such as a lined ditch should be used to collect and divert the runoff to a pipe slope drain or other device to convey the clean water off of the site. Ensure that roped together sand bags, concrete blocks, tires or other weighted objects are used to hold the plastic in place. Plastic sheeting will sterilize soils in warm weather, killing vegetation and soil biota. Consider using another method (such as mulch or blankets) if preservation of topsoil biota is desirable.



Maintenance:

- Replace torn sheets and repair open seams.
- Completely remove and replace plastic when it begins to deteriorate.
- Check anchoring system and repair or add anchors.
- Check for erosion; address and repair damage if found.
- Completely remove all plastic once it is no longer needed.



NOTES:

1. MINIMUM 12" OVERLAP OF ALL SEAMS REQUIRED.
2. BARRIER REQUIRED @ TOE OF STOCK PILE.
3. COVERING MAINTAINED TIGHTLY IN PLACE BY USING SANDBAGS OR TIRES ON ROPES WITH A MAXIMUM 10' GRID SPACING IN ALL DIRECTIONS.

(image courtesy of Clean Water Services; adapted)

2.8 Dust Control



Description

In dry weather, soil is particularly prone to displacement by wind erosion on unpaved roads and construction sites. Use administrative controls and prevention. Dust may be controlled by reducing vehicular speeds, using street sweepers fitted with filters and vacuums, or planting vegetation cover. Irrigation is a temporary measure involving a light application of water to moisten the soil surface. Apply the correct amount of water because excess water could lead to further erosion and tracking of soil off site. When other methods are not adequate or appropriate, use controls such as palliatives (chemical soil treatments) that are applied as spray-on adhesives. The chemicals act to bind soil particles together and form a more durable, resilient ground surface. Common palliatives include calcium chloride, anionic asphalt emulsion, latex emulsion, and resin-water emulsions.

Sandy sites may be able to control erosion of soil by the use of sand (beach erosion) fences, adding a layer of top soil, amended top soil, or compost and planting vegetation. Providing any of these BMPs would also hold water better than watering alone, particularly in sandy areas.

Design Considerations:

- Do not drive vehicles over the treated area to prevent the tracking of the chemicals to other areas on or off the site and to prevent the breaking of the bond holding the fine soils in place.
- Watering is the most common method of dust control, but is also the most temporary. The use of chemicals to treat exposed surfaces generally provides longer dust suppression.
- Dust may also be minimized by limiting the speed of vehicles on the construction site.
- Since certain chemicals may be inappropriate for some soil types or application areas, and may be detrimental to the environment, verify application of chemical treatments with DEQ or the local government prior to application.
- Minimize soil exposure by temporary or permanent soil stabilization controls, such as mulching, seeding, applying topsoil, spreading coarse gravel



or crushed stone (relatively flat sites only), or planting trees. If existing vegetation on the site can be maintained, this will help in controlling dust.

- Install temporary or permanent windbreaks or barriers that reduce airborne particles by slowing wind velocities and causing the particles to drop out of the air after suspension. Large trees and shrubs left in place can provide wind barriers, while temporary measures include solid board fences, tarp curtains, sediment walls, crate walls, and sand dune fencing.
- Polymers can be used in tackifying and hydroseeding applications, either in temporary erosion control applications or as a part of a final revegetation project. Natural tackifiers such as guar gum are best as some of the polymers may be detrimental to the environment under some conditions.
- In arid regions, use tillage or deep plowing of soil to provide dust control. Large clumps of soil are deposited on top of the finer soil particles, preventing their movement by wind or water.
- Use phased construction to expose only the minimum amount of soil necessary to wind and water.



Maintenance:

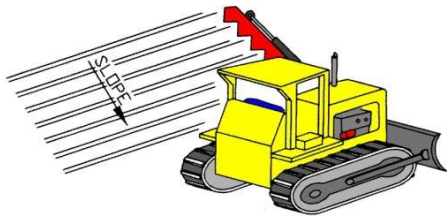
- Inspect areas requiring dust controls frequently and reapply materials or controls as needed.

2.9 Surface Roughening

Description

Surface roughening includes a variety of methods to create ridges or furrows in the soil surface. Leaving slopes in a roughened condition after clearing or creating a rough soil surface with horizontal depressions or grooves will trap seed and reduce runoff velocity. Roughening can be accomplished by 'track walking' slopes with tracked equipment, by using a serrated wing blade attached to the side of a bulldozer, or by other agricultural equipment.

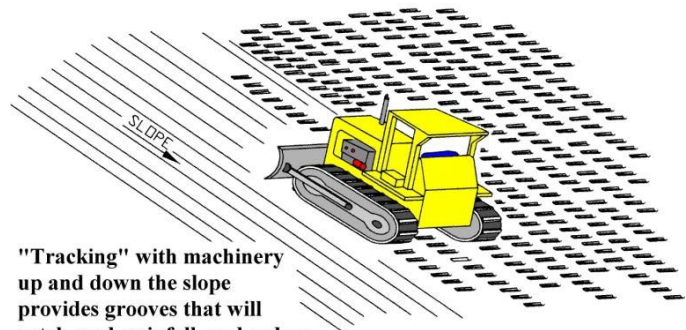
Design Considerations:



Note:

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

- Do not rely on roughening as a sole means of erosion control.
- Immediately seed and mulch roughened areas.
- Tracking by driving equipment up and down slope to create horizontal depressions and grooves.



"Tracking" with machinery up and down the slope provides grooves that will catch seed, rainfall, and reduce runoff.

Maintenance:

Check slopes for erosion rills and washes. Fill these areas slightly above the original grade, then re-seed,

mulch, or mat as soon as possible.

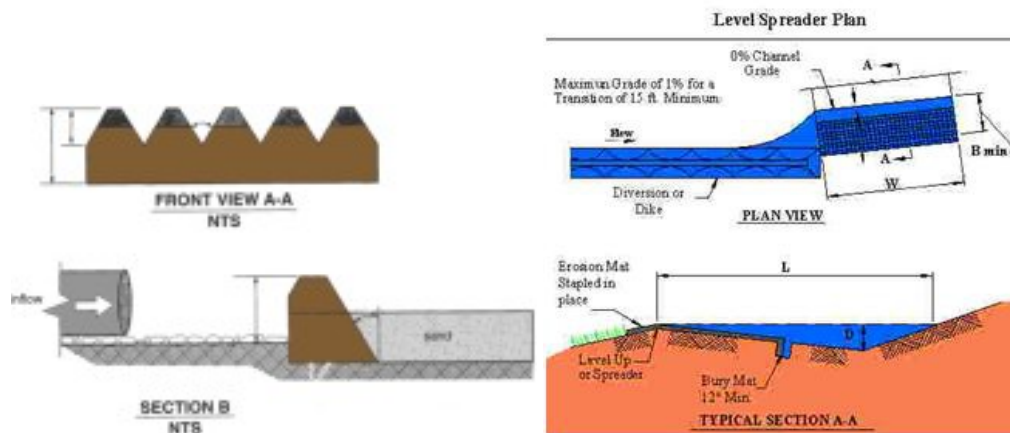
2.13 2.10 Level Spreaders

Description

Level spreaders or velocity dissipaters are used at outfalls or discharge pipes or along swales to reduce erosion of channelized water. They reduce runoff velocity and convert channelized flow to sheet flow or spread the flow from concentrated to sheet flow at conveyance outlets. Level spreaders provide a moderate amount of infiltration by providing temporary storage of discharges and spreading runoff over a larger area for potential infiltration into the soil.

Design and Construction Specifications:

- The spreader should be level across the top to prevent channelized flow leaving the spreader.
- Create a slope leading into the spreader that is less than or equal to 1%. Leaving the spreader, create slopes less than 6%.
- Construct spreaders at least 6 feet wide and least 6 inches high.
- Material can be washed rock, concrete curb, stabilized level earthen bank, or wooden boards.



Maintenance:

- Check spreaders after every rainfall event to make sure they are level and functioning as intended (See 1200-C permit for detailed inspection requirements).

2.14 Check Dams

Description

A check dam is a small dam constructed in a drainage way to reduce channel erosion by restricting the flow velocity. Check dams are appropriate for use in small drainage areas. Dams can be built from rock, logs, gravel filled bags, or staked bio bags; and can be temporary measures or permanent installations. They not dams in the traditional sense, and should not function like dams – they are velocity dissipaters only. They should leak a lot; that is, flow should pass through as well as over them. These structures also tend to act as sediment control structures, so it is important that they be inspected and maintained regularly to ensure adequate performance. Never use check dams in natural streams unless appropriate state and federal permits are first obtained.



Check dams are useful:

- In temporary swales and ditches where lining with non-erodible materials is not practical, but erosion protection is necessary.
- When construction delays or weather conditions prevent timely installation of non-erodible lining.
- In either temporary or permanent ditches or swales which need protection during the establishment of grass linings.
- In permanent swales and ditches that have a slope of 5 % or more where permanent energy reduction (velocity) is needed.

Design Considerations:

- Check dams are designed for velocity reduction and erosion control and are not intended to trap sediment, although sediment buildup will often occur. Sedimentation can clog the dam causing ponding. Lengthy submergence or excessive sedimentation can kill the vegetative lining of the ditch or swale. This is especially likely to occur if the rock is minus 2 inches due to smaller void spaces.
- If the overflow area immediately downstream of the check dam is not stabilized, downstream erosion may result. Stabilize the streambed and bank with riprap or equivalent. Extension of downstream embankments to stable grades is also effective.
- When overflow occurs at the abutments, the spillway will need to be lowered or enlarged in order to ensure that the banks do not erode. Inspect the check dam for plugging of the spaces between the rock before modifying the check dam.
- Check dams may be removed when their useful life has been completed. Remove all stones from grass channels that require mowing. When removing check dams, use caution so as not to damage channels that are permanent.

Design and Construction Specifications:

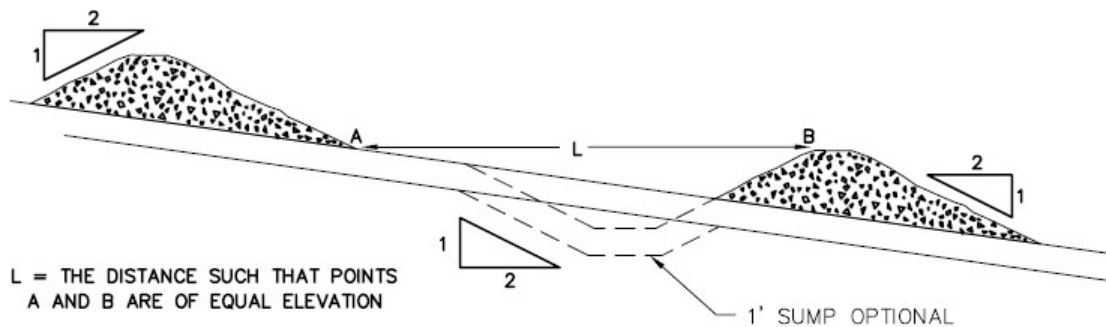
- Check dams are usually constructed of 3”-6” riprap, logs, or sandbags.
- For a check dam that is 6 feet or less in width, construct the center of the check dam at least 6 inches lower than the ends to act as a spillway for runoff and prevent water from flowing around the check dam or eroding the bank.
- For check dams wider than 6 feet, construct the center of the check dam more than 6 inches lower than the edges, up to a maximum of 2 feet lower than the edge of the check dam.
- Maximum check dam height is 2 feet, unless it is an engineered structure, due to the possible

water pressure behind the dam.

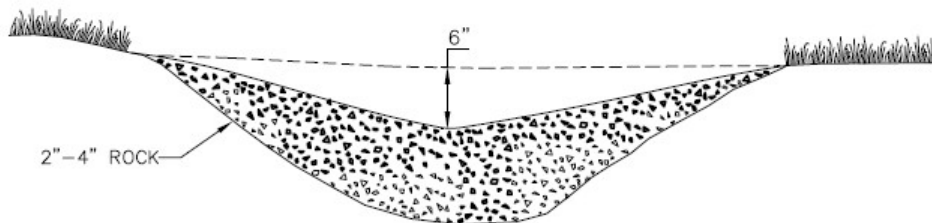
- Space multiple check dams so that the bottom elevation of the upper dam is the same as the top center elevation of the next dam downstream. That is, space dams so that the toe of the upstream dam is at the same elevation as the top of the center of the downstream dam.
- Stabilize overflow areas to resist erosion.
- Construct log check dams with 4 to 6 inch diameter logs. Embed logs a minimum of 2 feet. A spillway is needed in the log check dam. Do not exceed a drainage area of 5 acres for a log check dam. Note that removal of a log check dam can result in more soil disturbance than removal of other types of check dam.

Maintenance:

- Regularly inspect a check dam to ensure the dam has not been breached or otherwise damaged.
- Check the center elevation of the dam to ensure it is lower than the ends of the dam.
- Remove sediment accumulation behind the dam as needed to prevent damage to channel vegetation and to allow the channel to drain through the dam. Remove sediment when it reaches half the dam's height.
- Repair a damaged check dam promptly so the check dam will be fully functional for the next runoff event.
- If the spaces between the rock in a check dam become filled, removal and replacement of the check dam may be necessary.

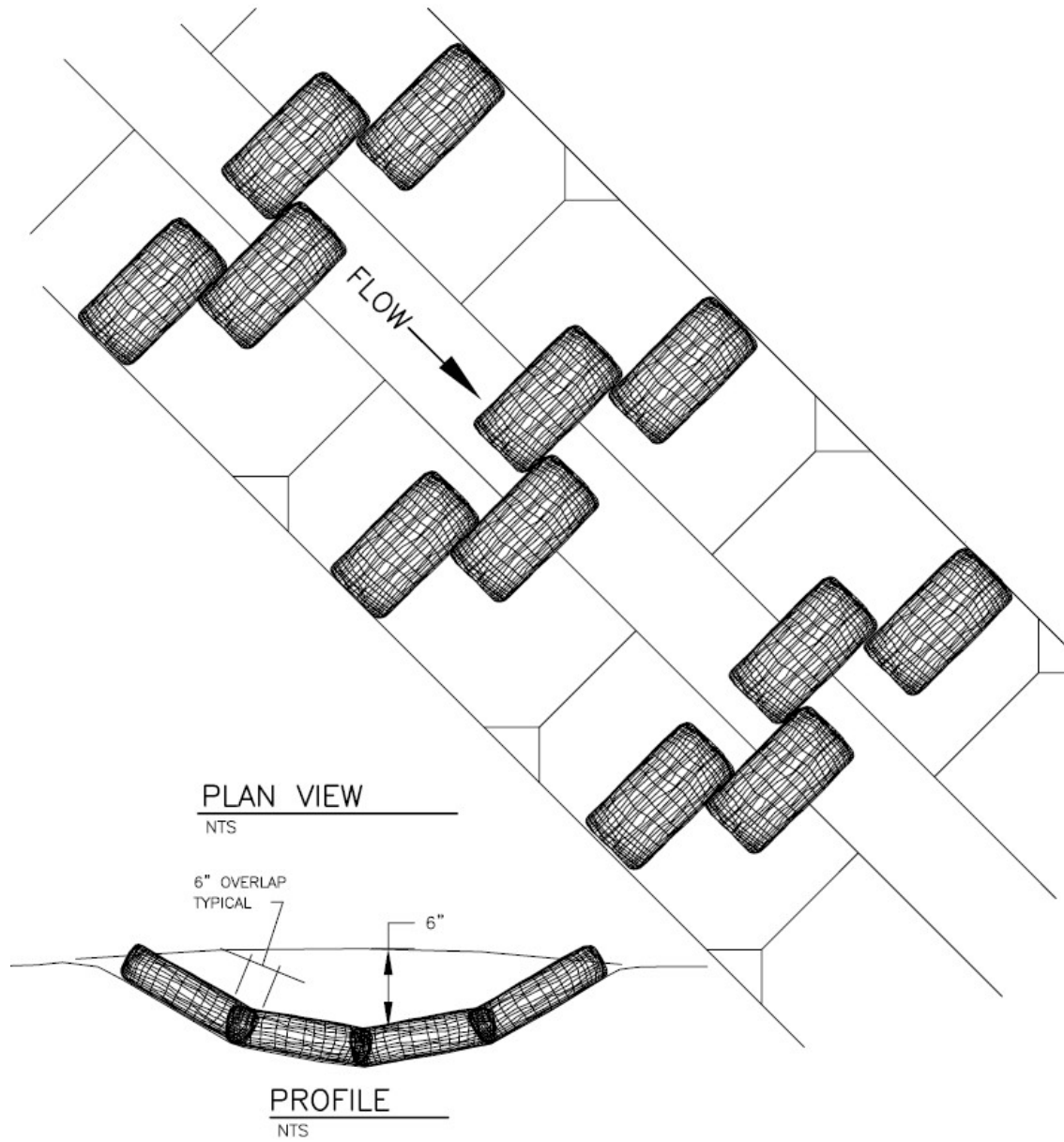


SPACING BETWEEN CHECK DAMS



ROCK CHECK DAM

(figure courtesy of Clean Water Services; adapted)



BIO-FILTER BAG CHECK DAM

(figure courtesy of Clean Water Services; adapted)

2.15 Diversions

Description

A diversion can be a berm (dike or ridge), a swale, an excavated channel, or a ditch used to prevent sediment-laden waters from leaving a site or to prevent off-site or upstream waters from entering a site. Diversion structures guide water around unstable areas to prevent both erosion and saturation with water. Typical diversions are combination berm/swale and may be temporary or permanent structures. Diversions are used:

- At the toe of cuts or fills to direct sediment-laden runoff to sediment traps.
- At the top of cuts or around disturbed areas to divert clean runoff until the disturbed areas are permanently stabilized.
- At the top of steep slopes where excess runoff would cause erosion problems.
- At selected intervals on long, sloping routes to prevent erosion.
- Around a site to prevent entry of off-site runoff and to reduce flooding.
- If clean water flows from above or across the site and picks up sediment from the site, consider piping the water across the site or using diversion ditches lined with geotextile fabric. The ditch to the right is lined with geotextile fabric to prevent erosion and limit soil contact with stormwater.

Design Considerations

- If the berm is not properly compacted and stabilized, it could fail in a heavy storm.
- A steep grade requires a protective liner or realignment to reduce grade.
- Sedimentation where channel grade decreases or changes course may cause overtopping. Realign or deepen channel to maintain grade.
- At a low point in berm where diversion crosses a natural depression, the berm will need to be built up.
- At vehicle crossing points, maintain berm height, flatten side slopes, and protect ridge with geotextile fabric and gravel at the crossing point.

Design and Construction Specifications:

- Do not use diversions on drainage areas exceeding 5 acres, though stream diversions may exceed this.
- Design diversions to handle the peak runoff from a 10-year storm or the runoff a typical local peak annual three or four hour storm event if the information is available.
- Construct berms from compacted soil, with a minimum top width of 2 feet, and a minimum height of 1 foot (with or without a swale). Allow for 10% settling. Berms may also be constructed from staked straw bales tightly packed end to end.
- When equipment crossing is necessary, diversions may be wider with flatter side slopes and lined with gravel to minimize erosion with a geotextile fabric under the gravel.
- When practical, minimize temporary diversions needed by constructing embankment ridges to slope to one side.
- Stabilize outlets to prevent erosion and convey runoff to a point where it will not cause damage.
- Vegetate diversion immediately after construction unless the diversion will be in place fewer than 30 working days and then provide a close knit jute, burlap, or similar liner in order to minimize erosion of the diversion structure.



Maintenance

Permanent diversions should be checked following each rainfall until disturbed areas are stabilized. Inspect temporary diversions daily when runoff is occurring and at least once every two weeks (See 1200-

C permit for detailed inspection requirements). Remove accumulated sediment from the channel. Check the dike, swale, and outlets and make necessary repairs immediately. Reseed areas that fail to establish a vegetative cover. Temporary diversions may be removed and blended with the natural topography when the area protected is permanently stabilized.

2.16 Bioswales

Description:

Bioswales are shallow, trapezoid-shaped ditches lined with with grass or other vegetation that act as filters for runoff. Bioswales do well with first flush runoff, are economically feasible, improve aesthetics and have minimum environmental impacts. The organic topsoil layer is good for degrading petroleum solvents, heavy metals, nutrients and hydrocarbons. They can be placed anywhere with careful site design, but are best when located where water can pond and settle out sediments, such as at a stormwater outfall, commercial development or roadside.

Design Considerations:

- The bioswale needs to be of sufficient width that vegetation does not die off when submerged, and so that flow is slow enough to provide efficient treatment and to not cause erosion of the swale.
- Grade the bioswale to create sheet flow rather than a concentrated stream in the bottom of the swale. Sheet flow decreases the chance of producing gully erosion and distributes contaminants over a wider area. Level spreaders (such as slotted curbs) can be used to facilitate sheet flow.
- Bioswales work best when used for treatment and conveyance of stormwater after rather than before a settling pond.
- Do not use bioswales on steep, unstable slopes or landslides.

Design and Construction Specifications:

- Design swales to deal with the peak runoff for a 2-year, 24-hour storm event.
- Critical design elements include: size of drainage area to be treated, location of bioretention areas, sizing guidelines, and water budget.
- Biofiltration is suitable for smaller sites 10 or less acres per biofilter.
- Bioswales work best when they are at 200 feet in length. In tight spaces obtain more length by using a curved path.
- Construct bioswales with a maximum bottom width of 8 feet. A low height divider can be used in wider swales to split the low flows to one side of the swale.
- Install level spreaders periodically starting no more than 10 feet downstream from the inflow point, at the inflow to any curves, in the curve, and at the outfall of a curve, in order to maintain sheet flow at low intensity rain events. For sharp curves it may be necessary to armor the outside bank to prevent erosion.

Maintenance:

- Trim vegetation in the bioswale every year if the vegetation can grow to heights over 12 inches. Remove woody species periodically. Dispose of plant clippings properly as they may have absorbed hazardous materials which may be released upon decomposition.
- Regrading may be necessary to reshape the shallow-broad shape as sediments collect and form pools. As with plant waste, remove sediments dispose of properly.

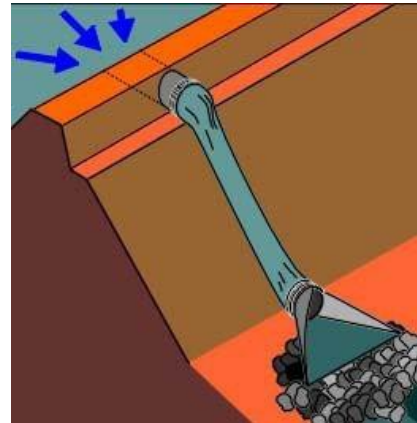
For additional information on Bioswales see the Biofilters document at:
<http://www.deq.state.or.us/wq/stormwater/nwrinfo.htm>

2.17 Pipe Slope Drains

Description:

A temporary pipe slope drain is a structure used to convey clean water down the face of a cut or fill without causing erosion. Temporary slope drains are used in conjunction with berms along the edges of newly constructed slopes to prevent erosion. They are used along cut and fill slopes until permanent stormwater drainage structures are installed.

They can also be used to conduct water across a site without contamination. Design the inlets and outlets for adequate stabilization. The outlet area is particularly important, as the higher velocity water at the end of pipe can be extremely erosive. Outlet design and correct installation are the keys to the success of this type of control.



(figure courtesy of Clean Water Services)

Design and Construction Specifications:

- Do not exceed 5 acres of drainage area for each slope drain.
- Install pipe slope drains at frequent intervals along continuous unprotected slopes and at low points in the roadway profile grade.

- Plastic lining; fiber matting; wooden flumes; metal, rigid, or flexible plastic pipe; and half round pipe are commonly used. When plastic lining is used, provide a smooth, uniform ditch to prevent water from overflowing the sides. Do not use fiber matting and plastic sheeting on slopes steeper than 4:1 except for short distances of 20 feet or less.
- Ensure that pipe connections are watertight and secure so joints will not separate.
- Pipe diameters should be calculated by a qualified engineer.
- Construct inlets to channel water into the drain.
- If the water entering the pipe slope drain contains sediment, then staked bio bags, rice straw wattles, or some other inlet protection should be used.
- Anchor drains to withstand the force of the water. Anchoring can be accomplished by staking at approximately 10 foot intervals or by weighing down the drains with items such as riprap, sandbags, or compacted soil.
- Compact the base for temporary slope in a concave form to channel the water or to hold the slope drain in place.
- Construct outlets to reduce erosion downstream with items such as dumped rock, small sediment basins, or other approved devices.
- Remove all temporary slope drains when no longer necessary and restore the site to match the surroundings.

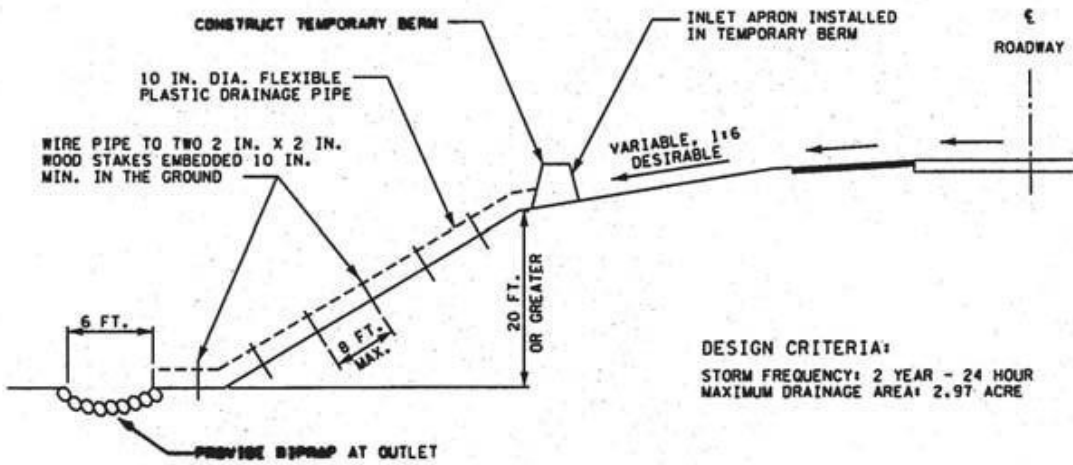


Common Problems:

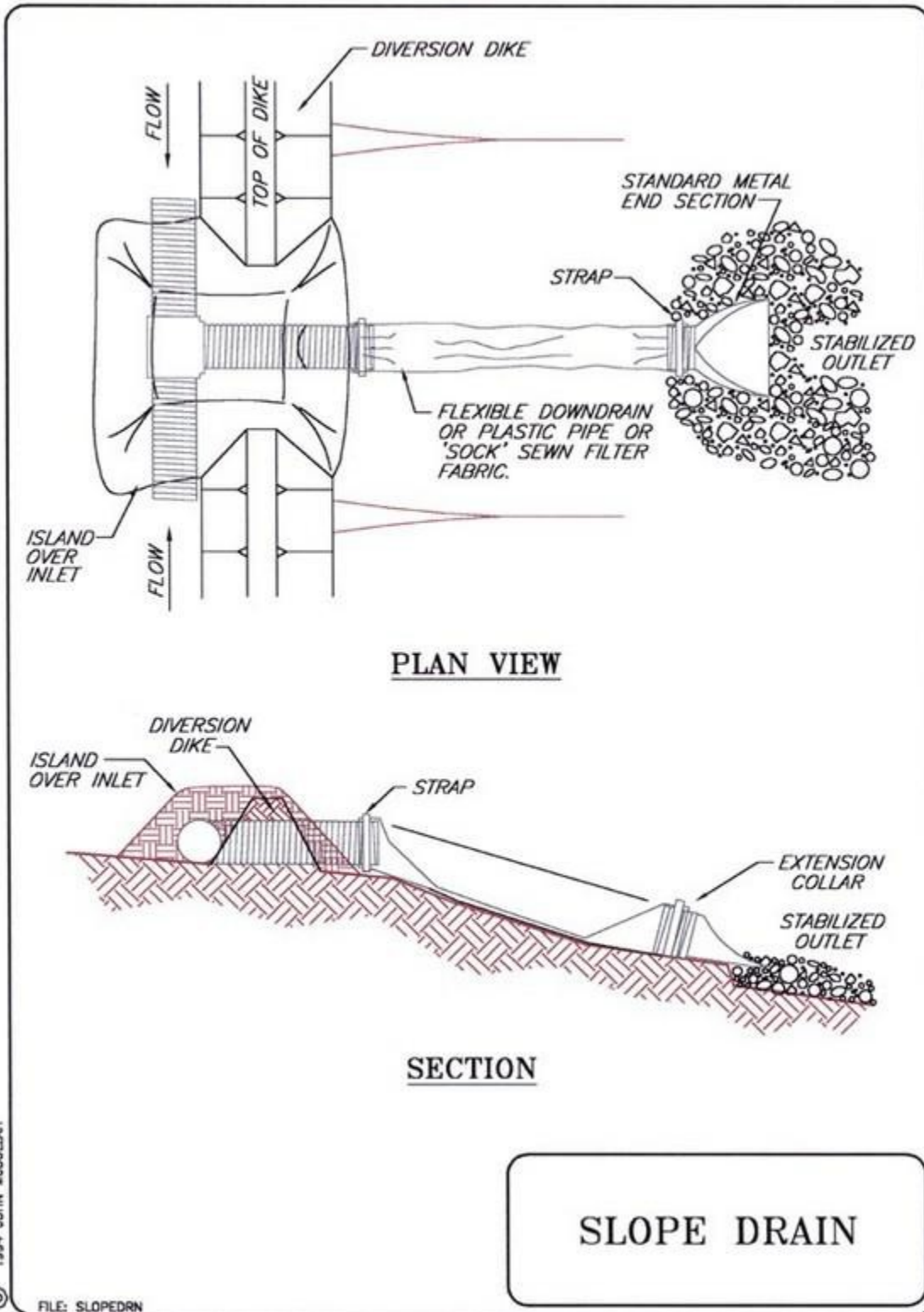
- Washout along the pipe/matting/flume due to seepage, piping, and/or overflow. A washout may occur because of inadequate compaction, insufficient fill, installation of drain too close to edge of slope, too steep a slope (open drains), too large a drainage area, or undersized conveyance channel.
- Overtopping of diversion. This can be caused by undersized pipe (drainage area too large) or a blocked pipe, or by improper grade of channel and ridge.
- Erosion at outlet. This can occur when the pipe does not extend to stable grade or outlet. A stabilization structure may be needed.
- Displacement or separation of slope drain. The drain has inaccurate or insufficient anchorage.

Maintenance:

- Inspect temporary slope drains daily when runoff is occurring and at least once every two weeks (See 1200-C permit for detailed inspection requirements). Some critical points that should be checked at each inspection are as follows.
 - Check inlet and outlet for sediment or trash accumulation; clear and restore to proper condition.
 - Check the fill over the pipe for settlement, cracking, or piping holes (seepage holes where pipe emerges from dike); repair problems promptly.
 - Check conduits for leaks or inadequate lateral support; repair problems promptly.



Pipe Slope Drain Example



(Figure courtesy of Clean Water Services)

2.18 Outlet Protection

Description

Outlet protection involves the use of an energy-dissipating device at the outlet of a pipe or conduit to prevent excessive erosion (scour) from the discharge of runoff. Outlet protection structures can be manufactured from a number of different materials.

Design and Construction Specifications

Concrete/Paved Outlet Protection

Concrete or paved outlet protection is a permanent structure and therefore should be designed by a qualified engineer. The design and installation of such a structure should follow plan specifications.

Riprap Outlet Protection

Excavate subgrade below design elevation to allow for thickness of filter and riprap. Compact any fill used in the subgrade to the density of the surrounding undisturbed material. When applicable, smooth the subgrade to prevent tears of the filter fabric. Even if not shown on plans, place filter stone, fabric, or a blanket prior to placing the riprap to help prevent subgrade erosion. Use extra-strength quality filter fabrics, installed in continuous sections, placing the upstream section of fabric a minimum of 1 foot over the downstream section of fabric. Completely replace any fabric that is torn during riprap installation.

Install riprap of the size and thickness as shown on plans to ensure a minimum thickness of 1.5 times the maximum stone diameter. Maintain final structure to the lines and elevations as shown in plans, taking care not to place stones above the finished grade.



(Photo courtesy of Clean Water Services)

Apron Installation

Nondefined Channel: Construct apron on a zero grade, aligned straight, and long enough to adequately dissipate energy. Construct so that there are no restrictions or overfall from the apron end to the receiving grade.

Well-Defined Channel: Construct apron straight and properly aligned with the receiving stream. Extend the apron to the top of the bank and long enough to adequately dissipate energy. Construct so that there are no restrictions or overfall from the apron end to the receiving channel.

For outlet piping of relative small diameter (generally 18 inches or less), completely burying the outfall side of the pipe in rip rap generally provides the velocity diffusing feature without concern for the length

of protection needed.

Design Considerations:

- If the foundation is not excavated deep enough or wide enough, riprap will restrict flow across sections, resulting in erosion around apron and scour holes at outlet.
- If the riprap apron is not on a zero grade, erosion will result downstream.
- If the stones are too small or not properly graded, stones will move, resulting in downstream erosion.
- If riprap not extended far enough to reach a stable section of channel or adequately dissipate energy, there will be downstream erosion.
- If an appropriate geotextile fabric is not installed under riprap, this may result in stone displacement and erosion of the foundation.

Maintenance:

- Riprap outlet structures do not require much maintenance when properly installed. Check periodically (particularly after heavy rains) for erosion at sides and ends of the apron and for stone displacement. Repair damage immediately using appropriate stone sizes.
- Modify size and depth as needed to prevent erosion and scouring.
- Check outsides of pad to verify that pad is wide and long enough to prevent erosion along the edges.

2.15 Terracing

Description

Terraces are constructed across slopes and form a series of channels and earthen embankments that reduce erosion by breaking the long slope into several shorter sections. The speed of the runoff is thereby reduced as is the amount of sediment loss. Runoff is collected in the terrace channel and can be stored for infiltration into the soil or diverted through some kind of erosion resistant outlet.



2.16 Straw Wattles

Description

Straw wattles are manufactured tubular plastic netting filled with rice straw. They are approximately 9 inches in diameter, 7 to 25 feet long, weigh about 35 pounds, and are easy to install. They can be installed on steep slopes and must be staked in position. Straw wattles act to disperse runoff laterally and trap sediments on the upslope side. If the soils are poor with respect to nutrients and need to be fertilized, the mini-terraces formed by the wattles encourage the nutrients to stay on the slope.



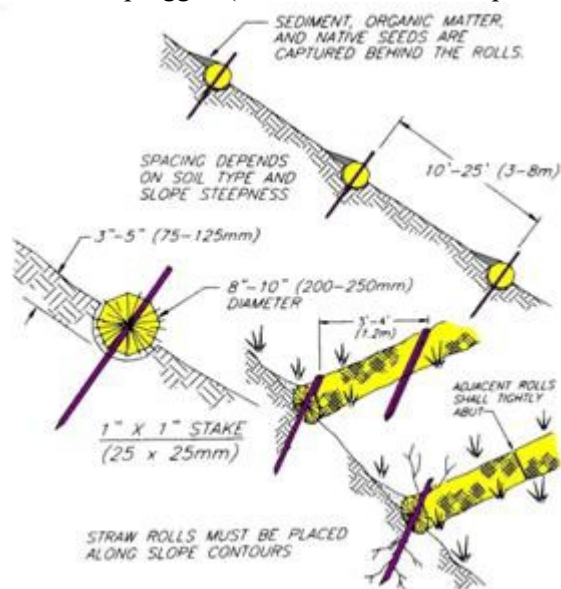
(Image courtesy of Clean Water Services)

Basic Design and Construction:

- Excavate a trench in which to lay the wattles, ensuring that water does not seep underneath the wattles. If the soil is loose enough, you can walk the straw wattle enough to create the required depression.
- Wattles are placed along the contour of the slope to reduce water flow velocities and trap sediments mainly through settling.
- Make sure the wattle fits snugly against the adjoining wattle, without gaps or cracks.

Maintenance:

Regularly remove sediment behind the wattles. Replace the wattles every three years or when they appear to become plugged (that is, water will not pass through).



2.17 Compost Berm

Description

A compost berm is an efficient way of preventing sediment and turbidity discharges from a construction

site. Yard debris compost is used to build a dike which filters the stormwater runoff. Most sediment and colloidal soil particles are negatively charged.

Compost is positively charged which tends to attract and hold the soil particles. In addition, the biota in the compost consume oil and grease and can convert some soluble



pollutants into insoluble forms. Compost berms can benefit vegetation when the compost is spread out or if the berm is seeded for the vegetation growth on the berm itself.

For further information on Compost for Erosion Control see the Biofilters document at:

<http://www.deq.state.or.us/wq/stormwater/nwrinfo.htm>.

Design and Construction Specifications

The basic compost berm consists of at least a 2 feet wide by 1 foot high continuous pile of compost. Use compost made up of yard debris, leaf, or composted biosolids from a sewage treatment plant. The compost grade can be either two-inch minus, one inch minus, or half-inch minus, depending on the slope of the area behind the berm. Steeper slopes generally require larger-sized compost. Sheet flow of runoff is a must upgradient of the berm. This may be established by the application of a 2 inch thick compost layer on the slope, a silt fence installation, or some other method for dispersing or preventing concentrated flows from occurring. The downstream side of the berm should not be bare soil or the runoff will pick up sediment and turbidity after the berm.

Maintenance

Regularly inspect the berm to ensure that it does not blow out from concentrated flows and to ensure that the compost does not become saturated, plugged, or rendered ineffective for some other reason. Inspect during stormwater runoff, so that turbidity breakthrough will be evident by muddy water flowing through the berm.

2.18 Compost Sock

Description

Compost Socks are close weave sock either of synthetic or cotton fiber filled with mixed yard debris compost, available in sizes that generally range from 8 to 24 inches in diameter. They tend to be heavy, but can be moved. Because socks deform (flatten), they make a good seal between the sock and concrete or asphalt surfaces. Socks are available in preset lengths or can be blown on site to the



desired length. Synthetic socks deteriorate in a couple of years and cotton socks deteriorate in about a year. Seed can be incorporated with the compost fill. Socks are very ineffective in removing turbidity and suspended solids. For this purpose, it may be necessary to use more than one sock, side-by-side.

Compost socks can be staked and used as check dams, but exercise caution when using in this way, because very little flow can go through socks, and thus will usually overflow when used as check dams. For this reason, special sock tubes are available that have a downstream skirt to protect the stream bed from any damage that may be caused from water overflowing the sock and undercutting the stream bed. When used as a check dam stake the sock to prevent the water pressure from moving it.



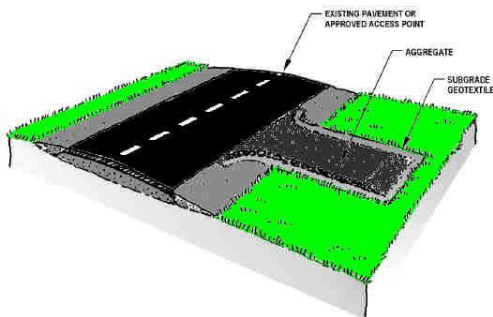
2.19 Gravel Construction Entrance and Wheel Wash

Description

A gravel construction entrance is a stabilized rock pad, placed at construction site ingress/egress locations. Constructing paved or rock roads or entrances can reduce the amount of mud and sediment that is tracked onto areas where the material could be washed into the storm drainage system. Construction entrances also typically include a curb ramp.

Design Considerations:

- Vehicle traffic leaving the site should be restricted to only those locations fitted with a gravel exit or wheel wash.
- Locate the entrance to provide for maximum utility by all construction vehicles.

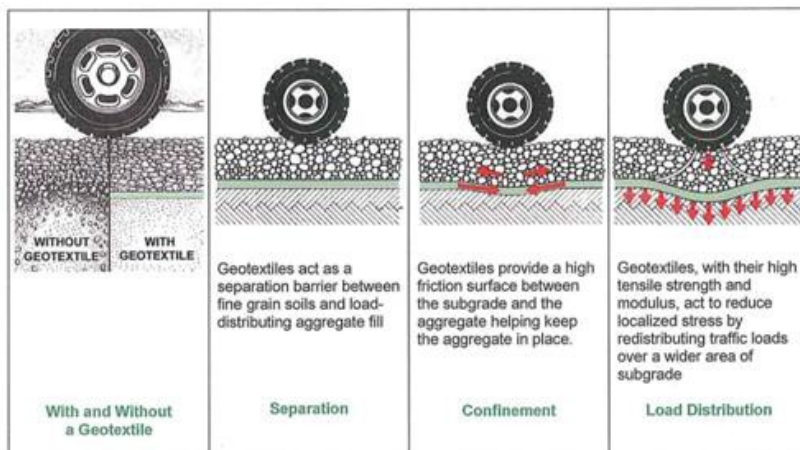


(graphic courtesy of Clean Water Services)



Design and Construction Specifications

Construct the gravel pad to extend to the structure (minimum of 50 feet), at least 10 inches deep and 20 feet wide. Use geotextile fabric as a barrier between the rock and the native soil to prevent migration of the soil fines through the rock to the surface and thus back to being tracked offsite. Use a large size rock aggregate; 6 – 4 inch quarry spalls are best with little or no fines. Aggregate of this size will deform tires of vehicles thus reducing or eliminating the need for a wheel wash. If the pad is to be located in a future driveway, the existing ground can be excavated deep enough before installation so that the final rock and pavement can be applied over the top. Ensure that the turning radius of the entrance is sufficient to accommodate larger trucks.



A product which shows some promise on paved areas is the Rumble Track. The Rumble Track is a reusable matting for paved entrances that will deform the tires thus knocking of a large amount of any clinging sediment. If there is a lot of sediment being tracked, frequent cleaning of the mat will be needed.



A reusable grate could also be used for some entrances as shown below.



Shaker Rack

Wheel washes can also be installed at site exits to remove dirt and rocks from truck tires. A series of railroad rails spaced 2 to 8 inches apart can be used to shake dirt and rocks loose while the vehicle is driving through the wheel wash. Large rock (6 – 4 inches) can also serve this purpose. Water used to wash trucks must be treated to remove solids and turbidity before being discharged from the site.

The installation of a pressure washer is a relatively quick and low cost method of washing wheels and can be used on a construction entrance that uses the large aggregate. It can be added if the large aggregate in itself was insufficient to prevent tracking of sediments off site. It just takes a couple of minutes to clean the wheels.

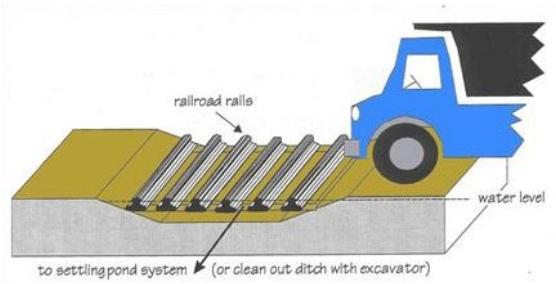




(Photo courtesy of Clean Water Services)



If water is not yet available on the site, a water truck can be used on the construction entrance (However, this should not be done on a paved street, as shown below). This will typically release larger amounts of water for short time intervals and some method for capturing this excess water and ensuring that it does not cause erosion and sediment control problems will have to be provided. Some portable wheel washers also use water from trucks (shown above).



Maintenance:

- Any material that reaches the road must be cleaned up immediately by vacuum sweeping and not washed off with water.
- Additional rock may be needed periodically to maintain a clean surface.

2.20 Road Sweeping

Description

When roads through a construction site are paved, they can quickly become coated with sediments. A common, but harmful, practice is to wash down the surface with water. The sediment laden runoff then drains to the stormwater system, polluting the receiving water. Operations involving heavy vehicle traffic also produce elevated metal levels in stormwater from vehicle brake shoes or clutches (copper) and tire particles (zinc).

Basic Design and Construction

Sweeping of paved roads, parking lots, and storage areas with a vacuum sweeper that incorporates HEPA filtration or other high efficiency method of filtration of the exhaust air from the sweeper to trap the very fine metallic particles found in road or parking lot dust can reduce these discharges to stormwater. If the filter is not fine enough and well contained, materials that the vacuum picks up will be dispersed into the air.

Information from some manufacturer's reports indicate that some sweepers will retain particles 10 microns (0.01 mm) or larger. The smaller size of the model and four-wheel steering makes it easy to maneuver in small spaces that traditional sweepers would not fit.

Ensure that good control measures are implemented when dumping the contents of the sweeper and practice proper disposal methods for the emptied contents to ensure that there is no adverse environmental impact

2.21 Catch Basin Inlet Protection

Description

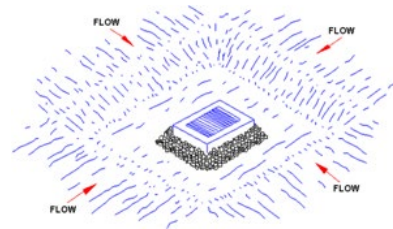
Inlet protection involves using a temporary barrier to prevent the flow of sediment and debris into a storm drain or other form of conduit. Inlet protection is used to prevent sediment from entering and clogging the storm drainage system prior to permanent stabilization of a construction area. This practice helps to keep the conveyance channel free from debris or sedimentation that could reduce the capacity of the channel.

Basic Design and Construction

There are several techniques for inlet protection. Some of the methods actually filter out larger particulates, while others may require excavation and/or the use of a dike or berm to establish a drop area. Drop areas are used to promote ponding or slowing of the runoff flow that allows sediment to settle. Some inlet protection devices are designed for use on sites that have not been paved, while others are effective when used on paved surfaces or bare soil areas. Basic design and installation procedures for some of the most commonly applied processes are described below, although other innovative techniques exist for accomplishing the same purpose.

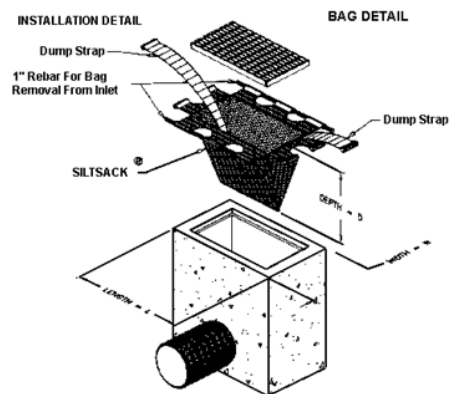
Excavated Drop Inlet Protection

This process is limited to maximum drainage areas of 1 acre. The area is excavated 1 to 2 feet deep, as shown in the diagram on the right, and wide enough to create a total storage volume of at least 35 cubic yards per acre. Construct slopes to be 2:1 or flatter. When possible, shape the basin to orient the longest dimension toward the largest inflow.



Catch Basin Insert Bag Inlet Protection

An insert bag is a woven fabric bag that has a fairly large filtering area so that it reduces, under normal circumstances, water back up and has relatively little to no maintenance depending on loading. Some manufactures use a non-woven material that has been punched with micro holes. Select bags based on filter surface area and normal rather than high flow characteristics. Initial water flow rate is generally around 40 gallons per minute. Bags are installed below the grate to minimize damage that can occur due to vehicles and machinery. Experience has shown that the material will last from between three months and one year without replacement, depending on traffic. Cleaning may be required (depending on loading), and the bag can be reused after cleaning as long as it has not deteriorated. A bag will generally capture 0.0117 inch (297 micron) particle size and above, but as it traps sediment it will become more efficient and capture finer particles. Along with the finer particle capture will be a reduction in the flow capacity, and this may eventually result in localized standing water or flooding. This type of inlet protection is highly recommended for areas where vehicle traffic occurs as it will result in significantly less maintenance compared to most other inlet protection methods



Catch Basin Insert Bag
No overflow and normal flow only

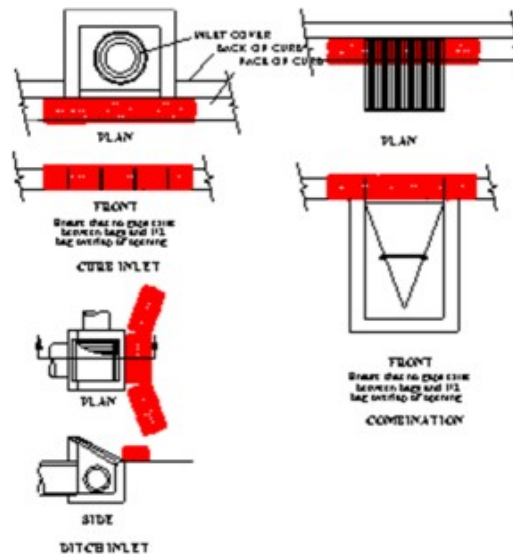
Bio-Filter Bags

Bio-filter bags (Biobags) are woven 12" by 9" by 40" nylon mesh bags containing bark and/or wood chips. There are at least two sizes of biobags. The most common size of biobag is approximately eighteen inches long. They are commonly used to remove energy from concentrated flows or for protection around some types of catch basins.

Stake biobags to keep them in place in concentrated flow areas.

Biobags can be used in a number of locations and in a variety of arrangements around the storm-drains. Position biobags so that there are no gaps between the bags that could allow runoff to reach the storm

drains unfiltered. Due to their high maintenance and potential for damage or displacement on paved areas, biobags are not recommended for paved areas. . If biobags are used in high-traffic areas, use additional measures to help prevent them from being run over (for example, flagging several feet high).



Biobags slow water sufficiently to trap sand, silt and clay in and upstream of the bag. They fit the contours of the land. They hold together well unless damaged by traffic, and can therefore be removed easily when saturated. Wildlife won't tear them apart to eat them and they will not introduce grass and weed seeds to the site.

Biobags have the least retention of any of the erosion controls but can serve a valuable purpose in retaining larger particulate sizes when properly maintained. Unfortunately, they are seldom maintained and are quite frequently damaged by traffic shortly after installation. Also, at the time of removal, very few are removed properly. If the sediment that has dropped out behind the bags is not cleaned up, then the purpose of the inlet protection is lost as the next rain event will wash this sediment into the storm drainage system.

Maintenance:

- Remove accumulated sediment from behind biobags to ensure efficient sediment removal.
- Replace biobags whenever they become plugged with sediments or damaged, such as when vehicles run over or dislodge them. With their much more open voids and their ability to retain larger particle sizes of sediment, it is very important to replace the biobag when water can no longer pass through them.

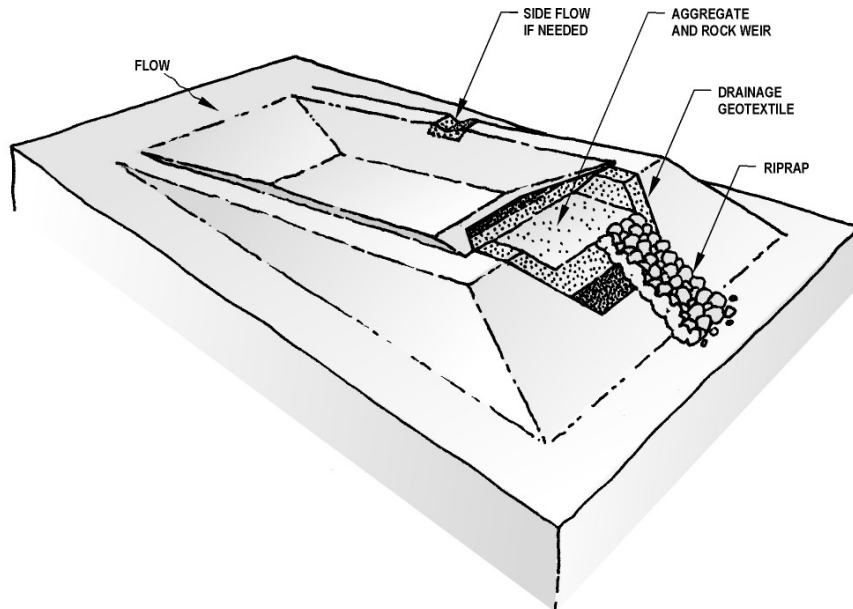
Maintenance - Essential to all Inlet Protection

The effectiveness of the inlet protection is dependent on follow-up maintenance. Inspect inlets following each storm event and daily when runoff is occurring (See 1200-C permit for detailed inspection requirements). Remove accumulated sediment and debris. Make any needed repairs immediately.

2.22 Excavated Sediment Trap

Description

A sediment trap is a small, temporary ponding area, designed to remove sediment from runoff by holding a volume of water for a length of time, allowing larger (sand-sized) particles to settle out. They are placed on the downslope side of the exposed areas in the temporary drainage channel on the site and not in the receiving stream. Periodic sediment removal is necessary to maintain the effectiveness of the trap in capturing sediment from upland sources. Sediment traps are very small pits designed to only remove the heaviest of the sediment, because the retention times are extremely short.



(Image courtesy of Clean Water Services)

Design Considerations:

- Sediment trap design is based on the amount of unstabilized area, anticipated runoff rate, the amount of heavy sediment to be removed from the runoff, and particle size (See “Settling Velocities of Sediment Particles in Water” table).
- When choosing a location for a trap, make sure that the site will be low enough to accommodate any diversion berms, dikes or pipes.
- Design the storage capacity of the basin based on the anticipated rate of sediment accumulation and frequency of maintenance. Balance the capacity of the sediment trap should with the need to conform the sediment trap to the surrounding topography.
- Ensure that excavated side slopes are stable from erosion under ponded conditions.
- Ensure that the drainage channel above and below the proposed excavation is generally stable and vegetated or lined so that additional erosion of the channel does not occur.
- Discharge runoff from the trap onto a stabilized area or to the outfall from the site.
- Ensure that the sediment trap inlet and outlet are stable. The necessary stability can be achieved with the aid of channel stabilization measures including grade control structures and channel lining.

Maintenance:

- Repair grade structures or channel lining as needed.
- Remove obstructions which may divert stream flow.
- Remove sediment when it reaches half the depth of the sediment storage area.
- Check after all significant rainfall, and daily when runoff is occurring, for effectiveness in trapping sediments and to determine if repairs are needed (See 1200-C permit for detailed inspection requirements).

2.23 Sediment Basin

Description

A sediment basin is a temporary pond built to capture eroded or disturbed soil that is washed off during rain storms. Sediment basins are usually earthen embankments, but may be constructed aboveground with straw bales, and may also be constructed of concrete movable barriers with a plastic liner to enable water retention. The outfall from a sediment basin may be a stand pipe (perforated or not) or some other floating or elevated discharge such that a wet settling area is created upstream of the outfall.

Sometimes a wet or dry water quality detention pond is temporarily modified to create a sediment basin during the construction activities of the site.

Design Considerations:

- The potential impacts of dam failure need to be considered, if this is a bermed ravine or depression.
- Once the sediment basin is constructed, ensure that equipment and vehicles can access the pond to remove accumulated sediment.
- Consider availability of suitable spoil (dredged sediment from the basin) locations on-site and feasibility of off-site spoil locations.
- Do not construct sediment basins in natural streams or waterways.

Design and Construction Specifications:

- Locate basins in low gradient reaches of the site. Elevated portions of the site can be used if the runoff is pumped into it.
- Build the basin large enough to control the expected volume of water runoff and with enough retention time to settle out the expected particulate size in the runoff.
- Keep inlet and outlets a maximum distance apart in order to obtain the maximum settling volume and retention time.
- Avoid channelizing the water flow in the basin as the resulting velocity may resuspend the soil particles.

Maintenance:

- Excavate accumulated sediment regularly based upon observed loading rate and periodic depth measurements.
- Remove obstructions which may plug outlet.

2.24 Sediment Fence

Description

Sediment fencing consists of a geotextile fabric, usually 36 inches wide, with regular spaced pockets for supporting posts. Sediment fencing causes heavy soil particles to be retained both through a filtering

operation and through the creation of a small settling basin upslope of the fence through restriction and retardation of the runoff flow velocity. The main benefit of sediment fencing is slowing the runoff, which causes the heavier particles in the runoff to settle out. The weave of the fabric determines the size of the soil particle retained by the sediment fence to a great extent. Filtering is generally in the 297 micron (0.0117 inch) and above particle size. As heavy, large-sized particles are retained, they create a buildup effect, which will retain smaller-sized particulate similar to the way an air filter becomes more effective as it retains dust. At some point the material behind a sediment fence becomes too efficient, causing the material to rise higher behind the fence and start the retention cycle all over again.



(Photo courtesy of Clean Water Services)

Design Considerations

Sediment fences are effective only in sheet flow conditions; do not install sediment fences across streams or other concentrated flows. Do not use sediment fences in gravel, as the sediment-laden runoff will likely flow under the sediment fence. Turbidity reduction generally does not occur, and data indicate that a sediment fence may in fact be detrimental in controlling turbidity. At best, a sediment fence can be used to retain the heavy, settleable solids, while other erosion controls are necessary to reduce turbidity.

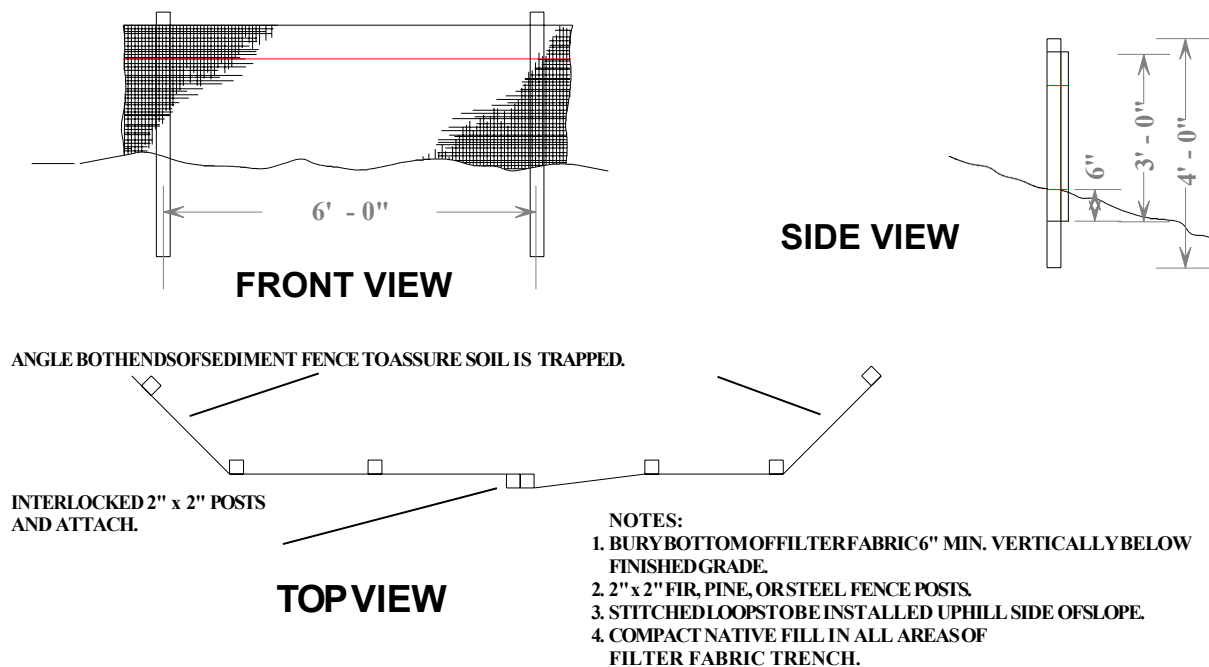
Design and Construction Specifications:

- Trench the sediment fence at least 6" into the ground. The use of a "ditch witch" or other mechanical means is helpful.
- Stretch the sediment fence stretched tightly between the posts. Do not allow the fence to sag or break away from the fence posts. Caution: Do not over stretch or the fence will be damaged.
- More than one row of sediment fences may be required.
- Sediment fence spacing on slopes should be at no greater distance than:

	Slope	Spacing
	<10%	300 ft.
	<15%	150 ft.
	<20%	100 ft.
	<30%	50 ft.
	<50%	25 ft.
Stock Pile Slope	>50%	25 ft.

Maintenance:

Remove accumulated sediment frequently, and replace fabric at least every six months when exposed to fine clay sediment runoff. A more proactive approach would be to replace the sediment fence every 30 days when exposed to clay-silt-loam runoff. Do not allow sediment to accumulate behind the sediment fence any higher than 1/3 the above-ground height.

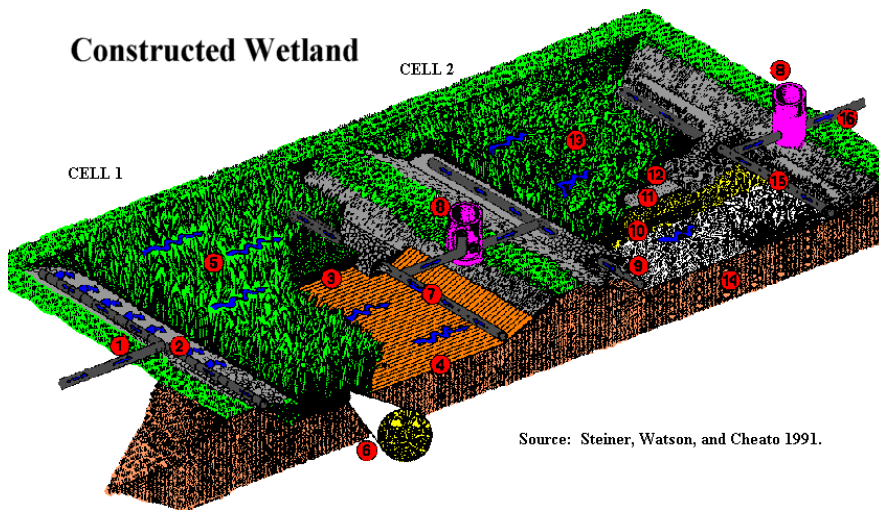


Sediment Fence

NTS

2.25 Constructed Wetlands

For further information on Wetlands see the Biofilters document at:
<http://www.deq.state.or.us/wq/stormwater/nwrinfo.htm>.



Description

Constructed wetlands are man-made, engineered wetland areas created through a combination of excavation and/or berming. The basic types of constructed wetlands are shallow marsh, 2- or 3-celled pond/marsh, extended-detention wetland, and pocket wetland. Extended-detention and pocket wetlands are less effective in removal of some types of pollution than other types of wetlands. Wetlands are particularly effective for the removal of nutrients and conventional pollutants such as oil and grease and some heavy metals.

Design Considerations:

- Constructed wetlands are suitable for larger sites, up to 100 acres where there is insufficient length to construct a settling pond with bioswale.
- Constructed wetlands cannot be used in areas with shallow depth to bedrock or unstable slopes.
- Constructed wetlands have larger land requirements for equivalent service compared to wet ponds.
- Hydrologic factors (flow) are very important in siting and designing wetlands, because constructed wetlands are complex, have a substantial amount of vegetation, and are relatively shallow with a large surface area. There must be enough flow to provide an adequate, ongoing water supply for wetland plants. However, flows must not be so high that they overwhelm wetland processes.
- Constructed wetlands need to have a shallow marsh system to deal with nutrients.
- Utilize a wetland specialist for selection of vegetation.
- There is a delayed efficiency until plants are well established (1 to 2 seasons).
- Water level fluctuations can kill plants.
- Constructed wetlands have relatively high construction costs.

- Constructed wetlands have relatively low maintenance costs.

Design and Construction Specifications:

- Design wetlands as a flow through facility, with a flat bottom to facilitate sedimentation.
- Include a method of quickly getting the concentrated inflow to full wetland width and to then collect the flow back to the concentrated outflow. This ensures that short circuiting does not occur and maximizes the retention time - qualities needed for the wetland to be effective.
- Construct the permanent pool depth between 3 to 6 feet, plus one foot of dead storage for sediment. Six feet is the maximum depth or the pond will stratify in summer and create low oxygen conditions which result in the re-release of phosphorus and other pollutants. In addition, if the pond is deeper than 6 feet wetland plant selection is more difficult.
- The best wetlands design is multi-celled, preferably three cells of equal sizes. Make the first cell 3 feet deep to trap coarse sediments and slow turbulence.
- Include an overflow system/emergency spillway to deal with a 100 year 24 hour flood, and a gravity drain.
- Pond embankments over 6 feet high should be designed by a registered engineer.
- Construct berm tops be 15 feet wide for maintenance access.
- Constructed wetlands need a buffer width of 25 to 50 feet.
- Test soils to determine suitability, particularly when located in clay loams, silty clay loams, sandy clays, silty clays and clays. This is to ensure that enough water retention occurs to maintain wetland plants.
- For mosquito control, either stock the pond with fish or allow it to be drained for short periods of time (do not kill the marsh vegetation).
- Fence off for safety and to protect plants and wildlife.



Maintenance:

Maintenance is of primary importance. The person responsible for site operations must be the responsible party for maintaining the wetland. Develop a maintenance plan that addresses removal of dead vegetation (that release nutrients) prior to the winter wet season, debris removal from trash racks, and sediment monitoring in forebays and in the basin. Because sediments are likely to contain significant amounts of heavy metals and organics, regular testing is advised.

2.26 Flocculants and Coagulants

Description

Turbidity may be caused by particulates which require an extended period of time to settle out due to their very small size, often much less than 0.001 mm in diameter. Removal of these small particles by settling alone is not practical. Polymers and inorganic chemicals speed the process of clarification.

Cationic polymers can be used as primary coagulants to reduce turbidity in stormwater. Inorganic chemicals such as aluminum or ferric sulfate and aluminum or ferric chloride can also be used. The added chemical destabilizes the suspension and causes the smaller particles to agglomerate into larger particles referred to as “floc” which settle more rapidly. The process consists of three steps: coagulation, flocculation, and settling or clarification.



Treatment systems typically require constant adjustment in order to not under or over flocculate the runoff. Under-flocculation can result in carryover of the particulate through the discharge of the treatment system and thus to the receiving waters. Over-flocculation may discharge the flocculant, with adverse effects on aquatic life, including death of organisms.

The following textbooks contain detailed presentations on this subject:

- Fair, G., J. Geyer and D. Okun, Water and Wastewater Engineering, Wiley and Sons, NY, 1968.
- American Water Works Association, Water Quality and Treatment, McGraw- Hill, NY, 1990.
- Weber, W.J, Physiochemical Processes for Water Quality Control, Wiley and Sons, NY, 1972.

FLOCCULATION SYSTEMS MUST BE DESIGNED BY
KNOWLEDGEABLE PERSONNEL. A CONSULTANT SHOULD BE
CONTRACTED TO DEVELOP AND IMPLEMENT A SYSTEM.
OPERATING PERSONNEL MUST BE SPECIFICALLY TRAINED TO
OPERATE THESE SYSTEMS.

Direct Soil Application of Flocculant

As an alternative to an extensive flocculation system, a polyacrylamide (PAM) can be applied to the bare soil surface to bind the soil particles together and minimize erosion, and promote infiltration. PAMs are long chains of polymers synthesized from natural gas. Until recently, PAM has been used most frequently on agricultural land as a soil conditioner, but its use has expanded to include construction sites and industrial water treatment. Since it is a flocculant, it may cause silt deposition when it comes in contact with sediment laden waters downstream from the site. For this reason, runoff should be collected and treated to remove the chemical before releasing it from the site.

The City of Redmond, Washington successfully tested this method on at least two construction sites of 3,000 square feet of clay soils. The PAM was applied at a rate of three pounds per acre, a level that was determined to be environmentally non-toxic, and spread dry with a hand held fertilizer spreader. The City of Redmond recommends that

periodic bioassays be performed to confirm the absence of toxicity.

Design Considerations:

It may not be possible to fully incorporate all of the design considerations at a particular location because of practical limitations at construction sites. Nonetheless it is important to recognize the following:

- Use the right polymer at the right dosage. A dosage that is either too low or too high will not produce the lowest turbidity. There is an optimum dosage rate, and more is not always better.
- Rapidly mix the coagulant into the water to ensure proper dispersion.
- A distinct flocculation step is important to increase the rate of settling, to produce the lowest turbidity and to keep the dosage rate as low as possible.
- Too little energy input into the water during the flocculation stage results in floc that is too small and/or insufficiently dense. Too much energy can rapidly destroy floc as it is formed.
- Since the volume of the basin is a determinant in the amount of energy per unit volume, a basin can be too big relative to the size of the energy input system.
- Care must be taken in the design of the withdrawal system to minimize outflow velocities.

In practice, the only way to determine whether a polymer is effective for a specific application is to perform preliminary or on-site testing. Polymer effectiveness can degrade with time and also from other influences. Thus, manufacturers' recommendations for storage must be followed.

Application of coagulants and flocculant-aids at the appropriate concentration or dosage rate for optimum turbidity removal is important for management of chemical cost, as well as for effective performance. The optimum dose in a given application depends on several site-specific features. The turbidity of untreated water is a primary determinant.

The surface charge of particles to be removed is also important. Environmental factors that can influence dosage rate are water temperature, pH, and the presence of constituents that consume or otherwise affect polymer effectiveness (for example, color, oils).

Preparation of working solutions and thorough dispersal of polymers in water to be treated is also important to establish the appropriate dosage rate. A well-managed treatment system is extremely important.

Number of treatment cells

It is far better to have two treatment cells rather than one. With two cells, if something goes wrong with the treatment of a particular batch, treatment can continue in the second cell while addressing the problem in the first cell. In addition, because it takes time to empty the cell after treatment, while one cell is being emptied, the other can be filled and treated. Finally, there is always uncertainty over the time required to achieve satisfactory clarification. If one had confidence that satisfactory settling could be achieved consistently within 30 to 60 minutes, it might be reasonable to conclude that only one cell is needed, since turnover could occur rapidly. Using two treatment cells thus helps ensure that there is always storage available for incoming flow.

Volume of treatment cells

When determining the volume per cell, there are two opposing considerations. A large cell is desirable to treat a large volume of water each time a batch is processed. However, the larger the cell the longer the time required to empty the cell. It is also possible that in

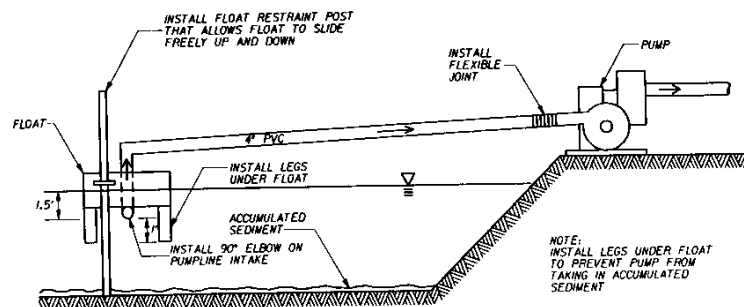
a larger the cell the flocculation process will be less effective, resulting in longer settling times. The simplest approach to sizing the treatment cell is to multiply the allowable discharge rate by the desired draw-down time. A good rule of thumb is to allow about four hours for draw-down.

A four-hour draw-down time allows one batch to be processed in each cell during an eight-hour work period. A batch can be prepared in the morning, including an hour or so of flocculation, about two hours of settling, and then discharge (although discharge could occur after hours). Or a batch can be prepared in the afternoon, followed by settling overnight, with discharge the following morning. Whatever timing is used, a logical approach is to size the cell to fit the desired draw-down time, constrained by the allowable release rate.

Flow control, inlets and outlets

Currents in the treatment cell can reduce settling efficiency. Currents can be produced by wind, by differences between the temperature of the incoming water and the water in the settling pond or tank, by differences in the temperature in the upper and lower portions of the settling containment (in low flow conditions), and by flow conditions near the inlets and outlets. Calm water such as that which occurs during batch clarification provides a good environment for effective performance, as many of these factors become less important in comparison to flow-through settling basins. The use of four rather than one inlet pipe reduces the inlet velocity. Reduced inlet velocity reduces the possibility that sediments will be picked up and discharged. Flow leaving the settling unit is an important source of currents in batch systems. Because flocs are relatively small and light, the exit velocity of the water must be as low as possible. Sediment on the bottom of the basin can be resuspended and removed by fairly modest velocities.

Design the withdrawal device used for removing the liquid from the settling pond to avoid pulling settled sediments from the bottom of the treatment cell. One approach is to place the discharge outlet near the area where treated water enters the cell. At this location there will be relatively little accumulation of solids because of the turbulence created by the incoming water. A second approach is to use the float configuration as shown in the diagram below.



FLOATING PUMPLINE INTAKE (TYP.)

A third approach is to modify the float to include a square or circular weir that the water enters before reaching the outlet pipe. Weirs reduce the exit velocity of the water leaving the clarification area of the cell. For example, a weir with 10 feet of circumference would significantly reduce the flow rates (velocity) over the weir. Another example is used in

water and wastewater clarifiers that include what is known as effluent launders. These are long troughs, placed at the outlet end the clarifier or around the outside circumference in the case of circular clarifiers, into which the water flows.

The weir may provide at least one and possibly two benefits with the treatment of stormwater. First, by reducing the carry-out of floc that is still settling while the cell is being drawn down, it could result in lower effluent turbidities and/or allow a reduction in the settling time to achieve the same effluent turbidity. Secondly, the weir could reduce if not eliminate the tendency for the withdrawal pipe to discharge previously settled sediment.

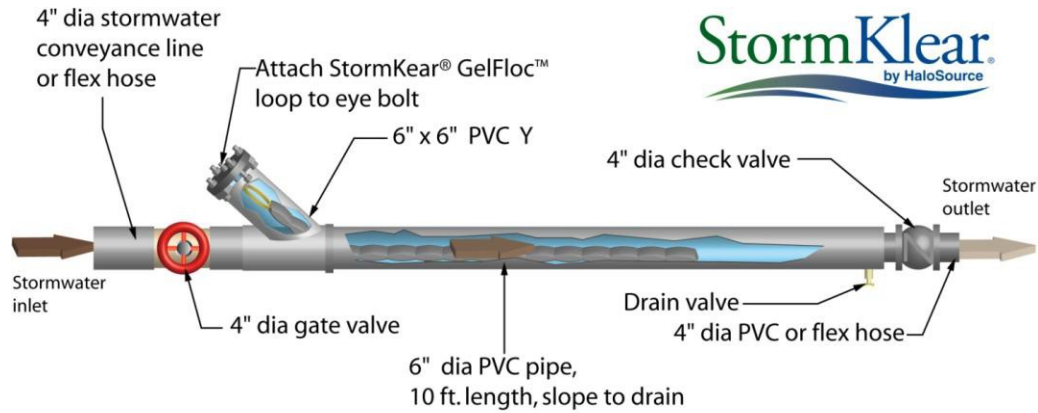
Flocculant Example

The following example illustrates treatment considerations common to most flocculant systems. There is a flocculant made from crab and shrimp shells call Chitosan¹, available as a liquid or a solid. The solid form is packaged in a multi-chambered sock for placement inside of a pipe where the stormwater runoff will flow around it, dissolving the amount of flocculant needed to settle out sediments and turbidity. Settling is readily apparent after five minutes of retention time.



Chitosan Sock (Left) and Treated high turbidity sample after five minutes (Right)

¹ Use of trade names is for illustrative purposes only and should not be construed as a DEQ endorsement of a particular product.



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The diagram below depicts a single pipe system for use of the Chitosan GelFloc® Sock before a tank. If the turbidity is very high a parallel pipe splitting half of the flow may be needed in order to provide sufficient Chitosan for the loading.



Chitosan Treatment System with Sand Filter

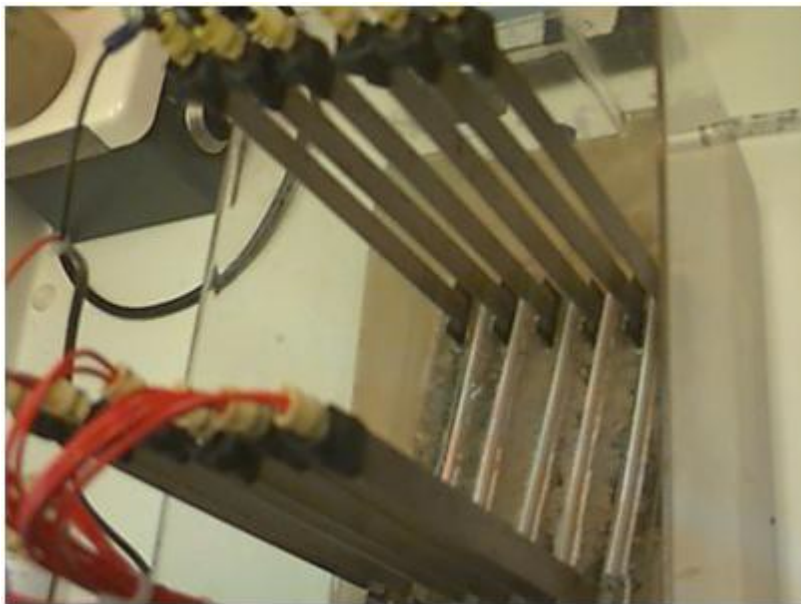
The system in the photo above adds a sand filter to remove the suspended solids when the retention time is less than the minimum to obtain full settling. The larger particles formed which have not settled out will be trapped by the sand filters.

2.27 ElectroFloc

Description

Experiments with a process tentatively called ElectroFloc indicate that it may be possible to use electricity to floc dissolved metals, TSS, and turbidity from stormwater runoff.

Charging aluminum plates with about 40 volts DC in a batch process has been shown to create an approximately equal number of positively and negatively charged particles in suspension. These dissimilarly charged particles attract each other and due to aluminum ions present remain in contact with each other in as little as five minutes per liter. This works for TSS and turbidity in the lab and should work for dissolved metals as the metals usually are not really dissolved but submicron in size. Dissolved oxygen is increased in the water due to the splitting of the water molecule into hydrogen and oxygen.



Laboratory Test Cell

Flocculated turbidity can be seen forming between the plates.

2.28 Concrete and Asphalt Production

Description

Asphalt application can contribute high levels of toxic hydrocarbons, oils and greases, and heavy metal to runoff. Concrete pouring can contribute suspended solids and heavy metals to stormwater runoff and cause pH increases in receiving waters.

Design Considerations:

- Use drip pans, ground cloths and perhaps even heavy cardboard or plywood wherever concrete, asphalt and asphalt emulsion chunks and drips are likely to fall, such as beneath extraction points from mixing equipment.
- Place storm drain covers over all nearby drains at the beginning of the workday. Catch basin inserts or other suitable protection may also be used.
- Collect all accumulations with a shovel for proper disposal at the end of the workday.

- Contain and collect the slurry from exposed aggregate washing, where the top layer of unhardened concrete is hosed or scraped off to leave a rough finish. Use a cover to protect storm drains.
- Designate a washout area on-site where cleaning of concrete trucks, troughs, and pumps can take place and where the rinse water is controlled in an infiltration sump on-site.
- If possible, cover portable asphalt mixing equipment with an awning to avoid contact with rainfall.

Maintenance:

- Sweep the pouring area, if it is paved, at the end of each day to collect loose aggregate particles. Do not hose down the area to a storm drain.
- If the concrete truck washout area (pit) is full, then either relocate it to an area that infiltrates better or remove the excess liquid and properly dispose of it.

2.29 Concrete Truck Washout and Cleanup



Description

Cleanup from the chute and other equipment from a concrete truck after emptying can cause high pH in stormwater runoff and can fill catch basins and storm sewer piping with fine particles. BMPs are needed to remove this material.

Concrete Washout Area

This approach uses an infiltration pit or collects the washout material in a tank. Select an area of the site for the washdown activities from concrete truck. Size the pit based on the infiltration rate of the soil and the anticipated usage rate (an estimated two gallons of water is needed per concrete truck chute washout), in which the residual concrete, aggregate, and water would settle and infiltrate. The area should also be on rock so that the truck does not become stuck. The washout will occur from directly behind the truck. It is a good idea to use a graveled road or parking area that may or may not become paved later. With care to prevent or minimize loss from carryover or splash-over, the use of a pit can neutralize the high pH with the low pH soil contact and virtually eliminate this particulate runoff issue.

Recycling System

A recycling system, similar to that shown the photograph on the right above, can be added to the concrete truck to catch the wash-down materials and pump them back into the truck for transport back to the concrete batch plant for recycling. Benefits of using a truck mounted recycling system include that the concrete trucks do not have to relocate from the pouring area to perform clean-up, and that the material washed off is recycled.

2.30 Above-ground Storage Tanks

Description

Tanks used on construction sites to refuel construction vehicles need to have secondary containment. The tank shown on the left is held in place by earthen berms and is a single walled tank. Notice the darker stained soil in front of the tank. Keep the hose inside of a contained area when not in use so that any residual fuel in the hose does not leak out into the soil and thus to stormwater runoff.



A containment pallet similar to the one shown on the right could provide the secondary containment needed. The amount of rainfall on the small surface area involved with the tank and pallet would not accumulate significant amounts of stormwater to be of concern. A plastic sheeting roof over the containment area can be erected to reduce even this amount of



stormwater contact.

Maintenance:

- Check containers daily for leaks and spills. Replace containers that are leaking, corroded, or otherwise deteriorating.
- Collect all spilled liquids and properly dispose of them.
- Sweep and clean the storage area monthly if it is paved; never hose down the area to a storm drain.

2.31 Container and Waste Storage

Description

This BMP refers to containers located outdoors and used to temporarily store materials, such as accumulated food wastes, paints, oils, vegetable or animal grease, solvents, and waste materials. If the construction site has container storage of materials in an outdoor location, consider using a portable building. These storage buildings have secondary containment, can be sprinklered, and can be heated or cooled to control the temperature of the materials. The doors typically can be locked for secure storage. The fuel tank from the previous BMP could be placed in one of these buildings.

Design Considerations

Segregate and securely store incompatible or reactive materials in separate containment areas in order to prevent the mixing of chemicals should spills occur.

Maintenance

Sweep the area regularly, if paved, to collect dirt and debris; never use water to hose down the area into a storm drain.

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Electrocoagulation, Universal Systems, Inc., 541-523-0220, info@universalsystemsinc.net, <http://www.universalsystemsinc.net/electrocoagulation.html>

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