

Erosion Prevention and Sediment Control

General

Erosion is a natural process that can be greatly accelerated by human activities, especially those that change or remove vegetation or that disturb the soil. In addition to human activities, fire and animal activities can also accelerate erosion. Soil is composed of mineral and organic matter and takes thousands of years to develop. The U. S. is losing topsoil seventeen times faster than it develops¹. All construction activities have the potential to cause soil erosion. Therefore, erosion prevention and sediment control are components of any project that disturbs vegetation or soil horizons. Erosion prevention will reduce both the need for costly sediment controls and the risk of environmental damage.

Federal, state, and local water quality regulations prohibit the discharge of turbid water from construction activities into adjacent water bodies and require WSDOT to use approved Best Management Practices (BMPs). The water quality and stormwater BMPs can be found in the *Highway Runoff Manual* and the *Standard Specifications for Road, Bridge and Municipal Construction 2002*.

All highway construction projects and any activities involving earthwork require a Temporary Erosion and Sediment Control (TESC) Plan and may require a Stormwater Site Plan (SSP).

Adding any new impervious surface can require that an SSP be included in your project. Check with the regional environmental office and the *Highway Runoff Manual* for compliance with the applicable regulations. An SSP includes the permanent and temporary stormwater pollution prevention BMPs and includes the TESC Plan. When the project clears vegetation, a NPDES permit might be required. Check with the environmental office to determine area thresholds for permit requirements. The SSP will be used to satisfy the requirements of the NPDES permit. In addition, the SSP will be used to aid acquisition of HPA, Shoreline, and Army Corps of Engineer (ACOE) permits.

References

RCW 90.48.080 -- Discharge of polluting matters in waters prohibited

¹ Pimentel, David, "Environment and Economic Costs of Soil Erosion and Conservation Benefits," *Science*, 24 February 1995.

WAC 173-201A -- Water quality standards for surface waters of the state of Washington

Highway Runoff Manual M 31-16, WSDOT

Hydraulics Manual M 23-03, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction M 41-10, WSDOT and APWA.

<http://www.wsdot.wa.gov/eesc/environmental/WQTESC.htm>

Resources

The region's Erosion Control Specialist

The region's Water Quality Unit

The region's Environmental Staff

The region's Hydraulics

The region's Landscape Architect

HQ M&OP Geotechnical Engineers

HQ Environmental Affairs Office

Statewide Erosion Control Coordinator

HQ Design Office Landscape Architect

Definitions

Best Management Practices (BMPs) Physical, structural, and managerial practices that, when used singly or in combination, improve the downstream quality of stormwater and reduce the downstream quantity impacts of stormwater.

bioregion A geographic region based on topography and biological similarities such as watersheds, plant/animal ecosystems, or relative elevations.

check dam A small barrier, such as quarry spalls, sand bags, or silt fencing, that slows water velocity and allows solids to settle out behind the barrier.

wood chip berm A berm with a minimum height of 2 feet constructed to trap sediments on a construction site. Berms must be constructed on contour to distribute treatment along entire berm and prevent blowouts by accumulating water. Once vegetation has been established, berms may be raked and leveled to provide a mulch layer around woody vegetation.

detention facility An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility.

erosion The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep; also detachment and movement of soil or rock fragments by human and animal activities.

Erosion Control: Any temporary or permanent BMPs taken to prevent or reduce soil erosion, whether from wind or water.

fascine A tied bundle of plant stems or branches, laid in a trench or a terrace on the contour and staked into position. Used to slow water velocities, trap sediment and establish vegetation. Used on basically stable slopes that have a shallow, unstable surface layer.

hydraulic conveyance system Natural and man made drainage facilities that collect, contain, and provide for the flow of surface and stormwater from the highest elevations down to a receiving water body. The natural elements of the conveyance system include swales, and small drainage courses, streams, rivers, lakes, and wetlands. The man made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.²

retention The process of collecting and holding surface and stormwater runoff with no surface outflow.

retention/detention facility (R/D) A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground; or to hold surface and stormwater runoff for a short period of time and then release it to the surface and stormwater management system.

Sediment control The trapping of soil particles moved by wind or water.

settleable solids (SS) The materials which settle out of suspension within a defined period (typically one hour). It is reported on a volume basis (milliliter per liter, mL/L), but can also be reported on a weight basis (milligrams per liter, mg/L).

steppe A grass covered semi-arid plain, such as those found in Washington east of the Cascade mountain range.

Stormwater Site Plan (SSP) A plan and report that documents the BMPs that will be taken during and after project construction to provide temporary erosion and sediment control and permanent stormwater quality and quantity control. The SSP also includes the

² [Highway Runoff Manual](#), WSDOT

Hydraulics Report, Vegetation Management Plan, Downstream Analysis Report, as well as other reports. The SSP is required by the Washington State Department of Ecology (Ecology) in order to get a NPDES baseline/general permit. In addition, the SSP will be used to aid acquisition of HPA, Shoreline, and ACOE Permits.

tackifier An amendment, resistant to water, which is added to organic material such as mulch to cause it to adhere to adjacent particles and to the soil.

Temporary Erosion and Sediment Control (TESC) Plan A “living” plan that provides for the prevention, interception, and treatment of all potential turbidity and silt-laden runoff that could occur during clearing, grading, construction, and site stabilization. The TESC Plan describes stabilization and structural practices, both of which are implemented to minimize erosion and the transport of sediments.

Total Suspended Solids (TSS) The entire weight of organic and inorganic particles dispersed in a volume of water, expressed in milligrams per liter (mg/L).

turbidity The visual clarity of the water as measured in Nephelometric Turbidity Units (NTUs). The turbidity, or clarity, of surface streams is an important determinant of its condition and productivity. Turbidity in water is caused by suspended and colloidal matter, such as clay, silt, organic and inorganic matter, and microorganisms. Turbidity does not settle out of water in a reasonable time period. The turbidity of drinking water is less than 1 NTU, while the turbidity of stream water can vary from fewer than 10 NTUs to greater than a few hundred NTUs.

water bars Small logs, or concrete barriers, usually less than 15cm in diameter, placed along a trail or slope to intercept the downhill flow of precipitation and direct it to a desired location.

water quality standards The discharge of polluted waters to waters of the state is a violation of the Washington State Water Pollution Control Law ([RCW 90.48.080](#)). Ecology establishes surface water quality standards ([WAC 173-021A](#)) as required by the Environmental Protection Agency (EPA). These standards are intended to protect surface waters of the state for beneficial uses including: public health, enjoyment, and the propagation and protection of fish, shellfish, and wildlife. State water quality criteria are defined for classifications of waters and include turbidity, fecal coliforms, dissolved oxygen, temperature, and pH. All water discharged from construction sites shall meet the water quality standards for turbidity at the discharge point into the surface water resource. There is not a “dilution” or “mixing zone.”

wattle A length of straw contained in a sausage-shaped netting. These are biodegradable and are generally buried to half their depth along the contour to reduce slope length, slow water velocity, and trap sediment.

Process of Erosion (Water)

Raindrop – The impact of raindrops on bare soil displaces soil particles. Over the duration of a storm, significant volumes of sediment are made available to be transported.

Sheet – As rain accumulates a non-concentrated, uniform layer of runoff is formed. This sheet flow transports detached soil from raindrop impacts, as well as plucks off additional soil particles caused by the shear stress of the runoff.

Rill – When sheet flows converge, increased volumes and velocities of water are concentrated. Small, intermittent watercourses with steep sides, known as rills, are formed. They are usually only a few inches deep.

Gully – When rills converge and/or impervious surfaces focus runoff in a single location, a large channel, known as a gully, is formed. Volumes and velocities of water, along with shear stress are increasing dramatically.

Stream Bank - Bank erosion of existing streams/channels is caused by increased peak flows.

Process of Erosion (Wind)

As is the case with water erosion, the loss of soil by wind movement involves detachment and transportation processes. The lifting and abrasive action of the wind results in some detachment of tiny soil grains from the granules or clods of which they are a part. When the wind is laden with soil particles, however, its abrasive action is greatly increased. The impact of these rapidly moving grains dislodges other particles from soil clods and aggregates. These dislodged particles are now ready for movement.

Saltation – The most important of the mechanics of wind erosion is saltation, defined by soil particles bouncing short distances. They remain close to the ground, usually no higher than twelve inches. Depending on soil conditions, saltation may account for 50-70% of total erosion.

Surface Creep – Saltation encourages surface creep, which is the rolling and sliding along the surface of larger soil particles. Not only is surface creep initiated by saltation, it is actually prolonged by the ricocheting action of saltating particles. Surface creep may account

for 5-25% of total erosion.

Suspension – Dust particles of fine sand size or smaller are moved parallel and upward to the ground surface. Suspension can reach ten feet to many miles into the sky. Very fine particles are lifted from the surface by impact/saltation and carried high into the air, remaining suspended in air for long distances. Although it is a spectacular and visible method of transporting soil, it may account for only 15% of total erosion.

Factors Affecting Severity of Erosion

- √ Gravity
- √ Soil Type and Texture
- √ Precipitation & Climate
- √ Storm intensity, storm duration,
- √ Vegetation
- √ Surface Area
- √ Slope Length & Gradient
- √ Surface Texture

Vegetation is the single most important element in the prevention and control of erosion from wind and water.

Maintaining or reestablishing vegetation is fundamental in preventing erosion. Eroding sites require stabilization through the use of measures such as:

- √ vegetation
- √ check dams to slow water
- √ impervious soil tackifiers
- √ soil particle binders to bind soil particles together
- √ erosion prevention blankets to reduce the force of water splash on soils
- √ In more extreme cases, walls to decrease slope angle or barriers to block wind may be needed.

Site Analysis

An assessment of the factors affecting erodibility, whether before, during, or after construction, can provide critical information about erosion potential. Erosion and sediment control efforts are most effective when addressed during the planning or design phase.

Address the following elements in a comprehensive appraisal of the site:

- Topography.
- Water source, direction of flow, and local depressions.
- Prevailing wind direction.
- Average and extreme rainfall patterns.
- Vegetation present on site and at an appropriate reference site.
- Sensitive areas such as adjacent wetlands or streams.
- General soil type(s).
- Angle and length of slope.
- Type of erosion feature, when present: rills, gullies, bank undercutting, alluvial fans, etc..
- Pre-development stormwater runoff flow.
- Adjacent land use and associated impervious surfaces and runoff.

Erosion Prevention & Control BMPs

Erosion control BMPs are used to prevent and/or minimize soil loss. Erosion control is more effective at preventing turbid runoff than sediment control. Project sites require erosion control when vegetation is removed, when the soil is disturbed, or when water flow has the potential to cause erosion. All erosion control BMPs require regular maintenance.

Principles for vegetative erosion control include, but are not limited to:

- Minimize the disturbance to desirable vegetation (The less disturbed, the less to stabilize).
- Limit or eliminate the following activities in the area:
 - Soil compaction.
 - Mechanical damage to roots and above-ground vegetation.
 - Alterations to desired hydrological patterns.
 - Deposition or addition of chemicals detrimental to plants or soil environment.
 - Clearing. (If grubbing is not necessary, cut off tops and leave roots.)

The following table gives an overview of recommended erosion prevention & control practices.

Recommended Erosion Prevention & Control Practices
• Design the Temporary Erosion Control Plan (TESC) for the project.
• Avoid extensive grading and earthwork in erosion prone areas.
• Preserve desirable vegetation whenever reasonable.
• Consider clearing the site in small increments whenever vegetation must be removed. Limit the duration of exposure to erosional processes.
• Install erosion prevention BMPs prior to any grading activity.
• Install hydraulic conveyance system to handle increased runoff.
• Keep runoff velocities low.
• Divert runoff from steep slopes and bare areas by constructing interceptor drains and berms.
• Divert “clean” water away from disturbed areas.
• Protect cleared areas with mulches and temporary, fast growing herbaceous covers.
• Soils that create exceptionally highly turbid runoff, such as clay and silt, should receive further protection.
• Inspect and maintain BMPs.
• Understand that erosion control plans and SSPs must be modified to fit the site conditions at any point in time.

Figure 710.1 Recommended Erosion Prevention Practices

For more detailed information refer to the [Standard Specifications for Road, Bridge, and Municipal Construction](#).

Sediment Control BMPs

Conventional sediment control BMPs are capable of removing a certain size soil particle, but in most cases it is not enough to bring the runoff in compliance with state water quality standards. Detention time and volume is critical in sediment control. Sand and gravel takes only seconds to trap, but silt and clay can take hours to weeks to settle. Providing such detention time is not always possible. Thus, preventing erosion in the first place makes sediment control more effective.

There are 13 minimum requirements in the *Highway Runoff Manual* and installing sediment control BMPs is one outlined as one of the first orders of work on a site.

Methods

Vegetation

Vegetation slows or prevents erosion by intercepting raindrop impacts, retaining soil with its roots, slowing runoff velocities, and decreasing runoff volumes by increasing infiltration and transpiring water to the atmosphere.

Erosion prevention & control BMPs are most likely to succeed when planned as part of the construction process. In much of the roadside environment there is no topsoil after construction. Mulches, water, lime, and/or fertilizers might be required in order to establish vegetation. Use a soil analysis to establish these additional requirements. A Horticulturist can interpret the soil analysis.

If outside the optimum planting seasons, a method of soil cover, other than vegetation, may be necessary. These include mulches and erosion control fabrics.

Seeding

Establish grass to stabilize soils whenever possible, especially before winter rains (temporary irrigation may be necessary - see the region's Landscape Architect for assistance). See the region's Landscape Architect or region's Environmental Office for site-specific seed mixes. Seed within the following time frames:

- In Western Washington: March 1 to May 15 and August 15 to October 1.
- In Eastern Washington: October 1 to November 15.

Long Term Erosion Control

Native trees, shrubs, and groundcovers or emergent plants (as appropriate) are used to revegetate disturbed areas as a BMP for long-term erosion control and sediment control. To restore disturbed areas to continuous vegetative cover, consider the following points in conjunction with the *Highway Runoff Manual* Best Management Practices (BMPs):

- Maintain continuous vegetative cover. This might not be possible in the steppe ecosystem, but maximum cover is desirable.

- Leave the soil surface rough and loose after soil preparation and final grading, with ridges and furrows perpendicular to the slope (on contour). This will slow the water's velocity, increase water detention and infiltration, decrease runoff, and promote vegetative growth. (This differs from soil treatment prior to installing a grass lawn.)
- Facilitate bonding of the topsoil with the subsoil. Consider ripping the subsoil prior to placing topsoil. Rough-grade, stair-step, or groove slopes along the contours.

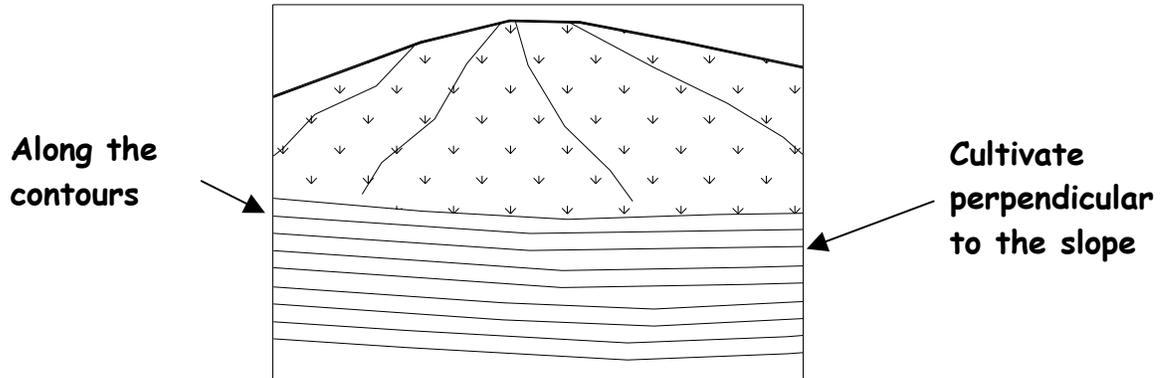


Figure 710.2 Groove Slopes Along Contours

- When applying compost or topsoil, incorporate it several inches deeper than the topsoil layer. This is needed to minimize the formation of a slip plane, eliminates a perched water table, and provides roots a zone of penetration into the existing subsoil. The final surface of the topsoil will be rough in both cases.

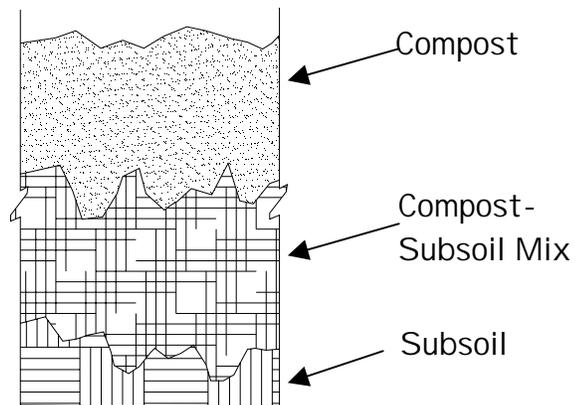


Figure 710.3 Soil Profile After Tilling to Mix Soil Layers

Topsoil can be added on slopes of 2H:1V or flatter. In some sites, it is better to amend existing soil than to add topsoil. Check with the

region's Landscape Architecture Office for soil sampling and additional soil amendment information.

Mulches

Mulches can be used on the surface for temporary erosion prevention and control and incorporated into the soil to improve the soil environment for establishing vegetation. Organic mulches such as straw, wood fiber, chips, Compost Type 2, and bark are most effective for these purposes.

Both organic and synthetic tackifiers are available and can be added to bind the mulch, seed, and fertilizer to the disturbed soil surface until vegetation is established. These tackifiers can reduce the displacement of soil particles, seeds, and mulch caused by wind or rainfall.

Silt Fence

- Silt fencing is a temporary sediment control measure and must be installed per *Standard Specification* 8-01.3(9)A. There are numerous types of silt fencing available. Check with the region's Environmental Office or the Statewide Erosion Control Coordinator for more information.
- Stronger, more positive controls are desirable for erosion control on projects that will overwinter, or where the BMPs may need to operate with little more than occasional inspection.
- Consider design elements in the project's earthwork and drainage that will allow good construction staging for erosion control methods and use silt fence only as a very short term (90 days) solution to erosion control.
- Flair ends to allow ponding of water and sediment. Be sure to check with the local jurisdictional agencies for specific local requirements for silt fence installation.
- Maintenance is crucial for proper silt fence performance. Redistribute the accumulated sediment in an appropriate location as directed by the Construction Inspector or the Environmental Coordinator.

Rolled Erosion Control Products(RECPs)

RECPs, also known as blankets and mats, are available in various materials and strengths depending upon the desired function. They can be used to cover soil during establishment of vegetation. Some may be left in place, if biodegradable, and will degrade over time when exposed to light. Contact the region's Environmental Office,

Hydraulics, the Statewide Erosion Control Coordinator, or the HQ Design Office Landscape Architect for aid in calculating the strength and type of material needed for each site.

RECPs must be installed properly to function well. An anchor trench is typically used and the fabric must be pinned and staked firmly in an overlapped position so that water does not lift the material from below.

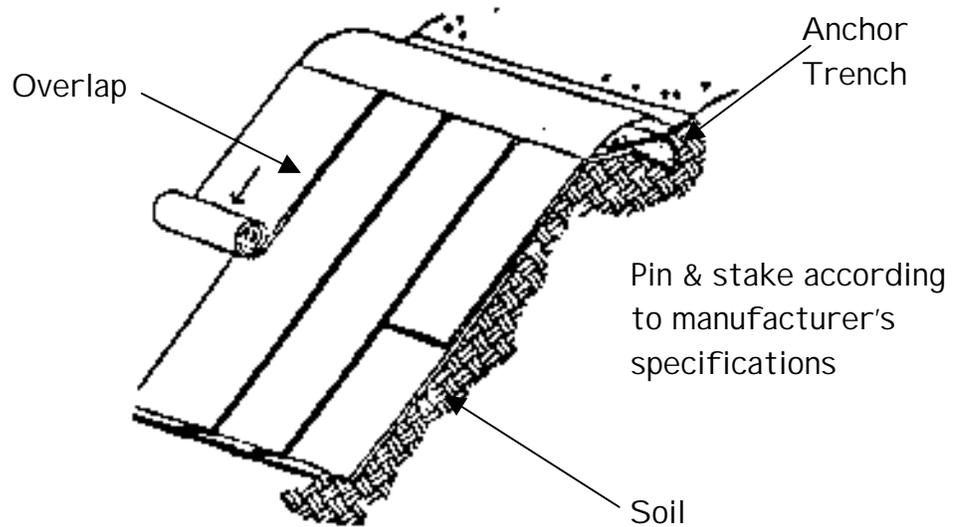


Figure 710.4 Typical RECP installation

The following table lists types of erosion control fabrics. See manufacturers for details.

ROLLED EROSION CONTROL PRODUCTS		
<i>PRODUCT</i>	<i>ADVANTAGES</i>	<i>DISADVANTAGES</i>
Netting Not recommended		<ul style="list-style-type: none"> • Temporary (<1 yr.) and used with dry mulch • More costly than tackifier • Netting might interfere with maintenance if improperly anchored • Wildlife, such as birds, reptiles, and amphibians, might get tangled in the netting
Open Weave Mats	<ul style="list-style-type: none"> • Low to moderate cost • Moderate sediment yields • Allows moderate vegetative density • Moderate moisture absorption 	<ul style="list-style-type: none"> • Temporary (1-2 years) • Low flows only • Incomplete ground cover (approximately 60% Open Space)
Blankets	<ul style="list-style-type: none"> • Low to moderate cost • Easy to install • Good moisture absorption • Very low sediment yield • Allows high vegetative density 	<ul style="list-style-type: none"> • Temporary (1-3 years) • Low to moderate flows • Netting might interfere with maintenance if improperly anchored.
Turf Reinforcing Mats	<ul style="list-style-type: none"> • Moderate costs • Long-term (indefinite) • Moderate to high flows • Encourages infiltration • Allows moderate to high vegetative density • Extends performance limits of vegetation • Flexible - conforms to differential settlement 	<ul style="list-style-type: none"> • Low to moderate sediment yields (unvegetated) • Requires vegetative establishment for effective long-term performance

Figure 710.5 Advantages and Disadvantages of Rolled Erosion Prevention Products by Type

Wattles, Water Bars and Fascines

Wattles, water bars and fascines can be used to intercept runoff and to direct water across a slope to a selected location. They are common bioengineering techniques. Imbed and stake wattles, water bars, and fascines into the slope. They may be used in sets or in combination with other erosion control and sediment control methods.

Straw Bales

- As check dams, they are not an approved BMP.
- Other materials, such as quarry spalls, washed gravel, sand bags, and geotextile-encased silt dikes, are approved.
- Straw bale barriers are similar to silt fence in function and are an approved BMP.

Sandbags

Sandbags can be used as a temporary interceptor to slow water velocity. Sandbags placed across access or interior construction roads provide for a means to divert or slow erosive water flows on a construction site.

Bonded Fiber Matrix

A bonded fiber matrix is a continuous layer of wood fiber strands held together by a water-resistant bonding agent. When properly applied, it eliminates direct raindrop impact on soil, allows no gaps between the product and the soil, and it has a high water-holding capacity. A bonded fiber matrix will not form an impervious crust that can inhibit plant growth, and it will biodegrade completely into materials known beneficial to plant growth.

PAM

Polyacrylamide (PAM) is an inorganic polymer flocculant, with the ability to stabilize soils and remove fine suspended sediments from stormwater runoff. It is an approved BMP for soil binding and tacking mulch. The approved standard specification is as follows:

8-01.3(2)C Soil Binding Using Polyacrylamide (PAM)

PAM shall be applied only to areas that drain to completed sedimentation control BMPs in accordance with the TESC plan. PAM shall not be applied to the same area more than once in a 48 hour period, or more than 7 times in a 30 day period.

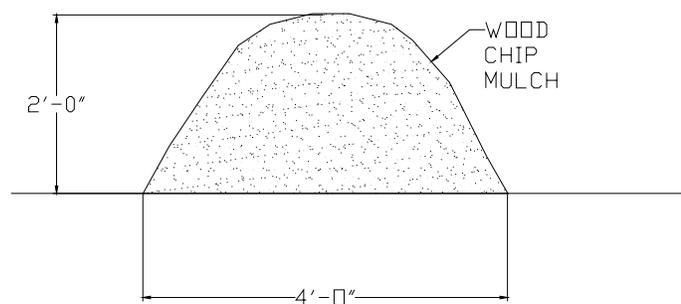
When applied with water, it shall be completely dissolved and mixed prior to application to the soil. PAM shall be applied at a rate of 0.5 pounds/1000 gallons water/1 acre. A minimum of 200 pounds of cellulose fiber mulch, treated with a non-toxic dye, shall be added and applied with the PAM.

When applied dry, the maximum rate is 5 pounds/1 acre. The PAM cannot be applied when it is raining. For small areas, a hand-held “organ grinder” fertilizer spreader, set to the smallest setting, will work. Tractor-mounted spreaders will work for larger areas.

Polyacrylamide (PAM) products shall meet ANSI/NSF Standard 60 for drinking water treatment. PAM shall be “anionic” (non-ionic) and linear (non-crosslinked). The minimum average molecular weight shall be 5 Mg/mole. See the latest [Standard Specifications for Road, Bridge and Municipal Construction](#) for full PAM specifications.

Wood Chip Berms

Wood chip berms are an approved Standard Specification for erosion control. Studies have shown they are effective in slowing and treating stormwater runoff when installed and maintained properly. In addition to their immediate benefits, these berms can be either left in place or can be redistributed around adjacent plantings once vegetation has stabilized the upslope surfaces.



WOOD CHIP BERM

NOT TO SCALE

Figure 710.6 Wood chip berm detail

