
CHAPTER

3

SEDIMENT AND EROSION CONTROL

Soil erosion and sediment controls are measures which are used to reduce the amount of soil particles that are carried off of a land area and deposited in a receiving water. Soil erosion and sediment control is not a new technology. The USDA Soil Conservation Service and a number of State and local agencies have been developing and promoting the use of erosion and sediment control devices for years.

This chapter provides a general description of some of the most commonly used measures today and a method to select the most appropriate measures for your project. The descriptions contained in this chapter are very simple and are intended to provide general understanding rather than specific design information. You are encouraged to consult your State or local guidance books for sediment and erosion control measure design standards. You are also encouraged to consult the design fact sheets contained in Appendix B of this manual.

3.1 SELECTION OF SOIL EROSION AND SEDIMENT CONTROL PRACTICES

Your selection of the best soil erosion and sediment controls for your site should be primarily based upon the nature of the construction activity and the conditions which exist at the construction site.

The soil erosion and sediment control portion of the Storm Water Pollution Prevention Plan should:

- \$ Minimize the amount of disturbed soil
- \$ Prevent runoff from offsite areas from flowing across disturbed areas
- \$ Slow down the runoff flowing across the site
- \$ Remove sediment from onsite runoff before it leaves the site
- \$ Meet or exceed local or State requirements for sediment and erosion control plans.

Your soil erosion and sediment control plan should meet each of the objectives listed above. How you meet these objectives depends primarily on the nature of the construction activity and the characteristics of the site. The following subsections are presented in a question and answer format. The questions concern certain characteristics of your construction site. Your answer to each of these questions will help you determine what sediment and erosion control practices are best suited for your construction project.

Appendix A includes an Erosion and Sediment Control Checklist. This checklist can be used in your review of the erosion and sediment control portion of your Pollution Prevention Plan to evaluate compliance with typical storm water construction permit requirements. You should also review your projects.

The major problem associated with erosion at construction sites is the movement of soil off the site and its impact on water quality. Construction site erosion is a source of sediments, toxicants, and nutrients which pollute the receiving water(s). Clearing, grading, or otherwise altering previously undisturbed land at a construction site increases the erosion rate by as much as 1,000 times the pre-construction rate. Millions of tons of sediment are generated annually by the construction industry in the United States alone, and erosion rates, typically 100 to 200 tons per acre, have been reported as high as 500 tons per acre (State of North Carolina, 1988).

Q. What is Erosion?

Erosion, by the action of water, wind, and ice, is a natural process in which soil and rock material is loosened and removed. There are two major classifications of erosion: (1) geological erosion, and (2) man-made erosion.

Geological erosion, which includes soil-forming as well as soil-removing, has contributed to the formation of soils and their distribution on the surface of the earth. Man-made erosion, which can greatly accelerate the natural erosion process, includes the breakdown of soil aggregates and the increased removal of organic and mineral particles; it is caused by clearing, grading, or otherwise altering the land. Erosion of soils that occurs at **construction sites** is **man-made erosion**.

Factors Influencing Erosion by Water

Erosion of the land surface may be caused by water, wind, ice, or other geological agents. **Water erosion**, which is the focus of this document, is the loosening and removal of soil from the land by running water, including runoff from melted snow and ice. The major factors affecting soil erosion are soil characteristics, climate, rainfall intensity and duration, vegetation or other surface cover, and topography.

Understanding the factors that effect erosion makes it possible to predict the extent and consequences of onsite erosion.

3.1.1 Minimize the Amount of Disturbed Soil

Why?

Minimizing the amount of disturbed soil on the construction site will decrease the amount of soil which erodes from the site, and it can decrease the amount of controls you have to construct to remove the sediment from the runoff.

Q. How does disturbing soil cause erosion?

Disturbing soil can remove the vegetation. Vegetation is the most effective way to control erosion. Vegetative covers reduce erosion by: (1) shielding the soil surface from the impact of falling rain and thus reducing runoff; (2) dispersing and decreasing the velocity of surface flow; (3) physically restraining soil movement; (4) increasing infiltration rates by improving the soil's structure and porosity through the incorporation of roots and plant residues; and (5) conducting transpiration, which decreases soil moisture content and increases soil moisture storage capacity. Figure 3.1 illustrates some of the ways that vegetation helps control erosion.

Nonvegetative covers such as mulches and stone aggregates similarly protect soils from erosion. Like vegetative covers, these ground covers shield the soil surface from the impact of falling rain, reduce flow velocity, and disperse flow. Each of these types of cover provides a rough surface that slows the runoff velocity and promotes infiltration and deposition of sediment. The condition as well as the type of ground cover influences the rate and volume of runoff. It should be noted that although impervious surfaces (such as parking lots) protect the covered area, they prevent infiltration and consequently increase the peak flow rate which increases the potential for erosion at the discharge area.

Q. Did you develop a site plan that does not require a significant amount of grade changes?

A construction project site should be selected and laid out so that it fits into existing land contours. When you try to significantly change the grades in an area you can increase the amount of disturbed soil which increases the amount of erosion which will occur. Significant regrading can also disturb the natural drainage of an area, and can be more costly.

Q. Are there portions of the site which will not have to be cleared for construction to proceed?

Only clear and grub the portions of the site where it is necessary for construction. When less area is disturbed for construction, there is less erosion of soil. Natural vegetation can also improve the aesthetics of the site. See page 3-24 Preservation of Natural Vegetation for further discussion on this BMP.

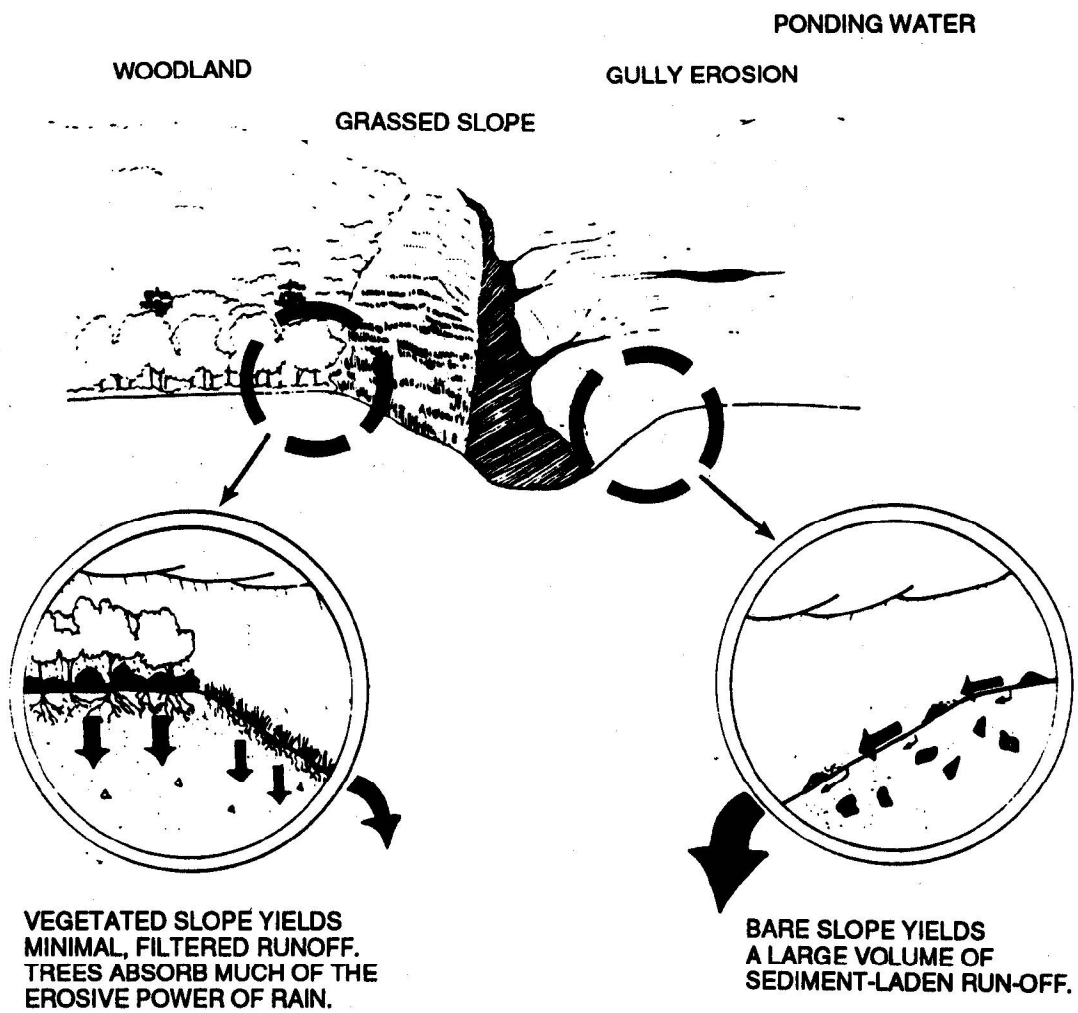


FIGURE 3.1 EROSION PREVENTION BY STABILIZATION
(From State of North Carolina, 1988)

Q. Can the construction be performed in stages, so that the entire site does not have to be cleared at one time?

If your construction project will take place over a wide spread area, consider staging the project so that only a small portion of the site will be disturbed at any one time. For example, if you were developing a 100-acre housing subdivision, rather than clear the entire 100 acres at the start of construction, only clear a 20-acre parcel, grade the area, install the utilities, pave the roads, construct the houses, landscape and seed the lawn areas, then move on to the next 20-acre parcel. Phased construction helps to lessen the risk of erosion by minimizing the amount of disturbed soil that is exposed at any one time.

Q. Are there portions of the site which will be disturbed then left alone for long periods of time?

If there are disturbed portions of the site that will not be re-disturbed for a long period (check your permit to see what the maximum time is), then these areas should be stabilized with Temporary Seeding (see page 3-14) or Mulching (see page 3-16). This will reduce the amount of erosion from these areas until they are disturbed again. For example, if soil excavated from a temporary sediment trap is stockpiled to be used later to backfill the trap (when the area is stabilized) then the stockpile should be stabilized with temporary seed.

Q. Do you stabilize all disturbed areas after construction is complete?

By permanently stabilizing the disturbed areas as soon as possible after construction is complete in those areas, you can significantly reduce the amount of sediment which should be trapped before it leaves your site. An area can be stabilized by Permanent Seeding and Planting (see page 3-20), Mulching (see page 3-16), Geotextiles (see page 3-17), and Sod Stabilization (see page 3-26).

Q. Does snow prevent you from seeding an area?

If snow cover prevents you from seeding a disturbed area or planting other types of vegetation, then you should wait until the snow melts before stabilizing the area.

Q. Is there not enough rainfall to allow vegetation to grow on your construction site.

If there is not enough rainfall on the area you have disturbed to allow vegetation to grow then you should;

- \$ Seed and irrigate the disturbed area (if allowed by your permit-see non storm-water flows) or,
- \$ Stabilize the disturbed areas by non-vegetative methods (See Mulching (page 3-16), Geotextiles (page 3-17), or Chemical Stabilization (page 3-19).

3.1.2 Prevent Runoff From Offsite Areas From Flowing Across Disturbed Areas

Why?

Diverting offsite runoff around a disturbed area reduces the amount of storm water which comes into contact with the exposed soils. If there is less runoff coming in contact with exposed soil, then there will be less erosion of the soil and less storm water which has to be treated to remove sediment.

Q. Does runoff from undisturbed uphill areas flow onto your construction site?

Overland flow can be diverted around a construction site by installing an Earth Dike (see page 3-37), an Interceptor Dike and Swale (see page 3-41), or a Drainage Swale (see page 3-39). Your choice of diversion methods depends upon the size of the uphill area and the steepness of the slope the diversion must go down. Interceptor dikes and swales are effective in diverting overland flows from smaller areas (3 acres or less) down gentle slopes (10 percent or less). A temporary swale is most effective diverting runoff from concentrated channels and an earth dike is capable of diverting both sheet and concentrated flows from larger areas down steeper slopes. (See Appendix B for specific design information regarding each of these diversion measures.) These devices should be installed from the uphill side of the site down to a point where they can discharge to an undisturbed area on the downhill side of the site.

Q. Will runoff flow down a steeply sloped, disturbed area on the site?

Steeply sloped areas are especially susceptible to erosion. If there are steep areas on your site which will be disturbed, then an Earth Dike (page 3-37) or Interceptor Dike and Swale (page 3-41) may be used to divert the runoff from the top of the slope to the inlet of a Pipe Slope Drain (page 3-48) or to a less steeply sloped area. These measures will minimize the amount of runoff flowing across the face of a slope and decrease the erosion of that slope.

Q. Is there a swale or stream which runs through your construction site?

Swales and streams which run through construction sites must be protected from erosion and sediment because they can be significantly damaged. Streams and other water bodies should be protected by Preservation of Natural Vegetation (see page 3-24) or Buffer Zones (see page 3-22). Where possible, these techniques should also be used to protect swales or intermittent streams.

Where construction requires that the stream or swale be disturbed, then the amount of area and time of disturbance should be kept at a minimum. All stream and channel crossings should be made at right angles to the stream, preferably at the most narrow portion of the channel. Once a stream or swale is disturbed, construction should proceed as quickly as possible in this area. Once completed, the stream banks should be stabilized with Stream Bank Stabilization (see page 3-28), Gabions. Swales and intermittent streams disturbed by construction should be seeded and stabilized with Geotextiles (see page 3-17) as soon as possible.

Q. Does construction traffic have to cross a drainage swale or stream?

If it is necessary to cross a swale or stream to get to all or parts of your construction site, then before you begin working on the opposite side of the stream, you should construct a Temporary Stream Crossing (see page 3-43). Stream crossings can be either permanent or temporary depending upon the need to cross the stream after construction is complete.

3.1.3 Slow Down the Runoff Traveling Across the Site

Why?

The quantity and size of the soil particles that are loosened and removed increase with the velocity of the runoff. This is because high runoff velocities reduce infiltration into the soil (and therefore also increase runoff volume) and exert greater forces on the soil particles causing them to detach. It is no surprise, therefore, that high flow velocities are associated with severe rill and gully erosion.

Q. Is your site gently sloped?

When preparing the grading plan, try to make grades as gradual as possible without modifying the existing site conditions significantly. Steeper slopes result in faster moving runoff, which results in greater erosion. Erosion can occur on even the gentlest of slopes depending on soil and climate conditions. The State/local representative of the Soil Conservation Service is a good source of area-specific considerations. (The USDA defines slopes of 2 to 9 percent as gently sloping; slopes of 9 to 15 percent are considered moderately steep; slopes of 30 to 50 percent are considered to be steep slopes; and slopes greater than 50 percent are considered very steep slopes.)

Q. Are there steeply sloped areas on your site?

Steeply sloped areas can be protected from erosion in a number of ways. Section 3.1.2 describes how flow can be diverted away from the face of the slope; however, this technique does not address runoff from the slope itself. Gradient Terraces (see page 3-70) should be used to break the slope and slow the speed of the runoff flowing down the hillside. Surface Roughening (see page 3-67) can also be used on sloped areas as a method to slow down overland flow on a steep slope.

Q. Is your site stabilized with vegetation?

In addition to holding soil in place and shielding it from the impact of rain drops, vegetative cover also increases the roughness of the surface runoff flows over. The rougher surface slows the runoff. An area can be stabilized by Permanent Seeding (see page 3-20), Mulching (see page 3-16), Geotextiles (see page 3-17), and Sod Stabilization (see page 3-26).

Q. Does runoff concentrate into drainage swales on your site?

Concentrated runoff can be more erosive than overland flow. Runoff concentrated into swales or channels can be slowed by reducing the slope and increasing the width of a channel. When site conditions prevent decreasing the slope and widening a channel, then runoff can be slowed with Check Dams (see page 3-65). Runoff can also be slowed in channels by establishing a vegetative cover. Geotextiles (see page 3-17) are often used to hold the channel soil in place while the grass is growing.

3.1.4 Remove Sediment From Onsite Runoff Before it Leaves the Site

Why?

Despite the many advances in meteorology, it is not possible to predict more than a few days in advance when it will rain. It takes several weeks to establish a grass cover which can effectively control erosion, and, even if there were advanced warning of rainfall, it is not always possible to halt construction activities in an area to allow grass to grow. Therefore, it is necessary on most construction sites to install measures which can remove sediment from runoff before it flows off of the construction site.

Q. Does your construction disturb an area 10 acres or larger that drains to a common location?

The sediment control device which is most suitable for large disturbed areas is the Sediment Basin (see page 3-60). A sediment basin should be installed at all locations where there is an upstream disturbed area of 10 acres or more. Only if a sediment basin is not attainable should other sediment controls be installed. A sediment basin may not be attainable at a location if:

- \$ Shallow bedrock prevents excavation of a basin
- \$ Topography in the common drainage location prohibits the construction of a basin of adequate storage volume
- \$ There is insufficient space available at the common drainage location to construct a basin, due to the presence of existing structures, pavement, or utilities which cannot be relocated
- \$ The only common drainage location is beyond the property line or "right of way" of the construction activity and a temporary construction easement cannot be obtained
- \$ State, local, or other Federal regulations prohibit a basin or the construction of a basin in the common drainage locations.

Q. Does your construction disturb an area less than 10 acres that drains to a common location?

Disturbed areas less than 10 acres in size have more variety in the measures which are suitable for sediment control. Several types of measures can be used for sediment control including: Sediment Basins, Sediment Trap, Silt Fence, and Gravel Filter Berms. The selection among these measures depends upon a number of criteria. The following questions should help you determine which is the most appropriate.

Q. What if a sediment basin is not attainable on a site where there are 10 or more disturbed acres which drain to a common location?

If you cannot install a sediment basin on your site, then you should install Sediment Traps (see page 3-58), Silt Fences (see page 3-52), or other equivalent sediment control measures such as Gravel Filter Berms (see page 3-54).

Q. Does runoff leave the disturbed area as overland flow?

Sediment can be removed from overland flow using filtration controls such as Silt Fences (see page 3-52) and Gravel Filter Berms (see page 3-54). These methods have limitations (which are described in Section 3.2.2) regarding the specific conditions in which they are effective.

Overland flow runoff from a disturbed area can also be directed to a Sediment Trap (see page 3-58) or a Temporary Sediment Basin (see page 3-60) using diversion devices such as an Earth Dike (see page 3-37) or an Interceptor Dike and Swale (see page 3-41).

Q. Is flow concentrated in channels as it leaves the disturbed area?

Sediment should be removed from concentrated runoff by either a Sediment Trap (see page 3-58) or a Temporary Sediment Basin (see page 3-60) depending upon the disturbed area upstream. Filtration measures are generally not effective when used in concentrated flow because flow will back-up behind the filter until it overtops it.

Q. Are structural controls located along the entire downhill perimeter of all disturbed areas?

Runoff which passes over disturbed soil should pass through sediment controls before it can be allowed to flow off of the construction site. Therefore the entire downslope and side slope borders of the disturbed area should be lined with filtration devices, such as silt fence, or with a diversion device which will carry the runoff to a sediment basin or sediment trap prior to discharging it off site.

Q. Is there a piped storm drain system with inlets in a disturbed area?

If there is a yard drain or curb inlet which receives flow from a disturbed area then a Sediment Basin, Sediment Trap, or Inlet Protection should be constructed to remove the sediment from the runoff before it flows into the inlet.

3.1.5 Meet or Exceed Local/State Requirements for Erosion and Sediment Control

Why?

Many State and local authorities also have sediment and erosion control regulations in place. It is important that these requirements still be met. The NPDES storm water permit your construction project may be required to obtain for storm water is not intended to supersede State or local requirements. It is intended to provide another means to regulate storm water.

Q. Does your State or local government require erosion and sediment control for construction projects?

Consult State or local authorities to determine what, if any, requirements there are for sediment and erosion control on construction projects. Many State and local authorities provide their own design manuals or guidance to assist in preparing a plan which meets their requirements. These State and local requirements should be incorporated into the pollution prevention plan.

If the State or local authority requires review and approval of the sediment and erosion control plan, then a reviewed and approved copy of that plan should be included in the pollution prevention plan.

Q. Does your State or local government have an erosion and sediment control requirement which is different from the requirements of your NPDES storm water permit?

Although most of the provisions of the NPDES storm water permits for construction activities are consistent with most State and local requirements, there may be differences in the specific requirements for control measures. When there is a difference in requirements, you should use the more stringent one. For example, your State may only require you to stabilize a disturbed area within 30 days of the last disturbance; however, the your permit may require you to stabilize an area 14 days after the last disturbance. Under this example, you would be required to stabilize after 14 days.

3.2 SEDIMENT AND EROSION CONTROL PRACTICES

Any site where soils are exposed to water, wind or ice can have soil erosion and sedimentation problems. Erosion is a natural process in which soil and rock material is loosened and removed. Sedimentation occurs when soil particles are suspended in surface runoff or wind and are deposited in streams and other water bodies.

Human activities can accelerate erosion by removing vegetation, compacting or disturbing the soil, changing natural drainage patterns, and by covering the ground with impermeable surfaces (pavement, concrete, buildings). When the land surface is developed or "hardened" in this manner, storm water and snowmelt can not seep into or "infiltrate" the ground. This results in larger amounts of water moving more quickly across a site which can carry more sediment and other pollutants to streams and rivers.

The following sections describe stabilization practices and structural practices for erosion and sediment control. Using the measures to control erosion and sedimentation is an important part of storm water pollution prevention. These measures are well established and have been required by a number of State and local agencies for years.

3.2.1 Stabilization Practices

Preserving existing vegetation or revegetating disturbed soil as soon as possible after construction is the most effective way to control erosion. A vegetation cover reduces erosion potential in four ways: (1) by shielding the soil surface from the direct erosive impact of raindrops; (2) by improving the soil's water storage porosity and capacity so more water can infiltrate into the ground; (3) by slowing the runoff and allowing the sediment to drop out or deposit; and (4) by physically holding the soil in place with plant roots.

Vegetative cover can be grass, trees, or shrubs. Grasses are the most common type of cover used for revegetation because they grow quickly, providing erosion protection within days. Other soil stabilization practices such as straw or mulch may be used during non-growing seasons to prevent erosion. Newly planted shrubs and trees establish root systems more slowly, so keeping existing ones is a more effective practice.

Vegetative and other site stabilization practices can be either temporary or permanent controls. Temporary controls provide a cover for exposed or disturbed areas for short periods of time or until permanent erosion controls are put in place. Permanent vegetative practices are used when activities that disturb the soil are completed or when erosion is occurring on a site that is otherwise stabilized.

EPA BASELINE GENERAL PERMIT REQUIREMENTS
Stabilization Requirements
Part IV.D.2.a.(1).
<p>Except as provided in paragraphs IV.D.2.(a).(1).(a), (b), and (c) below, stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.</p> <p>(a). Where the initiation of stabilization measures by the 14th day after construction activity temporary or permanently cease is precluded by snow cover, stabilization measures shall be initiated as soon as practicable.</p> <p>(b). Where construction activity will resume on a portion of the site within 21 days from when activities ceased, (e.g. the total time period that construction activity is temporarily ceased is less than 21 days) then stabilization measures do not have to be initiated on that portion of site by the 14th day after construction activity temporarily ceased.</p> <p>(c). In arid areas (areas with an average annual rainfall of 0-10 inches) and semi-arid areas (areas with an average annual rainfall of 10-20 inches), where the initiation of stabilization measures by the 14th day after construction activity has temporarily or permanently ceased is precluded by seasonal arid conditions, stabilization measures shall be initiated as soon as practicable.</p>

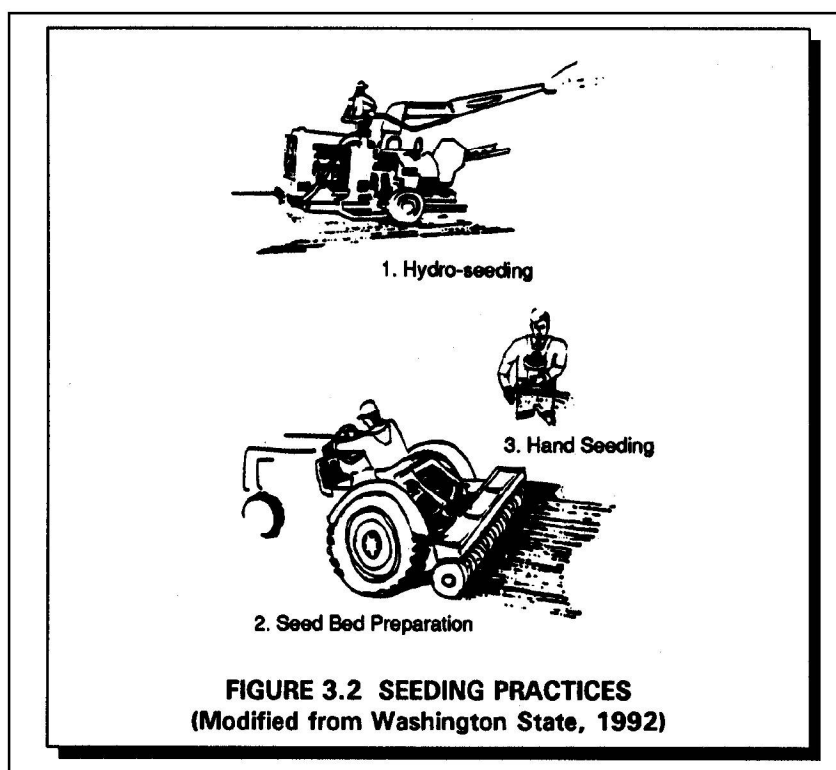
The remainder of this section describes the common vegetative practices listed below:

- \$ Temporary Seeding
- \$ Mulching
- \$ Geotextiles
- \$ Chemical Stabilization
- \$ Permanent Seeding and Planting
- \$ Buffer Zones
- \$ Preservation of Natural Vegetation
- \$ Sod Stabilization
- \$ Stream Bank Stabilization
- \$ Soil Retaining Measures
- \$ Dust Control.

Temporary Seeding

What Is It

Temporary seeding means growing a short-term vegetative cover (plants) on disturbed site areas that may be in danger of erosion. The purpose of temporary seeding is to reduce erosion and sedimentation by stabilizing disturbed areas that will not be stabilized for long periods of time or where permanent plant growth is not necessary or appropriate. This practice uses fast-growing grasses whose root systems hold down the soils so that they are less apt to be carried offsite by storm water runoff or wind. Temporary seeding also reduces the problems associated with mud and dust from bare soil surfaces during construction.



When and Where to Use It

Temporary seeding should be performed on areas which have been disturbed by construction and which are likely to be redisturbed, but not for several weeks or more. Typical areas might include denuded areas, soil stockpiles, dikes, dams, sides of sediment basins, and temporary roadbanks. Temporary seeding should take place as soon as practicable after the last land disturbing activity in an area. Check the requirements of your permit for the maximum amount of time allowed between the last disturbance of an area and temporary stabilization. Temporary seeding may not be an effective practice in arid and semi-arid regions where the climate prevents fast plant growth, particularly during the dry seasons. In those areas, mulching or chemical stabilization may be better for the short-term (see sections on Mulching, Geotextiles, and Chemical Stabilization).

What to Consider

Proper seed bed preparation and the use of high-quality seed are needed to grow plants for effective erosion control. Soil that has been compacted by heavy traffic or machinery may need to be loosened. Successful growth usually requires that the soil be tilled before the seed is applied. Topsoiling is not necessary for temporary seeding; however, it may improve the chances of establishing temporary vegetation in an area. Seed bed preparation may also require applying fertilizer and/or lime to the soil to make conditions more suitable for plant growth. Proper fertilizer, seeding mixtures, and seeding rates vary depending on the location of the site, soil types, slopes, and season. Local suppliers, State and local regulatory agencies, and the USDA Soil Conservation Service will supply information on the best seed mixes and soil conditioning methods.

Seeded areas should be covered with mulch to provide protection from the weather. Seeding on slopes of 2:1 or more, in adverse soil conditions, during excessively hot or dry weather, or where heavy rain is expected should be followed by spreading mulch (see section on Mulching). Frequent inspections are necessary to check that conditions for growth are good. If the plants do not grow quickly or thick enough to prevent erosion, the area should be reseeded as soon as possible. Seeded areas should be kept adequately moist. If normal rainfall will not be enough, mulching, matting, and controlled watering should be done. If seeded areas are watered, watering rates should be watched so that over-irrigation (which can cause erosion itself) does not occur.

Advantages of Temporary Seeding
<ul style="list-style-type: none">\$ Is generally inexpensive and easy to do\$ Establishes plant cover fast when conditions are good\$ Stabilizes soils well, is aesthetic, and can provide sedimentation controls for other site areas\$ May help reduce costs of maintenance on other erosion controls (e.g., sediment basins may need to be cleaned out less often)
Disadvantages of Temporary Seeding
<ul style="list-style-type: none">\$ Depends heavily on the season and rainfall rate for success\$ May require extensive fertilizing of plants grown on some soils, which can cause problems with local water quality\$ Requires protection from heavy use, once seeded\$ May produce vegetation that requires irrigation and maintenance

Mulching

What Is It

Mulching is a temporary soil stabilization or erosion control practice where materials such as grass, hay, woodchips, wood fibers, straw, or gravel are placed on the soil surface. In addition to stabilizing soils, mulching can reduce the speed of storm water runoff over an area. When used together with seeding or planting, mulching can aid in plant growth by holding the seeds, fertilizers, and topsoil in place, by helping to retain moisture, and by insulating against extreme temperatures.

When and Where to Use It

Mulching is often used alone in areas where temporary seeding cannot be used because of the season or climate. Mulching can provide immediate, effective, and inexpensive erosion control. On steep slopes and critical areas such as waterways, mulch matting is used with netting or anchoring to hold it in place.

Mulch seeded and planted areas where slopes are steeper than 2:1, where runoff is flowing across the area, or when seedlings need protection from bad weather.

What to Consider

Use of mulch may or may not require a binder, netting, or the tacking of mulch to the ground. Final grading is not necessary before mulching. Mulched areas should be inspected often to find where mulched material has been loosened or removed. Such areas should be reseeded (if necessary) and the mulch cover replaced immediately. Mulch binders should be applied at rates recommended by the manufacturer.

Advantages of Mulching
\$ Provides immediate protection to soils that are exposed and that are subject to heavy erosion
\$ Retains moisture, which may minimize the need for watering
\$ Requires no removal because of natural deterioration of mulching and matting

Disadvantages of Mulching
\$ May delay germination of some seeds because cover reduces the soil surface temperature
\$ Mulch can be easily blown or washed away by runoff if not secured
\$ Some mulch materials such as wood chips may absorb nutrients necessary for plant growth

Geotextiles

What Are They

Geotextiles are porous fabrics known in the construction industry as filter fabrics, road rugs, synthetic fabrics, construction fabrics, or simply fabrics. Geotextiles are manufactured by weaving or bonding fibers made from synthetic materials such as polypropylene, polyester, polyethylene, nylon, polyvinyl chloride, glass and various mixtures of these. As a synthetic construction material, geotextiles are used for a variety of purposes in the United States and foreign countries. The uses of geotextiles include separators, reinforcement, filtration and drainage, and erosion control. We will discuss the use of geotextiles in preventing erosion at construction sites in this section.

Some geotextiles are also biodegradable materials such as mulch matting and netting. Mulch mattings are materials (jute or other wood fibers) that have been formed into sheets of mulch that are more stable than normal mulch. Netting is typically made from jute, other wood fiber, plastic, paper, or cotton and can be used to hold the mulching and matting to the ground. Netting can also be used alone to stabilize soils while the plants are growing; however, it does not retain moisture or temperature well. Mulch binders (either asphalt or synthetic) are sometimes used instead of netting to hold loose mulches together.

When and Where to Use Them

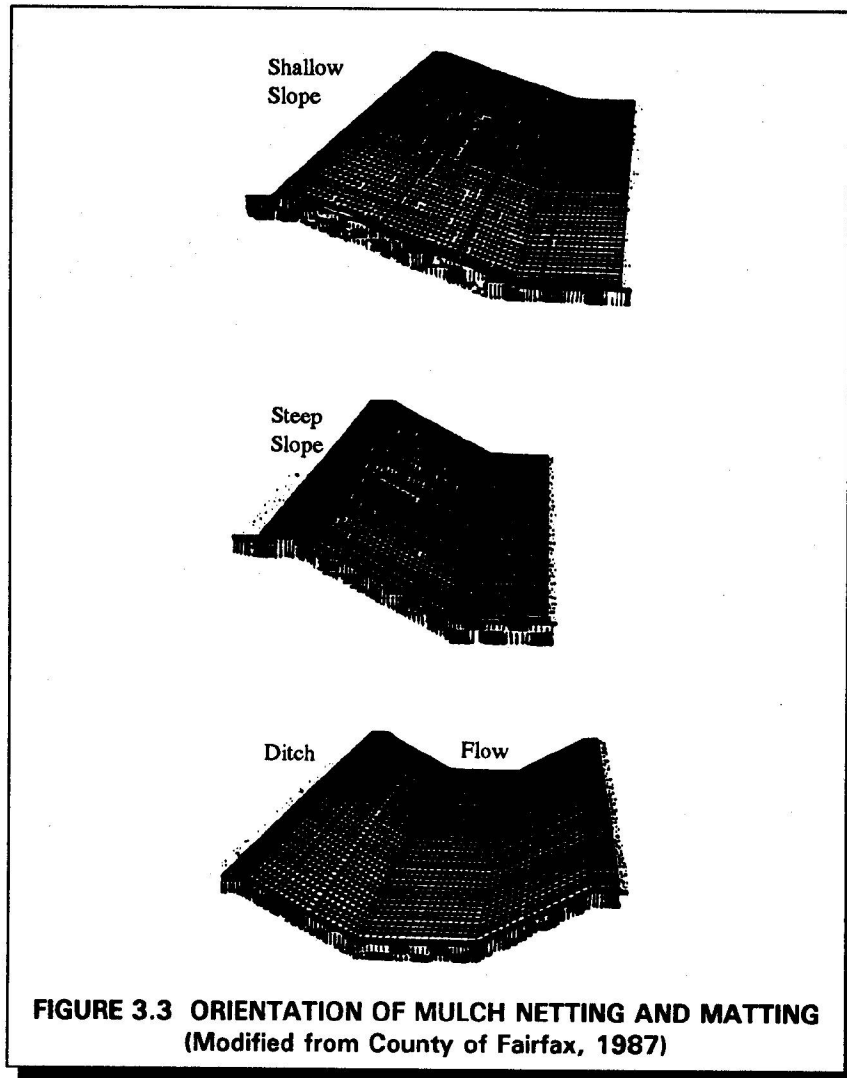
Geotextiles can be used for erosion control by using it alone. Geotextiles, when used alone, can be used as matting. Mattings are used to stabilize the flow on channels and swales. Also, matting is used on recently planted slopes to protect seedlings until they become established. Also, matting may be used on tidal or stream banks where moving water is likely to wash out new plantings.

Geotextiles are also used as separators. An example of such a use is geotextile as a separator between riprap and soil. This "sandwiching" prevents the soil from being eroded from beneath the riprap and maintaining the riprap's base.

What to Consider

As stated above, the types of geotextiles available are vast, therefore, the selected fabric should match its purpose. Also, State or local requirements, design procedures, and any other applicable requirements should also be consulted. In the field, important concerns include regular inspections to determine if cracks, tears, or breaches are present in the fabric and appropriate repairs should be made.

Effective netting and matting require firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil and erosion will occur underneath the material.



Advantages of Geotextiles	
\$	Fabrics are relatively inexpensive for certain applications
\$	Offer convenience to the installer
\$	Design methodologies for the use of geotextiles are available
\$	A wide variety of geotextiles to match specific needs are available
\$	Mulch matting and netting are biodegradable
Disadvantages of Geotextiles	
\$	If the fabric is not properly selected, designed, or installed, the effectiveness may be reduced drastically
\$	Many synthetic geotextiles are sensitive to light and must be protected prior to installation

Chemical Stabilization

What Is It

Chemical stabilization practices, often referred to as a chemical mulch, soil binder, or soil palliative, are temporary erosion control practices. Materials made of vinyl, asphalt, or rubber are sprayed onto the surface of the soil to hold the soil in place and protect against erosion from storm water runoff and wind. Many of the products used for chemical stabilization are human-made, and many different products are on the market.

When and Where to Use It

Chemical stabilization can be used as an alternative in areas where temporary seeding practices cannot be used because of the season or climate. It can provide immediate, effective, and inexpensive erosion control anywhere erosion is occurring on a site.

What to Consider

The application rates and procedures recommended by the manufacturer of a chemical stabilization product should be followed as closely as possible to prevent the products from forming ponds and from creating large areas where moisture cannot get through.

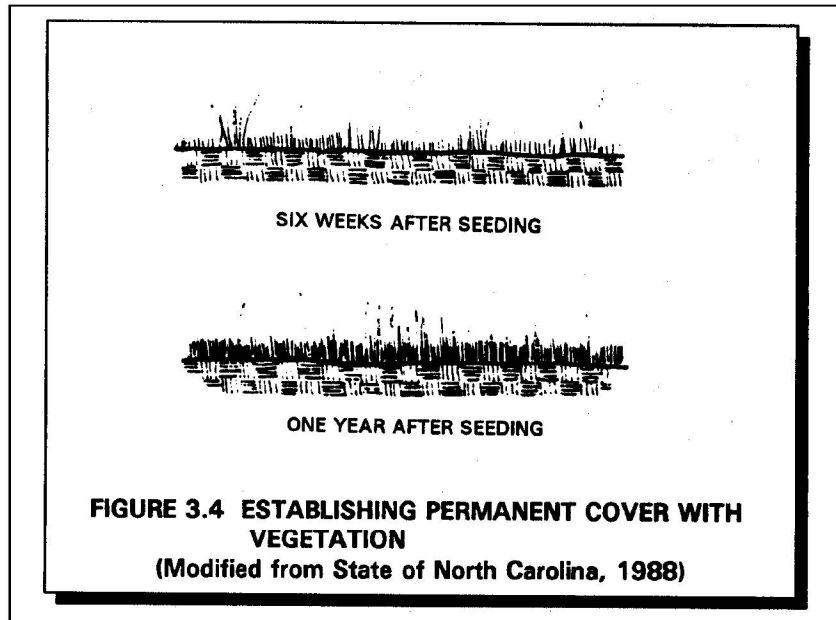
Advantages of Chemical Stabilization
\$ Is easily applied to the surface of the soil
\$ Is effective in stabilizing areas where plants will not grow
\$ Provides immediate protection to soils that are in danger of erosion

Disadvantages of Chemical Stabilization
\$ Can create impervious surfaces (where water cannot get through), which may in turn increase the amount and speed of storm water runoff
\$ May cause harmful effects on water quality if not used correctly
\$ Is usually more expensive than vegetative cover

Permanent Seeding and Planting

What Is It

Permanent seeding of grass and planting trees and brush provides stabilization to the soil by holding soil particles in place. Vegetation reduces sediments and runoff to downstream areas by slowing the velocity of runoff and permitting greater infiltration of the runoff. Vegetation also filters sediments, helps the soil absorb water, improves wildlife habitats, and enhances the aesthetics of a site.



When and Where to Use It

Permanent seeding and planting is appropriate for any graded or cleared area where long-lived plant cover is desired. Some areas where permanent seeding is especially important are filter strips, buffer areas, vegetated swales, steep slopes, and stream banks. This practice is effective on areas where soils are unstable because of their texture, structure, a high water table, high winds, or high slope.

What to Consider

For this practice to work, it is important to select appropriate vegetation, prepare a good seedbed, properly time planting, and to condition the soil. Planting local plants during their regular growing season will increase the chances for success and may lessen the need for watering. Check seeded areas frequently for proper watering and growth conditions.

When seeding in cold climates during fall or winter, cover the area with mulch to provide a protective barrier against cold weather (see Mulching). Seeding should also be mulched if the seeded area slopes 4:1 or more, if soil is sandy or clayey, or if weather is excessively hot or dry.

Plant when conditions are most favorable for growth. When possible, use low-maintenance local plant species.

Topsoil should be used on areas where topsoils have been removed, where the soils are dense or impermeable, or where mulching and fertilizers alone cannot improve soil quality. Topsoiling should be coordinated with the seeding and planting practices and should not be planned while the ground is frozen or too wet. Topsoil layers should be at least 2 inches deep (or similar to the existing topsoil depth).

To minimize erosion and sedimentation, remove as little existing topsoil as possible. All site controls should be in place before the topsoil is removed. If topsoils are brought in from another site, it is important that its texture is compatible with the subsoils onsite; for example, sandy topsoils are not compatible with clay subsoils.

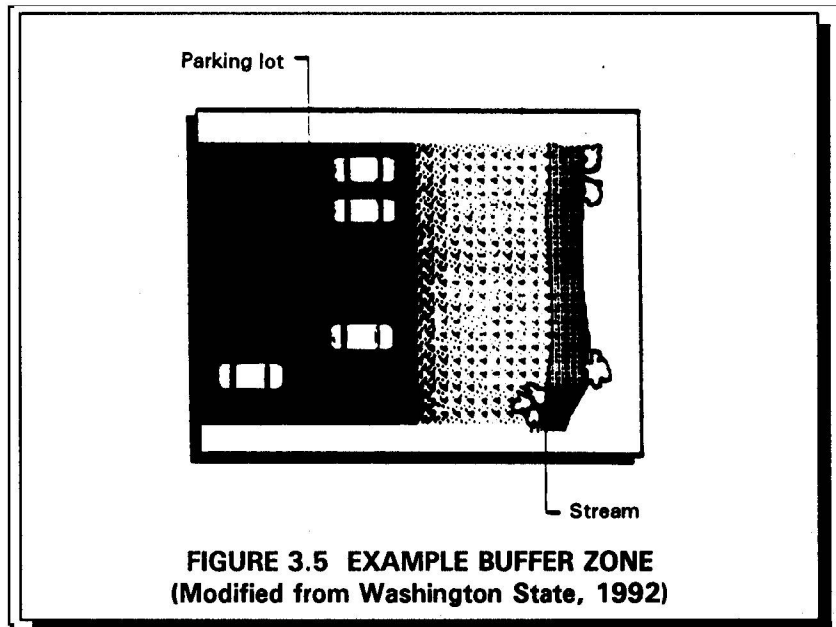
Stockpiling of topsoils onsite requires good planning so soils will not obstruct other operations. If soil is to be stockpiled, consider using temporary seeding, mulching, or silt fencing to prevent or control erosion. Inspect the stockpiles frequently for erosion. After topsoil has been spread, inspect it regularly, and reseed or replace areas that have eroded.

Advantages of Permanent Seeding and Planting
<ul style="list-style-type: none">\$ Improves the aesthetics of a site\$ Provides excellent stabilization\$ Provides filtering of sediments\$ Provides wildlife habitat\$ Is relatively inexpensive
Disadvantages of Permanent Seeding and Planting
<ul style="list-style-type: none">\$ May require irrigation to establish vegetation\$ Depends initially on climate and weather for success

Buffer Zones

What Are They

Buffer zones are vegetated strips of land used for temporary or permanent water quality benefits. Buffer zones are used to decrease the velocity of storm water runoff, which in turn helps to prevent soil erosion. Buffer zones are different from vegetated filter strips (see section on Vegetated Filter Strips) because buffer zone effectiveness is not measured by its ability to improve infiltration (allow water to go into the ground). The buffer zone can be an area of vegetation that is left undisturbed during construction, or it can be newly planted.



When and Where to Use Them

Buffer zones technique can be used at any site that can support vegetation. Buffer zones are particularly effective on floodplains, next to wetlands, along stream banks, and on steep, unstable slopes.

What to Consider

If buffer zones are preserved, existing vegetation, good planning, and site management are needed to protect against disturbances such as grade changes, excavation, damage from equipment, and other activities. Establishing new buffer strips requires the establishment of a good dense turf, trees, and shrubs (see Permanent Seeding and Planting). Careful maintenance is important to ensure healthy vegetation. The need for routine maintenance such as mowing, fertilizing, liming, irrigating, pruning, and weed and pest control will depend on the species of plants and trees involved, soil types, and climatic conditions. Maintaining planted areas may require debris removal and protection against unintended uses or traffic. Many State/local storm water program or zoning agencies have regulations which define required or allowable buffer zones especially near sensitive areas such as wetlands. Contact the appropriate State/local agencies for their requirements.

Advantages of Buffer Zones
<ul style="list-style-type: none">\$ Provide aesthetic as well as water quality benefits\$ Provide areas for infiltration, which reduces amount and speed of storm water runoff\$ Provide areas for wildlife habitat\$ Provide areas for recreation\$ Provide buffers and screens for onsite noise if trees or large bushes are used\$ Low maintenance requirements\$ Low cost when using existing vegetation
Disadvantages of Buffer Zones
<ul style="list-style-type: none">\$ May not be cost effective to use if the cost of land is high\$ Are not feasible if land is not available\$ Require plant growth before they are effective

Preservation of Natural Vegetation

What Is It

The preservation of natural vegetation (existing trees, vines, brushes, and grasses) provides natural buffer zones. By preserving stabilized areas, it minimizes erosion potential, protects water quality, and provides aesthetic benefits. This practice is used as a permanent control measure.

When and Where to Use It

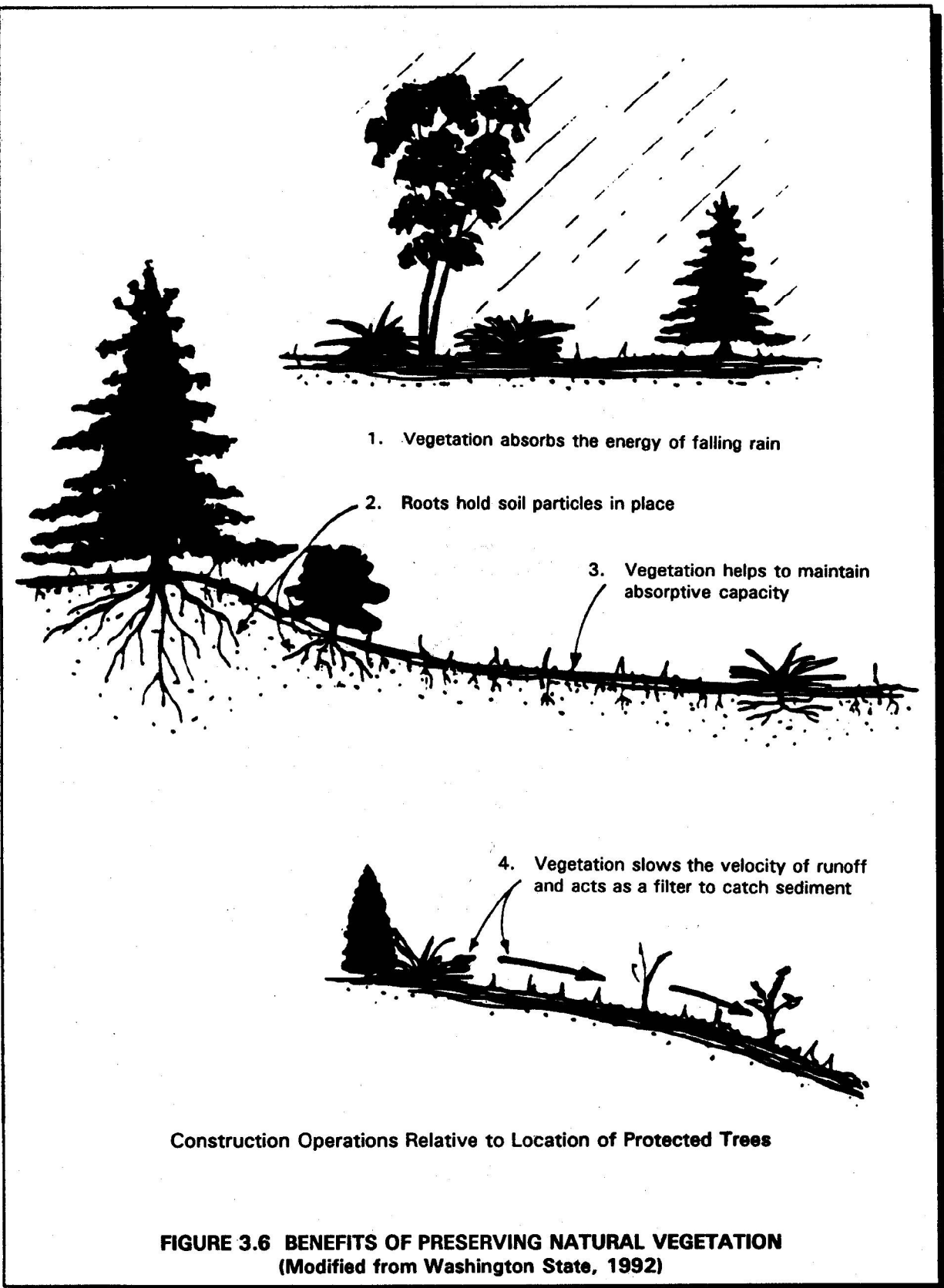
This technique is applicable to all types of sites. Areas where preserving vegetation can be particularly beneficial are floodplains, wetlands, stream banks, steep slopes, and other areas where erosion controls would be difficult to establish, install, or maintain.

What to Consider

Preservation of vegetation on a site should be planned before any site disturbance begins. Preservation requires good site management to minimize the impact of construction activities on existing vegetation. Clearly mark the trees to be preserved and protect them from ground disturbances around the base of the tree. Proper maintenance is important to ensure healthy vegetation that can control erosion. Different species, soil types, and climatic conditions will require different maintenance activities such as mowing, fertilizing, liming, irrigation, pruning, and weed and pest control. Some State/local regulations require natural vegetation to be preserved in sensitive areas; consult the appropriate State/local agencies for more information on their regulations. Maintenance should be performed regularly, especially during construction.

Advantages of Preservation of Natural Vegetation
\$ Can handle higher quantities of storm water runoff than newly seeded areas
\$ Does not require time to establish (i.e., effective immediately)
\$ Increases the filtering capacity because the vegetation and root structure are usually denser in preserved natural vegetation than in newly seeded or base areas
\$ Enhances aesthetics
\$ Provides areas for infiltration, reducing the quantity and velocity of storm water runoff
\$ Allows areas where wildlife can remain undisturbed
\$ Provides noise buffers and screens for onsite operations
\$ Usually requires less maintenance (e.g., irrigation, fertilizer) than planting new vegetation

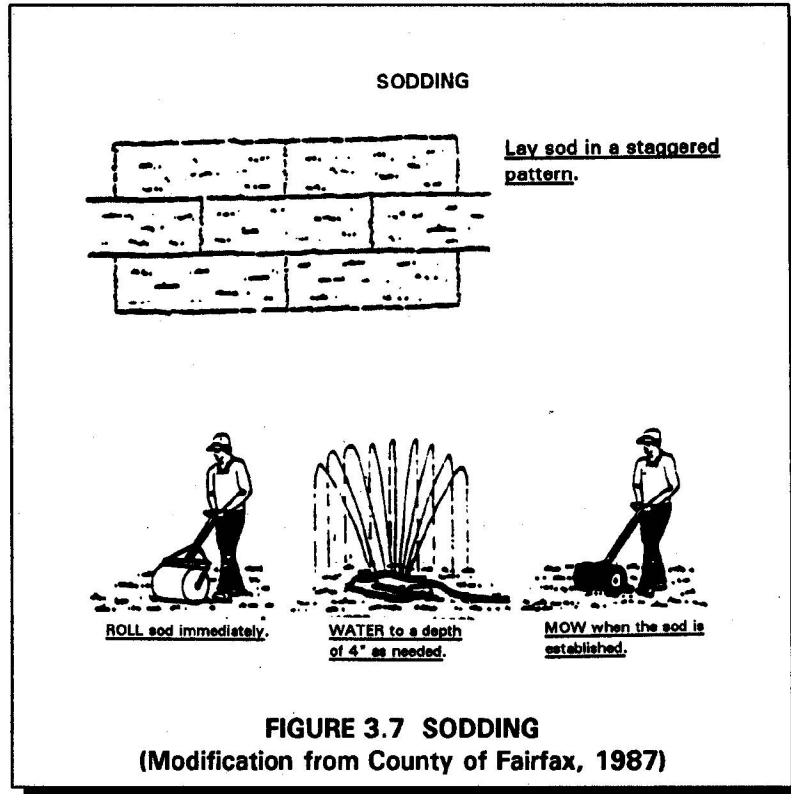
Disadvantages of Preservation of Natural Vegetation
\$ Requires planning to preserve and maintain the existing vegetation
\$ May not be cost effective with high land costs
\$ May constrict area available for construction activities



Sod Stabilization

What Is It

Sodding stabilizes an area by immediately covering the surface with vegetation and providing areas where storm water can infiltrate into the ground.



When and Where to Use It

Sodding is appropriate for any graded or cleared area that might erode and where a permanent, long-lived plant cover is needed immediately. Examples of where sodding can be used are buffer zones, stream banks, dikes, swales, slopes, outlets, level spreaders, and filter strips.

What to Consider

The soil surface should be fine-graded before laying down the sod. Topsoil may be needed in areas where the soil textures are inadequate (see topsoil discussion in section on Permanent Seeding and Planting). Lime and fertilizers should be added to the soil to promote good growth conditions. Sodding can be applied in alternating strips or other patterns, or alternate areas can be seeded to reduce expense. Sod should not be planted during very hot or wet weather. Sod should not be placed on slopes that are greater than 3:1 if they are to be mowed. If placed on steep slopes, sod should be laid with staggered joints and/or be pegged. In areas such as steep slopes or next to

running waterways, chicken wire, jute, or other netting can be placed over the sod for extra protection against lifting (see Mulching and Geotextiles). Roll or compact immediately after installation to ensure firm contact with the underlying topsoil. Inspect the sod frequently after it is first installed, especially after large storm events, until it is established as permanent cover. Remove and replace dead sod. Watering may be necessary after planting and during periods of intense heat and/or lack of rain (drought).

Advantages of Sod Stabilization
<ul style="list-style-type: none">\$ Can provide immediate vegetative cover and erosion control\$ Provides more stabilizing protection than initial seeding through dense cover formed by sod\$ Produces lower weed growth than seeded vegetation\$ Can be used for site activities within a shorter time than can seeded vegetation\$ Can be placed at any time of the year as long as moisture conditions in the soil are favorable
Disadvantages of Sod Stabilization
<ul style="list-style-type: none">\$ Purchase and installation costs are higher than for seeding\$ May require continued irrigation if the sod is placed during dry seasons or on sandy soils

Stream Bank Stabilization

What Is It

Stream bank stabilization is used to prevent stream bank erosion from high velocities and quantities of storm water runoff. Typical methods include the following:

- \$ **Riprap** Large angular stones placed along the stream bank or lake
- \$ **Gabion** Rock-filled wire cages that are used to create a new stream bank
- \$ **Reinforced Concrete** Concrete bulkheads and retaining walls that replace natural stream banks and create a nonerosive surface
- \$ **Log Cribbing** Retaining walls built of logs to anchor the soils against erosive forces. Usually built on the outside of stream bends
- \$ **Grid Pavers** Precast or poured-in-place concrete units that are placed along stream banks to stabilize the stream bank and create open spaces where vegetation can be established
- \$ **Asphalt** Asphalt paving that is placed along the natural stream bank to create a nonerosive surface.

When and Where to Use It

Stream bank stabilization is used where vegetative stabilization practices are not practical and where the stream banks are subject to heavy erosion from increased flows or disturbance during construction. Stabilization should occur before any land development in the watershed area. Stabilization can also be retrofitted when erosion of a stream bank occurs.

What to Consider

Stream bank stabilization structures should be planned and designed by a professional engineer licensed in the State where the site is located. Applicable Federal, State, and local requirements should be followed, including Clean Water Act Section 404 regulations. An important design feature of stream bank stabilization methods is the foundation of the structure; the potential for the stream to erode the sides and bottom of the channel should be considered to make sure the stabilization measure will be supported properly. Structures can be designed to protect and improve natural wildlife habitats; for example, log structures and grid pavers can be designed to keep vegetation. Only pressure-treated wood should be used in log structures. Permanent structures should be designed to handle expected flood conditions. A well-designed layer of stone can be used in many ways and in many locations to control erosion and sedimentation. Riprap protects soil from erosion and is often used on steep slopes built with fill materials that are subject to harsh weather or seepage. Riprap can also be used for flow channel liners, inlet and outlet protection at culverts, stream bank protection, and protection of shore lines subject to wave action. It is used where water is turbulent and fast flowing and where soil may erode under the design flow conditions. It is used to expose the water to air as well as to reduce water energy. Riprap and gabion (wire mesh cages filled with rock) are usually placed over a filter blanket (i.e., a gravel layer or filter cloth). Riprap is either a uniform size or graded (different sizes) and is usually applied in an even layer throughout the stream. Reinforced concrete structures may require positive

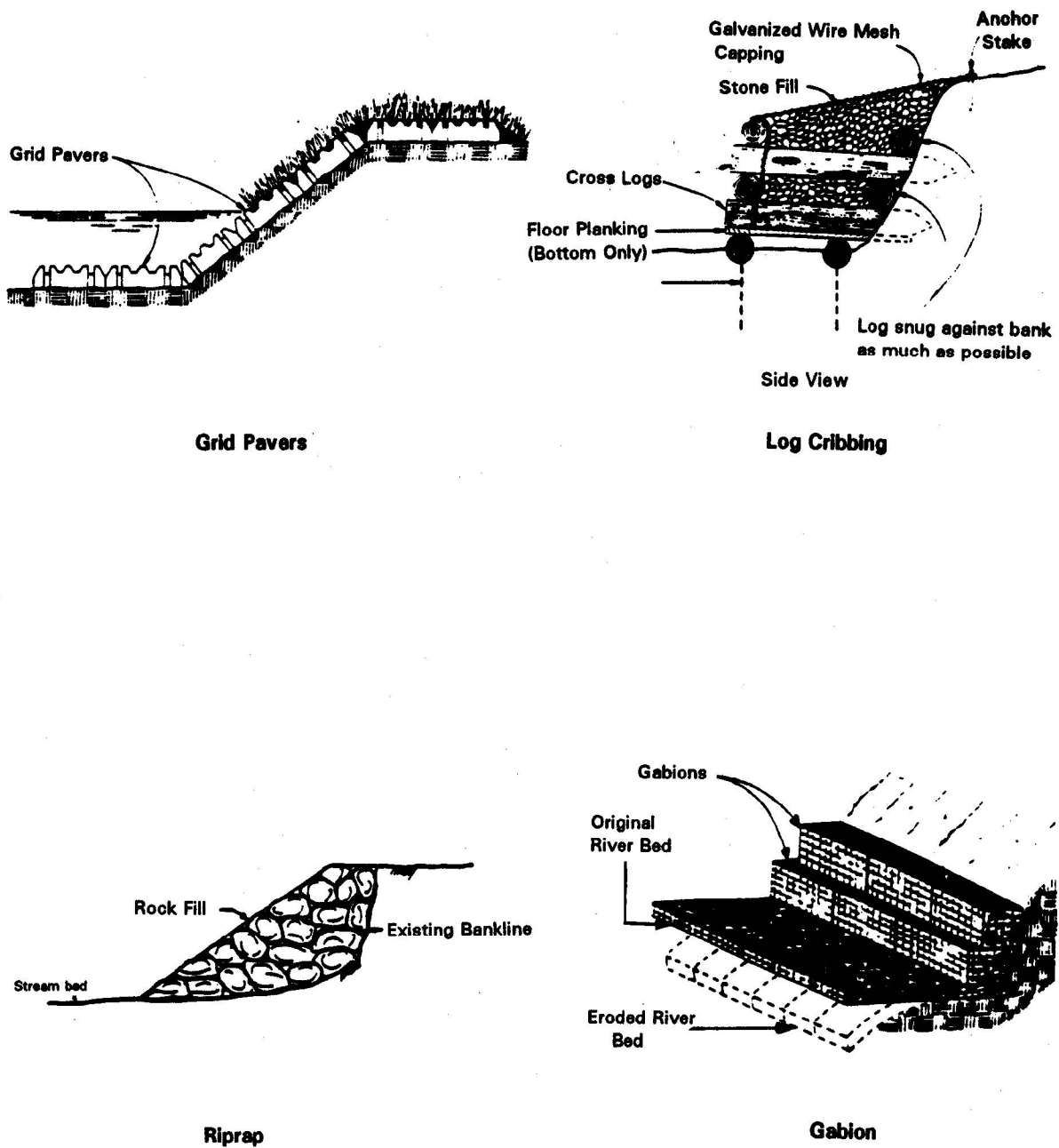


FIGURE 3.8 EXAMPLES OF STREAM BANK STABILIZATION PRACTICES
 (Modified from Commonwealth of Virginia, 1980, and Commonwealth of Pennsylvania, 1990)

drainage behind the bulkhead or retaining wall to prevent erosion around the structure. Gabion and grid pavers should be installed according to manufacturers' recommendations.

Stream bank stabilization structures should be inspected regularly and after each large storm event. Structures should be maintained as installed. Structural damage should be repaired as soon as possible to prevent further damage or erosion to the stream bank.

Advantages of Stream Bank Stabilization
<ul style="list-style-type: none">\$ Can provide control against erosive forces caused by the increase in storm water flows created during land development\$ Usually will not require as much maintenance as vegetative erosion controls\$ May provide wildlife habitats\$ Forms a dense, flexible, self-healing cover that will adapt well to uneven surfaces (riprap)
Disadvantages of Stream Bank Stabilization
<ul style="list-style-type: none">\$ Does not provide the water quality or aesthetic benefits that vegetative practices could\$ Should be designed by qualified professional engineers, which may increase project costs\$ May be expensive (materials costs)\$ May require additional permits for structure\$ May alter stream dynamics which cause changes in the channel downstream\$ May cause negative impacts to wildlife habitats

Soil Retaining Measures

What Are They

Soil retaining measures refer to structures or vegetative stabilization practices used to hold the soil firmly to its original place or to confine as much as possible within the site boundary. There are many different methods for retaining soil; some are used to control erosion while others are used to protect the safety of the workers (i.e., during excavations). Examples of soil retaining measures include reinforced soil retaining systems, wind breaks, and stream bank protection using shrubs and reeds.

Reinforced soil retaining measures refer to using structural measures to hold in place loose or unstable soil. During excavation, for example, soil tiebacks and retaining walls are used to prevent cave-ins and accidents. But these same methods can be used to retain soils and prevent them from moving. While detailed discussion of soil retaining methods is beyond the scope of this manual, several are briefly described.

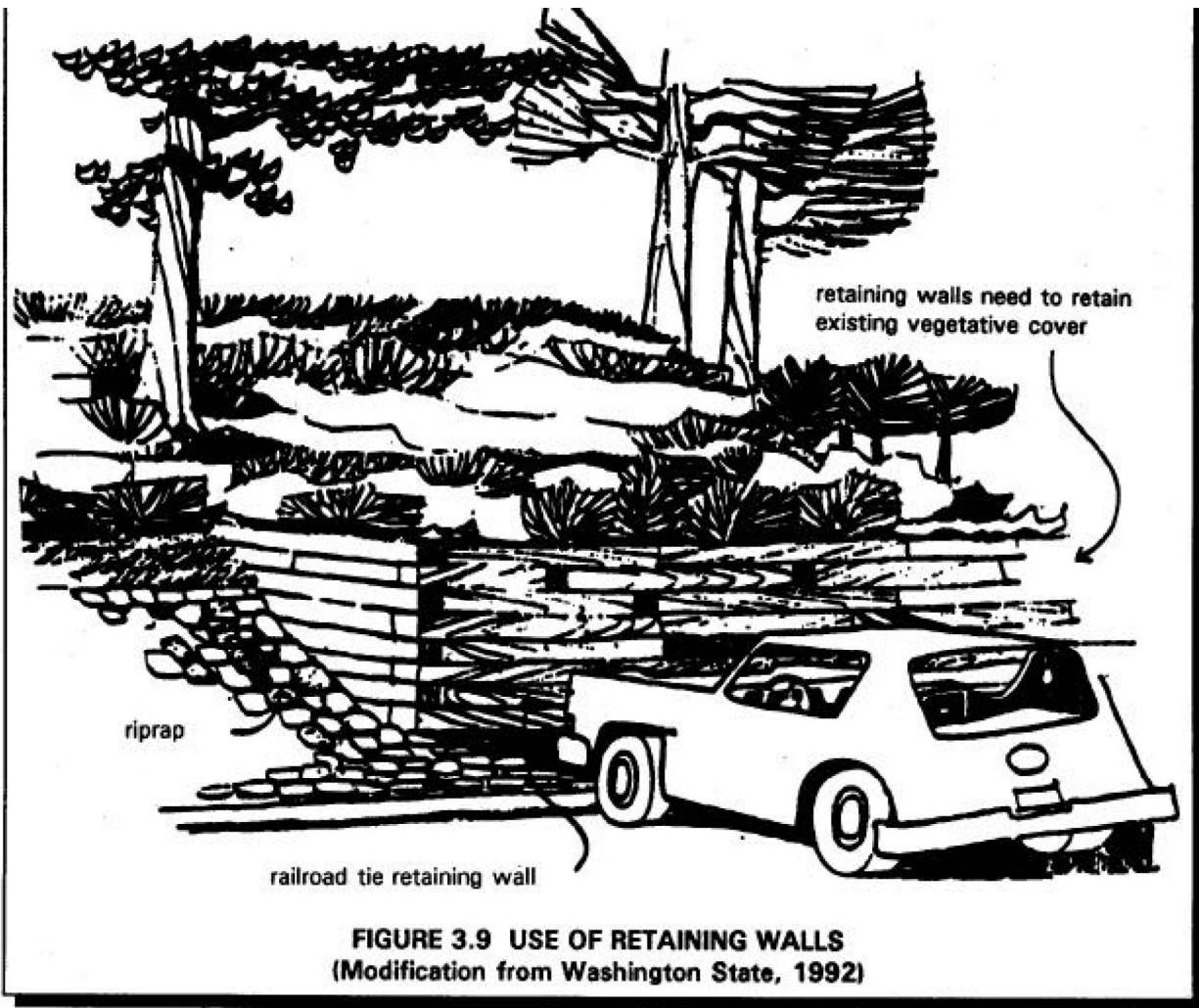
- \$ **Skeleton Sheeting**CSkeleton sheeting, the least expensive soil bracing system, requires the soil to be cohesive (i.e., like clay). Construction grade lumber is used to brace the excavated face of the slope.
- \$ **Continuous Sheeting**CContinuous sheeting involves using a material that covers the face of the slope in a continuous manner. Struts and boards are placed along the slope which provide continuous support to the slope face. The material used can be steel, concrete, or wood.
- \$ **Permanent Retaining Walls**CPermanent construction walls may be necessary to provide support to the slope well after the construction is complete. In this instance, concrete masonry or wood (railroad tie) retaining walls can be constructed and left in place.

When and Where to Use Them

Use reinforced soil retaining methods where using other methods of soil retention (e.g., vegetation) is not practical. Some sites may have slopes or soils that do not lend themselves to ordinary practices of soil retention. In these instances, a reinforced soil retaining measure should be considered.

What to Consider

As emphasized earlier, the use of reinforced soil retaining practices serve both safety and erosion control purposes. Since safety is the first concern, the design should be performed by qualified and certified engineers. Such design normally involves understanding the nature of soil, location of the ground water table, the expected loads, and other important design considerations.



Advantages of Soil Retaining Measures	
\$	Provide safety to workers, and some types of reinforced retention can be left as permanent structures
\$	Prevent erosion of soil difficult to stabilize using conventional methods
Disadvantages of Soil Retaining Measures	
\$	Require the expertise of a professional engineer and may be expensive to design and install

Dust Control

What Is It

Wind is capable of causing erosion, particularly in dry climates or during the dry season. Wind erosion can occur wherever the surface soil is loose and dry, vegetation is sparse or absent, and the wind is sufficiently strong. Wind erodes soils and transports the sediments offsite, where they may be washed into the receiving water by the next rainstorm. Therefore, various methods of dust control may need to be employed to prevent dust from being carried away from the construction site. There are many ways to accomplish this and some are described below:

- \$ **Vegetative Cover**CFor disturbed areas not subject to traffic, vegetation provides the most practical method of dust control (see Temporary Seeding and Permanent Seeding and Planting).
- \$ **Mulch (Including Gravel Mulch)**CWhen properly applied, mulch offers a fast, effective means of controlling dust (see Mulching).
- \$ **Spray-on Adhesive**CAsphalt emulsions, latex emulsions, or resin in water can be sprayed onto mineral soil to prevent their blowing away (see Chemical Stabilization).
- \$ **Calcium Chloride**CCalcium chloride may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage.
- \$ **Sprinkling**CThe site may be sprinkled until the surface is wet. Sprinkling is especially effective for dust control on haul roads and other traffic routes.
- \$ **Stone**CUsed to stabilize construction roads; can also be effective for dust control.
- \$ **Barriers**CA board fence, wind fence, sediment fence, or similar barrier can control air currents and blowing soil. All of these fences are normally constructed of wood and they prevent erosion by obstructing the wind near the ground and preventing the soil from blowing offsite.

Barriers can be part of long-term dust control strategy in arid and semiarid areas; however, they are not a substitute for permanent stabilization. A wind barrier generally protects soil downward for a distance of 10 times the height of the barrier. Perennial grass and stands of existing trees may also serve as wind barriers.

When and Where to Use It

The above measures for dust control should be used when open dry areas of soil are anticipated on the site. Clearing and grading activities create the opportunity for large amounts of dust to be blown, therefore, one or several dust control measures should be considered prior to clearing and grading. One should also note that many of the water erosion control measures indirectly prevent wind erosion.

As the distance across bare soil increases, wind erosion becomes more and more severe. In arid and semiarid regions where rainfall is insufficient to establish vegetative cover, mulching may be used to conserve moisture, prevent surface crusting, reduce runoff and erosion, and help establish vegetation. It is a critical treatment on sites with erosive slopes.

What to Consider

The direction of the prevailing winds and careful planning of clearing activities are important considerations. As a standard practice, any exposed area should be stabilized using vegetation to prevent both wind and water erosion. If your site is located in an arid or semiarid area, you may wish to contact the USDA Soil Conservation Service representative in your area or the appropriate State/local government agency for additional information.

Advantages of Dust Control
\$ Reduces movement of soil to offsite areas
Disadvantages of Dust Control
\$ Excessive sprinkling may result in non-storm water discharges from the site

3.2.2 Structural Erosion and Sediment Control Practices

Structural practices used in sediment and erosion control divert storm water flows away from exposed areas, convey runoff, prevent sediments from moving offsite, and can also reduce the erosive forces of runoff waters. The controls can either be used as permanent or temporary measures. Practices discussed include the following:

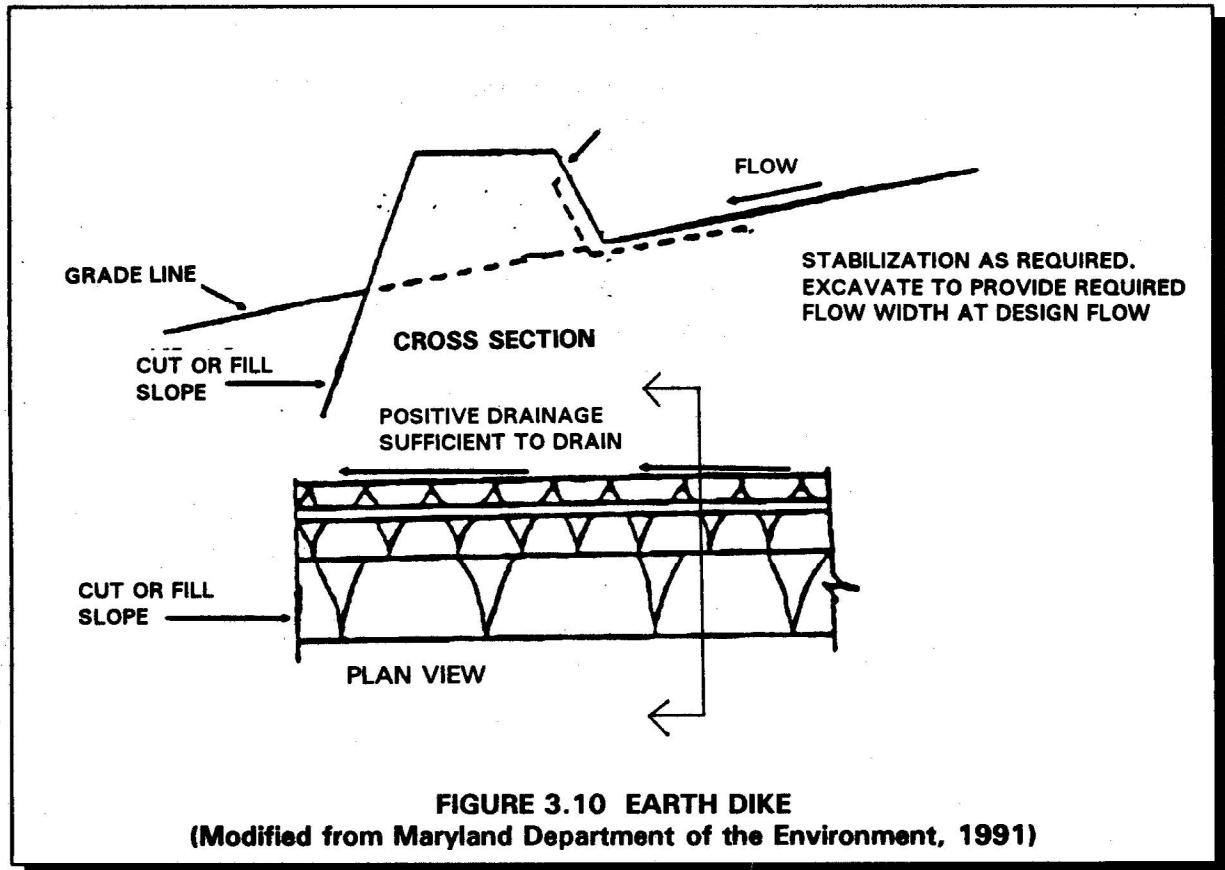
- \$ Earth Dike
- \$ Drainage Swale
- \$ Interceptor Dikes and Swales
- \$ Temporary Stream Crossing
- \$ Temporary Storm Drain Diversion
- \$ Pipe Slope Drains
- \$ Subsurface Drains
- \$ Silt Fence
- \$ Gravel or Stone Filter Berm
- \$ Storm Drain Inlet Protection
- \$ Sediment Trap
- \$ Temporary Sediment Basin
- \$ Outlet Protection
- \$ Check Dams
- \$ Surface Roughening
- \$ Gradient Terraces.

EPA BASELINE GENERAL PERMIT REQUIREMENTS	
Structural Practices	
Parts IV.D.2.a.(2).(a). and (b).	
<p>For common drainage locations that serve an area with 10 or more disturbed acres at one time, a temporary (or permanent) sediment basin providing 3,600 cubic feet of storage per acre drained, or equivalent control measures, shall be provided where attainable until final stabilization of the site. The 3,600 cubic feet of storage area per acre drained does not apply to flows from offsite areas and flows from onsite areas that are either undisturbed or have undergone final stabilization where such flows are diverted around the sediment basin. For drainage locations which serve 10 or more disturbed acres at one time and where a temporary sediment basin providing 3,600 cubic feet of storage per acre drained, or equivalent controls is not attainable, sediment traps should be used. At a minimum, silt fences or equivalent sediment controls are required for all sideslope and downslope boundaries of the construction area.</p> <p>For drainage locations serving less than 10 acres, sediment traps, silt fences or equivalent sediment controls are required for all sideslope and downslope boundaries of the construction area unless a sediment basin providing storage for 3,600 cubic feet of storage per acre drained is provided.</p>	

Earth Dike

What Is It

An earth dike is a ridge or ridge and channel combination used to protect work areas from upslope runoff and to divert sediment-laden water to appropriate traps or stable outlets. The dike consists of compacted soil and stone, riprap, or vegetation to stabilize the channel.



When and Where to Use It

Earth dikes are used in construction areas to control erosion, sedimentation, or flood damage. Earth dikes can be used in the following situations:

- \$ Above disturbed existing slopes and above cut or fill slopes to prevent runoff over the slope
- \$ Across unprotected slopes, as slope breaks, to reduce slope length
- \$ Below slopes to divert excess runoff to stabilized outlets
- \$ To divert sediment laden water to sediment traps
- \$ At or near the perimeter of the construction area to keep sediment from leaving the site

-
- \$ Above disturbed areas before stabilization to prevent erosion and maintain acceptable working conditions
 - \$ Temporary diversions may also serve as sediment traps when the site has been overexcavated on a flat grade or in conjunction with a sediment fence.

What to Consider

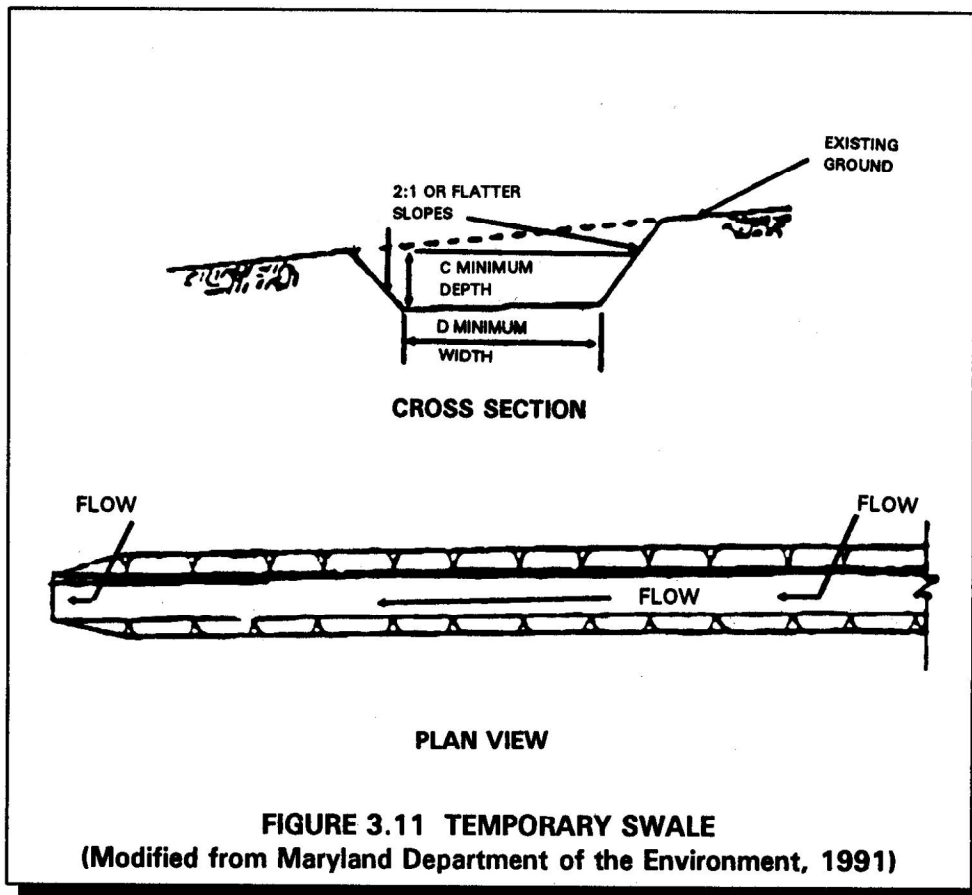
Despite an earth dike's simplicity, improper design can limit its effectiveness; therefore, the State or local requirements should be consulted. Some general considerations include proper compaction of the earth dike, appropriate location to divert the intercepted runoff, and properly designed ridge height and thicknesses. Earth dikes should be constructed along a positive grade. There should be no dips or low points in an earth dike where the storm water will collect (other than the discharge point). Also, the intercepted runoff from disturbed areas should be diverted to a sediment-trapping device. Runoff from undisturbed areas can be channeled to an existing swale or to a level spreader. Stabilization for the dike and flow channel of the drainage swale should be accomplished as soon as possible. Stabilization materials can include vegetation or stone/riprap.

Advantages of an Earth Dike
\$ Can be constructed from materials and equipment which are typically already present on a construction site
Disadvantages of an Earth Dike
\$ Frequent inspection and maintenance required

Drainage Swale

What Is It

A drainage swale is a channel with a lining of vegetation, riprap, asphalt, concrete, or other material. It is constructed by excavating a channel and applying the appropriate stabilization.



When and Where to Use It

A drainage swale applies when runoff is to be conveyed without causing erosion. Drainage swales can be used to convey runoff from the bottom or top of a slope. Drainage swales accomplish this by intercepting and diverting the flow to a suitable outlet. For swales draining a disturbed area, the outlet can be to a sediment trapping device prior to its release.

What to Consider

Since design flows, channel linings, and appropriate outlet devices will need to be considered, consult your State's requirements on such erosion control measures prior to constructing a drainage swale. General considerations include:

- \$ Divert the intercepted runoff to an appropriate outlet.

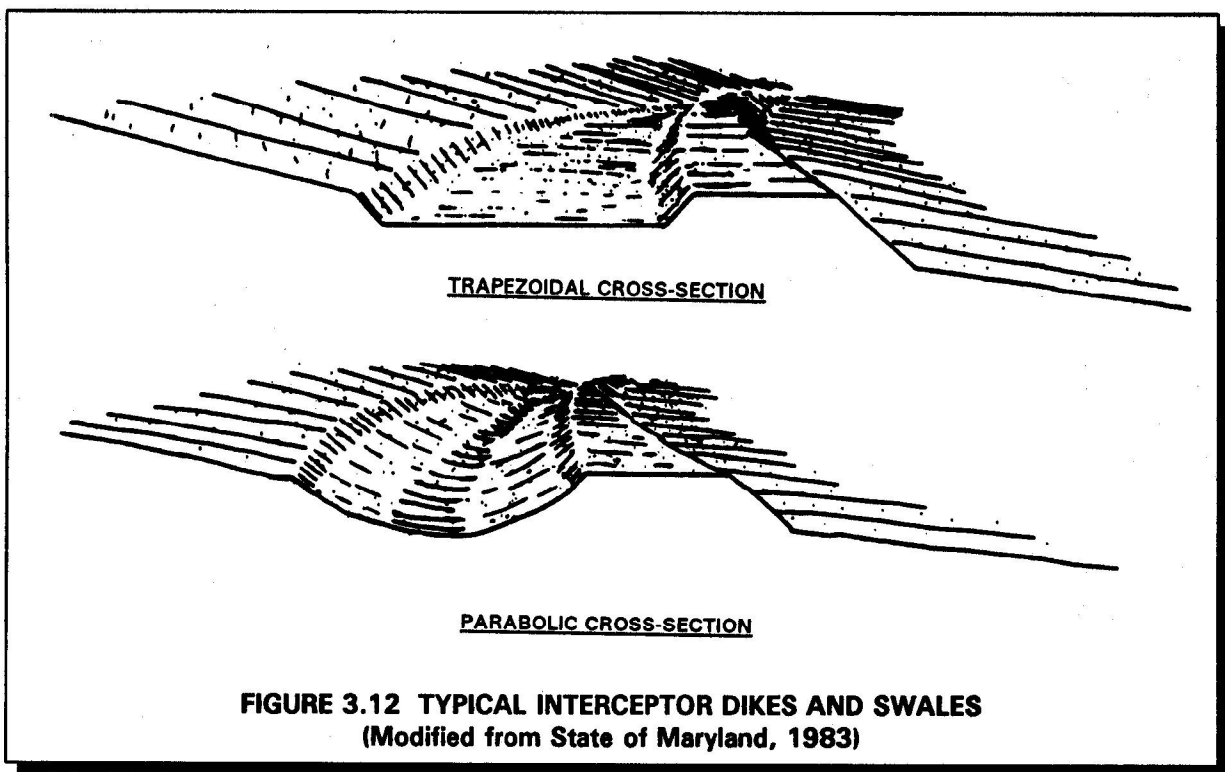
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- \$ The swale should be lined using geotextiles, grass, sod, riprap, asphalt, or concrete. The selection of the liner is dependent upon the volume and the velocity of the anticipated runoff.
 - \$ The swale should have a positive grade. There should be no dips or low points in the swale where storm water will collect.

Advantages of a Drainage Swale
<ul style="list-style-type: none">\$ Excavation of swale can be easily performed with earth moving equipment\$ Can transport large volumes of runoff
Disadvantages of a Drainage Swale
<ul style="list-style-type: none">\$ Stabilization and design costs can make construction expensive\$ Use is restricted to areas with relatively flat slopes

Interceptor Dikes and Swales

What Are They

Interceptor dikes (ridges of compacted soil) and swales (excavated depressions) are used to keep upslope runoff from crossing areas where there is a high risk of erosion. They reduce the amount and speed of flow and then guide it to a stabilized outfall (point of discharge) or sediment trapping area (see sections on Sediment Traps and Temporary Sediment Basins). Interceptor dikes and swales divert runoff using a combination of earth dike and vegetated swale. Runoff is channeled away from locations where there is a high risk of erosion by placing a diversion dike or swale at the top of a sloping disturbed area. Dikes and swales also collect overland flow, changing it into concentrated flows. Interceptor dikes and swales can be either temporary or permanent storm water control structures.



When and Where to Use Them

Interceptor dikes and swales are generally built around the perimeter of a construction site before any major soil disturbing activity takes place. Temporary dikes or swales may also be used to protect existing buildings; areas, such as stockpiles; or other small areas that have not yet been fully stabilized. When constructed along the upslope perimeter of a disturbed or high-risk area (though not necessarily all the way around it), dikes or swales prevent runoff from uphill areas from crossing the unprotected slope. Temporary dikes or swales constructed on the down slope side of the disturbed or high-risk area will prevent runoff that contains sediment from leaving the site before sediment is removed. For short slopes, a dike or swale at the top of the slope reduces the amount of runoff

reaching the disturbed area. For longer slopes, several dikes or swales are placed across the slope at intervals. This practice reduces the amount of runoff that accumulates on the face of the slope and carries the runoff safely down the slope. In all cases, runoff is guided to a sediment trapping area or a stabilized outfall before release.

What to Consider

Temporary dikes and swales are used in areas of overland flow; if they remain in place longer than 15 days, they should be stabilized. Runoff channeled by a dike or swale should be directed to an adequate sediment trapping area or stabilized outfall. Care should be taken to provide enough slope for drainage but not too much slope to cause erosion due to high runoff flow speed. Temporary interceptor dikes and swales may remain in place as long as 12 to 18 months (with proper stabilization) or be rebuilt at the end of each day's activities. Dikes or swales should remain in place until the area they were built to protect is permanently stabilized. Interceptor dikes and swales can be permanent controls. However, permanent controls: should be designed to handle runoff after construction is complete; should be permanently stabilized; and should be inspected and maintained on a regular basis. Temporary and permanent control measures should be inspected once each week on a regular schedule and after every storm. Repairs necessary to the dike and flow channel should be made promptly.

Advantages of Interceptor Dikes and Swales
<ul style="list-style-type: none">\$ Are simple and effective for channeling runoff away from areas subject to erosion\$ Can handle flows from large drainage areas\$ Are inexpensive because they use materials and equipment normally found onsite
Disadvantages of Interceptor Dikes and Swales
<ul style="list-style-type: none">\$ If constructed improperly, can cause erosion and sediment transport since flows are concentrated\$ May cause problems to vegetation growth if water flow is too fast\$ Require additional maintenance, inspections, and repairs

Temporary Stream Crossing

What Is It

A temporary stream crossing is a bridge or culvert across a stream or watercourse for short-term use by construction vehicles or heavy equipment. Vehicles moving over unprotected stream banks will damage the bank, thereby releasing sediments and degrading the stream bank. A stream crossing provides a means for construction vehicles to cross streams or watercourses without moving sediment to streams, damaging the streambed or channel, or causing flooding.

When and Where to Use It

A temporary stream crossing is used when heavy equipment should be moved from one side of a stream channel to another, or where light-duty construction vehicles have to cross the stream channel frequently for a short period of time. Temporary stream crossings should be constructed only when it is necessary to cross a stream and a permanent crossing is not yet constructed.

\$ Bridges Where available materials and designs are adequate to bear the expected loadings, bridges are preferred as a temporary stream crossing.

\$ Culverts Culverts are the most common type of stream crossings and are relatively easy to construct. A pipe, which is to carry the flow, is laid into the channel and covered by gravel.

What to Consider

When feasible, one should always attempt to minimize or eliminate the need to cross streams. Temporary stream crossings are a direct source of pollution; therefore, every effort should be made to use an alternate method (e.g., longer detour), when feasible. When it becomes necessary to cross a stream, a well planned approach will minimize the damage to the stream bank and reduce erosion. The design of temporary stream crossings requires knowledge of the design flows and other information; therefore, a professional engineer and specific State and local requirements should be consulted. State/local jurisdictions may require a separate permit for temporary stream crossings; contact them directly to learn about their exact requirements.

The specific loads and the stream conditions will dictate what type of stream crossing to employ. Bridges are the preferred method to cross a stream as they provide the least obstruction to flows and fish migration.

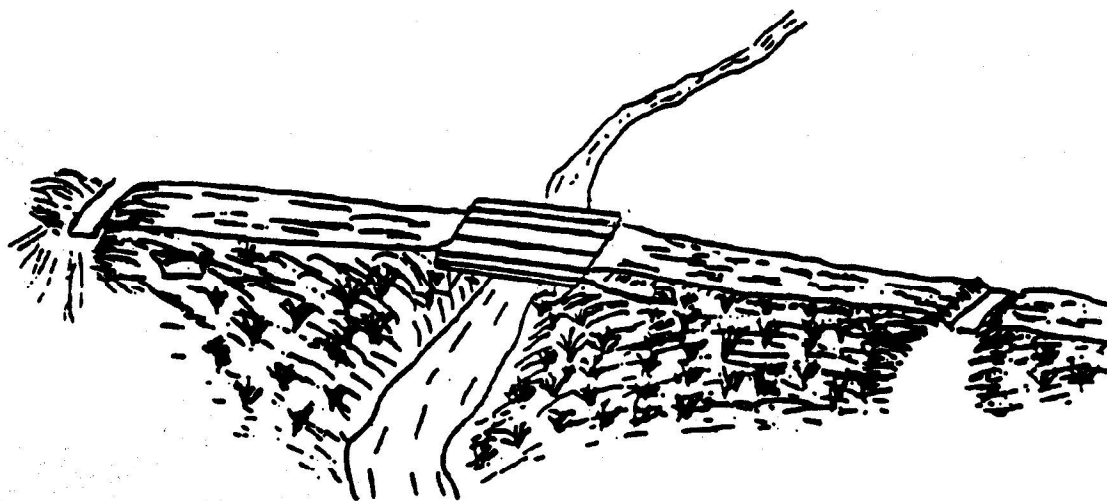
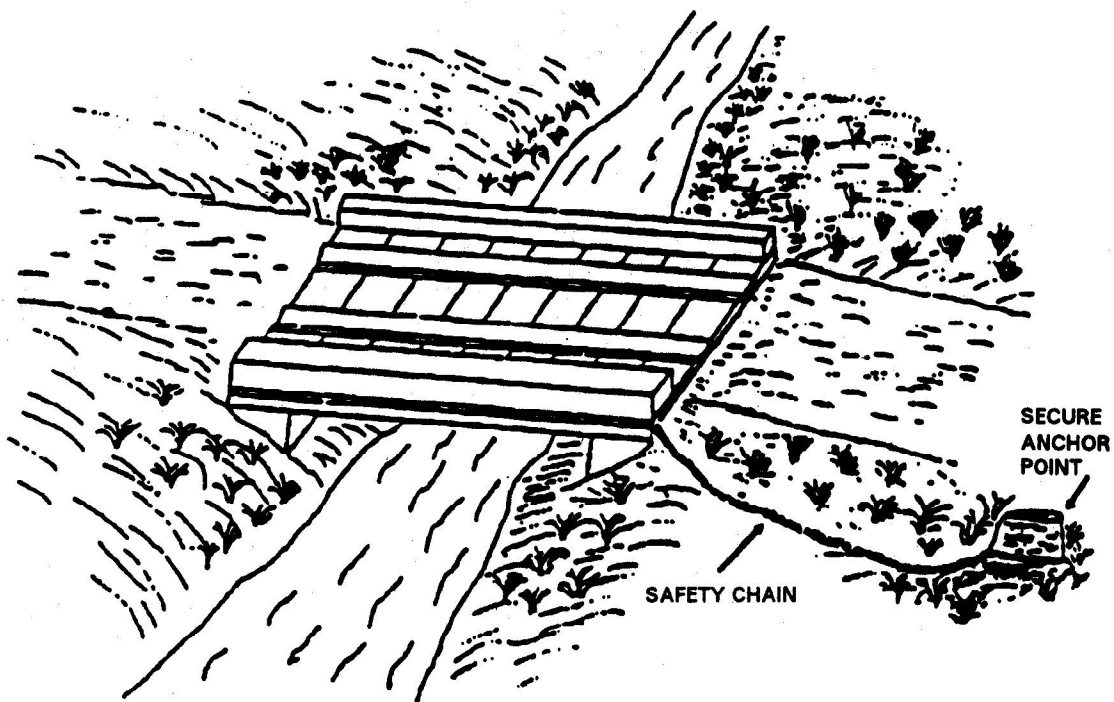


FIGURE 3.13 TEMPORARY ACCESS BRIDGE
(Modified from Maryland Department of the Environment, 1991)

Advantages of a Temporary Stream Crossing
\$ Bridges provide the least obstruction to flow and fish migration and the construction material can be salvaged
\$ Culverts are inexpensive and easily installed structures
Disadvantages of a Temporary Stream Crossing
\$ Bridges are expensive to design and install
\$ Culverts cause greater disturbances during installation and removal

Temporary Storm Drain Diversion

What Is It

A temporary storm drain is a pipe which redirects an existing storm drain system or outfall channel to discharge into a sediment trap or basin.

When and Where to Use It

Use storm drain diversions to temporarily divert flow going to a permanent outfall. This diverted flow should be directed to a sediment-trapping device. A temporary storm drain diversion should remain in place as long as the area draining to the storm sewer remains disturbed. Another method is to delay completion of the permanent outfall and instead using temporary diversions to a sediment trapping device before discharge. Finally, a sediment trap or basin can be constructed below a permanent storm drain outfall. The basin would be designed to trap any sediment before final discharge.

What to Consider

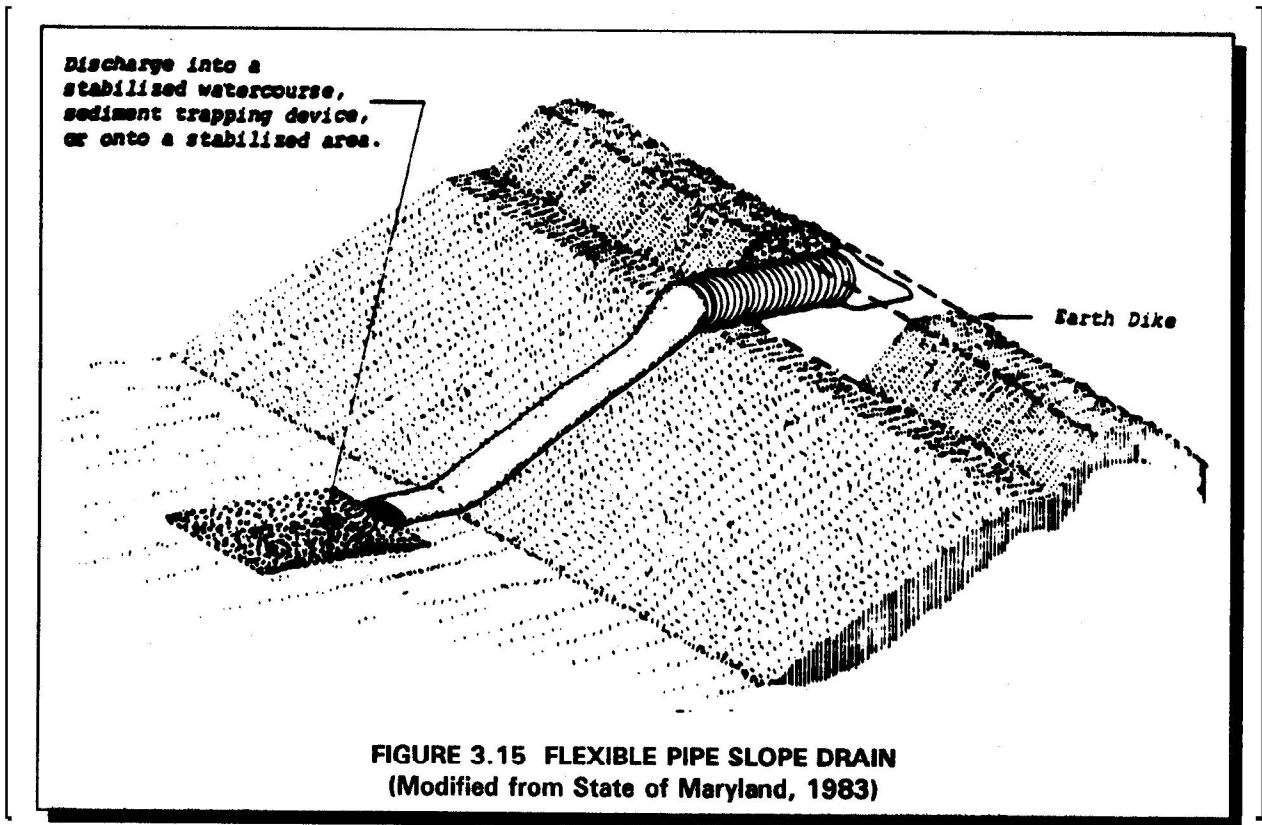
Since the existing storm draining systems will be modified, careful consideration to piping configuration and resulting impact of installing a temporary storm drain diversion should be given. The temporary diversions will also need to be moved, once the construction has ceased and it is necessary to restore the original storm drainage systems. Therefore, appropriate restoration measures such as flushing the storm drain prior to removal of the sediment trap or basin, stabilizing the outfall, restoration of grade areas, etc. should be taken. And finally, the State or local requirements should be consulted for detailed requirements.

Advantages of a Temporary Storm Drain Diversion
\$ Requires little maintenance once installed
Disadvantages of a Temporary Storm Drain Diversion
\$ Disturbs existing storm drainage patterns

Pipe Slope Drains

What Are They

Pipe slope drains reduce the risk of erosion by discharging runoff to stabilized areas. Made of flexible or rigid pipe, they carry concentrated runoff from the top to the bottom of a slope that has already been damaged by erosion or is at high risk for erosion. They are also used to drain saturated slopes that have the potential for soil slides. Pipe slope drains can be either temporary or permanent depending on the method of installation and material used.



When and Where to Use Them

Pipe slope drains are used whenever it is necessary to convey water down a slope without causing erosion. They are especially effective before a slope has been stabilized or before permanent drainage structures are ready for use. Pipe slope drains may be used with other devices, including diversion dikes or swales, sediment traps, and level spreaders (used to spread out storm water runoff uniformly over the surface of the ground). Temporary pipe slope drains, usually flexible tubing or conduit, may be installed prior to the construction of permanent drainage structures. Permanent slope drains may be placed on or beneath the ground surface; pipes, sectional downdrains, paved chutes, or clay tiles may be used.

Paved chutes may be covered with a surface of concrete or other impenetrable material. Subsurface drains can be constructed of concrete, PVC, clay tile, corrugated metal, or other permanent material.

What to Consider

The drain design should be able to handle the volume of flow. The inlets and outlets of a pipe slope drain should be stabilized. This means that a flared end section should be used at the entrance of the pipe. The soil around the pipe entrance should be fully compacted. The soil at the discharge end of the pipe should be stabilized with riprap (a combination of large stones, cobbles, and boulders). The riprap should be placed along the bottom of a swale which leads to a sediment trapping structure or another stabilized area.

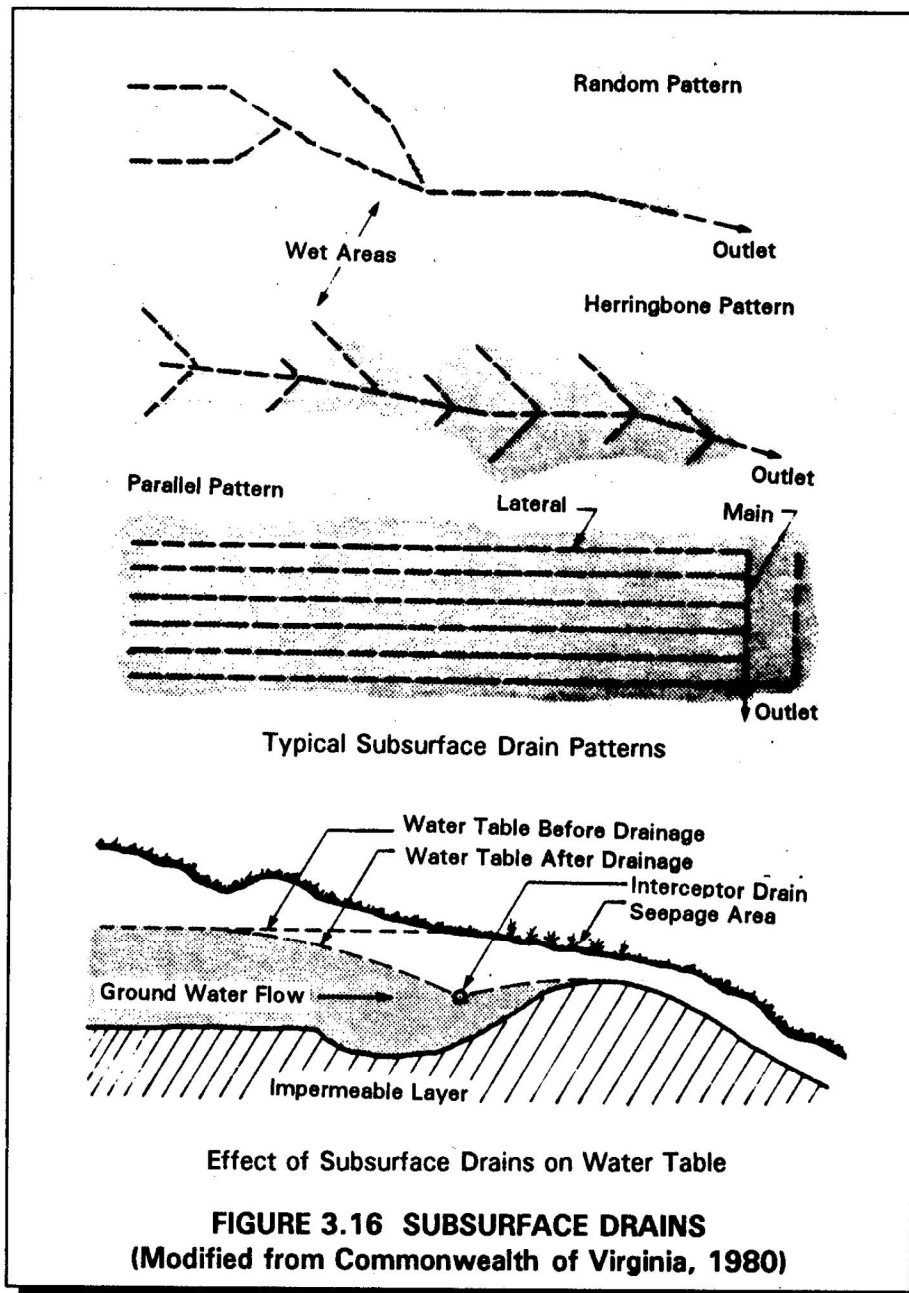
Pipe slope drains should be inspected on a regular schedule and after any major storm. Be sure that the inlet from the pipe is properly installed to prevent bypassing the inlet and undercutting the structure. If necessary, install a headwall, riprap, or sandbags around the inlet. Check the outlet point for erosion and check the pipe for breaks or clogs. Install outlet protection if needed and promptly clear breaks and clogs.

Advantages of Pipe Slope Drains
<ul style="list-style-type: none">\$ Can reduce or eliminate erosion by transporting runoff down steep slopes or by draining saturated soils\$ Are easy to install and require little maintenance
Disadvantages of Pipe Slope Drains
<ul style="list-style-type: none">\$ Require that the area disturbed by the installation of the drain should be stabilized or it, too, will be subject to erosion\$ May clog during a large storm

Subsurface Drains

What Are They

A subsurface drain is a perforated pipe or conduit placed beneath the surface of the ground at a designed depth and grade. It is used to drain an area by lowering the water table. A high water table can saturate soils and prevent the growth of certain types of vegetation. Saturated soils on slopes will sometimes "slip" down the hill. Installing subsurface drains can help prevent these problems.



When and Where to Use Them

There are two types of subsurface drains: relief drains and interceptor drains. Relief drains are used to dewater an area where the water table is high. They may be placed in a gridiron, herringbone, or random pattern. Interceptor drains are used to remove water where sloping soils are excessively wet or subject to slippage. They are usually placed as single pipes instead of in patterns. Generally, subsurface drains are suitable only in areas where the soil is deep enough for proper installation. They are not recommended where they pass under heavy vehicle crossings.

What to Consider

Drains should be placed so that tree roots will not interfere with drainage pipes. The drain design should be adequate to handle the volume of flow. Areas disturbed by the installation of a drain should be stabilized or they, too, will be subject to erosion. The soil layer must be deep enough to allow proper installation.

Backfill immediately after the pipe is placed. Material used for backfill should be open granular soil that is highly permeable. The outlet should be stabilized and should direct sediment-laden storm water runoff to a sediment trapping structure or another stabilized area.

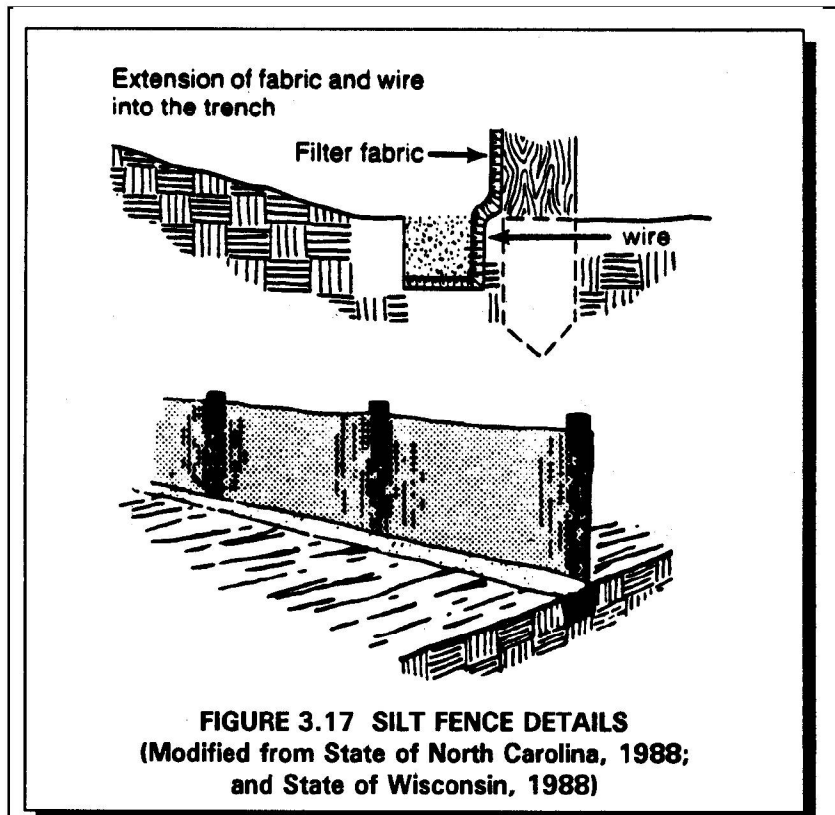
Inspect subsurface drains on a regular schedule and check for evidence of pipe breaks or clogging by sediment, debris, or tree roots. Remove blockage immediately, replace any broken sections, and restabilize the surface. If the blockage is from tree roots, it may be necessary to relocate the drain. Check inlets and outlets for sediment or debris. Remove and dispose of these materials properly.

Advantages of Subsurface Drains
\$ Provide an effective method for stabilizing wet sloping soils
\$ Are an effective way to lower the water table
Disadvantages of Subsurface Drains
\$ May be pierced and clogged by tree roots
\$ Should not be installed under heavy vehicle crossings
\$ Cost more than surface drains because of the expenses of excavation for installation

Silt Fence

What Is It

A silt fence, also called a "filter fence," is a temporary measure for sedimentation control. It usually consists of posts with filter fabric stretched across the posts and sometimes with a wire support fence. The lower edge of the fence is vertically trenched and covered by backfill. A silt fence is used in small drainage areas to detain sediment. These fences are most effective where there is overland flow (runoff that flows over the surface of the ground as a thin, even layer) or in minor swales or drainageways. They prevent sediment from entering receiving waters. Silt fences are also used to catch wind blown sand and to create an anchor for sand dune creation. Aside from the traditional wooden post and filter fabric method, there are several variations of silt fence installation including silt fence which can be purchased with pockets presewn to accept use of steel fence posts.



When and Where to Use It

A silt fence should be installed prior to major soil disturbance in the drainage area. The fence should be placed across the bottom of a slope along a line of uniform elevation (perpendicular to the direction of flow). It can be used at the outer boundary of the work area. However, the fence does not have to surround the work area completely. In addition, a silt fence is effective where sheet and rill erosion may be a problem. Silt fences should not be constructed in streams or swales.

What to Consider

A silt fence is not appropriate for controlling runoff from a large area. This type of fence can be more effective than a straw bale barrier if properly installed and maintained. It may be used in combination with other erosion and sediment practices.

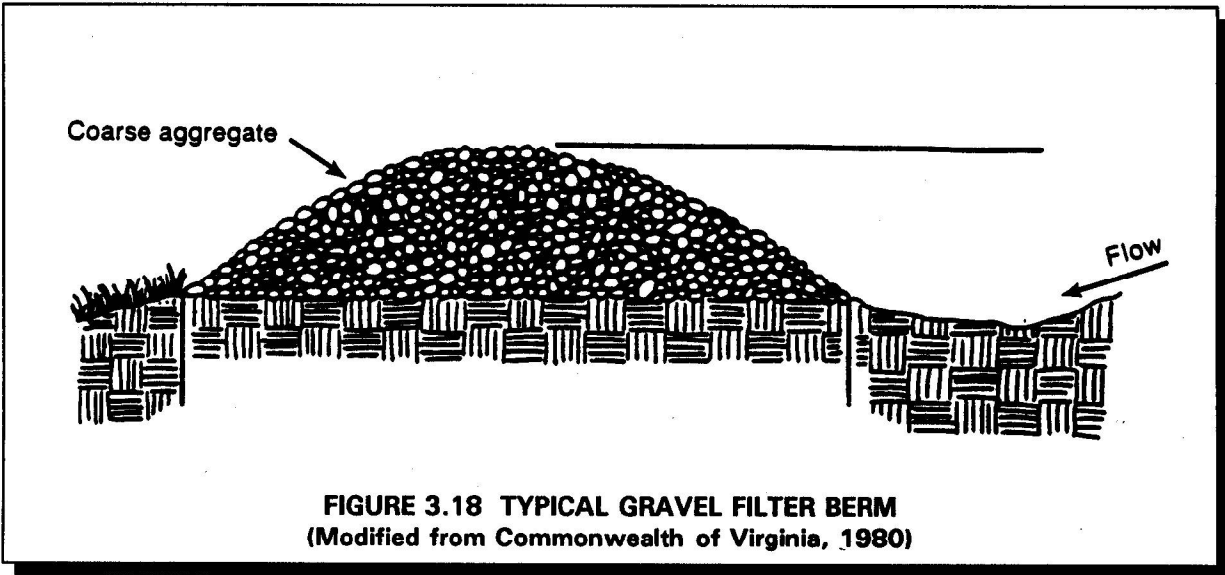
The effective life span for a silt fence depends upon the material of construction and maintenance. The fence requires frequent inspection and prompt maintenance to maintain its effectiveness. Inspect the fence after each rainfall. Check for areas where runoff eroded a channel beneath the fence, or where the fence was caused to sag or collapse by runoff flowing over the top. Remove and properly dispose of sediment when it is one-third to one-half the height of the fence or after each storm.

Advantages of a Silt Fence
<ul style="list-style-type: none">\$ Removes sediments and prevents downstream damage from sediment deposits\$ Reduces the speed of runoff flow\$ Minimal clearing and grubbing required for installation\$ Inexpensive
Disadvantages of a Silt Fence
<ul style="list-style-type: none">\$ May result in failure from improper choice of pore size in the filter fabric or improper installation\$ Should not be used in streams\$ Is only appropriate for small drainage areas with overland flow\$ Frequent inspection and maintenance is necessary to ensure effectiveness

Gravel or Stone Filter Berm

What Is It

A gravel or stone filter berm is a temporary ridge constructed of loose gravel, stone, or crushed rock. It slows and filters flow, diverting it from an exposed traffic area. Diversions constructed of compacted soil may be used where there will be little or no construction traffic within the right-of-way. They are also used for directing runoff from the right-of-way to a stabilized outlet.



When and Where to Use It

This method is appropriate where roads and other rights-of-way under construction should accommodate vehicular traffic. Berms are meant for use in areas with gentle slopes. They may also be used at traffic areas within the construction site.

What to Consider

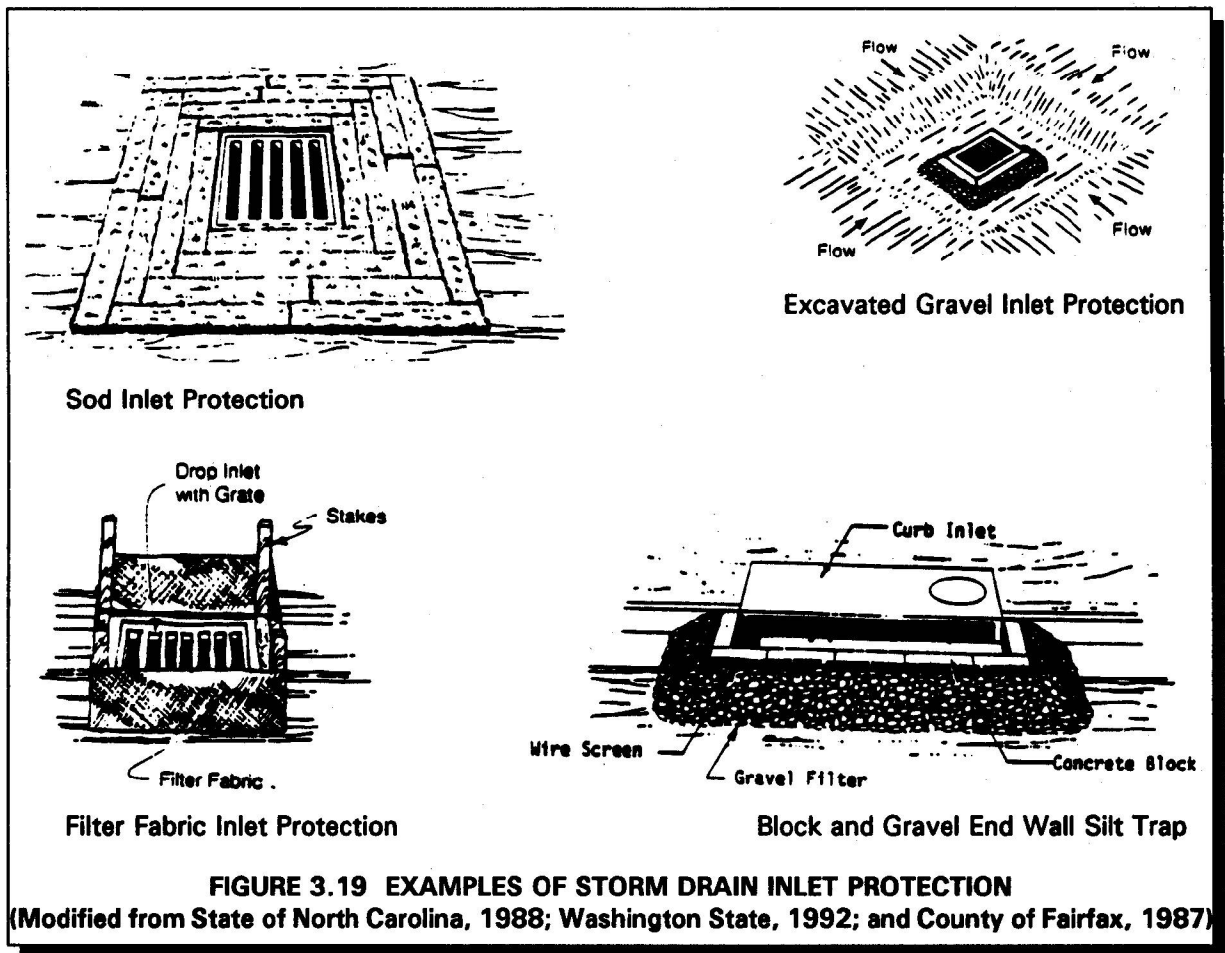
Berm material should be well graded gravel or crushed rock. The spacing of the berms will depend on the steepness of the slope: berms should be placed closer together as the slope increases. The diversion should be inspected regularly after each rainfall, or if breached by construction or other vehicles. All needed repairs should be performed immediately. Accumulated sediment should be removed and properly disposed of and the filter material replaced, as necessary.

Advantages of a Gravel or Stone Filter Berm
\$ Is a very efficient method of sediment control
\$ Reduces the speed of runoff flow
Disadvantages of a Gravel or Stone Filter Berm
\$ Is more expensive than methods that use onsite materials
\$ Has a very limited life span
\$ Can be difficult to maintain because of clogging from mud and soil on vehicle tires

Storm Drain Inlet Protection

What Is It

Storm drain inlet protection is a filtering measure placed around any inlet or drain to trap sediment. This mechanism prevents the sediment from entering inlet structures. Additionally, it serves to prevent the silting-in of inlets, storm drainage systems, or receiving channels. Inlet protection may be composed of gravel and stone with a wire mesh filter, block and gravel, filter fabric, or sod.



When and Where to Use It

This type of protection is appropriate for small drainage areas where storm drain inlets will be ready for use before final stabilization. Storm drain inlet protection is also used where a permanent storm drain structure is being constructed onsite. Straw bales are not recommended for this purpose. Filter fabric is used for inlet protection when storm water flows are relatively small with low velocities. This practice cannot be used where inlets are paved because the filter fabric should be staked. Block and gravel filters can be used where velocities are higher. Gravel and mesh filters can be used where flows are higher and subject to disturbance by site traffic. Sod inlet filters are generally used where sediments in the storm water runoff are low.

What to Consider

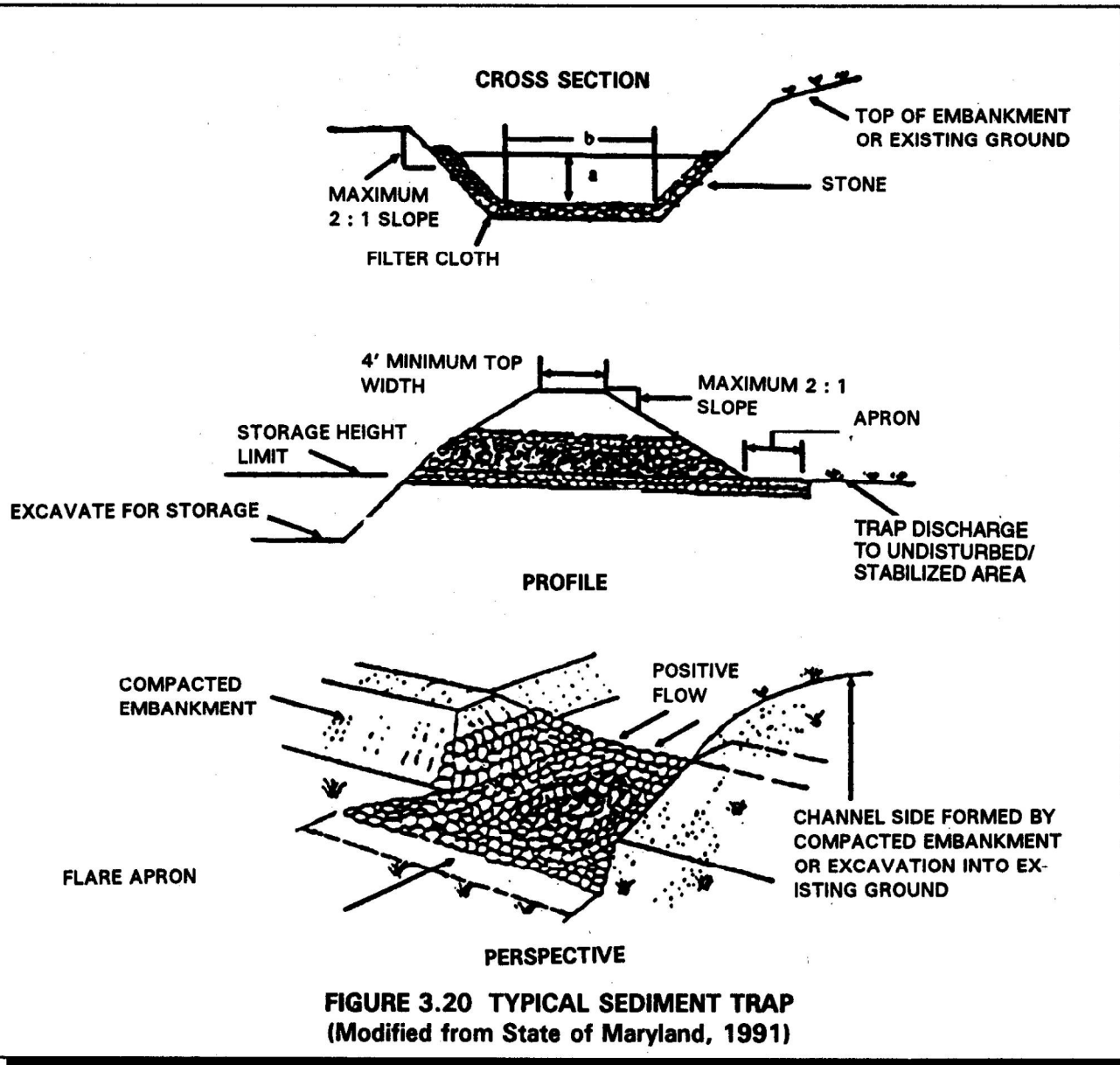
Storm drain inlet protection is not meant for use in drainage areas exceeding 1 acre or for large concentrated storm water flows. Installation of this measure should take place before any soil disturbance in the drainage area. The type of material used will depend on site conditions and the size of the drainage area. Inlet protection should be used in combination with other measures, such as small impoundments or sediment traps, to provide more effective sediment removal. Inlet protection structures should be inspected regularly, especially after a rainstorm. Repairs and silt removal should be performed as necessary. Storm drain inlet protection structures should be removed only after the disturbed areas are completely stabilized.

Advantages of Storm Drain Inlet Protection
\$ Prevents clogging of existing storm drainage systems and the siltation of receiving waters
\$ Reduces the amount of sediment leaving the site
Disadvantages of Storm Drain Inlet Protection
\$ May be difficult to remove collected sediment
\$ May cause erosion elsewhere if clogging occurs
\$ Is practical only for low sediment, low volume flows (disturbed areas less than one acre)

Sediment Trap

What Is It

A sediment trap is formed by excavating a pond or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is constructed using large stones or aggregate to slow the release of runoff. The trap retains the runoff long enough to allow most of the silt to settle out.



When and Where to Use It

A temporary sediment trap may be used in conjunction with other temporary measures, such as gravel construction entrances, vehicle wash areas, slope drains, diversion dikes and swales, or diversion channels.

What to Consider

Sediment traps are suitable for small drainage areas, usually no more than 10 acres. The trap should be large enough to allow the sediments to settle and should have a capacity to store the collected sediment until it is removed. The volume of storage required depends upon the amount and intensity of expected rainfall and on estimated quantities of sediment in the storm water runoff. Check your Permit to see if it specifies a minimum storage volume for sediment traps.

The effective life of a sediment trap depends upon adequate maintenance. The trap should be readily accessible for periodic maintenance and sediment removal. Traps should be inspected after each rainfall and cleaned when no more than half the design volume has been filled with collected sediment. The trap should remain in operation and be properly maintained until the site area is permanently stabilized by vegetation and/or when permanent structures are in place.

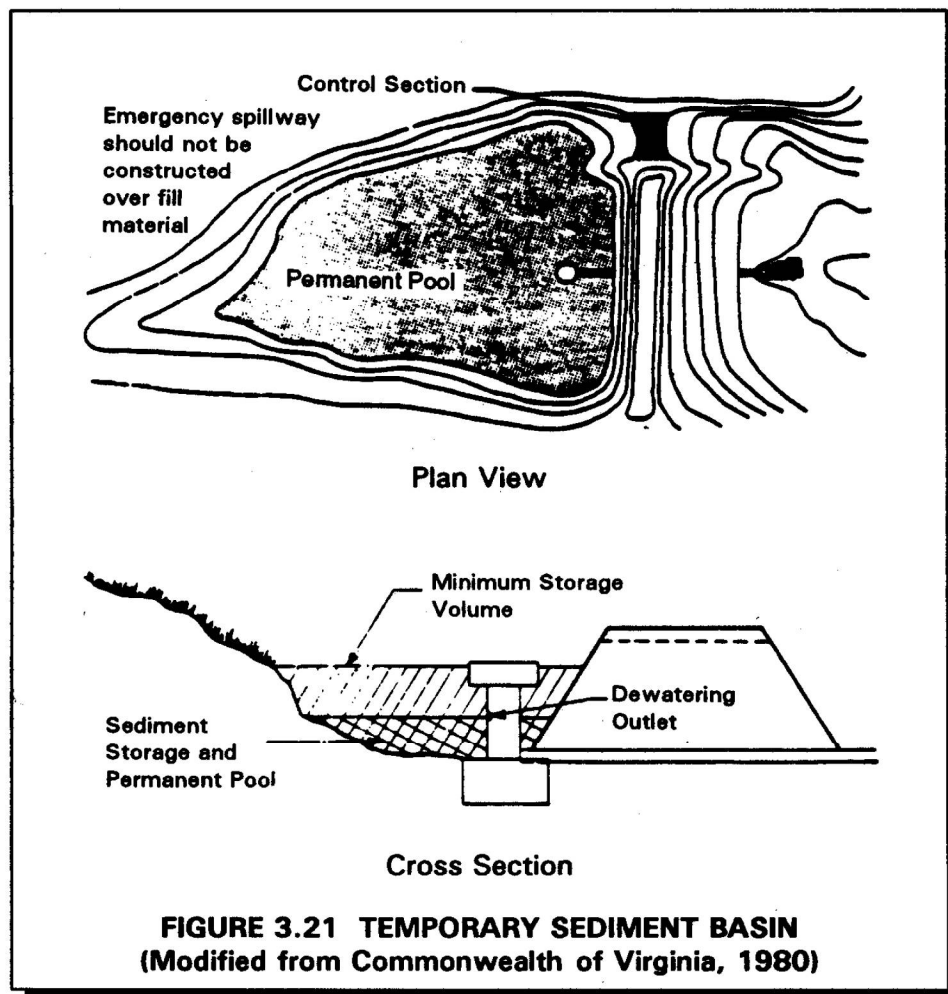
Advantages of a Temporary Sediment Trap
\$ Protects downstream areas from clogging or damage due to sediment deposits
\$ Is inexpensive and simple to install
\$ Can simplify the design process by trapping sediment at specific spots onsite
Disadvantages of a Temporary Sediment Trap
\$ Is suitable only for a limited area
\$ Is effective only if properly maintained
\$ Will not remove very fine silts and clays

Temporary Sediment Basin

What Is It

A temporary sediment basin is a settling pond with a controlled storm water release structure used to collect and store sediment produced by construction activities. A sediment basin can be constructed by excavation and/or by placing an earthen embankment across a low area or drainage swale. Sediment basins can be designed to maintain a permanent pool or to drain completely dry. The basin detains sediment-laden runoff from larger drainage areas long enough to allow most of the sediment to settle out.

The pond has a riser and pipe outlet with a gravel outlet or spillway to slow the release of runoff and provide some sediment filtration. By removing sediment, the basin helps prevent clogging of offsite conveyance systems and sediment-loading of receiving waterways. In this way, the basin helps prevent destruction of waterway habitats.



When and Where to Use It

A temporary sediment basin should be installed before clearing and grading is undertaken. It should not be built on an embankment in an active stream. The creation of a dam in such a site may result in the destruction of aquatic habitats. Dam failure can also result in flooding. A temporary sediment basin should be located only if there is sufficient space and appropriate topography. The basin should be made large enough to handle the maximum expected amount of site drainage. Fencing around the basin may be necessary for safety or vandalism reasons.

A temporary sediment basin used in combination with other control measures, such as seeding or mulching, is especially effective for removing sediments.

What to Consider

Temporary sediment basins are usually designed for disturbed areas larger than 5 acres. The pond should be large enough to hold runoff long enough for sediment to settle. Sufficient space should be allowed for collected sediments. Check the requirements of your permit to see if there is a minimum storage requirement for sediment basins. The useful life of a temporary sediment basin is dependent upon adequate maintenance.

Sediment trapping efficiency is improved by providing the maximum surface area possible. Because finer silts may not settle out completely, additional erosion control measures should be used to minimize release of fine silt. Runoff should enter the basin as far from the outlet as possible to provide maximum retention time.

Sediment basins should be readily accessible for maintenance and sediment removal. They should be inspected after each rainfall and be cleaned out when about half the volume has been filled with sediment. The sediment basin should remain in operation and be properly maintained until the site area is permanently stabilized by vegetation and/or when permanent structures are in place. The embankment forming the sedimentation pool should be well compacted and stabilized with vegetation. If the pond is located near a residential area, it is recommended for safety reasons that a sign be posted and that the area be secured by a fence. A well built temporary sediment basin that is large enough to handle the post construction runoff volume may later be converted to use as a permanent storm water management structure.

The sediment basins outlet pipe and spill way should be designed by an engineer based upon an analysis of the expected runoff flow rates from the site. Consult your state/local requirements to determine the frequency of the storm for which the outlet must be designed.

EPA BASELINE GENERAL PERMIT REQUIREMENTS
Sediment Basin Requirements
Part IV.D.2.a.(2).(a).
For common drainage locations that serve an area with 10 or more disturbed acres at one time, a temporary (or permanent) sediment basin providing 3,600 cubic feet of storage per acre drained, or equivalent control measures, shall be provided where attainable until final stabilization of the site. The 3,600 cubic feet of storage area per acre drained does not apply to flows from offsite areas and flows from onsite areas that are either undisturbed or have undergone final stabilization where such flows are diverted around the sediment basin. For drainage locations which serve 10 or more disturbed acres at one time and where a temporary sediment basin providing 3,600 cubic feet of storage per acre drained, or equivalent controls is not attainable, sediment traps, silt fences, or equivalent sediment controls are required for all sideslope and downslope boundaries of the construction area.

Advantages of a Temporary Sediment Basin
<ul style="list-style-type: none"> \$ Protects downstream areas from clogging or damage due to sediment deposits generated during construction activities \$ Can trap smaller sediment particles than sediment traps can because of the longer detention time \$ Can be converted to a permanent storm water detention structure, once construction is complete
Disadvantages of a Temporary Sediment Basin
<ul style="list-style-type: none"> \$ Is generally suitable for small areas \$ Requires regular maintenance and cleaning \$ Will not remove very fine silts and clays unless used in conjunction with other measures \$ Is a more expensive way to remove sediment than several other methods \$ Requires careful adherence to safety practices since ponds are attractive to children

Outlet Protection

What Is It

Outlet protection reduces the speed of concentrated storm water flows and therefore it reduces erosion or scouring at storm water outlets and paved channel sections. In addition, outlet protection lowers the potential for downstream erosion. This type of protection can be achieved through a variety of techniques, including stone or riprap, concrete aprons, paved sections and settling basins installed below the storm drain outlet.

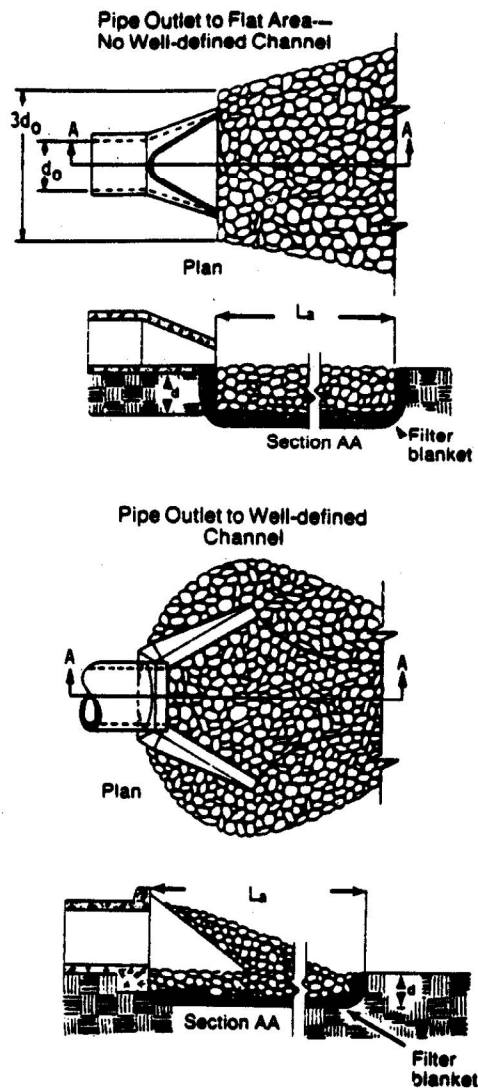


FIGURE 3.22 TYPICAL DETAILS FOR ROCK OUTLET PROTECTION
(Modified from State of North Carolina, 1988)

When and Where to Use It

Outlet protection should be installed at all pipe, interceptor dike, swale, or channel section outlets where the velocity of flow may cause erosion at the pipe outlet and in the receiving channel. Outlet protection should also be used at outlets where the velocity of flow at the design capacity may result in plunge pools (small permanent pools located at the inlet to or the outfall from BMPs). Outlet protection should be installed early during construction activities, but may be added at any time, as necessary.

What to Consider

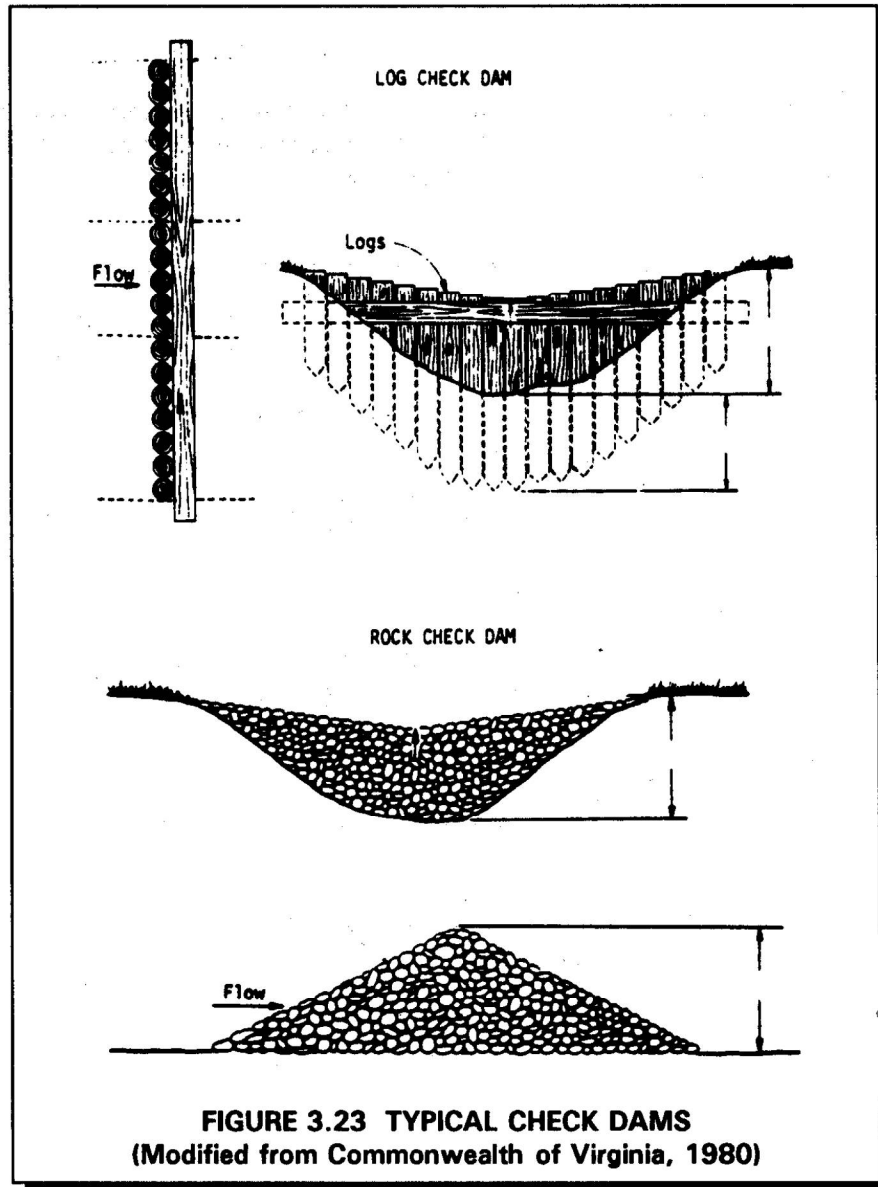
The exit velocity of the runoff as it leaves the outlet protection structure should be reduced to levels that minimize erosion. Outlet protection should be inspected on a regular schedule to look for erosion and scouring. Repairs should be made promptly.

Advantages of Outlet Protection
<ul style="list-style-type: none">\$ Provides, with riprap-line apron (the most common outlet protection), a relatively low cost method that can be installed easily on most sites\$ Removes sediment in addition to reducing flow speed\$ Can be used at most outlets where the flow speed is high\$ Is an inexpensive but effective measure\$ Requires less maintenance than many other measures
Disadvantages of Outlet Protection
<ul style="list-style-type: none">\$ May be unsightly\$ May cause problems in removing sediment (without removing and replacing the outlet protection structure itself)\$ May require frequent maintenance for rock outlets with high velocity flows

Check Dams

What Are They

A check dam is a small, temporary or permanent dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows. Reduced runoff speed reduces erosion and gullying in the channel and allows sediments to settle out.



When and Where to Use Them

A check dam should be installed in steeply sloped swales, or in swales where adequate vegetation cannot be established. A check dam may be built from logs, stone, or pea gravel-filled sandbags.

What to Consider

Check dams should be used only in small open channels which will not be overtopped by flow once the dams are constructed. The dams should not be placed in streams (unless approved by appropriate State authorities). The center section of the check dam should be lower than the edges. Dams should be spaced so that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

After each significant rainfall, check dams should be inspected for sediment and debris accumulation. Sediment should be removed when it reaches one half the original dam height. Check for erosion at edges and repair promptly as required. After construction is complete, all stone and riprap should be removed if vegetative erosion controls will be used as a permanent erosion control measure. It will be important to know the expected erosion rates and runoff flow rate for the swale in which this measure is to be installed. Contact the State/local storm water program agency or a licensed engineer for assistance in designing this measure.

Advantages of Check Dams
<ul style="list-style-type: none">\$ Are inexpensive and easy to install\$ May be used permanently if designed properly\$ Allow a high proportion of sediment in the runoff to settle out\$ Reduce velocity and may provide aeration of the water\$ May be used where it is not possible to divert the flow or otherwise stabilize the channel
Disadvantages of Check Dams
<ul style="list-style-type: none">\$ May kill grass linings in channels if the water level remains high after it rains or if there is significant sedimentation\$ Reduce the hydraulic capacity of the channel\$ May create turbulence which erodes the channel banks

Surface Roughening

What Is It

Surface roughening is a temporary erosion control practice. The soil surface is roughened by the creation of horizontal grooves, depressions, or steps that run parallel to the contour of the land. Slopes that are not fine-graded and that are left in a roughened condition can also control erosion. Surface roughening reduces the speed of runoff, increases infiltration, and traps sediment. Surface roughening also helps establish vegetative cover by reducing runoff velocity and giving seed an opportunity to take hold and grow.



When and Where to Use It

Surface roughening is appropriate for all slopes. To slow erosion, roughening should be done as soon as possible after the vegetation has been removed from the slope. Roughening can be used with both seeding and planting and temporary mulching to stabilize an area. For steeper slopes and slopes that will be left roughened for longer periods of time, a combination of surface roughening and vegetation is appropriate. Surface roughening should be performed immediately after grading activities have ceased (temporarily or permanently) in an area.

What to Consider

Different methods can be used to roughen the soil surface on slopes. They include stair-step grading, grooving (using disks, spring harrows, or teeth on a front-end loader), and tracking (driving a crawler tractor up and down a slope, leaving the cleat imprints parallel to the slope contour). The selection of an appropriate method depends on the grade of the slope, mowing requirements after vegetative cover is established, whether the slope was formed by cutting or filling, and type of equipment available.

Cut slopes with a gradient steeper than 3:1 but less than 2:1 should be stair-step graded or groove cut. Stair-step grading works well with soils containing large amounts of small rock. Each step catches material discarded from above and provides a level site where vegetation can grow. Stairs should be wide enough to work with standard earth moving equipment. Grooving can be done by any implement that can be safely operated on the slope, including those described above. Grooves should not be less than 3 inches deep nor more than 15 inches apart. Fill slopes with a gradient steeper than 3:1 but less than 2:1 should be compacted every 9 inches of depth. The face of the slope should consist of loose, uncompacted fill 4 to 6 inches deep that can be left rough or can be grooved as described above, if necessary.

Any cut or filled slope that will be mowed should have a gradient less than 3:1. Such a slope can be roughened with shallow grooves parallel to the slope contour by using normal tilling. Grooves should be close together (less than 10 inches) and not less than 1 inch deep. Any gradient with a slope greater than 2:1 should be stair-stepped.

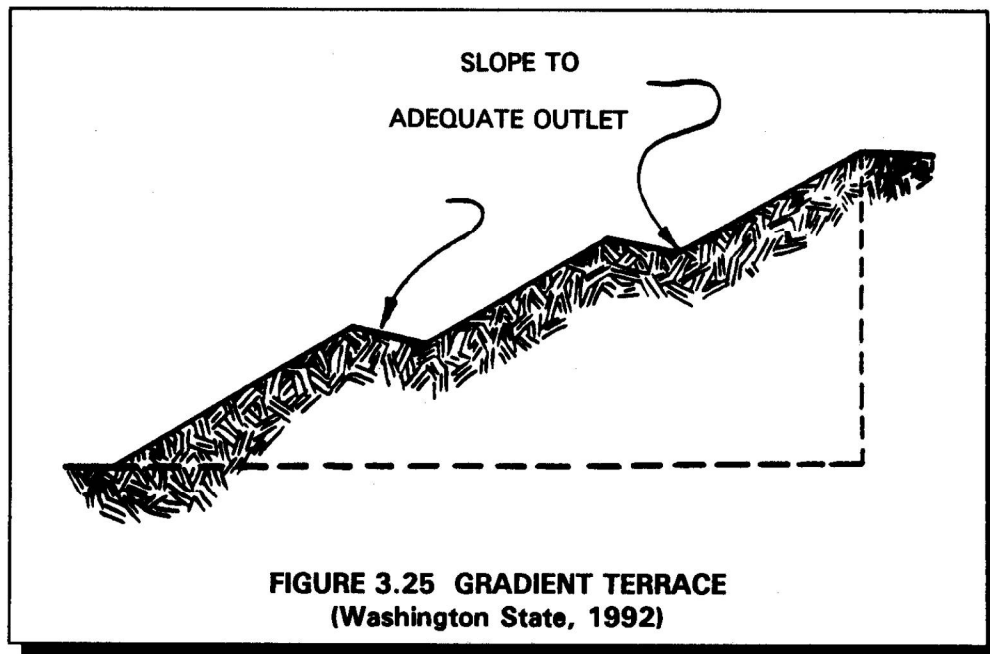
It is important to avoid excessive compacting of the soil surface, especially when tracking, because soil compaction inhibits vegetation growth and causes higher runoff speed. Therefore, it is best to limit roughening with tracked machinery to sandy soils that do not compact easily and to avoid tracking on clay soils. Surface roughened areas should be seeded as quickly as possible. Also, regular inspections should be made of all surface roughened areas, especially after storms. If rills (small watercourses that have steep sides and are usually only a few inches deep) appear, they should be filled, graded again, and reseeded immediately. Proper dust control procedures should be followed when surface roughening.

Advantages of Surface Roughening
\$ Provides a degree of instant erosion protection for bare soil while vegetative cover is being established
\$ Is inexpensive and simple for short-term erosion control
Disadvantages of Surface Roughening
\$ Is of limited effectiveness in anything more than a gentle rain
\$ Is only temporary; if roughening is washed away in a heavy storm, the surface will have to be re-roughened and new seed laid

Gradient Terraces

What Are They

Gradient terraces are earth embankments or ridge-and-channels constructed along the face of a slope at regular intervals. Gradient terraces are constructed at a positive grade. They reduce erosion damage by capturing surface runoff and directing it to a stable outlet at a speed that minimizes erosion.



When and Where to Use Them

Gradient terraces are usually limited to use on long, steep slopes with a water erosion problem, or where it is anticipated that water erosion will be a problem. Gradient terraces should not be constructed on slopes with sandy or rocky soils. They will be effective only where suitable runoff outlets are or will be made available.

What to Consider

Gradient terraces should be designed and installed according to a plan determined by an engineering survey and layout. It is important that gradient terraces are designed with adequate outlets, such as a grassed waterway, vegetated area, or tile outlet. In all cases, the outlet should direct the runoff from the terrace system to a point where the outflow will not cause erosion or other damage. Vegetative cover should be used in the outlet where possible. The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow. Terraces should be inspected regularly at least once a year and after major storms. Proper vegetation/stabilization practices should be followed while constructing these features.

Advantages of Gradient Terraces
<ul style="list-style-type: none">\$ Reduce runoff speed and increase the distance of overland runoff flow\$ Hold moisture better than do smooth slopes and minimize sediment loading of surface runoff
Disadvantages of Gradient Terraces
<ul style="list-style-type: none">\$ May significantly increase cut and fill costs and cause sloughing if excessive water infiltrates the soil\$ Are not practical for sandy, steep, or shallow soils

3.3 SUMMARY

Erosion of disturbed soils on construction sites can be prevented in many cases. When it is not possible to prevent the erosion, then the sediment can be trapped onsite. This chapter describes the measures used for erosion and sediment control and provides guidance for selecting the most appropriate measure for a particular site. The descriptions of the measures contained in this chapter are intended to provide general understanding of the measures rather than detailed design information. Check with your State or local erosion and sediment control agency to obtain a copy of their design standards or guidance. If your State or local agency does not have design standards or guidance, then refer to the design "Fact Sheets" contained in Appendix B of this manual.

Erosion and sediment control measures are a critical component of a Storm Water Pollution Prevention Plan and of a construction project. These measures should be designed and constructed in the most effective manner.

APPENDIX B

BMP FACT SHEETS

SILT FENCE

September 1992

Design Criteria

- ▲ Silt fences are appropriate at the following general locations:
 - ▲ Immediately upstream of the point(s) of runoff discharge from a site before flow becomes concentrated (maximum design flow rate should not exceed 0.5 cubic feet per second).
 - ▲ Below disturbed areas where runoff may occur in the form of overland flow.
- ▲ Ponding should not be allowed behind silt fences since they will collapse under high pressure; the design should provide sufficient outlets to prevent overtopping.
- ▲ The drainage area should not exceed 0.25 acre per 100 feet of fence length.
- ▲ For slopes between 50:1 and 5:1, the maximum allowable upstream flow path length to the fence is 100 feet; for slopes of 2:1 and steeper, the maximum is 20 feet.
- ▲ The maximum upslope grade perpendicular to the fence line should not exceed 1:1.
- ▲ Synthetic silt fences should be designed for 6 months of service; burlap is only acceptable for periods of up to 60 days.

Materials

- ▲ Synthetic filter fabric should be a pervious sheet of polypropylene, nylon, polyester, or polyethylene yarn conforming to the requirements in Table 1 below.

TABLE 1. SYNTHETIC FILTER FABRIC REQUIREMENTS

Physical Property	Requirements
Filtering Efficiency	75% - 85% (minimum)
Tensile Strength at 20% (maximum) Elongation	Standard Strength - 30 lb/linear inch (minimum)
	Extra Strength - 50 lb/linear inch (minimum)
Slurry Flow Rate	0.3 gal/ft ² /min (minimum)

- ▲ Synthetic filter fabric should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 to 120°F.
- ▲ Burlap of 10 ounces per square yard of fabric can also be used.
- ▲ The filter fabric should be purchased in a continuous roll to avoid joints.
- ▲ While not required, wire fencing may be used as a backing to reinforce standard strength filter fabric. The wire fence (14 gauge minimum) should be at 22-48 inches wide and should have a maximum mesh spacing of 6 inches.
- ▲ Posts should be 2-4 feet long and should be composed of either 2" x 2-4" pine (or equivalent) or 1.00 to 1.33 lb/linear ft steel. Steel posts should have projections for fastening wire and fabric to them.

Construction Specifications

- ▲ The maximum height of the filter fence should range between 18 and 36 inches above the ground surface (depending on the amount of upslope ponding expected).

SILT FENCE

- ▲ Posts should be spaced 8 to 10 feet apart when a wire mesh support fence is used and no more than 6 feet apart when extra strength filter fabric (without a wire fence) is used. The posts should extend 12 to 30 inches into the ground.
- ▲ A trench should be excavated 4 to 8 inches wide and 4 to 12 inches deep along the upslope side of the line of posts.
- ▲ If standard strength filter fabric is to be used, the optional wire mesh support fence may be fastened to the upslope side of the posts using 1 inch heavy duty wire staples, tie wires, or hog rings. Extend the wire mesh support to the bottom of the trench. The filter fabric should then be stapled or wired to the fence, and 8 to 20 inches of the fabric should extend into the trench (Figure 1).
- ▲ Extra strength filter fabric does not require a wire mesh support fence. Staple or wire the filter fabric directly to the posts and extend 8 to 20 inches of the fabric into the trench (Figure 1).
- ▲ Where joints in the fabric are required, the filter cloth should be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.
- ▲ Do not attach filter fabric to trees.
- ▲ Backfill the trench with compacted soil or 0.75 inch minimum diameter gravel placed over the filter fabric.

Maintenance

- ▲ Inspect filter fences daily during periods of prolonged rainfall, immediately after each rainfall event, and weekly during periods of no rainfall. Make any required repairs immediately.
- ▲ Sediment must be removed when it reaches one-third to one-half the height of the filter fence. Take care to avoid damaging the fence during cleanout.
- ▲ Filter fences should not be removed until the upslope area has been permanently stabilized. Any sediment deposits remaining in place after the filter fence has been removed should be dressed to conform with the existing grade, prepared, and seeded.

Cost

- ▲ Silt fence installation costs approximately \$6.00 per linear foot.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.

PIPE SLOPE DRAIN

September 1992

Design Criteria

- ▲ Pipe Slope Drains (PSD) are appropriate in the following general locations:
 - ▲ On cut or fill slopes before permanent storm water drainage structures have been installed.
 - ▲ Where earth dikes or other diversion measures have been used to concentrate flows.
 - ▲ On any slope where concentrated runoff crossing the face of the slope may cause gullies, channel erosion, or saturation of slide-prone soils.
 - ▲ As an outlet for a natural drainageway.
- ▲ The drainage area may be up to 10 acres; however, many jurisdictions consider 5 acres the recommended maximum.
- ▲ The PSD design should handle the peak runoff for the 10-year storm. Typical relationships between area and pipe diameter are shown in Table 2 below.

TABLE 2. RELATIONSHIP BETWEEN AREA AND PIPE DIAMETER

Maximum Drainage Area (Acres)	Pipe Diameter (D) (Inches)
0.5	12
0.75	15
1.0	18

Materials

- ▲ Pipe may be heavy duty flexible tubing designed for this purpose, e.g., nonperforated, corrugated plastic pipe, corrugated metal pipe, bituminous fiber pipe, or specially designed flexible tubing.
- ▲ A standard flared end section secured with a watertight fitting should be used for the inlet. A standard T-section fitting may also be used.
- ▲ Extension collars should be 12-inch long sections of corrugated pipe. All fittings must be watertight.

Construction Specifications

- ▲ Place the pipe slope drain on undisturbed or well-compacted soil.
- ▲ Soil around and under the entrance section must be hand-tamped in 4-inch to 8-inch lifts to the top of the dike to prevent piping failure around the inlet.
- ▲ Place filter cloth under the inlet and extend 5 feet in front of the inlet and be keyed in 6-inches on all sides to prevent erosion. A 6-inch metal toe plate may also be used for this purpose.
- ▲ Ensure firm contact between the pipe and the soil at all points by backfilling around and under the pipe with stable soil material hand compacted in lifts of 4-inches to 8-inches.
- ▲ Securely stake the PSD to the slope using grommets provided for this purpose at intervals of 10 feet or less.
- ▲ Ensure that all slope drain sections are securely fastened together and have watertight fittings.

PIPE SLOPE DRAIN

- ▲ Extend the pipe beyond the toe of the slope and discharge at a nonerosive velocity into a stabilized area (e.g., rock outlet protection may be used) or to a sedimentation trap or pond.
- ▲ The PSD should have a minimum slope of 3 percent or steeper.
- ▲ The height at the centerline of the earth dike should range from a minimum of 1.0 foot over the pipe to twice the diameter of the pipe measured from the invert of the pipe. It should also be at least 6 inches higher than the adjoining ridge on either side.
- ▲ At no point along the dike will the elevation of the top of the dike be less than 6 inches higher than the top of the pipe.
- ▲ Immediately stabilize all areas disturbed by installation or removal of the PSD.

Maintenance

- ▲ Inspect regularly and after every storm. Make any necessary repairs.
- ▲ Check to see that water is not bypassing the inlet and undercutting the inlet or pipe. If necessary, install headwall or sandbags.
- ▲ Check for erosion at the outlet point and check the pipe for breaks or clogs. Install additional outlet protection if needed and immediately repair the breaks and clean any clogs.
- ▲ Do not allow construction traffic to cross the PSD and do not place any material on it.
- ▲ If a sediment trap has been provided, clean it out when the sediment level reaches 1/3 to 1/2 the design volume.
- ▲ The PSD should remain in place until the slope has been completely stabilized or up to 30 days after permanent slope stabilization.

Cost

- ▲ Pipe slope drain costs are generally based upon the pipe type and size (generally, flexible PVC at \$5.00 per linear foot). Also adding to this cost are any expenses associated with inlet and outlet structures.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
- ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

STABILIZED CONSTRUCTION ENTRANCE

September 1992

Design Criteria

- ▲ A Stabilized Construction Entrance (SCE) is appropriate in the following locations:
 - ▲ Wherever vehicles are leaving a construction site and enter onto a public road
 - ▲ At any unpaved entrance/exit location where there is risk of transporting mud or sediment onto paved roads.
- ▲ The width should be at least 10 feet to 12 feet or the as wide as the entire width of the access. At sites where traffic volume is high the entrance should be wide enough for two vehicles to pass safely.
- ▲ The length should be between 50 to 75 feet in length.
- ▲ Flare the entrance where it meets the existing road to provide a turning radius.
- ▲ Runoff from a stabilized construction entrance should drain to a sediment trap or sediment basin.
- ▲ Pipe placed under the entrance to handle runoff should be protected with a mountable berm.
- ▲ Dust control should be provided in accordance with Section 3.2.1.

Materials

- ▲ Crushed stone 2-inches-4-inches in diameter
- ▲ Geotextile (filter fabric) with the properties listed in Table 3 below.

TABLE 3. GEOTEXTILE REQUIREMENTS

Physical Property	Requirements
Grab Tensile Strength	220 lbs. (ASTM D1682)
Elongation Failure	60 % (ASTM D1682)
Mullen Burst Strength	430 lbs. (ASTM D3768)
Puncture Strength	125 lbs. (ASTM D751) (modified)
Equivalent Opening	Size 40-80 (US std Sieve) (CW-02215)

Construction Specifications

- ▲ Clear all vegetation, roots and all other obstructions in preparation for grading.
- ▲ Prior to placing geotextile (filter fabric) make sure that the entrance is properly graded and compacted.

STABILIZED CONSTRUCTION ENTRANCE

- ▲ To reduce maintenance and loss of aggregate place geotextile fabric (filter cloth) over the existing ground before placing the stone for the entrance.
- ▲ Stone should be placed to a depth of 6-inches or greater for the entire width and length of the SCE.

Maintenance

- ▲ Inspect the measure on a regular basis and after there has been a high volume of traffic or storm event.
- ▲ Apply additional stone periodically and when repair is required.
- ▲ Immediately remove sediments or any other materials tracked onto the public roadway.
- ▲ Ensure that associated sediment control measures are in good working condition.

Cost

- ▲ Stabilized construction entrances cost ranges from \$1,500 to \$5,000 to install.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

FILTER FABRIC INLET PROTECTION

September 1992

Design Criteria

- ▲ Inlet protection is appropriate in the following locations:
 - ▲ In small drainage areas (less than 1 acre) where the storm drain inlet is functional before the drainage area has been permanently stabilized.
 - ▲ Where there is danger of sediment silting in an inlet which is in place prior to permanent stabilization.
- ▲ Filter fabric inlet protection is appropriate for most types of inlets where the drainage area is one acre or less.
- ▲ The drainage area should be fairly flat with slopes of 5% or less and the area immediately surrounding the inlet should not exceed a slope of 1%.
- ▲ Overland flow to the inlet should be no greater than 0.5 cfs.
- ▲ This type of inlet protection is not appropriate for use in paved areas because the filter fabric requires staking.
- ▲ To avoid failure caused by pressure against the fabric when overtopping occurs, it is recommended that the height of the filter fabric be limited to 1.5 feet above the crest of the drop inlet.
- ▲ It is recommended that a sediment trapping sump of 1 to 2 feet in depth with side slopes of 2:1 be provided.

Materials

- ▲ Filter fabric (see the fabric specifications for silt fence).
- ▲ Wooden stakes 2" x 2" or 2" x 4" with a minimum length of 3 feet.
- ▲ Heavy-duty wire staples at least 1 inch in length.
- ▲ Washed gravel 1/2 inches in diameter.

Construction Specifications

- ▲ Place a stake at each corner of the inlet and around the edges at no more than 3 feet apart. Stakes should be driven into the ground 18 inches or at a minimum 8 inches.
- ▲ For stability a framework of wood strips should be installed around the stakes at the crest of the overflow area 1.5 feet above the crest of the drop inlet.
- ▲ Excavate a trench of 8 inches to 12 inches in depth around the outside perimeter of the stakes. If a sediment trapping sump is being provided then the excavation may be as deep as 2 feet.
- ▲ Staple the filter fabric to the wooden stakes with heavy-duty staples, overlapping the joints to the next stake. Ensure that between 12 inches to 32 inches of filter fabric extends at the bottom so it can be formed into the trench.
- ▲ Place the bottom of the fabric in the trench and backfill the trench all the way around using washed gravel to a minimum depth of 4 inches.

FILTER FABRIC INLET PROTECTION**Maintenance**

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Sediment should be removed and the trap restored to its original dimensions when sediment has accumulated to the design depth of the trap.
- ▲ If the filter fabric becomes clogged it should be replaced immediately.
- ▲ Make sure that the stakes are firmly in the ground and that the filter fabric continues to be securely anchored.
- ▲ All sediments removed should be properly disposed.
- ▲ Inlet protection should remain in place and operational until the drainage area is completely stabilized or up to 30 days after the permanent site stabilization is achieved.

Cost

- ▲ The cost of storm drain inlet protection varies dependent upon the size and type of inlet to be protected but generally is about \$300.00 per inlet.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

EXCAVATED GRAVEL INLET PROTECTION

September 1992

Design Criteria

- ▲ Inlet protection is appropriate in the following locations:
 - ▲ In small drainage areas (less than 1 acre) where the storm drain inlet is functional before the drainage area has been permanently stabilized.
 - ▲ Where there is danger of sediment silting in an inlet which is in place prior to permanent stabilization.
 - ▲ Where ponding around the inlet structure could be a problem to traffic on site.
- ▲ Excavated gravel and mesh inlet protection may be used with most inlets where overflow capability is needed and in areas of heavy flows, 0.5 cfs or greater.
- ▲ The drainage area should not exceed 1 acre.
- ▲ The drainage area should be fairly flat with slopes of 5% or less.
- ▲ The trap should have a sediment trapping sump of 1 to 2 feet measured from the crest of the inlet. Side slopes should be 2:1. The recommended volume of excavation is 35 yd /acre disturbed.
- ▲ To achieve maximum trapping efficiency the longest dimension of the basin should be oriented toward the longest inflow area.

Materials

- ▲ Hardware cloth or wire mesh with 1/2 inch openings.
- ▲ Filter fabric (see the fabric specifications for silt fence).
- ▲ Washed gravel 1/2 inches to 4 inches in diameter.

Construction Specifications

- ▲ Remove any obstructions to excavating and grading. Excavate sump area, grade slopes and properly dispose of soil.
- ▲ The inlet grate should be secured to prevent seepage of sediment laden water.
- ▲ Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Overlap the strips of mesh if more than one is necessary.
- ▲ Place filter fabric over the mesh extending it at least 18 inches beyond the inlet opening on all sides. Ensure that weep holes in the inlet structure are protected by filter fabric and gravel.
- ▲ Place stone/gravel over the fabric/wire mesh to a depth of at least 1 foot.

EXCAVATED GRAVEL INLET PROTECTION**Maintenance**

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Sediment should be removed and the trap restored to its original dimensions when sediment has accumulated to the design depth of the trap.
- ▲ Clean or remove and replace the stone filter or filter fabric if they become clogged.
- ▲ Inlet protection should remain in place and operational until the drainage area is completely stabilized or up to 30 days after the permanent site stabilization is achieved.

Cost

- ▲ The cost of storm drain inlet protection varies dependent upon the size and type of inlet to be protected but generally is about \$300.00 per inlet.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

BLOCK AND GRAVEL INLET PROTECTION

September 1992

Design Criteria

- ▲ Inlet protection is appropriate in the following locations:
 - ▲ In drainage areas (less than 1 acre) where the storm drain inlet is functional before the drainage area has been permanently stabilized.
 - ▲ Where there is danger of sediment silting in an inlet which is in place prior to permanent stabilization.
- ▲ Block and gravel inlet protection may be used with most types of inlets where overflow capability is needed and in areas of heavy flows 0.5 cfs or greater.
- ▲ The drainage area should not exceed 1 acre.
- ▲ The drainage area should be fairly flat with slopes of 5% or less.
- ▲ To achieve maximum trapping efficiency the longest dimension of the basin should be oriented toward the longest inflow area.
- ▲ Where possible the trap should have sediment trapping sump of 1 to 2 feet in depth with side slopes of 2:1.
- ▲ There are several other types of inlet protection also used to prevent siltation of storm drainage systems and structures during construction, they are:
 - ▲ Filter Fabric Inlet Protection
 - ▲ Excavated Gravel Inlet Protection

Materials

- ▲ Hardware cloth or wire mesh with 1/2 inch openings
- ▲ Filter fabric (see the fabric specifications for silt fence)
- ▲ Concrete block 4 inches to 12 inches wide.
- ▲ Washed gravel 1/2 inches to 4 inches in diameter

Construction Specifications

- ▲ The inlet grate should be secured to prevent seepage of sediment laden water.
- ▲ Place wire mesh over the drop inlet so that the wire extends a minimum of 12 inches to 18 inches beyond each side of the inlet structure. Overlap the strips of mesh if more than one is necessary.
- ▲ Place filter fabric (optional) over the mesh and extend it at least 18 inches beyond the inlet structure.
- ▲ Place concrete blocks over the filter fabric in a single row lengthwise on their sides along the sides of the inlet. The foundation should be excavated a minimum of 2 inches below the crest of the inlet and the bottom row of blocks should be against the edge of the structure for lateral support.
- ▲ The open ends of the block should face outward not upward and the ends of adjacent blocks should abut. Lay one block on each side of the structure on its side to allow for dewatering of the pool.
- ▲ The block barrier should be at least 12 inches high and may be up to a maximum of 24 inches high and may be from 4 inches to 12 inches in depth depending on the size of block used.
- ▲ Prior to backfilling, place wire mesh over the outside vertical end of the blocks so that stone does not wash down the inlet.
- ▲ Place gravel against the wire mesh to the top of the blocks.

BLOCK AND GRAVEL INLET PROTECTION**Maintenance**

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Sediment should be removed and the trap restored to its original dimensions when sediment has accumulated to the design depth of the trap.
- ▲ All sediments removed should be properly disposed of.
- ▲ Inlet protection should remain in place and operational until the drainage area is completely stabilized or up to 30 days after the permanent site stabilization is achieved.

Cost

- ▲ The cost of storm drain inlet protection varies dependent upon the size and type of inlet to be protected but generally is about \$300.00 per inlet.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

CHECK DAMS

September 1992

Design Criteria

- ▲ Check dams are appropriate for use in the following locations:
 - ▲ Across swales or drainage ditches to reduce the velocity of flow.
 - ▲ Where velocity must be reduced because a vegetated channel lining has not yet been established.
- ▲ Check dams may never be used in a live stream unless approved by the appropriate government agency.
- ▲ The drainage area above the check dam should be between 2 acres and 10 acres.
- ▲ The dams must be spaced so that the toe of the upstream dam is never any higher than the top of the downstream dam.
- ▲ The center of the dam must be 6 inches to 9 inches lower than either edge, and the maximum height of the dam should be 24 inches.
- ▲ The check dam should be as much as 18 inches wider than the banks of the channel to prevent undercutting as overflow water re-enters the channel.
- ▲ Excavating a sump immediately upstream from the check dam improves its effectiveness.
- ▲ Provide outlet stabilization below the lowest check dam where the risk of erosion is greatest.
- ▲ Consider the use of channel linings or protection such as plastic sheeting or riprap where there may be significant erosion or prolonged submergence.

Materials

- ▲ Stone 2 inches to 15 inches in diameter
- ▲ Logs 6 inches to 8 inches in diameter
- ▲ Sandbags filled with pea gravel
- ▲ Filter fabric (see the fabric specifications for silt fence)

Construction Specifications

- ▲ Rock Check Dams
 - ▲ Place the stones on the filter fabric either by hand or using appropriate machinery; do not simply dump them in place.
 - ▲ Extend the stone 18 inches beyond the banks and keep the side slopes 2:1 or flatter.
 - ▲ Lining the upstream side of the dam with 1/2 inch to 1 inch gravel 1 foot in depth is a suggested option.
- ▲ Log Check Dams
 - ▲ Logs must be firmly embedded in the ground; 18 inches is the recommended minimum depth.
- ▲ Sand Bag Check Dams
 - ▲ Be sure that bags are all securely sealed.
 - ▲ Place bags by hand or use appropriate machinery.

CHECK DAMS**Maintenance**

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Accumulated sediment and leaves should be removed from behind the dams and erosive damage to the channel restored after each storm or when the original height of the dam is reached.
- ▲ All accumulated material removed from the dam shall be properly disposed.
- ▲ Replace stone as necessary for the dams to maintain their correct height.
- ▲ If sand bags are used, the fabric of the bags should be inspected for signs of deterioration.
- ▲ Remove stone or riprap if grass lined channel requires mowing.
- ▲ Check dams should remain in place and operational until the drainage area and channel are completely stabilized or up to 30 days after the permanent site stabilization is achieved.
- ▲ Restore the channel lining or establish vegetation when each check dam is removed.

Cost

- ▲ The costs for the construction of check dams varies with the material used. Rock costs about \$100 per dam. Log check dams are usually slightly less expensive than rock check dams. All costs vary depending on the width of channel to be checked.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

EARTH DIKE

September 1992

Design Criteria

- ▲ Earth dikes are appropriate in the following situations:
 - ▲ To divert upslope flows away from disturbed areas such as cut or fill slopes and to divert runoff to a stabilized outlet
 - ▲ To reduce the length of the slope runoff will cross
 - ▲ At the perimeter of the construction site to prevent sediment-laden runoff from leaving the site
 - ▲ To direct sediment-laden runoff to a sediment trapping device.
- ▲ When the drainage area to the earth dike is greater than 10 acres, the United States Department of Agriculture - Soil Conservation Service (USDA - SCS) standards and specification for diversions should be consulted.
- ▲ Table 4 contains suggested dike design criteria.

TABLE 4. SUGGESTED DIKE DESIGN CRITERIA

Drainage Area	Under 5 Acres	Between 5-10 Acres
Dike Height	18 inches	30 inches
Dike Width	24 inches	36 inches
Flow Width	4 feet	6 feet
Flow Depth	12 inches	24 inches
Side Slopes	2:1 or less	2:1 or less
Grade	0.5% - 10%	0.5% - 10%

- ▲ The base for a dike 18 inches high and 24 wide at the top should be between 6 feet - 8 feet. The height of the dike is measured on the upslope side.
- ▲ If the dike is constructed using coarse aggregate the side slopes should be 3:1 or flatter.
- ▲ The channel formed behind the dike should have a positive grade to a stabilized outlet. The channel should be stabilized with vegetative or other stabilization measures.
- ▲ Grades over 10% may require an engineering design.
- ▲ Construct the dike where it will not interfere with major areas of construction traffic so that vehicle damage to the dike will be kept to the minimum.
- ▲ Diversion dikes should be installed prior to the majority of soil disturbing activity, and may be removed when stabilization of the drainage area and outlet are complete.

Materials

- ▲ Compacted Soil
- ▲ Coarse Aggregate

EARTH DIKE**Construction Specifications**

- ▲ Clear the area of all trees, brush, stumps or other obstructions.
- ▲ Construct the dike to the designed cross-section, line and grade making sure that there are no irregularities or bank projections to impede the flow.
- ▲ The dike should be compacted using earth moving equipment to prevent failure of the dike.
- ▲ The dike must be stabilized as soon as possible after installation.

Maintenance

- ▲ Inspect regularly and after every storm, make any repairs necessary to ensure the measure is in good working order.
- ▲ Inspect the dike, flow channel and outlet for deficiencies or signs of erosion.
- ▲ If material must be added to the dike be sure it is properly compacted.
- ▲ Reseed or stabilize the dike as needed to maintain its stability regardless if there has been a storm event or not.

Cost

- ▲ The cost associated with earth dike construction is roughly \$4.50 per linear foot which covers the earthwork involved in preparing the dike. Also added to this cost is approximately \$1.00 per linear foot for stabilization practices. It should be noted that for most construction projects, the cost of earth dike construction is insignificant compared to the overall earthwork project costs.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

DRAINAGE SWALE

September 1992

Design Criteria

- ▲ Temporary drainage swales are appropriate in the following situations:
 - ▲ To divert upslope flows away from disturbed areas such as cut or fill slopes and to divert runoff to a stabilized outlet
 - ▲ To reduce the length of the slope runoff will cross
 - ▲ At the perimeter of the construction site to prevent sediment-laden runoff from leaving the site
 - ▲ To direct sediment-laden runoff to a sediment trapping device.
- ▲ When the drainage area is greater than 10 acres the United States Department of Agriculture - Soil Conservation Service (USDA - SCS) standards and specifications for diversions should be consulted.
- ▲ Swales may have side slopes ranging from 3:1 to 2:1.
- ▲ The minimum channel depth should be between 12 inches and 18 inches.
- ▲ The minimum width at the bottom of the channel should be 24 inches and the bottom should be level.
- ▲ The channel should have a uniform positive grade between 2% and 5%, with no sudden decreases where sediments may accumulate and cause overtopping.
- ▲ The channel should be stabilized with temporary or permanent stabilization measures.
- ▲ Grades over 10% may require an engineering design.
- ▲ Construct the swale away from areas of major construction traffic.
- ▲ Runoff must discharge to a stabilized outlet.

Materials

- ▲ Grass seed for temporary or permanent stabilization
- ▲ Sod
- ▲ Coarse aggregate or riprap

Construction Specifications

- ▲ Clear the area of all trees, brush, stumps or other obstructions.
- ▲ Construct the swale to the designed cross-section, line and grade making sure that there are no irregularities or bank projections to impede the flow.
- ▲ The lining should be well compacted using earth moving equipment and stabilization initiated as soon as possible.
- ▲ Stabilize lining with grass seed, sod, or riprap.
- ▲ Surplus material should be properly distributed or disposed of so that it does not interfere with the functioning of the swale.
- ▲ Outlet dissipation measures should be used to avoid the risk of erosion.

Maintenance

- ▲ Inspect regularly and after every storm, make any repairs necessary to ensure the measure is in good working order.
- ▲ Inspect the flow channel and outlet for deficiencies or signs of erosion.
- ▲ If surface of the channel requires material to be added be sure it is properly compacted.
- ▲ Reseed or stabilize the channel as needed to prevent erosion during a storm event.

DRAINAGE SWALE**Cost**

- ▲ Drainage swale can vary widely depending on the geometry of the swale and the type of lining material:
 - ▲ Grass \$3.00/square yard
 - ▲ Sod \$4.00/square yard
 - ▲ Riprap \$45.00/square yard
- ▲ No matter which liner type is used, the entire swale must be stabilized (i.e., seeded and mulched at a cost of \$1.25/square yard).

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

TEMPORARY SEDIMENT TRAP

September 1992

Design Criteria

- ▲ Temporary sediment traps are appropriate in the following locations:
 - ▲ At the outlet of the perimeter controls installed during the first stage of construction.
 - ▲ At the outlet of any structure which concentrates sediment-laden runoff, e.g. at the discharge point of diversions, channels, slope drains, or other runoff conveyances.
 - ▲ Above a storm water inlet that is in line to receive sediment-laden runoff.
- ▲ Temporary sediment traps may be constructed by excavation alone or by excavation in combination with an embankment.
- ▲ Temporary sediment traps are often used in conjunction with a diversion dike or swale.
- ▲ The drainage area for the sediment trap should not exceed 5 disturbed acres.
- ▲ The trap must be accessible for ease of regular maintenance which is critical to its functioning properly.
- ▲ Sediment traps are temporary measures and should not be planned to remain in place longer than between 18 and 24 months.
- ▲ The capacity of the sedimentation pool should provide storage volume for 3,600 cubic feet/acre drainage area.
- ▲ The outlet should be designed to provide a 2 foot settling depth and an additional sediment storage area 1 foot deep at the bottom of the trap.
- ▲ The embankment may not exceed 5 feet in height.
- ▲ The recommended minimum width at the top of the embankment is between 2 feet and 5 feet.
- ▲ The minimum recommended length of the weir is between 3 feet and 4 feet, and the maximum is 12 feet in length.
- ▲ Table 5 illustrates the typical relationship between the embankment height, the height of the outlet (H_o), and the width (W) at the top of the embankment.

TABLE 5. EMBANKMENT HEIGHT vs. OUTLET HEIGHT AND WIDTH

H	H_o	W
1.5	0.5	2.0
2.0	1.0	2.0
2.5	1.5	2.5
3.0	2.0	2.5
3.5	2.5	3.0
4.0	3.0	3.0
4.5	3.5	4.0
5.0	4.0	4.5

Materials

- ▲ Filter fabric (see fabric requirement for silt fence)
- ▲ Coarse aggregate or riprap 2 inches to 14 inches in diameter
- ▲ Washed gravel to 1 inches in diameter
- ▲ Seed and mulch for stabilization

TEMPORARY SEDIMENT TRAP**Construction Specifications**

- ▲ Clear the area of all trees, brush, stumps or other obstructions.
- ▲ Construct the embankment in 8 inch lifts compacting each lift with the appropriate earth moving equipment. Fill material must be free of woody vegetation, roots, or large stones.
- ▲ Keep cut and fill slopes between 3:1 and 2:1 or flatter.
- ▲ Line the outlet area with filter fabric prior to placing stone or gravel.
- ▲ Construct the gravel outlet using heavy stones between 6 inches and 14 inches in diameter and face the upstream side with a 12 inch layer of 1/2 inch to 1 inch washed gravel on the upstream side.
- ▲ Seed and mulch the embankment as soon as possible to ensure stabilization.

Maintenance

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Frequent removal of sediment is critical to the functioning of this measure. At a minimum sediment should be removed and the trap restored to its original volume when sediment reaches 1/3 of the original volume.
- ▲ Sediment removed from the trap must be properly disposed.
- ▲ Check the embankment regularly to make sure it is structurally sound.

Cost

- ▲ Costs for a sediment trap vary widely based upon their size and the amount of excavation and stone required, they usually can be installed for \$500 to \$7,000.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
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