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A Guide for

Environmental Protection and Best Management Practices

for

Tennessee Valley Authority

Transmission Construction and Maintenance Activities

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Transmission/Power Supply Group

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CHAPTER I

INTRODUCTION

This Guide for Environmental Protection and Best Management Practices (BMPs) was prepared to serve as a practical resource document for Tennessee Valley Authority (TVA) personnel and contractors when planning and conducting transmission construction and maintenance activities. This guide will also assist agency personnel in meeting performance standards related to state/federal storm water discharge and non-point source (NPS) pollution control legislation.

BMPs are practices chosen to minimize erosion and prevent or control sedimentation and contributions of other pollutants from land disturbance and land management activities. If properly applied, BMPs will help protect the quality of surface waters and ground water. BMPs are economical and effective methods for ensuring that TVA's construction and maintenance forces and contractors contribute to a high standard of water quality throughout the Tennessee River Watershed and the TVA Power Service Area.

The recommended BMPs outlined herein are based on current knowledge and the best judgment of experts. Other BMPs not listed or modifications of these practices may be used when known to be effective through personal knowledge and experience.

CHAPTER II

POTENTIAL POLLUTANTS RESULTING FROM TRANSMISSION CONSTRUCTION AND MAINTENANCE ACTIVITIES

Eroded soil, organic debris, heat and chemicals are the principal potential non-point source (NPS) water pollutants from transmission construction and maintenance activities. These NPS pollutants can impose adverse effects on water quality in streams, rivers, wetlands, ponds, lakes, and ground water. Eroded soil is the most prevalent pollutant.

A. Sediment

The major ground disturbing activities associated with transmission construction and maintenance are right-of-way clearing and reclearing, construction and maintenance of access roads, and site grading for the construction of transmission line structures, substations and communication facilities. Excessive right-of-way clearing, improper or careless road construction, and construction site grading can result in soil erosion and sediment deposition in surface waters, wetlands, and points of access to ground water. Sediment transport can also contribute both nutrients and contaminants trapped on the soil particles when flushed into water bodies. Suspended sediment in surface waters reduces their beneficial uses, increases water treatment costs, and harms the growth of aquatic life. Sediment deposition can block navigation channels, springs and ground water infiltration zones, reduce water storage capacities of surface waters and wetlands, increase flooding, degrade or destroy wildlife and fishery habitat, and adversely impact sensitive plants and animals.

With proper care and planning, however, transmission construction and maintenance activities can be completed in ways that will minimize soil disturbance. The amount of erosion and sedimentation occurring at a particular site depends upon the following factors or conditions:

- Inherent erodibility of the soil;
- Steepness and length of slope;
- Amount and duration of overland water flow;
- Degree and length of time the soil is exposed;
- Natural or man-made impediments to overland water flow;
- Type and density of vegetative or other cover.

Because sediment is the major potential pollutant, and because sediment is a product of soil erosion, the major emphasis of this BMP manual will be on those practices designed to reduce or prevent erosion. Practices that keep the soil in place also aid in reducing the risk of other pollutants reaching surface waters, wetlands, and ground water.

B. Organic Matter

Oxygen can be depleted in slow-moving surface waters, ponds and wetlands when leaves, tree tops, wood chips, and other organic debris are deposited directly or are flushed into water bodies. This condition can adversely affect the habitat of water-borne organisms and the quality of the water supply. Tree tops and slash left in streams, wetlands, and ground water access points may slow the water flow and change the water environment. Debris may also block the flow of water, especially during high flows, resulting in channel course alteration and accelerated streambank erosion or sinkhole development in karst areas. Excessive amounts of tree tops and slash can cause further damage to streams and wetlands if they are washed in or out by flooding. They can scour the streambed and

damage the ground seal as well as deposit sediment loads further downstream as they are washed along by flood waters.

C. Heat

The temperature of forest streams, wetlands and other surface waters can be raised if vegetation adjacent to the water bodies is removed during construction and maintenance activities. Severity of the impact depends upon size and flow of the surface water and/or ground water source and upon the kinds of aquatic life present. Small streams may be severely impacted immediately, but are usually less adversely affected through time because they are quickly shaded by small trees and shrubs that sprout after clearing or re-clearing. Large streams, wetlands, and ponds may change temperature more slowly due to their high thermal capacity, but they may have more surface exposed to direct sun. In either case, when a right-of-way or access road parallels or crosses and recrosses a stream or pond in a limited area, the impacts will be more severe.

D. Chemicals

Herbicides are selectively used during right-of-way construction and are often used to remove or control unwanted vegetation during maintenance phases. They are applied directly to individual tree stumps during clearing and are selectively applied or broadcast during maintenance using either ground equipment or aircraft. If chemicals such as herbicides are allowed to enter water channels, they may have a significant impact on water-borne organisms and alter the quality of water for consumptive use. The particular impact varies widely from one chemical to another and depends primarily on the chemical's absorption into the plants, rate of degradation, mobility, persistence, and the accuracy of its placement. Lime and fertilizers used in re-establishing vegetation can also be washed into surface or ground waters and alter their quality.

CHAPTER III

SENSITIVE RESOURCES

A. Wetlands

Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands are generally swamps, marshes, bogs, wet meadows and other similar areas where the water table is at or near the surface. They also can be less obvious areas such as flats and bottoms that do not appear wet.

Wetlands have been recognized as one of the Nation's important resources. Wetlands have many functions and values among which are: water quality improvement, timber production, fish and wildlife habitat, scenic beauty, recreation, nutrient cycling, ground water recharge, flood abatement, education, and research.

Properly and carefully implemented BMPs will protect and enhance important wetland functions on most sites under most weather conditions. On extremely sensitive sites or in extremely severe weather conditions, more stringent protection measures may be required, including complete avoidance of such sites.

A national standard exists that helps reduce some of the confusion about identifying wetland areas and delineating their boundaries. The methodology is found in the Federal Manual for Identifying and Delineating

Jurisdictional Wetlands (Environmental Laboratory 1987). According to federal guidelines, wetlands possess three essential characteristics: (1) wetland hydrology, (2) hydrophytic vegetation, and (3) hydric soils. Each characteristic is described in the following text.

Questions regarding wetlands should be directed to Siting and Environmental Design in Transmission Line Projects (423-751-3133) or to TVA's Natural Heritage program (865-632-1593).

Wetland Hydrology

Areas with wetland hydrology are periodically inundated or have soils saturated to the surface at some time during the growing season. This situation usually creates anaerobic conditions in the soil which affect the types of plants that can grow and the types of soils that develop. All wetlands usually have an abundance of seasonal water that may come from direct precipitation, overbank flooding, surface water runoff, or ground water discharge. Factors that influence the wetness of an area include precipitation, stratigraphy, topography, soil permeability, and plant cover.

Evidence of the periodic presence of inundation typically seen in wetlands are water marks, drift lines, water-borne sediment deposits, surface scouring, and morphological plant adaptions such as cypress knees and buttressed trunks on trees.

Hydrophytic Vegetation

Hydrophytic plants are adapted to growing in water, soil or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content. A national interagency panel has developed a "National List of Plant Species That Occur in Wetlands" that has been subdivided into regional lists (Reed 1988). The list separates vascular plants into five basic groups commonly called "wetland indicator status" based on a plant species frequency of occurrence in wetlands. They are (1) obligate wetland, (2) facultative wetland, (3) facultative, (4) facultative upland, and (5) obligate upland. An area has met the hydrophytic vegetation criteria when, under normal circumstances, more than 50 percent of the composition of the dominant species from all strata (trees, shrubs, grasses) are obligate wetland (OBL), facultative wetland (FACW), and/or facultative (FAC) species.

Hydric Soils

The U.S. Department of Agriculture Natural Resource Conservation Service (1999) has defined hydric soils as soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. Most soils in TVA's Power Service Area are Thermic with a growing season of March-October. The National Technical Committee for Hydric Soils has developed a list of the Nation's hydric soils that has been subdivided into state and county lists based on the physical characteristics of organic and mineral soils. This list is updated regularly and can be accessed via the internet at www.statlab.iastate.edu/soils/hydric/.

Endangered or threatened species (plants and animals), public water supplies, ground water sources, and critical wildlife habitats (e.g., trout streams, waterfowl habitat, wading-bird nesting areas, heronries) must not be jeopardized by discharges from construction or other activities. This includes other sensitive environmental areas such as sinkholes, special aquatic features or organisms.

Site preparation, construction and subsequent maintenance activities must not directly or indirectly adversely impact sites or areas that possess certain unique values. These values include archaeological and historical, ecological, geologic, recreational and scenic. Examples of these special sites or areas include archaeological sites and historical structures or sites; state parks, forests, wildlife management areas and refuges, monuments, designated natural areas, and recreation areas; and scenic rivers or parts of the National Wild and Scenic River System.

TVA Watershed Technical Services in Resource Stewardship has professionals who are familiar with these special areas and the agencies that manage them. Plans should be coordinated with the respective program in Watershed Technical Services (865-632-1602). The programs are Cultural Resources, Land Reclamation, Recreation, and Natural Heritage. All applicable state and federal laws protecting these resources must be adhered to at all times.

CHAPTER IV

FACTORS INFLUENCING THE SOIL EROSION PROCESS

Erosion is the process by which soil particles are broken loose by rainfall and overland water flow and transported away. The primary factors influencing the erosion process are climate, soil properties, topography, and vegetation. Knowledge of these factors will assist construction and maintenance personnel in minimizing the impact of their activities on individual sites.

A. Climate

Free-falling raindrops impact the soil with much greater energy than does an equal amount of flowing water. If land surfaces have no vegetative cover or other protective debris to cushion the impact, the total energy of falling rain is expended on dislodging soil particles. Loose particles are easily moved and, under certain conditions, carried away by overland water flow or from wind and wave action in flooded situations. The erosive power of rainfall depends on the amount, intensity, duration, and frequency of storm events. For example, intense, short duration storms are more erosive than longer duration rainfalls of low intensity.

Temperature can also affect the erosion process. Frozen soils are very resistant to erosion; however, the action of freezing and thawing can loosen the soil surface and make it more susceptible to erosion. Temperature and precipitation patterns also influence the development of soils and vegetation.

B. Soil Properties

The volume of overland flow that develops from a given rainstorm is related to physical factors that influence the infiltration and movement of water through the soil. Knowledge of the following factors will assist construction and maintenance personnel in predicting the tolerance different sites may have when disturbed by clearing, construction, re-clearing and maintenance activities. For example, on deep sands and on level terrain, regardless of texture, the likelihood of creating conditions for rapid overland flow is small or negligible. With fine textured soils and steeper terrain, both the kind and the intensity of operations should be modified to reduce the amount and velocity of overland flow. The local USDA Soil and Water Conservation District representative and published soil surveys can be consulted to obtain soil information on specific sites.

1. Soil Texture

Soil texture is the relative proportions of sand, silt, and clay particles in a soil (Figure 1). Soil texture is determined both by the nature of the parent rocks from which the soil was derived, and by the time and conditions under which weathering took place. Sandy soils have larger sized pores than do finer textured soils such as clays, and therefore they let more water enter the soil surface. The influence soil texture has on its susceptibility to erosion is shown in Table 1.

Construction and maintenance personnel have no control over texture and so must recognize the areas where different soil textures occur and select the best materials to use in roads or other construction or maintenance needs.

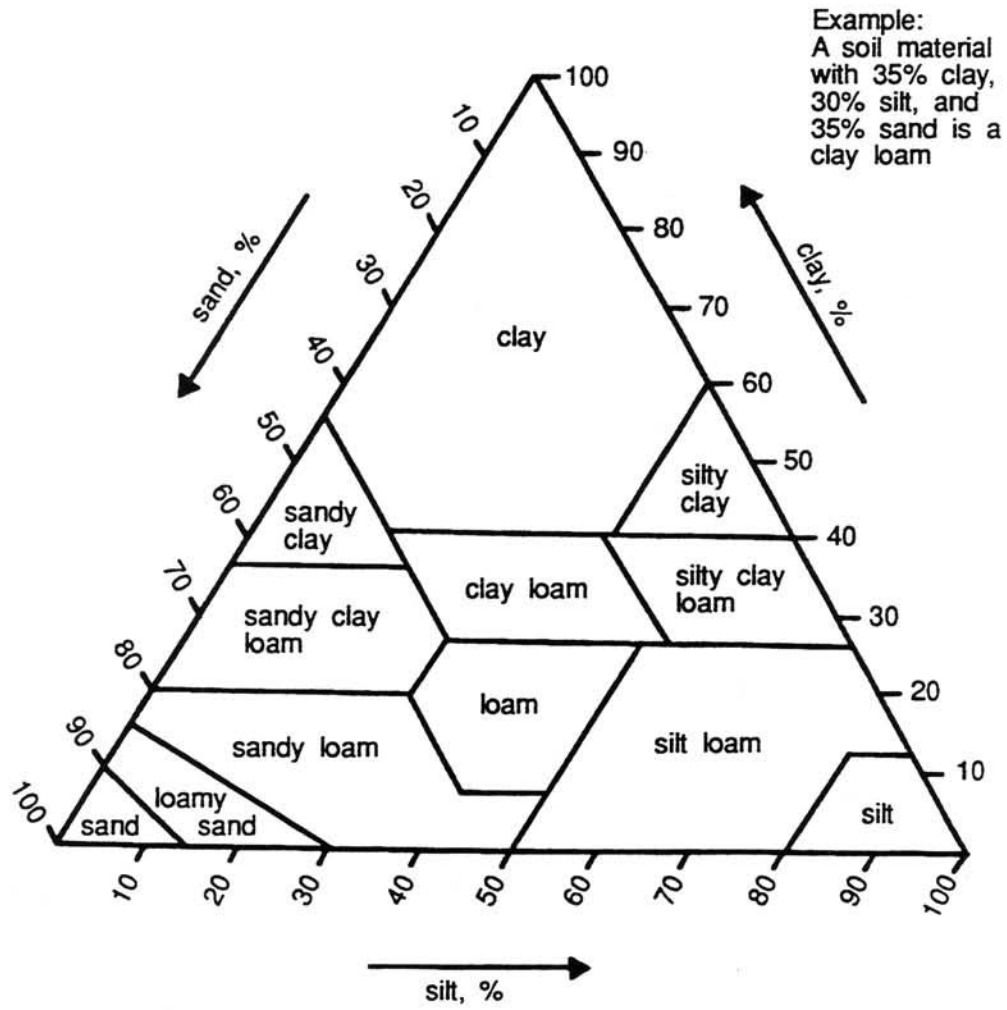


Figure 1. Soil textural triangle (expressed as a percent of soil dry weight).

Table 1. Soil erosion susceptibility of texture phases.

Surface Soil Texture	Susceptibility to Erosion
1. Silt loam, loam, very fine sandy loam	Highest
2. Sandy clay loam, silty clay loam, clay	
3. Clay, silty clay, sandy clay	
4. Fine sandy loam, sandy loam	
5. Loamy sand, sand	Lowest

2. Soil Structure

Soil structure refers to the arrangement of soil particles into aggregates. Fine-textured soils can have individual particles forming aggregates with spaces between them which provide room for considerable water storage and retention. Thus, well structured soils often permit faster rain infiltration equal to or better than do coarse sands. Fine textured soils with very weak or platy structure usually have poor water infiltration.

3. Soil Porosity

Porosity is the total volume of void space within a soil that can contain air or water and is expressed as percent by volume. Porosity is influenced by soil texture and structure, freeze/thaw and wet/dry cycles, activity of soil organisms, and patterns of root size and distribution. Compaction by heavy equipment operation reduces porosity.

4. Soil Bulk Density

This is the weight per unit volume of dry soil. Bulk density is an indication of soil porosity and is reduced by operation of heavy equipment which compacts the soil.

5. Infiltration Capacity and Soil Permeability

Infiltration capacity and soil permeability refer to the capacity that soil has for water movement into and through its particles. Infiltration and permeability are highest for undisturbed forest and grassland soils and soils with good

structure; that is, a relatively high proportion of large, interconnected pores, and a relatively low bulk density. Surface runoff and erosion occur least when infiltration and permeability of the soils are highest. Operation of heavy equipment that compacts and/or churns the soil or removes the coarser upper horizon destroys the soil structure, reduces porosity, increases bulk density and thereby reduces infiltration capacity and permeability.

6. Soil Moisture Content

The amount of water in the soil influences available air space and therefore the potential soil storage capacity when precipitation begins. Infiltration capacity is highest when the soil is dry and lowest when the soil is saturated (i.e., all pores are filled with water). Also, when the soil moisture content is high, the soil is more easily deformed with resulting destruction of soil structure and reduction of porosity (bulk density). Soil erodibility is also higher when moisture content is high.

7. Unique Features of Some Soils

Some soil material is so fine that the particles may not settle out from suspension in water for months. Soils possessing these characteristics can swell on wetting or shrink on drying, forming large cracks. Swelling causes soil pores to shrink, making water intake difficult (or impossible) and thus increasing the likelihood of overland flow. Operators need to recognize soil types in which clay or finely-divided organic matter can hinder water intake, and those that are subject to easy compaction and plastic flow. Such soil types may suffer severe damage during wet weather operations.

8. Frozen Soils

When a surface soil is frozen, it is no better for intake of water than a paved parking lot. With a good forest floor layer as an insulating protective mantle, soil surfaces remain unfrozen for long periods after bare soil is frozen and incapable of admitting moisture. Destruction of the forest floor should be avoided as a means of minimizing temporary conditions of frozen soils and providing an impact absorption layer for raindrops. Frozen soils might be a temporary problem in the TVA Power Service Area during a few winter days when an ice layer occurs, or at high elevations.

9. Soil Organisms and Organic Matter

Pore size and distribution (the number of air spaces in the soil) are greatly affected by the activities of earthworms, grubs, ants, mice, shrews, and other soil animals. Their activities create channels through which water enters and moves through the soil. In this way too, organic matter is incorporated into the soil surface. Consequently, any operation that destroys organisms and reduces organic matter will invariably accelerate the amount and velocity of overland flow.

C. Topography

The erosivity of water falling on or flowing over the ground surface increases as the volume and velocity of flow increase. Therefore, steeper, longer slopes, and topography that causes surface runoff to concentrate in large volumes will increase erosion. Runoff velocity can be decreased by reducing the steepness of slopes, increasing the roughness of the ground surface (e.g., by tracking with a dozer), and shortening the length of the slope by using diversion structures.

Ephemeral and intermittent wet season streams or wet weather conveyances (hollows, gullies, etc.) carry surface runoff during precipitation events (called stormflow) when downslope subsurface flow of infiltrated water creates a saturated zone at the base of slopes. As rainfall continues, the zone of saturation, from which water is seeping into the usually dry channels, expands upslope and the length and area of stream flow expands. If the soil is disturbed in the intermittent and ephemeral channels, large amounts of sediment can be picked up by the flowing water and delivered to the perennial surface waters, wetlands, or sinkholes.

D. Vegetation

Vegetation protects the soil from the impacts of rain droplets and slows the velocity of surface runoff by increasing flow friction. Root systems help hold the soil particles together and can increase the soil porosity and thus its infiltration capacity. Plants also increase the amount of water that soil can absorb by removing water from the soil through transpiration and by providing organic matter on the surface and in the soil. A dense vegetative cover is one of the best defenses against soil erosion.

CHAPTER V

BEST MANAGEMENT PRACTICES FOR TRANSMISSION CONSTRUCTION AND MAINTENANCE ACTIVITIES

Best Management Practices (BMPs) are practices chosen to minimize erosion and prevent or control water pollution resulting from land disturbance and land management activities. If properly applied, BMPs will protect the quality of our waters. The best stormwater management strategy is to use BMPs that increase infiltration in the drainage area to reduce the amount of rainfall that actually becomes runoff.

The basic principles of erosion and sediment control which must be considered in selecting appropriate BMPs are as follows:

- Plan clearing, grading and construction to minimize the area and duration of soil exposure.
- Maintain existing vegetation wherever and whenever possible.
- Minimize disturbance of natural contours and drains.
- As much as practicable, operate on dry soils when they are least susceptible to structural damage and erosion.
- Limit vehicular and equipment traffic in disturbed areas.
- Keep equipment paths dispersed or designate single traffic flow paths with appropriate road BMPs to manage runoff.
- Divert runoff away from disturbed areas.
- Provide for dispersal of surface flow that carries sediment into undisturbed surface zones that have high infiltration capacity and ground cover conditions.
- Prepare drainage ways and outlets to handle concentrated or increased runoff.
- Minimize length and steepness of slopes. Interrupt long slopes frequently.

- Keep runoff velocities low and/or check flows.
- Trap sediment on site.
- Inspect and maintain control measures on a regular basis and after significant rainfall events.
- Revegetate and mulch disturbed areas as soon as practical after each disturbance.

- BMPs for transmission clearing, construction, re-clearing and maintenance activities can be categorized as follows: (1) pre-construction planning, (2) access road measures, (3) clearing practices, (4) construction site measures, (5) structural controls, (6) vegetative controls, (7) good housekeeping, (8) waste disposal, (9) herbicide use, (10) storm water discharge control, and (11) inspection, recordkeeping, and reporting. Some measures or controls can be used independently, others must be used jointly. Erosion and sediment controls are not limited to the following practices. However, alternative measures must be at least as effective in controlling erosion and sedimentation.

A. Preconstruction Planning

First and foremost, an erosion and sediment control/BMP/storm water control plan should be developed prior to each ground disturbing project. Preconstruction planning includes the collection and use of information about the project site and adjacent areas as well as any borrow areas and access roads. An effective preconstruction plan will consider all aspects of clearing, construction, re-clearing and maintenance activities which might cause erosion and/or water quality degradation. The plan shall identify the specific BMPs needed to minimize these adverse effects along with the proposed locations for their implementation.

Stream Crossing - See also our course "A Guide to Low Water Stream Crossings"

The written plan must address the regulatory requirements of the respective state water pollution control department as well as any applicable federal agencies (e.g., U.S. Army Corps of Engineers, U.S. Fish and Wildlife Services, etc.). In addition to the information required by regulatory agencies, the plan should also address the following: property boundaries; existing vegetation; soils; slopes; wetlands, ground water infiltration zones and other sensitive resources; timing of construction (season or weather); construction approach (i.e., shear clearing, chipping, grading or fill, helicopter use); watercourses; streamside management zones; approximate location and drainage of access roads; planned temporary stream crossings; locations to spot mobile or portable fuel and oil storage tanks; installation and/or removal of water and sediment control measures; retiring access roads; revegetation of disturbed lands (temporary and permanent cover); and other rehabilitative measures as appropriate.

A specific individual shall be designated to be responsible for overseeing BMP plan implementation on each project site. Each employee on the site has an obligation to ensure that the BMPs are properly installed, inspected, and maintained until the site is fully stabilized. A copy of the plan must be kept on site and be made available to the respective state inspector on request.

Temporary Stream Crossings - See also our course related to temporary stream crossings "A Guide to Low Water Stream Crossings"

B. Access Road Measures

Proper drainage, together with proper location and construction on relatively gentle gradient, is one of the most important factors in minimizing soil movement from access roads and keeping them in serviceable condition. The goal should be to drain water off the roads as soon as possible within practical and economical limits. Several drainage structures and techniques are available (Figure 2). The type, number, and combination needed depends upon topography, soil types, equipment usage, and objectives for road use. Locations and types of drainage structures should be identified before road constructions begins.

1. Roads should be located as high above and as far away as possible from surface waters, wetlands, and sinkholes or other ground water infiltration zones and still perform their intended function. Where possible, locate roads near crests of ridges on gentle side slopes to ensure adequate side drainage. Avoid wet flood plain soils where good drainage is difficult to establish and maintain. To the extent possible, avoid disturbing the natural drainage system.
2. Streams shall not be used as transportation routes for vehicles or equipment. Erosion and sediment control measures must be used where the stream bank is disturbed.
3. Minimize the number of stream crossings. When necessary, cross at right angles to the streambed to minimize disturbance within and adjacent to the channel. Stream-crossing structures should be sized and installed so as not to impede fish passage (where applicable) or stream flow. Any stone or riprap placed in a stream must not negatively impact water chemistry.

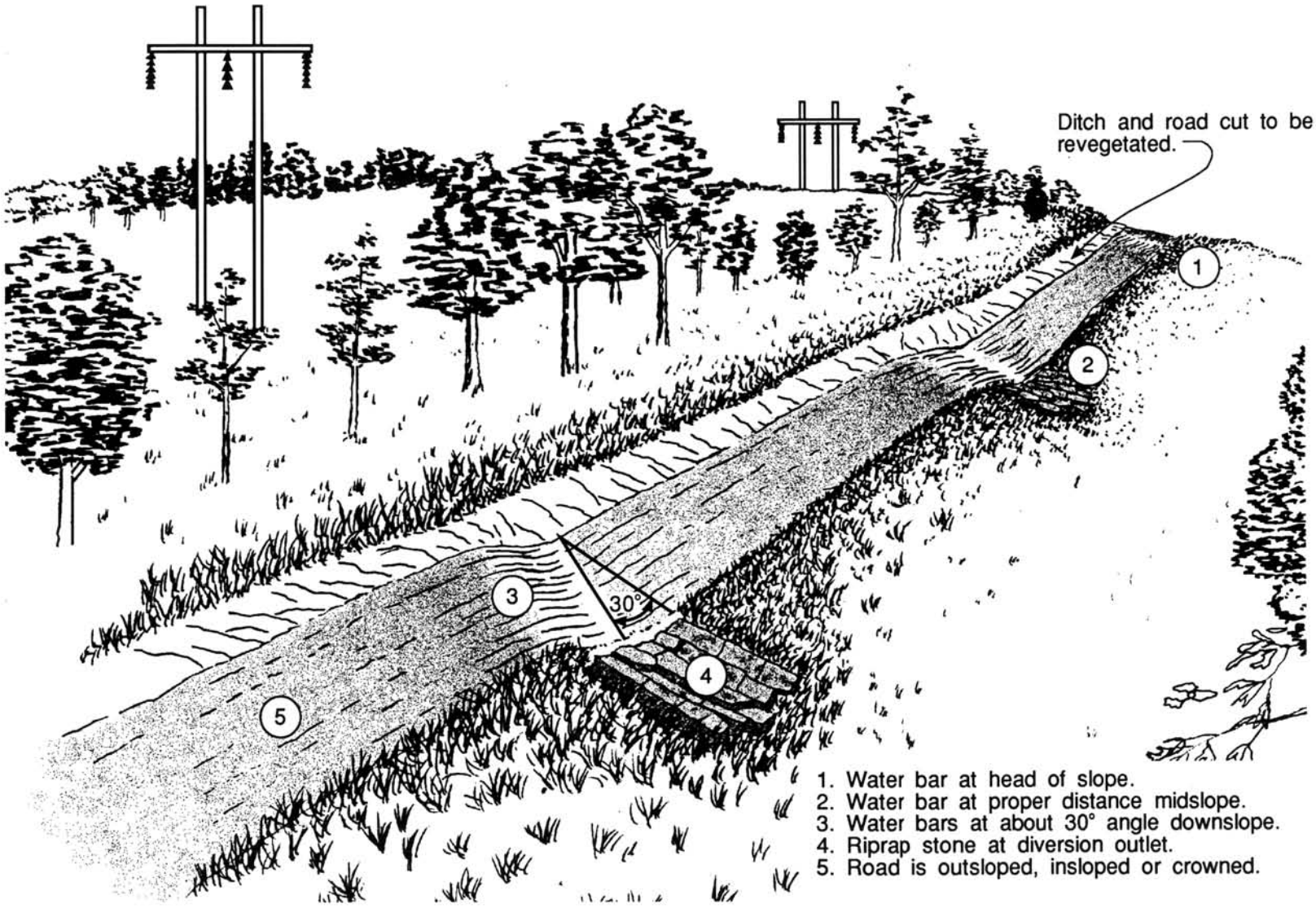


Figure 2. Select features of a protected access road.

4. Sloping road approaches to intermittent and perennial stream crossings should have effective water control measures installed to protect stream channels from direct surface flows. Cross drains and/or water turnouts may be used to direct surface flow away from the road or ditch and into undisturbed areas. Such diversions should be installed at least 25 feet from the stream channel to allow concentrated flows to slow and spread before entering the stream channel. Such diversions should be installed as needed at all fords, pipe culverts, or bridge crossings.
5. When possible, avoid wetlands and problem areas such as wet areas, seeps, fragile soils, steep slopes, and other areas where disturbance could result in serious problems with drainage, soil compaction, or erosion. If wetlands access is necessary, appropriate measures must be taken to minimize disturbance within the wetlands.
6. Gradient (or steepness) is a major factor in the amount of erosion that may occur on access roads. Ideally, road grades should range from 3 to 10 percent. Steeper grades of up to 20 percent may be acceptable for short distances provided adequate drainage structures are constructed. When possible, avoid constructing road sections on grades of less than three percent as they are difficult to drain and tend to develop mud holes. Also, avoid long sustained grades by varying the degree of slope. Shortening the length of slope by breaking grade can reduce erosion by reducing the volume and slowing the speed of water flowing along the road surface.
7. Cuts, fills, and borrows should be balanced to the extent practical to minimize soil disturbance and the amount of material which must be moved. Side slopes on cuts, fills, and borrow areas should be stable and should vary in length according to the soil type present. Vertical road bank cuts in erodible material should normally not exceed five feet in height. Road bank cuts more than five feet high should be sloped to

at least a 2:1 ratio and a ground cover provided to control erosion. Roads having high-cut banks should be used only when no better alternative exists. All fill material should be kept above stream flood levels and away from wetlands, wet weather conveyances and ground water infiltration zones.

8. On major truck access road entrances that intersect public highways, gravel, wooden mats, or other means should be placed on the first 100 feet of entrance to minimize mud from being carried to and deposited on the highway. Promptly clean up mud deposited on these highways at the end of the work day.
9. Temporary (overnight, weekend, and holidays) erosion and sediment control measures must be installed at the intersection of access roads with public highways or private driveways. The most effective measure to minimize sediment from being washed onto these areas during short periods of nonuse is establishing proper surface water drainage patterns on the access roads.
10. Wooden mats, constructed of undressed 2 inch x 8 inch hardwood lumber, can be used as a replacement for surface aggregate to protect culverts, bridges, and soft soils.
11. Geotextiles or fabric materials may be used to increase soil-bearing capability. Geotextiles placed under borrow or fill will reduce soil failure or deep rutting. Geotextiles reduce the thickness of base material needed, reduce deep road compaction, and allow natural flow of ground water.
12. Trim shading vegetation as needed to maximize drying of the roadbed (daylighting).
13. Use cleared materials for brush barriers or check dams along road fills or other erodible areas, but do not place them in wet weather conveyances, wetlands, streams, or sinkholes.

14. Proper road drainage should be accomplished through outsloping, insloping, crowning, dips, and culverts.

a. Outsloping: Outsloping is an effective way to rapidly drain excess water from roads constructed on gentle and moderate slopes. Outsloped roads also reduce the number of other structures needed for proper drainage. Roads constructed in this manner should be outsloped toward the fill bank at the rate of 1/4-inch per foot of road width or 2 to 3 percent.

b. Insloping: Roads should be insloped 2 to 3 percent on steep, sharp turns, and slippery soils as a safety measure. Drainage ditches should be constructed to collect inslope drainage, and culverts should be installed to carry drainage to the downhill side of the road.

c. Crowning: Roads or road sections constructed on gently sloping or flat land should be built with a high center or crowned, and side ditches should be provided to catch water draining from the surface. Provide water turnouts or wing ditches to divert water onto the adjacent undisturbed areas.

d. Dips: Dips are economical, relatively trouble free structures for providing effective drainage of access roads. Dips are considerably lower in cost than culverts; so time spent in careful construction is well justified.

(1) Broad-based Dips: Use broad-based drainage dips to provide cross drainage on flat and insloped roads to prevent buildup of excessive surface runoff and subsequent erosion. Broad-based dips are usually not used on steep roads (greater than 12 percent).

(2) Narrow-based Dips: Use narrow-based dips, water bars, or mound-trenches to intercept and divert surface water off the road and to minimize excessive erosion and/or gullying.

e. Culverts: Use pipe culverts to carry cross road drainage on any road where storm water runoff, ditch to ditch transfer, or overland seepage might create wet areas and erosion. Above culverts, use coarse rock to slow the water velocity and prevent blockage. Below cross drain outlets, install riprap, logs, or heavy brush to function as energy absorbers and to spread water. The use of culverts should be minimized. Alteration of the natural flow of surface water usually results in a loss of biological productivity and a reduction in the scenic value of the area. Increased velocity of water flowing through pipes and manmade channels aggravates erosion, especially downstream from the site. Culverts also require frequent maintenance.

15. As soon as all construction activity has ceased, roads should be retired or "put to bed." Several steps should be taken to protect roads from erosion during periods of nonuse. Roads should be regraded and smoothed. Dips, side ditches, and turnouts should be reshaped, and sediment and debris should be removed to promote proper drainage. In order to minimize soil movement, such areas should be revegetated as quickly as possible after road construction. Consider seeding roads and banks with plants that enhance wildlife. Continue traffic control on roads to reduce erosion, sedimentation, and maintenance problems.

16. Roads not needed for maintenance purposes or landowner needs should be blocked to stop unnecessary vehicular traffic and associated land disturbance.

C. Clearing Practices

1. Clearing, grubbing, and other land disturbances must be held to the minimum necessary for the construction need.
2. Chipped woody vegetation must be uniformly spread over the cleared area or disposed of in other environmentally sound ways. No chips are to be placed inside a streamside management zone (SMZ), wetland, sinkhole or other sensitive area.
3. Where possible, trees should be felled away from and out of any surface waters, wetlands, sinkholes or wet weather conveyances. If they must be felled into those areas, they must be removed immediately and placed above high water flow or backflow, at a location where they will not be washed or floated into watercourses. Trees must be removed by hand labor or by use of a cable or low ground pressure equipment. The removal method which causes the least amount of damage to the banks or bottom of the waterbody should be utilized.
4. Cutting of trees in SMZs must be accomplished using hand-held equipment or other appropriate clearing equipment such as a feller-buncher. The clearing method should be selected based on site specific conditions and topography to minimize soil disturbance and impacts to the stream or other waterbody. Stumps within SMZs must not be uprooted or removed.
5. Equipment crossing of streams must be at right angles and minimized to prevent further impacts.

6. Stream side vegetation that will not impact the lines, such as small mature trees or trees in ravines should not be cut (only an access path should be cut), in order to mitigate temperature and sediment runoff impacts.

7. Steps must be taken to protect all wet weather conveyances, even when they are not identified as a blue line stream on a topographic map.

D. Construction Site Measures

1. Large construction projects must be staged or phased to minimize the exposure time of cleared areas. Areas of one phase must be stabilized before another phase can be initiated. Stabilization shall be accomplished by temporarily or permanently protecting the disturbed soil surface from rainfall impacts and runoff.

2. Grading activities must be avoided to the maximum extent possible during months of highly erosive rainfall.

3. If practicable, erosion and sediment control measures must be in place and functional before earth moving operations begin. All control measures must be properly constructed and maintained throughout the construction and stabilization period.

4. Construction debris must be kept from entering surface waters, wetlands, wet weather conveyances and other types of access to existing water bodies or ground water.

5. Stockpiled soil shall be located far enough from streams, wetlands and drainage ways so that runoff cannot carry sediment downstream or into adjacent wetlands.

E. Structural Controls

1. Staked and entrenched straw bales and/or silt fences should be installed along the base of all backfills and cuts, on the downhill side of stockpiled soil, and between soil disturbance areas and any water bodies, wetlands or conveyances to them. An effective approach is to use both silt fence and straw bales together. The straw bales are to be entrenched on the upslope side of the entrenched silt fence.
2. All surface water flowing toward a concentrated construction area shall be diverted around disturbance areas using diversion dikes, berms, channels, or temporary check dams, as necessary. Temporary diversion channels must be lined (i.e., erosion control blankets or liners, riprap, etc.) to above the expected high-water level and protected by nonerodible material to minimize erosion. Clean rock, log, sandbag, or straw bale check dams shall be properly constructed to detain runoff and trap sediment.
3. Erosion and sediment control measures shall be designed, according to the size and slope of disturbed or drainage areas, to detain runoff and trap sediment.
4. Discharges from sediment basins and traps must be through a pipe or lined channel so that the discharge does not cause erosion.
5. Muddy water to be pumped from excavation and work areas must be held in settling basins or treated by filtration prior to its discharge into surface waters or sinkholes. Dewatering discharges must be covered by a National Pollutant Discharge Elimination Permit (NPDES) permit. Water must be discharged through a pipe or lined channel so that the discharge does not cause erosion and sedimentation.

F. Vegetative Controls

The best and most cost-effective protection against soil erosion is a good vegetative cover. The role of vegetation in stabilizing soils and protecting watersheds is universally recognized. Vegetation dissipates the energy of rain and slows the movement of runoff water. Roots and organic matter hold the soil in place. Vegetation tends to increase water movement through the soil, thus reducing runoff. Existing vegetation, particularly on steep slopes and in natural drains, should be protected.

1. A streamside management zone (SMZ) or filter/buffer strip of vegetation must be left along both sides of perennial and intermittent streams and other water bodies. Recommended widths for SMZs are outlined in the Streamside Management Zone section of this guide.
2. Unnecessary canopy removal along streams, in wetlands, and around springs and sinkholes or other infiltration zones must be avoided. When necessary, trees and shrubs should be cut so that they fall away from the stream. It is recommended that at least 50 to 75 percent of the low canopies (under 15 feet mature height) shading the stream be left to maintain normal water temperatures.
3. Trees and/or shrubs located in hollows, valleys, down slope side hills, or other topographic low spots that do not interfere with construction needs, safety considerations, operations, or maintenance (danger trees) must remain undisturbed. This also applies to visually sensitive or recreation areas.
4. Preconstruction vegetative ground cover should not be destroyed, removed, or disturbed more than 20 calendar days prior to grading or earth moving.

5. Temporary soil stabilization with annual vegetation or other appropriate cover material shall be initiated as soon as practicable on all disturbed areas, including roads, where construction activities have temporarily (less than 21 days) or permanently ceased.
6. Permanent soil stabilization with perennial vegetation shall be applied to all disturbed areas at the earliest opportunity after soil disturbance activities have permanently ceased.

G. Good Housekeeping

BMPs will also minimize the movement of many pollutants other than sediments. Those pollutants that are mixed in solution or are carried on fine grained sediments may pass through all BMPs and eventually reach downstream water bodies. Materials such as petrochemicals are nearly impossible to control once they are present in runoff water. The only practical control option available is to prevent these pollutants from reaching runoff or flood waters through the use of proper application techniques and good housekeeping practices.

Control of petrochemical runoff, such as oils, gasoline, and greases involves the use of BMPs since these materials adhere to, or coat sediment particles. Additional control practices are as follows:

1. Used oil, grease, and rags must be disposed of in proper receptacles and kept out of contact with rainfall or runoff water.
2. The dumping of waste materials, including any used petrochemical containers, at the site is prohibited.
3. Liquid and solid waste must be collected in containers and regularly transported from the site to sanitary landfills.

4. Equipment repairs and washing must be undertaken at specific locations (i.e., away from surface waters, drains and sinkholes).
5. All on-site vehicles must be monitored for leaks and receive regular preventative maintenance to reduce the chance of leakage.
6. Any petroleum products, paints, or chemicals present at the site must be stored in tightly sealed containers which are clearly labeled and are properly stored when not in use.
7. Mobile or portable oil storage tanks should be positioned or located to prevent spilled oil from reaching water courses. A secondary means of containment, such as dikes or catchment basins, should be furnished for the tank(s). The tank(s) should be located where it will not be subjected to periodic flooding or washout.
8. Spill response equipment and sufficient absorbent material to contain and clean up fuel or chemical spills or leaks must be maintained onsite or be readily available. Spills of paint, chemicals, oil, etc. must be immediately cleaned up, and contaminated soil and absorbent materials must be promptly removed and placed into appropriate waste containers. The wastes must then be properly characterized in order to determine the required method of disposal. Solid wastes may be removed and disposed in an approved landfill. Special or hazardous wastes must be managed by appropriate permitted facilities according to all applicable regulations.

H. Waste Disposal

Waste Materials: All trash and construction debris from the site will be hauled to an approved landfill. No construction waste material will be buried or burned on-site. Clearing debris (brush and timber) may be burned on-site in accordance with local fire regulations. Employee waste and other loose

materials will be collected and properly disposed of so as to prevent the release of floatables during runoff or flood events. Liquid wastes will be properly collected in a DOT-approved container onsite. An environmental engineer will be designated to characterize the waste and coordinate and manage the disposal with the appropriate permitted facilities according to applicable regulations.

Hazardous Waste: In general, hazardous wastes are not expected to be generated or encountered in these projects. However, the hazardous materials used do present the potential for hazardous waste generation (e.g., painting/stripping, chemical spills, fuel spills). In the event that hazardous waste is encountered or generated, all wastes will be properly collected, managed and disposed according to EPA, state and/or local regulations. An environmental engineer will be designated to support any events.

Sanitary Waste: Portable sanitary units will be provided for use by all workers throughout the life of construction projects. All sanitary waste will be regularly collected from the portable units by a licensed sanitary waste management contractor.

I. Herbicide Use

Herbicides are sometimes used on stumps and low growing brush during right-of-way clearing and more often during maintenance. All alternatives to herbicide use should be considered and implemented when possible (e.g., landowner maintenance, livestock grazing). Herbicides can be liquid, granular, pellets, or powder and can be applied aerially or by ground equipment and may be selectively applied or broadcast depending on the site requirements, species present, and condition of the vegetation. Water

quality considerations include measures taken to keep herbicides from reaching streams whether by direct application or through runoff of or flooding by surface water. "Applicators" must be trained, licensed and follow manufacturers' label instructions, EPA guidelines, and respective state regulations and laws.

1. If herbicide use is deemed necessary, their potential adverse impacts must be considered in selecting the compound, formulation, and application method. Conditions that contribute to the offsite migration of a herbicide should be avoided. For example, a herbicide that is hand applied in pelletized form can be very mobile and adversely impact nontarget areas, e.g., picloram is very mobile in water.
2. Herbicides that are designated "Restricted Use" by the Environmental Protection Agency require application by or under the supervision of applicators certified by the respective state control board. They also require detailed records of application developed on a timely basis.
3. Knowledge of the chemical being used and adherence to the manufacturer's specifications and directions are essential to the protection of water quality. The label contains information regarding applicator safety; species for which the chemical is registered; the application rate or concentration; appropriate weather conditions during application; environmental impacts; and proper container disposal. Material Safety Data Sheets provide toxicological data that are available from the chemical manufacturer.
4. Transportation regulations for herbicides must be followed. Accidents that result in spillage must be promptly reported to proper authorities and immediately cleaned up.
5. Disposal of herbicide containers must be in accordance with directions given on the label.

6. Herbicide containers or applicator equipment must never be cleaned in or near streams, water bodies, or ground water infiltration zones.
7. Mixing of herbicides must be done with care to avoid spillage and to ensure that excessive amounts of chemicals are not being applied.
8. Application equipment will be properly maintained and adjusted to prevent spillage and excessive application of vegetation control materials. Frequent inspection and calibration of equipment is recommended.
9. Aerial application and ground application of liquid, granular, pellet, or powder formulations will be done in accordance with the following guides:
    a. Whether the application is made by contractors or TVA forces, the sites to be treated should be selected and the application directed by the appropriate TVA official (i.e., contract administrator, Transmission Service Center Manager, Right-of-way Program Administrator, or line foreman).
    b. A preflight walking or flying inspection must be made within 72 hours prior to applying herbicides aerially. This inspection should ensure that no land use changes have occurred, that sensitive areas are clearly pointed out to the pilot, and that proper buffer zones are maintained.
    c. Aerial application of liquid herbicides normally will not be made when surface wind speeds exceed five miles per hour, in areas of fog, or during periods of temperature inversion.
    d. Pellet application normally will not be made when the surface wind speeds exceed ten miles per hour, or on frozen or water saturated soils.
    e. Liquid application will cease when the temperature reaches 95 degrees (F) or above.

f. Application during unstable, unpredictable, or changing weather patterns will be avoided.

g. Equipment and techniques will be used that are designed to ensure maximum control of the spray swath with minimum drift.

h. Under no circumstances will herbicides or fertilizers be applied to the surface of water bodies, wetlands or ground water infiltration zones unless specifically labeled for aquatic use. Filter and buffer strips must conform at least to federal and state regulations and any label requirements. The use of aerial or broadcast application of herbicides is not allowed in any SMZ (200 feet minimum width) adjacent to perennial streams, ponds, and other water sources. Hand application of certain herbicides may be labeled for use within SMZs; however, they should be used only selectively. For additional information on SMZs, see the Streamside Management Zone section of this guide.

i. Buffers and filter strips (200 feet minimum width) are required next to agricultural crops, gardens, farm animals, orchards, apiaries, horticultural crops, and other valuable vegetation.

j. During all ground applications, the applicator should periodically calibrate the application equipment to ensure that the herbicide is being applied at the proper rate.

k. Herbicides used for stump treatments and tree growth regulators must be applied according to the specimen label.

l. Herbicides are not to be applied in the following areas or times:

   (1) On lawns or within 300 feet of a residence.

   (2) Around trees that would fall and hit a conductor or support structure.

(3) In areas highly visible from interstates and other heavily traveled roads or scenic locations and high-use recreational areas.

(4) In fence rows and other areas where cattle might eat wilted cherry leaves.

(5) In city, state, and national parks or forests or other special areas without written permission and/or required permits from the proper governmental officials.

(6) Off the right-of-way.

(7) Without permission of the property owner on property leased or rented to TVA.

(8) During rainy periods or during the 48-hour interval prior to rainfall predicted with a 20 percent or greater probability by local forecasters (this applies when soil-active herbicides are used).

(9) In areas where soil erosion might occur or soil might be mechanically relocated (this applies when soil-active herbicides are used).

10. Accurate and up-to-date records are to be maintained concerning the plan for and the application of all herbicides. The locations, herbicide applied, amount of herbicide applied, application method, and the size of the area treated are to be recorded on the appropriate form (i.e., TVA 7046).

J. Storm Water Discharge Management

All potential sources of pollution which could affect the quality of storm water discharges must be identified, and the appropriate control measures must be implemented to ensure that the following conditions are met both during and after construction activities:

1. There shall be no distinctly visible floating scum, oil, or other matter contained in the storm water discharge.
2. The storm water discharge must not cause an objectionable color contrast in the receiving stream.
3. The storm water discharge must result in no materials in concentrations sufficient to be hazardous or otherwise detrimental to humans, livestock, wildlife, plant life, fish, or aquatic life in the receiving stream.

I. Inspection, Recordkeeping, and Reporting

1. Regular maintenance is vital to the success of an erosion and sediment control system. All control measures shall be checked and repaired as necessary. Checks shall be made in dry periods and following rainfall events as required under the state construction storm water permit. During prolonged rainfall, daily checking and repairing is necessary. Discharge monitoring and stream sampling may be required to verify there is minimal site sediment contributions to water bodies.
2. Records must be kept on all checks and repairs to erosion and sediment control measures. These records are to be maintained on site or at a nearby office. A chronological pictorial record is recommended as well as the written record of inspections.

3. Inspection records and information resulting from water quality monitoring activities required by state regulations must be retained for a minimum of three (3) years, or longer if requested by the respective state water pollution control department.

CHAPTER VI

BMP STANDARDS AND SPECIFICATIONS

A. Straw Bale Barrier

Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales (Figures 3 and 4).

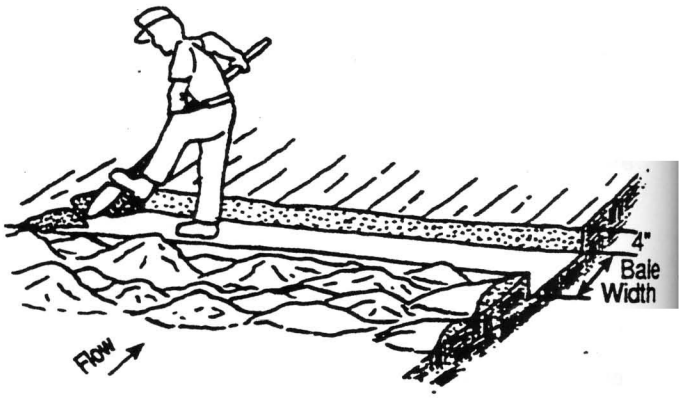
Purposes

- To intercept and detain small amounts of sediment from disturbed areas of limited extent in order to keep sediment on site.
- To decrease the velocity of sheet flows and maintain low-to-moderate level channel flows.

Conditions Where Practice Applies

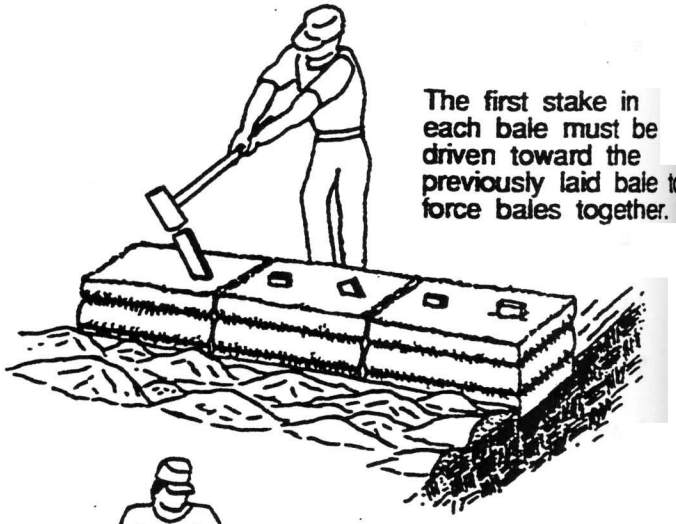
- Below disturbed areas subject to sheet and rill erosion.
- Where the size of the drainage area is no greater than 1/4 acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and, the maximum slope gradient behind the barrier is 50 percent (2:1).
- In minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres.
- Where effectiveness is required for less than 3 months.
- Under no circumstances should straw bale barriers be constructed in live streams or in swales where there is the possibility of a washout.

1. Excavate the trench on the contour.

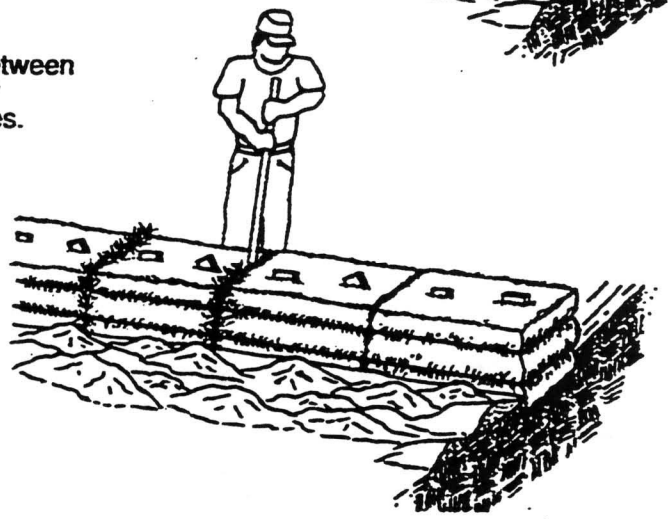


2. Place bales on edges so bindings are oriented around the sides and secure each bale with two stakes.

The first stake in each bale must be driven toward the previously laid bale to force bales together.



3. Wedge loose straw between bales to prevent water escaping between bales.



4. Backfill excavated soil into the trench and compact.

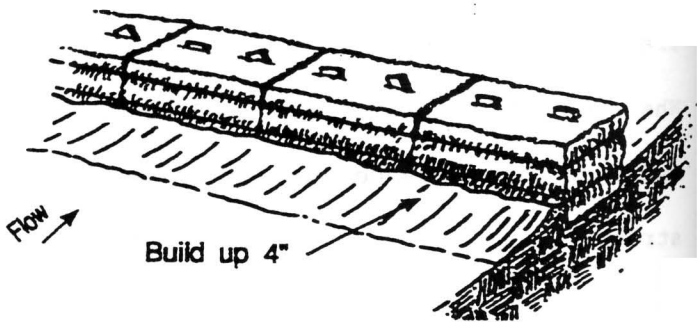
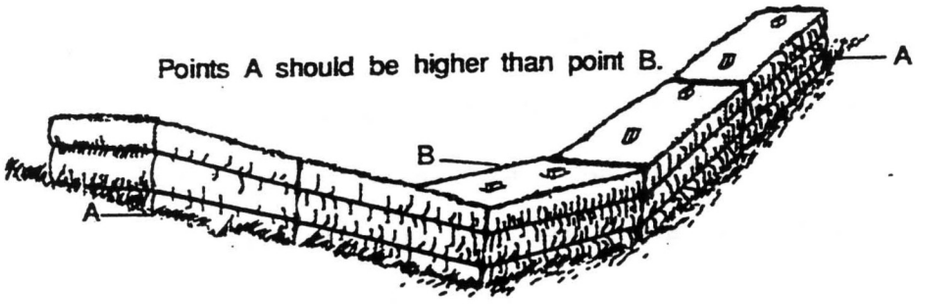
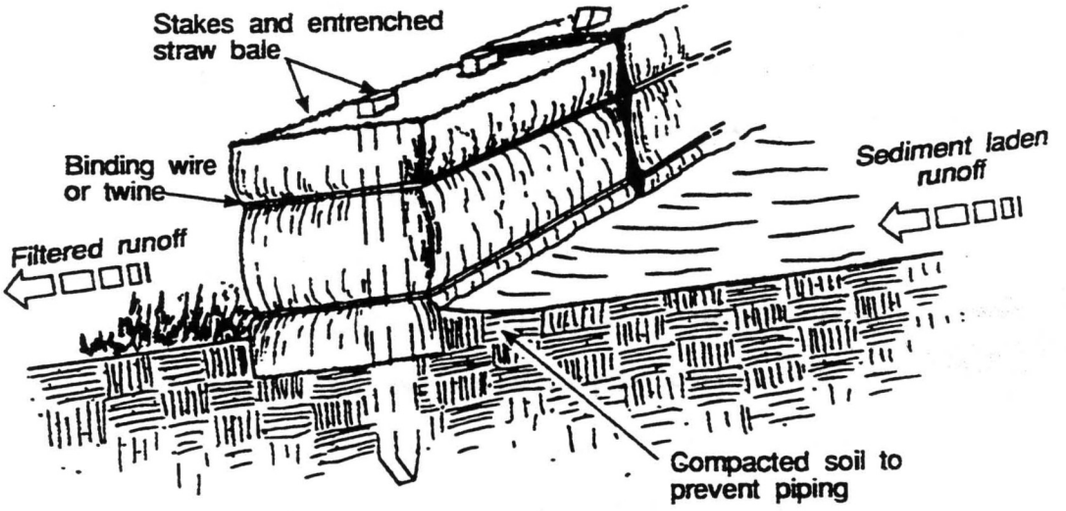


Figure 3. Construction of a straw bale barrier.



A. Proper placement of a straw bale barrier in a drainage way.



B. Cross-section of a properly installed straw bale.

Figure 4. Details of a straw bale barrier.

Planning Considerations

Straw bale barriers must not be used in streams and drainage ways where high water velocities and volumes will destroy or impair their effectiveness. Improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, allows undercutting and end flow. This results in the addition of sediment to runoff waters instead of sediment removal. Trapping efficiencies of carefully installed straw bale barriers may drop dramatically due to lack of maintenance.

Design Criteria

A formal design is not required.

Specifications

Sheet Flow Applications

- Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.
- All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales (in order to prevent premature deterioration of the bindings).
- The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. After the bales are staked and chinked, the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier.

- Each bale shall be securely anchored by at least two stakes or rebars driven through the bale. The first stake in each bale must be driven toward the previously laid bale to force the bales together. Stakes or rebars shall be driven deep enough into the ground to securely anchor the bales.
- The gaps between bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency.
- Straw bales and/or silt fence may be removed (weather permitting) at the beginning of the work day but must be properly replaced at the end of the work day.
- Inspections shall be frequent, and repair or replacement shall be made promptly as needed.

Channel Flow Applications

- Bales shall be placed in a single row, lengthwise, oriented perpendicular to the contour, with ends of adjacent bales tightly abutting one another.
- The remaining steps for installing a straw bale barrier for sheet flow applications apply here, with the following addition. The barrier shall be extended so that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale to ensure that sediment-laden runoff will flow either through or over the barrier but not around it.

Maintenance

- Straw bale barriers shall be inspected immediately after each significant rainfall event and at least daily during prolonged rainfall.

- Close attention shall be paid to the repair of damaged bales, end runs, and undercutting beneath bales.
- Necessary repairs to barriers or replacement of bales shall be accomplished promptly.
- Sediment deposits must be removed when the level of deposition reaches approximately 1/2 the height of the barrier.
- Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared, and seeded.

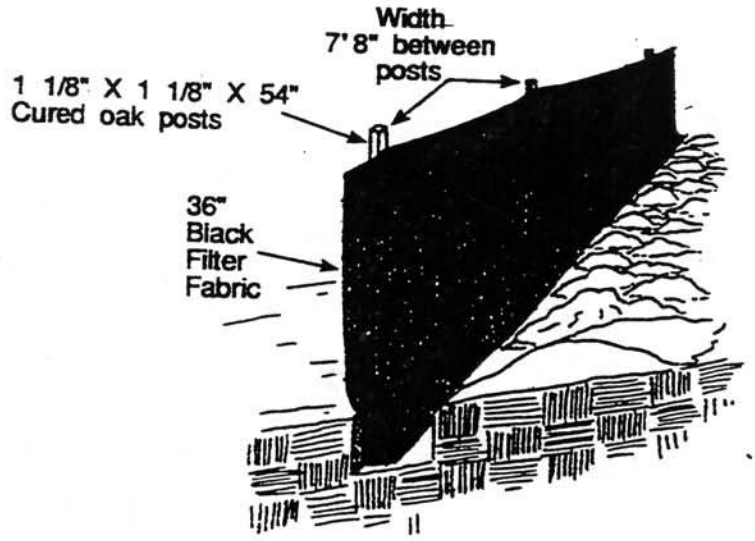
B. Silt Fence/Filter Barrier

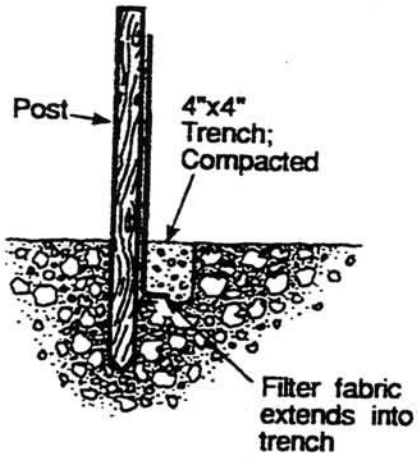
Definition

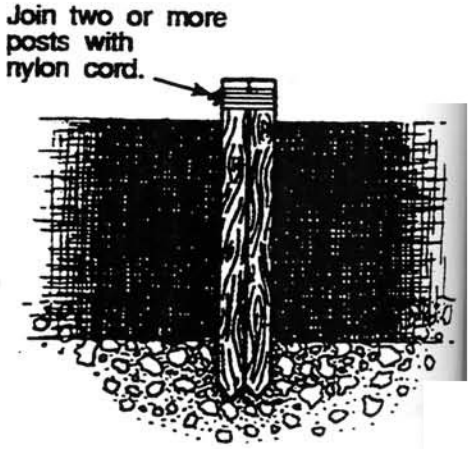
A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. There are two types. The silt fence is a temporary linear filter barrier constructed of synthetic filter fabric, posts, and, depending upon the strength of the fabric used, wire fence for support (Figures 5 and 6). The filter barrier is constructed of stakes and burlap or synthetic filter fabric (Figure 7).

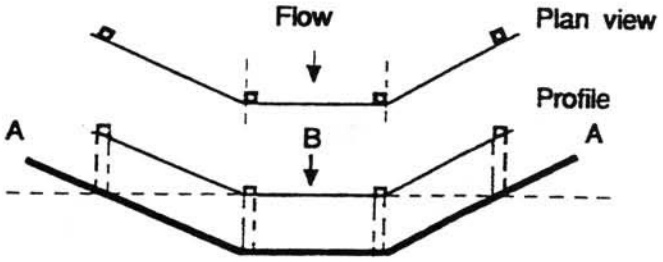
Purposes

- To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.
- To decrease the velocity of sheet flows and low-to-moderate level channel flows.





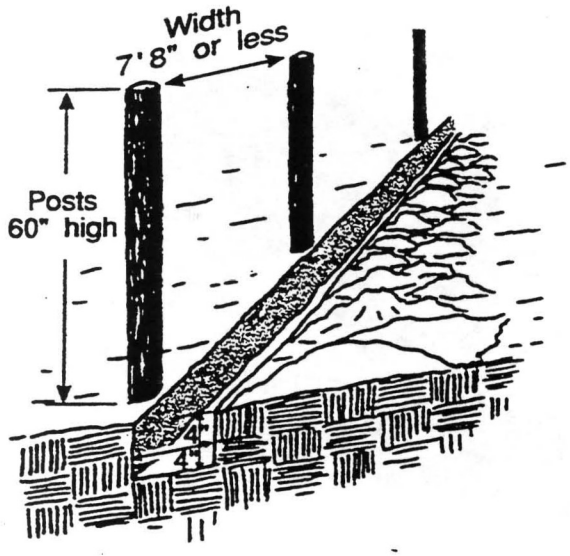




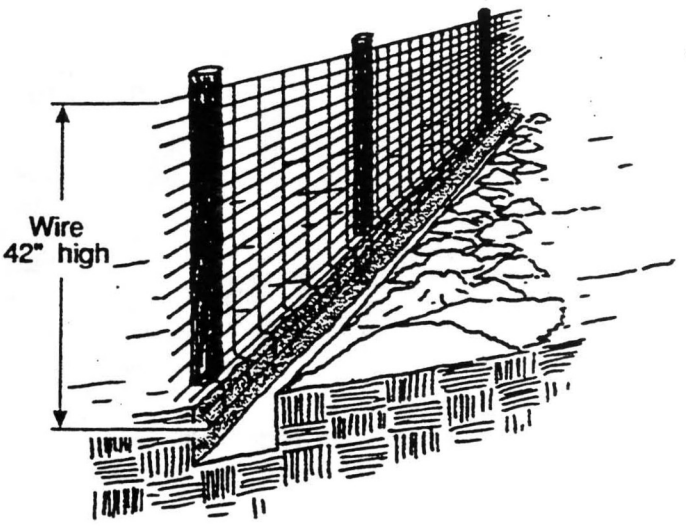
Points A should be higher than point B.

Proper placement for a silt fence in a drainage way (use only where runoff is low and does not exceed 1 cubic feet per second)

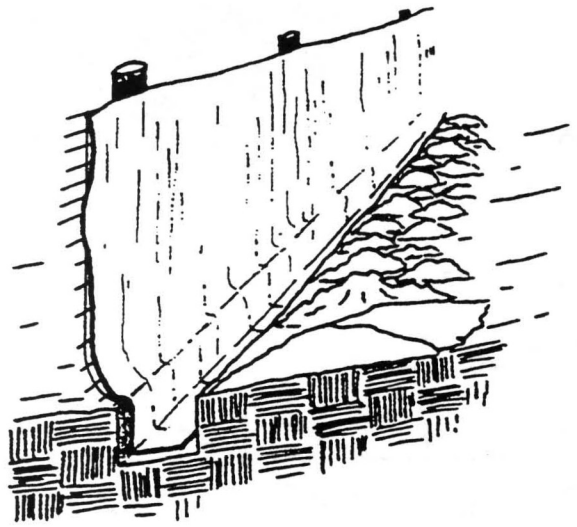
Figure 6. Details of a silt fence with prefabricated fencing.



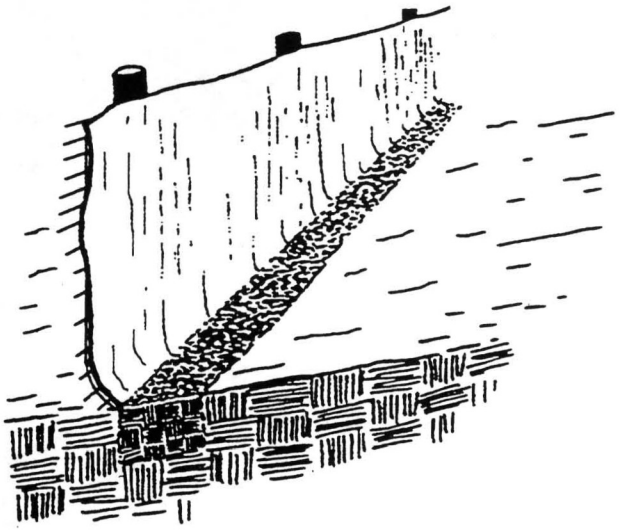
1. Set posts (metal or 4" diameter wooden) on the contour and excavate a 4"x4" trench upslope along the line of posts.



2. Secure wire fencing to the posts. Wire shall have a maximum mesh spacing of 6" and be a minimum of 14 gauge.

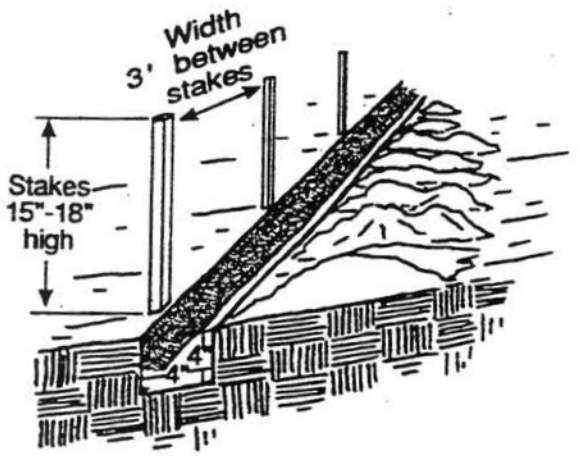


3. Attach the filter fabric to the wire fence and extend it into the trench.

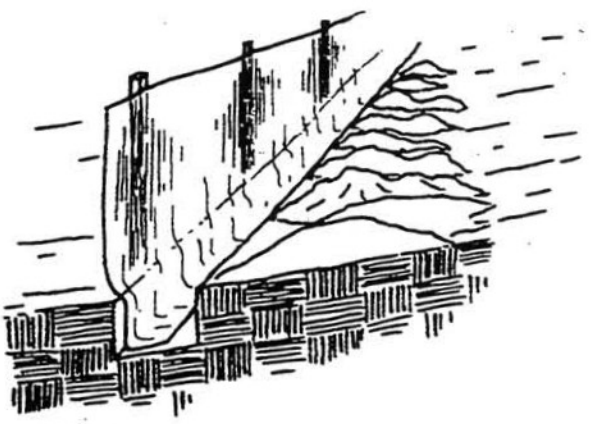


4. Backfill excavated soil into the trench and compact.

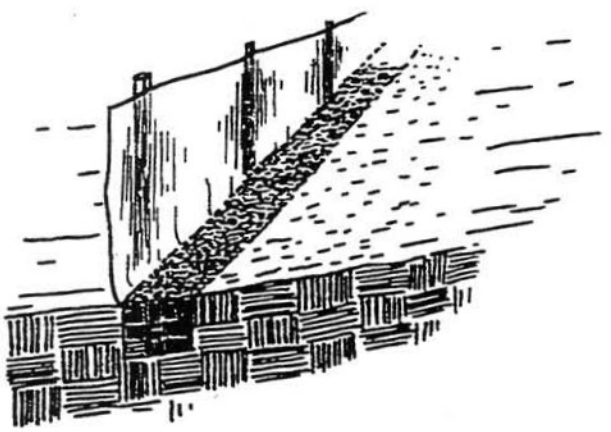
Figure 5. Details of a silt fence with wire, posts, and synthetic filter fabric.



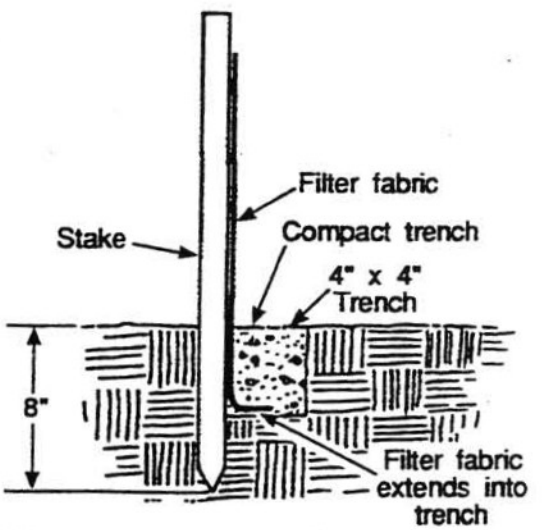
1. Drive wooden stakes on the contour and excavate a 4"X4" trench upslope.



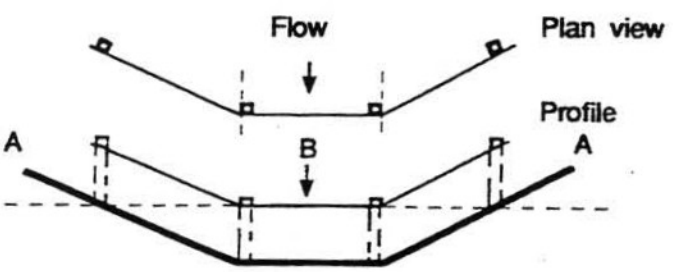
2. Staple filter fabric to wooden stakes and extend it into the trench.



3. Backfill excavated soil into the trench and compact.



4. Extension of filter fabric into the trench.



Points A should be higher than point B.

Proper placement for a filter barrier in a drainage way (use only where runoff is low and does not exceed 1 cubic feet per second).

Figure 7. Details of a filter barrier with wooden stakes and burlap or synthetic filter fabric.

Conditions Where Practice Applies

- Below disturbed areas where erosion would occur in the form of sheet and rill erosion.
- Above steep slopes to intercept sheet runoff and slow flow onto the steep slope.
- Where the size of the drainage area is no more than 1/4 acre per 100 feet of silt fence length; the maximum slope length behind the silt fence is 100 feet; and the maximum gradient behind the silt fence is 50 percent (2:1).
- In minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres.
- Under no circumstances should silt fences be constructed in live streams or in swales or ditch lines where flows are likely to exceed 1 cubic foot per second (cfs).

Planning Considerations

Silt fences/filter barriers may be preferable to straw bale barriers in some cases. While the failure rate of silt fences/filter barriers is lower than that of straw bale barriers, there have been instances in which silt fences/filter barriers were improperly installed. The installation methods outlined here should be followed.

Filter barriers are inexpensive structures composed of burlap or standard weight synthetic filter fabric stapled to wooden stakes. Flow rates through burlap filter barriers are slightly slower and filtering efficiency is significantly higher than for straw bale barriers.

Silt fences composed of a wire support fence and an attached synthetic filter fabric slow the flow rate significantly and have a higher filtering efficiency than burlap. Both woven and nonwoven synthetic fabrics are commercially available. The woven fabrics generally display higher strength than the nonwoven fabrics. When tested under acid and alkaline water conditions, most of the woven fabrics increase in strength. There is a variety of reactions among the nonwoven fabrics. The same is true of testing under extensive ultraviolet radiation. Permeability rates vary regardless of fabric type.

Design Criteria

- No formal design is required.
- Filter barriers shall have an expected usable life of 3 months. Filter barriers are applicable in ditch lines, around drop inlets, and at temporary locations where continuous construction changes the earth contour and runoff characteristics and where low or moderate flows (not exceeding 1 cfs) are expected.
- Silt fences, because they have a much lower permeability than burlap filter barriers, have their applicability limited to situations in which only sheet or overland flows are expected. They normally cannot filter the volumes of water generated by channel flows, and many of the fabrics do not have sufficient structural strength to support the weight of water ponded behind the fence line. Their expected usable life is 6 months.

Specifications

Materials

- Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester, or ethylene yarn and shall be certified by the manufacturer or supplier.
- Burlap shall be 10-ounce per square yard fabric.
- Posts for silt fences shall be either 4-inch diameter wood or 1.33 pounds per linear foot steel with a minimum length of 5 feet. Steel posts shall have projections for fastening wire to them.
- Stakes for filter barriers shall be 1-inch x 2-inch wood (preferred) or equivalent metal with a minimum length of 3 feet.
- Wire fence reinforcement for silt fences using standard strength filter cloth shall be a minimum of 42 inches in height, a minimum of 14 gauge, and shall have a maximum mesh spacing of 6 inches.

Filter Barrier This sediment barrier may be constructed using burlap or standard strength synthetic filter fabric. It is designed for low or moderate flows not exceeding 1 cfs.

- The height of a filter barrier shall be a minimum of 15 inches and shall not exceed 18 inches.
- Burlap or standard strength synthetic filter fabric shall be purchased in a continuous roll and cut to the length of the barrier to avoid the use of joints (and thus improve the strength and efficiency of the barrier).
- The stakes shall be spaced a maximum of 3 feet apart at the barrier location and driven securely into the ground (minimum of 8 inches).
- A trench shall be excavated approximately 4 inches wide and 4 inches deep along the line of stakes and upslope from the barrier.
- The filter material shall be stapled to the wooden stakes, and

8 inches of the fabric shall be extended into the trench. Heavy duty wire staples at least 1/2-inch long shall be used. Filter material shall not be stapled to existing trees.

- The trench shall be backfilled and the soil compacted over the filter material.
- If a filter barrier is to be constructed across a ditch line or swale, the barrier shall be of sufficient length to eliminate end flow, and the plan configuration shall resemble an arc or horseshoe with the ends oriented upslope.
- Filter barriers shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

Silt Fence This sediment barrier utilizes standard strength or extra strength synthetic filter fabrics. It is designed for situations in which only sheet or overland flows are expected.

- The height of a silt fence shall not exceed 36 inches.
- The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.
- Posts shall be spaced a maximum of 10 feet apart at the barrier location and driven securely into the ground a minimum of 12 inches. When extra strength fabric is used without the wire support fence, post spacing shall not exceed 6 feet.
- A trench shall be excavated approximately 4 inches wide and 4 inches deep along the line of posts and upslope from the barrier.
- When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy duty wire staples at least 1 inch long or tie wires. The wire mesh shall

extend into the trench a minimum of 2 inches and shall not extend more than 36 inches above the original ground surface.

- The standard strength filter fabric shall be stapled or wired to the fence, and 8 inches of the fabric shall be extended into the trench. The fabric shall not extend more than 36 inches above the original ground surface.
- When extra strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case the filter fabric is stapled or wired directly to the posts.
- The trench shall be backfilled and the soil compacted over the filter fabric.
- Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

Maintenance

- Silt fences and filter barriers shall be inspected immediately after significant rainfall events and at least daily during prolonged rainfall. Any required repairs shall be made immediately.
- Should the fabric on a silt fence or filter barrier decompose or become ineffective prior to the end of the expected usable life and the barrier is still necessary, the fabric shall be replaced promptly.
- Sediment deposits should be removed after storm events. They must be removed when deposits reach approximately one-half the height of the barrier.
- Any sediment deposits remaining in place after the silt fence of sediment barrier is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

C. Temporary Sediment Trap

Definition

A small temporary ponding area, formed by constructing an earthen embankment with a gravel outlet, across a drainage swale (Figure 8).

Purpose

To detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out.

Conditions Where Practice Applies

- Below drainage areas of 5 acres or less and where the sediment trap will be used no longer than 18 months.
- The sediment trap may be constructed either independently or in conjunction with a temporary diversion dike.

Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 5 acres, sediment basin design criteria must be followed.

Sediment must be periodically removed from the trap. Plans should detail how this sediment is to be disposed of, such as by use in fill areas on site or by removal to an approved off-site disposal area.

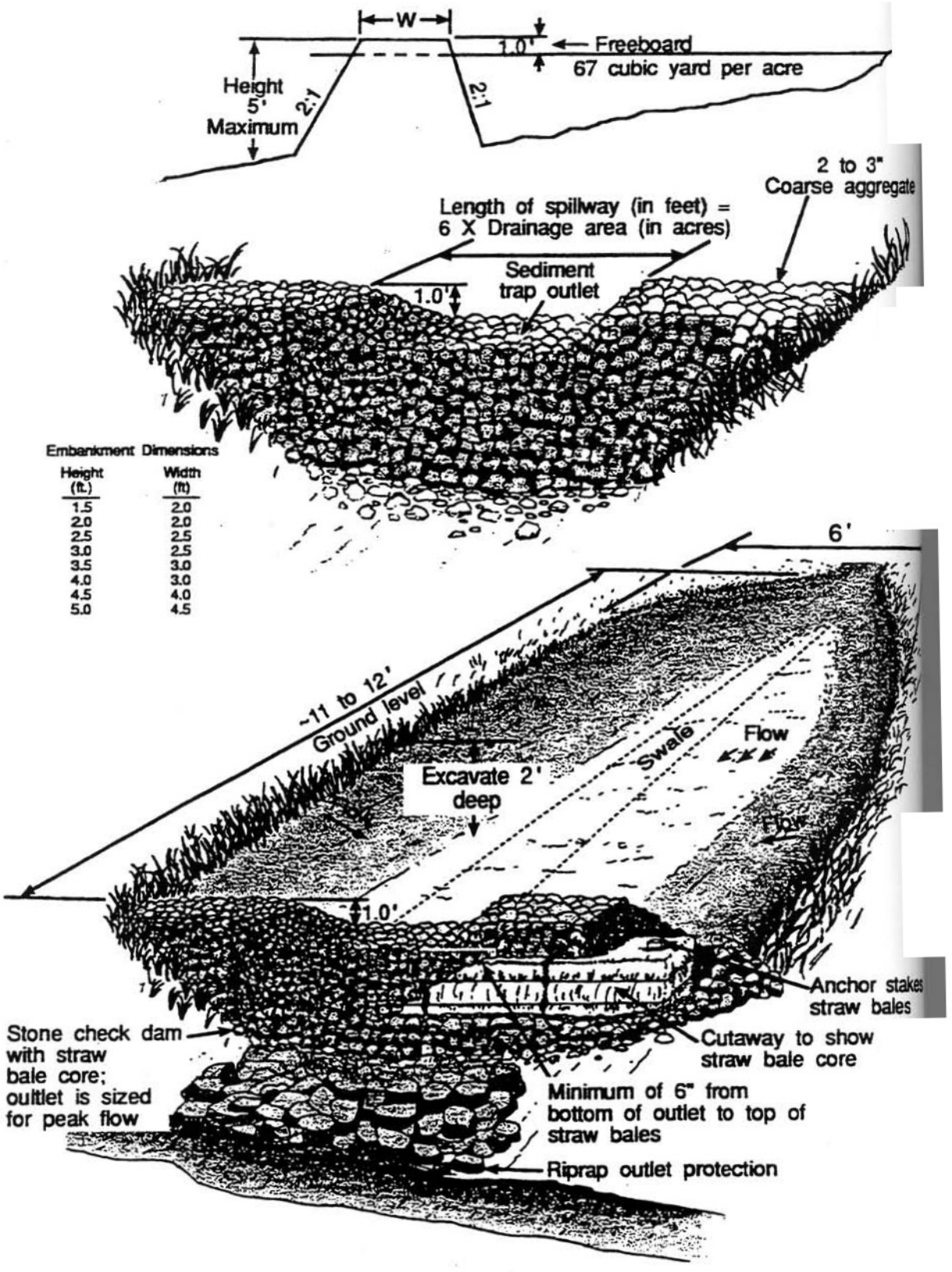


Figure 8. Details of a temporary surface sediment trap.

Design Criteria

Trap Capacity

The sediment trap must have an initial storage volume of 67 cubic yards per acre of drainage area, measured from the low point of the ground to the crest of the gravel outlet. Sediment should be removed from the basin when the volume is reduced by one-half. For a natural basin, the volume may be approximated as follows:

$V = 0.4 \times A \times D$

where,

V = the storage volume in $ft.^3$

A = the surface area of the flooded area at the crest of the outlet, in $ft.^2$

D = the maximum depth, measured from the low point in the trap to the crest of the outlet, in ft.

Sediment traps, along with other perimeter controls, shall be installed before any significant land disturbance takes place in the drainage area.

Excavation

If excavation is necessary to attain the required storage volume, side slopes should be no steeper than 2:1.

Outlet

The outlet for the sediment trap shall consist of a crushed stone section of the embankment located at the low point in the basin. The minimum length of the outlet shall be 6 (feet) times the acreage of the drainage area. The crest of the outlet must be at least 1 foot below the top of the embankment.

The outlet shall be constructed of appropriately sized, clean, crushed stone.

Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 5 feet as measured from the low point. Minimum top widths (W) and various embankment heights (H) are shown in Figure 8. Side slopes of the embankment shall be 2:1 or flatter.

Removal

Sediment traps must be removed after the contributing drainage area is stabilized. Plans should show how the site of the sediment trap is to be graded, stabilized, and revegetated after removal.

Specifications

- The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat. To facilitate cleanout, the pool area should be cleared.
- Fill material for the embankment shall be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 8-inch layers by traversing with appropriate construction equipment.
- Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.
- The structure shall be removed and the area stabilized when the upslope drainage area has been stabilized.
- All cut and fill slopes shall be 2:1 or flatter.

Maintenance

- Sediment shall be removed and the trap restored to its original dimension when the sediment has accumulated to 1/2 the design volume of the trap. Sediment removed from the basin shall be deposited in a suitable area and in such a manner that it will not erode.
- The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the outlet should be checked to ensure that its center is at least one foot below the top of the embankment.

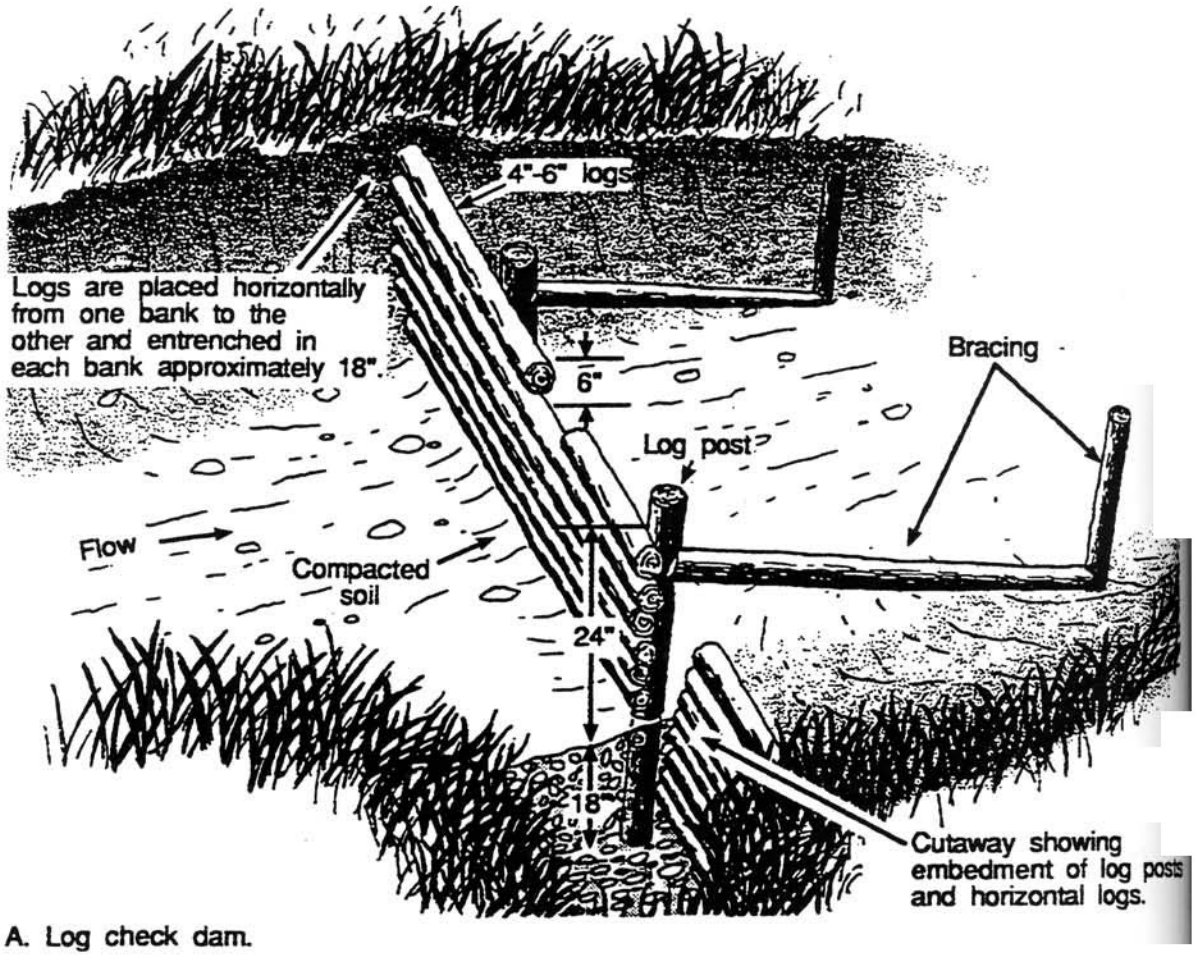
D. Check Dams

Definition

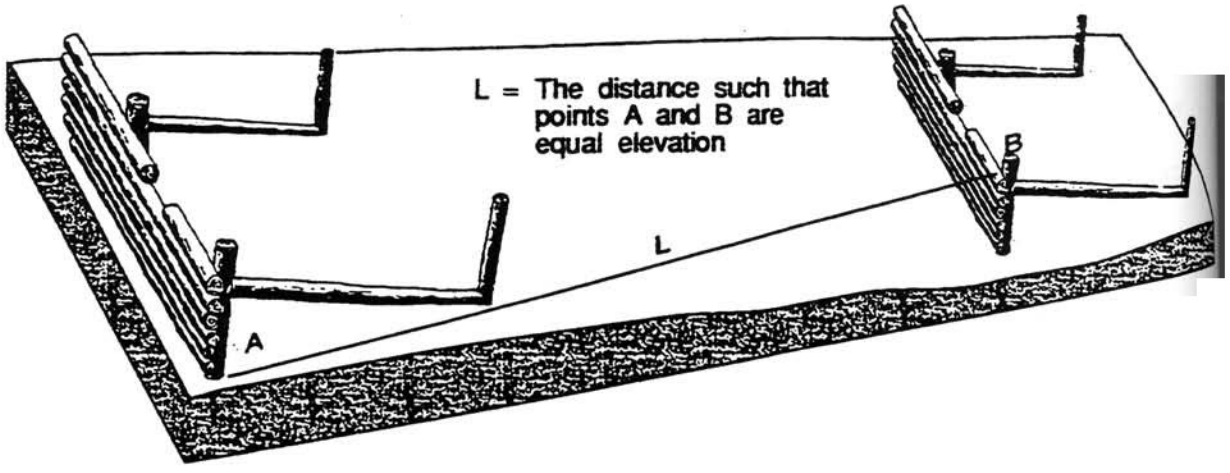
Small temporary dams constructed across a swale or drainage ditch (Figures 9 and 10).

Purpose

To reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps small amounts of sediment generated in the ditch itself. However, this is not a sediment trapping practice and should not be used as such.

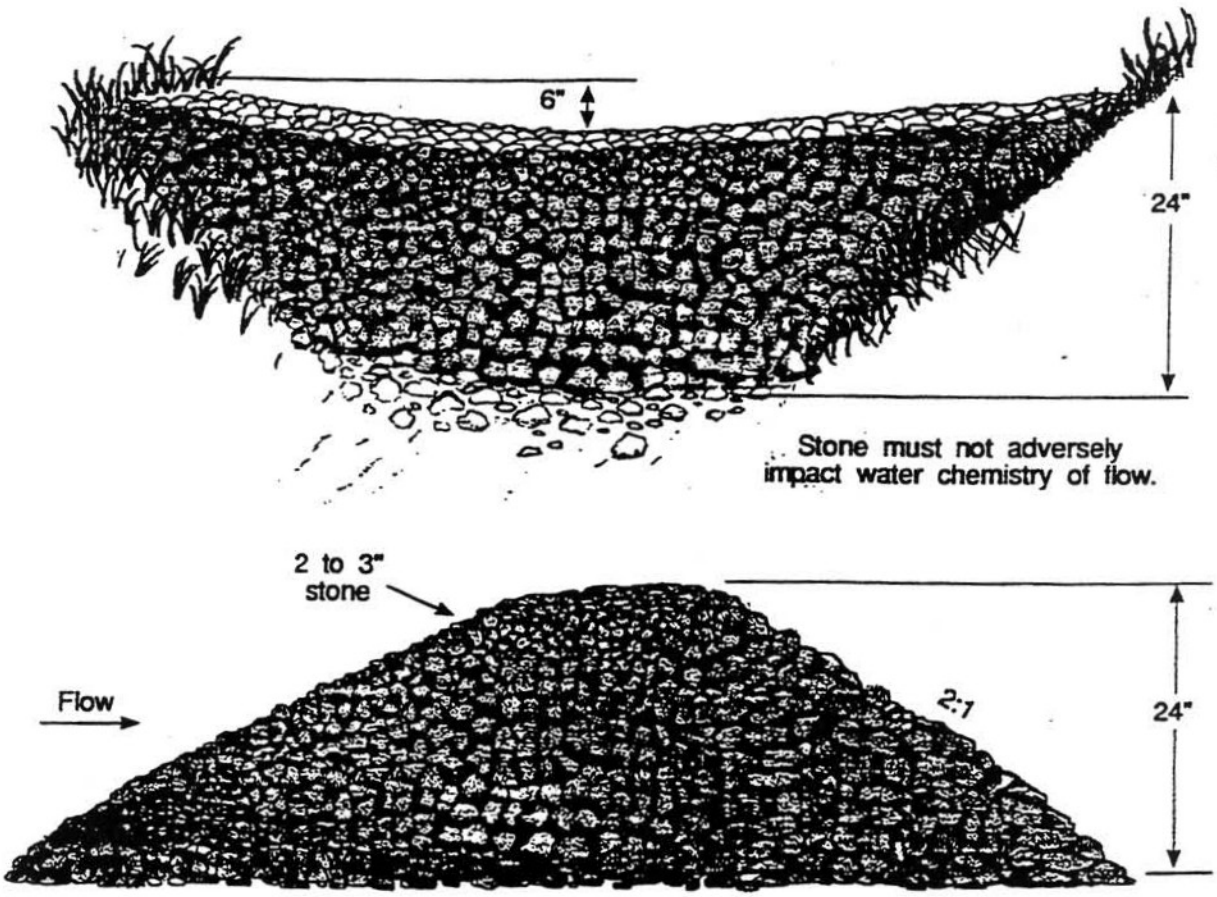


A. Log check dam.

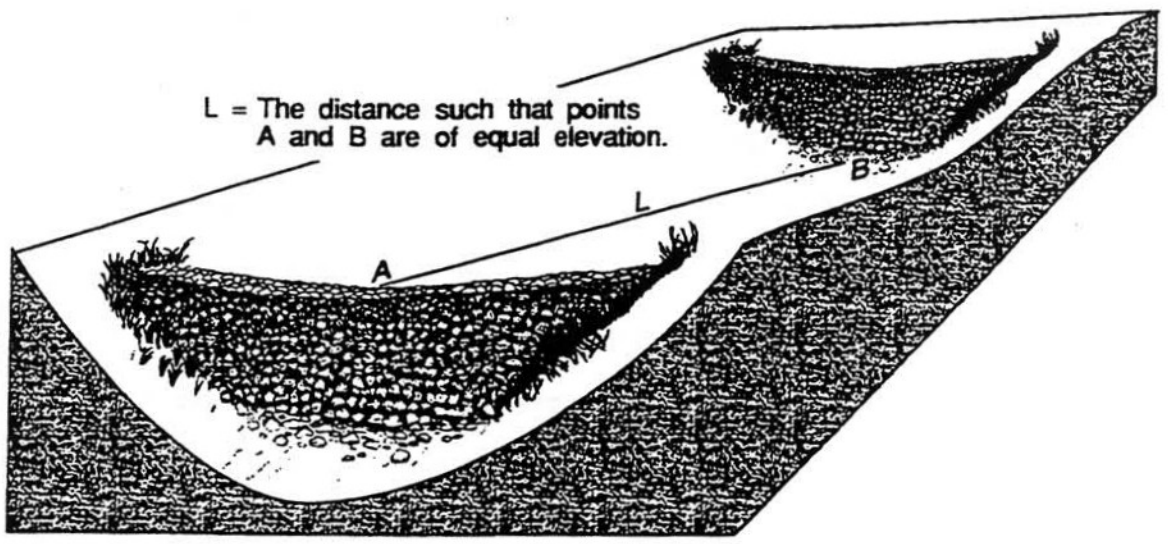


B. Spacing between log check dams.

Figure 9. Details of a log check dam.



A. Rock check dam.



B. Spacing between rock check dams.

Figure 10. Details of a rock check dam.

Conditions Where Practice Applies

This practice is limited to use in small open channels which drain 10 acres or less. It should not be used in a live stream. Some specific applications include:

- Temporary ditches or swales which, because of their short length of service, cannot receive a nonerodible lining but still need some protection to reduce erosion.
- Permanent ditches or swales that for some reason cannot receive a permanent nonerodible lining for an extended period time.
- Either temporary or permanent ditches or swales which need protection during the establishment of grass linings.

Planning Considerations

Check dams can be constructed of either stone or logs. For drainage areas of 2 acres or less, straw bale check dams may be used (see Section A., Straw Bale Barriers). Log check dams are more economical from the standpoint of material costs, since logs can usually be salvaged from clearing operations. However, log check dams require more time and hand labor to install. Stone for check dams, on the other hand, must generally be purchased. However, this cost is offset somewhat by the ease of installation. Straw bale check dams may offer low material costs as well as ease of installation.

If stone check dams are used in grass-lined channels which will be mowed, care should be taken to remove all the stone from the dam when the dam is removed. This should include any stone which has washed downstream.

Since log check dams are embedded in the soil, their removal will cause more soil disturbance than will removal of stone check dams. Extra care should

be taken to stabilize the area when log dams are used in permanent ditches or swales.

Specifications

No formal design is required for a check dam; however, the following criteria should be followed when specifying check dams.

The drainage area of the ditch or swale being protected should not exceed 10 acres. The maximum height of the check dam should be 2 feet. The center of the check dam must be at least 6 inches lower than the outer edges. The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

Stone check dams should be constructed of 2- to 3-inch stone. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges.

Log check dams should be constructed of 4- to 6-inch logs (e.g., oaks and hickories) salvaged from on-site clearing operations, if possible. The logs should be horizontally entrenched or embedded into both the ditch bottom and walls at least 18 inches. The 6-inch lower height required at the center can be achieved either by careful placement of the logs or by cutting the logs after they are in place. Logs, brush, or rocks should be placed on the downstream side of the dam to prevent scour during high flows. Rock also should be placed on the upstream side to prevent cutting around or washing under the check dam that would render it ineffective.

Removal

Check dams may be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when it is no longer needed. In permanent structures, check dams should be removed when a permanent lining can be installed. In the case of grass-lined ditches, check dams should be removed when the grass has matured enough to protect the ditch or swale. The area beneath the check dams should be seeded and mulched immediately after they are removed.

Maintenance

Although this practice is not intended to be used primarily for sediment trapping, some sediment will accumulate behind check dams. Check dams should be monitored for sediment accumulation after each significant rainfall. Sediment should be removed from behind the check dams when it has accumulated to one-half of the original height of the dam.

Regular inspections should be made to ensure that the center of the dam is lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.

E. Temporary Diversion Dike

Definition

A temporary ridge of compacted soil located at the top or base of a sloping disturbed area.

Purposes

- To divert storm runoff from higher drainage areas away from unprotected slopes to a stabilized outlet.
- To divert sediment-laden runoff from a disturbed area to a sediment trapping facility.

Conditions Where Practice Applies

Wherever stormwater runoff must be temporarily diverted to protect disturbed slopes or retain sediments on site during construction. These structures generally have a life expectancy of 18 months or less.

Planning Considerations

A temporary diversion dike is intended to divert overland sheet flow to a stabilized outlet or a sediment trapping facility during establishment of permanent stabilization on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

If the dike is going to remain in place for longer than 30 days, it should be stabilized with temporary or permanent vegetation. The slope behind the dike is also an important consideration. The dike must have a positive

grade to ensure drainage, but if the slope is too great, precautions must be taken to prevent erosion due to high velocity flow behind the dike.

This practice is considered economical because it uses material available on the site, and the dike can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the dike with vegetation.

This practice is intended to be temporary. However, with more stringent design criteria, it can be made permanent in accordance with criteria for diversions.

Design Criteria

No formal design is required. The following criteria shall be met.

Drainage Area

The maximum allowable drainage area is 5 acres.

Height

The minimum allowable height measured from the upslope side of the dike is 18 inches.

Side Slopes

1.5:1 or flatter. (Minimum base width of 4.5 feet.)

Grade

The channel behind the dike shall have a positive grade to a stabilized outlet. If the channel slope is greater than 2 percent, the channel shall be stabilized.

Outlet

- The diverted runoff, if free of sediment, must be released through a stabilized outlet or channel.
- Sediment-laden runoff must be diverted and released through a sediment trapping structure.

Specifications

- Whenever feasible, the dike should be built before project construction begins.
- The dike should be adequately compacted to prevent failure.
- Temporary or permanent seeding and mulch shall be applied to the dike within 15 calendar days of construction.
- The dike should be located to minimize damages by construction operations and traffic.

Maintenance

The dike shall be inspected after every significant storm event and repairs made to the dike, flow channel, and outlet, as necessary. Approximately once every week, whether a storm has occurred or not, the dike site shall be inspected and repairs made if needed. Damages caused by construction traffic or other activity must be repaired before the end of each working day.

F. Diversion

Definition

A channel constructed across a slope with a supporting ridge on the lower side (Figure 11).

Purpose

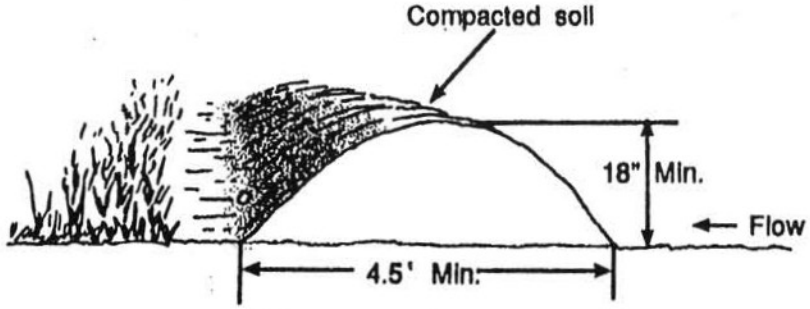
To reduce slope length and to intercept and divert stormwater runoff to stabilized outlets at nonerosive velocities.

Conditions Where Practice Applies

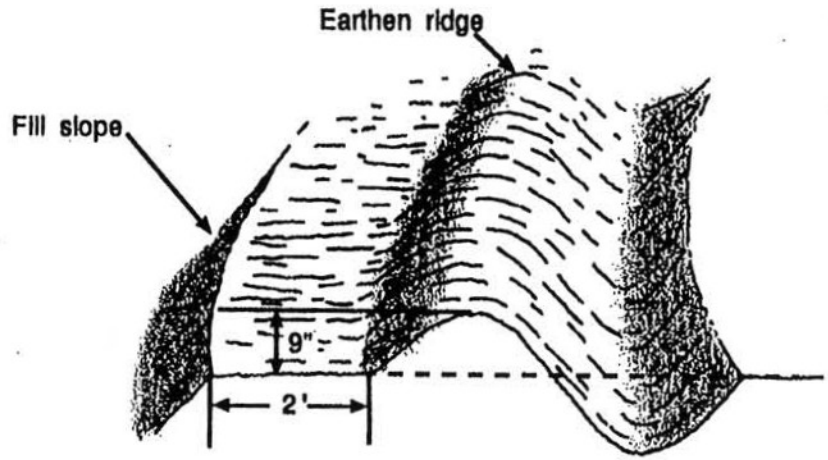
- Where runoff from higher areas may damage property, cause erosion, or interfere with the establishment of vegetation on lower areas.
- Where surface and/or shallow subsurface flow is damaging sloping upland.
- Where the slope length needs to be reduced to minimize soil loss.

Planning Considerations

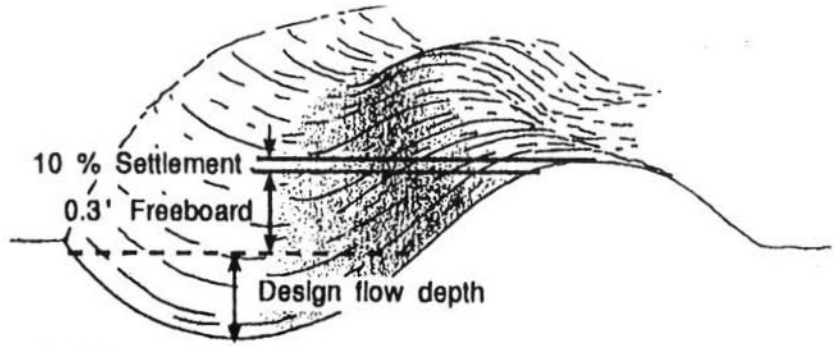
Diversions can be useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion. They may be placed at the top of the cut or fill slopes to keep runoff from upland drainage areas off the slope. They can be used to protect structures, parking lots, adjacent properties, and other special areas from flooding.



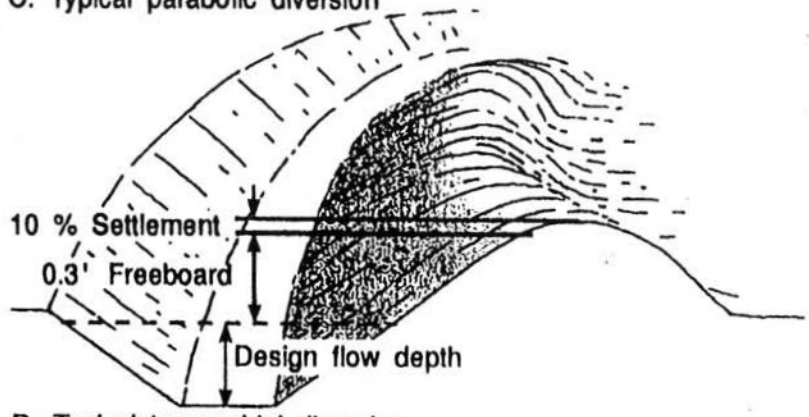
A. Temporary diversion dike



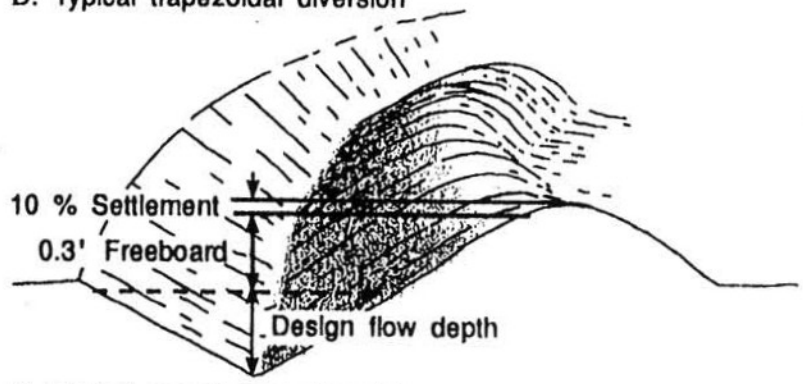
B. Temporary fill diversion



C. Typical parabolic diversion



D. Typical trapezoidal diversion



E. Typical vee-shaped diversion

Figure 11. Details of diversions.

Diversions are preferable to other types of man-made storm water conveyance systems because they more closely simulate natural flow patterns and characteristics. Flow velocities are generally kept to a minimum. When properly coordinated into the landscape design of a site, diversions can be visually pleasing as well as functional.

As with any earthen structure, adequate vegetation should be established as soon as possible after installation. It is equally important to stabilize the drainage area above the diversion so that sediment will not enter and accumulate in the diversion channel.

Design Criteria

Location

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seepage planes (where seepage is a problem), and the development layout.

Capacity

- The diversion channel must have a minimum capacity to carry the runoff expected from a 10-year frequency storm with a freeboard of at least 0.3 foot.
- Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high-risk areas, and those designed to function along with other structures, shall have sufficient capacity to carry peak runoff expected from a storm frequency consistent with the hazard involved.

Channel Design

The diversion channel may be parabolic, trapezoidal, or V-shaped.

Ridge Design

The supporting ridge cross-section shall meet the following criteria.

- The side slopes shall be no steeper than 2:1.
- The width at the design water elevation shall be a minimum of 4 feet.
- The minimum freeboard shall be 0.3 foot.
- The design shall include a 10 percent settlement factor.

Outlet

Diversions shall have adequate outlets which will convey concentrated runoff without erosion.

Stabilization

- Unless otherwise stabilized, the ridge and channel shall be seeded and mulched within 15 calendar days of installation.
- Disturbed areas draining into the diversion shall be seeded and mulched prior to or at the time the diversion is constructed.

Specifications

- All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of to allow the proper functioning of the diversion.
- The diversion shall be excavated or shaped to line, grade, and cross-section as required to meet the specified criteria, free of irregularities that will impede flow.

- Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the complete diversion.
- All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the diversion.

Maintenance

Before final stabilization, the diversion should be inspected after every significant rainfall. Sediment shall be removed from the ditchline and repairs made as necessary. Seeded areas which fail to establish a vegetative cover shall be reseeded as necessary.

G. Riprap

Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone.

Purposes

- To protect the soil surface from the erosive forces of concentrated runoff.
- To slow the velocity of concentrated runoff while enhancing the potential for infiltration.
- To stabilize slopes with seepage problems and/or noncohesive soils.

Conditions Where Practice Applies

Wherever the soil conditions, water turbulence and velocity, expected vegetative cover, etc. are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at stormdrain outlets,

on channel banks and/or bottoms, roadside ditches, drop structures, at the toe of slopes, etc.

Planning Considerations

Graded vs. Uniform Riprap

Riprap is classified as either graded or uniform. A sample of graded riprap would contain a mixture of stones which vary in size from small to large. A sample of uniform riprap would contain stones which are all fairly close in size.

For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, while uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass. Hand or mechanical placement of individual stones may be necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform pattern, requiring more hand or mechanical labor.

Riprap sizes can be designated by either the diameter or the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be rectangular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Tables 2 and 3 list some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed specific weight of 165 pounds per cubic foot.

Table 2. Sizes of typical riprap stones.

Weight (lbs.)	Diameter (ft.)	Rectangular Shape	
		Length (ft.)	Width, Height (ft.)
50	0.8	1.40	0.50
100	1.1	1.75	0.60
150	1.3	2.00	0.67
300	1.6	2.60	0.90
500	1.9	3.00	1.00
1000	2.2	3.70	1.25

Table 3. Sizes of typical graded riprap.

Riprap Class	d_{15} Weight (lbs.)	Mean d_{15} Spherical Diameter (ft.)	Mean d_{50} Spherical Diameter (ft.)
Class I	50	0.8	1.1
Class II	150	1.3	1.6
Class III	500	1.9	2.2
Type I	1500	2.6	2.8
Type II	6000	4.0	4.5

Because graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in the mixture for which some percentage, by weight, will be smaller. For example, d_{85} refers to a mixture of stones in which 85 percent of the stone by weight would be smaller than the diameter specified. Most designs are based on d_{50}. In other words, the design is based on the average size of stone in the mixture.

Sequence of Construction

Because riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

Gradation

The riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50 percent of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size.

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water or windows to toss the stones into.

Thickness

The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter but not less than 6 inches.

Quality of Stone

Stone for riprap shall consist of clean or washed field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering, and it shall be suitable in all other respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5. Riprap stone must not adversely impact water chemistry of streams. Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirements outlined here.

Riprap at Outlets

A stabilized discharge structure must be provided. Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlets of drainage structures are contained in several of the references cited in this manual.

Riprap for Channel Stabilization

State water pollution control departments require that they be contacted prior to any stream channel disturbance.

Riprap for channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of the channel being stabilized. Riprap shall extend up the banks of the channel to a height equal to the

maximum depth of flow or to a point where vegetation can be established to adequately protect the channel.

The riprap size to be used in a channel bend shall extend upstream from the point of curvature and downstream from the point of tangency a distance of at least 5 times the channel bottom width. The riprap shall extend across the bottom and up both sides of the channel.

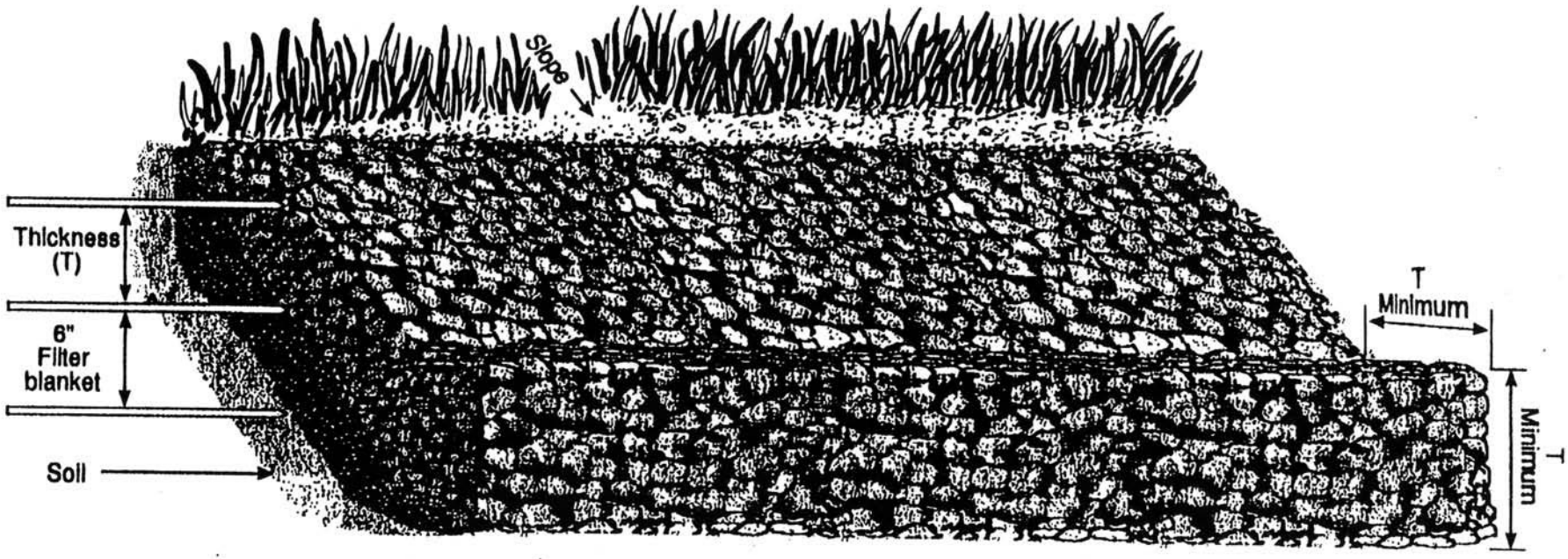
Where riprap is used only for bank protection (Figure 12) and does not extend across the bottom of the channel, riprap shall be keyed into the bottom of the channel to a minimum depth equal to the thickness of the blanket, and it shall extend across the bottom of the channel the same distance.

Riprap for Slope Stabilization

Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is greater than the gradient of the slope being stabilized.

Maintenance

A riprap installation should require very little maintenance. It should, however, be inspected periodically to determine if highflows have caused scour beneath the riprap or dislodged any stone. If repairs are needed, they should be done immediately.



T = 1.5 x maximum diameter; (6 inch minimum)

Note:
6" filter blanket can be a gravel layer or plastic filter cloth.

Figure 12. Toe requirements for riprap bank stabilization.

H. Access Road and Parking Area Stabilization

Definition

The temporary stabilization of access roads, parking areas, and other on-site vehicle transportation routes with stone immediately after grading in preparation of excessive use.

Purposes

- To reduce the erosion of temporary roadbeds caused by construction traffic during wet weather.
- To reduce erosion and any regrading of permanent roadbeds between the time of initial grading and final stabilization.

Conditions Where Practice Applies

Wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

Planning Considerations

Areas that are graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy and generate significant quantities of sediment that may pollute nearby streams or be transported off site on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable. Establishing appropriate slope grades followed by immediate stabilization of such areas with stone may cost money at the outset, but it

may actually save money in the long run by increasing the usefulness of the road during wet weather.

Specifications

Temporary Access Roads and Parking Areas

- Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes should not exceed 10 percent.
- Temporary parking areas should be located on naturally flat areas to minimize grading. Grades should be sufficient to provide drainage but should not exceed 4 percent.
- Roadbeds shall be about 14 feet wide for one-way traffic and 20 feet wide for two-way traffic.
- All cuts and fills shall be 2:1 or flatter to the extent possible.
- Drainage ditches shall be provided as needed and shall be designed and constructed to carry anticipated storm flows.
- The roadbed or parking surface shall be cleared of all vegetation, roots, and other objectionable material.
- At least a 6-inch course of clean aggregate shall be applied immediately after grading on select areas. Filter fabric may be applied to the roadbed for additional stability in accordance with fabric manufacturer's specifications.

Permanent Roads and Parking Areas

Permanent roads and parking areas shall be designed and constructed in accordance with applicable state Department of Transportation or local criteria except that an initial base course of gravel of at least 6 inches shall be applied after grading.

Vegetation

All roadside ditches, cuts, fills, and disturbed areas adjacent to parking areas and roads shall be stabilized with appropriate temporary or permanent vegetation.

Maintenance

Both temporary and permanent roads and parking areas may require periodic top dressing with new gravel. Seeded areas adjacent to the roads and parking areas should be checked periodically to ensure that a vigorous stand of vegetation is maintained. Roadside ditches and other drainage structures should be checked regularly to ensure that they do not become clogged with silt or other debris.

I. Temporary Stream Crossing

Definition

A temporary structural span installed across a flowing watercourse for use by construction or maintenance traffic. Structures may include bridges, round pipes, or pipe arches (Figure 13). Nonstructural is a ford-type crossing (Figure 14).

Purposes

- To provide a means for traffic to cross flowing streams without damaging the stream channel or banks.
- To keep sediment generated by traffic out of the stream.
- To cross waterways with minimal negative impact to the stream.

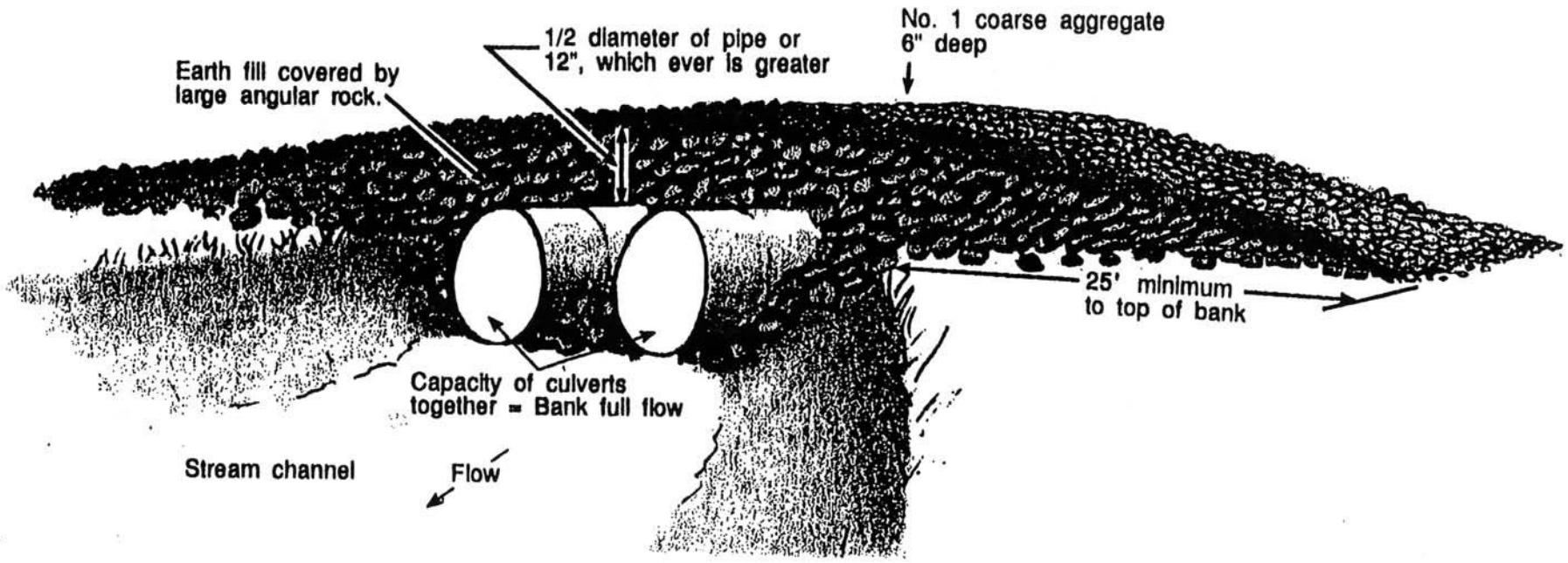


Figure 13. Details of a temporary structural (round pipes) stream crossing.

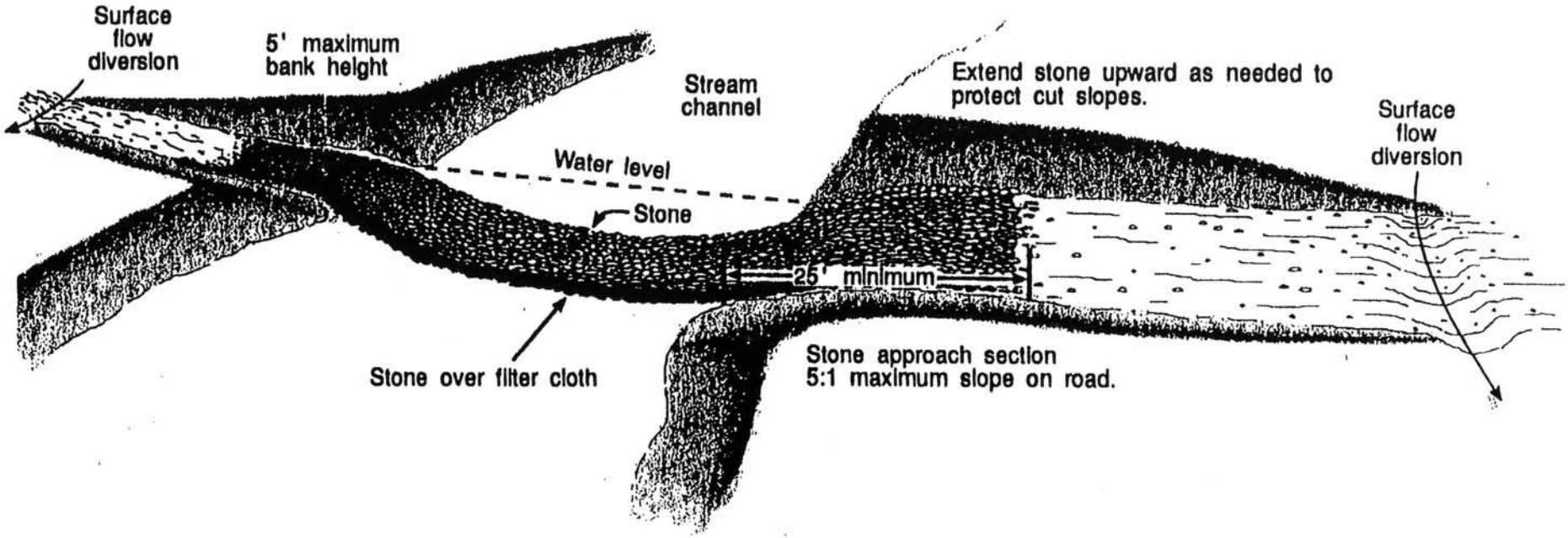


Figure 14. Details of a ford stream crossing.

- To keep petrochemical leakage on the undersurfaces of construction or maintenance equipment out of the water course.

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than one square mile. Structures that must handle flow from larger drainage areas should be designed as permanent structures by a professional engineer.

Planning Considerations

Temporary stream crossings are necessary to prevent vehicles and heavy equipment from damaging streambanks and continually tracking sediment and other pollutants into the water course. However, these structures are also undesirable in that they represent a channel constriction that can cause flow backups or washouts during periods of high flow. For this reason, the temporary nature of stream crossings is stressed. They should be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed.

The specifications contained in this practice pertain primarily to flow capacity and resistance to washout of the structure. From a safety and utility standpoint, the designer must also be sure that the span is capable of withstanding the expected loads from heavy equipment. The designer must also be aware that such structures are subject to the rules and regulations of the U.S. Army Corps of Engineers, state water pollution control departments and TVA's Resource Stewardship organization for in-stream modifications.

Design Criteria

- The structure shall be large enough to convey the flow expected from a 2-year, 24-hour frequency storm without appreciably altering the stream-flow characteristics. The structure may be a span or culvert. If culverts are used, Table 4 provides aid in selecting the appropriate size. Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert that may be used is 24 inches.
- Where culverts are installed, clean crushed stone shall be used to form the crossing. The depth of soil cover over the culvert shall be equal to 1/2 of the diameter of the culvert or 12 inches, whichever is greater. To protect the sides of the fill from erosion, riprap shall be used.
- The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.
- The slope of the culvert shall be at least 0.25 inch per foot.
- The culvert shall be placed on or as close as possible to the stream bed to prevent impoundment.
- The approaches to the structure shall consist of stone pads meeting the following specifications:

  a. Stone--Class I (Table 3)

  b. Minimum thickness--6 inches

  c. Minimum width equal to the width of the structure

  d. Minimum approach lengths--25 feet

Table 4. Pipe diameters for stream crossings[1/].

Drainage Area (Acres)	Average Slope of Watershed 1%	4%	8%	16%
1-25	24	24	30	30
26-50	24	30	36	36
51-100	30	36	42	48
101-150	30	42	48	48
151-200	36	42	48	54
201-250	36	48	54	54
251-300	36	48	54	60
301-350	42	48	60	60
351-400	42	54	60	60
401-450	42	54	60	72
451-500	42	54	60	72
501-550	48	60	60	72
551-600	48	60	60	72
601-640	48	60	72	72

[1/]Assumptions for determining the table: USDA-SCS Peak Discharge Method; CN = 65; Rainfall depth = 3.5" for 2-year frequency storm.

Specifications

- Clearing and excavation of the stream bed and banks shall be kept to a minimum.
- The structure shall be removed as soon as it is no longer necessary for project construction.
- Upon removal of the structure, the stream shall immediately be reshaped to its original cross-section and properly stabilized.
- Fords are "minimum use" crossings where the stream system has an existing or applied firm base. To avoid unacceptable impacts, apply adequate riprap stone or other effective material to crossings to stabilize road banks and stream channel. Riprap stone must not adversely impact water chemistry of streams.

Maintenance

The structure shall be inspected after every significant rainfall and at least once a week, whether it has rained or not, and all damages must be immediately repaired. Ford-type crossings require frequent inspections to determine their functional condition.

J. Broad-based Drainage Dips

Definition

A technique used to form a reverse slope in a road surface with an outsloped cross drain (Figure 15). Usually not used on steep roads.

Purpose

To provide cross drainage on flat and insloped access roads to prevent buildup of excessive surface runoff and subsequent erosion.

Conditions Where Practice Applies

Usually used on access roads having gradient of 12 percent or less. They should not be used for cross draining of spring seeps or intermittent or perennial streams.

Broad-based drainage dips in the road surface are very effective in collecting surface water and directing it safely off the road. This type structure allows normal truck speed with minimal stress to the vehicle.

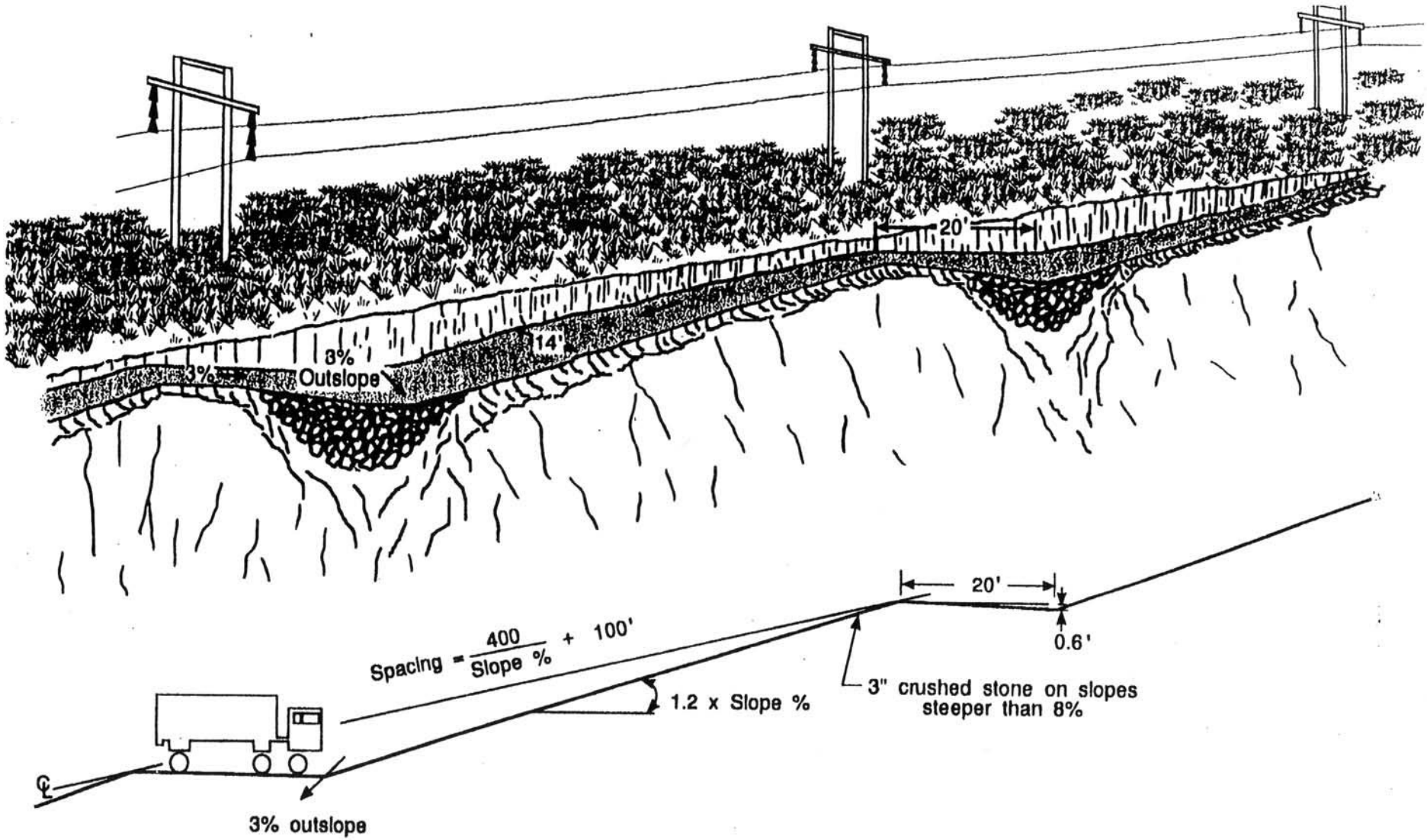


Figure 15. Details of a broad-based drainage dip.

Specifications

- Install broad-based drainage dips following basic clearing and grading of roadway.
- A 20-foot (approx.) long, 3-percent reverse grade is formed using cut material from the upper side of the dip.
- The bottom of the dip will be outsloped 2- to 3-percent maximum and extend the full width of the roadway. For maximum self-cleaning, angle cross drain 10- to 25-degrees downslope.
- An energy absorber such as riprap or a level spreader, should be installed at the outlet of the dip to dissipate water velocity ensuring minimal erosion of cast materials.
- The dip and reverse grade section may require bedding with 3-inch crushed stone in some soils to stabilize and avoid unacceptable rutting (i.e., grades over 10 percent and/or areas having highly erosive soils).

An inherent problem in construction of a broad-based drainage dip is to recognize that this structure consists of two planes rather than one unbroken plane. One plane is the 15- to 20-foot reverse grade toward the uphill grade and outlet. The second plane is the long grade from the top of a hump or start of a down grade and ends at the outlet of the dip. Neither the dip nor the hump should have a sharp, angular break but should be rounded to allow a smooth flow of traffic. Only the dip itself should be outsloped to provide sufficient break in grade to turn the water.

Spacing of broad-based drainage dips (Table 5) may be determined by the following formula:

$$\text{Spacing (ft.)} = \frac{400'}{\text{Slope \%}} + 100'$$

Table 5. Recommended spacing of broad-based drainage dips.

Road Grade (Percent)	Distance Between Dips (Feet)
4	200
5	180
6	165
7	155
8	150
9	145
10	140
12	135

Maintenance

During on-going operations, inspect frequently. Check for erosion, rutting, plugging, and general effectiveness. Correct unacceptable situations promptly.

K. Narrow-based Drainage Dips or Water Bars

Definition

A combination "mound-trench" built into an access road and placed on a downslope angle across the travelway (Figure 16). Water bars can provide conditions suitable for natural or artificial vegetative cover.

Purpose

To intercept and divert surface water off the road or trail and minimize excessive erosion and/or gullying.

Conditions Where Practice Applies

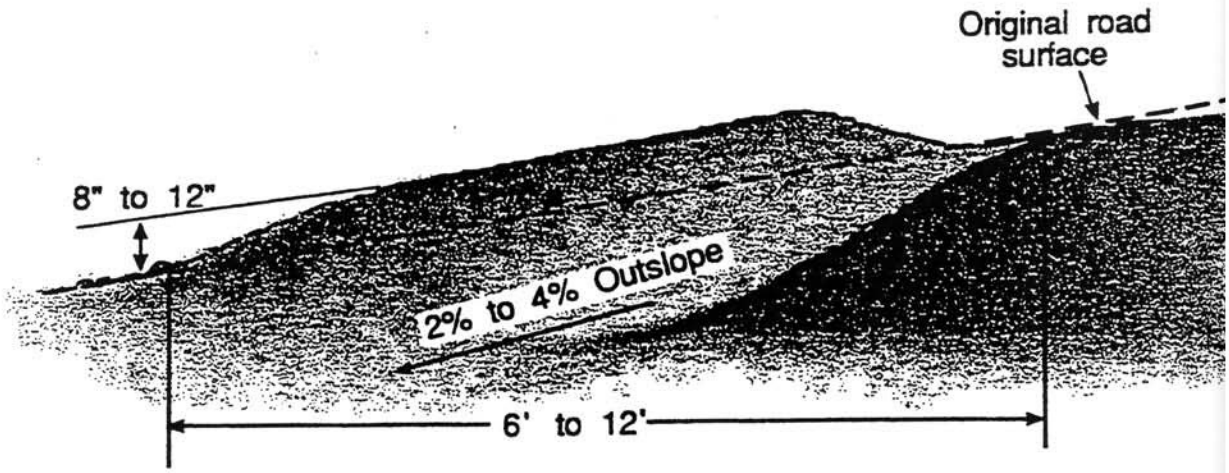
This practice can be used on road grade where runoff may cause erosion of the exposed soil. Water bars are usually installed after regular use of the road has ended.

Specifications

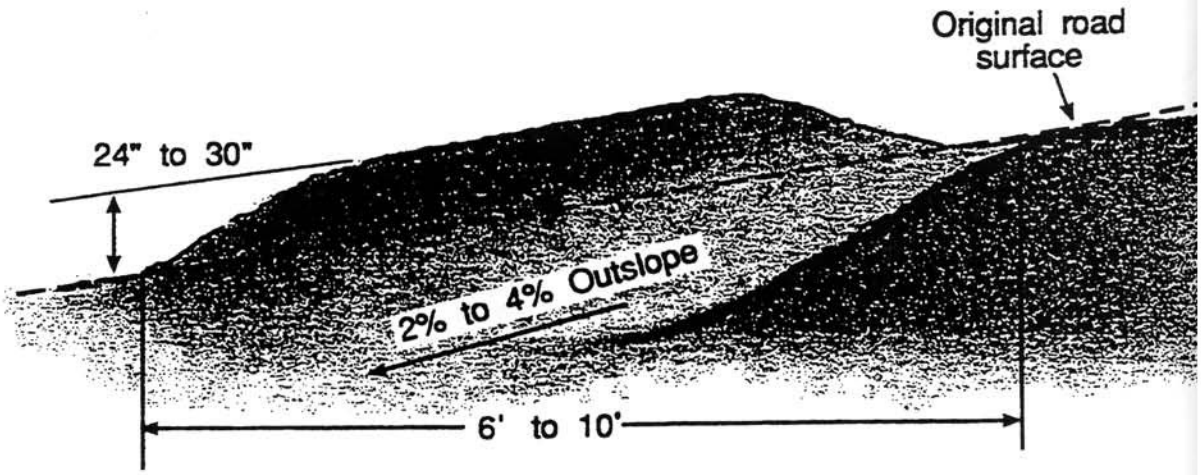
- Proper spacing between water bars can be determined from Table 6.

Table 6. Recommended spacing of narrow-based drainage dips or water bars.

Road Grade (Percent)	Distance Between Water Bars (Feet)
5	135
10	80
15	60
20	45
30	35



A. Shallow dip



B. Deep dip

Note: All waterbars should be constructed at a 30° angle downslope.

Figure 16. Details of a narrow-based drainage dip or water bar.

- Water bars should be at an angle of 15- to 30- degrees downslope to turn surface water off the road depending upon the terrain.
- The uphill end of the bar should extend into the side ditch line of the road and tie into the bank to fully intercept any ditch flows.
- The outlet end of the bar is to be fully open and extend far enough to safely disperse runoff onto an undisturbed area.
- Place energy absorbers at water bar outlets when the potential for gullying is evident.

Maintenance

Inspect quarterly and after major rain storms until area becomes adequately stabilized. Promptly correct failing conditions.

L. Water Turnouts

Definition

A ditch, trench, or waterway that diverts water away from the road and/or side ditch (Figure 17). The turnout is usually formed of on-site soil material. Shape and size varies to meet site-specific needs.

Purpose

To carry water into undisturbed areas and to disperse surface flow to prevent energy build-up.

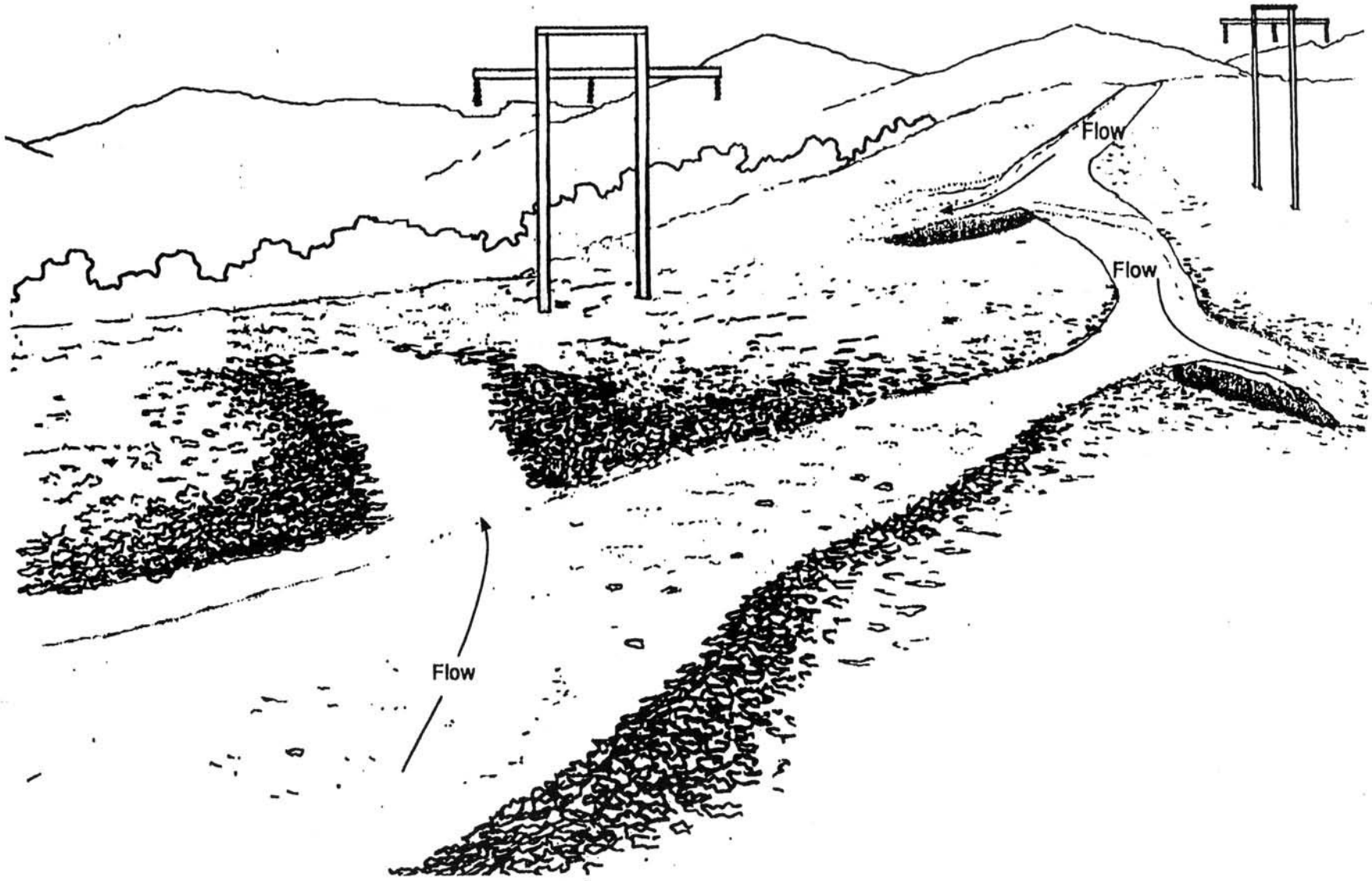


Figure 17. Examples of water dispersal by turnouts.

Conditions Where Practice Applies

Usually any road or ditch section where water accumulates. Turnouts are used to dissipate water energy, velocity, and volume.

Specifications

- A turnout should intersect the ditch line at the same depth and be outsloped 1 to 3 percent.
- On sloping roads, a turnout should be 30- to 45-degrees downslope. Turnouts should not empty directly into adjacent drainages or channels of any type.

Maintenance

Inspect frequently during on-going operations and immediately following significant rain events to evaluate their effectiveness. Promptly correct conditions or situations that are ineffective.

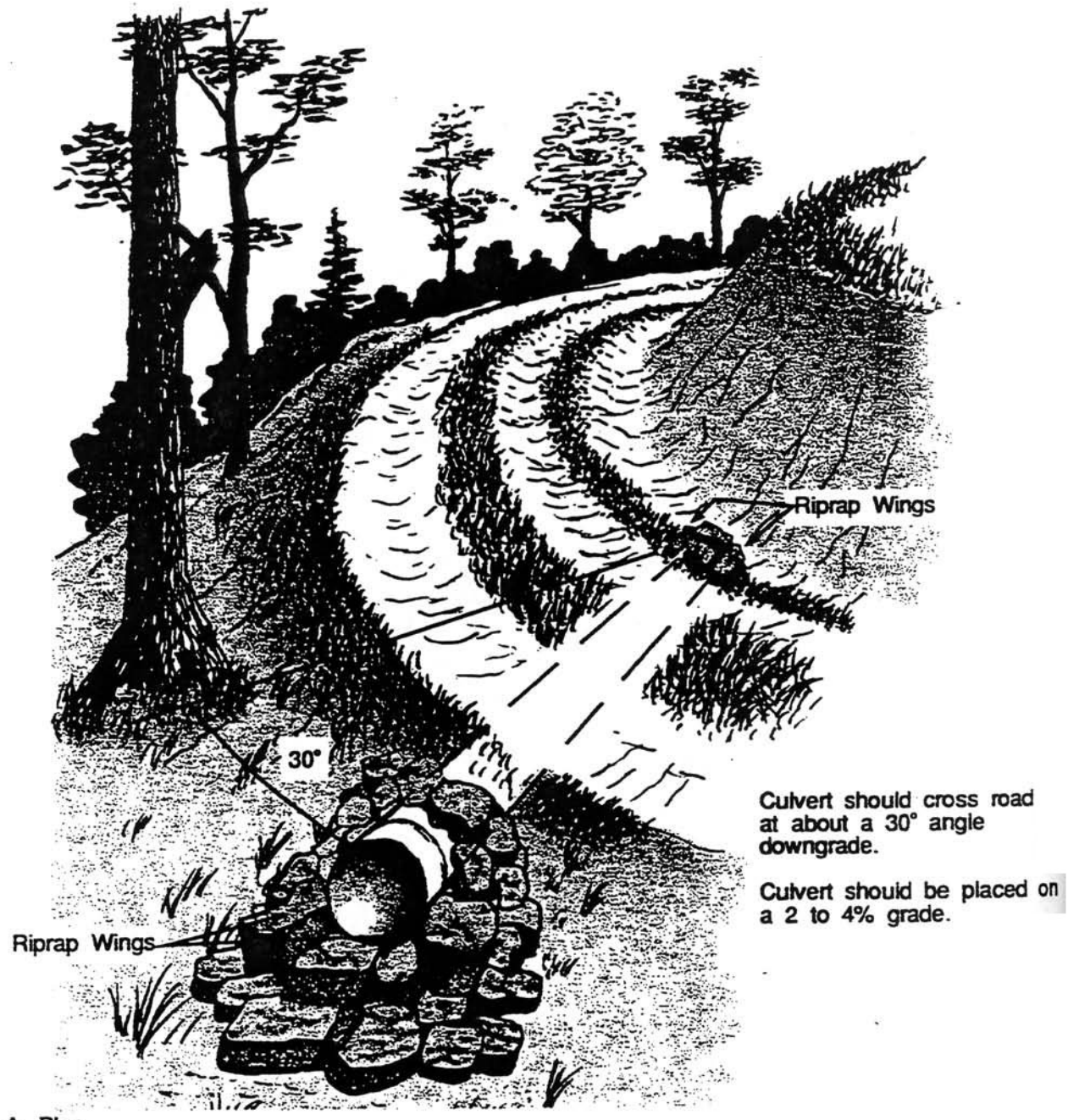
M. Cross-Road Drainage by Pipe Culvert

Definition

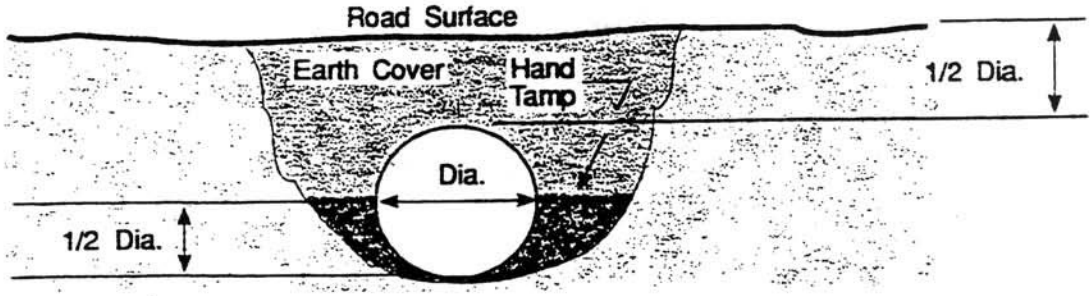
Cross-road drainage is the movement or transfer of storm water across the road (Figure 18). Round culverts are appropriate for transferring water under roads from major ditches.

Purpose

To provide cross drainage or ditch-to-ditch transfer of surface water.



A. Plan.



B. Cross-section.

Figure 18. Details for installing a pipe culvert.

Conditions Where Practice Applies

Cross-road drainage is recommended on any road where storm water runoff, ditch-to-ditch transfer, or overland seepage might create wet areas and erosion.

Specifications

Pipe culverts are usually installed on permanent roads at the time of construction. They are used where vehicle traffic will be relatively heavy following construction. Pipe culverts are costly to buy and maintain and therefore crossings that require pipe culverts should be adequately justified.

- Pipe culverts should be long enough so both ends extend beyond the toe of the fill slopes.
- Culvert sizing is determined by the area to be drained. However, pipe sizes of less than 18 inches in diameter tend to clog easily with floating leaves, twigs, etc. For this reason, cross-drain pipe culverts should be 18 inches or larger (Table 7).
- A culvert should be placed on a 2- to 4-percent grade to aid self-cleaning.
- On steep slopes, installation should be skewed 15- to 30-degrees downgrade to provide better entrance conditions at inlet end.
- Frequency or spacing to be on an "as needed" basis.
- Erosion protection may be needed at inlet and outlet ends of the pipe. Where channel scouring and gullying is excessive, riprap stone or other material or techniques may be used to function as an energy absorber.
- Earth cover (compacted) over a pipe culvert must be at least 1/2 the pipe diameter but never less than 12 inches.

Table 7. Pipe culvert sizing for access roads.

Acres Drained	Light Soils[1/] Flat 0-5%	Light Soils[1/] Mod. -15%	Light Soils[1/] Steep 15%+	Medium Soils Flat 0-5%	Medium Soils Mod. -15%	Medium Soils Steep 15%+	Heavy Soils Flat 0-5%	Heavy Soils Mod. -15%	Heavy Soils Steep 15%+
	inches								
2	18	18	18	18	18	18	18	18	18
4	18	18	18	18	18	18	21	21	21
6	18	18	18	18	18	21	21	27	27
8	18	18	18	18	18	21	24	27	30
10	18	18	18	18	21	24	27	30	36
20	18	18	18	21	24	30	30	36	42
30	18	18	18	21	27	36	36	42	48
40	18	18	18	24	30	36	42	48	54
50	18	18	18	27	36	42	42	48	
60	18	18	18	27	36	42	42	54	
70	18	18	18	27	36	42	48	54	
80	18	18	21	30	36	48	48		
90	18	18	21	30	36	48	48		
100	18	18	21	30	42	48	48		
150	18	21	24	36	42	54	54		
200	21	21	27	36	48				
250	21	24	27	42	48				
300	21	27	30	42	54				
350	24	27	30	42	54				
400	24	27	36	48					

[1/] Soils which have a dominant coarse-textured, sand component are termed light compared to heavy soils which are fine textured and mostly silt and clay. Light soils are more permeable than heavy soils.

Maintenance

Inspect cross drainages frequently. Look for clogging, plugging, collapsed or broken structures and general effectiveness. Correct ineffective conditions promptly.

N. Construction Entrance/Exit

Gravel Construction Entrance

A gravel construction entrance is a pad of crushed stone that reduces the tracking of mud onto a paved street. To construct the pad, place a layer of 2- to 3-inch stone across the full width of the vehicle ingress and egress area. The stone pad should be at least 50 feet along and at least 6 inches thick. Additional stone may have to be added periodically to maintain the proper functioning of the pad.

Construction Road Closure

An effective road closure structure is illustrated in Figure 19. When using this structure the following points should be considered.

a. Locate the structure where by-passing will be most difficult.
b. Minimum height of earth mounds should be four feet above original roadbed surface.
c. The approach side should be as steep as the soil type will allow.
d. Mounds should be spaced 8 to 10 feet apart (or the wheel base length of the most likely violator). Closer spacing may be necessary to stop all-terrain vehicles.
e. Road closure signs should be in front of the structure, not in the earth mounds.
f. Large rocks imbedded in the earth mounds during construction will help prevent vehicles from over riding the structure.
g. Revegetate the disturbed area.

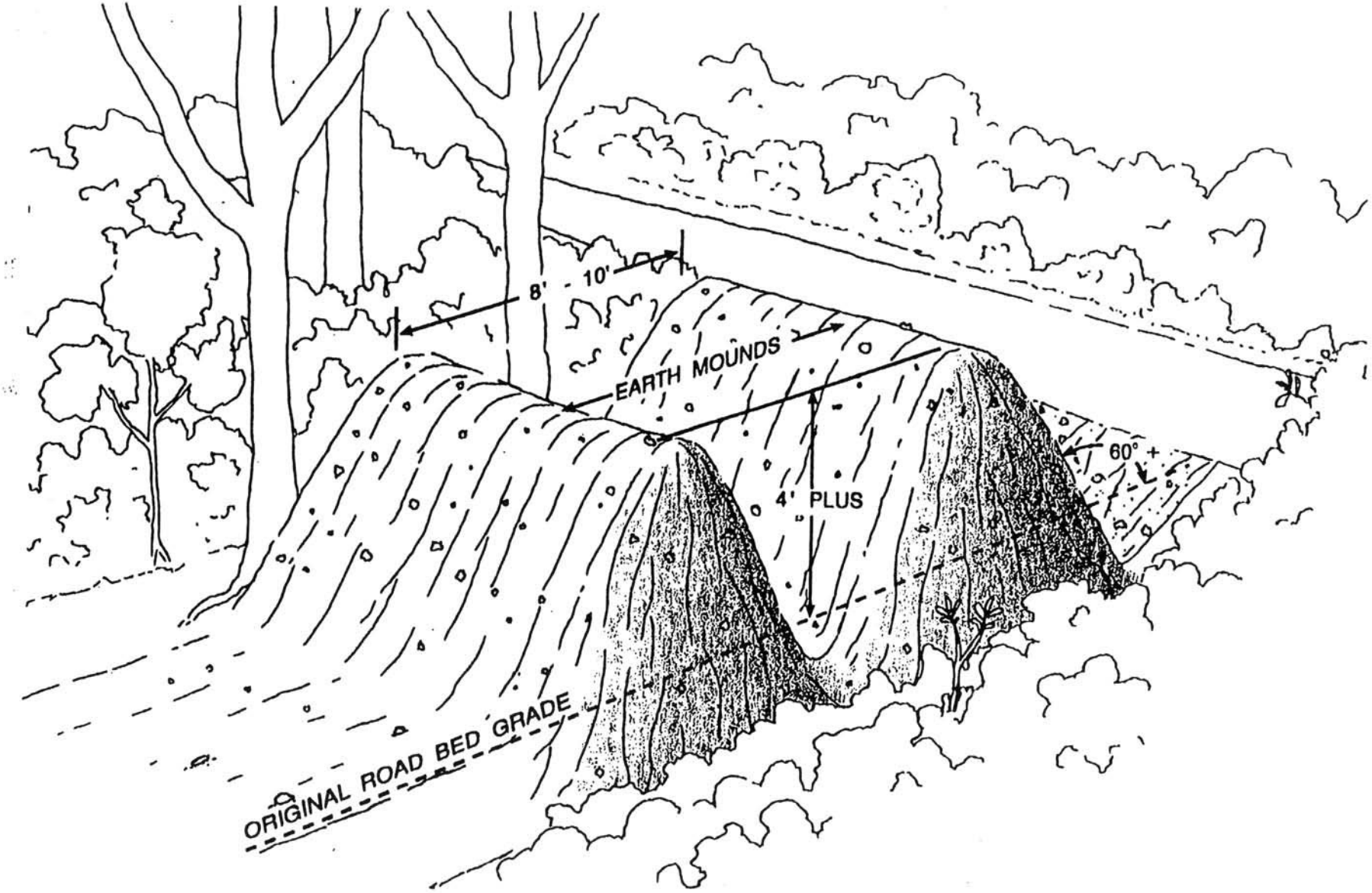


Figure 19. Details of an earth road closure structure (double tank trap).

O. Streamside Management Zone

Definition

An area or zone, covered with vegetation on both sides of perennial and intermittent streams and zones along the margins of bodies of open water, where extra precaution is used in carrying out construction activities to protect stream banks and water quality (Figure 20). The zone also provides stream shade and functions as a buffer when herbicides, fertilizers, etc., are applied to adjacent lands.

Purpose

- To slow and spread surface-water flow, trap, and filter out suspended sediment before these particulates reach the stream channel.
- To protect stream bank integrity.
- To protect stream water temperature.

Conditions Where Practice Applies

Along perennial and intermittent streams and along edges of bodies of water where disturbances occur and where surface runoff, flooding, or back flows may carry sediment loads to the watercourse.

Specifications

- Establish a SMZ along each intermittent and perennial stream and perennial waterbody.
- The width of the SMZs may vary depending on type of watercourse, primary use of water resource, topography, or other physical barrier (Table 8).

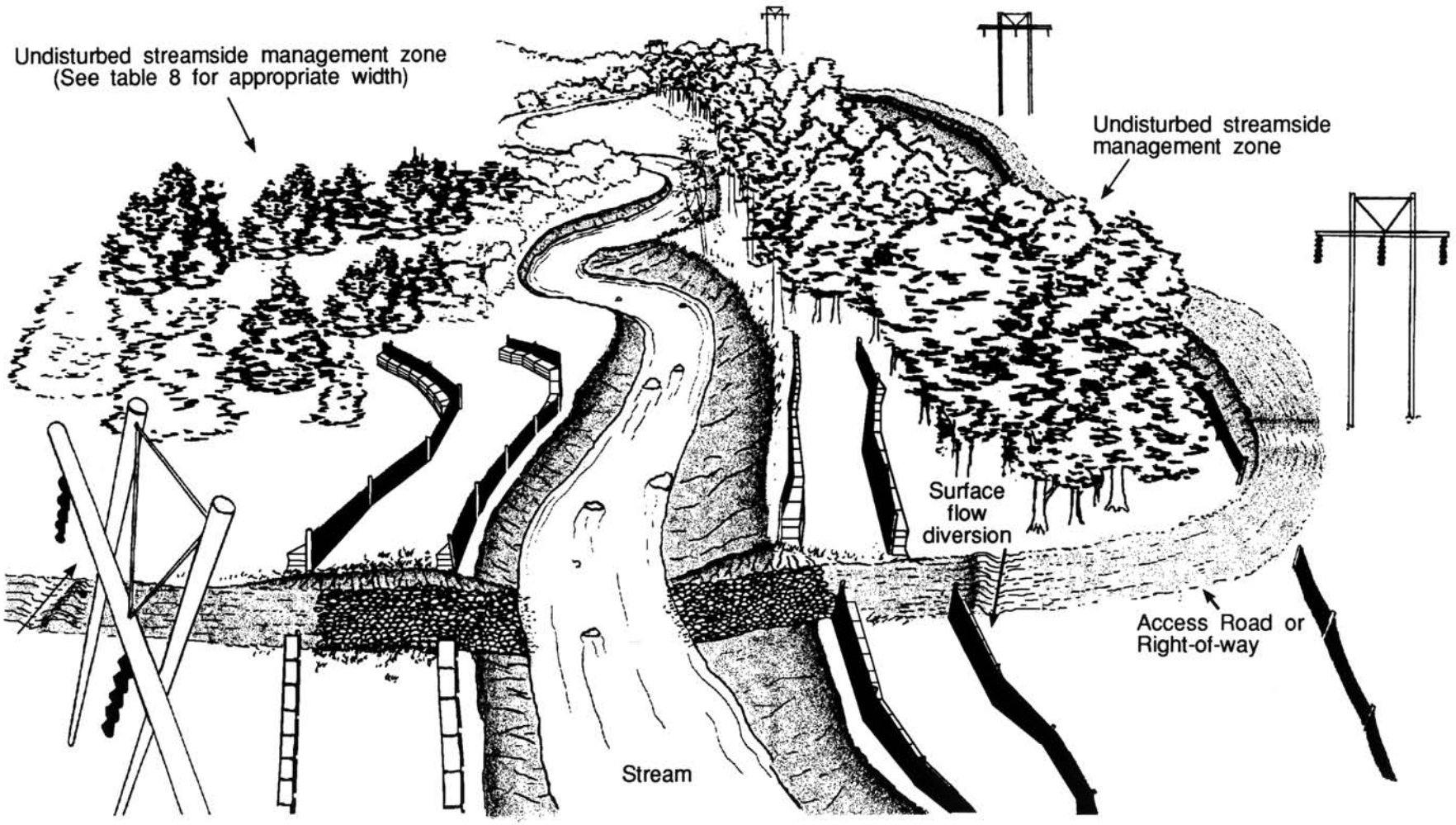


Figure 20. Example of a streamside management zone.

SMZ width is measured along the slope in linear feet on each side from the edge of the waterbody to the toe of road or other surface disturbance.

Table 8. Recommended minimum width of streamside management zone.

	Percent Slope of Adjacent Lands				
	0-5	6-10	11-20	21-45	46+
Type Stream or Waterbody	- - - SMZ Width each side - - -				
Intermittent	50	50	50	50	50
Perennial	50	50	65	75	100
Perennial, Trout Waters	50	65	75	100	125
Sensitive Aquatic Resources	100	125	150	200	250

- Regardless of the width, the SMZ must provide effective sediment protection for the watercourse.
- Limited construction and maintenance activities are allowed within most SMZ situations. Where activities are allowed additional and more effective BMPs may be required to fully protect the stream channel or other water body and water quality. Extra care is recommended within SMZs near public water supplies (streams and reservoirs) or springs and sinkholes to reduce the risk of sudden and severe contamination due to failure of BMPs with unusual storms.
- Unnecessary canopy removal along streams is discouraged during clearing or re-clearing. Fell trees away from the watercourse. Remove trees and tops with extreme care and leave the ground cover vegetation essentially undisturbed. Within SMZ areas along perennial streams, no more than 20 percent bare ground, evenly distributed, is allowed resulting from construction or maintenance activities. And, along intermittent streams,

no more than 40 percent bare ground, evenly distributed, is allowed. On those areas where bare ground exceeds the 20 or 40 percent limit, a ground cover must be provided. Seeding or planting native materials that stabilize the soil surface and benefit wildlife should be considered.

- Within SMZ areas where ephemeral streams intersect perennial or intermittent streams (confluence), only minimal surface disturbance is allowed. Wheel- or track-type equipment should not operate within these zones.
- All construction debris resulting from clearing and re-clearing operations or building or structure removal must be kept out of intermittent and perennial stream channels, wetlands, or ground water infiltration zones. Should debris reach these areas, it will be promptly removed.
- Broadcast application of herbicides, fertilizers, or broadcast spraying of herbicides (except those labeled for aquatic use) should be conducted so that chemicals are not applied directly into intermittent and perennial streams and perennial waterbodies, or allowed to drift into such watercourses. Chemicals should not be applied to the land surface closely adjacent to water surfaces or channels, or to the surface of ephemeral streams or drainage channels within SMZs where direct washoff into the stream or waterbody could occur.
- Operations involving chemical or fuel storage, resupply and vehicle servicing will be handled outside of SMZs and in such a manner as to prevent these items from reaching the watercourse. Earthen berms or other effective means must be installed to protect the stream channel from direct surface runoff. Servicing will be done with care to avoid leakage, spillage, and subsequent stream, wetland, or ground water contamination. Oil waste, filters, and other litter will be collected

and disposed of properly. See section "Good Housekeeping" (Chapter V., G.) for further discussion.

- Locate roads outside of SMZs except where stream crossings are necessary and where physical restrictions (right-of-way boundary, property boundary, topography, etc.) cause roads to be within the SMZ. Where restrictions exist and roads and trails are inside an SMZ, alternate techniques or measures must be employed to effectively protect the stream channel. Establish right-angle crossings to stream channels. Avoid the use of fill material placed over construction debris as a stream crossing.
- Promptly revegetate or provide adequate ground cover for bare soil areas within an SMZ (roads, ditches, crossings, cut and fill banks).
- Alter SMZ planning to include development and enhancement of wildlife habitat. Consultation with a wildlife biologist is recommended.

During the pre-construction review of a proposed transmission line, substation, or telecommunication facility TVA Resource Stewardship staff will classify each crossing into one of three classifications: A) standard protection, B) protection of important permanent streams, wetlands, springs, or sinkholes C) protection of unique habitats. The guidelines for each stream classification are summarized in Table 9.

Table 9: TVA transmission construction guidelines near streams

Guidelines	A: Standard	B: Important Permanent Streams	C: Unique Water Habitats
1. Reference	• All TVA construction work around streams will be done using pertinent BMPs such as those described in "A Guide for Environmental Protection and Best Management Practices for TVA Construction and Maintenance Activities," especially Chapter 6, BMP Standards and Specifications.	• Except as modified by guidelines 2-4 below, all construction work around streams will be done using pertinent BMPs such as those described in "A Guide for Environmental Protection and Best Management Practices for TVA Construction and Maintenance Activities," especially Chapter 6, BMP Standards and Specifications.	• Except as modified by guidelines 2-4 below, all construction work around the unique habitat will be done using pertinent BMPs such as those described in "A Guide for Environmental Protection and Best Management Practices for TVA Construction and Maintenance Activities," especially Chapter 6, BMP Standards and Specifications.
2. Equipment Crossings	• All crossings of streams must comply with appropriate state and federal permitting requirements. • Crossings of all drainage channels, intermittent streams, and permanent streams must be done in ways that avoid erosion problems and long-term changes in water flow. • Crossings of any permanent streams must allow for natural movement of fish and other aquatic life.	• All crossings of streams must comply with appropriate state and federal permitting requirements. • Crossings of drainage channels and intermittent streams must be done in ways that avoid erosion problems and long-term changes in water flow. • Proposed crossings of permanent streams must be discussed in advance with Resource Stewardship staff and may require an on-site planning session before any work begins. The purpose of these discussions will be to minimize the number of crossings and their impact on the important resources in the streams.	• All crossings of streams must comply with appropriate state and federal permitting requirements. • All construction activity in and within 30 meters (100 feet) of the unique habitat must be approved in advance by Resource Stewardship staff, preferably as a result of an on-site planning session. The purpose of this review and approval will be to minimize impacts on the unique habitat.

Table 9: TVA transmission construction guidelines near streams (continued)

Guidelines	A: Standard	B: Important Permanent Streams	C: Unique Water Habitats
3. Cutting Trees	• Cutting of trees within SMZs must be accomplished by using either hand-held equipment or other appropriate clearing equipment (e.g. a feller-buncher) that would result in minimal soil disturbance and damage to low-lying vegetation. The method will be selected based on site specific conditions and topography to minimize soil disturbance and impacts to the SMZ and surrounding area. • Stumps can be cut close to ground level but must not be removed or uprooted.	• Cutting of trees within SMZs must be accomplished by using either hand-held equipment or other appropriate clearing equipment (e.g. a feller-buncher) that would result in minimal soil disturbance and damage to low-lying vegetation. The method will be selected based on site specific conditions and topography to minimize soil disturbance and impacts to the SMZ and surrounding area. • Cutting of trees near permanent streams must be limited to those meeting NESC and danger tree requirements. • Stumps can be cut close to ground level but must not be removed or uprooted.	• Cutting of trees within 30 meters (100 feet) of the unique habitat must be discussed in advance with Resource Stewardship staff, preferably during the on-site planning session. Cutting of trees near the unique habitat must be kept to an absolute minimum. • Stumps must not be removed or uprooted.
4. Other Vegetation	• Other vegetation near streams must be disturbed as little as possible during construction. • Soil displacement by the actions of plowing, discing, blading or other tillage or grading equipment will not be allowed in SMZs, however, a minimal amount of soil disturbance may occur as a result of clearing operations. • Shorelines which have to be disturbed must be stabilized as soon as feasible.	• Other vegetation near streams must be disturbed as little as possible during construction. • Soil displacement by the actions of plowing, discing, blading or other tillage or grading equipment will not be allowed in SMZs, however, a minimal amount of soil disturbance may occur as a result of clearing operations. • Shorelines that have to be disturbed must be stabilized as soon as possible and revegetated as soon as feasible.	• Other vegetation near the unique habitat must be disturbed as little as possible during construction. • The soil must not be disturbed by plowing, discing, blading, or grading. • Areas that have to be disturbed must be stabilized as soon as possible and revegetated as soon as feasible, in some cases with specific kinds of native plants. These and other vegetative requirements will be coordinated with Resource Stewardship staff.

Maintenance

During on-going operations inspect SMZs frequently; inspect occasionally during inactive periods. Check for potentially damaging or failing situations that may cause unacceptable water quality impacts. Correct failing situations as soon as practical.

P. In-Wetland Clearing, Construction, and Restoration Techniques

Properly and carefully implemented BMPs will protect important wetland functions on most sites under most weather conditions. On extremely sensitive sites or in extremely severe weather conditions, more stringent protection measures may be required, including complete avoidance of such sites.

The following material describes some of the methods that can be used to minimize impacts of clearing and construction in wetland areas. All of these methods should be used with the PRIOR approval of the appropriate regulatory agencies (US Army Corps of Engineers, state water pollution control agency, etc.) and must be carefully selected on a site-by-site basis. Any of these methods may be modified or eliminated by a regulatory agency at any time. A site specific clearing/construction/restoration plan should be prepared for each project which involves work in wetlands. This plan would outline the selected and APPROVED methods that will be used as the project proceeds.

Possible Wetland Clearing Methods

CM-1:

Brush and timber will be cut close to ground level using shear blades and/or a hydro-axe. Stumps will not be removed or grubbed. Brush and timber will be burned away from the wetland or the flow paths to it according to local fire regulations. Timber will be removed by standard forestry practices(skidders) with minimal ground disturbance (no rutting deeper than 12 inches).

CM-2:

Brush & timber will be cut using a low-ground pressure (LGP) hydro-axe. Though, when heavily saturated or "flooded" water levels are present, brush and timber will be power sawed. Low-ground pressure equipment will be used in the wetland area to remove timber and brush. A cut & cross-lay road may be constructed (if saturated conditions exist) for clearing and line construction or re-clearing and maintenance access. If a cut & cross-lay road is constructed, the road will be removed and disposed of by traditional means once line construction or maintenance is complete so that fill will not occur.

CM-3:

Brush and timber will be power sawed by hand; timber and debris shall be removed unless regulatory authorities specifically allow it to remain in place rather than be removed from site. Branches will be trimmed until brush/debris present no electrical clearance or safety problems. (Density Rule: < 6, 8 in. diameter trees within 50 ft^2)

CM-4:

Only timber exceeding the electrical safety clearance zone, plus one maintenance cycle (4-6 years growth) will be power sawed and winched without damaging the under soil water seal when feasible. Equipment in the site will be minimzed when winching timber. Lower growing brush and vegetation will remain to provide ground cover.
Note: This method should be utilized when Streamside Management Zones (SMZs) are adjacent to delineated wetlands.

CM-5:

Brush and timber will be power sawed. The timber will be winched, when feasible, to upland sites for disposal by traditional means. Equipment in site will be minimized when winching timber and timber will be winched to the closest bank. Brush and debris will be removed unless specifically allowed to remain by the appropriate regulatory agency.

CM-6:

The wetland is a scrub-shrub, emergent, or grazed wetland with no clearing required. No heavy equipment will be used in the site. There will be minimal intrusion by all mechanized equipment.

Note: When applying CM-2, the cut & cross-lay road may be allowed to remain based upon the U.S. Army Corps of Engineers' District determination in order to minimize soil disturbance and water quality impacts.

Possible Wetland Structure Placement/Access Methods:

SP-1:

No structures will be located within the boundaries of this wetland area.

SP-2:

Cut timber will be placed in a temporary cut and cross-lay road to allow low ground pressure (LGP) equipment to install structure. The cut and cross-lay road will be removed following completion of construction activities. When soil is not saturated or "flooded", the cut and cross-lay road may be omitted from use.

SP-3:

Structure placement will be accomplished using low ground pressure equipment. Rutting will not exceed 12 inches within the boundaries of the wetland. Visual inspections of soil/hydraulic conditions will be used to determine appropriate times for ingress and egress.

SP-4:

Structure placement will be accomplished using standard construction techniques, with access accomplished from upland sites. Matting will be used to minimize soil disturbance in immediate vicinity of structure. When the ground is not saturated and when rutting would be <12", mats may be omitted from use.

SP-5:

Structure placement will be accomplished using a helicopter. Excavation will be accomplished by hand, pneumatic power equipment, or some other method not requiring ingress & egress of heavy equipment/large vehicles.

Note: When applying SP-2, the cut & cross-lay road may be allowed to remain based upon the U.S. Army Corps of Engineers' District determination in order to minimize soil disturbance and water quality impacts.

Possible Wetland Restoration Methods

RM-1:

Only hand broadcasting of a native grass species may be used for temporary erosion control. No mechanical seedbed preparation (disking) will be done, and no fertilizer will be used. Natural regeneration is the primary means of restoration. No herbicides will be used in the designated wetland areas unless approved by the U.S. Army Corps of Engineers and the U.S. Fish & Wildlife. Herbicide usage would be limited to direct application (stump treatment) only and not broadcast application techniques.

RM-2:

Native wetland plant species will be planted to encourage facultative-wet species dominance in the designated wetland and to accelerate natural regeneration/habitat. Hand broadcasting of a native grass species may be used for temporary erosion control. No mechanical seedbed preparation (disking) will be done, and no fertilizers will be used. No herbicides will be used in the designated wetland areas unless approved by the U.S. Army Corps of Engineers and U.S. Fish & Wildlife. Herbicide usage would be limited to direct application (stump treatment) only and not broadcast application techniques.

RM-3:

Hydroseeding, straw mulch, and native wetland plants will be used to increase wetland survival rate and restoration time. A detailed erosion control and wetland restoration plan will be followed for the designated wetland area.

Possible Structure Retirement Methods

REM-1:

The existing transmission line will be retired (demolished) by using a low-ground pressure crane, an "a-frame" dozer, and labor crews. The equipment will use mats, cut & cross-lay roads, or other low-impact techniques when needed.

REM-2:

Conventional equipment (dozers, trucks, etc.) will be used to take down the existing line.

REM-3:

Precision cutting and helicopter removal will be used to remove the line. No wheeled equipment will be allowed in the wetland area.

CHAPTER VII

REVEGETATION OF DISTURBED LANDS

Many lands disturbed by transmission construction, maintenance, clearing and re-clearing activities do not revegetate naturally or promptly and require artificial revegetation to prevent soil movement and pollution of streams. These may include erodible or severely eroded areas, access roads, cut and fill slopes, ditches, and other areas where there has been prolonged and extensive work, such as around foundations and tower structures. Disturbed lands should be immediately revegetated after construction activities in the area have ceased.

Establishment of cover on areas disturbed by construction and maintenance activities is often more difficult than on agricultural lands. Disturbed areas are often steep, compacted, low in fertility and organic matter, and/or droughty. Thus, the following principles should be carefully considered when planning revegetation of disturbed lands.

- Conduct grading and/or prepare a seedbed.
- Lime and fertilize throughout the initial establishment period, which may take as long as two or three years.
- Mulch to create an environment suitable for plant establishment.
- Provide stability so seed can remain in place long enough to germinate and grow.
- Select plants adapted to the site and match appropriate species with the time of seeding or season of year.

A. Grading

Grading, leveling, or smoothing of a construction site or access road normally precedes revegetation activities. Designed grading and shaping can enhance the land for most uses. In addition, a newly graded soil usually provides a suitable seedbed. However, some grading practices can hinder successful revegetation and should be avoided. For example, grading wet or muddy soils can alter the physical properties of soil particles and create a compacted and pavement-like surface. Grading dry materials to a fine or smooth finish also can produce surface conditions that are undesirable for vegetation establishment.

B. Site/Seedbed Preparation

A suitable seedbed is required for successful establishment of seeded vegetation. A suitable seedbed is one that provides numerous microsites favorable for seed germination and seedling growth.

Preparation of a seedbed by mechanical tillage or scarification often is essential, especially on soils that are crusted or compacted, and for seedings made in late spring, summer, and fall. However, broadcast seedings made on the surface in late winter and early spring are generally successful without mechanical preparation of a seedbed because the seed are "planted" by the alternate freezing and thawing of the soil. Also, tillage may not be necessary where seeding is done immediately after grading.

A seedbed can be prepared with a variety of implements. The physical condition of the land surface and size of the area are factors governing the

size and type of implements that can be used effectively. Normally, heavy-duty implements will be more useful and suffer less breakage than lighter ones.

Road surfaces should be shaped and smoothed prior to seeding. Heavily compacted areas such as road surfaces may require scarification or disking to promote infiltration of water and create suitable seedbed conditions. Gentle cut and fill slopes and ditches may also be scarified and disked, but avoid loosening soil on steeper slopes.

Crawler-type bulldozers can be used for seedbed preparation and to "drill" seed on moderately steep slopes. After the final grade has been established and seeded the surface should not be "back-bladed" but left rough and then "tracked-in" with the cleats or tracks of the bulldozer (Figure 21). Vegetation should become well established in these small depressions or microsites. This practice encourages infiltration of surface water runoff.

C. Soil Tests and Sampling

Soil tests are useful for defining properties that limit or prevent plant growth and for determining the kinds and amounts of amendments needed to correct properties that hinder vegetation establishment. Soil acidity and low soil fertility are two major limiting factors in establishing adequate vegetation.

Soil acidity is measured in terms of pH and is represented on a scale in units from 0-14. A pH less than 6.0 indicates possible acid problems; a pH

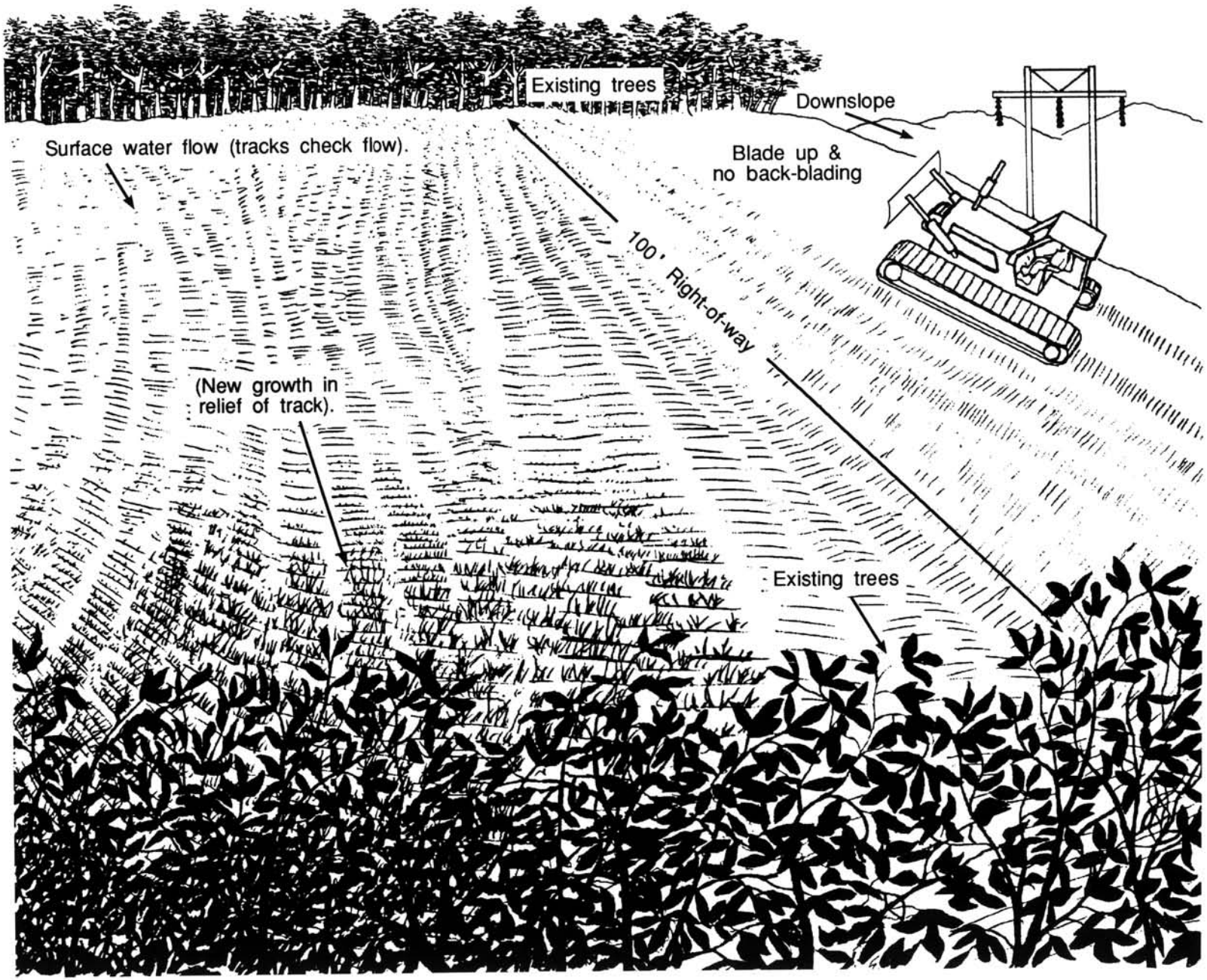


Figure 21. Tracking-in disturbed land with a crawler-type tractor.

of 7.0 is neutral. A pH greater than 8.0 indicates an alkaline soil. For agricultural uses, a pH of about 6.0 to 6.5 is generally recommended because nutrients are most available at this point. Agricultural lime is the material most used for amending acid soils. Although plants require a number of nutrients, the ones needed in large amounts are nitrogen (N), phosphorus (P), and potassium (K). The three numbers describing a fertilizer grade, such as 6-12-12, refer to the content (percentage) of available nitrogen, phosphate, and potash. Liberal amounts of these nutrients are required at establishment for rapid growth.

Very acid soils and/or soils of extremely low fertility often are problem sites. Chemical soil testing is a proven method of determining soil acidity and nutrient content. The results can pinpoint soil problems and help determine corrective measures.

To collect soil samples, use a spade with a rounded cutting edge or a small garden trowel. First, make a vertical cut about 4 to 6 inches deep and discard the soil. Then make a second cut 2 to 3 inches behind the first cut to obtain the sample. Discard rock fragments larger than about 1/2-inch in diameter. If a composite sample is being collected, place this slice in a plastic bucket and continue to the next sampling site and repeat the sampling procedure. In stone-free soils, samples can be collected with an agricultural soil sampling tube or auger. After the final subsample has been placed in the bucket, thoroughly mix the composite of samples and transfer about 1 quart of the mixed material to a plastic bag, wax or plastic lined paper carton, or similar container. Dry samples can be placed in paper bags. Be sure to identify and label each sample. If the soil at each sample point is to be analyzed, follow the previously mentioned

procedure for obtaining the sample, but place each sample in a separate container and label the containers.

D. Liming and Fertilization

Because soil acidity and low fertility may limit establishment of vegetation on most disturbed areas, it is usually necessary to apply agricultural limestone and fertilizer to ensure early establishment, rapid growth and development of vegetation. Lime should be applied in accordance with soil test results; but, in the absence of tests, apply at the rate of 2 to 3 tons per acre (90-140 pounds per 1,000 square feet). For temporary seeding, apply 300 pounds of 15-15-15 fertilizer per acre. For permanent seeding, apply 6-12-12 fertilizer or its equivalent in accordance with soil test rates or at the rate of 1,000 pounds per acre (23 pounds per 1,000 square feet). Excessive (greater than 60 pounds of nitrogen per acre) nitrogen applications should be avoided at seeding so that the natural nitrogen fixing processes of the legume(s) are not inhibited.

When possible, incorporate lime and fertilizer into the top 2 to 4 inches of soil. Shallower mixing is advisable on steeper slopes to prevent washing. On extremely steep slopes apply lime and fertilizer to soil surface only. If necessary, a second application of fertilizer could be made within one year of establishment by broadcast application to secure full plant growth and establishment. Apply 6-12-12 fertilizer at the rate of 500 pounds per acre (12 pounds per 1,000 square feet) or a similar fertilizer (i.e., 12-24-24) at an equivalent rate.

E. Mulching and Stabilizers

Under certain conditions, straw mulch should be used in revegetating disturbed areas to hold seed, fertilizer, and lime in place, maintain moisture, and prevent extreme temperatures on the soil surface. Apply straw mulch uniformly leaving about 25 percent of the ground visible. About one and one-half tons of clean straw or unmolded hay per acre (about 70 pounds per 1,000 square feet) should be used to provide adequate mulch density.

Other organic mulches include bark and wood chips, wood fiber, and wood cellulose. There are many forms of stabilizer products that can be used as chemical tacks to hold straw, hay, and other light weight mulches in place. The stabilizers also are used in combination with wood fiber and wood cellulose mulches. Do not use stabilizers with bark or wood chips.

Anchoring straw mulch is an effective method of keeping it in place. A mulch anchoring tool that is designed to punch straw into the soil provides maximum erosion control. A farm disk, weighted and set straight, is another tractor-drawn implement that could be used.

Quick-developing annual grasses can be sown for growing mulch in place. Perennial species can be subsequently established by seeding or planting them directly into the annual crop residue (in-place mulch). Where mulch is produced by summer annuals, this planting can be done the following spring. But spring planting of perennials into a winter annual crop may first require the disking or mowing of the temporary cover or the use of a herbicide to kill the annual-plant competition. Seeding perennial herbs could wait until late summer, after the winter annual vegetation is mature.

F. Erosion Control Blankets and Netting

On critical sites, steep slopes, and areas with heavy surface water runoff conditions, erosion control blankets or mats are effective in providing temporary erosion control and mulch during the critical seedling establishment period. The blankets eliminate erosion problems in these areas by significantly reducing the erosive forces of rainfall, runoff, and wind on the soil surface while enhancing seed germination and vegetative growth.

Several types and grades of blankets or mats are commercially available. These degradable materials are generally made with wood excelsior, straw, or coconut fibers. The mulch material is generally held together with a plastic or nylon mesh netting and/or cotton thread and is manufactured in rolls. Metal clip type pins or wooden stakes are used to attach the material to the ground.

An alternative approach to using these blankets or mats is to use the plastic mesh netting by itself to hold in place uniformly spread straw mulch, seed, and soil amendments. The plastic/nylon mesh netting is commercially available.

An alternative to using riprap to line shorelines and channels is to use nondegradable channel liners. They are made from various nondegradable materials. Degradable materials such as tightly woven coconut fibers also work.

G. Ground Cover Characteristics

Herbaceous plants are nonwoody and are classified as grasses or forbs. Grasses all belong to the Gramineae (grass) family. Most species have a fibrous root system that helps bind together soil particles and prevent erosion. Forbs are herbaceous plants other than those in the grass, sedge, and rush families. They generally are broad-leaved plants that have a tap root or branching tap root system. The forbs are further classified as legumes or nonlegumes. For disturbed lands, legumes usually are used and are especially valuable because they are nitrogen-fixing plants (i.e., by their symbiotic relationship with Rhizobium bacteria they convert atmospheric nitrogen into a form in the soil that is usable by plants).

The forbs are especially beneficial for quick establishment of vegetative cover for erosion control. Some herbaceous species also provide long-term site protection and are suitable for agricultural purposes or for wildlife habitat.

Life Span

The life span of herbaceous plants is either annual, biennial, or perennial (long-lived), whereas trees and shrubs all are perennial species. This knowledge can help the revegetation manager in planning the best use of different species.

Annuals

These plants grow, flower, produce seed, and die all within one season or one year. Annuals reproduce only from the seed they produce during this

life cycle. Some annuals, such as Korean and kobe lespedeza (scientific names for plant species discussed are listed in Table 17, Appendix A), usually regenerate (volunteer) a stand each year from the seed they produce, but other annuals such as rye and millet cannot be depended on to volunteer satisfactory stands. Annuals are usually the best species to plant for the quick establishment of a vegetative cover.

Biennials

These are plants that live for only two growing seasons. Some biennials, such as yellow sweetclover, produce most of their vegetative growth in the year they are sown. In the second year they produce vegetative growth early in the season, then flower, produce seed, and die.

Perennials

Most of these plants live at least three years and usually longer. Herbaceous perennials die back to the ground each year but regenerate new growth from roots or crowns. They also reproduce from seed. Plants of a few perennials such as perennial ryegrass are relatively short-lived (two to four years) and many perennials have indefinite or indeterminate life spans.

Season of Major Growth

Knowledge of when herbaceous plants grow is helpful in determining how and when each species can be used to the best advantage in the revegetation scheme. The growth period of herbaceous plants is grouped into two major seasons--cool and warm.

Cool-Season

Cool-season species grow mostly in the spring and fall and usually are dormant, semidormant, or grow slowly in the summer. These plants normally are dormant in the winter, though there are exceptions in the southern part of TVA's Power Service Area (Alabama and Mississippi) where some of the cool-season species may continue growth during the winter months. Cool-season species normally are most easily established by seeding in the spring and late summer to early fall. A few species, such as alfalfa, crownvetch, and birdsfoot trefoil will also grow in the summer, but usually are sown in the spring or late summer and are classified as cool-season plants.

Some cool-season plants are called winter annuals. They normally are sown in the fall. After the seeds germinate, the plants grow some before going dormant or semidormant over winter. These plants resume growth in the early spring, produce seed in late spring or early summer, and then die. Most of the winter annuals also produce cover when sown in the spring. Rye, winter wheat, annual ryegrass, and hairy vetch are examples of winter annuals.

Warm-Season

Warm-season species grow mostly in the late spring and summer and are dormant in early spring, fall, and winter. Warm-season species usually are sown in the spring. Summer annuals, such as foxtail millet and sorghum, are normally sown in late spring and early summer and are especially useful for the quick establishment of vegetative cover. These species complete their life cycle during late summer and early fall. Both summer and winter annuals can be grown to produce mulch in place.

H. Time of Seeding

The best time of seeding varies throughout TVA's Power Service Area. However, weather patterns in the Tennessee Valley Region generally favor early spring seeding for cool-season species; but fall seeding may produce the greatest success in some areas. For example, in western Tennessee or western Kentucky, fall seedings are often more successful than spring seedings because spring-sown plants sometimes die out during rainless periods in late spring and early summer. Early to mid spring normally is the best time to sow perennial and some annual warm-season species. Mid spring to early summer is the best time for seeding most summer annual species.

Sometimes, construction is completed and an area is ready for seeding in the summer or winter months. Seeding in late spring and summer is more risky than early-spring or fall seedings, and is not recommended in areas with hot, dry summers. But in some areas, summer rainfall is sufficient to establish stands of warm-season annuals sown in late spring to mid summer. Occasionally, summer precipitation is adequate for establishment of cool- and warm-season perennial species. Thus, in areas where summer precipitation is normally adequate, sites that are graded and ready for seeding in late spring and summer should be seeded as soon as possible after grading. Usually, this will shorten the period of time that the soils lie barren and exposed to erosion.

I. Methods of Seeding

Basically, there are two ways to apply seed: broadcast and drill. Seed can be mixed with water and broadcast through a hydroseeder; or it may be broadcast dry by hand, by ground-seeding equipment, or by aircraft. Seed can also be planted with a drill such as a grassland or rangeland drill.

J. Seed Mixtures

Revegetation strategies for most disturbed lands require seed mixtures of plant species. These mixtures for establishment of long-term vegetation generally include one annual or one quick-cover species, one or two perennial species, and one or two legumes. Any more is redundant or "shotgunning." Ideally, the perennial species will succeed and replace the temporary species.

When obtaining large quantities of a seed mixture it should be premixed by the supplier. This avoids incorrect mixing in the field and simplifies the process. It is especially important to follow seeding rate recommendations for the quick-cover temporary species, because higher rates of these species could produce dense stands that prevent or retard establishment of the permanent species.

K. Seed Purity, Germination, and Pure Live Seed

The use of good-quality seed that has been properly tested and tagged will help ensure the successful establishment of vegetative cover. Seed quality can be determined from information listed on the seed tag. Two of

the values listed on the seed tag--purity and germination percentage--are used to determine pure live seed (PLS). Pure live seed is useful for figuring proper seeding rates and the real cost of seed.

Purity tells you how pure the bag of seed is. A percentage number indicates how much is really the specified variety or blend and how much is other seed, weed seed or inert material and debris.

Germination percentage tells you how much of the good seed is actually going to grow, based on standardized laboratory tests. A 50 lb. bag of seed with a 50 percent germination rating is really only a 25 lb. bag of seed!

To calculate PLS, multiply the percent of pure crop seed (purity) times the germination percentage and divide by 100. For example, if a batch of seed contains 95 percent pure seed and has 80 percent germination, the percent of pure live seed (PLS) is 76; (95 x 80) ÷ 100 = 76 percent. This means that in a quantity of seed weighing 100 pounds, only 76 pounds have the potential to germinate.

When purchasing seed, comparative pricing should be done on the basis of pure live seed. This is especially important when buying species that inherently differ in purity and germination between seed lots. To determine the cost per 100 pounds of pure live seed--the real or actual cost of seed--divide the cost per 100 pounds by the percent PLS and multiply by 100. For example: Lot A of fescue seed costs $35.00 per 100 pounds and has 89 percent PLS; ($35.00 ÷ 89) x 100 = $39.33, the cost of 100 pounds of pure live seed. Lot B of fescue seed costs $31.00 per 100 pounds but has only 68.4 percent PLS; ($31.00 ÷ 68.4) x 100 = $45.32 per 100 pounds of pure live

seed. Although its bulk price was less, seed lot B actually costs more than lot A for an equal amount of pure live seed.

L. Inoculation of Legume Seed

Seed of herbaceous legumes should be inoculated with the appropriate strain of rhizobia. There are several methods of inoculating seed. For dry seeding, the inoculant can be mixed with lightly moistened seed just before sowing. The inoculant should be generously applied--using even more than that recommended by the manufacturer. Moistening seed with a "sticker" such as sugar mixed with water, molasses, or synthetic gums helps bind the inoculum to the seed and extends longevity of the rhizobia. Soil implant inoculants are available whereby the rhizobia is placed in the soil instead of on the seed. Preinoculated legume seed can be purchased from some seed dealers.

When seeding with a hydroseeder, the inoculant is added to the slurry just before it is spread. When mixed with a slurry that includes fertilizer, the inoculating bacteria may be killed by high acidity (low pH) caused by the fertilizer. To reduce loss of the bacteria, the slurry pH should be kept above 5.0 and spread as soon as possible after mixing. Where slurry pH is below 5.0, hydrated lime can be added at 100 pounds for each 1,000 gallons of water to lessen the effect of the acidity. For hydroseeding, inoculants should be added at double the amount recommended for dry seeding.

Commercial inoculants are stamped with an expiration date because the viability period of the packaged rhizobia is limited. Inoculant with an expired date should not be used. The environment in which inoculant is

stored also affects its viability. High temperatures will destroy it, so beware of buying and using inoculant stored or displayed in abnormally warm places such as in attics or next to stoves. Inoculant should be kept in a cool place, and partially used packages should be tightly resealed. Use inoculant only on the legume species for which it is specified.

M. Selection of Plant Materials

Although it is desirable to establish permanent vegetative cover on disturbed areas as soon as practical, it is not always possible due to drought or extreme temperatures which may interfere with seed germination and stand establishment. The following list of treatments is provided for guidance in selecting appropriate cover for disturbed areas depending upon project completion date (Table 10).

Table 10. A seasonal vegetative seeding approach.

Project Completion Date	Treatment to Provide Cover
February 15 - April 15	Permanent Seeding
April 15 - August 15	Temporary Seeding
August 15 - October 15	Permanent Seeding
October 15 - November 30	Temporary Seeding
December 1 - February 15	Mulch

Areas treated by temporary seeding or mulch should be seeded with permanent vegetation as soon as possible (August 15 - October 15 or February 15 - April 15) to ensure stabilization of disturbed areas. When possible, temporary cover should be disked or mowed before permanent seed and

fertilizer are applied. Table 11 provides information on how to determine surface area and associated material needs for revegetation activities.

Table 11. How to calculate surface area and seed and fertilizer needs.

Roads

Step 1: Determine acres from table below

Access Road Surface Area Determination Table - Acres

Road Length	Road Width - Feet					
Feet	8'	10'	12'	14'	18'	20'
	- - - - - - - - - - - - acres - - - - - - - - - - - -					
50	.010	.01	.01	.02	.02	.02
100	.022	.02	.03	.03	.04	.05
250	.050	.06	.07	.08	.10	.11
500	.090	.12	.14	.16	.21	.23
750	.144	.17	.21	.24	.31	.34
1000	.180	.24	.28	.32	.41	.46
1500	.280	.34	.41	.48	.62	.69
2000	.360	.48	.56	.64	.83	.92
5000	.920	1.15	1.38	1.61	2.07	2.30
5280	.970	1.21	1.45	1.70	2.18	2.43

Step 2: Multiply the appropriate acre figure times the pounds/acre rate that is recommended in seed mixture.

Other Disturbed Lands

Step 1: To determine acreage and pounds of seed needed for other disturbed areas use the following formula:

Average length x average width = sq. ft.
Sq. ft. x 23 and point off 6 places.
Multiply the answer times the pounds per acre as recommended in seed mixtures for the amount of seed.

Plant and plant mixtures recommended for temporary and permanent cover are shown in Tables 12, 13, 14, and 15. These tables also provide rates of application, optimum seeding dates, and other characteristics. Table 16 outlines seed weight per bushel and seeds per pound of selected species.

Table 12. Suggested seed mixtures and rates for revegetation of disturbed lands.[1]

Seeding Group	Percent of Mixture	Seeding Rate (PLS)[2] Total Acre	Pounds Per 1,000 Sq. Ft.	Seeding Dates	Remarks
I. Temporary Cover[3]					
A. Annual ryegrass	100	20-25	0.5-0.6	Feb. 15 - Apr. 15	• Temporary cover should be disked or mowed before permanent vegetation is established.
B. Foxtail millet	100	20-30	0.5-0.7	Apr. 15 - Aug. 15	
C. Sudangrass hybrid	100	25-40	0.6-0.9	Apr. 15 - Aug. 15	
D. Winter wheat or rye	100	80-120	1.8-2.8	Oct. 15 - Nov. 30	
II. Permanent Cover[4]					
A. Orchardgrass	100	15	0.4	Feb. 15 - Apr. 15 Aug. 15 - Oct. 15	• Fertilize annually to maintain an adequate cover.
B. Orchardgrass	83	15	0.4	Feb. 15 - Apr. 15	• Fertilize annually to maintain an adequate cover.
Ladinoclover	17	3	0.1	Aug. 15 - Oct. 15	
C. Perennial ryegrass	75	15	0.4	Feb. 15 - Apr. 15	• Crownvetch should not be used on areas that will receive heavy traffic. Use on sloped areas for added stabilization.
Crownvetch	25	5	0.1	Aug. 15 - Oct. 15	

Table 12. Suggested seed mixtures and rates for revegetation of disturbed lands.[1] (Continued)

Seeding Group	Percent of Mixture	Seeding Rate (PLS)[2] Pounds Per Acre	Seeding Rate (PLS)[2] Pounds Per 1,000 Sq. Ft.	Seeding Dates	Remarks
D. Sericea lespedeza (hulled)	53	20	0.5	Mar. 1 - Apr. 15	• Sericea lespedeza is good cover for droughty sites. Appalow is a low growing form of sericea that could be substituted. Appalow is useful on road banks or intersections because it does not require mowing. It is not recommended for quail food plots.
Orchardgrass	21	8	0.2		
Korean or kobe lespedeza (hulled)	26	10	0.2		
E. Sericea lespedeza (hulled)	61	20	0.5	Mar. 1 - Apr. 15	• Weeping lovegrass provides good temporary cover, but if the recommended seeding rate is exceeded it may cause extremely dense stands that retard establishment of companion species. See above remarks for other species.
Weeping lovegrass	9	3	0.1		
Korean or kobe lespedeza(hulled)	30	10	0.2		

[1]Other special mixtures must be identified for agricultural or residential situations.
[2]Pure live seed (PLS).
[3]Apply 300 pounds of 15-15-15 fertilizer per acre (7 pounds per 1,000 square feet) or its equivalent.
[4]Apply 1,000 pounds of 6-12-12 fertilizer per acre (23 pounds per 1,000 square feet) or its equivalent. Apply 2 to 3 tons of lime per acre (90-140 pounds per 1,000 square feet). Increase seeding rate by 20 percent where a seedbed cannot be prepared. KY-31 tall fescue (fungus-free variety) may be substituted for orchardgrass or perennial ryegrass where wildlife benefits are not a major concern.

Notes: Agricultural limestone and fertilizer should be applied in accordance with soil test results. The above rates are recommended in the absence of tests. All legume seed must be inoculated with the appropriate Rhizobium species to ensure adequate nitrogen fixation in the plant.

Table 13. Special seed mixtures for enhancing wildlife habitat.[1]

Seeding Mixture	Percent of Mixture	Seeding Rate (PLS)[2] Total Acre	Pounds Per 1,000 Sq. Ft.	Seeding Dates	Remarks
I. Temporary Wildlife Habitat[3]					
A. Soybean	40	8	0.20	May 1 - June 15	• This annual seed mixture must be replanted each year. It provides an excellent fall and winter wildlife food source for white-tailed deer, bobwhite quail, mourning dove, eastern cottontail rabbit, waterfowl, and songbirds.
Cowpea	20	4	0.10		
Browntop millet	20	4	0.10		
Milo	10	2	0.05		
Buckwheat	10	2	0.05		
II. Permanent Wildlife Habitat[4]					
A. Orchardgrass	19	10	0.30	Feb. 20 - Apr. 1	• These seed mixtures (A, B, C, and D) provide long-term plants that are attractive year-round to a variety of wildlife species. The plants are used for brood rearing and feeding habitat, in the spring and summer, by eastern wild turkey, ruffed grouse, an bobwhite quail. These mixtures provide excellent winter (Continued)
Ladino clover	6	3	0.07		
Korean or kobe lespedeza (hulled)	15	8	0.20		
Oats (spring variety)	60	32	0.75		
B. Orchardgrass	14	8	0.20	Feb. 20 - Apr. 1	
Timothy	7	4	0.10		
Kobe lespedeza (hulled)	20	12	0.30		
Oats (spring variety)	57	32	0.75		
(Continued)					

Table 13. Special seed mixtures for enhancing wildlife habitat.[1] (Continued)

Seeding Mixture	Percent of Mixture	Seeding Rate (PLS)[2] Pounds Per Acre	Seeding Rate (PLS)[2] Pounds Per 1,000 Sq. Ft.	Seeding Dates	Remarks
B. Orchardgrass Timothy Kobe lespedeza (hulled) Oats (spring variety)					forage for white-tailed deer, eastern cottontail rabbit, bobwhite quail, ruffed grouse, eastern wild turkey, and songbirds.
C. Orchardgrass	12	10	0.30	Aug. 15 - Sept. 15	
Ladino clover	4	3	0.07		
Korean or kobe lespedeza (unhulled)	10	8	0.20		
Winter wheat	74	60	1.40		
D. Perennial ryegrass	10	8	0.20	Aug. 15 - Oct. 1	
Timothy	5	4	0.10		
Kobe lespedeza (unhulled)	14	12	0.30		
Winter wheat	71	60	1.40		

[1]The manual section "Enhancing Wildlife Habitat" (Chapter VII., O.) offers further direction on grass-legume seed mixtures.
[2]Pure live seed (PLS).
[3]Apply 300 pounds of 15-15-15 fertilizer per acre (7 pounds per 1,000 square feet) or its equivalent.
[4]Apply 1,000 pounds of 6-12-12 fertilizer per acre (23 pounds per 1,000 square feet) or its equivalent. Apply 2 to 3 tons of lime per acre (90-140 pounds per 1,000 square feet).

Notes: Agricultural limestone and fertilizer should be applied in accordance with soil test results. The above rates are recommended in the absence of tests. All legume seed must be inoculated with the appropriate Rhizobium species to ensure adequate nitrogen fixation in the plant.

Table 14. Characteristics of grasses most frequently used in revegetating disturbed lands.

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Annual ryegrass	I	A	Cool	4.5	4-7 20-25	Fall or Spring	• Erosion Control; forage. • This grass is used mostly for quick temporary cover and sown in mixtures with long-lived perennial grasses and legumes. The rapid-growing vigorous plants of annual rye grass can strongly compete with the companion perennials; thus, its seeding rate should not exceed the above recommendation.
Bermudagrass	I	P	Warm	4.0	3-5 7-12	Mid to late spring after mean daily temperature exceeds 65°F	• Erosion control; forage. • Bermudagrass is adapted to a wide range of soils; but its practical use is limited because the most winter-hardy cultivars must be planted vegetatively (springs). Bermuda grass grows best with pieces of rhizomes and stolons on moist heavy soils in warm and hot weather, but is also very tolerant of droughty soils conditions and of salty soils.

Table 14. Characteristics of grasses most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Big bluestem and Little blue stem	N	P	Warm	4.5	4-8 8-15	Spring	• Erosion control; forage; wildlife habitat. • These species may be slow to develop cover, but once established, the stands require little maintenance. Height of big bluestem may reach 6-7 feet; little bluestem 3-4 feet. Sow these grasses in mixture with other native species.
Deertongue	N	P	Warm	4.0	6-8 12-15	Late fall; winter; spring	• Erosion control; wildlife habitat. • This grass frequently volunteers on low fertility and eroded acid sites. Stands usually develop slowly, but once established they persist without additional fertilizer or maintenance. Stands establish best where seeded alone.
Foxtail millet	I	A	Warm	4.5	10-15 20-30	Late spring to mid summer	• Erosion control; wildlife food. • This summer annual provides quick temporary cover and grows rapidly and matures in 60-80 days after seeding. Requires high summer temperatures for best growth.

Table 14. Characteristics of grasses most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Indiangrass	N	P	Warm	4.5	5-12	Spring	• It can be sown in mixtures with other native grasses and legumes. It is difficult to establish this grass in pure stands. Seed is light and fluffy, and is more difficult to sow than seed of most other species.
Orchardgrass	I	P	Cool	4.5	5-8 10-15	Spring; late summer to early fall	• Forage; wildlife habitat; erosion control. • This grass is considered superior to fescue for use in wildlife plantings. Grows well in combination with legumes such as alfalfa or red clover. It is more adapted than most grasses to growing in shade.
Perennial ryegrass	I	P	Cool	4.5	5-10 20-25	Fall or Spring	• Erosion control; forage. • Plants usually live only 2-3 years. Used mostly to provide quick temporary cover where sown in mixture with long-lived perennial grasses and legumes. This species is less vigorous and less competitive than annual ryegrass with companion species.

Table 14. Characteristics of grasses most frequently used in revegetating disturbed land. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Redtop	I	P	Cool	4.0 to 4.5	2-4 3-6	Spring; late summer	• Erosion control. • Redtop provides temporary cover and is adapted to wet sites and poorly drained soils, but is drought resistant when established. Redtop is relatively short lived (3-4 years).
Reed canarygrass	I	P	Cool	4.5	5-8 8-12	Spring; late summer	• Erosion control; wildlife habitat. • This grass is recommended primarily for moist or wet sites such as pond shorelines, drainage ditches, grasses waterways, and stream channel banks. This species is drought resistant and also will grow on upland sites. Generally, legumes sown with this grass are not successful.
Rye	I	A	Cool	4.5	30-60 80-120	Fall; spring	• Erosion control • Rye is widely used as a quick cover companion crop with perennial species. It is most useful and effective in fall seedings and can be sown alone to produce mulch in place. Rye seed germinates rapidly; the seedlings are (Continued)

Table 14. Characteristics of grasses most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Rye							vigorous and quickly provide ground cover. Rye can be sown later in the fall than most species and still be expected to produce some winter cover.
Sorghum and Sundangrass	I	A	Warm	4.5 to 5.0	15-20 25-40	Late spring mid summer	• Erosion control. • CAUTION: When grown under certain environmental conditions the herbage of these species can be poisonous to livestock. • These species provide the quick, temporary cover component of mixtures. They also can be sown alone to grow mulch in place; perennial species can be planted or sown into the plant residue (mulch) the following spring.
Switchgrass	N	P	Warm	4.0 to 4.5	2-5 5-12	Spring	• Erosion control; forage; wildlife habitat. • This tall plant has been used on disturbed lands throughout the region.
Tall fescue KY-31	I	P	Cool	4.5	10-15 20-35	Spring and fall	• Erosion control. • CAUTION: Care must be taken to ensure only fungus-free (endophyte-free) seed is used. Nonfungus-free fescue can be highly toxic to (Continued)

Table 14. Characteristics of grasses most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Tall fescue KY-31							livestock, including horses. There are several available varieties of fungus-free fescue. • Most used and most versatile of the grasses suited for vegetating disturbed lands. It is adapted to a wide range of environmental conditions including wet soils, droughty soils, acid soils, and alkaline soils. Stand establishment is reasonably fast, but usually should be sown with a "quick cover" grass such as rye in the fall, or weeping lovegrass in mid to late spring. Value for wildlife, especially for game birds, considered low.
Timothy	I	P	Cool	4.5 to 5.0	4-7	Late summer early fall; spring	• Forage; wildlife habitat; erosion control. • Used primarily for hay. Often used on disturbed lands as a substitute for KY-31 tall fescue in plantings for wildlife habitat. Should be sown with legumes and other grasses.

Table 14. Characteristics of grasses most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Weeping lovegrass	I	P	Warm	4.0	2-3	Spring to early summer	• Erosion control. • This grass is one of the most tolerant of extremely acid soils. It is best used as the quick cover component in a mixture with perennial grasses and legumes, especially in mid- to late- spring seedings. Exceeding the recommended seeding rate may cause extremely dense stands that retard the establishment of the companion perennial species.
Winter wheat	I	A	Cool	4.5	30-60 80-120	Fall	• Erosion control; grain crop; wildlife food. • Can be used as a quick cover companion crop with perennial species or can be sown alone to produce mulch in place.

[1] I = Introduced; N = Native.
[2] A = Annual; B = Biennial; P = Perennial.
[3] First line is recommended rate for use in mixtures; second line for seeding alone. Use only in mixtures where one range of rates is shown.
[4] Pure live seed (PLS).

Table 15. Characteristics of forbs-legumes most frequently used in revegetating disturbed lands.

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Alfalfa	I	P	Cool	5.5	4-12 12-18	Spring; late summer	• Forage; wildlife habitat; erosion control. • Alfalfa is one of the most valuable forage plants in the U.S. It thrives on fertile, nonacid, and well-drained soils. Not recommended for acid soils unless the soils are limed to near neutrality (pH 7.0) and adequately fertilized with phosphorus. Use primarily on areas that will be managed for forage production or wildlife openings. It makes good pasture when mixed with orchardgrass or tall fescue.
Common lespedeza and Kobe lespedeza	I	A	Warm	4.5	8-15 25-30	Spring	• Wildlife food, forage; companion legume with trees. • Kobe is the most widely used and most widely familiar cultivar of common lespedeza. Generally used for quickly establishing a legume in mixtures with grasses or with grasses and perennial legumes.
Crimson clover	I	A	Cool	5.0	10-15 15-25	Late summer to fall	• Erosion control; forage. • This winter annual can be used alone for cover, and sow perennial species the next spring.

Table 15. Characteristics of forbs-legumes most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Crownvetch	I	P	Cool	5.0	5-10 15-20	Spring; late summer to early fall	• Erosion control; forage. • Crownvetch is one of the best plants for providing continuous, maintenance-free cover for erosion control. Plants are especially useful for developing total cover on steep slopes. Should be sown in mixture with a quick-cover companion grass such as weeping lovegrass or perennial ryegrass. Do not plant crownvetch with tree seedlings.
Korean Lespedeza	I	A	Warm	5.0	6-12 20-25	Spring	• Wildlife food; forage; companion legume with trees. • Readily reseeds in adapted climatic range; thus it can be considered as a long-term component in spring-sown grass-legume mixtures.
Red clover	I	B/P	Cool	5.0	4-8 8-12	Spring; late summer	• Erosion control; wildlife habitat; forage. • Red clover is one of the most important hay crops. Its use on disturbed lands is primarily to improve or enrich the soil and to add to species diversity in food plantings for wildlife.

(Continued)

Table 15. Characteristics of forbs-legumes most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
Red clover							It should be sown with long-lived grasses and legumes because it has a biennial or short-lived perennial growth habit. It is used as a winter annual in the South.
Sericea lespedeza	I	P	Warm	4.5	10-20 hulled	Late winter to early summer	• Erosion control. • Sericea is widely used for erosion control and soil building. Stand establishment is relatively slow; thus it should be sown with a "quick cover" grass, such as weeping lovegrass. It usually forms dense stands that prevent or retard the natural invasion of other plants. It is considered low in value for wildlife. The main advantage of sericea for revegetation is that it provides a permanent cover that requires little or no maintenance. Appalow is a low-growing form that could be substituted.
White clover and Ladino clover	I	P	Cool	5.5	2-4	Spring; late summer	• Wildlife habitat; forage. • Common white clover is used for pasture. Its use on disturbed lands should primarily be to provide diversity in species composition,

(Continued)

Table 15. Characteristics of forbs-legumes most frequently used in revegetating disturbed lands. (Continued)

Common Name	Origin[1]	Life Span[2]	Growth Season	Lower pH Limit	Seeding Rate[3] (lbs/acre) PLS[4]	Time of Seeding	Major Uses and Remarks
White clover and Ladino clover							especially in food patches or openings planted for wildlife. It should be planted with grasses and other legumes. Ladino, a large form of white clover, is the most widely sown cultivar for use as hay and pasture.
Yellow sweetclover and White sweetclover	I	B	Cool	5.5	4-7 10-15	Spring	• Erosion control. • Sweetclover makes rapid growth and quickly provides a vegetative cover. On suitable soils it may suppress slower growing companion perennial species, especially where its seeding rate is excessive.

[1]I = Introduced; N = Native.
[2]A = Annual; B = Biennial; P = Perennial.
[3]First line is recommended rate for use in mixtures; second line for seeding alone. Use only in mixtures where one range of rates is shown.
[4]Pure live seed (PLS).

Table 16. Weight per bushel and number of seeds per pound of selected grasses and forbs-legumes.

Common Name	Approximate lb/bu	Approximate no. of seeds/lb
Grasses		
Annual ryegrass	24	224,000
Bermudagrass, common (hulled)	40	2,071,000
Browntop millet	-	142,000
Foxtail millet	50	213,000
Indiangrass	-	200,000
Oats	32	16,000
Orchardgrass	14	416,000
Reed canarygrass	47	480,000
Rye	56	18,000
Sorghum	50	24,000
Sudangrass	40	43,000
Switchgrass	-	280,000
Tall fescue	25	227,000
Timothy	45	1,152,000
Wheat	60	11,000
Forbs-Legumes		
Alfalfa	60	227,000
Common lespedeza	25	238,000
Cowpea	60	3,600
Crimson clover	60	150,000
Kobe lespedeza	25	200,000
Korean lespedeza (hulled)	59	238,000
Red clover	60	272,000
Sericea lespedeza (hulled)	60	372,000
Soybean	60	4,500
White clover	60	768,000
White sweetclover	60	259,000

N. Aesthetic Considerations

Aesthetic values should be considered in plans for revegetating all disturbed lands. The concept of aesthetics involves all of the senses, but it is most often equated with the visual sense to denote quality and attractiveness or "visual appeal" of the landscape scene or scenes being viewed. The major components of the characteristic landscape are landform, vegetation, water forms, and structures.

Vegetation removal during site development or right-of-way clearing and vegetation reestablishment during rehabilitation create significant changes in the visual relationships of cover types, patterns, and open spaces. This is especially noticeable in landscapes with continuous forest cover. Revegetation for aesthetic purposes reestablishes the visual character of the landscape by integrating the postconstruction land use or uses of the rehabilitated area with the surrounding area. Land use objectives and an evaluation of the characteristic landscape should guide revegetation treatments and aesthetic design.

O. Enhancing Wildlife Habitat

The place where a wildlife species usually lives is called its habitat. The basic components of habitat are food, cover, water, home range, and interspersion. All are essential for the success of wildlife. Food provided by a variety of plants must be available during all seasons and within foraging range of protective cover. Different types of plant cover are required for different purposes such as nesting, brooding (rearing of young), escape, and shelter. Some species of wildlife require open water;

others obtain moisture from succulent plants, dew, or their own metabolic processes. The home range of a species is the size of its habitat or living area. The required size varies for different species. Interspersion is the arrangement of food, cover, and water within the living area of a species. Food and cover that otherwise meet the needs of a species may be of little value where they are not properly interspersed.

Habitat for wildlife can be developed either as the primary land use or in association with other land uses. However, it should not be assumed that every revegetation effort will automatically develop or improve wildlife habitat. Most any vegetational community will in some degree contribute to habitat, but the best habitat is developed by planning and providing for the needs of the desired wildlife species. In revegetating disturbed areas, the maximum benefit for wildlife may be obtained by establishing vegetational communities that are not presently available or that are in short supply in the vicinity.

Each species of wildlife has different habitat requirements. Thus, the vegetation established for different land uses will affect the diversity and productivity of wildlife populations. For example, bird populations in the East are most diverse and productive in a mixed hardwood forest.

Different species of birds are attracted to and inhabit open grasslands; others prefer edges between forest and grassland that are partially vegetated with shrubs and small trees. Thus, even in a forested region, the overall diversity of bird species is increased by developing shrub and grassland vegetational types on disturbed lands.

Habitat can be developed on disturbed land to favor one or two species, several species, or wildlife in general. However, newly revegetated disturbed areas should not be expected to provide habitat for all resident species of wildlife. Thus, habitat requirements should be determined before attempting to establish habitat for particular species of wildlife.

Grass-legume mixtures for revegetating disturbed land are generally tailored for seeding on steep slopes and other areas subject to severe erosion. For less critically eroding sites, grasses such as orchardgrass, timothy, and deertongue are recommended in place of KY-31 tall fescue in seed mixtures for wildlife habitat. Similarly, limited use should be made of common sericea lespedeza and crownvetch because these legumes usually dominate the vegetational cover and limit the diversity in food and cover. Also, the dense persistent cover of these legumes may retard or prevent the invasion and establishment of native plant species that contribute to habitat and food diversity. Herbaceous legumes that are desirable food plants but less aggressive and persistent than the two previously mentioned should be used. These include red clover, ladino clover, alfalfa, and annual lespedeza species.

Mixtures of native warm-season grasses--switchgrass, Indiangrass, big bluestem, and little bluestem--are useful for providing nesting cover for certain game birds and eastern cottontail rabbit. Mixtures containing redtop and reed canarygrass are suggested for wet or poorly drained areas and pond borders. Mixtures seeded in food patches for game and song birds could include common sunflower, soybean, foxtail millet, browntop millet, or buckwheat. There are commercially available wildlife food plot seed mixtures that target several species of birds and mammals.

Outstanding opportunities exist for using wildlife habitat enhancement projects on agency-managed rights-of-way for improving TVA's corporate image with regard to environmental leadership. By inviting the participation of private conservation groups (Quail Unlimited, Inc., The National Wild Turkey Federation, Inc., etc.), TVA can successfully reduce maintenance costs and at the same time demonstrate its concern for, and commitment to, improved wildlife habitat. By encouraging such groups to secure land use agreements with private landowners, and then cooperating with them in development of wildlife food plots and other habitat enhancement projects; TVA can reduce its right-of-way maintenance costs, bolster its corporate image, and improve habitat for a variety of game and nongame species. Such habitat enhancement projects would then make TVA eligible for awards and other forms of recognition provided by the cooperating conservation groups, further reinforcing our environmental leadership image. Within TVA, the Resource Stewardship program is available to assist the Transmission Power Supply Group in securing habitat enhancement agreements with cooperators.

P. Young Wildlife and Bushhogging

Low growth vegetation on rights-of-way offers excellent nesting, brooding (rearing of young), escape, and shelter for various species of wildlife. A common right-of-way maintenance practice is to remove this low growth vegetation through bushhogging. Bushhogging during the critical wildlife brooding period is very detrimental. It not only can kill the young of the year but removes the nesting and protective escape cover and shelter from predation. Thus, much care must be exercised in scheduling and conducting

bushhogging. Ideally, bushhogging should be done before March 15 or after August 15.

Q. Establishing Wildflowers

Establishing wildflowers is a relatively inexpensive and worthwhile revegetation alternative that is often overlooked. Wildflowers add color and natural beauty to an area. Under some circumstances, wildflower plots can be easily established and maintained with the assistance of cooperative landowners or private conservation groups. To maintain wildflower plots, these areas should actually be mowed on an annual schedule during the fall or early winter (after flowering and seed development). This generally helps prevent the invasion or resprouting and growth of woody plant species. In establishing wildflowers three items should be considered: soil preparation, weed control, and seeding method.

Regional wildflower seed mixtures are commercially available that include several species, with varieties of color and height of both annuals and perennials. However, care should be exercised in generically using such mixtures. These regional mixtures may include naturalized species or species that are not native to the locality. These nonnative species can become pests to the landowner or retard establishment of other native species that would volunteer into the area. A better approach is to select native species that are adapted to local site conditions. Because of limited availability, the cost of some wildflower seed is relatively high. The cost of seed of other wildflower species is competitive, although not as inexpensive as widely used seed such as KY-31 tall fescue.

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APPENDICES

APPENDIX A

Scientific Names of Plant Species

Table 17. Common and scientific names of grasses and forbs mentioned in text.

Common Name	Scientific Name and Authority
Grasses	
Annual ryegrass	Lolium multiflorum Lam.
Bermudagrass	Cynodon dactylon (L.) Pers.
Big bluestem	Andropogon gerardi Vitm.
Browntop millet	Brachiaria ramosa (L.) Stapf.
Deertongue	Panicum clandestinum L.
Foxtail millet	Setaria italica (L.) Beauv.
Indiangrass	Sorghastrum nutans (L.) Nash.
Little bluestem	Schizachyrium scoparium (Michx.) Nash
Milo	Sorghum vulgare Pers.
Oats	Avena sativa L.
Orchardgrass	Dactylis glomerata L.
Perennial ryegrass	Lolium perenne L.
Redtop	Agrostis gigantea Roth
Reed canarygrass	Phalaris arundinacea L.
Rye	Secale cereale L.
Sorghum	Sorghum bicolor (L.) Moench
Sudangrass	Sorghum sudanense (Piper) Stapf
Switchgrass	Panicum virgatum L.
Tall fescue KY-31	Festuca arundinacea Schreb., KY-31
Timothy	Phleum pratense L.
Weeping lovegrass	Eragrostis curvula (Schrad.) Nees
Winter wheat	Triticum aestivum L.
Forbs-Legumes	
Alfalfa	Medicago sativa L.
Common lespedeza	Lespedeza striata (Thunb. ex Murr.) Hook. & Arn.
Cowpea	Vigna unquiculata (L.) Walp.
Crimson clover	Trifolium incarnatum L.
Crownvetch	Coronilla varia L.
Kobe lespedeza	Lespedeza striata var. Kobe
Korean lespedeza	Lespedeza stipulacea Maxim.
Ladino clover	Trifolium repens L.
Red clover	Trifolium pratense L.
Sericea lespedeza	Lespedeza cuneata (Dum.) G. Don
Soybean	Glycine max (L.) Merr.
White clover	Trifolium repens L.
White sweetclover	Melilotus alba Medik.
Yellow sweetclover	Melilotus officinalis Lam.
Forbs-Nonlegumes	
Buckwheat	Fagopyrum esculentum Moench
Common sunflower	Helianthus annuus L.

APPENDIX B

English to Metric Conversion

Table 18. English to metric conversion.

English Unit	Metric Unit	Conversion Factor
	Length	
inch, in	centimeter, cm	2.540
foot, ft	meter, m	0.305
mile, mi	kilometer, km	1.609
	Area	
square feet, ft^2	square centimeters, cm^2	929.030
acre, acre	hectare, ha	0.405
	Weight	
pound lb	kilogram, kg	0.454
short ton, ton	tonne, t	0.907
short ton, ton	kilogram, kg	907.184
	Volume	
gallon, gal (liquid)	liter, 1	3.785
cubic yard, yd^3	cubic meter, m^3	0.764
	Yield or Rate	
pounds/acre	kilogram/hectare	1.121
short tons/acre	tons/hectare	2.242
cubic yards/acre	cubic meters/hectare	1.886
gallons/acre	liters/hectare	9.346
	Temperature	
Fahrenheit, °F	Celsius, °C	0.555(F-32)

APPENDIX C

Glossary

GLOSSARY

-A-

Access Road - A temporary or permanent road used to gain access to the construction site.

Acid Soil - Generally, a soil that is acid throughout most or all of the parts of it that plant roots occupy. Commonly applied to only the surface-plowed layer or to some other specific layer or horizon of a soil. Practically, this means a soil more acid than pH 6.6; precisely, a soil with a pH value less than 7.0. A soil having a preponderance of hydrogen over hydroxyl ions in the soil solution.

Adjacent Area - Land located outside the affected or right-of-way in which construction takes place, where air, surface, or ground water, fish, wildlife, vegetation, or other resources may be adversely affected by construction or maintenance activities.

Alkaline Soil - Generally, a soil that is alkaline throughout most or all of the parts of it occupied by plant roots; although the term is commonly applied to only a specific layer or horizon of a soil. Precisely, any soil horizon having a pH value greater than 7.0. Practically, a soil having a pH above 7.3.

Annual Plant (Annuals) - A plant that completes its life cycle and dies in one year or less.

Aspect - The direction that a slope faces. Exposure.

-B-

Barriers - Obstructions to pedestrian, horse, and/or vehicular traffic. They are intended to restrict such traffic to specific locations.

Best Management Practice (BMP) - A practice, or combination of practices, which is determined after problem assessment and examination of alternatives, to be the most effective, practical means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality.

Biennial - A plant that lives for two years, producing vegetative growth the first year, and usually blooming and fruiting the second year, and then dying.

Borrow Pit - An excavation site outside the limits of construction to provide materials necessary to that construction, such as fill materials for road construction.

Broad-based Dip - A surface drainage structure specifically designed to drain water from an access road while vehicles maintain normal travel speeds.

Broadcast Seeding - Scattering seed on the surface of the soil. Contrast with drill seeding which places the seed in rows in the soil.

Brood - Progeny of the same female, produced within a certain period, e.g., a clutch of birds' eggs, bee brood of a certain type, season, or year.

Buffer Strip - A barrier of permanent vegetation established or left undisturbed downslope from disturbed areas to filter out sediment from runoff before it reaches a watercourse.

-C-

Certified Seed - A lot of seed guaranteed as to source, cleanliness, purity, and other conditions.

Channel - The bed of a stream or watercourse.

Check Dam - A small dam constructed in a gully or other small watercourse to decrease the stream flow velocity, minimize channel scour, and promote deposition of sediment.

Contour - An imaginary line on the surface of the earth connecting points of the same elevation. A line drawn on a map connecting the points of the same elevation.

Cool-Season Plant - A plant that makes its major growth during the cool portion of the year, primarily in the spring but also in the winter in some localities.

Cultivar - An assemblage of cultivated plants that is clearly distinguished by its characteristics (morphological, physiological, cytological, chemical, or others) and which when reproduced (sexually or asexually) retains those characteristics. The terms cultivar and variety are exact equivalents.

Culvert - A metal, wooden, plastic, or concrete conduit through which surface water can flow under or across roads.

Cut - Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

Cut-and-fill - Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

-D-

Diversion - A channel with a supporting ridge on the lower side constructed across or at the bottom of a slope for the purpose of intercepting surface runoff.

Diversion Ditch - a drainage depression or ditch built across the top of a slope to divert surface water from that slope.

Drainage Crossing - Location where a stream (perennial or ephemeral) must be crossed.

Drainage Structure - Any device or land form constructed to intercept and/or aid surface water drainage.

-E-

Environment - All external conditions that may act upon an organism or soil to influence its development or existence; including sunlight, temperature, moisture, and other organisms.

Ephemeral Streams (Dry Wash) - A channel that carries water only during and immediately following rainstorms.

Erodible Soils - Those soils identified as being subject to erosion.

Erodibility - The relative ease that one soil erodes under specified conditions of slope as compared with other soils under the same conditions; this applies to both sheet and gully erosion.

Erosion - The process by which soil particles are detached and transported by water and gravity to some downslope or downstream point.

-F-

Fertilizers - Any substance or combination of substances used principally as a source of plant food or soil amendment.

Fill Slope - The surface formed where earth is deposited to build a road or trail.

Filter Strip - 1. See Streamside Management Zone. 2. An area on the downhill side of a construction site where woody vegetation removed during right-of-way clearing is placed to reduce water velocity and filter sediment.

Fish and Wildlife Habitat - Land dedicated wholly or partially to the production, protection, or management of species of fish and wildlife.

Forage - All browse and herbaceous foods that are available to grazing animals. It may be grazed or harvested for feeding.

Forb - Any herb that is not grass or grass-like.

Ford - A shallow place in a body of water, such as a river, where vehicles can cross.

-G-

Game Food - Numerous grasses, legumes, shrubs, and trees that are planted to provide sustenance and cover for wildlife whose habitat is natural or adaptable to that particular site.

Germination - Sprouting; beginning of growth.

Grade (Gradient) - The slope of a road or trail expressed as a percentage of change in elevation per unit of distance traveled.

Ground Cover - Any living or dead vegetative material on or just above the soil surface that stabilizes and protects the soil.

Ground Water - Subsurface water occupying the saturation zone, from which wells and springs are fed. In a strict sense the term applies only to water below the water table.

Growing Season - The season which, in general, is warm enough for the growth of plants, the extreme average limits of duration being from the average date of the last killing frost in spring to that of the first killing frost in autumn. On the whole, however, the growing season is confined to that period of the year when the daily means are above 42°F.

Grubbing - The operation of removing stumps and roots.

Gully Erosion - Erosion process whereby water accumulates in narrow channels, and over short periods removes soil from this narrow area to considerable depths (one foot plus).

-H-

Habitat - The environment within which the life-needs of a plant or animal are supplied.

Harrowing (Disking) - A mechanical method of scarifying the soil to prepare a site to be seeded or planted.

Herb - Any seed-producing plant that does not develop persistent woody tissue above ground (i.e., includes both forbs and grasses).

Herbaceous - Pertaining to or having characteristics of an herb; herb-like.

Herbicide - Any substance or mixture of substances intended to inhibit the growth of or destroy unwanted trees, shrubs, weeds, algae, and other vegetation.

Hydroseeding - Dissemination of seed hydraulically in a water medium. Mulch, lime, and fertilizer can be incorporated into the sprayed mixture.

-I J K-

Infiltration - The movement of water or solutions into a rock or soil through its pore spaces, cracks, or joints.

Inoculation - Treating seeds or plants with appropriate host organisms, such as N-fixing bacteria, prior to planting.

Inoculum - A natural or artificial culture of microorganisms used to produce beneficial plant response such as nitrogen fixation.

Interception - The process by which water from precipitation is caught and stored on plant surfaces and eventually returned to the atmosphere without reaching the ground.

Intermittent Streams - A watercourse that flows in a well defined channel during the wet seasons of the year, but not the entire year.

Introduced Species - A species or organism that may be adapted to the area in which it is found, but is not native.

-L-

Legume - A member of the legume or pulse family, leguminosae. One of the most important and widely distributed plant families. Includes many valuable food and forage species, such as the peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, and kudzu. Practically all legumes are nitrogen-fixing plants.

-M-

Mulch - A natural or artificial layer of plant residue or other materials covering the land surface that conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Mulching - Covering soil with any loose cover of organic residues, such as grass, straw, bark or wood fibers, to check erosion and stabilize exposed soil.

-N-

Narrow-based Dip - A diversion ditch and/or hump across a trail or road tied into the uphill side for the purpose of carrying water runoff into the vegetation, duff, or ditch so that it does not gain the volume and velocity which causes soil movement and erosion.

Native Species - A species that is part of the area's original fauna or flora.

Natural Drainage - Any water course that has a clearly defined channel, including ephemeral streams.

Nitrogen Fixation - The conversion of atmospheric (free) nitrogen to nitrogen compounds. In soils the assimilation of free nitrogen from the air by soil organisms (making the nitrogen eventually available to plants). Nitrogen-fixing organisms associated with plants such as the legumes are called symbiotic; those not definitely associated with plants are called nonsymbiotic.

Nonpoint Source Pollution (NPS) - Water pollution which is: (1) induced by natural processes, including precipitation, seepage, percolation, and runoff; (2) not traceable to any discrete or identifiable facility; and (3) better controlled through the utilization of Best Management Practices.

Noxious Weed - Species of plant certified by a particular state law as being noxious.

Nurse Crop - A planting or seeding used to protect a tender species during its early life. A nurse crop is usually temporary and gives way to the permanent crop. Sometimes referred to as a companion crop.

Nutrients - Any nutriment taken into a plant to sustain its existence, promote growth, replace loss, and provide energy.

-O-

Organic Material, Soil - The organic fraction of soil that includes plant and animal residues at various stages of decomposition.

Organics - Particles of vegetation or other biological material that can degrade water quality by decreasing dissolved oxygen and by releasing organic solutes during leaching.

ORVs (Off-Road Vehicles) - Includes any motorized vehicle when driven on surfaces other than public roads. Can include, but is not limited to, all terrain vehicles, automobiles, trucks, motorcycles, and farm implements.

Overland Flow - The part of surface runoff that flows over land surfaces toward stream channels.

-P Q-

Pasture Land - Land used primarily for the production of domesticated forage plants, to be grazed by livestock or occasionally cut and cured for livestock feed.

Percolation - Downward movement of water through soils.

Perennial - A plant having a life cycle lasting more than two years.

Perennial Stream - A watercourse that flows throughout the year or nearly so (90 percent) in a well defined channel.

Permeability, Soil - The quality of a soil horizon that enables water or air to move through it. The permeability of a soil may be limited by the presence of one nearly impermeable horizon even though the others are permeable.

pH - This symbol or term refers to a scale commonly used to express the degree of acidity or alkalinity. On this scale, pH of 1 is the strongest acid, pH of 14 is the strongest alkali, pH of 7 is the point of neutrality at which there is neither acidity nor alkalinity. pH is not a measure of the weight of acid or alkali contained in or available in a given volume.

Pollutant - "Dredged soil, solid wastes, incinerator residue, sewage, garbage, sewage sludge, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water." (P.L.92-500, Section 502(6)).

Pollution - The presence in a body of water of substances of such character and in such quantities that the natural quality of the environment is impaired or rendered harmful to health and life or offensive to the senses.

Precipitation - The deposition of moisture on the earth's surface from the atmosphere; includes dew, rain, snow, hail, sleet.

-R-

Reclamation - The process by which disturbed land is returned to its former or other productive uses.

Rehabilitation - Implies that the land will be returned to a form and productivity in conformity with a prior land-use plan, including a stable ecological state, that does not contribute substantially to environmental deterioration, and is consistent with surrounding aesthetic values.

Resource Management - Responsible and efficient management of both environmental and cultural resources implying a close and integrated relationship between the ecological basis and the operative socio-economic system involved.

Restoration - The process of restoring site conditions as they were before the land disturbance.

Retirement - Preparing a structure for a long period of nonuse. Methods include seeding, fertilizing, installing water bars, etc.

Revegetation - The establishment of vegetation which replaces original ground cover following land disturbance.

Rill Erosion - An erosion process in which numerous small channels only several inches deep are formed. Occurs mainly on disturbed and exposed soils.

Riprap - Aggregate placed on erodible sites to reduce the impact of rain or surface runoff.

Rolling Dip - See Narrow-Based Dip.

Root Zone - The soil depth at which a majority of plant roots occur. Characteristics of the plant and physical and chemical properties of the soil determine the depth of the root zone.

Runoff - That portion of precipitation that flows from a drainage area on the land surface or in open channels.

Ruts - Depressions in roads made by continuous passage of vehicles.

-S-

Scarify - To loosen or stir the surface soil without turning it over. Also, in the case of legume seeds, abrasion of the hard coat to decrease time required for germination.

Sediment - Solid material that is in suspension, is being transported, or has been moved for its site of origin.

Sedimentation - Process by which particles are removed from suspension.

Seedbed - The soil prepared by natural or artificial means to promote the germination of seed.

Shotgun Mixture - Seeding a number of species at random.

Sheet Erosion - The removal of a fairly uniform layer of soil from the land surface by water runoff.

Side Cast - The act of moving excavated material to the side and depositing such material.

Site Preparation - An activity to remove unwanted vegetation and other material, and to cultivate or prepare the soil for revegetation.

Silt - Small mineral soil grains, the particles of which range in diameter from 0.05 to 0.002 mm (or 0.02 to 0.002 mm in the international system).

Siltation - The deposition of fine-sized water-borne materials in streams, lakes, ponds, etc.

Slope - Degree of deviation of a surface from the horizontal, measured as a numerical ratio, percent, or in degrees. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), as 2:1. A 2:1 slope is a 50 percent slope. Expressed in degrees, the slope is the angle from the horizontal plane with a 90 degree slope being vertical (maximum) and 45 degrees being a 1:1 slope.

Soil - The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

Soil Amendment - Any material, such as lime, gypsum, sawdust, composited municipal wastes and sewage sludge, or synthetic conditioners, that is worked into the soil to make it more productive. Technically, a fertilizer is also an amendment but the term, "amendment" is used most commonly for added materials other than fertilizer.

Soil Conservation - Using soil within the limits of its physical characteristics and protecting it from unalterable limitations of climate and topography.

Soil Productivity - The output or productive capability of a soil to grow crops.

Soil Stabilizer - Any organic or inorganic material, applied in liquid form, that penetrates the soil surface and reduces erosion by physically binding the soil particles together.

Soil Structure - The combination or arrangement of primary soil particles into secondary particles, units, or peds.

Soil Texture - The relative portions of sand, silt, and clay in a soil.

Stabilize - Settle, fix in place, non-moving, usually accomplished on disturbed areas through revegetation or by mechanical compaction or aging.

Stormflow - Surface water runoff during precipitation events.

Stream - A continually, frequently, or infrequently flowing body of water that follows a defined course.

Streamside Management Zone (SMZ) - An area of 50 feet or more on both sides of the banks of bodies of open water, perennial streams, and some intermittent and ephemeral streams where extra precaution is used in carrying out construction activities in order to protect bank edges and water quality.

Stream Banks - The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

Subsoil - The B and sometimes the C horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil) in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when "soil" was conceived only as the plowed soil and that under it as "subsoil."

Succession - The process whereby one association of species replaces another; the progressive change in plant species over time on an area.

Susceptibility - The likelihood of soil erosion.

Suspended Solids - Sediment that is in suspension in water but settles out under quiescent conditions (as differentiated from dissolved material).

Swale - A gently sloping channel designed to transport intermittent runoff from storm events.

Switchbacks - A 180-degree direction change in a trail or road used to climb steep slopes.

-T U-

Tackifier - A chemical substance that is sprayed upon a slope for the purpose of holding mulch material (straw) in place.

Thermal Pollution - A temperature rise in a body of water sufficient to be harmful to the aquatic life.

Toxicity - The characteristic of being poisonous or harmful to plant or animal life; the relative degree or severity of this characteristic.

Turnout - (1) A widened space in a road to allow vehicles to pass one another. (2) A drainage ditch that drains water away from roads and road ditches.

-V-

Vegetation - General term including grasses, legumes, and other herbaceous plants, shrubs, trees naturally occurring or planted intentionally.

-W X Y Z-

Warm-Season Plant - A plant that makes its major growth in the warm portion of the year, primarily in the summer.

Waste - Materials and substances usually discarded as worthless to the user.

Water Bar - Terminology often given to narrow based dips for the purpose of trail or road retirement. See Narrow-based Dip.

Water Body - An area where water stands with relatively little or slow movement (ponds, lakes, bays).

Water Control Structure - Any structure used to regulate surface or subsurface water levels.

Water Courses - A definite channel with bed and banks within which concentrated water flows continuously, frequently, or infrequently.

Water Pollution - Any introduction of foreign material into water or other impingement upon water that produces undesirable changes in the physical, biological, or chemical characteristics of that water.

Water Quality - A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water Quality Standards - Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonate, pH, total dissolved salts, etc. In most states, these standards are set by some form of a state water control board.

Watershed Area - Surface region or area contributing to the supply of a stream or lake, drainage area, drainage basin, catchment area.

Wetlands - Geographic areas characteristically supporting hydrophytes, hydric soils, and some saturation or flooding during the growing season.

Wildlife - Undomesticated vertebrate animals, except fish, considered collectively.

Windrow - Woody vegetation and debris that have been piled in rows to decompose or be burned; or the act of constructing these piles.