APPENDIX A – STD & SPEC

STD & SPEC 3.01

SAFETY FENCE

Definition

A protective barrier installed to prevent access to an erosion control measure.

Purpose

To prohibit the undesirable use of an erosion control measure by the public.

Conditions Where Practice Applies

Applicable to any control measure or series of measures which can be considered unsafe by virtue of potential for access by the public.

Planning Considerations

The safety of the public must always be considered at both the planning and implementation phases of a land-disturbing activity. If there is any question concerning the risk of a particular erosion control measure to the general public, the measure should be relocated to a safer area, or an appropriate safety fence should be installed to prevent undesired access. Many times, the danger posed by a control may not be easily seen by plan designers and reviewers - that is when the on-site contractor or inspector must correct such situations in the field. Properly designed and installed safety fences prevent the trespassing of people into potentially dangerous areas, such as children using a sediment basin or a stormwater retention structure as play areas. The installation of these fences will protect people from hazards and the owner from possible litigation.

Two different types of fence will be discussed in this specification. The designer, developer, and contractor should always be sure that the most appropriate type of fence is utilized for a particular need.

Design Criteria

1. Safety fences should be located so as to create a formidable barrier to undesired access, while allowing for the continuation of necessary construction operations.

2. Safety fences are most applicable to the construction of berms, traps, and dams. In use with those structures, safety fences should be located far enough beyond the outer toe of the embankment to allow for the passage of maintenance vehicles. Fences should not be installed across the slope of a dam or dike.

3. The height of the fence shall be a minimum of 5 feet for plastic fence and 6 feet for metal fence. A fence must never be so short as to become an attraction for children to climb on or over.

4. Signs noting potential hazards such as "DANGER-QUICKSAND" or "HAZARDOUS AREA - KEEP OUT" should be posted and easily seen by anyone approaching the protected area.

5. Plastic (polyethylene) fence may be used as safety fencing, primarily in situations where the need is for a temporary barrier (see Plate 3.01-1). The fence should meet the physical requirements noted in the following table:

TABLE 3.01-A

PHYSICAL PROPERTIES OF PLASTIC SAFETY FENCE

Physical Property	Test	Requirements
Recommended color	N/A	"International" orange
Tensile yield	ASTM D638	Average 2000 lbs. per 4 ft. width
Ultimate tensile strength	ASTM D638	Average 2900 lbs. per 4 ft. width
Elongation at break(%)	ASTM D638	Greater than 1000%
Chemical resistance	N/A	Inert to most chemicals and acids

Source: Conwed Plastics

6. Metal or "chain-link" fence should be used when a potentially dangerous control measure will remain in place permanently, such as a stormwater detention or retention basin (see Plate 3.01-1). However, they may also be used for measures which will only serve a temporary function, at the discretion of those responsible for project safety. The metal fence must meet the following physical requirements:

    a. Fabric shall be zinc-coated steel, 2-inch mesh, 9-gauge, minimum.

    b. Zinc coating shall have a minimum weight of 1.8 ounces per square foot.

    c. Posts shall be steel pipe, zinc-coated.

    d. Top nails shall be steel pipe, zinc-coated.

    e. Braces shall be made of zinc-coated steel.

    f. Gates shall be single or double swing, zinc-coated steel. They shall be a minimum of 12-feet wide.

Construction Specifications

1. Safety fences must be installed prior to the E&S measure becoming accessible.

2. The polyethylene web of the plastic safety fence shall be secured to a conventional metal "T" or "U" post driven into the ground to a minimum depth of 18 inches; posts should be spaced at 6-foot centers. See "perspective" view in Plate 3.01-1.

3. The metal safety fence shall be installed as per the following procedure:

    a. Line posts shall be placed at intervals of 10 feet measured from center to center of adjacent posts. In determining the post spacing, measurement will be made parallel with the ground surface. See "perspective" view in Plate 3.01-1.

    b. Posts will be set in concrete and backfilled or anchored by other acceptable means.

    c. Posts set in the tops of concrete walls shall be grouted into preformed holes to a minimum depth of 12 inches.

    d. All corner posts, end posts, gate posts, and pull posts shall be embedded, braced, and trussed as shown in the "Standard Fence - Chain Link" detail found in the latest version of the Virginia Department of Transportation (VDOT) Road and Bridge Standards.

    e. Fencing fabric shall not be stretched until at least 4 days after the posts are grouted into walls or 14 days after the posts are set into concrete.

    f. The fabric shall be stretched taut and securely fastened, by means of tie clips, to the posts at intervals not exceeding 15 inches and to the top rails or tension wires at intervals not exceeding 2 feet. Care shall be taken to equalize the tension on each side of each post.

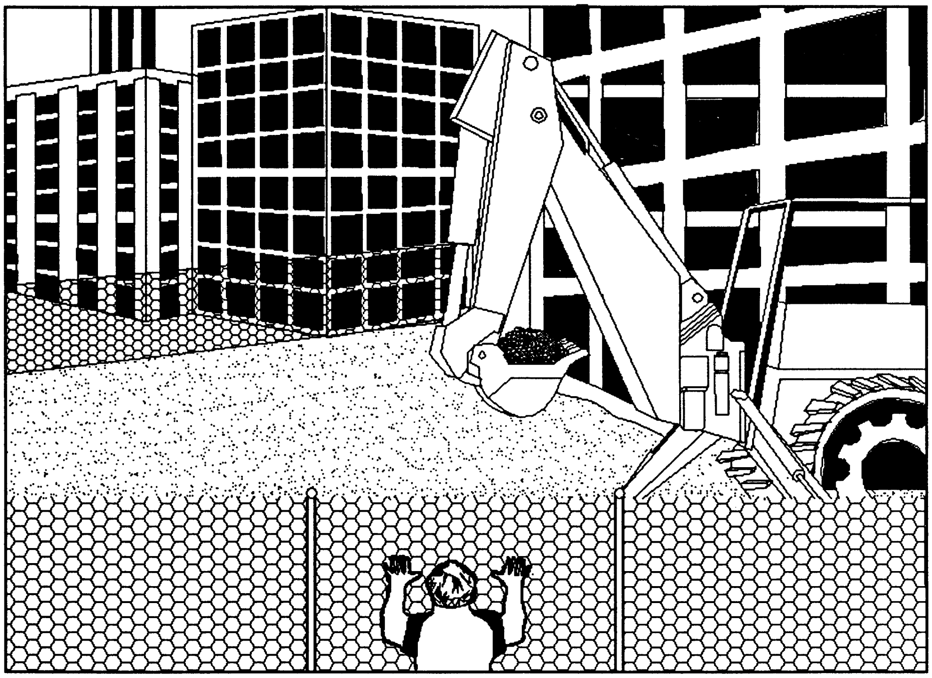
4. Applicable warning signs noting hazardous conditions must be installed immediately upon installation of safety fence.

Maintenance

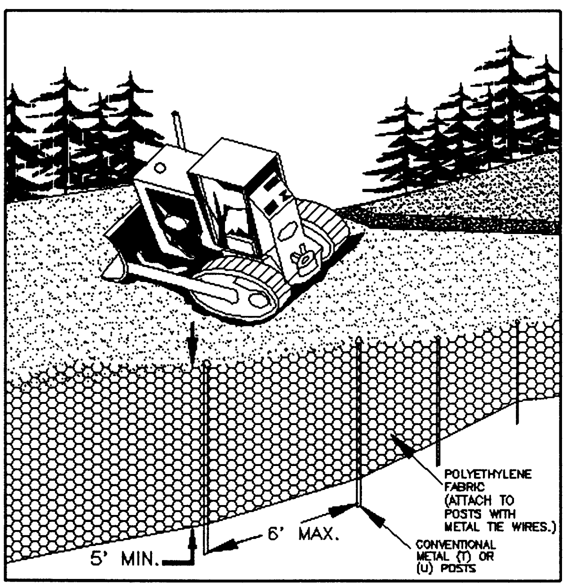
1. Safety fence shall be checked regularly for weather-related or other damage. Any necessary repairs must be made immediately.

2. Care should be taken to secure all access points (gates) at the end of each working day. All locking devices must be repaired or replaced as necessary.

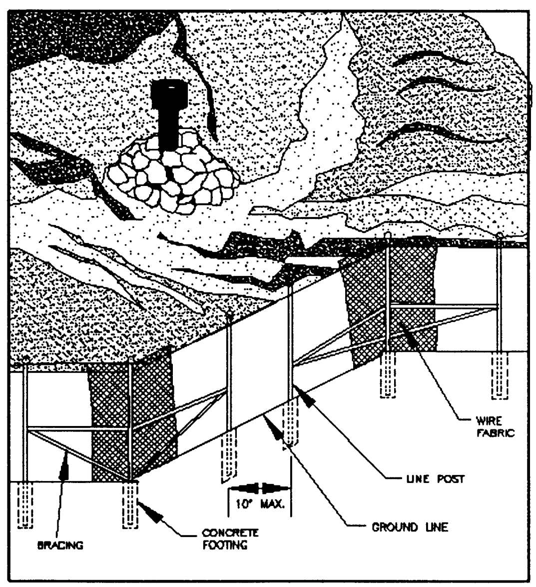
SAFETY FENCE



PERSPECTIVE VIEW



PERSPECTIVE VIEW
PLASTIC FENCE

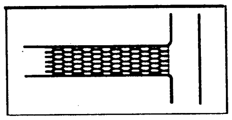


PERSPECTIVE VIEW
METAL FENCE

Source: Adapted from Conwed Plastics and VDOT <u>Road and Bridge Standards</u>

Plate 3.01-1

STD & SPEC 3.02



TEMPORARY STONE CONSTRUCTION ENTRANCE

CE

Definition

A stabilized stone pad with a filter fabric underliner located at points of vehicular ingress and egress on a construction site.

Purpose

To reduce the amount of mud transported onto paved public roads by motor vehicles or runoff.

Conditions Where Practice Applies

Wherever traffic will be leaving a construction site and move directly onto a public road or other paved area.

Planning Considerations

Minimum Standard #17 (MS #17) requires that provisions be made to minimize the transport of sediment by vehicular traffic onto a paved surface. Construction entrances provide an area where a significant amount of mud can be removed from construction vehicle tires before they enter a public road and, just as important, the soil adjacent to the paved surface can be kept intact. A filter fabric liner is used as a "separator" to minimize the dissipation of aggregate into the underlying soil due to construction traffic loads. If the action of the vehicles traveling over the gravel pad is not sufficient to remove the majority of the mud or there exists an especially sensitive traffic situation on the adjacent paved road, the tires must be washed before the vehicle enters the public road. If washing is necessary, provisions must be made to intercept the wash water and trap the sediment so it can be collected and stabilized. Construction entrances should be used in conjunction with the stabilization of construction roads (see Std. & Spec. 3.03, CONSTRUCTION ROAD STABILIZATION) to reduce the amount of mud picked up by construction vehicles and to do a better job of mud removal. Other innovative techniques for accomplishing the same purpose (such as a bituminous entrance) can be utilized, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

Design Criteria

Aggregate Size

VDOT #1 Coarse Aggregate (2- to 3-inch stone) should be used.

Entrance Dimensions

The aggregate layer must be at least 6 inches thick; a minimum three inches of aggregate should be placed in a cut section to give the entrance added stability and to help secure filter cloth separator. It must extend the full width of the vehicular ingress and egress area and have a minimum 12-foot width. The length of the entrance must be at least 70 feet (see Plate 3.02-1).

Washing

If conditions on the site are such that the majority of the mud is not removed by the vehicles traveling over the stone, then the tires of the vehicles must be washed before entering the public road. Wash water must be carried away from the entrance to a approved settling area to remove sediment. All sediment shall be prevented from entering storm drains, ditches, or watercourses. A wash rack may also be used to make washing more convenient and effective (see Plate 3.02-1).

Location

The entrance should be located to provide for maximum utilization by all construction vehicles.

Construction Specifications

The area of the entrance must be excavated a minimum of 3 inches and must be cleared of all vegetation, roots, and other objectionable material. The filter fabric underliner will then be placed the full width and length of the entrance.

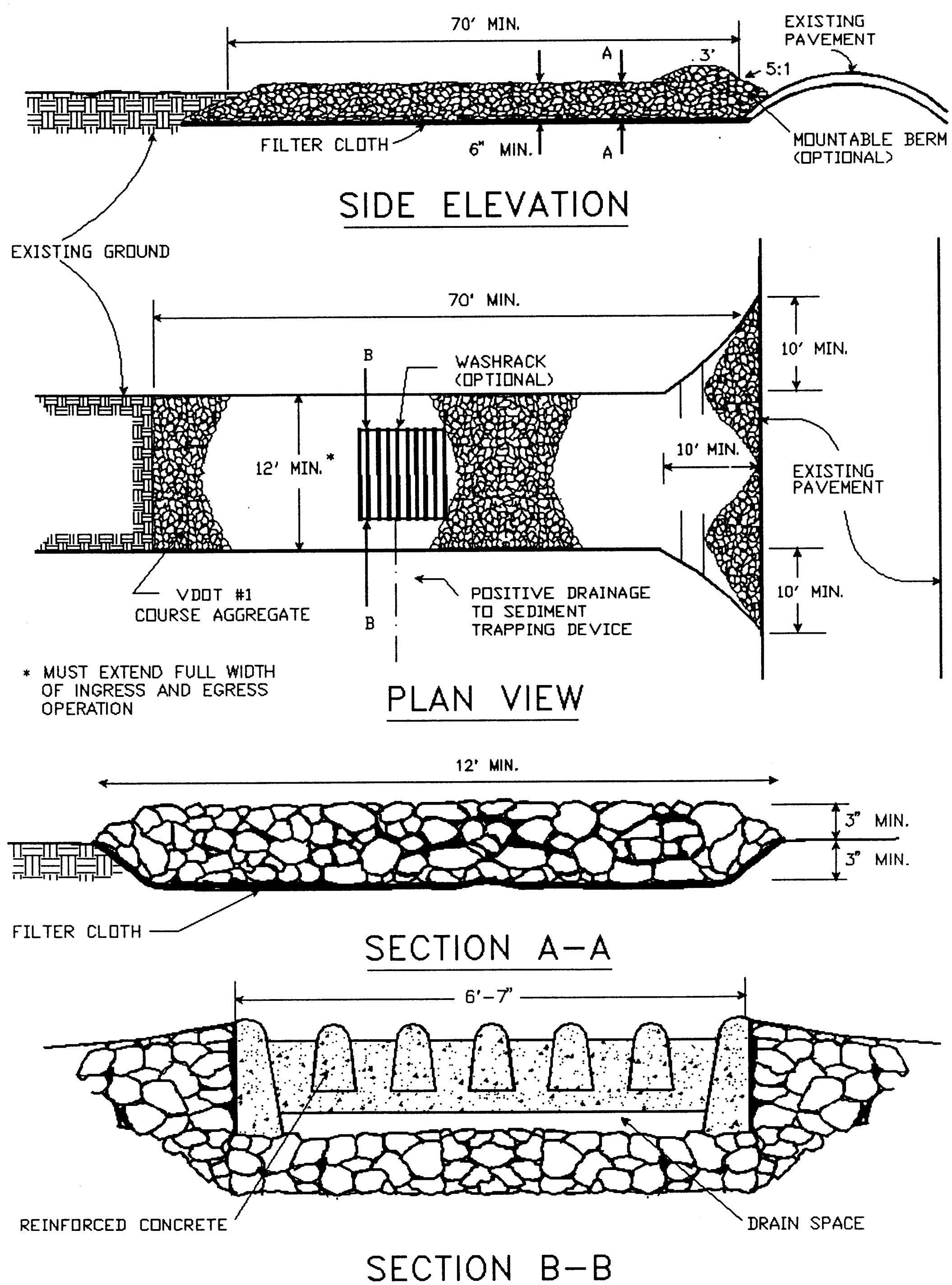
Following the installation of the filter cloth, the stone shall be placed to the specified dimensions. If wash racks are used, they should be installed according to manufacturer's specifications. Any drainage facilities required because of washing should be constructed according to specifications. Conveyance of surface water under entrance, through culverts, shall be provided as required. If such conveyance is impossible, the construction of a "mountable" berm with 5:1 slopes will be permitted.

The filter cloth utilized shall be a woven or nonwoven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The fabric shall be inert to commonly encountered chemicals and hydrocarbons, be mildew and rot resistant, and conform to the physical properties noted in Table 3.02-A.

Maintenance

The entrance shall be maintained in a condition which will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with additional stone or the washing and reworking of existing stone as conditions demand and repair and/or cleanout of any structures used to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately. The use of water trucks to remove materials dropped, washed, or tracked onto roadways will not be permitted under any circumstances.

STONE CONSTRUCTION ENTRANCE



Source: Adapted from 1983 Maryland Standards for Soil Erosion and Sediment Control, and Va. DSWC

Plate 3.02-1

TABLE 3.02-A

CONSTRUCTION SPECIFICATIONS FOR FILTER CLOTH UNDERLINER

Fabric Properties[1]	Light-Duty Entrance[2] (Graded Subgrade)	Heavy-Duty Entrance[3] (Rough Graded)	Test Method
Grab Tensile Strength (lbs.)	200	220	ASTM D1682
Elongation at Failure (%)	50	220	ASTM D1682
Mullen Burst Strength (lbs.)	190	430	ASTM D3786
Puncture Strength (lbs.)	40	125	ASTM D751 (modified)
Equivalent Opening Size (mm)	40-80	40-80	U.S. Standard Sieve CW-02215

[1] Fabrics not meeting these specifications may be used only when design procedure and supporting documentation are supplied to determine aggregate depth and fabric strength.

[2] Light Duty Entrance: Sites that have been graded to subgrade and where most travel would be single axle vehicles and an occasional multi-axle truck. Examples of fabrics which can be used are: Trevira Spunbond 1115, Mirafi 100X, Typar 3401, or equivalent.

[3] Heavy Duty Entrance: Sites with only rough grading and where most travel would be multi-axle vehicles. Examples of fabrics which can be used are: Trevira Spunbond 1135, Mirafi 600X, or equivalent.

Source: Virginia Highway and Transportation Research Council (VHTRC)

STD & SPEC 3.03

CONSTRUCTION ROAD STABILIZATION

CRS

Definition

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

Purposes

1. To reduce the erosion of temporary roadbeds by construction traffic during wet weather.

2. To reduce the erosion and subsequent 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 which 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 quagmires which 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.

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.

Permanent roads and parking areas should be paved as soon as possible after grading. However, it is understandable that weather conditions or the potential for damage may not make paving feasible in the early phases of the development project. As an alternative, the early application of stone may solve potential erosion and stability problems and eliminate later regrading costs. Some of the stone will also probably remain in place for use as part of the final base course in the construction of the road.

Specifications

Temporary Access Roads and Parking Areas

1. Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes should not exceed 10 percent.

2. 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.

3. Roadbeds shall be at least 14 feet wide for one-way traffic and 20 feet wide for two-way traffic.

4. All cuts and fills shall be 2:1 or flatter to the extent possible.

5. Drainage ditches shall be provided as needed and shall be designed and constructed in accordance with STORMWATER CONVEYANCE CHANNEL, Std. & Spec. 3.17.

6. The roadbed or parking surface shall be cleared of all vegetation, roots and other objectionable material.

7. A 6-inch course of VDOT #1 Coarse Aggregate shall be applied immediately after grading or the completion of utility installation within the right-of-way. Filter fabric may be applied to the roadbed for additional stability. Design specifications for filter fabric can be found within Std. & Spec. 3.02, TEMPORARY STONE CONSTRUCTION ENTRANCE. In "heavy duty" traffic situations (see Table 3.02-A), stone should be placed at an 8- to 10-inch depth to avoid excessive dissipation or maintenance needs.

Permanent Roads and Parking Areas

Permanent roads and parking areas shall be designed and constructed in accordance with applicable VDOT or local criteria except that an initial base course of gravel of at least 6 inches shall be applied immediately following 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 according to the applicable standards and specifications contained in this handbook.

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.

STD & SPEC 3.04

STRAW BALE BARRIER

STB

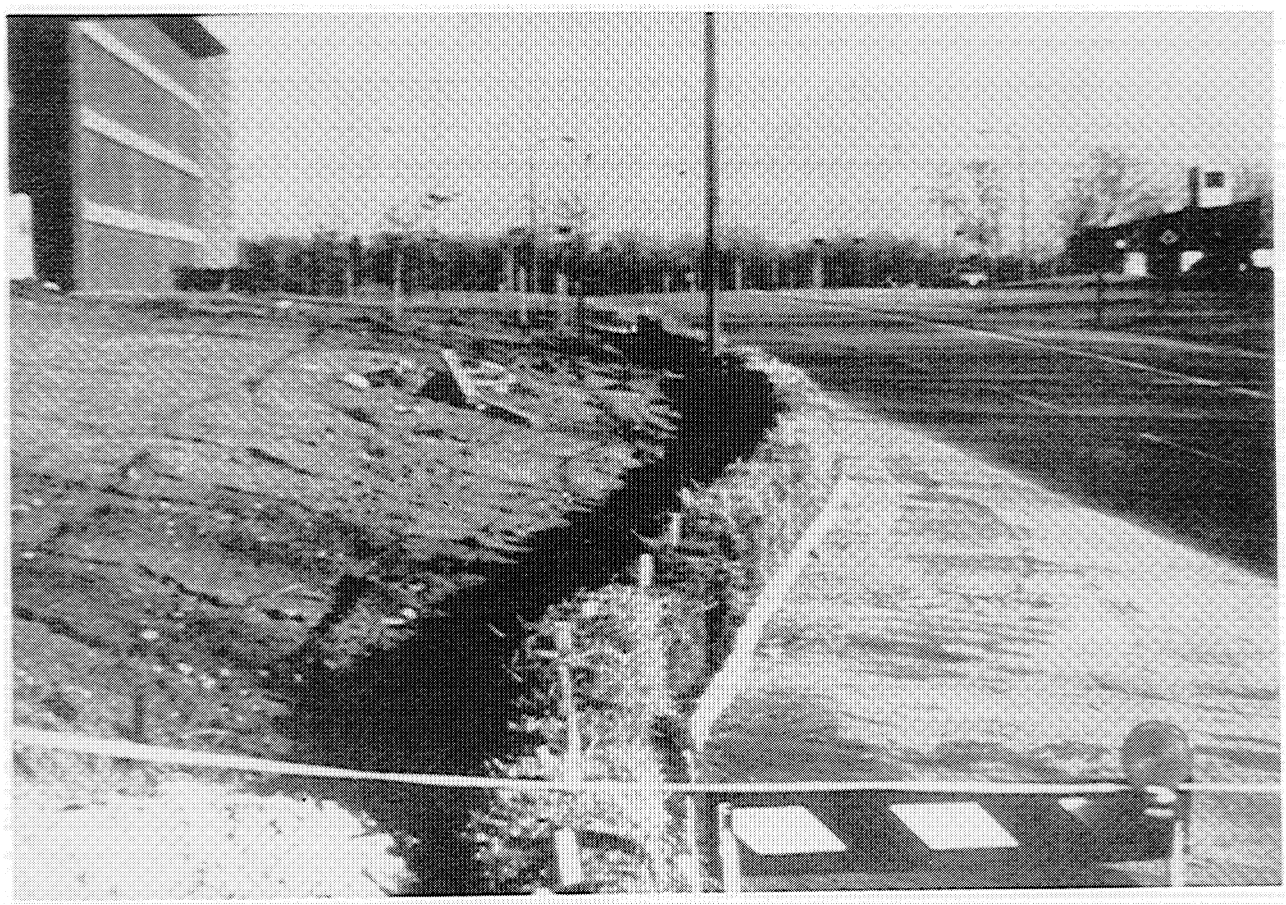
Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas of limited extent in order to prevent sediment from leaving the construction site.

2. To decrease the velocity of sheet flows.



Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion.

2. Where the size of the drainage area is no greater than one-fourth of an 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).

3. Where effectiveness is required for less than 3 months.

4. Under no circumstances should straw bale barriers be constructed in live streams or in swales where there is the possibility of a washout.

5. The measure should not be used where water may concentrate in defined ditches and minor swales.

6. Straw bale barriers shall not be used on areas where rock or another hard surface prevents the full and uniform anchoring of the barrier.

Planning Considerations

Based on observations made in Virginia, Pennsylvania, Maryland and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be - especially when used to slow down and filter concentrated flows. They should be used judiciously and with caution as erosion control measures. There are three major reasons for such ineffectiveness.

First, improper utilization of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water depth and velocities have destroyed or damaged the control. Secondly, improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions of, rather than removal of, sediment from runoff waters. Finally, inadequate maintenance lowers the effectiveness of these barriers. Trapping efficiencies of carefully installed straw bale barriers on one project in Virginia dropped from 57% to 16% in one month due to lack of maintenance.

There are serious questions about the continued use of straw bale barriers as they are presently installed and maintained. Averaging from $3 to $6 per linear foot, the thousands of straw bale barriers used annually in Virginia represent such a considerable expense that optimum installation procedures should be emphasized.

Design Criteria

A formal design is not required. However, an effort should be made to locate the straw bale barrier, as well as other perimeter controls, at least 5 to 7 feet from the base of disturbed slopes with grades greater than 7%. This will help prevent the measure from being rendered useless following the initial movement of soil.

Construction Specifications

Sheet Flow Application

1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

2. 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 deterioration of the bindings (see Plate 3.04-1).

3. 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 (gaps filled by wedging), 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 (see Plate 3.04-1).

4. Each bale shall be securely anchored by at least two stakes (minimum dimensions 2 inches x 2 inches x 36 inches) or standard "T" or "U" steel posts (minimum weight of 1.33 pounds per linear foot) driven through the bale. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or steel pickets shall be driven a minimum 18 inches deep into the ground to securely anchor the bales.

5. 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.

6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

Maintenance

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

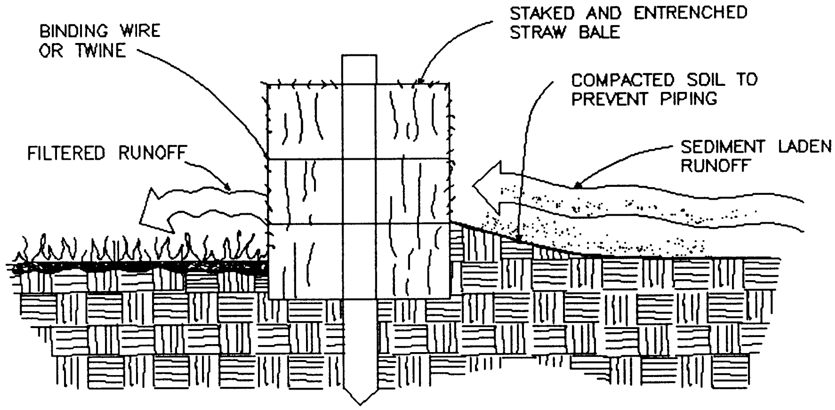
2. Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales.

3. Necessary repairs to barriers or replacement of bales shall be accomplished promptly.

4. Sediment deposits should be removed after each rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.

5. 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.

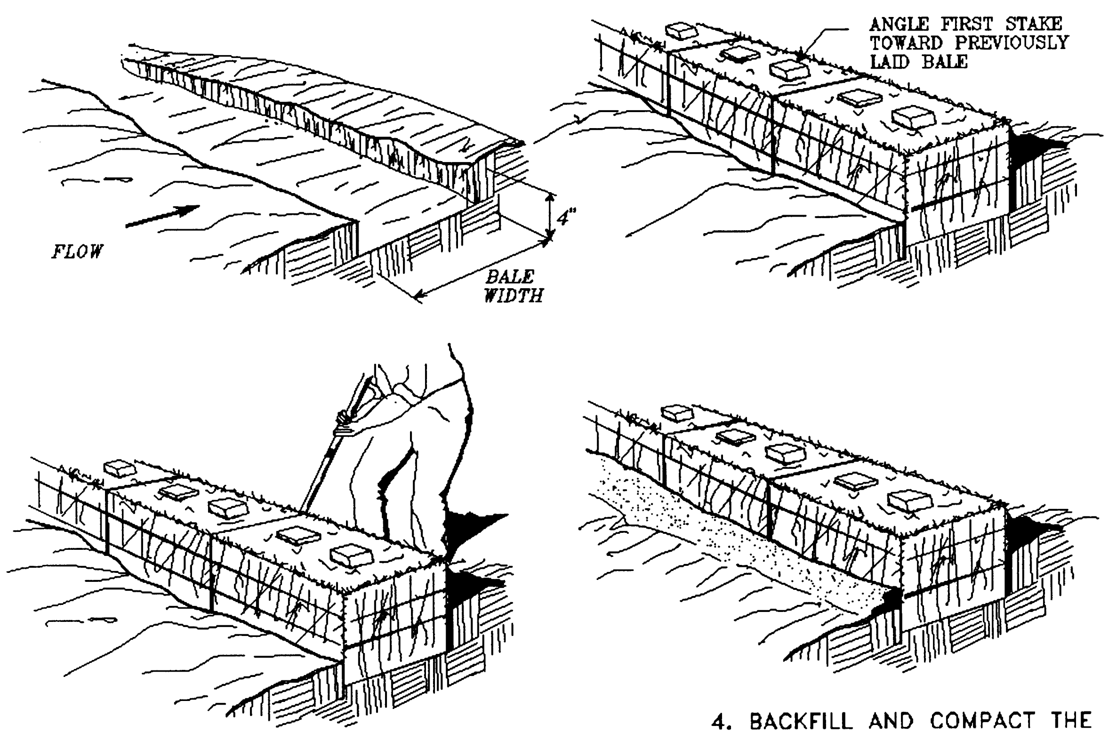
STRAW BALE BARRIER



PROPERLY INSTALLED STRAW BALE
(CROSS SECTION)

1. EXCAVATE THE TRENCH.

2. PLACE AND STAKE STRAW BALES.



3. WEDGE LOOSE STRAW BETWEEN BALES.

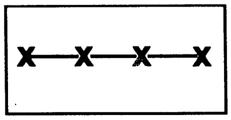
4. BACKFILL AND COMPACT THE EXCAVATED SOIL.

CONSTRUCTION OF STRAW BALE BARRIER

Source: Va. DSWC

Plate 3.04-1

STD & SPEC 3.05



SILT FENCE

SF

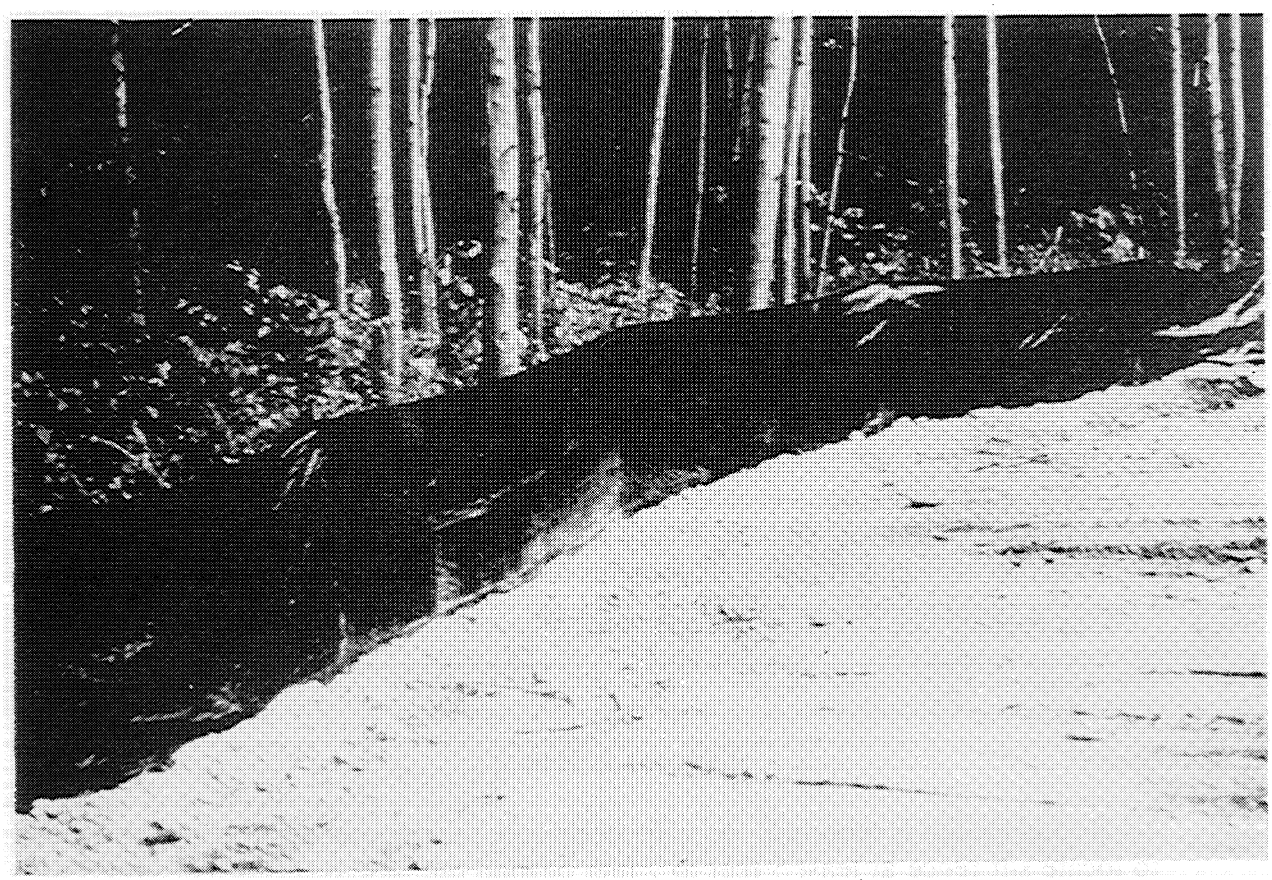
Definition

A temporary sediment barrier consisting of a synthetic filter fabric stretched across and attached to supporting posts and entrenched.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.



Conditions Where Practice Applies

1. Below disturbed areas where erosion would occur in the form of sheet and rill erosion.

2. Where the size of the drainage area is no more than one quarter acre per 100 feet of silt fence length; the maximum slope length behind the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2:1).

3. In minor swales or ditch lines where the maximum contributing drainage area is no greater than 1 acre and flow is no greater than 1 cfs.

4. Silt fence will not be used in areas where rock or some other hard surface prevents the full and uniform depth anchoring of the barrier.

Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council (VHTRC) has shown that silt fences can trap a much higher percentage of suspended sediments than straw bales, though silt fence passes the sediment-laden water slower. Silt fences are preferable to straw barriers in many cases because of their durability and potential cost savings. While the failure rate of silt fences is lower than that of straw barriers, many instances have been observed where silt fences are improperly installed, inviting failure and sediment loss. The installation methods outlined here can improve performance and reduce failures.

As noted, flow rate through silt fence is significantly lower than the flow rate for straw bale barriers. This creates more ponding and hence more time for sediment to fall out. Table 3.05-A demonstrates these relationships.

Both woven and non-woven synthetic fabrics are commercially available. The woven fabrics generally display higher strength than the non-woven fabrics and, in most cases, do not require any additional reinforcement. When tested under acid and alkaline water conditions, most of the woven fabrics increase in strength, while the reactions of non-woven fabrics to these conditions are variable. The same is true of testing under extensive ultraviolet radiation. Permeability rates vary regardless of fabric type. While all of the fabrics demonstrate very high filtering efficiencies for sandy sediments, there is considerable variation among both woven and non-woven fabrics when filtering the finer silt and clay particles.

Design Criteria

1. No formal design is required. As with straw bale barriers, an effort should be made to locate silt fence at least 5 feet to 7 feet beyond the base of disturbed slopes with grades greater than 7%.

TABLE 3.05-A

TYPICAL FLOW RATES AND FILTERING EFFICIENCIES OF PERIMETER CONTROL

Material	Flow Rate (gal./sq.ft./min)	Filter Efficiency(%)
Straw	5.6	67
Synthetic Fabric	0.3	97

Source: VHTRC

2. The use of silt fences, because they have such a low permeability, is limited to situations in which only sheet or overland flows are expected and where concentrated flows originate from drainage areas of 1 acre or less.

3. Field experience has demonstrated that, in many instances, silt fence is installed too short (less than 16 inches above ground elevation). The short fence is subject to breaching during even small storm events and will require maintenance "clean outs" more often. Properly supported silt fence which stands 24 to 34 inches above the existing grade tends to promote more effective sediment control.

Construction Specifications

Materials

1. Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester or ethylene yarn and shall be certified by the manufacturer or supplier as conforming to the requirements noted in Table 3.05-B.

2. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0° F to 120° F.

3. If wooden stakes are utilized for silt fence construction, they must have a diameter of 2 inches when oak is used and 4 inches when pine is used. Wooden stakes must have a minimum length of 5 feet.

TABLE 3.05-B

PHYSICAL PROPERTIES OF FILTER FABRIC IN SILT FENCE

Physical Property	Test	Requirements
Filtering Efficiency	ASTM 5141	75% (minimum)
Tensile Strength at 20% (max.) Elongation*	VTM-52	Extra Strength - 50 lbs./linear inch (minimum) Standard Strength - 30 lbs./linear inch (minimum)
Flow Rate	ASTM 5141	0.2 gal./sq.ft./ minute (minimum)
Ultraviolet Radiation Stability %	ASTM-G-26	90% (minimum)

* Requirements reduced by 50% after six months of installation.

Source: VHTRC

4. If steel posts (standard "U" or "T" section) are utilized for silt fence construction, they must have a minimum weight of 1.33 pounds per linear foot and shall have a minimum length of 5 feet.

5. Wire fence reinforcement for silt fences using standard-strength filter cloth shall be a minimum of 14 gauge and shall have a maximum mesh spacing of 6 inches.

Installation

1. The height of a silt fence shall be a minimum of 16 inches above the original ground surface and shall not exceed 34 inches above ground elevation.

2. 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 unavoidable, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.

3. A trench shall be excavated approximately 4-inches wide and 4-inches deep on the upslope side of the proposed location of the measure.

4. When wire support is used, standard-strength filter cloth may be used. Posts for this type of installation shall be placed a maximum of 10-feet apart (see Plate 3.05-1). The wire mesh fence must be fastened securely to the upslope side of the posts using heavy duty wire staples at least one inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of two inches and shall not extend more than 34 inches above the original ground surface. The standard-strength fabric shall be stapled or wired to the wire fence, and 8 inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees.

5. When wire support is not used, extra-strength filter cloth shall be used. Posts for this type of fabric shall be placed a maximum of 6-feet apart (see Plate 3.05-2). The filter fabric shall be fastened securely to the upslope side of the posts using one inch long (minimum) heavy-duty wire staples or tie wires and eight inches of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees. This method of installation has been found to be more commonplace than #4.

6. If a silt fence is to be constructed across a ditch line or swale, the measure must be of sufficient length to eliminate endflow, and the plan configuration shall resemble an arc or horseshoe with the ends oriented upslope (see Plate 3.05-2). Extra-strength filter fabric shall be used for this application with a maximum 3-foot spacing of posts.

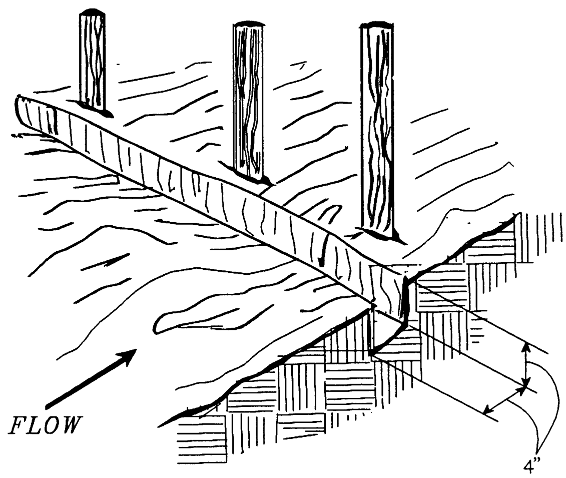
   All other installation requirements noted in #5 apply.

7. The 4-inch by 4-inch trench shall be backfilled and the soil compacted over the filter fabric.

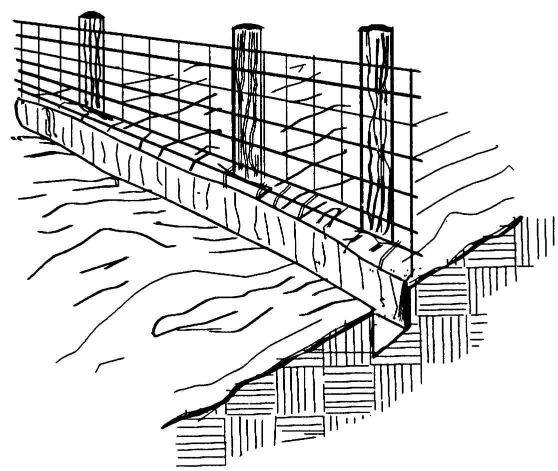
8. Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

CONSTRUCTION OF A SILT FENCE (WITH WIRE SUPPORT)

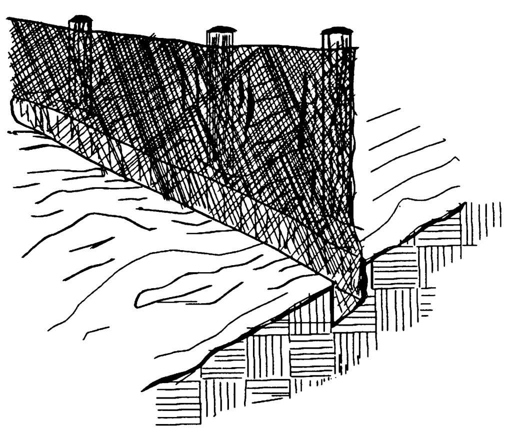
1. SET POSTS AND EXCAVATE A 4"X4" TRENCH UPSLOPE ALONG THE LINE OF POSTS.



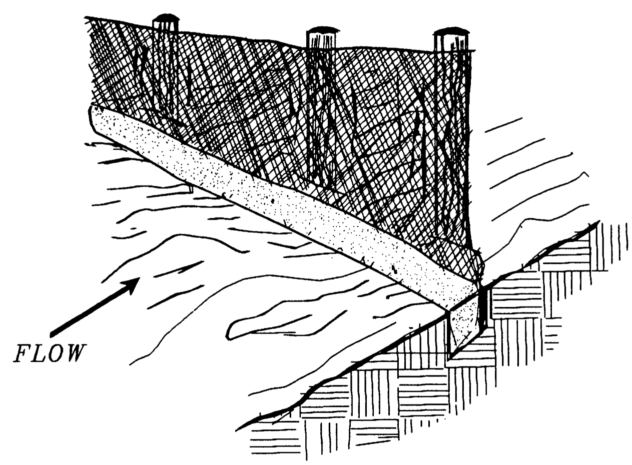
2. STAPLE WIRE FENCING TO THE POSTS.



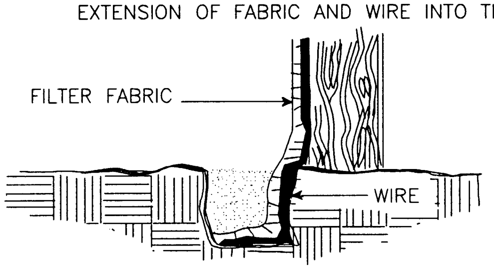
3. ATTACH THE FILTER FABRIC TO THE WIRE FENCE AND EXTEND IT INTO THE TRENCH.



4. BACKFILL AND COMPACT THE EXCAVATED SOIL.



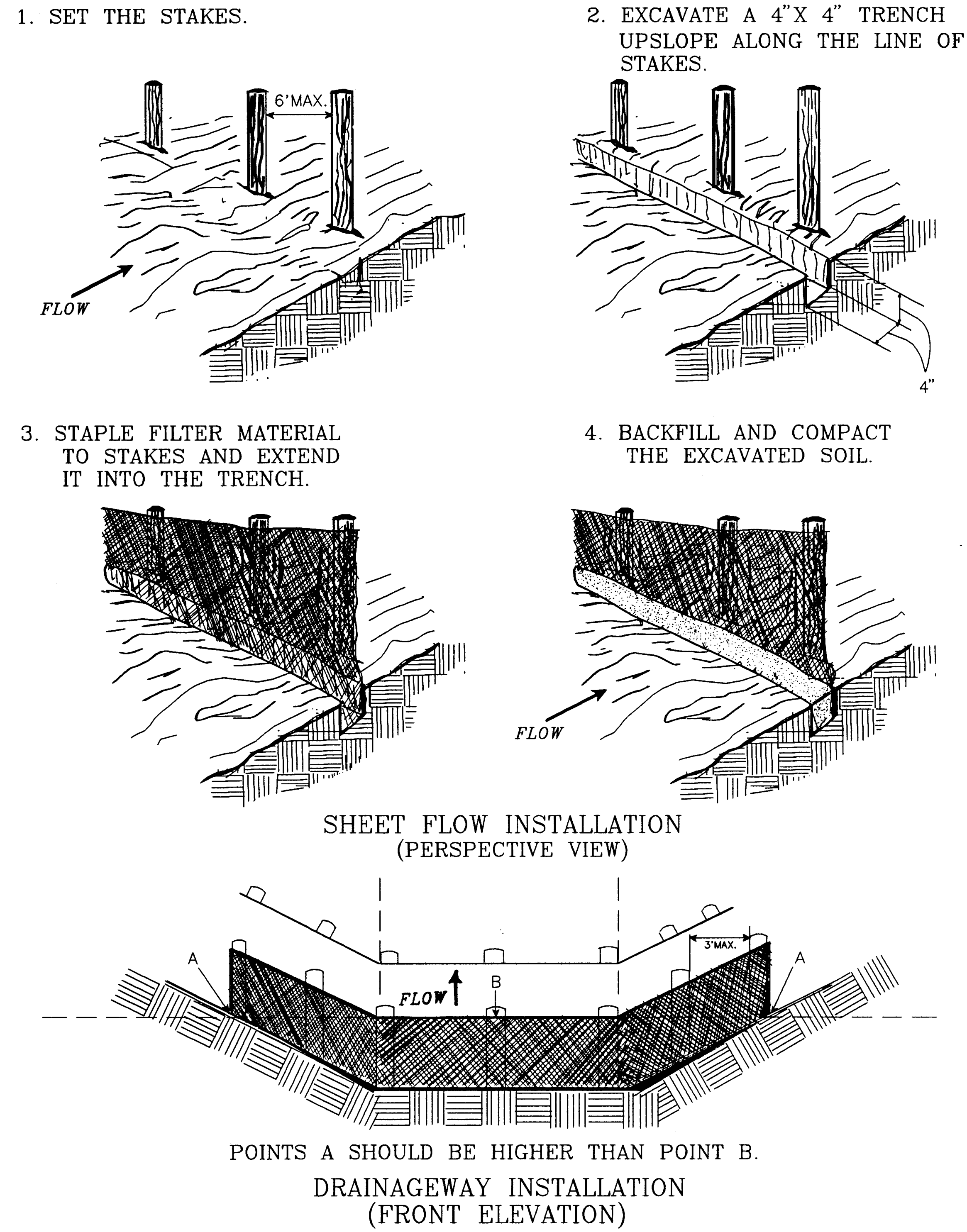
EXTENSION OF FABRIC AND WIRE INTO THE TRENCH.



Source: Adapted from Installation of Straw and Fabric Filter Barriers for Sediment Control, Sherwood and Wyant

Plate 3.05-1

CONSTRUCTION OF A SILT FENCE (WITHOUT WIRE SUPPORT)



Source: Adapted from Installation of Straw and Fabric Filter Barriers for Sediment Control, Sherwood and Wyant

Plate 3.05-2

Maintenance

1. Silt fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.

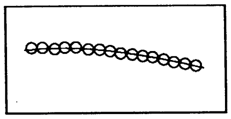
2. Close attention shall be paid to the repair of damaged silt fence resulting from end runs and undercutting.

3. Should the fabric on a silt fence decompose or become ineffective prior to the end of the expected usable life and the barrier still be necessary, the fabric shall be replaced promptly.

4. Sediment deposits should be removed after each storm event. They must be removed when deposits reach approximately one-half the height of the barrier.

5. Any sediment deposits remaining in place after the silt fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

STD & SPEC 3.06



BRUSH BARRIER

BB

Definition

A temporary sediment barrier constructed at the perimeter of a disturbed area from the residue materials available from clearing and grubbing the site.

Purpose

To intercept and retain sediment from disturbed areas of limited extent, preventing sediment from leaving the site.

Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier.

2. Where the size of the drainage area is no greater than one-fourth of an 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).

Planning Considerations

Organic litter and spoil material from site clearing operations is usually burned or hauled away to be dumped elsewhere. Much of this material can be used effectively on the construction site itself. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation and root mat along with minor amounts of rock into windrows along the toe of a slope where erosion and accelerated runoff are expected. Because brush barriers are fairly stable and composed of natural materials, maintenance requirements are small. Field experience has shown, however, that many brush barrier installations are not effective when there are large voids created by the use of material which is too large (such as tree stumps) to provide a compact, dense barrier. Therefore, it is necessary to use residual material under 6 inches in diameter which will create a more uniform barrier or utilize a filter fabric overlay to promote enhanced filtration of sediment-laden runoff.

Design Criteria

A formal design is not required.

Construction Specifications

Without Filter Cloth

1. The height of a brush barrier shall be a minimum of 3 feet.

2. The width of a brush barrier shall be a minimum of 5 feet at its base (the sizes of brush barriers may vary considerably based upon the amount of material available and the judgement of the design engineer).

3. The barrier shall be constructed by piling brush, stone, root mat and other material from the clearing process into a mounded row on the contour. Material larger than 6 inches in diameter should not be used to create the mound as the non-homogeneity of the mixture can lead to voids where sediment-laden flows can easily pass.

<u>If a Filter is Used</u> (see Plate 3.06-1)

1. Filter fabric must meet the minimum physical requirements noted in Table 3.05-B.

2. The filter fabric shall be cut into lengths sufficient to lay across the barrier from its up-slope base to just beyond its peak. Where joints are necessary, the fabric shall be spliced together with a minimum 6-inch overlap and securely sealed.

3. A trench shall be excavated 6-inches wide and 4-inches deep along the length of the barrier and immediately uphill from the barrier.

4. The lengths of filter fabric shall be draped across the width of the barrier with the uphill edge placed in the trench and the edges of adjacent pieces overlapping each other.

5. The filter fabric shall be secured in the trench with stakes set approximately 36 inches on center.

6. The trench shall be backfilled and the soil compacted over the filter fabric.

7. Set stakes into the ground along the downhill edge of the brush barrier, and anchor the fabric by tying twine from the fabric to the stakes.

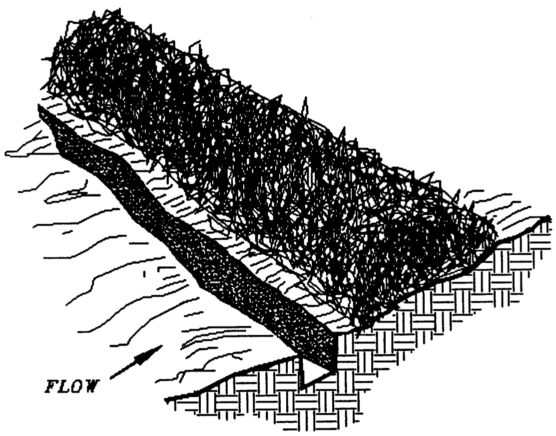
Maintenance

1. Brush barriers shall be inspected after each rainfall and necessary repairs shall be made promptly.

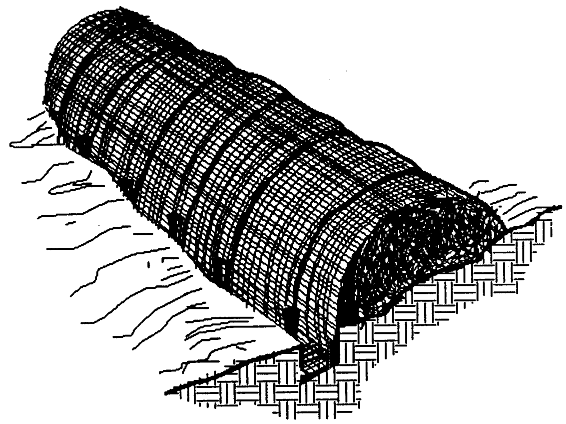
2. Sediment deposits must be removed when they reach approximately one-half the height of the barrier.

CONSTRUCTION OF A BRUSH BARRIER COVERED BY FILTER FABRIC

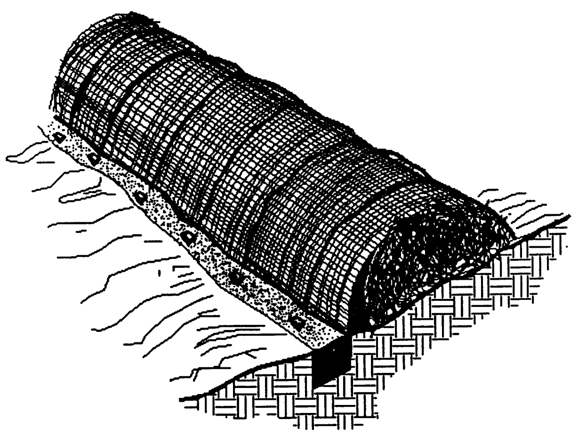
(TREE/RESIDUAL MATERIAL WITH DIAMETER > 6")



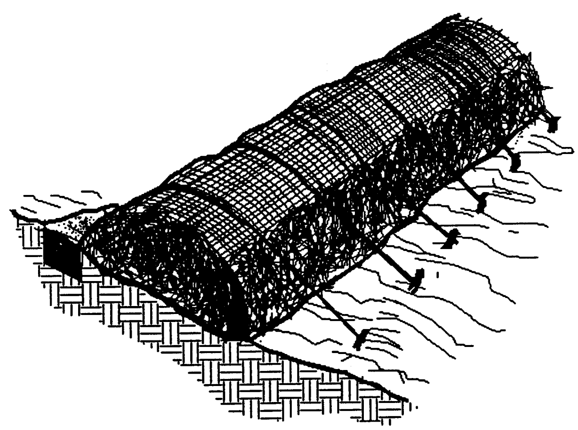
1. EXCAVATE A 4"X 4" TRENCH ALONG THE UPHILL EDGE OF THE BRUSH BARRIER.



2. DRAPE FILTER FABRIC OVER THE BRUSH BARRIER AND INTO THE TRENCH. FABRIC SHOULD BE SECURED IN THE TRENCH WITH STAKES SET APPROXIMATELY 36" O.C.



3. BACKFILL AND COMPACT THE EXCAVATED SOIL.

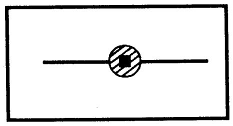


4. SET STAKES ALONG THE DOWN-HILL EDGE OF THE BRUSH BARRIER, AND ANCHOR BY TYING TWINE FROM THE FABRIC TO THE STAKES.

Source: Va. DSWC

Plate 3.06-1

STD & SPEC 3.07



STORM DRAIN INLET PROTECTION

IP

Definition

A sediment filter or an excavated impounding area around a storm drain drop inlet or curb inlet.

Purpose

To prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

Conditions Where Practice Applies

Where storm drain inlets are to be made operational before permanent stabilization of the corresponding disturbed drainage area. Different types of structures are applicable to different conditions (see Plates 3.07-1 through 3.07-8).

Planning Considerations

Storm sewers which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the storm sewer itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

This practice contains several types of inlet filters and traps which have different applications dependent upon site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

Care should be taken when choosing a specific type of inlet protection. Field experience has shown that inlet protection which causes excessive ponding in an area of high construction activity may become so inconvenient that it is removed or bypassed, thus transmitting sediment-laden flows unchecked. In such situations, a structure with an adequate overflow mechanism should be utilized.

The following inlet protection devices are for drainage areas of one acre or less. Runoff from larger disturbed areas should be routed to a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13) or a TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14).

The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

Stone is utilized as the chief ponding/filtering agent in most of the inlet protection types described in this specification. The various types of "coarse aggregates" which are depicted are able to filter out sediment mainly through slowing down flows directed to the inlet by creating an increased flow path for the stormwater (through void space in the respective stone). The stone filtering medium by no means slows stormwater flowrate as does filter cloth and therefore cannot provide the same degree of filter efficiency when smaller silt and clay particles are introduced into stormwater flows. However, as mentioned earlier, excessive ponding in busy areas adjacent to stormwater inlets is in many cases unacceptable - that is why stone must be utilized with many installations.

Fortunately, in most instances, inlet protection utilizing stone should not be the sole control measure. At the time that storm sewer inlet and associated appurtances become operational, areas adjacent to the structures are most likely at final grade or will not be altered for extended periods; this is the time when TEMPORARY SEEDING (Std. & Spec. 3.31) and other appropriate controls should be implemented to enhance sediment-loss mitigation. In addition, by varying stone sizes used in the construction of inlet protection, a greater degree of sediment removal can be obtained. As an option, filter cloth can be used with the stone in these devices to further enhance sediment removal. Notably, the potential inconvenience of excessive ponding must be examined with these choices, especially the latter.

Design Criteria

1. The drainage area shall be no greater than 1 acre.

2. The inlet protection device shall be constructed in a manner that will facilitate clean-out and disposal of trapped sediment and minimize interference with construction activities.

3. The inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.

4. Design criteria more specific to each particular inlet protection device will be found on Plates 3.07-1 through 3.07-8.

5. For the inlet protection devices which utilize stone as the chief ponding/filtering medium, <u>a range of stone sizes is offered</u>; VDOT #3, #357, or #5 Coarse Aggregate should be used. The designer/plan reviewer should attempt to get the greatest amount of filtering action possible (by using smaller-sized stone), while not creating significant ponding problems.

6. In all designs which utilize stone with a wire-mesh support as a filtering mechanism, the stone can be <u>completely wrapped</u> with the wire mesh to improve stability and provide easier cleaning.

7. <u>Filter Fabric</u> may be added to any of the devices which utilize "coarse aggregate" stone to significantly enhance sediment removal. The fabric, which must meet the physical requirements noted for "extra strength" found in Table 3.05-B, should be secured between the stone and the inlet (on wire-mesh if it is present). As a result of the significant increase in filter efficiency provided by the fabric, a <u>larger</u> range of stone sizes (VDOT #1, #2 or #3 Coarse Aggregate) may be utilized with such a configuration. The larger stone will help keep larger sediment masses from clogging the cloth. Notably, <u>significant ponding may occur at the inlet if filter cloth is utilized in this manner</u>.

Construction Specifications

1. <u>Silt Fence Drop Inlet Protection</u>

   a. Silt Fence shall conform to the construction specifications for "extra strength" found in Table 3.05-B and shall be cut from a continuous roll to avoid joints.

   b. <u>For stakes, use 2 x 4-inch wood</u> (preferred) or equivalent metal with a minimum length of 3 feet.

c. Space stakes evenly around the perimeter of the inlet a maximum of 3-feet apart, and securely drive them into the ground, approximately 18-inches deep (see Plate 3.07-1).

d. To provide needed stability to the installation, frame with 2 x 4-inch wood strips around the crest of the overflow area at a maximum of 1½ feet above the drop inlet crest.

e. Place the bottom 12 inches of the fabric in a trench (see Plate 3.07-1) and backfill the trench with 12 inches of compacted soil.

f. Fasten fabric securely by staples or wire to the stakes and frame. Joints must be overlapped to the next stake.

g. It may be necessary to build a temporary dike on the downslope side of the structure to prevent bypass flow.

2. Gravel and Wire Mesh Drop Inlet Sediment Filter

a. Wire mesh shall be laid over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Wire mesh with 1/2-inch openings shall be used. If more than one strip of mesh is necessary, the strips shall be overlapped.

b. Coarse aggregate shall be placed over the wire mesh as indicated on Plate 3.07-2. The depth of stone shall be at least 12 inches over the entire inlet opening. The stone shall extend beyond the inlet opening at least 18 inches on all sides.

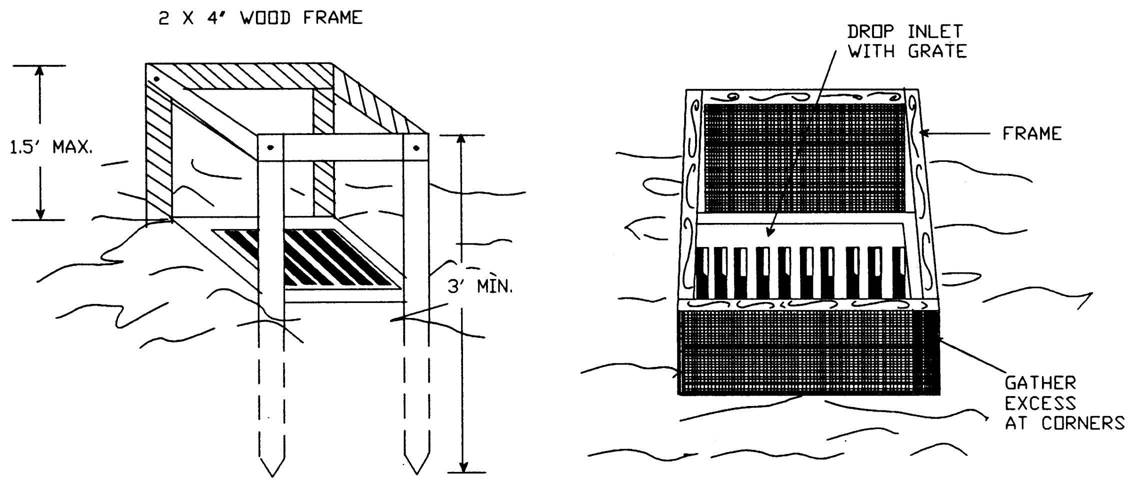
c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and/or replaced.

Note: This filtering device has no overflow mechanism; therefore, ponding is likely especially if sediment is not removed regularly. This type of device must never be used where overflow may endanger an exposed fill slope. Consideration should also be given to the possible effects of ponding on traffic movement, nearby structures, working areas, adjacent property, etc.

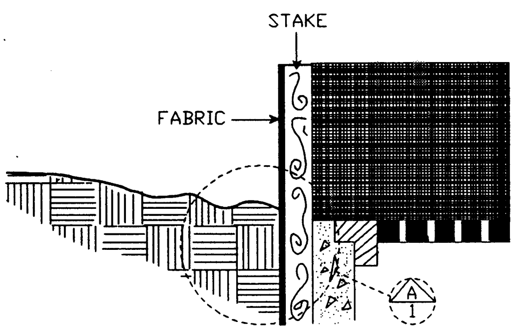
3. Block and Gravel Drop Inlet Sediment Filter

a. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, with the ends of adjacent blocks abutting. The height of the barrier can be varied, depending on design needs, by stacking combinations of 4-inch, 8-inch and 12-inch wide blocks. The barrier of blocks shall be at least 12-inches high and no greater than 24-inches high.

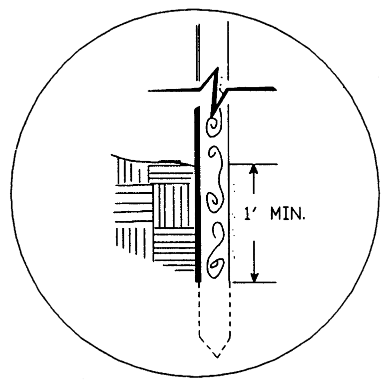
SILT FENCE DROP INLET PROTECTION



PERSPECTIVE VIEWS



ELEVATION OF STAKE AND FABRIC ORIENTATION



DETAIL A

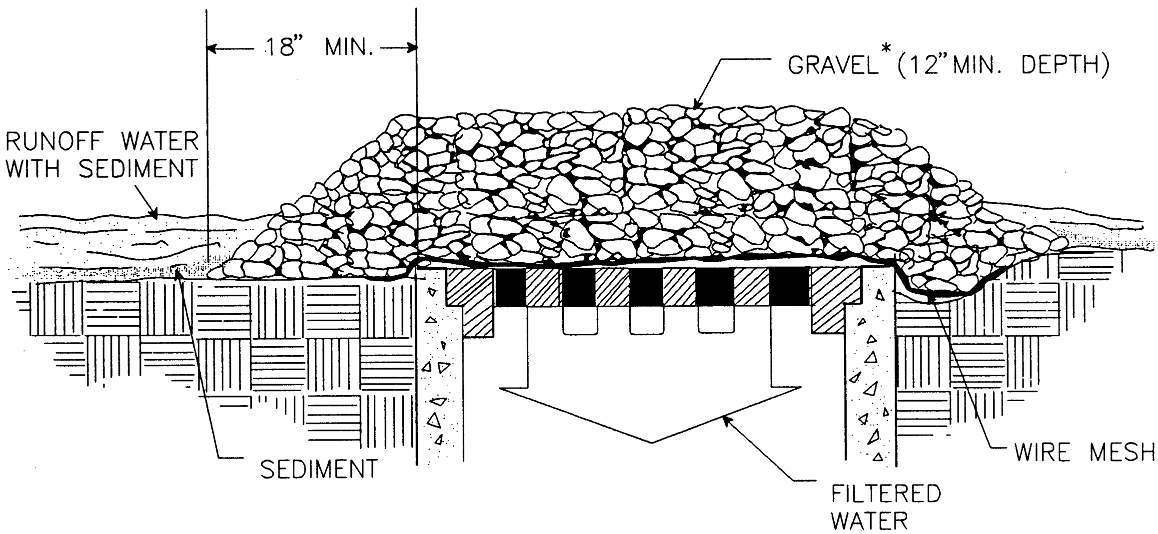
<u>SPECIFIC APPLICATION</u>

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE THE INLET DRAINS A RELATIVELY FLAT AREA (SLOPE NO GREATER THAN 5%) WHERE THE INLET SHEET OR OVERLAND FLOWS (NOT EXCEEDING 1 C.F.S.) ARE TYPICAL. THE METHOD SHALL NOT APPLY TO INLETS RECEIVING CONCENTRATED FLOWS, SUCH AS IN STREET OR HIGHWAY MEDIANS.

Source: N.C. <u>Erosion and Sediment Control Planning and Design Manual</u>, 1988

Plate 3.07-1

GRAVEL AND WIRE MESH DROP INLET SEDIMENT FILTER



SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY CONCENTRATED FLOWS ARE EXPECTED, BUT NOT WHERE PONDING AROUND THE STRUCTURE MIGHT CAUSE EXCESSIVE INCONVENIENCE OR DAMAGE TO ADJACENT STRUCTURES AND UNPROTECTED AREAS.

* GRAVEL SHALL BE VDOT #3, #357 OR #5 COARSE AGGREGATE.

Source: Va. DSWC

Plate 3.07-2

b. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 1/2-inch openings shall be used.

c. Stone shall be piled against the wire to the top of the block barrier, as shown in Plate 3.07-3.

d. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and replaced.

4. Excavated Drop Inlet Sediment Trap

a. The excavated trap shall be sized to provide a minimum storage capacity calculated at the rate of 134 cubic yards per acre of drainage area. A trap shall be no less than 1-foot nor more than 2-feet deep measured from the top of the inlet structure. Side slopes shall not be steeper than 2:1 (see Plate 3.07-4).

b. The slope of the basin may vary to fit the drainage area and terrain. Observations must be made to check trap efficiency and modifications shall be made as necessary to ensure satisfactory trapping of sediment. Where an inlet is located so as to receive concentrated flows, such as in a highway median, it is recommended that the basin have a rectangular shape in a 2:1 (length/width) ratio, with the length oriented in the direction of the flow.

c. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in a manner such that it will not erode.

5. Sod Drop Inlet Sediment Filter

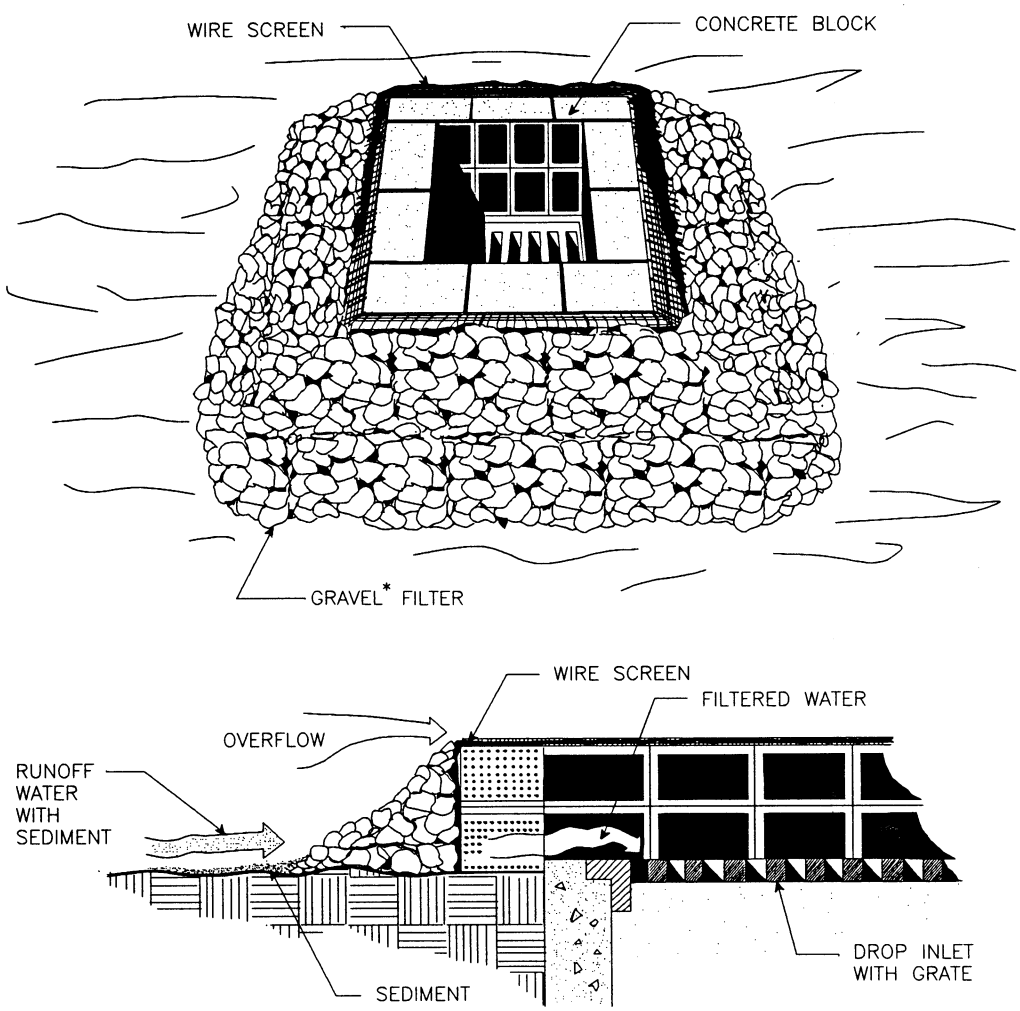
a. Soil shall be prepared and sod installed according to the specifications in Std. & Spec. 3.33, SODDING.

b. Sod shall be placed to form a turf mat covering the soil for a distance of 4 feet from each side of the inlet structure, as depicted in Plate 3.07-5.

6. Gravel Curb Inlet Sediment Filter

a. Wire mesh with 1/2-inch openings shall be placed over the curb inlet opening so that at least 12 inches of wire extends across the inlet cover and at least 12 inches of wire extends across the concrete gutter from the inlet opening, as depicted in Plate 3.07-6.

BLOCK AND GRAVEL DROP INLET SEDIMENT FILTER



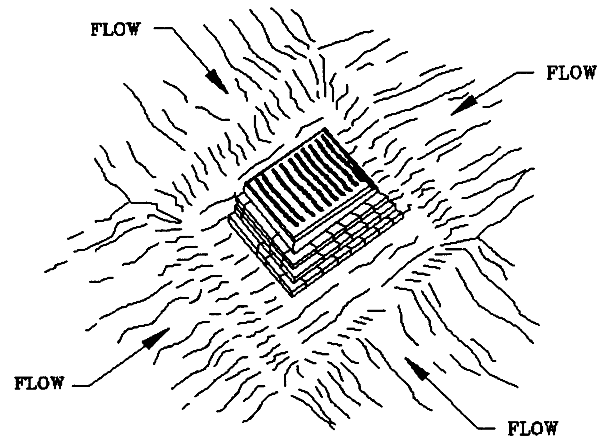
<u>SPECIFIC APPLICATION</u>

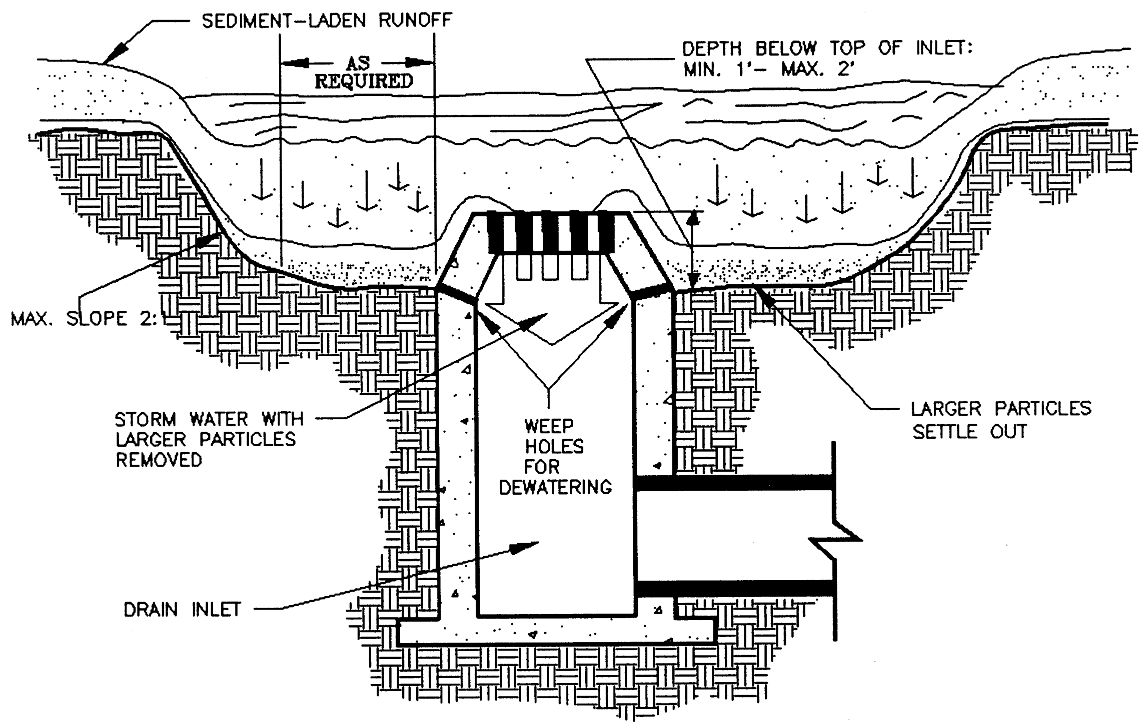
THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY FLOWS ARE EXPECTED AND WHERE AN OVERFLOW CAPACITY IS NECESSARY TO PREVENT EXCESSIVE PONDING AROUND THE STRUCTURE.

* GRAVEL SHALL BE VDOT #3, #357 OR #5 COARSE AGGREGATE.

Source: Va. DSWC Plate 3.07-3

EXCAVATED DROP INLET SEDIMENT TRAP





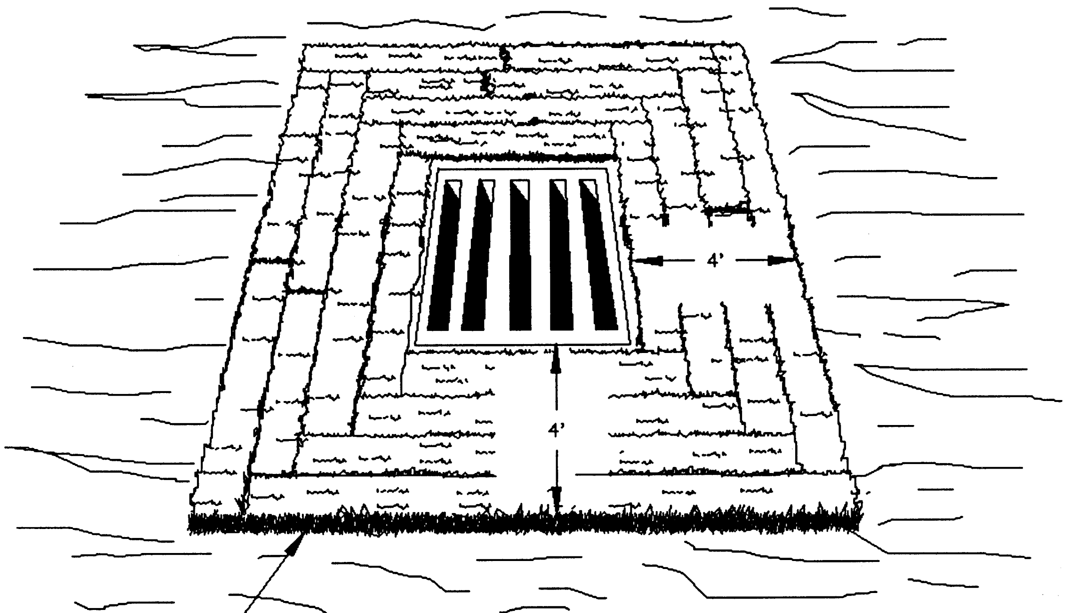
SPECIFIC APPLICATION

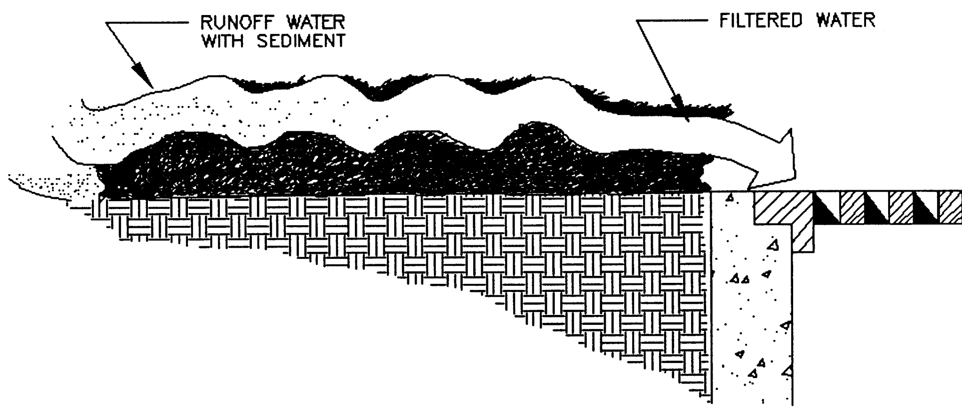
THIS METHOD OF INLET PROTECTION IS APPLICABLE WHERE HEAVY FLOWS ARE EXPECTED AND WHERE AN OVERFLOW CAPABILITY AND EASE OF MAINTENANCE ARE DESIRABLE.

Source: Michigan Soil Erosion and Sediment Control Guidebook, 1975, and USDA-SCS

Plate 3.07-4

SOD DROP INLET SEDIMENT FILTER





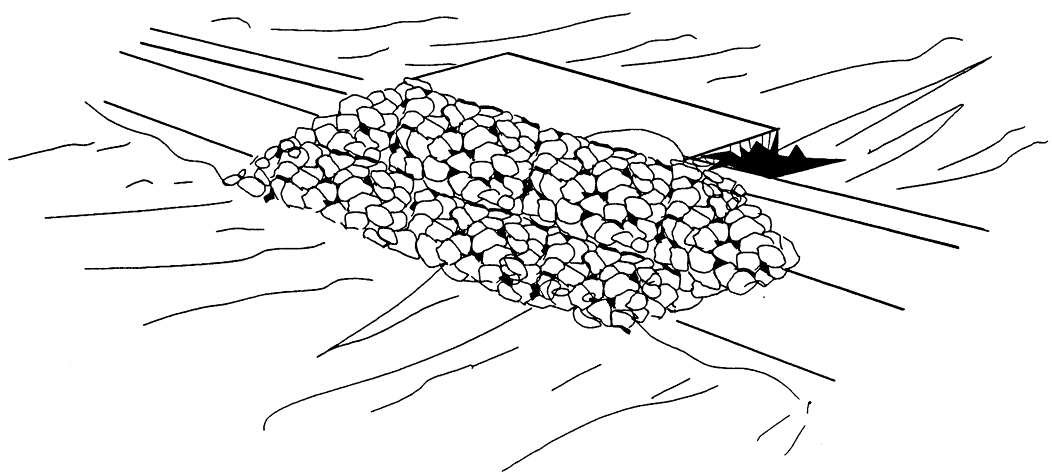
SPECIFIC APLLICATION

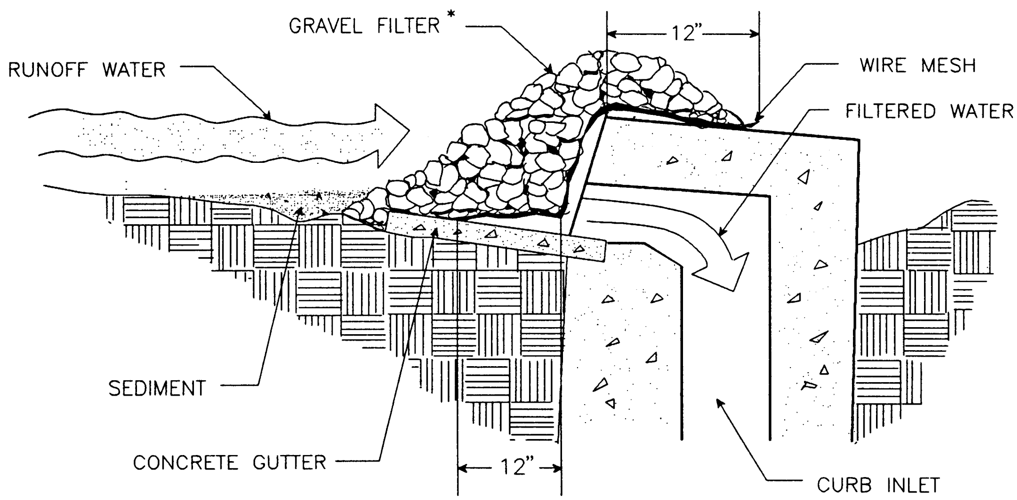
THIS METHOD OF INLET PROTECTION IS APPPLICABLE ONLY AT THE TIME OF PERMANENT SEEDING, TO PROTECT THE INLET FROM SEDIMENT AND MULCH MATERIAL UNTIL PERMANENT VEGETATION HAS BECOME ESTABLISHED.

Source: Va. DSWC

Plate 3.07-5

GRAVEL CURB INLET SEDIMENT FILTER





SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE AT CURB INLETS WHERE PONDING IN FRONT OF THE STRUCTURE IS NOT LIKELY TO CAUSE INCONVENIENCE OR DAMAGE TO ADJACENT STRUCTURES AND UNPROTECTED AREAS.

* GRAVEL SHALL BE VDOT #3, #357 OR 5 COARSE AGGREGATE.

Source: Va. DSWC

Plate 3.07-6

b. Stone shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely.

c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the block, cleaned and replaced.

7. Curb Inlet Protection with 2-inch x 4-inch Wooden Weir

a. Attach a continuous piece of wire mesh (30-inch minimum width x inlet throat length plus 4 feet) to the 2-inch x 4-inch wooden weir (with a total length of throat length plus 2 feet) as shown in Plate 3.07-7. Wood should be "construction grade" lumber.

b. Place a piece of approved "extra-strength" filter cloth of the same dimensions as the wire mesh over the wire mesh and securely attach to the 2-inch x 4-inch weir.

c. Securely nail the 2-inch x 4-inch weir to the 9-inch long vertical spacers which are to be located between the weir and inlet face at a maximum 6-foot spacing.

d. Place the assembly against the inlet throat and nail 2-foot (minimum) lengths of 2-inch x 4-inch board to the top of the weir at spacer locations. These 2-inch x 4-inch anchors shall extend across the inlet tops and be held in place by sandbags or alternate weight.

e. The assembly shall be placed so that the end spacers are a minimum 1 foot beyond both ends of the throat opening.

f. Form the wire mesh and filter cloth to the concrete gutter and against the face of curb on both sides of the inlet. Place coarse aggregate over the wire mesh and filter fabric in such a manner as to prevent water from entering the inlet under or around the filter cloth.

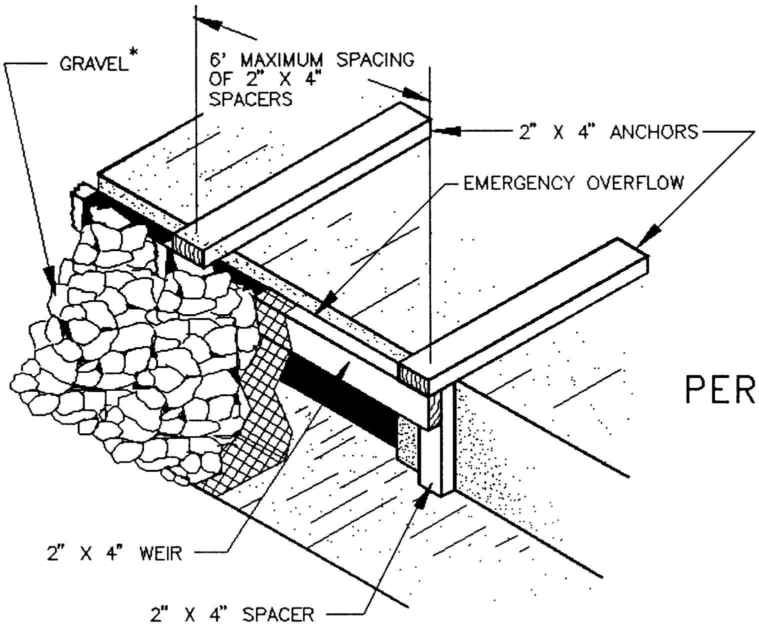
g. This type of protection must be inspected frequently and the filter cloth and stone replaced when clogged with sediment.

h. Assure that storm flow does not bypass inlet by installing temporary earth or asphalt dikes directing flow into inlet.

8. Block and Gravel Curb Inlet Sediment Filter

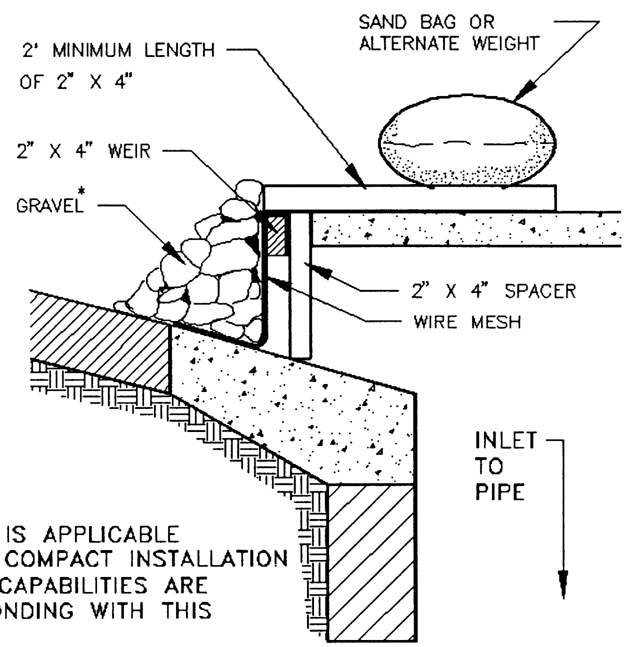
a. Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening.

CURB INLET PROTECTION WITH 2-INCH X 4-INCH WOODEN WEIR



PERSPECTIVE VIEW

SIDE ELEVATION



SPECIFIC APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE TO CURB INLETS WHERE A STURDY, COMPACT INSTALLATION IS DESIRED. EMERGENCY OVERFLOW CAPABILITIES ARE MINIMAL, SO EXPECT SIGNIFICANT PONDING WITH THIS MEASURE.

*GRAVEL SHALL BE VDOT COARSE AGGREGATE #3, #357 OR #5

Source: 1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control, and USDA-SCS

Plate 3.07-7

b. A 2-inch x 4-inch stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.

c. Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks as depicted in Plate 3.07-8.

d. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 1/2-inch openings shall be used.

e. Coarse aggregate shall be piled against the wire to the top of the barrier as shown in Plate 3.07-8.

f. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and/or replaced.

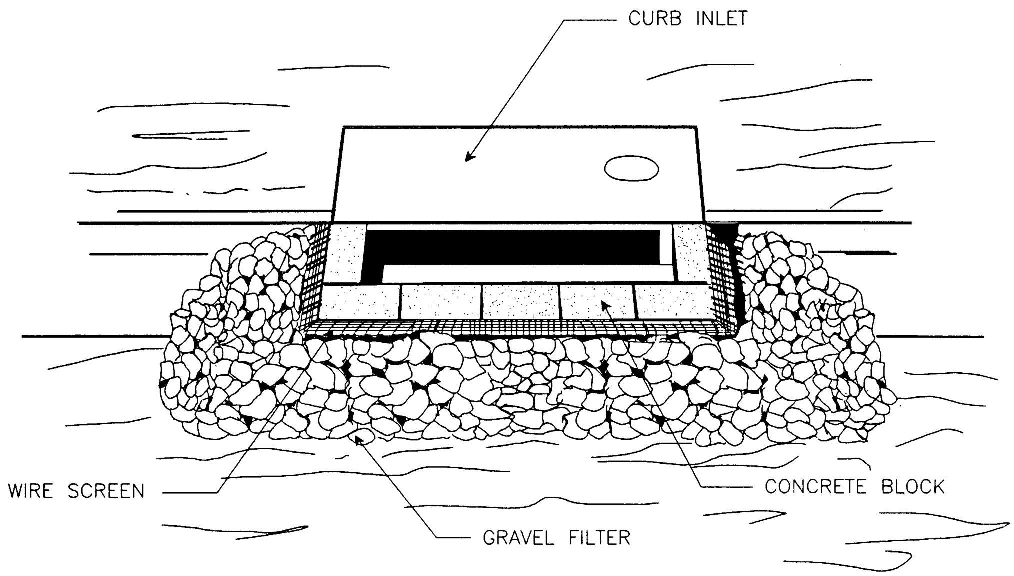
Maintenance

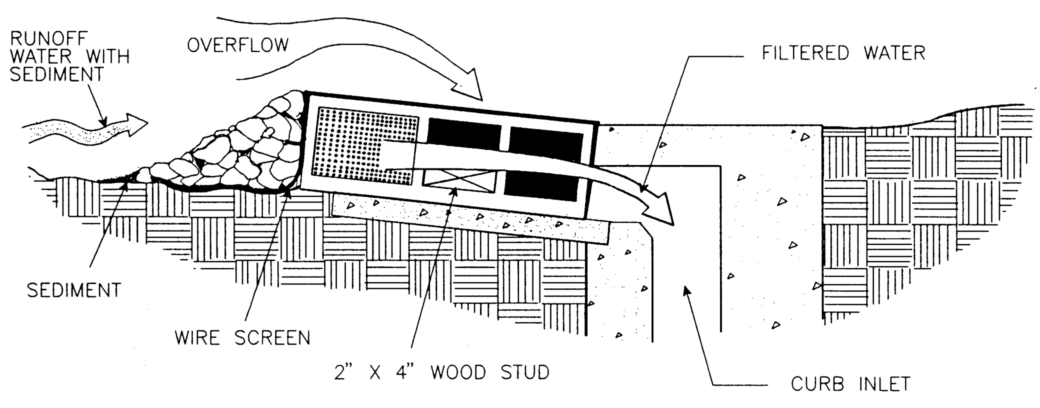
1. The structure shall be inspected after each rain and repairs made as needed.

2. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

3. Structures shall be removed and the area stabilized when the remaining drainage area has been properly stabilized.

BLOCK & GRAVEL CURB INLET SEDIMENT FILTER





SPECIAL APPLICATION

THIS METHOD OF INLET PROTECTION IS APPLICABLE AT CURB INLETS WHERE AN OVERFLOW CAPABILITY IS NECESSARY TO PREVENT EXCESSIVE PONDING IN FRONT OF THE STRUCTURE.

* GRAVEL SHALL BE VDOT #3, #357 OR #5 COARSE AGGREGATE

Source: Va. DSWC

Plate 3.07-8

STD & SPEC 3.08

CULVERT INLET PROTECTION

CIP

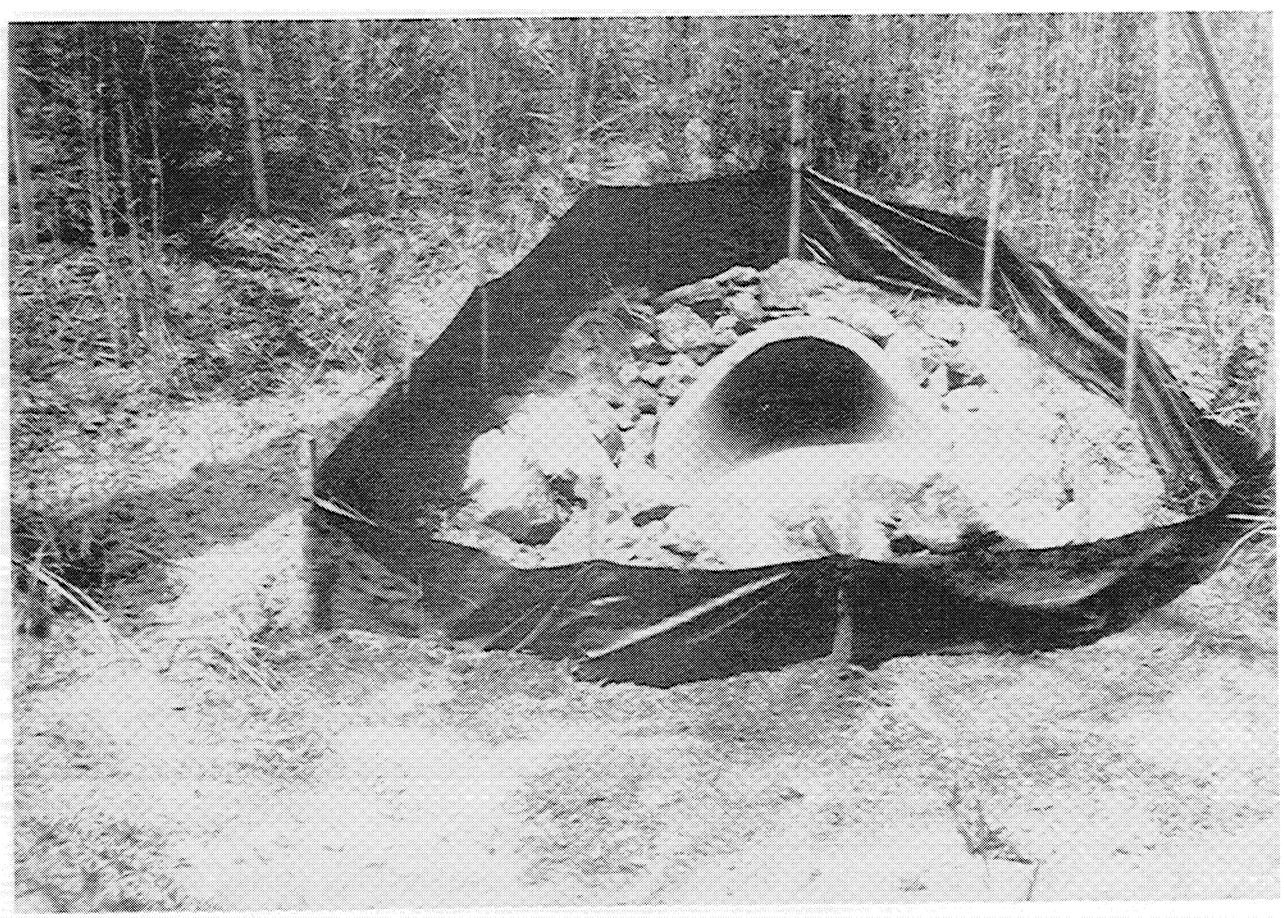
Definition

A sediment filter located at the inlet to storm sewer culverts.

Purposes

1. To prevent sediment from entering, accumulating in and being transferred by a culvert and associated drainage system prior to permanent stabilization of a disturbed project area.

2. To provide erosion control at culvert inlets during the phase of a project where elevation and drainage patterns change, causing original control measures to be ineffective or in need of removal.



Conditions Where Practice Applies

Where culvert and associated drainage system is to be made operational prior to permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions (see Plates 3.08-1 and 3.08-2).

Planning Considerations

When construction on a project reaches a stage where culverts and other storm sewer appurtenances are installed and many areas are brought to a desired grade, the erosion control measures used in the early stages normally need to be modified or may need to be removed altogether. At that time, there is a need to provide protection at the points where runoff will leave the area via culverts and drop or curb inlets.

Similar to drop and curb inlets, culverts which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the pipe or pipe system itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the culvert by using one of the methods noted in this section.

General Guidelines (All Types)

1. The inlet protection device shall be constructed in a manner that will facilitate clean-out and disposal of trapped sediment and minimize interference with construction activities.

2. The inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.

3. Design criteria more specific to each particular inlet protection device will be found in Plates 3.08-1 through 3.08-2.

Design Criteria

1. Silt Fence Culvert Inlet Protection

    a. No formal design is required.

    b. Silt fence culvert inlet protection has an expected maximum usable life of three months.

    c. The maximum area draining to this practice shall not exceed one acre.

2. <u>Culvert Inlet Sediment Trap</u>

   a. Runoff storage requirements shall be in accordance with information outlined under Std. & Spec. 3.13, TEMPORARY SEDIMENT TRAP.

   b. Culvert inlet sediment traps have a maximum expected useful life of 18 months.

   c. The maximum area draining to this practice shall not exceed 3 acres.

<u>Construction Specifications</u>

1. <u>Silt Fence Culvert Inlet Protection</u>

   a. The height of the silt fence (in front of the culvert opening) shall be a minimum of 16 inches and shall not exceed 34 inches.

   b. Extra strength filter fabric with a maximum spacing of stakes of 3 feet shall be used to construct the measure.

   c. The placement of silt fence should be approximately 6 feet from the culvert in the direction of incoming flow, creating a "horseshoe" shape as shown in Plate 3.08-1.

   d. <u>If silt fence cannot be installed properly</u> or the flow and/or velocity of flow to the culvert protection is excessive and may breach the structure, the <u>stone combination</u> noted in Plate 3.08-1 should be utilized.

2. <u>Culvert Inlet Sediment Trap</u>

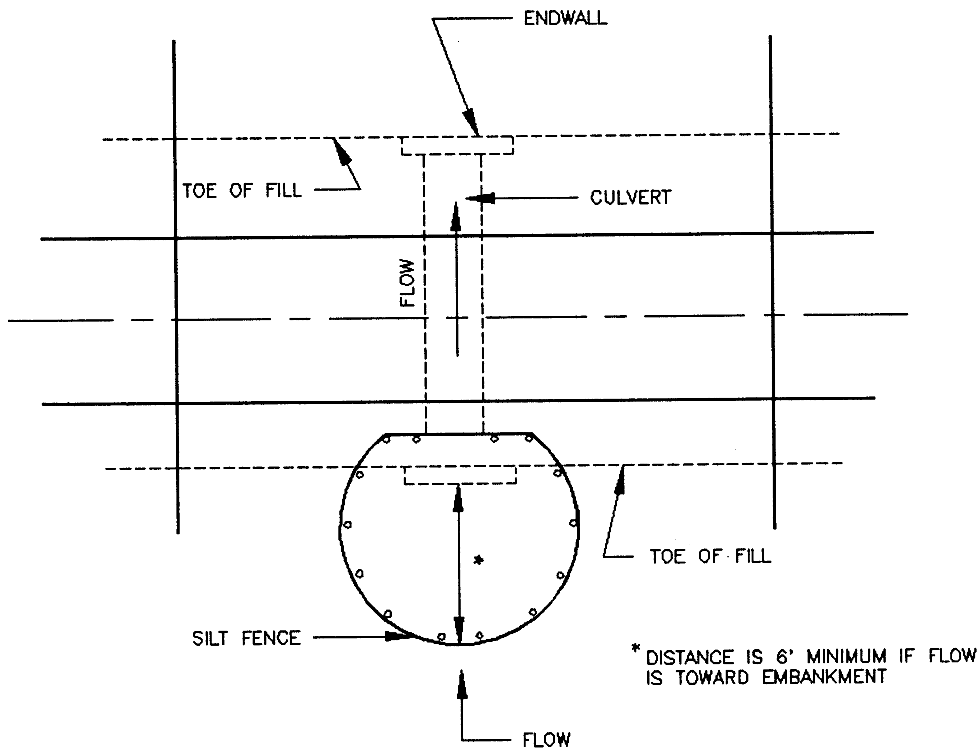
   a. Geometry of the design will be a "horseshoe" shape around the culvert inlet (see Plate 3.08-2).

   b. The toe of riprap (composing the sediment filter dam) shall be no closer than 24" from the culvert opening in order to provide an acceptable emergency outlet for flows from larger storm events.

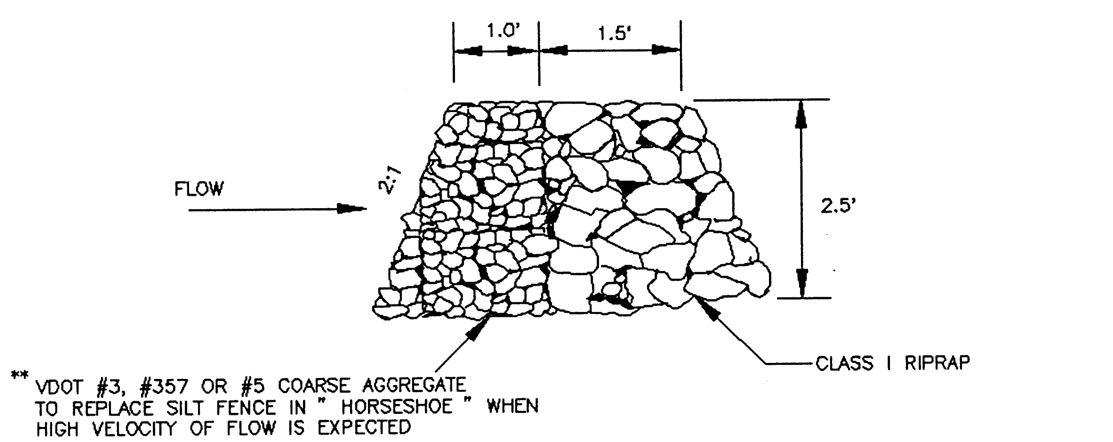
   c. All other "Construction Specifications" found within Std. & Spec. 3.13, TEMPORARY SEDIMENT TRAP, also apply to this practice.

   e. The proper installation of the culvert inlet sediment trap is <u>a viable substitute for the installation of the TEMPORARY SEDIMENT TRAP</u>.

SILT FENCE CULVERT INLET PROTECTION



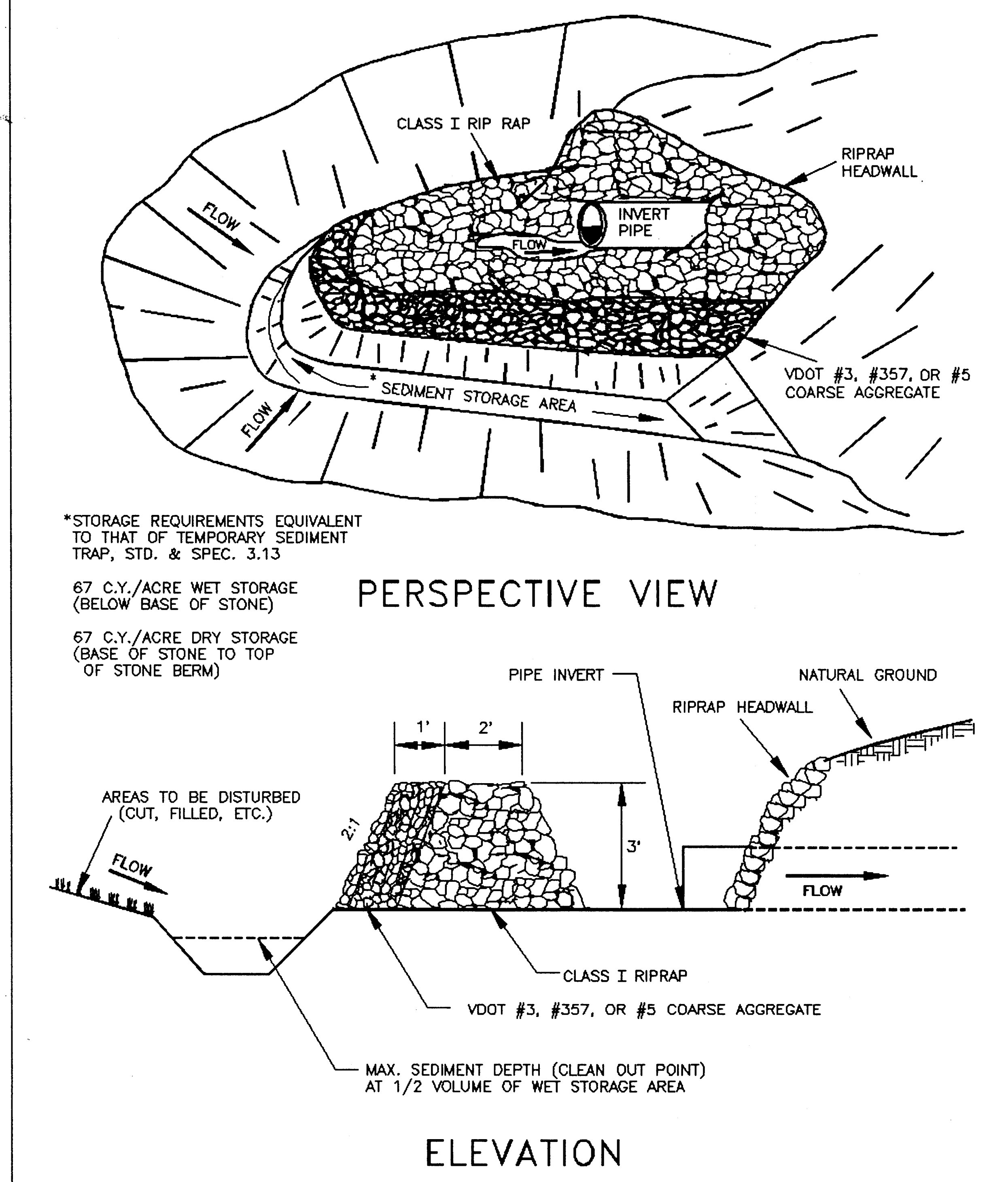
OPTIONAL STONE COMBINATION**



Source: Adapted from VDOT Standard Sheets and Va. DSWC

Plate 3.08-1

CULVERT INLET SEDIMENT TRAP



Source: North Carolina Sediment Control Commission

Plate 3.08-2

Maintenance

1. The structure shall be inspected after each rain and repairs made as needed.

2. Aggregate shall be replaced or cleaned when inspection reveals that clogged voids are causing ponding problems which interfere with on-site construction.

3. Sediment shall be removed and the impoundment restored to its original dimensions when sediment has accumulated to one-half the design depth. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

4. Temporary structures shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

STD & SPEC 3.09

TEMPORARY DIVERSION DIKE

DD

Definition

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

Purposes

1. To divert storm runoff from upslope drainage areas away from unprotected disturbed areas and slopes to a stabilized outlet.

2. To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a sediment trap or sediment basin.

Conditions Where Practice Applies

Wherever stormwater runoff must be temporarily diverted to protect disturbed areas and slopes or retain sediment on site during construction. These structures generally have a life expectancy of 18 months or less, which can be prolonged with proper maintenance.

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 a 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.

As per M.S. #5, it is very important that a temporary diversion dike be stabilized immediately following installation with temporary or permanent vegetation to prevent erosion of the dike itself. The gradient of the channel behind the dike is also an important consideration. The dike must have a positive grade to assure drainage, but if the gradient is too great, precautions must be taken to prevent erosion due to high-velocity channel flow behind the dike. The cross-section of the channel which runs behind the dike should be of a parabolic or trapezoidal shape to help inhibit a high velocity of flow which could arise in a vee ditch.

This practice is considered an economical one because it uses material available on the site and 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. Diversion dikes are preferable to silt fence because they are more durable, less expensive, and require much less maintenance when constructed properly. Along with a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13), they become a logical choice for a control measure once the control limits of the silt fence or straw bale barrier have been exceeded.

Temporary diversion dikes are often used as a perimeter control in association with a sediment trap or a sediment basin, or a series of sediment-trapping facilities, on moderate to large construction sites. If installed properly and in the first phase of grading, maintenance costs are very low. Often, cleaning of sediment-trapping facilities is the only associated maintenance requirement.

As specified herein, this practice is intended to be temporary. However, with more stringent design criteria, it can be made permanent in accordance with DIVERSIONS (Std. & Spec. 3.12).

Design Criteria

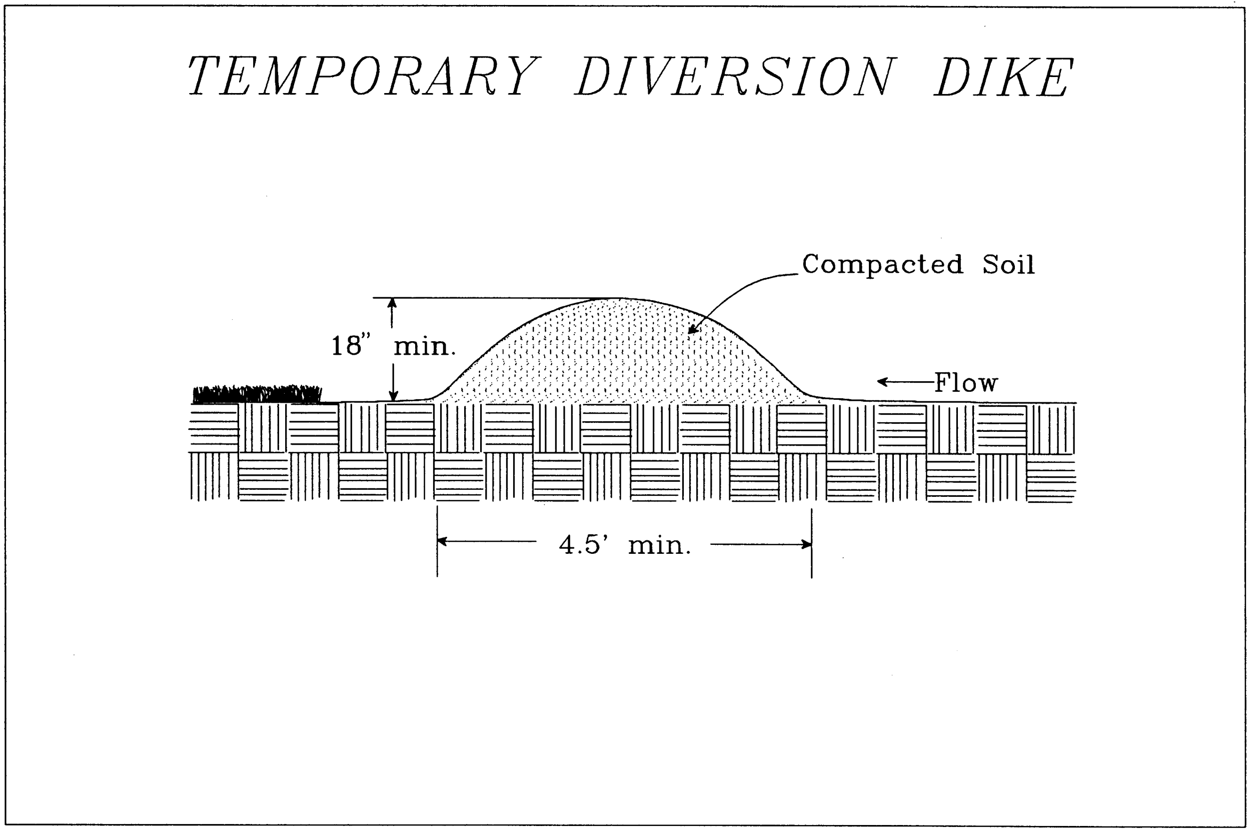
No formal design is required. The following criteria shall be met:

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 (see Plate 3.09-1).



Source: Va. DSWC

Plate 3.09-1

Side Slopes

1½:1 or flatter, along with a minimum base width of 4.5 feet (see Plate 3.09-1).

Grade

The channel behind the dike shall have a positive grade to a stabilized outlet. If the channel slope is less than or equal to 2%, no stabilization is required. If the slope is greater than 2%, the channel shall be stabilized in accordance with Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNEL.

Outlet

1. The diverted runoff, if free of sediment, must be released through a stabilized outlet or channel.

2. Sediment-laden runoff must be diverted and released through a sediment-trapping facility such as a TEMPORARY SEDIMENT TRAP (Std. & Spec. 3.13) or TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14).

Construction Specifications

1. Temporary diversion dikes must be installed as a first step in the land-disturbing activity and must be functional prior to upslope land disturbance.

2. The dike should be adequately compacted to prevent failure.

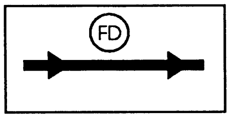
3. Temporary or permanent seeding and mulch shall be applied to the dike immediately following its construction.

4. The dike should be located to minimize damages by construction operations and traffic.

Maintenance

The measure shall be inspected after every storm and repairs made to the dike, flow channel, outlet or sediment trapping facility, as necessary. Once every two weeks, whether a storm event has occurred or not, the measure 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.

STD & SPEC 3.10



TEMPORARY FILL DIVERSION

FD

Definition

A channel with a supporting ridge of soil on the lower side, constructed along the top of an active earth fill.

Purpose

To divert storm runoff away from the unprotected slope of the fill to a stabilized outlet or sediment-trapping facility.

Conditions Where Practice Applies

Where the drainage area at the top of an active earth fill slopes toward the exposed slope and where continuous fill operations make the use of a DIVERSION (Std. & Spec. 3.12) unfeasible. This temporary structure should remain in place for less than one week.

Planning Considerations

One important principle of erosion and sediment control is to keep stormwater runoff away from exposed slopes. This is often accomplished by installing a dike, diversion, temporary slope drain or paved ditch at the top of a slope to carry the runoff away from the slope to a stabilized outlet. In general, these measures are installed after the final grade has been reached. On cuts, the measures may be installed at the beginning since the work proceeds from the top to the bottom of the slope, and the measures have little chance of being covered or damaged. On fills, the work proceeds from the bottom to the top and the elevation changes daily. It is therefore not feasible to construct a compacted dike or permanent diversion which may be covered by the next day's activity.

The temporary fill diversion is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed. This practice can be constructed by the use of a motor grader or a small dozer. To shape the diversion, the piece of machinery used may run near the top edge of the fill with its blade tilted to form the channel as depicted in Plate 3.10-1. This work would be done at the end of the working day and provide a channel with a berm to protect the slope. Wherever possible, the temporary diversion should be sloped to direct water to a stabilized outlet. If the runoff is diverted over the fill itself, the practice may cause erosion by concentrating water at a single point.

Good timing is essential to fill construction. The filling operation should be completed as quickly as possible and the permanent slope protection measures and slope stabilization measures installed as soon after completion as possible. With prompt and proper construction, the landowner or contractor will save both time and money in building, repairing and stabilizing the fill area. The longer the time period for construction and stabilization extends, the more prone the fill operation is to be damaged by erosion. Repairing the damages adds additional time and expense to the project.

Design Criteria

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

Drainage Area

The maximum allowable drainage area is 5 acres.

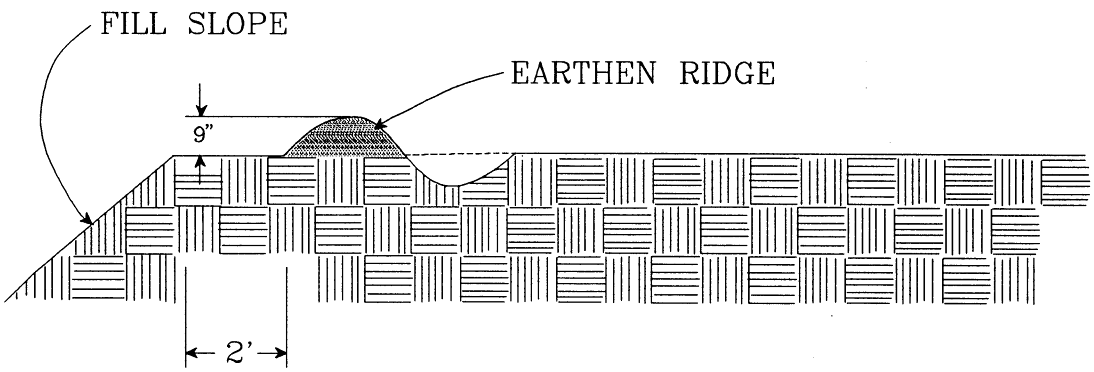
Height

The minimum height of the supporting ridge shall be 9 inches (see Plate 3.10-1).

Grade

The channel shall have a positive grade to a stabilized outlet.

TEMPORARY FILL DIVERSION



Source: Va. DSWC

Plate 3.10-1

Outlet

The diverted runoff should be released through a stabilized outlet, slope drain or sediment trapping measure.

Construction Specifications

1. The diversion shall be constructed at the top of the fill at the end of each work day as needed.

2. The diversion shall be located at least 2 feet inside the top edge of the fill (see Plate 3.10-1).

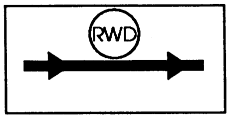
3. The supporting ridge shall be constructed with a uniform height along its entire length. Without uniform height, the fill diversion may be susceptible to breaching.

Maintenance

Since the practice is temporary and under most situations will be covered the next work day, the maintenance required should be low. If the practice is to remain in use for more than one day, an inspection will be made a the end of each work day and repairs made to the measure if needed. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the diversion.

STD & SPEC 3.11

TEMPORARY RIGHT-OF-WAY DIVERSION



RWD

Definition

A ridge of compacted soil or loose rock or gravel constructed across disturbed rights-of-way and similar sloping areas.

Purpose

To shorten the flow length within a sloping right-of-way, thereby reducing the erosion potential by diverting storm runoff to a stabilized outlet.

Conditions Where Practice Applies

Generally, earthen diversions are applicable where there will be little or no construction traffic within the right-of-way. Gravel structures are more applicable to roads and other rights-of-way which accommodate vehicular traffic.

Planning Considerations

Construction of utility lines and roads often requires the clearing of long strips of right-of-way over sloping terrain. The volume and velocity of stormwater runoff tend to increase in these cleared strips and the potential for erosion is much greater since the vegetative cover is diminished or removed. To compensate for the loss of vegetation, it is usually a good practice to break up the flow length within the cleared strip so that runoff does not have a chance to concentrate and cause erosion. At proper intervals, temporary right-of-way diversions can significantly reduce the amount of erosion which will occur until the area is permanently stabilized. Since many right-of-ways are constructed through heavily vegetated areas, runoff can often be diverted into a vegetative buffer strip (if it provides a minimum flow length of 75 feet).

Design Criteria

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

Height

The minimum allowable height of the diversion is 18 inches (see Plate 3.11-1).

Side Slopes

Side slopes should be 2:1 or flatter to allow the passage of construction traffic, along with a minimum base width of 6 feet (see Plate 3.11-1).

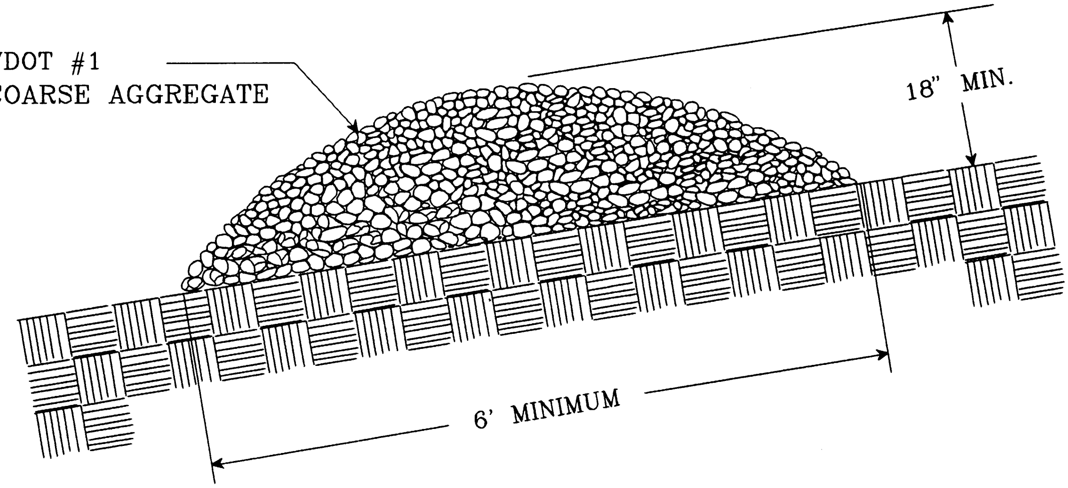
Width

The measure should be constructed completely across the disturbed portion of the right-of-way.

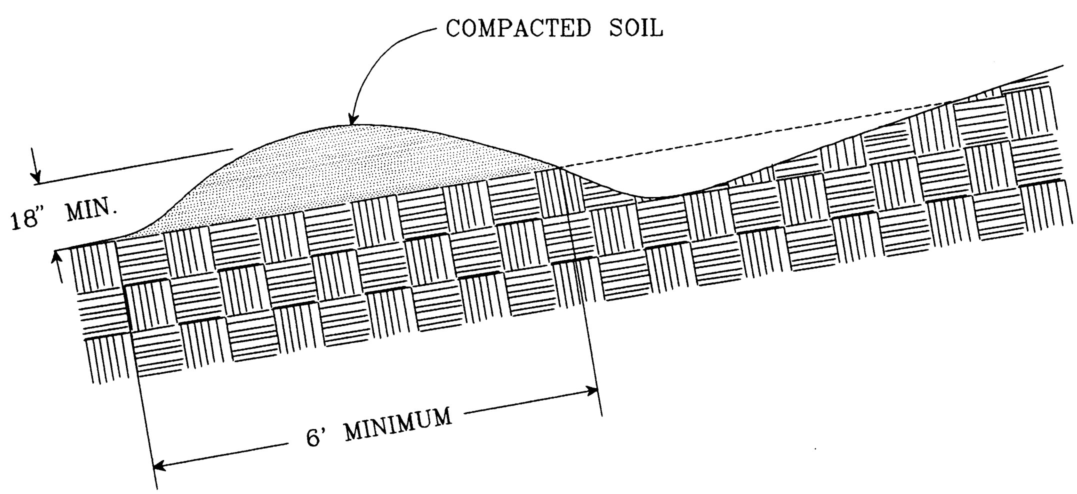
Spacing

Table 3.11-A will be used to determine the spacing of right-of-way diversions.

TEMPORARY RIGHT-OF-WAY DIVERSIONS



TYPICAL GRAVEL STRUCTURE



TYPICAL EARTHEN STRUCTURE

Source: Va. DSWC

Plate 3.11-1

TABLE 3.11-A

SPACING OF RIGHT-OF-WAY DIVERSIONS

% Slope	Spacing (ft.)
Less than 7%	100
Between 7% and 25%	75
Between 25% and 40%	50
Greater than 40%	25

Source: Va. DSWC

Grade

Positive drainage (with less than 2% slope) should be provided to a stabilized outlet, sediment-trapping facility, or a vegetative buffer strip of adequate size.

Outlet

Interceptor dikes must have an outlet which is not subject to erosion.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet. Concentrated flows should spread over the widest possible area after release. Flows with high sediment concentrations should pass through an appropriate sediment-trapping measure.

Construction Specifications

1. The diversion shall be installed as soon as the right-of-way has been cleared and/or graded.

2. All earthen diversions shall be machine- or hand-compacted in 8-inch lifts.

3. The outlet of the diversion shall be located on an undisturbed and stabilized area when at all possible. The field location should be adjusted as needed to utilize a stabilized outlet.

4. Earthen diversions which will not be subject to construction traffic should be stabilized in accordance with TEMPORARY SEEDING (Std. & Spec. 3.31).

Maintenance

The practice shall be inspected after every rainfall and repairs made if necessary. At least once every two weeks, whether a storm has occurred or not, the measure shall be inspected and repairs made if needed. Right-of-way diversions, which are subject to damage by vehicular traffic, should be reshaped at the end of each working day.

STD & SPEC 3.13

TEMPORARY SEDIMENT TRAP

ST

Definition

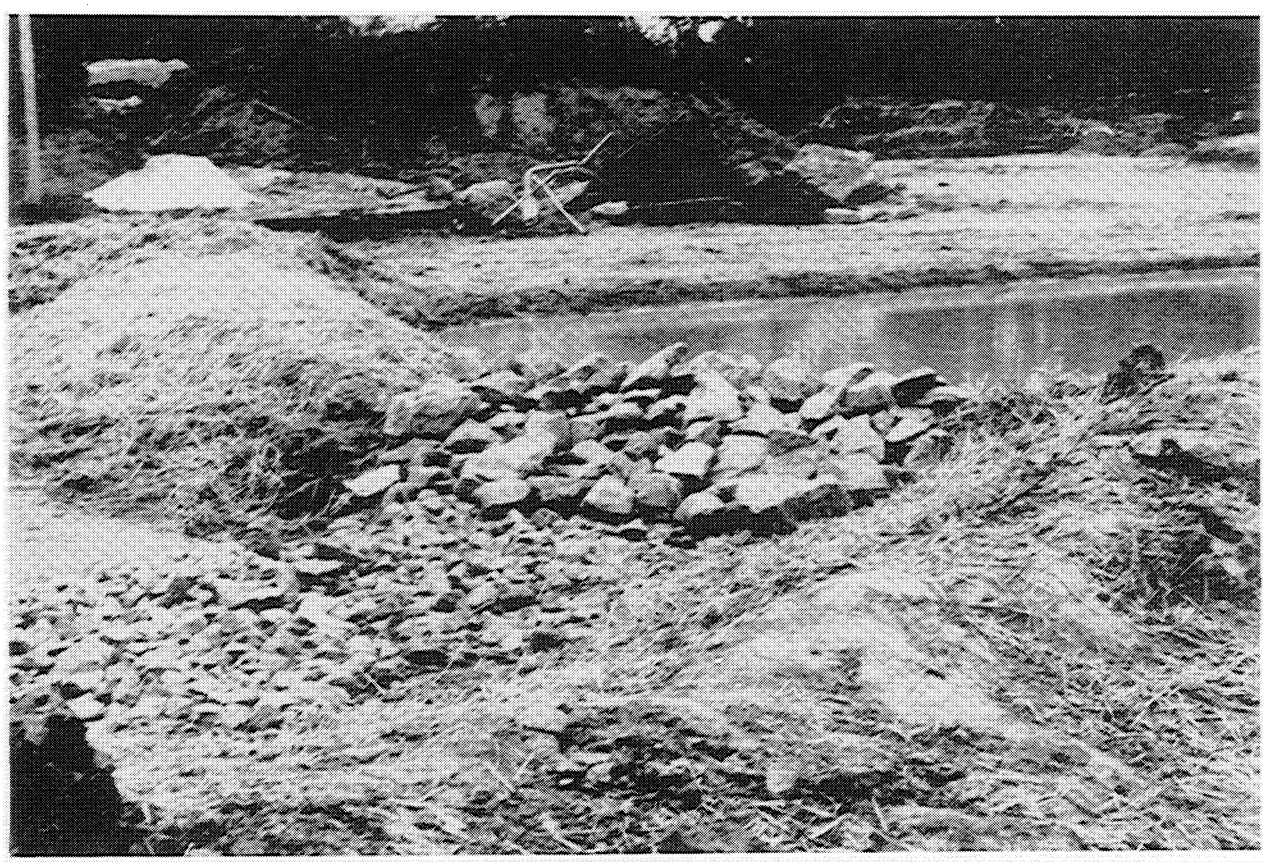
A temporary ponding area formed by constructing an earthen embankment with a stone outlet.

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

1. Below disturbed areas where the total contributing drainage area is less than 3 acres.



2. Where the sediment trap will be used no longer than 18 months (the maximum useful life is 18 months).

3. The sediment trap may be constructed either independently or in conjunction with a TEMPORARY DIVERSION DIKE (Std. & Spec. 3.09).

Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is 3 acres or greater, refer to SEDIMENT BASIN (Std. & Spec. 3.14).

Sediment traps, along with other perimeter controls intended to trap sediment, shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

Recent studies have been conducted on the performance of sediment traps (and basins) which were constructed using the design criteria found in previous editions of this handbook. The studies indicate that the control measures only achieved a 46% removal of sediment which flowed into them during storm events which caused measurable outflow. To achieve a more acceptable removal rate (60%), it was necessary to revise the design of these measures in this handbook. The total initial storage volume for both the sediment trap and the TEMPORARY SEDIMENT BASIN (Std. & Spec. 3.14) has been doubled. There are both a "wet" storage volume and a drawdown or "dry" storage volume which help to enhance sediment fall-out and prevent excessive sediment losses during large storm events which occur during the advanced stages of land disturbance (28).

In most cases excavation will be required to attain the necessary storage volume. Also, sediment must be periodically removed from the trap to maintain the required volume. Plans should detail how excavated sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site location.

As noted previously in this handbook, there are numerous other acceptable ways to design many of the erosion control practices within. This is certainly true in the case of the sediment trap. However, variations in its design should be considered judiciously by plan reviewers to ensure that the minimum storage requirements and structural integrity noted in this specification are maintained.

Design Criteria

Trap Capacity

The sediment trap must have an initial storage volume of 134 cubic yards per acre of drainage area, half of which shall be in the form of a permanent pool or wet storage to provide a stable settling medium. The remaining half shall be in the form of a drawdown or dry storage which will provide extended settling time during less frequent, larger storm events. The volume of the wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure. The volume of the dry storage shall be measured from the base of the stone outlet to the crest of the stone outlet (overflow mechanism). Sediment should be removed from the basin when the volume of the wet storage is reduced by one-half.

For a sediment trap, the wet storage volume may be approximated as follows:

$$V_1 = 0.85 \times A_1 \times D_1$$

where,

V_1 = the wet storage volume in cubic feet

A_1 = the surface area of the flooded area at the base of the stone outlet in square feet

D_1 = the maximum depth in feet, measured from the low point in the trap to the base of the stone outlet

The dry storage volume may be approximated as follows:

$$V_2 = \frac{A_1 + A_2}{2} \times D_2$$

where,

V_2 = the dry storage volume in cubic feet

A_1 = the surface area of the flooded area at the base of the stone outlet in square feet

A_2 = the surface area of the flooded area at the crest of the stone outlet (overflow mechanism), in square feet

D_2 = the depth in feet, measured from the base of the stone outlet to the crest of the stone outlet

The designer should seek to provide a storage area which has a minimum 2:1 length to width ratio (measured from point of maximum runoff introduction to outlet).

Note: Conversion between cubic feet and cubic yards is as follows:

number of cubic feet x 0.037 = number of cubic yards

Excavation

Side slopes of excavated areas should be no steeper than 1:1. The maximum depth of excavation within the wet storage area should be 4 feet to facilitate clean-out and for site safety considerations.

Outlet

The outlet for the sediment trap shall consist of a stone section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap shall be used to provide for filtering/detention as well as outlet stability. The smaller stone shall be VDOT #3, #357, or #5 Coarse Aggregate (smaller stone sizes will enhance filter efficiency) and riprap shall be "Class I." Filter cloth which meets the physical requirements noted in Std. & Spec. 3.19, RIPRAP shall be placed at the stone-soil interface to act as a "separator." The minimum length of the outlet shall be 6 feet times the number of acres comprising the total area draining to the trap. The crest of the stone outlet must be at least 1.0 foot below the top of the embankment to ensure that the flow will travel over the stone and not the embankment. The outlet shall be configured as noted in Plate 3.13-2.

Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 5 feet as measured from the base of the stone outlet. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in Plate 3.13-1. Side slopes of the embankment shall be 2:1 or flatter.

Removal

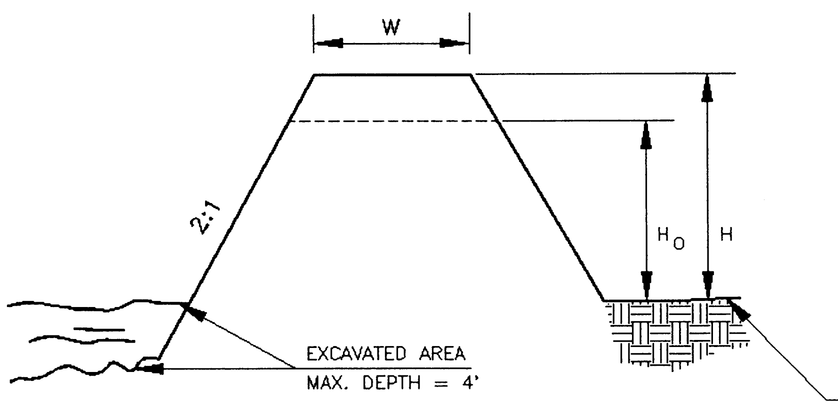
Sediment traps must be removed after the contributing drainage area is stabilized. Plans should show how the site of the sediment trap is to be graded and stabilized after removal.

Construction Specifications

1. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat.

2. 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 6-inch layers by traversing with construction equipment.

MINIMUM TOP WIDTH (W) REQUIRED FOR SEDIMENT TRAP EMBANKMENTS ACCORDING TO HEIGHT OF EMBANKMENT (FEET)



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

Source: Va. DSWC

Plate 3.13-1

3. The earthen embankment shall be seeded with temporary or permanent vegetation (see Std. & Spec.'s 3.31 and 3.32) immediately after installation.

4. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.

5. The structure shall be removed and the area stabilized when the upslope drainage area has been stabilized.

6. All cut and fill slopes shall be 2:1 or flatter (except for excavated, wet storage area which may be at a maximum 1:1 grade).

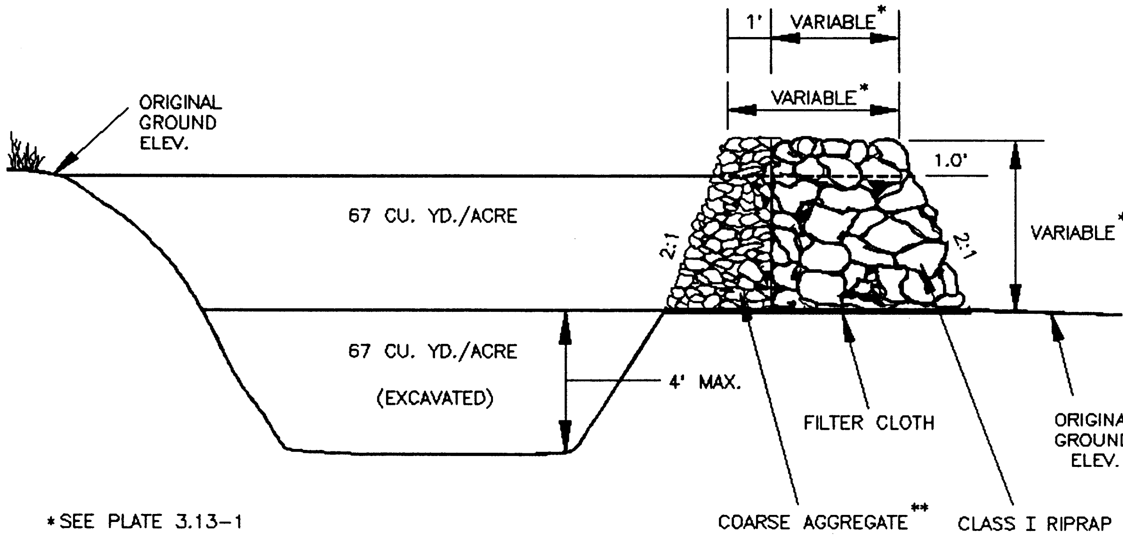
Maintenance

1. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design volume of the wet storage. Sediment removal from the basin shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

2. Filter stone shall be regularly checked to ensure that filtration performance is maintained. Stone choked with sediment shall be removed and cleaned or replaced.

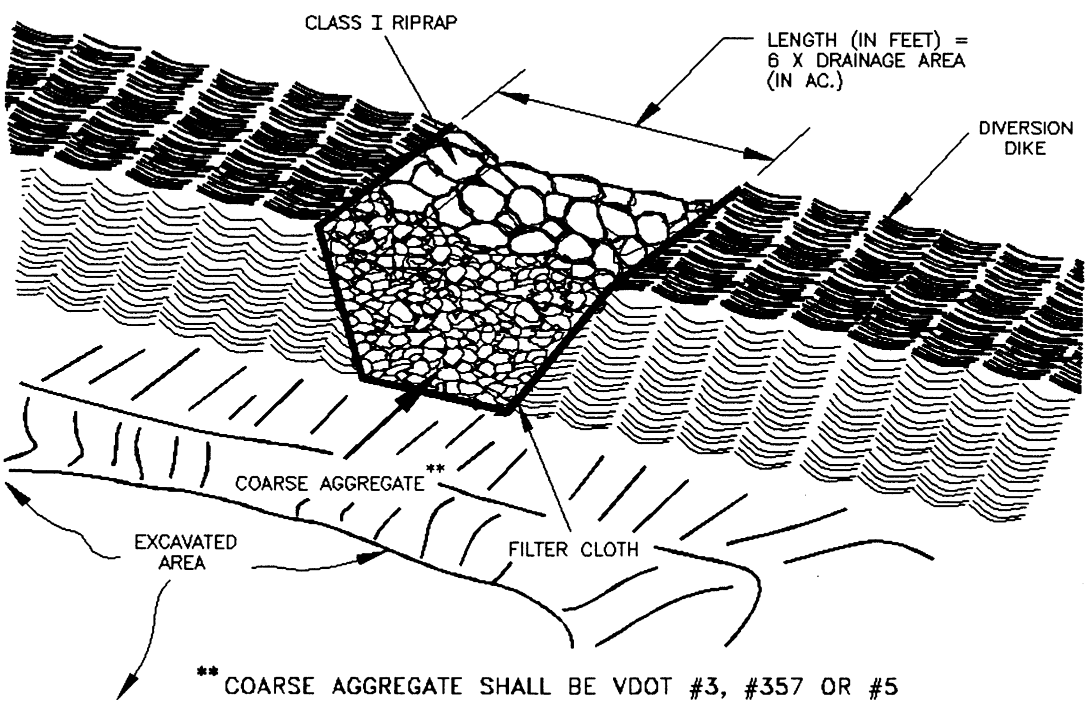
3. The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be checked to ensure that its center is at least 1 foot below the top of the embankment.

TEMPORARY SEDIMENT TRAP



*SEE PLATE 3.13-1

CROSS SECTION OF OUTLET



**COARSE AGGREGATE SHALL BE VDOT #3, #357 OR #5

OUTLET (PERSPECTIVE VIEW)

Source: Va. DSWC

Plate 3.13-2

STD & SPEC 3.15

TEMPORARY SLOPE DRAIN

TSD

Definition

A flexible tubing or conduit extending from the top to the bottom of a cut or fill slope.

Purpose

To temporarily conduct concentrated stormwater runoff safely down the face of a cut or fill slope without causing erosion on or below the slope.

Conditions Where Practice Applies

On cut or fill slopes where there is a potential for upslope flows to move over the face of the slope causing erosion and preventing adequate stabilization.

Planning Considerations

There is often a significant lag between the time a cut or fill slope is completed and the time a permanent drainage system can be installed. During this period, the slope is usually not stabilized and is particularly vulnerable to erosion. This situation also occurs on slope construction which is temporarily delayed before final grade is reached. Temporary slope drains can provide valuable protection of exposed slopes until permanent drainage structures can be installed or vegetation can be established.

Temporary slope drains can be used in conjunction with diversion dikes to convey runoff from the entire drainage area above a slope to the base of the slope without erosion. It is very important that these temporary structures be installed properly, since their failure will often result in severe gully erosion on the site and sedimentation below the slope. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be staked securely.

Design Criteria

Drainage Area

The maximum allowable drainage area per slope drain is 5 acres.

Flexible Conduit

The slope drain shall consist of heavy-duty, flexible material designed for this purpose. The diameter of the slope drain shall be equal over its entire length. Reinforced hold-down grommets shall be spaced at 10-foot (or less) intervals. Slope drains shall be sized as listed in Table 3.15-A.

Entrance Sections

The entrance to the slope drain shall consist of a standard VDOT flared end-section for metal pipe culverts (see Plates 3.15-2 and 3.15-3) with appropriate inlet protection as set forth in CULVERT INLET PROTECTION, Std. & Spec. 3.08. If ponding will cause a problem at the entrance and make such protection impractical, appropriate sediment-removing measures shall be taken at the outlet of the pipe. Extension collars shall consist of 12-inch long corrugated metal pipe. Watertight fittings shall be provided (see Plate 3.15-1).

Note: End-sections made of heavy-duty, flexible material may be utilized if determined by the Plan-Approving Authority to provide a stable inlet or outlet section.

TABLE 3.15-A

SIZE OF SLOPE DRAIN

Maximum Drainage Area (acres)	Pipe Diameter (inches)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

Source: Va. DSWC

Dike Design

An earthen dike shall be used to direct stormwater runoff into the temporary slope drain and shall be constructed as set forth in DIVERSION, Std. & Spec. 3.12. See Plate 3.15-1 for placement of dike in relation to the slope drain.

The height of the dike at the centerline of the inlet shall be equal to the diameter of the pipe plus 6 inches. Where the dike height is greater than 18 inches at the inlet, it shall be sloped at the rate of 3:1 or flatter to connect with the remainder of the dike (see Plate 3.15-1).

Outlet Protection

The outlet of the slope drain must be protected from erosion as set forth in OUTLET PROTECTION, Std. & Spec. 3.18.

Construction Specifications

1. The measure shall be placed on undisturbed soil or well-compacted fill.

2. The entrance section shall slope toward the slope drain at the minimum rate of 1/2-inch per foot.

3. The soil around and under the entrance section shall be hand-tamped in 8-inch lifts to the top of the dike to prevent piping failure around the inlet.

4. The slope drain shall be securely staked to the slope at the grommets provided.

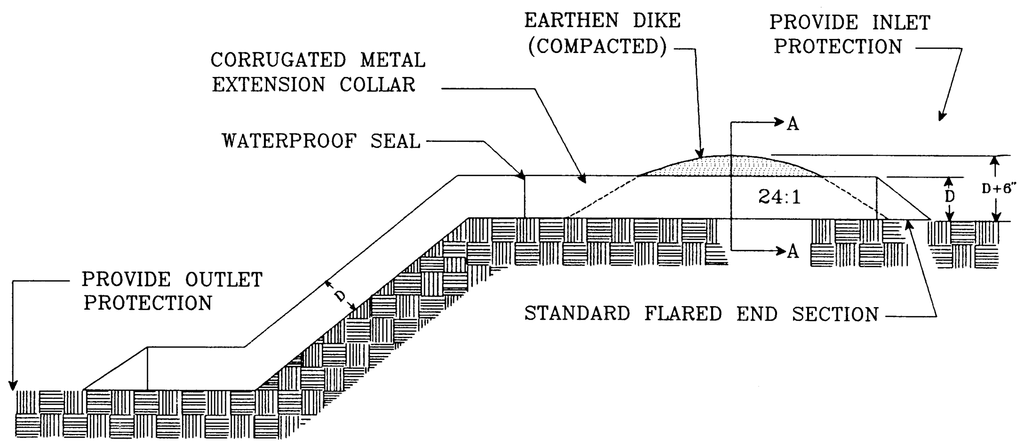
5. The slope drain sections shall be securely fastened together and have watertight fittings.

6. Install CULVERT INLET PROTECTION and OUTLET PROTECTION as per Std. & Spec.'s 3.08 and 3.18, respectively.

Maintenance

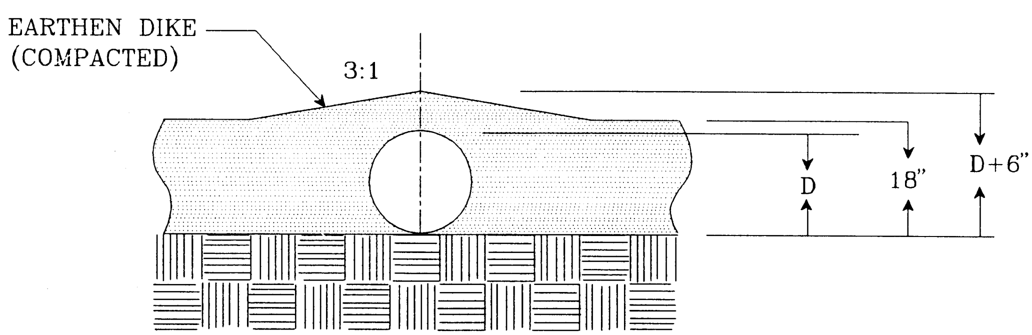
The slope drain structure shall be inspected weekly and after every storm, and repairs made if necessary. The contractor should avoid the placement of any material on and prevent construction traffic across the slope drain.

TEMPORARY SLOPE DRAIN



SECTION VIEW

NOTE: SEDIMENT MAY BE CONTROLLED AT OUTLET IF UPLAND PONDING WILL CREATE PROBLEMS

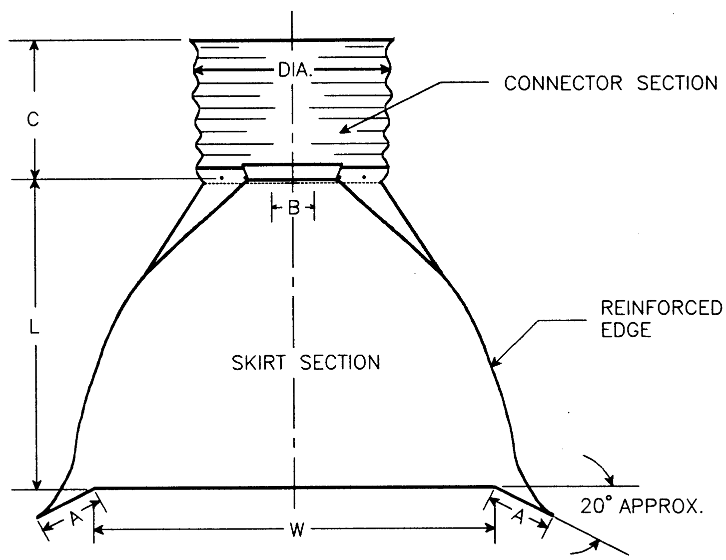


SECTION A – A

Source: Va. DSWC

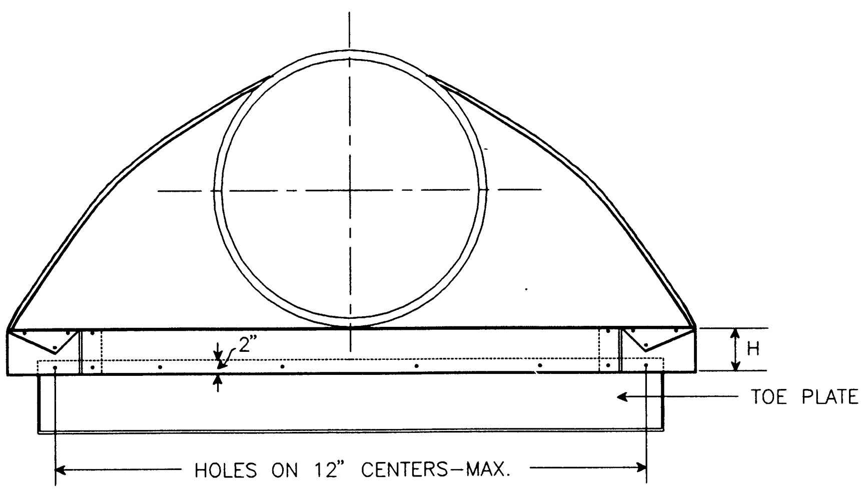
Plate 3.15-1

FLARED END-SECTION



PLAN

WHERE FLARED END-SECTIONS ARE
TO BE USED WITH BITUMINOUS
COATED AND PAVED METAL PIPE,
THEY ARE TO BE GALVANIZED ONLY.

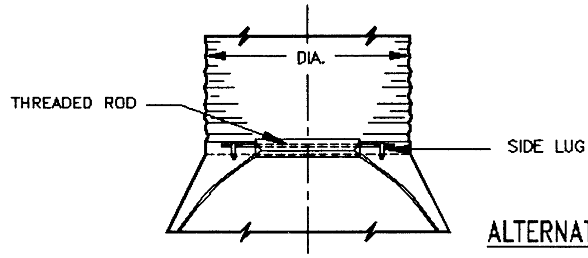


ELEVATION

Source: VDOT Road and Bridge Standards

Plate 3.15-2

FLARED END-SECTION
(CONTINUED)



ALTERNATE CONNECTION

TOE PLATE, WHERE NEEDED, TO BE PUNCHED TO MATCH IN SKIRT LIP. 3/8" GALV. BOLTS TO BE FURNISHED. LENGTH OF TOE PLATE IS W + 10" FOR 12" TO 30" DIA. PIPE AND W + 22" FOR 36" TO 60" DIA. PIPE.

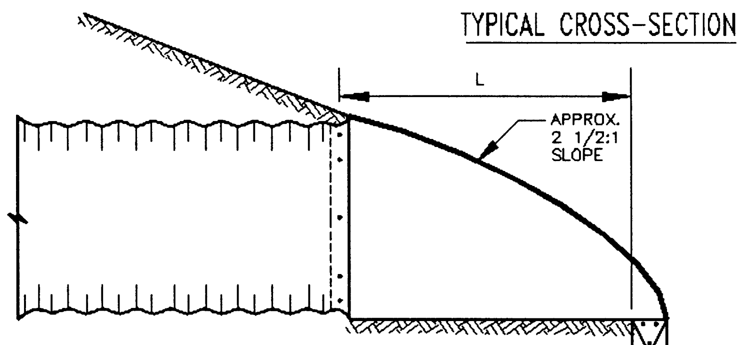
SKIRT SECTION FOR 12" TO 30" DIA. PIPE TO BE MADE IN ONE PIECE.

SKIRT SECTION FOR 36" TO 54" DIA. PIPE MAY BE MADE FROM TWO SHEETS JOINED BY RIVETING OR BOLTING ON CENTER LINE, 60" MAY BE CONSTRUCTED IN 3 PIECES.

CONNECTOR SECTION, CORNER PLATE AND TOE PLATE TO BE SAME SHEET THICKNESS AS SKIRT.

END-SECTIONS AND FITTINGS ARE TO BE GALVANIZED STEEL OR ALUMINUM ALLOY FOR USE WITH LIKE PIPE.

TYPICAL CROSS-SECTION



PIPE DIA.	SHEET THICKNESS		DIMENSIONS					
	STEEL	ALUMINUM	A 1" TOL.	B MAX.	H 1" TOL.	L 1 1/2" TOL.	W 2" TOL.	C
12"	.064"	.060"	6"	6"	6"	21"	24"	24"
15"	.064"	.060"	7"	8"	6"	26"	30"	24"
18"	.064"	.060"	8"	10"	6"	31"	36"	24"
21"	.064"	.060"	10"	12"	6"	36"	42"	24"
24"	.064"	.060"	10"	13"	6"	41"	48"	24"
27"/30"	.064"	.075"	12"	16"	8"	51"	60"	24"
36"	.064"	.075"	14"	19"	9"	60"	72"	36"
42"	.064"	.105"	16"	22"	11"	69"	84"	36"
48"	.064"	.105"	18"	27"	12"	78"	90"	24"
54"	.064"/.079"	.105"	18"	30"	12"	84"	102"	36"
60"	.064"/.109"	.105"/.135"	18"	33"	12"	87"	114"	36"

Source: VDOT Road and Bridge Standards Plate 3.15-3

STD & SPEC 3.18

OUTLET PROTECTION

OP

Definition

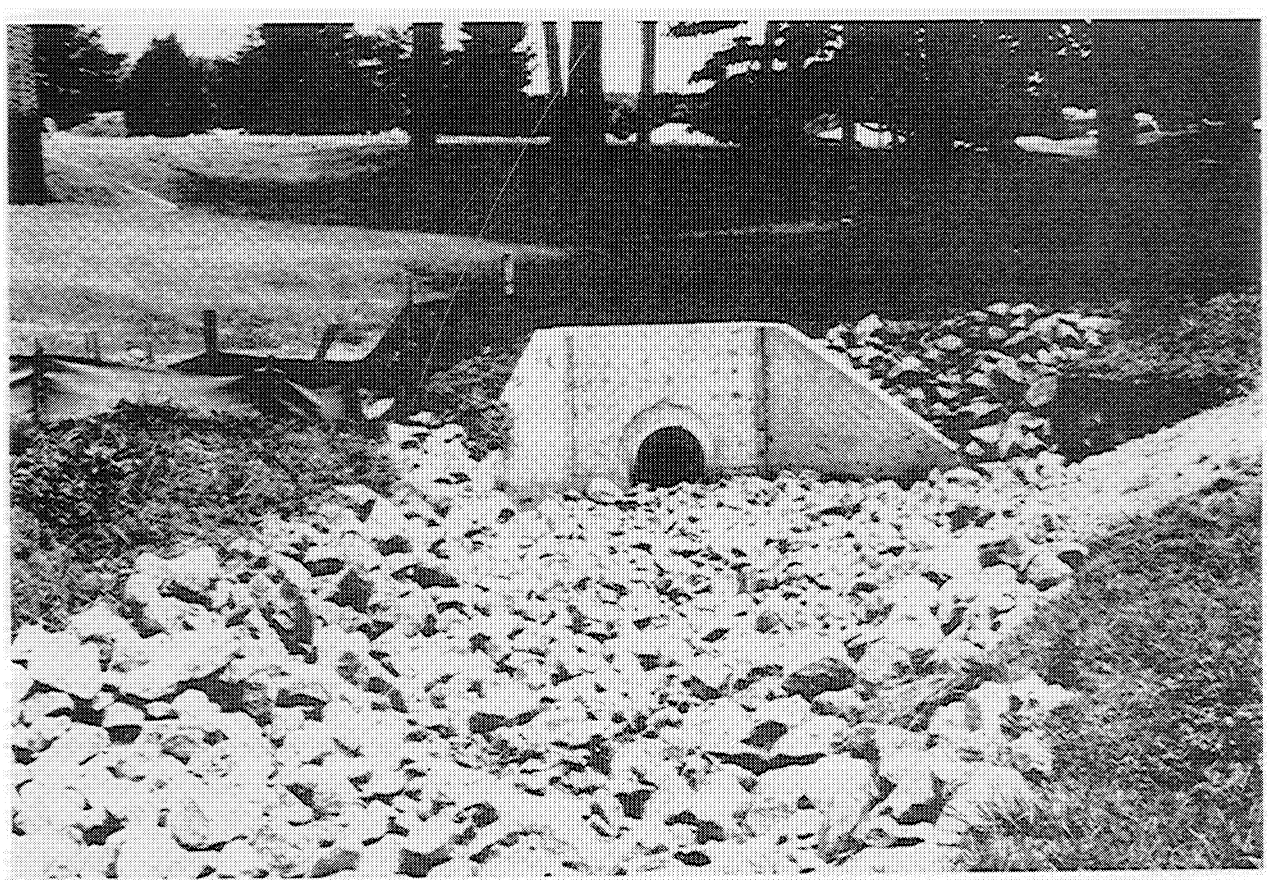
Structurally lined aprons or other acceptable energy dissipating devices placed at the outlets of pipes or paved channel sections.

Purpose

To prevent scour at stormwater outlets, to protect the outlet structure, and to minimize the potential for downstream erosion by reducing the velocity and energy of concentrated stormwater flows.

Conditions Where Practice Applies

Applicable to the outlets of all pipes and engineered channel sections.



Planning Considerations

The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

The most commonly used device for outlet protection is a structurally lined apron. These aprons are generally lined with riprap, grouted riprap or concrete. They are constructed at a zero grade for a distance which is related to the outlet flow rate and the tailwater level. Criteria for designing such an apron are contained in this practice. Sample problems of outlet protection design are contained in Appendix 3.18-a.

Where flow is excessive for the economical use of an apron, excavated stilling basins may be used. Acceptable designs for stilling basins may be found in the following sources:

1. Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulic Engineering Circular No. 14, U. S. Department of Transportation, Federal Highway Administration (83).

2. Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, U.S. Department of the Interior - Bureau of Reclamation, (74).

   Note: Both of the above are available from the U.S. Government Printing Office.

Design Criteria

The design of structurally lined aprons at the outlets of pipes and paved channel sections applies to the immediate area or reach below the pipe or channel and does not apply to continuous rock linings of channels or streams (See STORMWATER CONVEYANCE CHANNEL, Std. & Spec. 3.17). Notably, pipe or channel outlets at the top of cut slopes or on slopes steeper than 10% should not be protected using just outlet protection as a result of the reconcentration and large velocity of flow encountered as the flow leaves the structural apron. Outlet protection shall be designed according to the following criteria:

Pipe Outlets

(See Plate 3.18-1)

1. Tailwater depth: The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth (see Chapter 5, Engineering Calculations). If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a

Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition. Notably, in most cases where post-development stormwater runoff has been concentrated or increased, MS #19 will be satisfied only by outfall into a defined channel.

2. Apron length: The apron length shall be determined from the curves according to the tailwater condition:

   Minimum Tailwater - Use Plate 3.18-3.
   Maximum Tailwater - Use Plate 3.18-4.

3. Apron width: When the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank (whichever is less).

   If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

   a. The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.

   b. For a Minimum Tailwater Condition, the downstream end of the apron shall have a width equal to the pipe diameter plus the length of the apron.

   c. For a Maximum Tailwater Condition, the downstream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron.

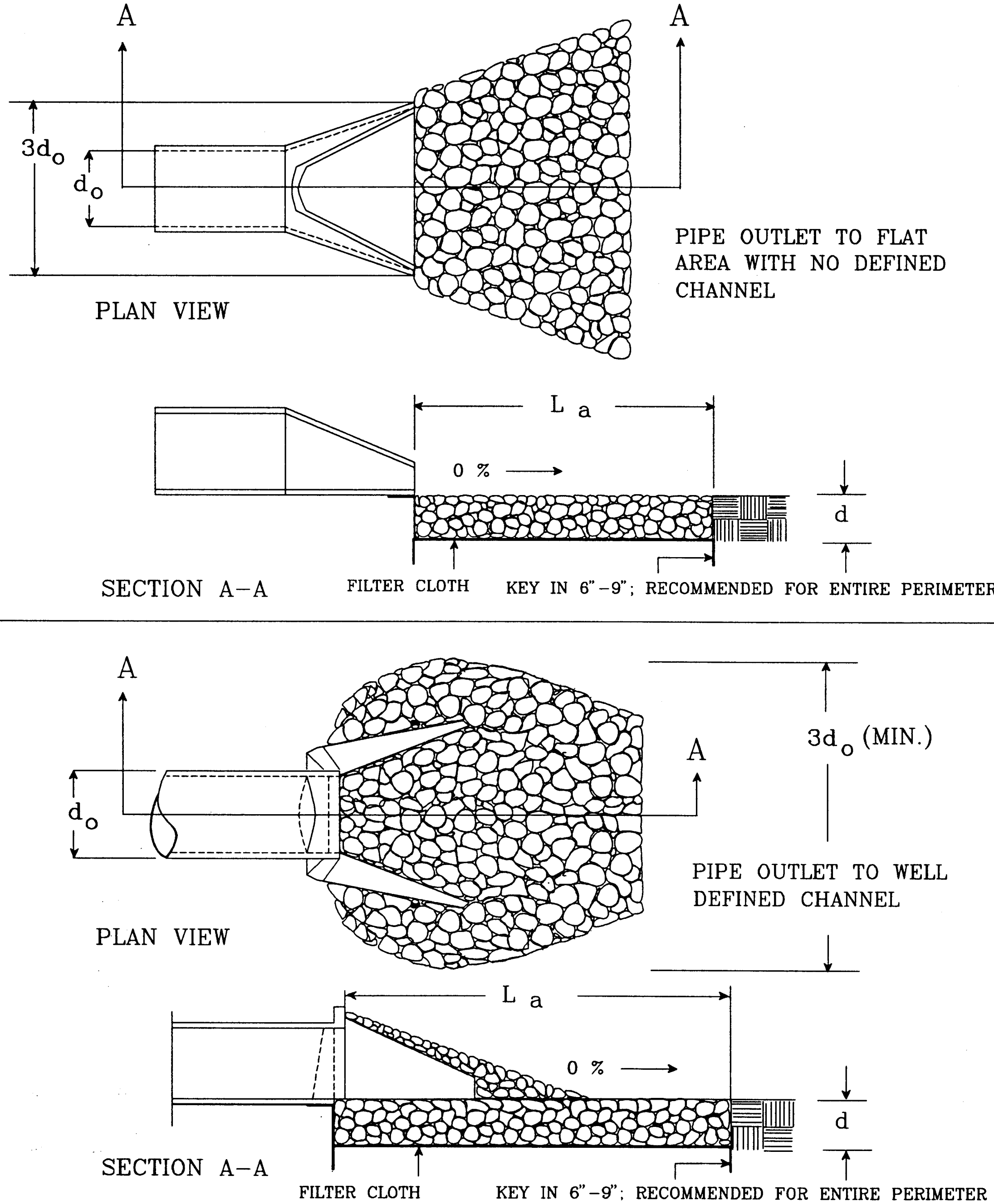
4. Bottom grade: The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

5. Side slopes: If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (horizontal: vertical).

6. Alignment: The apron shall be located so there are not bends in the horizontal alignment.

7. Materials: The apron may be lined with riprap, grouted riprap, concrete, or gabion baskets. The median sized stone for riprap shall be determined from the curves in Appendix 3.18-a (Plates 3.18-3 and 3.18-4) according to the tailwater condition. The gradation, quality and placement of riprap shall conform to Std. & Spec. 3.19, RIPRAP.

PIPE OUTLET CONDITIONS



NOTES: 1. APRON LINING MAY BE RIPRAP, GROUTED RIPRAP, GABION BASKET, OR CONCRETE.
2. La IS THE LENGTH OF THE RIPRAP APRON AS CALCULATED USING PLATES 3.18–3 AND 3.18–4.
3. d = 1.5 TIMES THE MAXIMUM STONE DIAMETER, BUT NOT LESS THAN 6 INCHES.

Source: Va. DSWC

Plate 3.18-1

8. Filter cloth: In all cases, filter cloth shall be placed between the riprap and the underlying soil to prevent soil movement into and through the riprap. The material must meet or exceed the physical properties for filter cloth found in Std. & Spec. 3.19, RIPRAP. See Plate 3.18-1 for orientation details.

Paved Channel Outlets

(See Plate 3.18-2)

1. The flow velocity at the outlet of paved channels flowing at design capacity must not exceed the permissible velocity of the receiving channel (see Tables 3.18-A and 3.18-B)

2. The end of the paved channel shall merge smoothly with the receiving channel section. There shall be no overfall at the end of the paved section. Where the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a transition section shall be provided The maximum side divergence of the transition shall be 1 in 3F where;

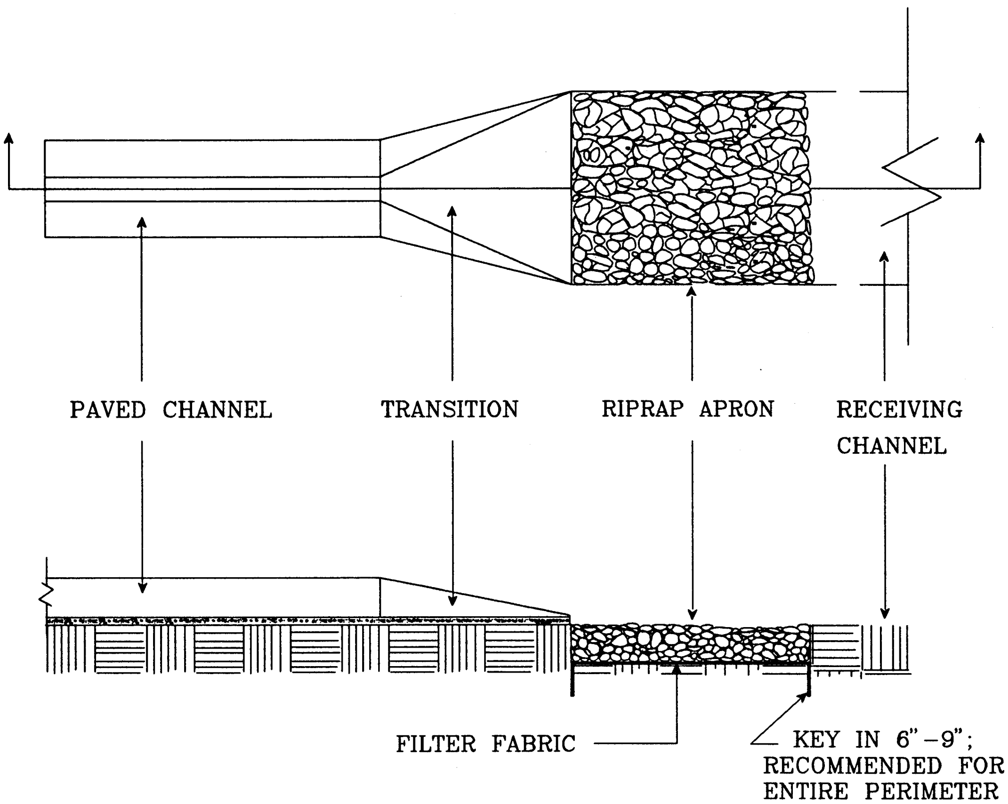
$$F = \frac{V}{\sqrt{gd}}$$

where,

F	=	Froude number
V	=	Velocity at beginning of transition (ft./sec.)
d	=	depth of flow at beginning of transition (ft.)
g	=	32.2 ft./sec.^{2}

3. Bends or curves in the horizontal alignment at the transition are not allowed unless the Froude number (F) is 1.0 or less, or the section is specifically designed for turbulent flow.

PAVED CHANNEL OUTLET



NOTES:

1. RIPRAP APRON REDUCES THE FLOW VELOCITY BELOW THE PERMISSIBLE VELOCITY OF THE NATURAL RECEIVING CHANNEL.
2. TRANSITION SIDE DIVERGENCE IS 1 IN 3F, WHERE

$$F = \text{FROUDE NUMBER} = \frac{V}{\sqrt{gd}}, \text{ WHERE}$$

V = VELOCITY AT THE BEGINING OF THE TRANSITION

d = DEPTH OF FLOW AT THE BEGINING OF THE TRANSITION

$g = 32.2 \text{ ft./sec}^2$

Source: Va. DSWC

Plate 3.18-2

TABLE 3.18-A

PERMISSIBLE VELOCITIES FOR GRASS-LINED CHANNELS

Channel Slope	Lining	Velocity* (ft./sec.)
0 - 0.5%	Bermudagrass	6
	Reed canarygrass Tall fescue Kentucky bluegrass	5
	Grass-legume mixture	4
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains Temporary vegetation	2.5
5 - 10%	Bermudagrass	5
	Reed canarygrass Tall fescue Kentucky bluegrass	4
	Grass-legume mixture	3
Greater than 10%	Bermudagrass	4
	Reed canarygrass Tall fescue Kentucky bluegrass	3

* For highly erodible soils, decrease permissible velocities by 25%.

Source: Soil and Water Conservation Engineering, Schwab, et. al. and American Society of Civil Engineers

TABLE 3.18-B?

PERMISSIBLE VELOCITIES FOR EARTH LININGS

Soil Types	Permissible Velocities (ft./sec.)
Fine Sand (noncolloidal)	2.5
Sandy Loam (noncolloidal)	2.5
Silt Loam (noncolloidal)	3.0
Ordinary Firm Loam	3.5
Fine Gravel	5.0
Stiff Clay (very colloidal)	5.0
Graded, Loam to Cobbles (noncolloidal)	5.0
Graded, Silt to Cobbles (colloidal)	5.5
Alluvial Silts (noncolloidal)	5.5
Alluvial Silts (colloidal)	5.0
Coarse Gravel (noncolloidal)	6.0
Cobbles and Shingles	5.5
Shales and Hard Plans	6.0

Source: Soil and Water Conservation Engineering, Schwab, et.al. and American Society of Civil Engineers

APPENDIX 3.18-a

Sample Problems: Outlet Protection Design

Example 1

Given: An 18-inch pipe discharges 24 cfs at design capacity onto a grassy slope (no defined channel).

Find: The required length, width and median stone size (d_{50}) for a riprap-lined apron.

Solution:

1. Since the pipe discharges onto a grassy slope with no defined channel, a Minimum Tailwater Condition may be assumed.

2. From Plate 3.18-3, an apron length (L_a) of 20 feet and a median stone size (d_{50}) of 0.8 ft. are determined.

3. The upstream apron width equals three times the pipe diameter; 3 x 1.5 ft = 4.5 ft.

4. The downstream apron width equals the apron length plus the pipe diameter; 20 ft. + 1.5 ft. = 21.5 ft.

Example 2

Given: The pipe in example No. 1 discharges into a channel with a triangular cross-section, 2 feet deep and 2:1 side slopes. The channel has a 2% slope and an "n" factor of .045.

Find: The required length, width and the median stone size (d_{50}) for a riprap lining.

Solution:

1. Determine the tailwater depth using Manning's Equation.

$$Q = \frac{1.49}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} A$$

$$24 = \frac{1.49}{.045}\left(\frac{2d}{2\sqrt{2^2+1}}\right)^{\frac{2}{3}}(.02)^{\frac{1}{2}}(2d^2)$$

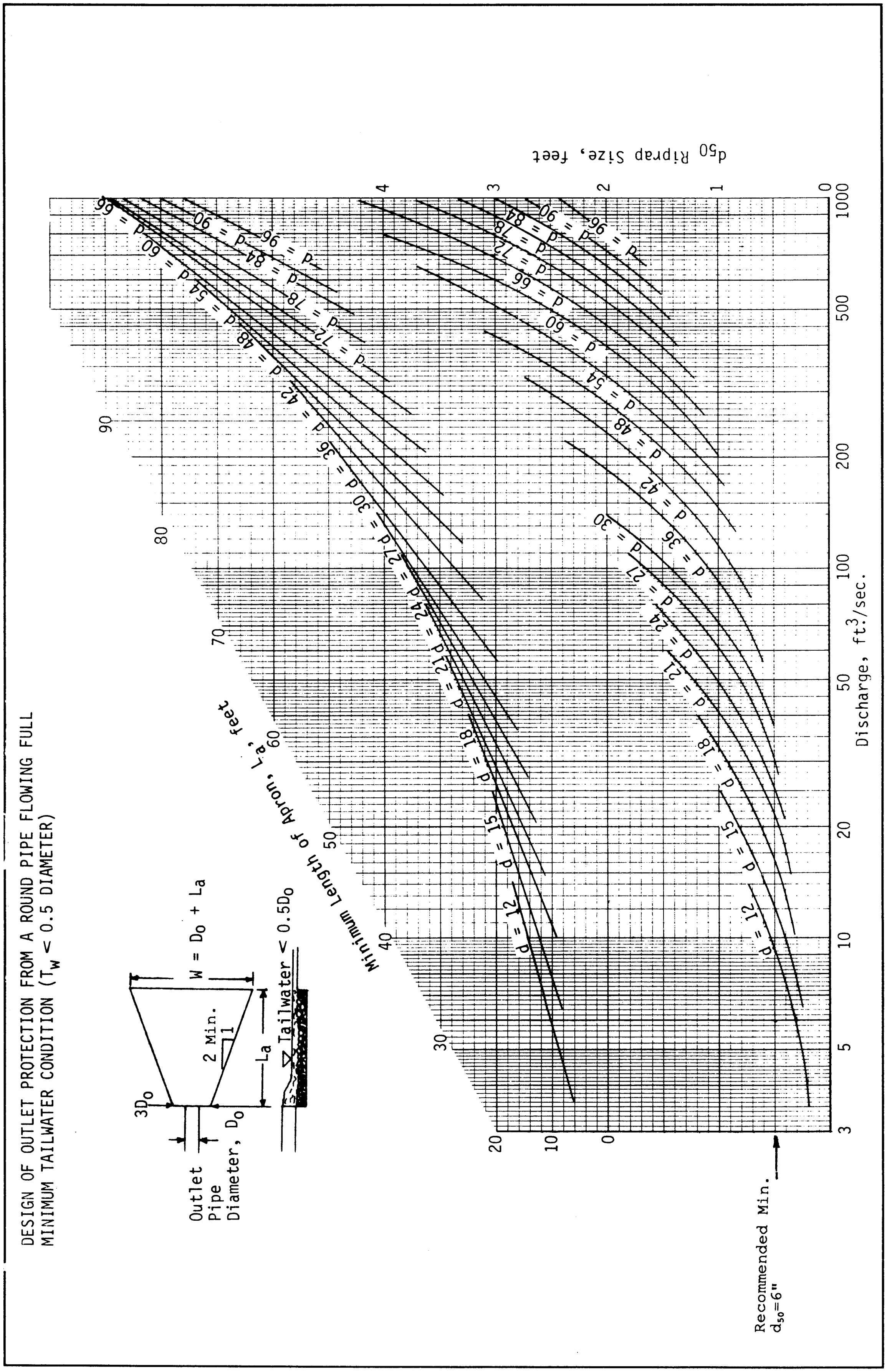
where,

d = depth of tailwater
d = 1.74 ft. *

* since d is greater than half the pipe diameter, a Maximum Tailwater Condition exists.

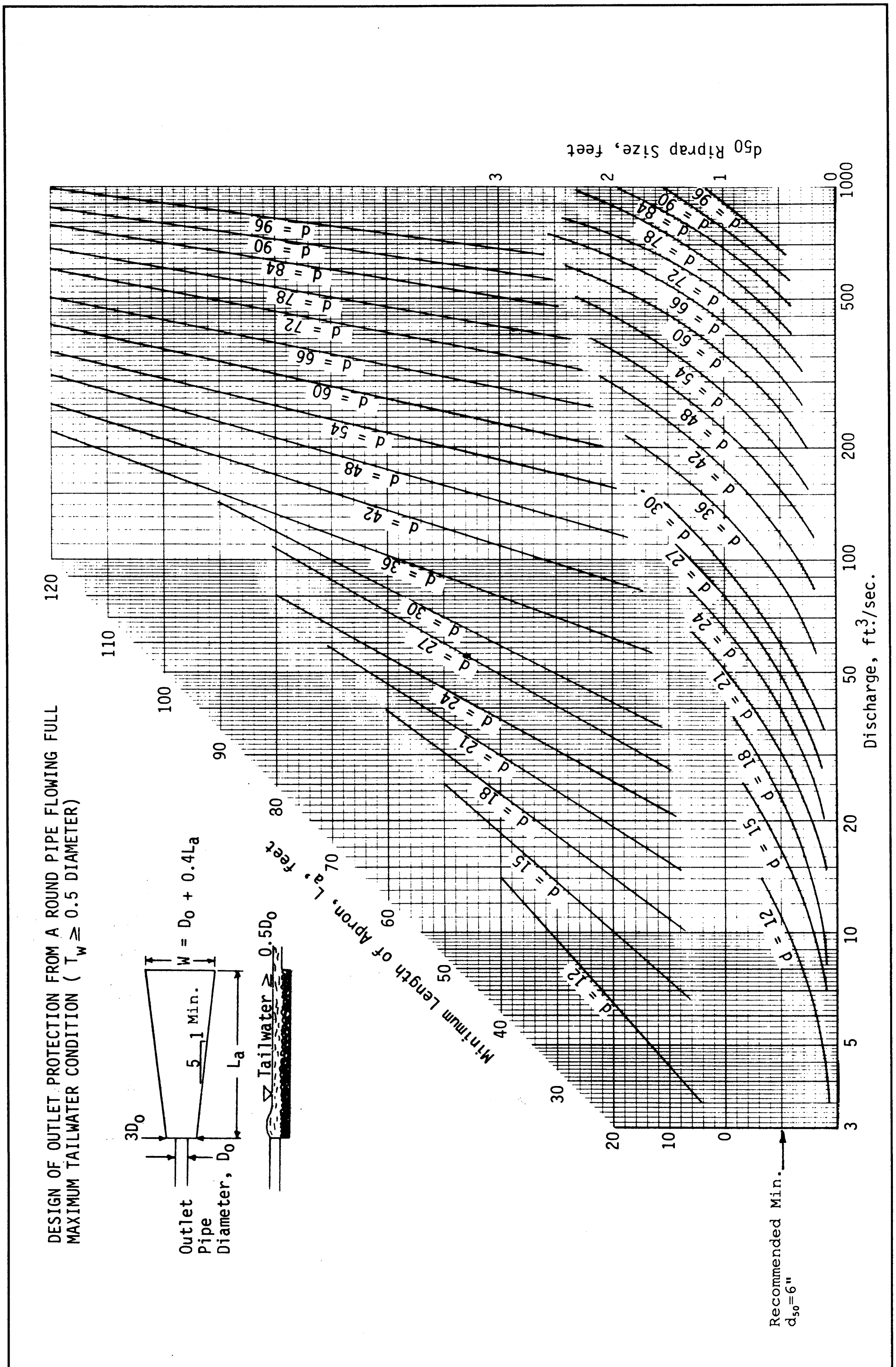
2. From Plate 3.18-4, a median stone size (d_{50}) of 0.5 ft. and an apron length (L_a) of 41 ft. is determined.

3. The entire channel cross-section should be lined since the maximum tailwater depth is within one foot of the top of the channel.



Source: USDA-SCS

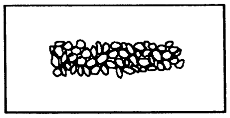
Plate 3.18-3



Source: USDA-SCS

Plate 3.18-4

STD & SPEC 3.19



RIPRAP

RR

Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone with filter fabric or granular underlining.

Purposes

1. To protect the soil from the erosive forces of concentrated runoff.

2. To slow the velocity of concentrated runoff while enhancing the potential for infiltration.

3. To stabilize slopes with seepage problems and/or non-cohesive soils.

Conditions Where Practice Applies

Wherever soil and water interface and 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, as transition from concrete channels to vegetated channels, 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 is limited to that 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 designed 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 angular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Table 3.19-A lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed specific weight of 165 lbs./ft^3.

Since 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% 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. Table 3.19-B lists VDOT standard graded riprap sizes by diameter the weight of the stone.

To ensure that stone of substantial <u>weight</u> is used when implementing riprap structures, specified weight ranges for individual stones and composition requirements should be followed. Such guidelines will help to prevent inadequate stone from being used in construction of the measures and will promote more consistent stone classification statewide. Table 3.19-C notes these requirements.

TABLE 3.19-A

SIZE OF RIPRAP STONES

Weight (lbs.)	Mean Spherical Diameter (ft.)	Angular Shape: Length (ft.)	Width, Height (ft.)
50	0.8	1.4	0.5
100	1.1	1.75	0.6
150	1.3	2.0	0.67
300	1.6	2.6	0.9
500	1.9	3.0	1.0
1,000	2.2	3.7	1.25
1,500	2.6	4.7	1.5
2,000	2.75	5.4	1.8
4,000	3.6	6.0	2.0
6,000	4.0	6.9	2.3
8,000	4.5	7.6	2.5
20,000	6.1	10.0	3.3

Source: VDOT Drainage Manual

Sequence of Construction

Since 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.

Design Criteria

Gradation

The riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50% 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 1½ times the d_{50} size.

TABLE 3.19-B

GRADED RIPRAP - DESIGN VALUES

Riprap Class	D_{15} Weight (lbs.)	Mean D_{15} Spherical Diameter (ft.)	Mean D_{50} Spherical Diameter (ft.)
Class AI	25	0.7	0.9
Class I	50	0.8	1.1
Class II	150	1.3	1.6
Class III	500	1.9	2.2
Type I	1,500	2.6	2.8
Type II	6,000	4.0	4.5

Source: VDOT Drainage Manual

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 a gully in which to toss the stones.

Thickness

The minimum thickness of the riprap layer shall be 2 times the maximum stone diameter, but not less than 6 inches.

Quality of Stone

Stone for riprap shall consist of 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 respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.

TABLE 3.19-C

GRADED RIPRAP - WEIGHT ANALYSIS

Riprap Class/Type	Weight Range* (lbs.)	Requirements for Stone Mixture
Class AI	25-75	Max. 10% > 75 lbs.
Class I	50-150	60% > 100 lbs.
Class II	150-500	50% > 300 lbs.
Class III	500-1,500	50% > 900 lbs.
Type I	1,500-4,000	Av. wt. = 2,000 lbs.
Type II	6,000-20,000	Av. wt. = 8,000 lbs.

* In all classes/types of riprap, a maximum 10% of the stone in the mixture may weigh less than the lower end of the range.

Source: Adapted from VDOT Road and Bridge Specifications

Filter Fabric Underlining

A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. Table 3.19-D notes the minimum physical properties of the filter fabric.

Filter fabric shall not be used on slopes greater than 1½:1 as slippage may occur and should be used in conjunction with a layer of course aggregate (granular filter blanket is described below) when the riprap to be placed is Class II or larger.

Granular Filter

Although the filter cloth underlining or bedding is the preferred method of installation, a granular (stone) bedding is a viable option when the following relationship exists:

$$\frac{d_{15}\ filter}{d_{85}\ base} < 5 < \frac{d_{15}\ filter}{d_{15}\ base} < 40$$

and,

$$\frac{d_{50}\ filter}{d_{50}\ base} < 40$$

In these relationships, filter refers to the overlying material and base refers to the underlying material. The relationships must hold between the filter material and the base material and between the riprap and the filter material. In some cases, more than one layer of filter material may be needed. Each layer of filter material should be approximately 6-inches thick.

TABLE 3.19-D

REQUIREMENTS FOR FILTER FABRIC USED WITH RIPRAP

Physical Property	Test Method	Requirements
Equivalent Opening Size	Corps of Engineers CWO 2215-77	Equal or greater than U.S. No. 50 sieve
Tensile Strength* @ 20% (maximum)	VTM-52	30 lbs./linear in. (minimum)
Puncture Strength	ASTM D751*	80 lbs. (minimum)

* Tension testing machine with ring clamp, steel ball replaced with 5/16 diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

Seams shall be equal in strength to basic material.

Additional fabric material or non-corrosive steel wire may be incorporated into the fabric to increase overall strength.

Source: VDOT Road and Bridge Specifications

Riprap at Outlets

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structure are contained in OUTLET PROTECTION (Std. & Spec. 3.18). A filter fabric underlining is required for riprap used as outlet protection.

Riprap for Channel Stabilization

Riprap for channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized. The design procedure in Appendix 3.19-a, which is extracted from the Federal Highway Administration's Design of Stable Channels with Flexible Linings (82), shall be used. This method establishes the stability of the rock material relative to the forces exerted upon it.

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 bottom of the channel to a minimum depth equal to the thickness of the blanket and shall extend across the bottom of the channel the same distance (see Plate 3.19-1).

Freeboard and Height of Bank

For riprapped and other lined channels, the height of channel lining above the water surface should be based on the size of the channel, the flow velocity, the curvature, inflows, wind action, flow regulation, etc.

The height of the bank above the water surface varies in a similar manner, depending on the above factors plus the type of soil.

Plate 3.19-2 is based on information developed by the U.S. Bureau of Reclamation for average freeboard and bank height in relation to channel capacity. This chart should be used by the designer to obtain a minimum freeboard for placement of riprap and top of bank.

Riprap for Slope Stabilization

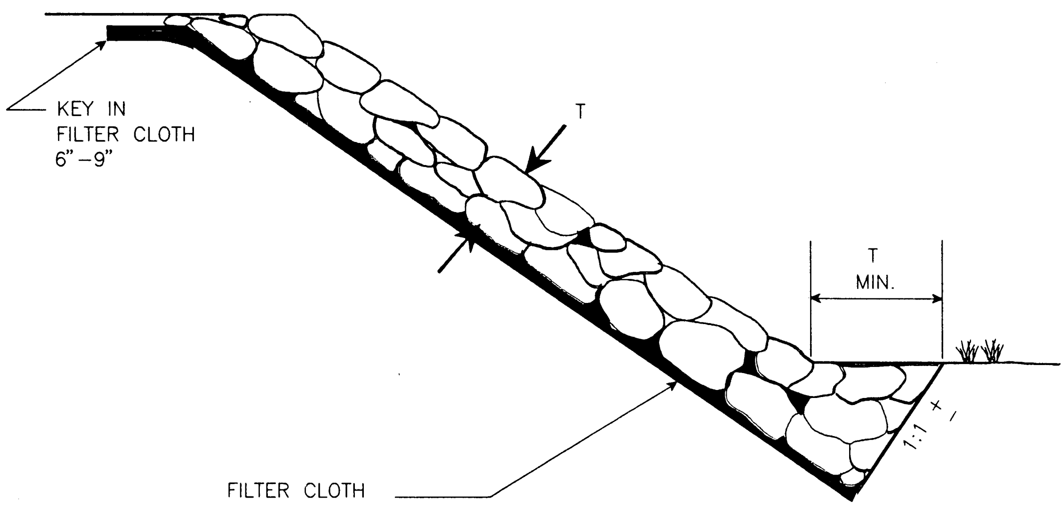
Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is greater than the gradient of the slope being stabilized (see Plate 3.19-5).

Riprap for Lakes and Ponds Subject to Wave Action

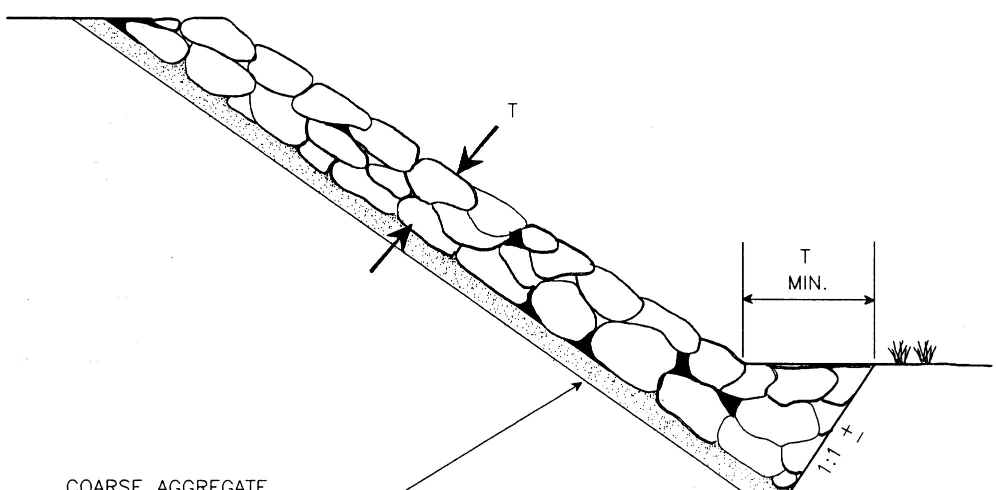
Riprap used for shoreline protection on lakes and ponds may be subject to wave action. The waves affecting the shoreline may be wind-driven or created by boat wakes. Consult

TOE REQUIREMENTS FOR BANK STABILIZATION

FILTER CLOTH UNDERLINER (PREFERRED)



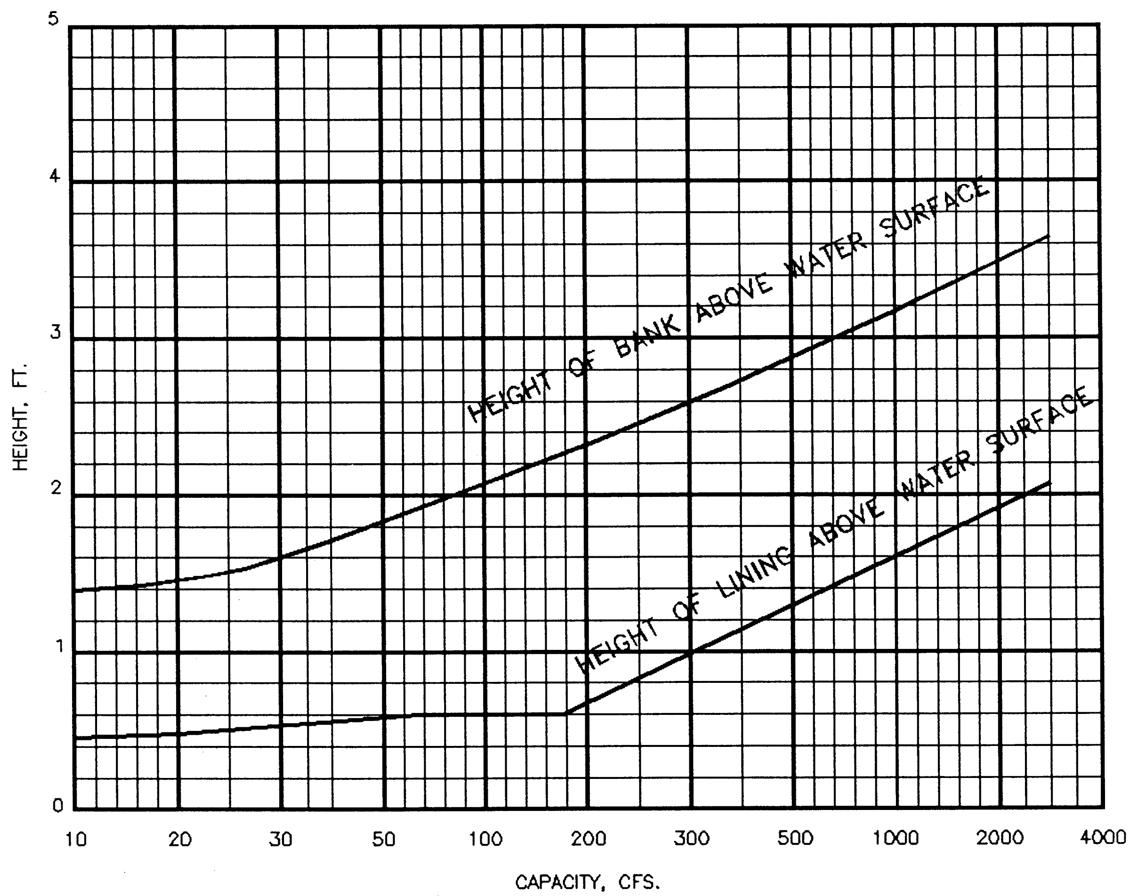
GRANULAR FILTER



Source: Adapted from VDOT Drainage Manual

Plate 3.19-1

RECOMMENDED FREEBOARD AND HEIGHT OF BANK OF LINED CHANNELS



Source: U. S. Bureau of Reclamation

Plate 3.19-2

the latest edition of the VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action") for specific design criteria in determining the required size of stones and the design wave height for such an installation. Use the equations in Appendix 3.19-b to calculate other pertinent design parameters. For more in-depth design criteria concerning these installations, see the U.S. Army Corps of Engineers' Shore Protection Manual (59).

Riprap for Abrupt Channel Contractions

Refer to latest edition of VDOT Drainage Manual.

Riprap for Installations Subject to Tidal and Wave Action

The design of riprap structures for tidal areas is beyond the scope of the VESCL and VESCR. The DSWC's Shoreline Programs Bureau provides advice regarding minimum design parameters for these installations. Notably, a riprap design for shoreline protection in tidal areas must meet all applicable state and federal requirements and should be carried out by a qualified professional.

Construction Specifications

Subgrade Preparation: The subgrade for the riprap or filter shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximately that of the surrounding undisturbed material. Brush, trees, stumps and other objectionable material shall be removed.

Filter Fabric or Granular Filter: Placement of the filter fabric should be done immediately after slope preparation. For granular filters, the stone should be spread in a uniform layer to the specified depth (normally 6 inches). Where more than one layer of filter material is used, the layer should be spread so that there is minimal mixing of the layers.

When installing geotextile filter cloths, the cloth should be placed directly on the prepared slope. The edges of the sheets should overlap by at least 12 inches. Anchor pins, 15 inches long, should be spaced every 3 feet along the overlap. The upper and lower ends of the cloth should be buried at least 12 inches. Care should be taken not to damage the cloth when placing the riprap. If damage occurs, that sheet should be removed and replaced. For large stone (Class II or greater), a 6-inch layer of granular filter will be necessary to prevent damage to the cloth.

Stone Placement: Placement of riprap should follow immediately after placement of the filter. The riprap should be placed so that it produces a dense well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry, controlled dumping of successive loads during final placing, or by a combination of these methods. The riprap should be placed to its full thickness in one operation. The riprap should not be placed in layers. The riprap should not be placed by dumping into chutes or similar methods which are likely to cause segregation of the various stone sizes. Care should be taken not to dislodge the underlying material when placing the stones.

The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve the required grades and a good distribution of stone sizes. Final thickness of the riprap blanket should be within plus or minus 1/4 of the specified thickness.

Maintenance

Once a riprap installation has been completed, it should require very little maintenance. It should, however, be inspected periodically to determine if high flows have caused scour beneath the riprap or filter fabric or dislodged any of the stone. Care must be taken to properly control sediment-laden construction runoff which may drain to the point of the new installation. If repairs are needed, they should be accomplished immediately.

APPENDIX 3.19-a

RIPRAP DESIGN IN CHANNEL

The design method described below is adapted from Hydraulic Engineering Circular No. 15 of the Federal Highway Administration. It is applicable to both straight and curved sections of channel where the flow is tangent to the bank of the channel.

Tangent Flow - Federal Highway Administration Method

This design method determines a stable rock size for straight and curved sections of channels. It is assumed that the shape, depth of flow, and slope of the channel are known. A stone size is chosen for the maximum depth of flow. If the sides of the channel are steeper than 3:1, the stone size must be modified accordingly. The final design size will be stable on both sides of the channel and the bottom.

1. Enter Plate 3.19-3 with the maximum depth of flow (feet) and channel slope (feet/foot). Where the two lines intersect, choose the d_{50} size of stone. (Select the d_{50} for the diagonal line above the point of intersection).

2. If channel side slopes are steeper than 3:1, continue with step 3; if not, the procedure is complete.

3. Enter Plate 3.19-4 with the side slope and the base width to maximum depth ratio (B/d). Where the two lines intersect, move horizontally left to read K_1.

4. Determine from Plate 3.19-5 the angle of repose for the d_{50} size of stone and the side slope of the channel. (Use 42° for d_{50} greater than 1.0. Do not use riprap on slopes steeper than the angle of repose for the size of stone).

5. Enter Plate 3.19-6 with the side slope of the channel and the angle of repose for the d_{50} size of stone. Where the two lines intersect, move vertically down to read k_2.

6. Compute $d_{50} \times K_1/K_2 = d'_{50}$ to determine the correct size stone for the bottom and side slopes of straight sections of channel.

For Curved Sections of Channel

1. Compute the radius of the curve (Ro), measured at the outside edge of the bottom.

2. Compute the ratio of the top width of the water surface (Bs) to the radius of the curve (Ro), Bs/Ro.

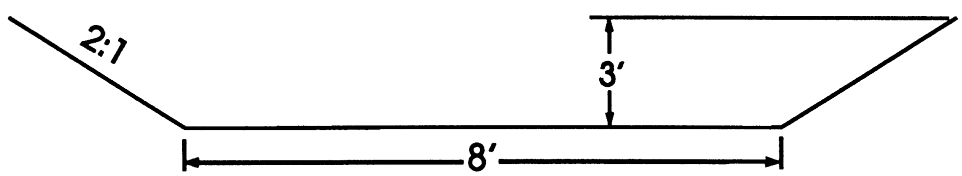
3. Enter Plate 3.19-7 with the radio Bs/Ro. Move vertically until the curve is intersected. Move horizontally left to read K_3.

4. Compute d'_{50} x K_3 = d_{50c} to determine the correct size stone for bottom and side slopes of the curved sections of channel.

Example Problem

Given:

A trapezoidal channel 3 feet deep, 8 foot bottom width, 2:1 side slopes, and a 2% slope.



Calculate:

A stable riprap size for the bottom and side slopes of the channel.

Solution:

1. From Plate 3.19-3, for a 3-foot-deep channel on a 2% grade, d_{50} = 0.75 feet or 9 inches.

2. Since the side slopes are steeper than 3:1, continue with step 3.

3. From Plate 3.19-4, B/d = 8/3 = 2.67, Z = 2, K_1 = 0.82.

4. From Plate 3.19-5, for d_{50} = 9 inches, = 41°.

5. From Plate 3.19-6, for Z = 2 and = 41°, K_2 = 0.73.

6. $d_{50} \times K_1/k_2 = d'_{50} = 0.75 \times 0.82/0.73 = 0.84$ feet.

$$0.84 \text{ feet} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 10.08. \text{ Use } d'_{50} = 10 \text{ inches.}$$

Given:

The preceding channel has a curved section with a radius of 50 feet.

Calculate:

A stable riprap size for the bottom and side slopes of the curved section of channel.

Solution:

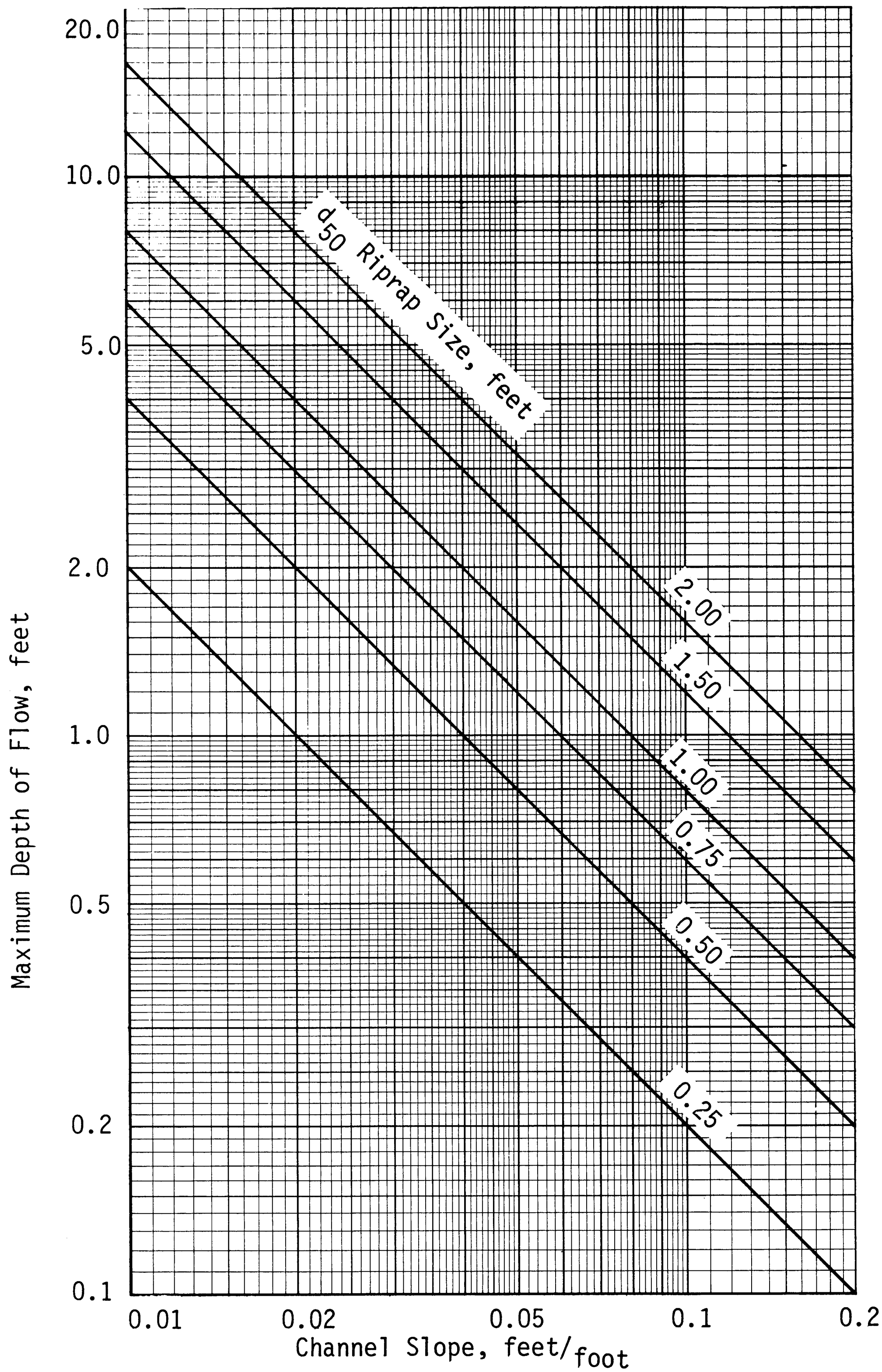
1. Ro = 50 feet

2. Bs/Ro = 20/50 = 0.40

3. From Plate 3.19-7, for Bs/Ro = 0.40, K_3 = 1.1

4. $d'_{50} \times K_3 = 0.84 \times 1.1 = 0.92$ feet

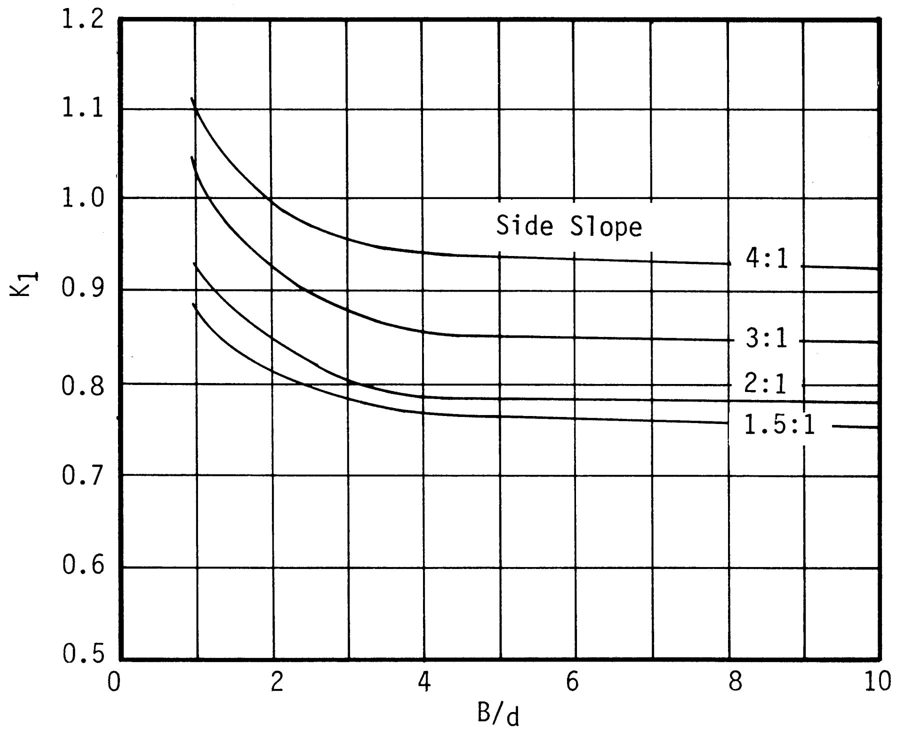
   $0.92 \text{ feet} \times \dfrac{12 \text{ inches}}{1 \text{ foot}} = 11.0.$



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

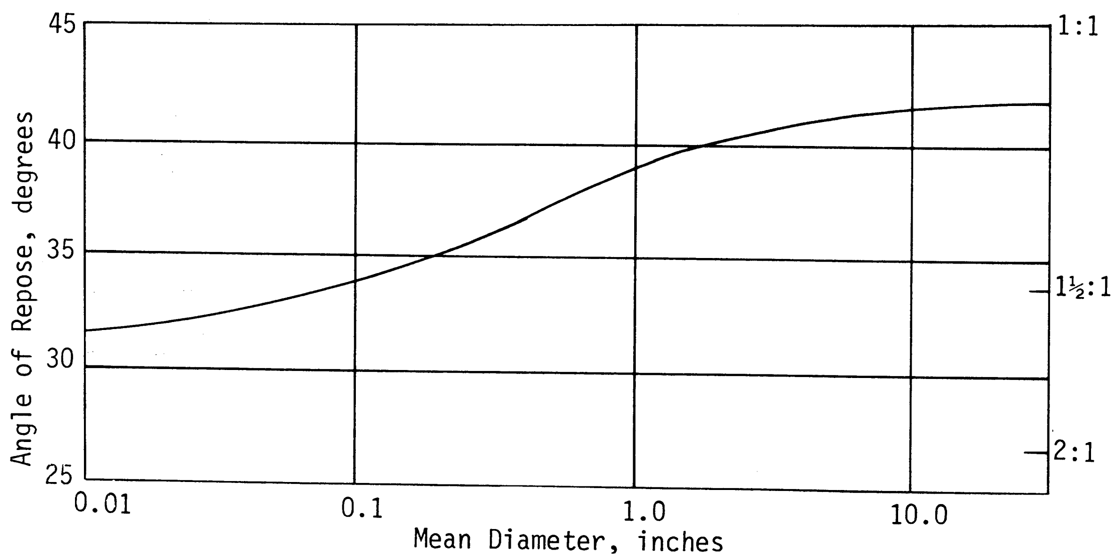
Source: VDOT Drainage Manual

Plate 3.19-3



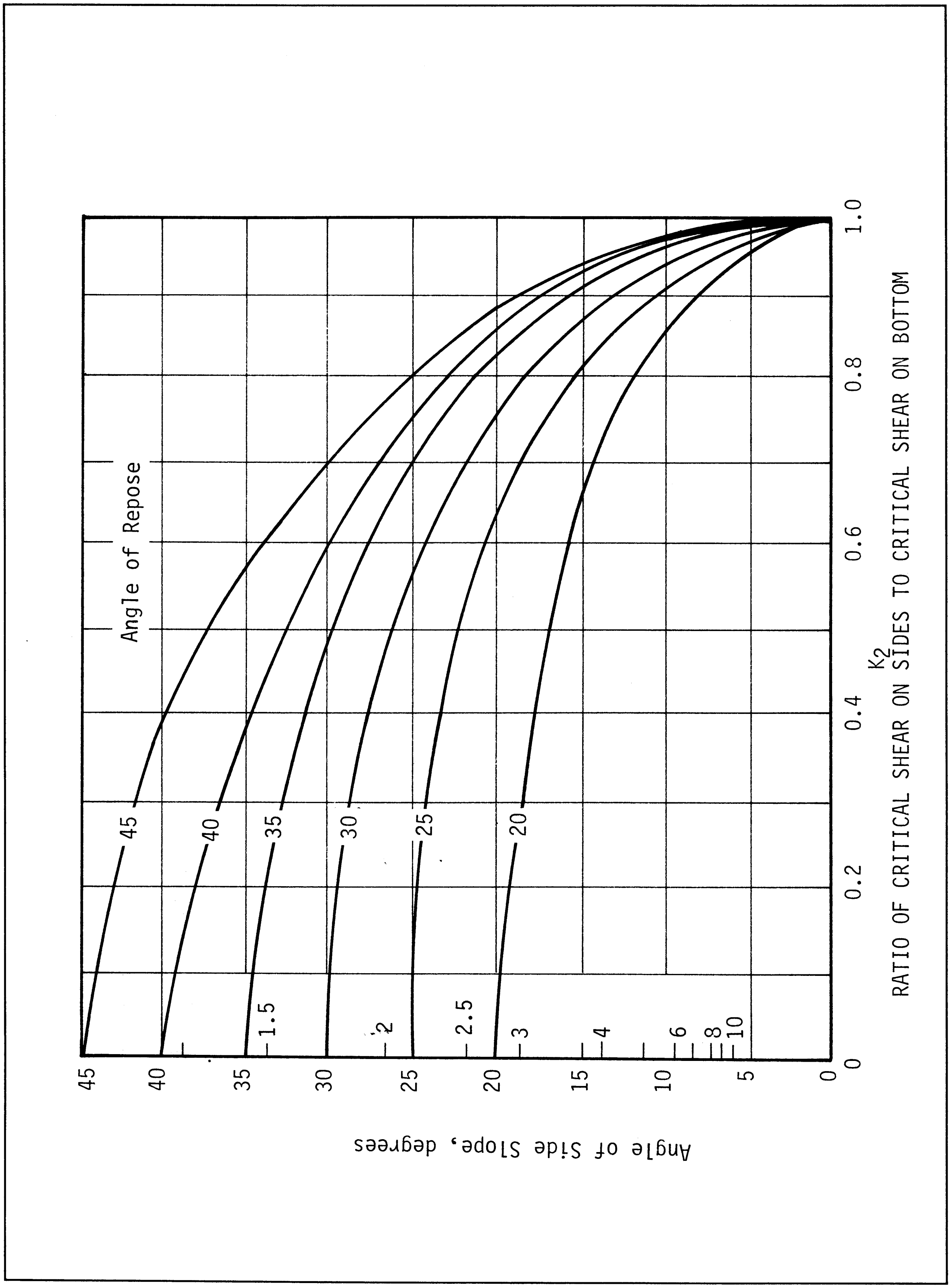
DISTRIBUTION OF BOUNDARY SHEAR AROUND WETTED PERIMETER OF TRAPEZOIDAL CHANNEL

Source: VDOT Drainage Manual Plate 3.19-4



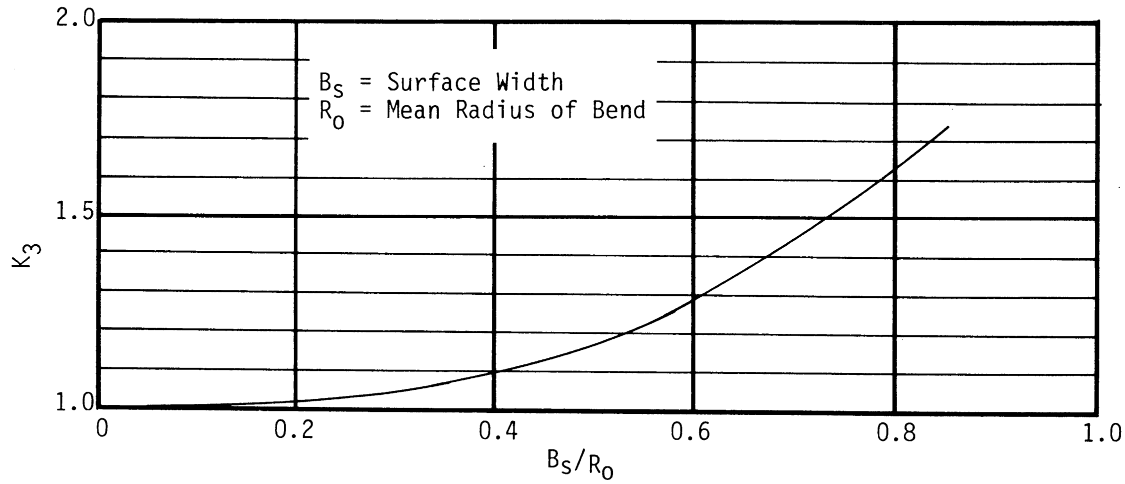
ANGLE OF REPOSE FOR RIPRAP STONES

Source: VDOT Drainage Manual Plate 3.19-5



Source: VDOT Drainage Manual

Plate 3.19-6



RATIO OF MAXIMUM BOUNDARY SHEAR IN BENDS TO MAXIMUM BOTTOM SHEAR IN STRAIGHT REACHES

Source: VDOT <u>Drainage Manual</u>

Plate 3.19-7

APPENDIX 3.19-b

RIPRAP DESIGN EQUATIONS FOR LAKES AND PONDS SUBJECT TO WAVE ACTION

In many instances, riprap is installed along the shoreline of nontidal ponds and lakes in order to protect them from the continual scour of wind-driven waves. The following methods/equations will produce minimum design parameters for size of stone, depth of buried toe (or width of riprap apron) and height of structure above average water level.

I. **Size of Riprap Required** - See VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action").

II. **DWH** (Design Wave Height) - See VDOT Drainage Manual ("Design of Slope Protection to Resist Wave Action") or U.S. Army Corps of Engineers' Shore Protection Manual.

III. **Depth of Buried Toe** = DWH at design wind speed.

IV. **Width of Riprap Apron** (Alternative to Buried Toe) = DWH x 2

V. **Height of Structure** (Above the Average Water Level) = DWH x 1.5

STD & SPEC 3.20

ROCK CHECK DAMS

CD

Definition

Small temporary stone dams constructed across a swale or drainage ditch.

Purpose

To reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps sediment generated from adjacent areas or the ditch itself, mainly by ponding of the stormwater runoff. Field experience has shown it to perform more effectively than silt fence or straw bales in the effort to stabilize "wet-weather" ditches.

Conditions Where Practice Applies

This practice, utilizing a combination of stone sizes, is limited to use in small open channels which drain 10 acres or less. It should not be used in a live stream as the objective should be to protect the live watercourse. Some specific applications include:

1. Temporary ditches or swales which, because of their short length of service, cannot receive a non-erodible lining but still need protection to reduce erosion.

2. Permanent ditches or swales which, for some reason, cannot receive a permanent non-erodible lining for an extended period of time.

3. Either temporary or permanent ditches or swales which need protection during the establishment of grass linings.

4. An aid in the sediment trapping strategy for a construction site. This practice is not a substitute for major perimeter trapping measures such as a SEDIMENT TRAP (Std. & Spec. 3.13) or a SEDIMENT BASIN (Std. & Spec. 3.14).

Planning Considerations

Check dams are effective in reducing flow velocity and thereby the potential for channel erosion. It is usually better to establish a protective vegetative lining before flow is confined or to install a structural channel lining than to install check dams. However, under circumstances where this is not feasible, check dams are useful.

Check dams installed in grass-lined channels may kill the vegetative lining if submergence after rains is too long and/or silting is excessive.

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

As previously mentioned, they have been found to be an effective aid in trapping sediment particles by virtue of their ability to pond runoff.

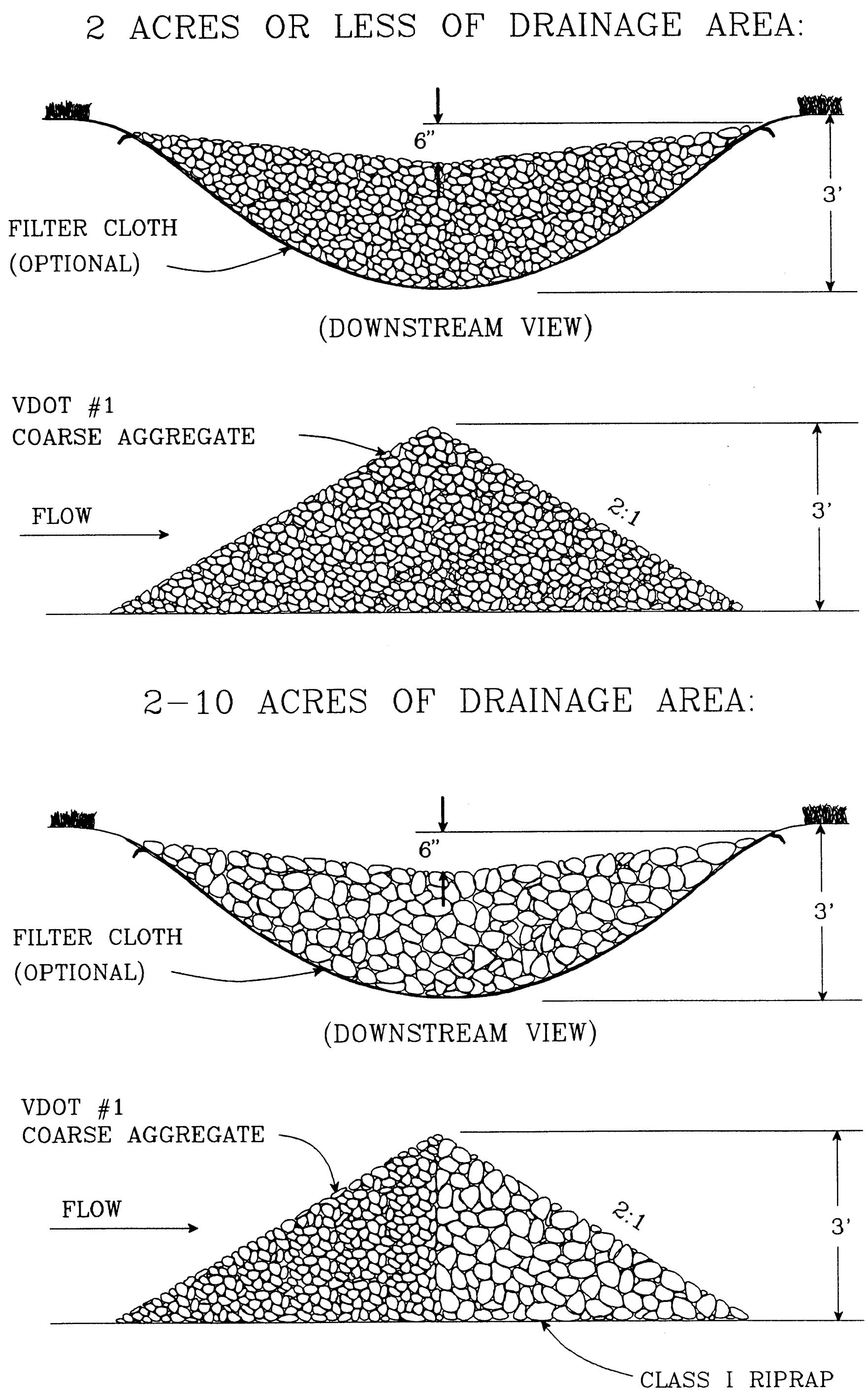
Specifications

No formal design is required for a check dam, however the following criteria should be adhered to when specifying check dams:

1. The drainage area of the ditch or swale being protected shall not exceed 2 acres when VDOT #1 Coarse Aggregate is used alone and shall not exceed 10 acres when a combination of Class I Riprap (added for stability) and VDOT #1 Coarse Aggregate is used. Refer to Plate 3.20-1 for orientation of stone and a cross-sectional view of the measure. An effort should be made to extend the stone to the top of channel banks.

2. However, the maximum height of the dam shall be 3.0 feet.

ROCK CHECK DAM



Source: Va. DSWC

Plate 3.20-1

3. The center of the check dam must be at least 6 inches lower than the outer edges. Field experience has shown that many dams are not constructed to promote this "weir" effect. Stormwater flows are then forced to the stone-soil interface, thereby promoting scour at that point and subsequent failure of the structure to perform its intended function.

4. For added stability, the base of the check dam can be keyed into the soil approximately 6 inches.

5. 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 (see Plate 3.20-2).

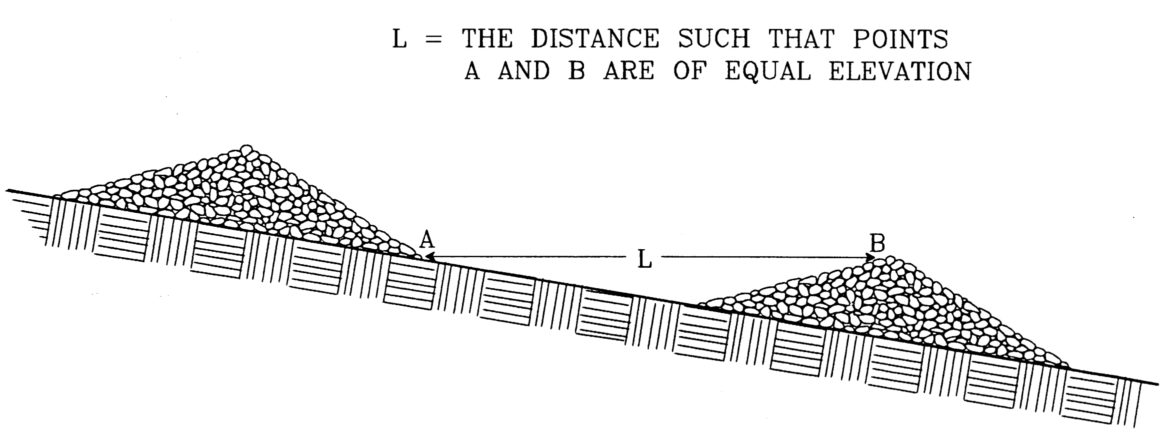
6. Stone should be placed according to the configuration in Plate 3.20-1. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.

7. Filter cloth may be used under the stone to provide a stable foundation and to facilitate the removal of the stone. See Std. and Spec. 3.19, RIPRAP, for required physical properties of the filter cloth.

Sediment Removal

Sediment should be removed from behind the check dams when it has accumulated to one half of the original height of the dam.

SPACING BETWEEN CHECK DAMS



Source: Va. DSWC

Plate 3.20-2

Removal of Practice

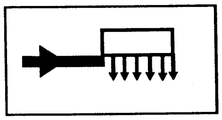
Unless they will be incorporated into a permanent stormwater management control, check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when they are no longer needed. In permanent structures, check dams 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 sufficiently to protect the ditch or swale. The area beneath the check dams should be seeded and mulched immediately after they are removed. The use of filter cloth underneath the stone will make the removal of the stone easier.

Maintenance

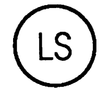
Check dams should be checked for sediment accumulation after each runoff-producing storm event. Sediment should be removed when it reaches one half of the original height of the measure.

Regular inspections should be made to insure 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.

STD & SPEC 3.21



LEVEL SPREADER



Definition

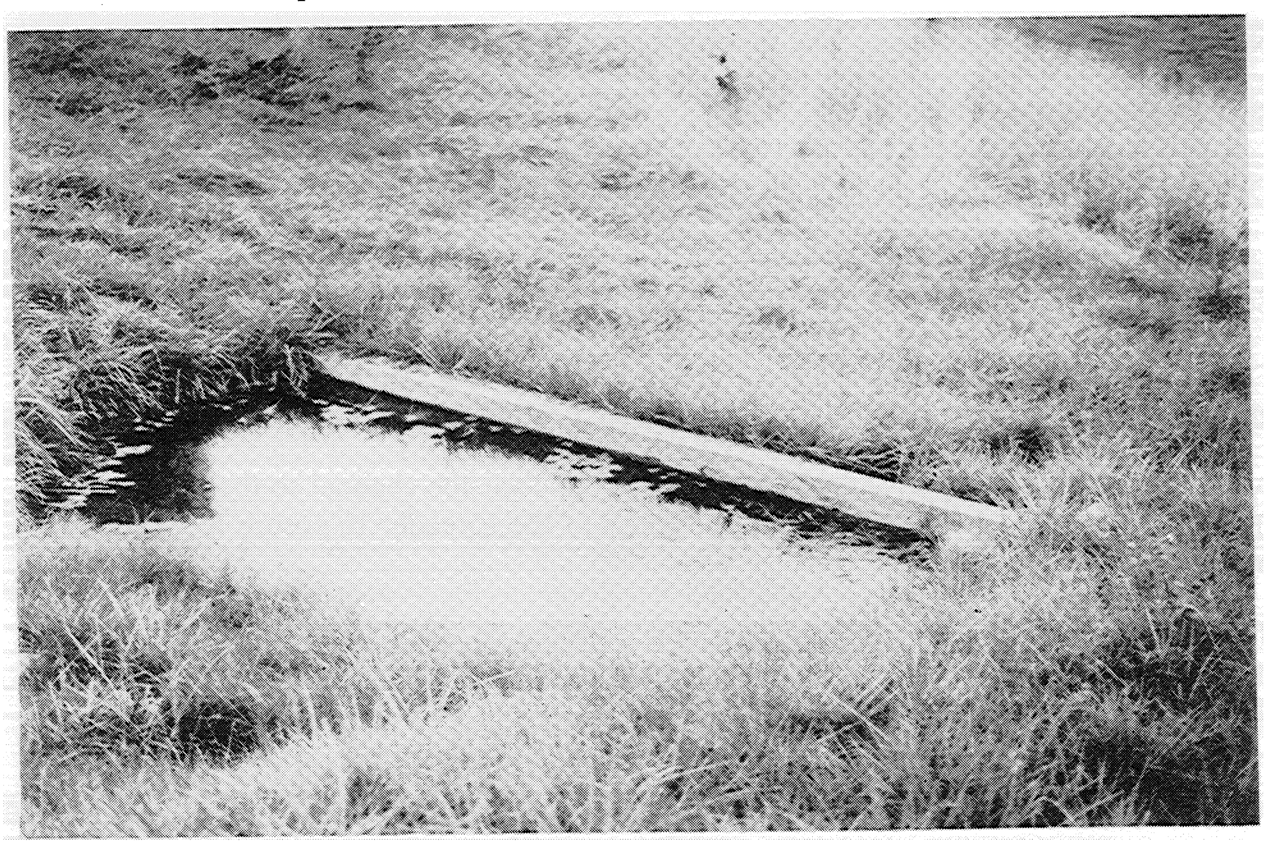
An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

Purpose

To convert concentrated runoff to sheet flow and release it uniformly onto areas stabilized by existing vegetation.

Conditions Where Practice Applies

Where there is a need to divert stormwater away from disturbed areas to avoid overstressing erosion control measures; where sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion.



This practice applies only in those situations where the spreader can be constructed on undisturbed soil and the area below the level lip is uniform with a slope of 10% or less and is stabilized by natural vegetation. The runoff water should not be allowed to reconcentrate after release unless it occurs during interception by another measure (such as a permanent pond or detention basin) located below the level spreader.

Planning Considerations

The TEMPORARY DIVERSION DIKE, (Std.& Spec. 3.09) and the TEMPORARY RIGHT-OF-WAY DIVERSION, (Std. & Spec. 3.11) each call for a stable outlet for concentrated stormwater flows. The level spreader is a relatively low-cost structure to release small volumes of concentrated flow where site conditions are suitable (see Plate 3.21-1).

The outlet area must be uniform and well-vegetated with slopes 10% or less. Particular care must be taken to construct the outlet lip completely level in a stable, undisturbed soil. Any depressions in the lip will concentrate the flow, resulting in erosion. Under higher design flow conditions, a rigid outlet lip design should be used to create the desired sheet flow conditions. Runoff water containing high sediment loads must be treated in a sediment trapping device before being released to a level spreader.

Design Criteria

No formal design is required. The following criteria must be met:

Spreader Dimensions

Determine the capacity of the spreader by estimating the peak flow expected from a 10-year storm (Q_{10}).

Select the appropriate length, width and depth of the spreader from Table 3.21-A.

For design flows greater than 20 cfs, the measure should be designed by a qualified engineer.

A 20-foot transition section should be formed in the diversion channel so that the width of the diversion will smoothly tie in with the width of the spreader to ensure more uniform outflow.

The depth of the level spreader, as measured from the lip, shall be at least 6 inches. The depth may be made greater to increase temporary storage capacity, improve trapping of debris and to enhance settling of any suspended solids.

TABLE 3.21-A

MINIMUM DIMENSIONS FOR LEVEL SPREADER

Design Flow, Q_{10} (cfs)	Depth (ft.)	Width of Lower Side Slope of Spreader (ft.)	Length (ft.)
0-10	0.5	6	10
10-20	0.6	6	20

Source: Va. DSWC

Grade

1. The grade of the channel for the last 20 feet of the dike or diversion entering the level spreader shall be less than or equal to 1% (see Plate 3.21-1).

2. The grade of the level spreader channel shall be 0%.

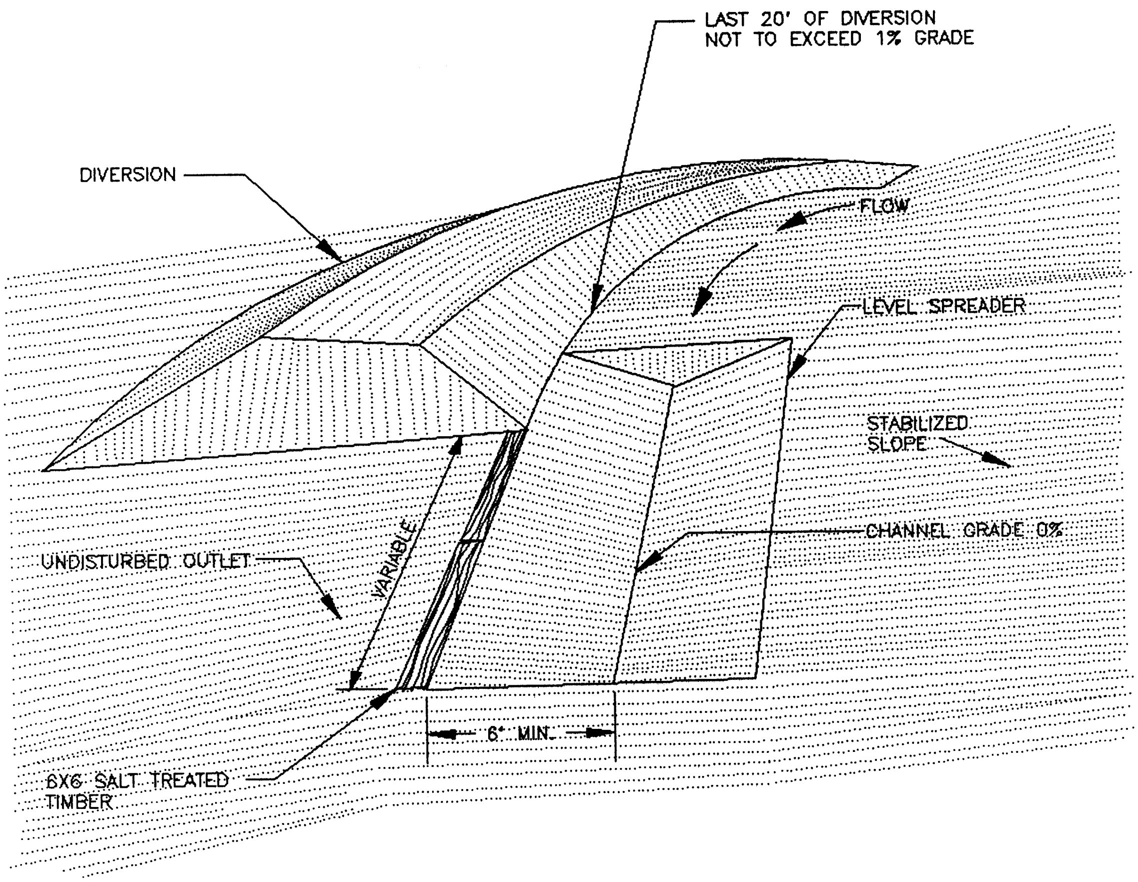
Spreader Lip

The release of the stormwater will be over the level lip onto an undisturbed well-vegetated area with a maximum slope of 10%. The level lip should be of uniform height and zero grade over the length of the spreader.

The level spreader lip may be stabilized by vegetation or may be of a rigid non-erodible material depending on the expected design flow:

Spreader Lip	Design Flow (cfs)
Vegetated	0 - 4
Rigid	5 - 20

LEVEL SPREADER



PERSPECTIVE VIEW

NOTE: ALL TEMPORARY BERMS, SWALES AND LEVEL SPREADER DITCH MUST RECEIVE TEMPORARY SEEDING IMMEDIATELY AFTER INSTALLATION

Source: Adapted from N.C. Erosion and Sediment Control Planning and Design Manual

Plate 3.21-1

A vegetated level lip must be constructed with an erosion-resistant material, such as jute or excelsior blankets, to inhibit erosion and allow vegetation to become established (see Plate 3.21-2).

For higher design flows and permanent installations, a rigid lip of non-erodible material, such as pressure-treated timbers or concrete curbing, should be used (see Plate 3.21-2).

Construction Specifications

1. Level spreaders must be constructed on undisturbed soil (not fill material).

2. The entrance to the spreader must be shaped in such a manner as to insure that runoff enters directly onto the 0% channel.

3. Construct a 20-ft. transition section from the diversion channel to blend smoothly to the width and depth of the spreader.

4. The level lip shall be constructed at <u>0% grade to insure uniform spreading of stormwater runoff</u>.

5. Protective covering for vegetated lip should be a minimum of 4 feet wide extending 6 inches over the lip and buried 6 inches deep in a vertical trench on the lower edge. The upper edge should butt against smoothly cut sod and be securely held in place with closely spaced heavy duty wire staples (see Plate 3.21-2).

6. Rigid level lip should be entrenched at least 2 inches below existing ground and securely anchored to prevent displacement. An apron of VDOT #1, #2 or #3 Coarse Aggregate should be placed to top of level lip and extended downslope at least 3 feet. Place filter fabric under stone and use galvanized wire mesh to hold stone securely in place (see Plate 3.21-2).

7. The released runoff must outlet onto undisturbed stabilized areas with slope not exceeding 10%. Slope must be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.

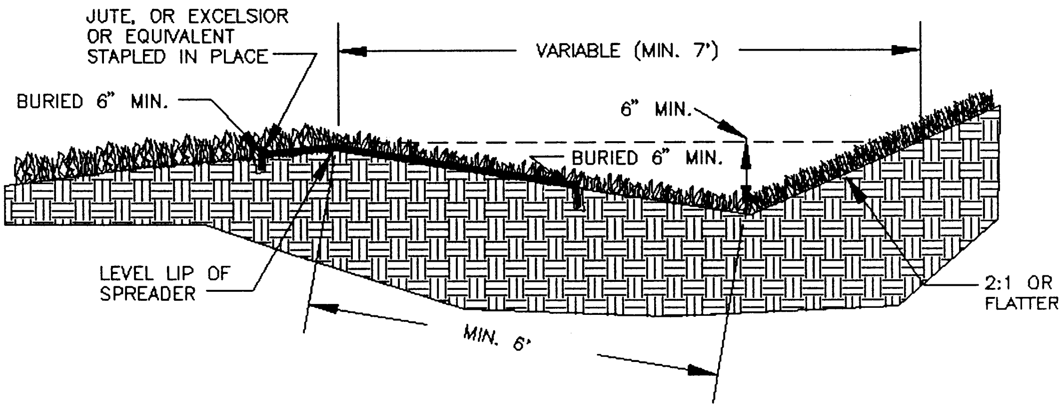
8. Immediately after its construction, appropriately seed and mulch the entire disturbed area of the spreader.

Maintenance

The measure shall be inspected after every rainfall and repairs made, if required. Level spreader lip must remain at 0% slope to allow proper function of measure. The contractor should avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, it shall be repaired immediately.

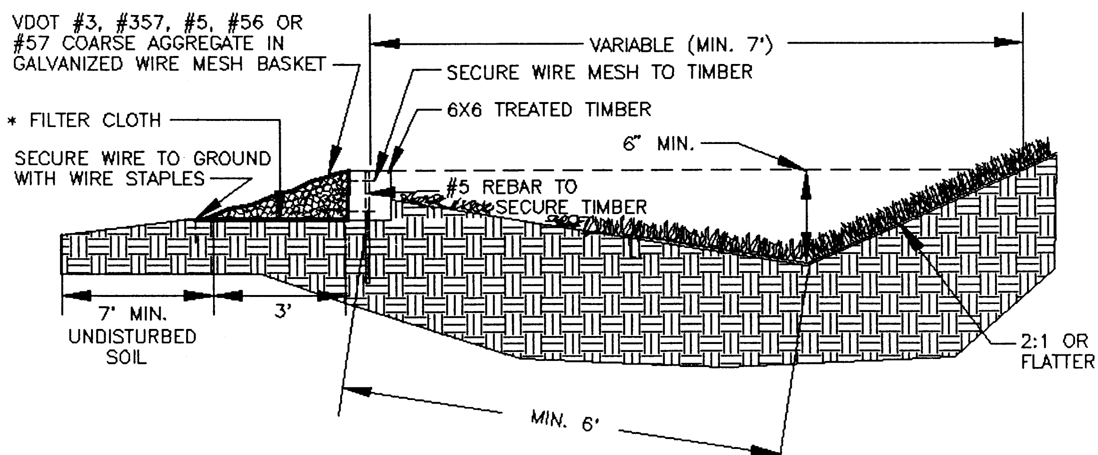
LEVEL SPREADER

CROSS SECTION



LEVEL SPREADER WITH VEGETATED LIP

CROSS SECTION



LEVEL SPREADER WITH RIGID LIP

* MIN. PHYSICAL REQUIREMENTS OF FILTER CLOTH NOTED IN STD. & SPEC. 3.19, RIPRAP

Source: Va. DSWC and N.C. Erosion and Sediment Control Planning and Design Manual

Plate 3.21-2

STD & SPEC 3.22

VEGETATIVE STREAMBANK STABILIZATION

VSS

Definition

The use of vegetation in stabilizing streambanks.

Purpose

To protect streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Along banks in creeks, streams and rivers subject to erosion from excess runoff. This practice is generally applicable where bankfull flow velocity does not exceed 5 ft./sec. and soils are erosion resistant. Above 5 ft./sec., structural measures are generally required. This practice does not apply where tidal conditions exist.

Planning Considerations

A primary cause of stream channel erosion is the increased frequency of bank-full flows which often result from upstream development. Most natural stream channels are formed with a bank-full capacity to pass the runoff from a storm with a 1½ to 2-year recurrence interval. However, in a typical urbanizing watershed, stream channels are subject to a 3- to 5-fold increase in the frequency of bank-full flows. As a result, stream channels that were once parabolic in shape and covered with vegetation are often transformed into wide rectangular channels with barren banks.

In recent years, a number of structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, if employed correctly, immediately insure a satisfactory protection of the banks. However, many such structures are expensive to build and to maintain and frequently cause downstream velocity problems. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent the re-establishment of native plants and animals, especially when the design is executed according to standard cross-sections which ignore natural variations of the stream system. Very often these structural measures destroy the appearance of the site.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural vegetation is more reliable and effective where the cover consists of natural plant communities which are native to the site. Planting vegetation is less damaging to the environment than installing structures. Vegetation also provides habitat for fish and wildlife and is aesthetically pleasing. Plants provide erosion protection to streambanks by reducing stream velocity, binding soil in place with a root mat and covering the soil surface when high flows tend to flatten vegetation against the banks. For these reasons, vegetation should always be considered first.

One disadvantage of vegetation is that it lowers the carrying capacity of the channel, which may promote flooding. Therefore, maintenance needs and the consequences of flooding should be considered. The erosion potential for the stream needs to be evaluated to determine the best solutions. The following items should be considered in the evaluation:

1. The frequency of bankfull flow based on anticipated watershed development.

2. The channel slope and flow velocity, by design reaches.

3. The antecedent soil conditions.

4. Present and anticipated channel roughness ("n") values.

5. The location of channel bends along with bank conditions.

6. The location of unstable areas and trouble spots. Steep channel reaches, high erosive banks and sharp bends may require structural stabilization measures such as riprap, while the remainder of the streambank may require only vegetation.

Where streambank stabilization is required and velocities appear too high for the use of vegetation, one should consider structural measures (see Std. & Spec. 3.23, STRUCTURAL STREAMBANK STABILIZATION) or the use of permanent erosion control matting (see Std. & Spec. 3.36, SOIL STABILIZATION MATTING). Notably, any applicable approval or permits from other state or federal agencies must be obtained prior to working in such areas.

Vegetation Zones Along Watercourses

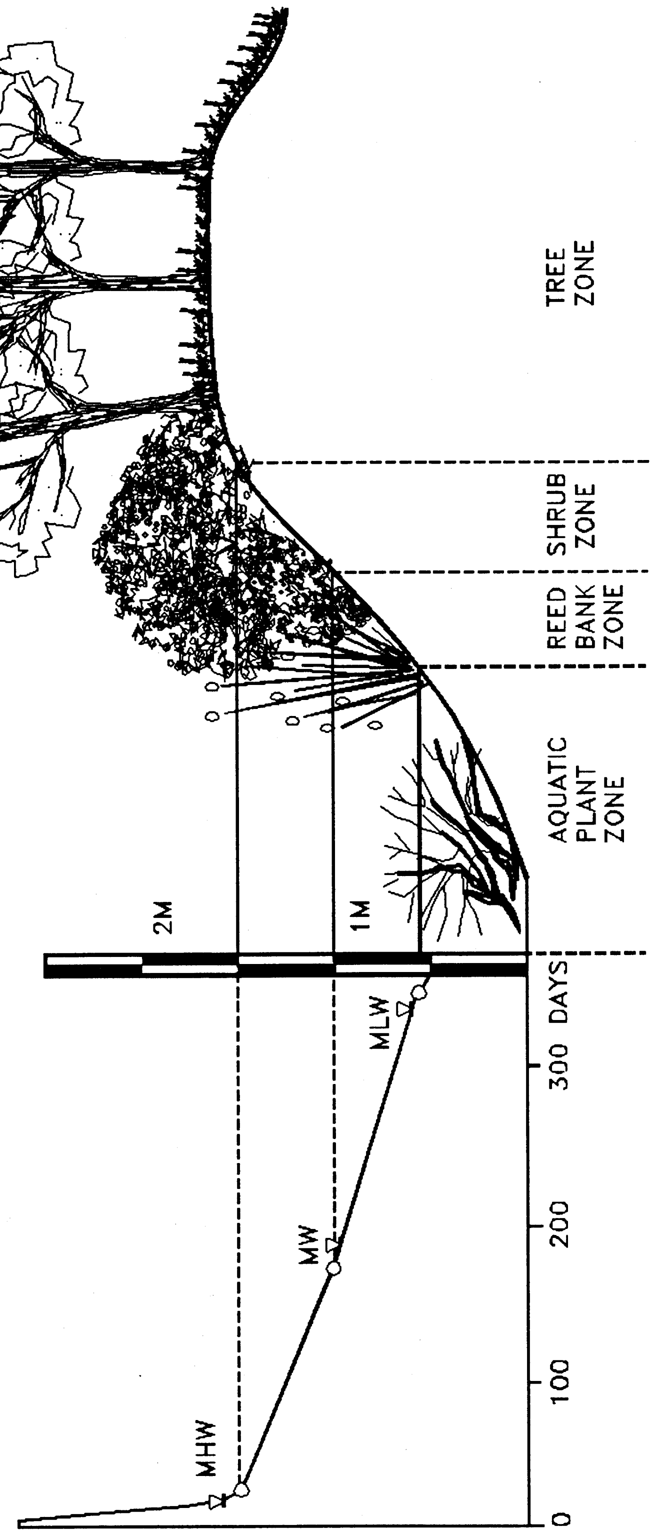
At the edge of all natural watercourses, plant communities exist in a characteristic succession of vegetative zones, the boundaries of which are dependent upon site conditions such as the steepness and shape of the bank and the seasonal and local variations in water depth and flow rate. Streambanks commonly exhibit the following zonation (see Plate 3.22-1):

1. Aquatic Plant Zone - This zone is normally permanently submerged. In Virginia, this zone is inhabited by plants such as pondweeds and water lilies, which reduce the water's flow rate by friction. The roots of these plants help to bind the soil, and they further protect the channel from erosion because the water flow tends to flatten them against the banks and bed of the stream.

2. Reed-Bank Zone - The lower part of this zone is normally submerged for only about half the year. In Virginia, this zone is inhabited by rushes, reed grasses, cattails, and other plants which bind the soil with their roots, rhizomes and shoots and slow the water's flow rate by friction.

3. Shrub Zone - This zone is flooded only during periods of average high water. In Virginia, the shrub zone is inhabited by trees and shrubs--such as willow, alder, dogwood and viburnum--with a high regenerative capacity. These plants hold the soil with their root systems and slow water speed by friction. They also protect tree trunks from damage caused by breaking ice and help to prevent the formation of strong eddies around large trees during flood flows. Shrub zone vegetation is particularly beneficial along the impact bank of a stream meander, where maximum scouring tends to occur. Infringement of shrub vegetation into the channel tends to reduce the channel width, increasing probability of floods. However, brief flooding of riverside woods and undeveloped bottomlands does no significant damage, and the silt deposits in these wooded areas are less of a problem than failed banks.

4. Tree Zone - This zone is flooded only during periods of very high water (i.e., the 2-year bank-full flow or greater flows). Typical plants in Virginia are trees in the ash-elm, alder-ash, and oak-horn-beam associations. These trees hold soil in place with their root systems.



TYPICAL ANNUAL CURVE OF WATER LEVELS CORRELATED WITH TYPICAL VEGETATIVE ZONES

Source: Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers and Canals, Seibert

Plate 3.22-1

Design Criteria

Table 3.22-A provides general guidelines for maximum allowable velocities in streams to be protected by vegetation.

1. Ensure that channel bottoms are stable before stabilizing channel banks.

2. Keep velocities at bankfull flow non-erosive for the site conditions.

3. Provide mechanical protection such as rip-rap on the outside of channel bends if bankfull stream velocities approach the maximum allowable for site conditions.

4. Be sure that requirements of other state or federal agencies are met in the design in the case that other approvals or permits are necessary.

TABLE 3.22-A

CONDITIONS WHERE VEGETATIVE STREAMBANK STABILIZATION IS ACCEPTABLE

Frequency of Bankfull Flow	Max. Allowable Velocity for Highly Erodible Soil	Maximum Allowable Velocity (Erosion Resistant Soil)
> 4 times/yr.	4 ft./sec.	5 ft./sec.
1 to 4 times/yr.	5 ft./sec.	6 ft./sec.
< 1 time/yr.	6 ft./sec.	6 ft./sec.

Source: Va. DSWC

Planting Guidelines

Guidelines will be presented only for the reed-bank and shrub zones. The aquatic plant zone is difficult to implant and establish naturally when reed-bank vegetation is present. There are presently many experts in this field at the federal, state, and private sector levels who can be consulted concerning successful establishment of plants in the aquatic zone. The tree zone is least significant in terms of protecting banks from more frequent erosion-force flows, since this zone is seldom flooded. Also, shade from trees in this zone can prevent adequate establishment of vegetation in other zones.

1. Establishing Reed-Bank Vegetation

There are various ways of planting reed-bank vegetation. The following plants are considered suitable:

Common Reed	(Phragmites communis)
Reed Canary Grass	(Phalaris arundinacae)
Great Bulrush	(Scirpus lacustris)
Common Cattail	(Typha latifolia)

The greatest protection seems to be provided by the Common Reed. It is a very robust plant whose stems become woody in the autumn, resulting in continued protection during the winter. Because the shoots and rhizomes are deeply and strongly rooted and densely intertwined, they bind the soil more firmly than any other reed. The stems and roots have dormant buds at the nodes and are capable of sprouting when planted. However, the Common Reed does grow high and thick, and periodic maintenance may be needed in order to achieve a neat appearance.

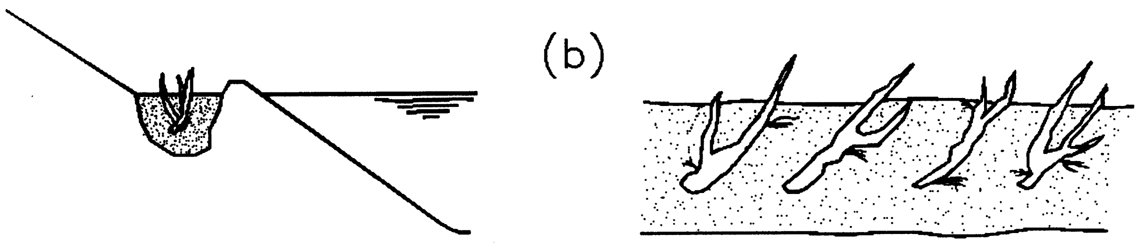
a. Planting in Clumps: The oldest and most common method of planting reeds is planting in clumps (see Plate 3.22-2 (a)). The stems of the reed colony are scythed. Then square clumps are cut out of the ground and placed in pits prepared in advance on the chosen site. The clumps are planted at a depth where they will be submerged to a maximum of two-thirds of their height.

b. Planting Rhizomes and Shoots: Less material is needed for the planting of rhizomes and shoots, a procedure which can be used to establish the Common Reed, Reed Grass, Bulrush, Cattail and other plants. Slips are taken from existing beds during the dormant season, after the stems have been cut. Rhizomes and shoots are carefully removed from the earth without bruising the buds or the tips of the sprouts. They are placed in holes or narrow trenches, along the line of the average summer water level, so that only the stem sprouts are showing above the soil.

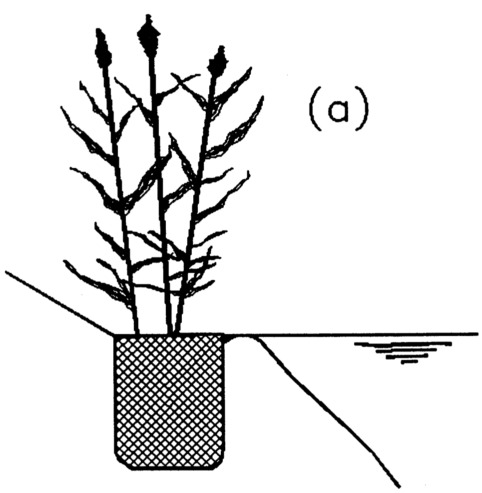
c. Planting Stem Slips: It is possible to plant stem slips of the Common Reed along slow-moving streams (see Plate 3.22-2 (b)). Usually, three slips are set in a pit 12 to 20 inches deep. If the soil is packed or strong, the holes must be made with a dibble bar or some other metal planting tool. The pits should be located approximately 1 foot apart.

d. Reed Rolls: In many cases, the previously described methods do not consolidate the banks sufficiently during the period immediately after planting. Combined structures have therefore been designed, in which protection of the bank is at first insured by structural materials. Along slow to fairly fast

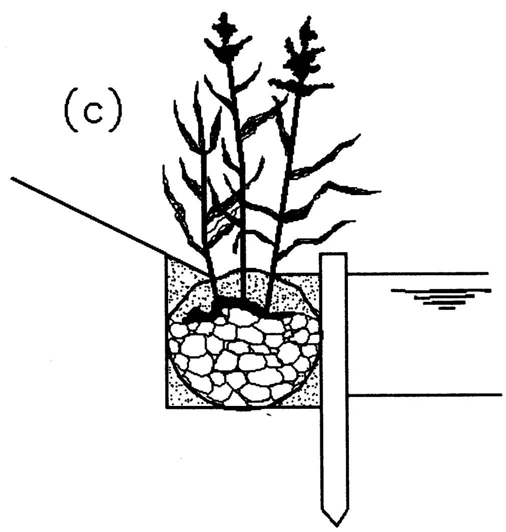
METHODS OF ESTABLISHING REED BANK VEGETATION



PLANTING STEM SLIPS



PLANTING CLUMPS



REED ROLLS

Source: Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers and Canals, Seibert

Plate 3.22-2

streams, the most effective method of establishing reed-bank vegetation has been found to be the use of Reed Rolls (see Plate 3.22-2 (c)). A trench 18 inches wide and deep is dug behind a row of stakes. Wire netting, such as ½-inch hardware cloth, is then stretched from both sides of the trench between upright planks. Onto this netting is dumped fill material such as coarse gravel, sod, or soil and other organic material. This material is then covered by reed clumps until the two edges of the wire netting can just be held together with wire. The upper edge of the roll should be no more than 2 inches above the level of the water. Finally, the planks are taken out, and any gaps along the sides of the roll are filled in with earth. This method provides greater protection from the possibility of a heavy flow washing away the vegetative materials before they have a chance to become established.

e. Seeding: Reed Canary Grass can be sown 1/2-inch deep on very damp bank soil, provided that the seeded surface is not covered by water for six months after sowing. Seed at a rate of 12-15 lbs./acre. Reed Canary Grass is a cool season grass and should not be seeded in the summer.

f. Vegetation and Stone Facing: Reed-bank and other types of vegetation can be planted in conjunction with rip-rap or other stone facing by planting clumps, rhizomes or shoots in the crevices and gaps along the line of the average summer water level.

2. Establishing Shrub Zone Vegetation: Stands of full-grown trees are of little use for protecting streambanks apart from the binding of soil with their roots. Shrubwood provides much better protection; and in fact, riverside stands of willow trees are often replaced naturally by colonies of shrub-like willows. Plants should be used which can easily adapt to the stream and site conditions.

a. Seeding and Sodding: Frequently, if the stream is small and a good seedbed can be prepared, grasses can be used alone to stabilize the streambanks. To seed the shrub zone, first grade eroded or steep streambanks to a maximum slope of 2:1 (3:1 preferred). Existing trees greater than 4 inches in diameter should be retained whenever possible. Topsoil should be conserved for re-use. Seeding mixtures should be selected and operations performed according to Std. & Spec. 3.32, PERMANENT SEEDING. Some type of erosion control blanket, such as jute netting, excelsior blankets, or equivalent should be installed according to Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS & MATTING. Sod can also be placed in areas where grass is suitable. Sod should be selected and installed according to Std. & Spec. 3.33, SODDING. Turf should only be used where the grass will provide adequate protection, necessary maintenance can be provided, and establishment of other streambank vegetation is not practical or possible.

b. Planting Cuttings and Seedlings: Shrub willows, shrub dogwoods and alders can be put into the soil as cuttings, slips or stems. In dense shade, shrubs such as the Blue Arctic Willow (Salix purpurea nana) and the Silky Dogwood (Cornus amomum) or evergreen ground covers such as Lily Turf (Liriope Muscari) or Hall's Honeysuckle (Linicera hallsiana) are appropriate. The Silky Dogwood also works well in sunny areas. On larger streams, "Streamco" Purpleosier Willow (Salix purpurea "Streamco") and Bankers' Dwarf Willow (Salix x Cotteti) have been widely used with success. Two native river alders (Alnus serrulata and Alnus rugosa), which occur throughout the northeast, also show great promise for streambank stabilization, although they have not been fully tested. Again, the first step in the planting process is to grade eroded or steep slopes to a maximum slope of 2:1 (3:1 preferred), removing overhanging bank edges.

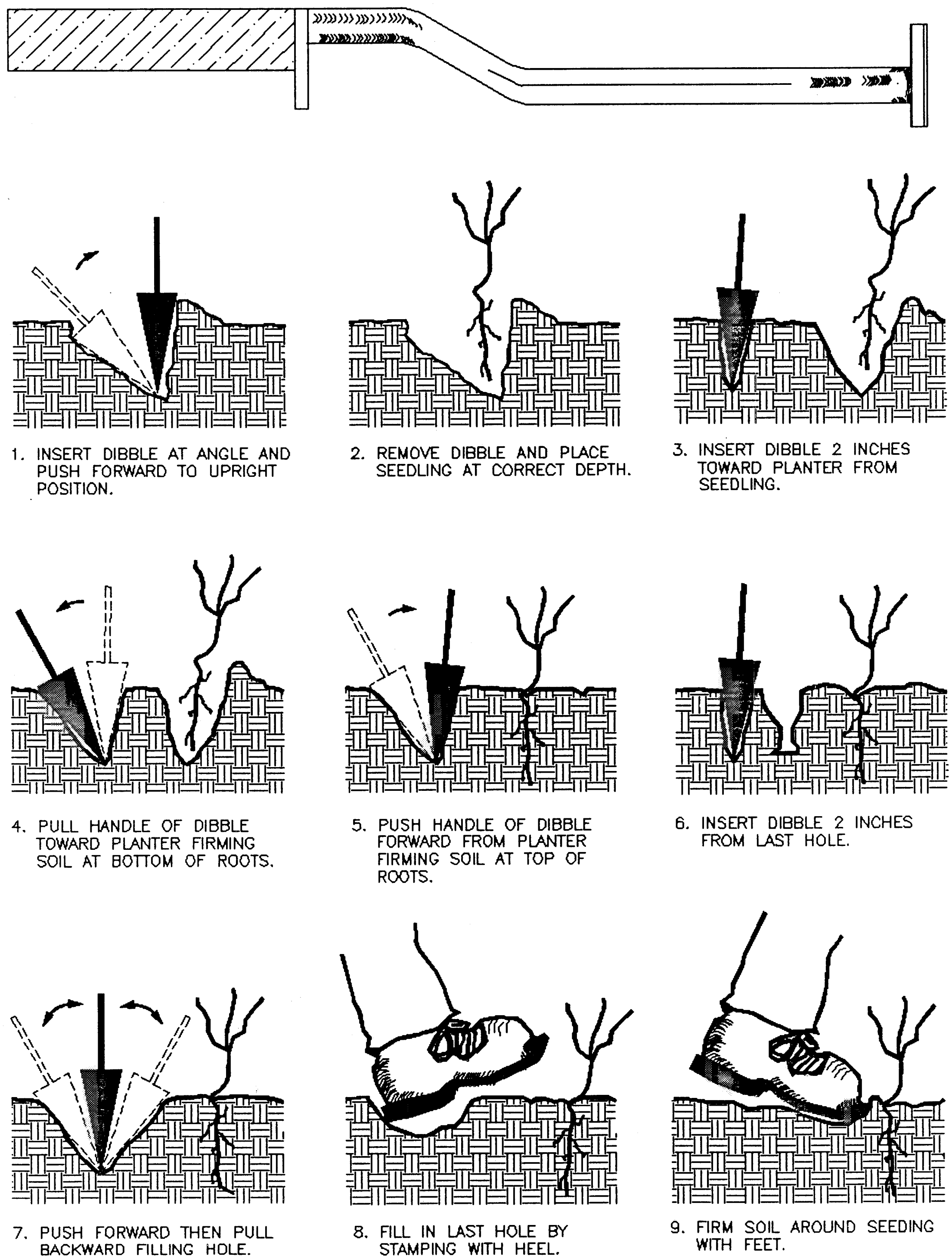
Willows can be planted as 1-year old, nursery-grown, rooted cuttings or as fresh hardwood cuttings gathered from local mother-stock plantings. Silky Dogwood and the alders should be nursery-grown seedlings 1 or 2 years old. Fresh cuttings should be 3/8- to 1/2-inch thick and 12 to 18 inches long. They should be kept moist. If not used at once, they should be stored in cool moist sand.

Streambanks are often difficult to plant, even when they are well-sloped. This is especially true in gravelly or strong banks. Where mattocks or shovels are unsatisfactory tools, a stiff steel bar, such as a crowbar, is better. The best tool for this purpose is a dibble bar, a heavy metal tool with a blade and a foot pedal. It is thrust into the ground to make a hole for the plant (see Plate 3.22-3).

Rooted cuttings should be planted vertically in the bank with 1 or 2 inches of wood protruding above the ground surface. They should be stuck in a hole large enough to accommodate the root system when well spread. The plant roots must be maneuvered into the bottom of the hole so they will grow down instead of up. The roots should not be twisted, nor should they be exposed above the ground surface. After the plant is placed, the dibble bar can be installed a few inches away from the plant to close the hole. Slow-release fertilizer should be applied on the surface, not in the hole. The soil should be tamped adequately to provide complete contact between the soil and the cutting. Cuttings should be planted 1 foot on center in at least 3 rows located at the top, middle and bottom of the shrub zone.

Plant seedings of the river alders vertically in the bank to the depth they were growing in the nursery. Use the same procedure described previously. Plant one row of alders at 2-foot intervals at the base of the shrub zone, not more than 1.5 to 3 feet from the average summer water level or from the reeds. A greater distance is of no use unless a belt of tall perennial herb colonies is established between the reeds and the alders. Plant the next row 2 feet up

DIBBLE PLANTING



Source: A Guide For Vegetating Surface-Mined Lands For Wildlife in Eastern Kentucky and West Virginia, USDI-Fish and Wildlife Service

Plate 3.22-3

the slope, with a third row 4 feet up the slope. Plant at least 3 rows. Locate the plants in a diamond pattern.

Since these plants are generally not effective for the first two years, grasses can be seeded immediately following their planting to provide initial streambank protection. The seed mixtures noted in Table 3.22-B are appropriate plantings.

TABLE 3.22-B

INITIAL STREAMBANK PLANTINGS: SEED MIXTURES BY REGION*

Appalachian Region	Piedmont Region	Coastal Plain
Kentucky-31 Tall Fescue: 65 lbs./acre Creeping Red Fescue: 15 lbs./acre Redtop Grass: 5 lbs./acre	Kentucky-31 Tall Fescue: 80 lbs./acre. Redtop Grass: 5 lbs./acre	Kentucky-31 Tall Fescue: 65 lbs./acre Bermudagrass: 15 lbs./acre Redtop Grass: 5 lbs./acre

* Physiographic Regions are described in Std. & Spec. 3.32, PERMANENT SEEDING.

Source: Va. DSWC

The seedbed should be roughened with rakes and fertilized with 500 to 1000 pounds per acre of 10-10-10, adjusted to meet the needs of the site. Special care should be used when fertilizing next to water sources to avoid any unnecessary introduction of nitrogen/phosphorus into the water. Seed should be broadcast, covered lightly and mulched with 2 tons of straw per acre (2-3 bales per 1000 square feet) or a minimum of 1500 pounds of wood fiber mulch per acre (2000 pounds per acre preferred). If straw is used, it should be properly anchored with netting or an effective tackifier. Erosion control blankets/mats are often very effective aids in the establishment of grasses or plant material along streambanks (see Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS & MATTING).

Willows and other softwoods can also be bound together in various ways in order to insure immediate protection of the streambank.

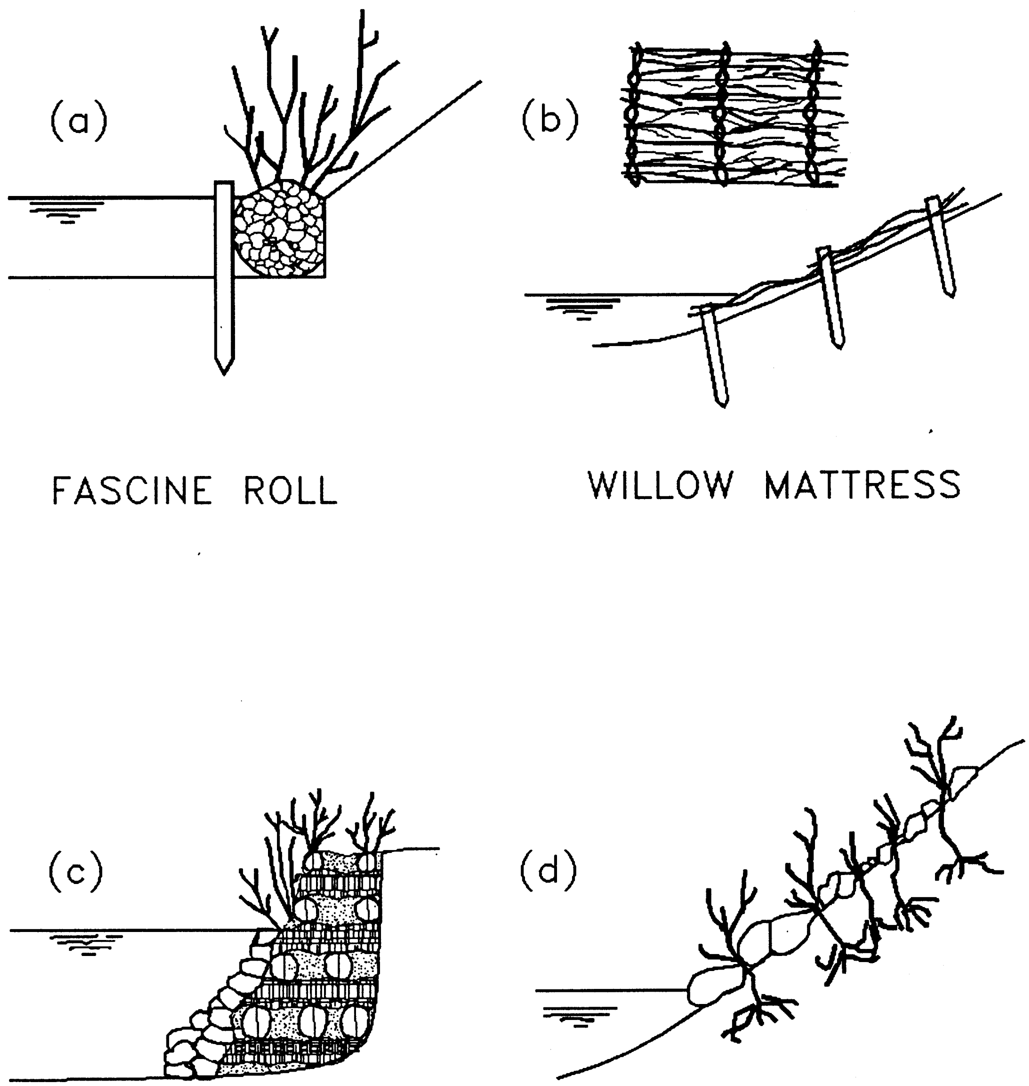
c. Fascine Rolls: Fascine rolls are bundles of brushwood and sticks, without branches if possible, that are filled with coarse gravel and rubble and wired tightly around the outside. They are 4 to 20 yards long and 4 to 16 inches in diameter. They are set against the bank so that the parts which are to take root touch the ground above the water level and are able to get sufficient moisture. Covering with earth improves the contact with the ground and retards the loss of moisture from the wood (see Plate 3.22-4 (a)).

d. Willow Mattresses: The degree of streambank protection can be increased by using willow mattresses or packed fascine work. Willow mattresses consist of 4- to 8-inch thick layers of growing branches set perpendicular to the direction of the current or sloping downstream. with the broad ends of the branches oriented downwards. The branches are held together with interweaving wire or other branches at intervals of 24 to 32 inches, set parallel to the direction of the current or at an angle of 30 degrees. If several layers of mattress are necessary, the tops of the lower layers should cover the bases of the upper layers. The bottom layer is fixed at the base in a trench previously dug at the base of the softwood zone. The whole mattress structure should be covered with 2 to 10 inches of earth or fine gravel (Plate 3.22-4 (b)).

e. Packed Fascine-Work: Packed fascine-work [Plate 3.22-4 (c)] consists essentially of layers of branches laid one across the other to a depth of 8 to 12 inches and covered with fascine rolls. The spaces between the fascine rolls are filled with gravel, stones and soil so that no gaps remain; and a layer of soil and gravel 8 to 12 inches thick is added on top. Packed fascine-work is particularly suitable for repairing large breaches in the banks of streams with high water levels.

f. Combination with Stone Facing: In many places, the bank is not adequately protected by vegetation until the roots are fully developed, and temporary protection must be provided by inanimate materials. There is a wide choice of methods, including the planting of woody plants in the crevices of stone facing (Plate 3.22-4 (d)). For structural protection measures, see Std. & Spec. 3.23, STRUCTURAL STREAMBANK PROTECTION.

METHODS OF ESTABLISHING SHRUB ZONE VEGETATION



(a) FASCINE ROLL

(b) WILLOW MATTRESS

(c) PACKED FASCINE WORK

(d) CUTTINGS BETWEEN RIPRAP

Source: Importance of Natural Vegetation for the Protection of the Banks of Streams, Rivers and Canals, Seibert

Plate 3.22-4

Maintenance

Streambanks are always vulnerable to new damage. Repairs are needed periodically. Banks should be checked after every high-water event is over. Gaps in the vegetative cover should be fixed at once with new plants, and mulched if necessary. Fresh cuttings from other plants on the bank can be used, or they can be taken from mother-stock plantings if they are available. Trees that become established on the bank should be removed at once.

STD & SPEC 3.23

STRUCTURAL STREAMBANK STABILIZATION

SSS

Definition

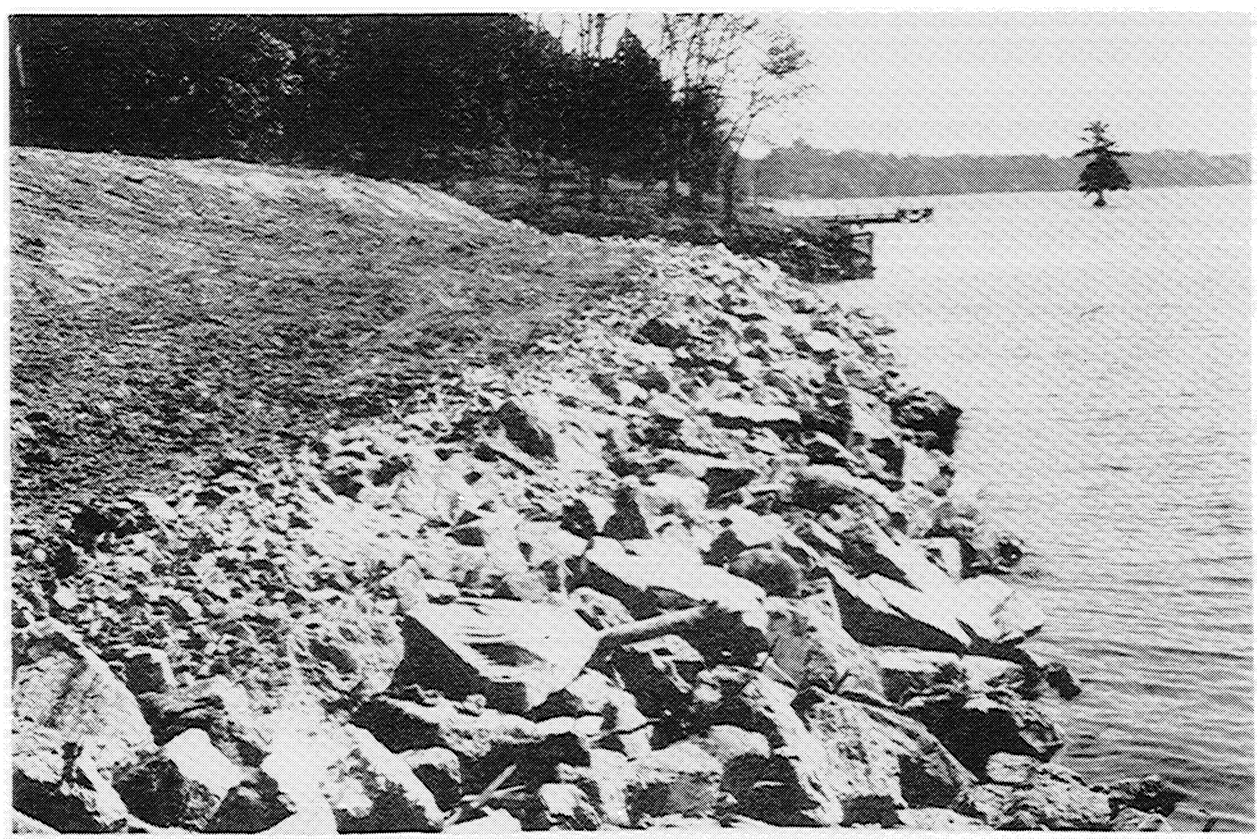
Methods of stabilizing the banks of live streams with permanent structural measures.

Purpose

To protect streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Applicable to streambank sections which are subject to excessive erosion due to increased flows or disturbance during construction. Generally applicable where flow velocities exceed 5 ft./sec. or where vegetative streambank protection is inappropriate.



Planning Considerations

Stream channel erosion problems vary widely in type and scale and there are many different structural stabilization techniques which have been employed with varying degrees of effectiveness. The purpose of this specification is merely to point out some of the practices which are available and to establish some broad guidelines for their selection and design. Such structures should be planned and designed in advance by an engineer or some other qualified individual with appropriate experience. Many of the practices referenced here involve the use of manufactured products and should be designed and installed in accordance with the manufacturers' specifications.

Before selecting a structural stabilization technique, the designer should carefully evaluate the possibility of using vegetative stabilization (Std. & Spec. 3.22) alone or in conjunction with structural measures, to achieve the desired protection. Vegetative techniques are generally less costly and more compatible with natural stream characteristics.

General Guidelines

Since each reach of channel requiring protection is unique, measures for streambank protection should be installed according to a plan and adapted to the specific site. Designs should be developed according to the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.
2. The bottom scour should be controlled, by either natural or artificial means, before any permanent type of bank protection can be considered feasible. This is not necessary if the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.
3. Streambank protection should be started and ended at a stabilized or controlled point on the stream.
4. Changes in channel alignment shall be made only after an evaluation of the effect upon land use, interdependent waste water systems, hydraulic characteristics and existing structures.
5. Special attention should be given to maintaining and improving habitat for fish and wildlife.
6. The design velocity should be that of the peak discharge of the 10-year storm. Structural measures must be effective for this design flow and must be capable of withstanding greater flows without serious damage.

7. All requirements of state law and permit requirements of local, state and federal agencies must be met.

8. Stabilize all areas disturbed by construction as soon as the structural measures are complete.

Streambank Protection Measures

Riprap - heavy angular stone placed (preferably) or dumped onto the streambank to provide armor protection against erosion. Riprap shall be designed and installed according to the practice entitled RIPRAP (Std. & Spec. 3.19).

Gabions - rectangular, rock-filled wire baskets are pervious, semi-flexible building blocks which can be used to armor the bed and/or banks of channels or to divert flow away from eroding channel sections. Gabions should be designed and installed in accordance with manufacturer's standards and specifications (see Plate 3.23-1). At a minimum, they should be constructed of a hexagonal triple twist mesh of heavily galvanized steel wire (galvanized wire may also receive a poly-vinyl chloride coating). The design water velocity for channels utilizing gabions should not exceed that given below:

Gabion Thickness (feet)	Maximum Velocity (feet per second)
1/2	6
3/4	11
1	14

Deflectors (groins or jetties) - Structural barriers which project into the stream to divert flow away from eroding streambank sections. Plate 3.23-2 contains general guidelines for designing and installing deflectors.

Installation of Structures Under Wave and/or Tidal Action

The installation of riprap, gabions or deflectors under significant wave action or under tidal conditions requires special design considerations to ensure stability of the measure and the area it protects. The design/installation of these measures for tidal areas is beyond the scope of the Virginia Erosion and Sediment Control Law and Virginia Erosion and Sediment Control Regulations. The DSWC's Shoreline Programs Bureau can be consulted in regard to minimum design parameters for tidal installations. For situations where there is significant wave action affecting the shoreline of a nontidal lake or pond, the design parameters presented in Std. & Spec. 3.19, RIPRAP, should be used. Notably, there are many other site specific factors which should be incorporated into a design; hence, it is recommended that the design parameters presented only be used as minimum requirements and that a qualified professional be consulted when the installation of such a structure is contemplated.

Reinforced Concrete - may be used to armor eroding sections of the streambank by constructing retaining walls or bulk heads. Positive drainage behind these structures must be provided. Reinforced concrete may also be used as a channel lining (see Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNEL).

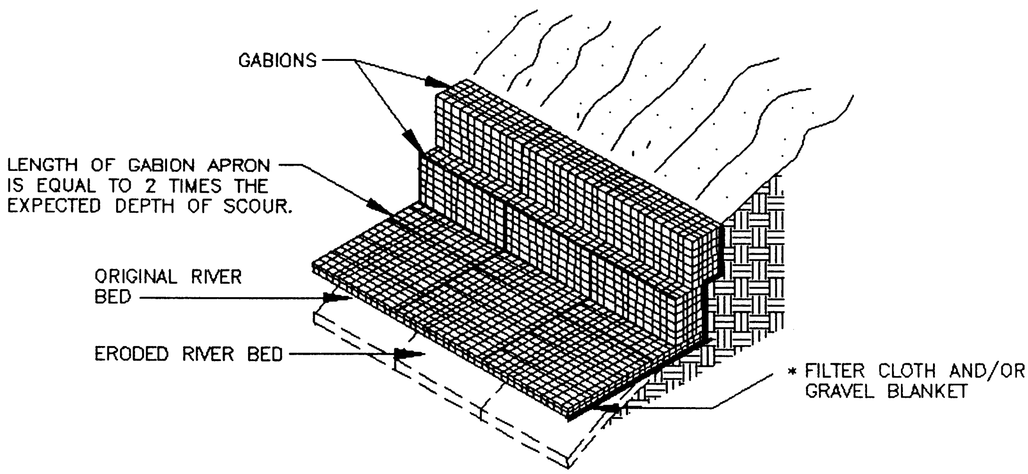
Log Cribbing - a retaining structure built of logs to protect streambanks from erosion. Log cribbing is normally built on the outside of stream bends to protect the streambank from the impinging flow of the stream (see Plate 3.23-3).

Grid Pavers - modular concrete units with interspersed void areas which can be used to armor the streambank while maintaining porosity and allowing the establishment of vegetation. These structures may be obtained in pre-cast blocks or mats, or they may be formed and poured in place. Design and installation should be in accordance with manufacturer's instructions (see Plate 3.23-4).

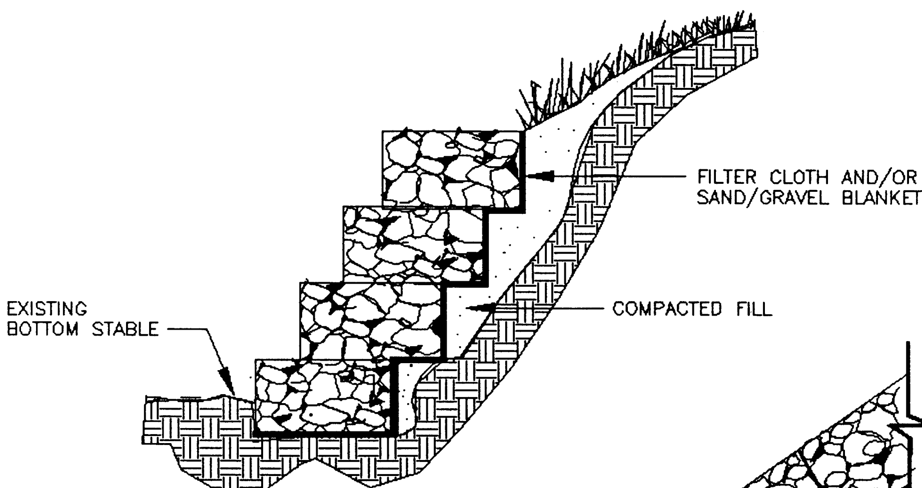
Maintenance

All structures should be maintained in an "as built" condition. Structural damage caused by storm events should be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank.

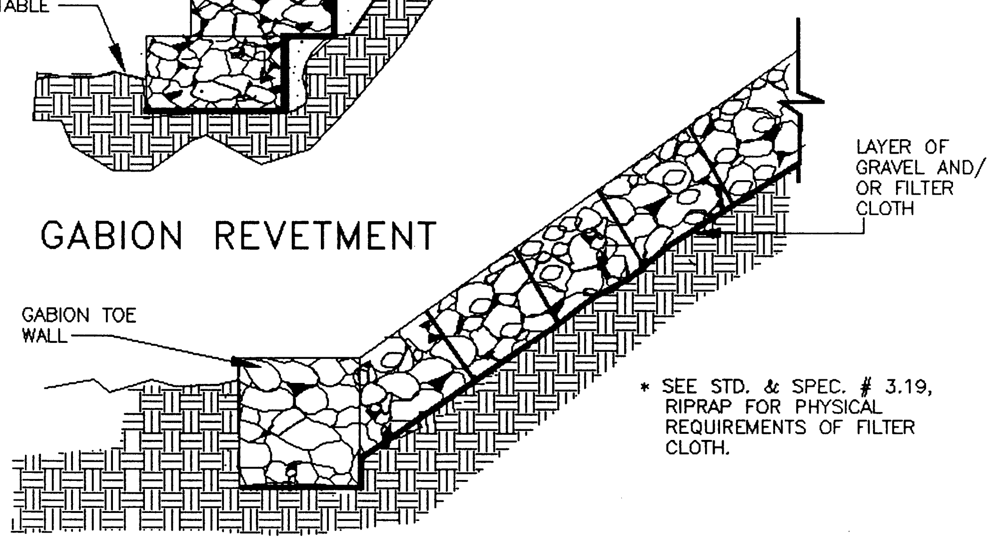
GABIONS



GABION TOE WALL



GABION REVETMENT

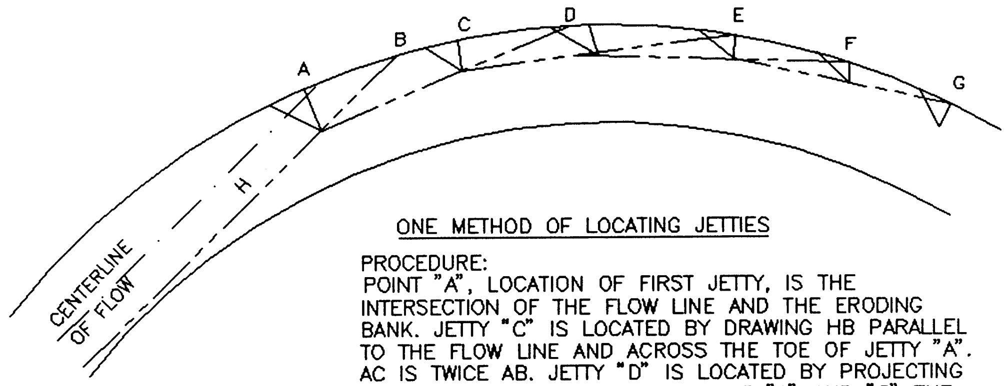


REVETMATTRESS / RENOMATTRESS

Source: Adapted from product literature of Bekaert Gabions

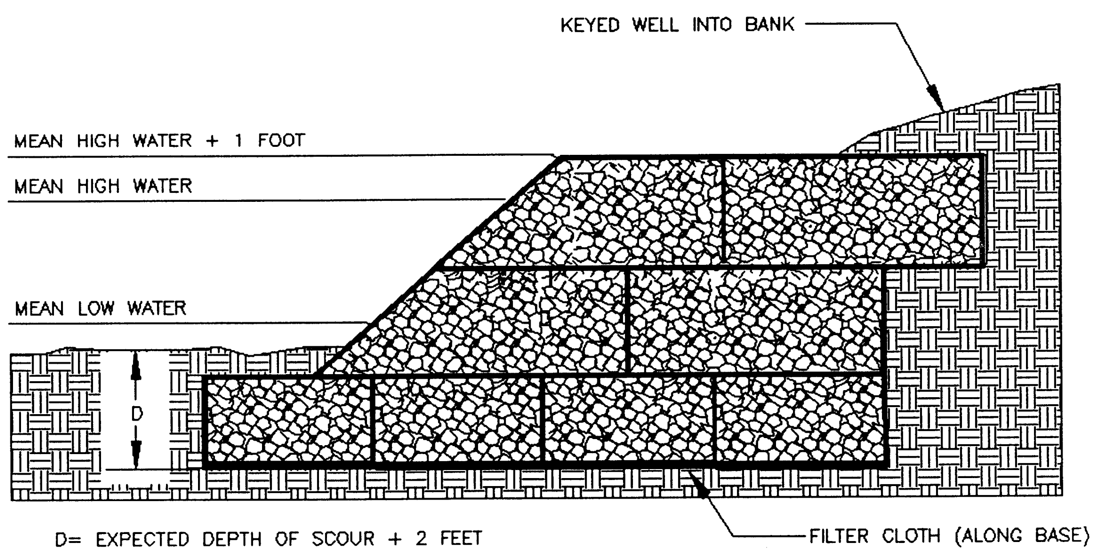
Plate 3.23-1

DEFLECTORS



ONE METHOD OF LOCATING JETTIES

PROCEDURE:
POINT "A", LOCATION OF FIRST JETTY, IS THE INTERSECTION OF THE FLOW LINE AND THE ERODING BANK. JETTY "C" IS LOCATED BY DRAWING HB PARALLEL TO THE FLOW LINE AND ACROSS THE TOE OF JETTY "A". AC IS TWICE AB. JETTY "D" IS LOCATED BY PROJECTING A LINE ACROSS THE TOE OF JETTIES "A" AND "C". THE REMAINING JETTIES ARE LOCATED THE SAME AS "D". SUPPLEMENTARY JETTY "K" IS LOCATED AC DISTANCE UPSTREAM FROM "A".

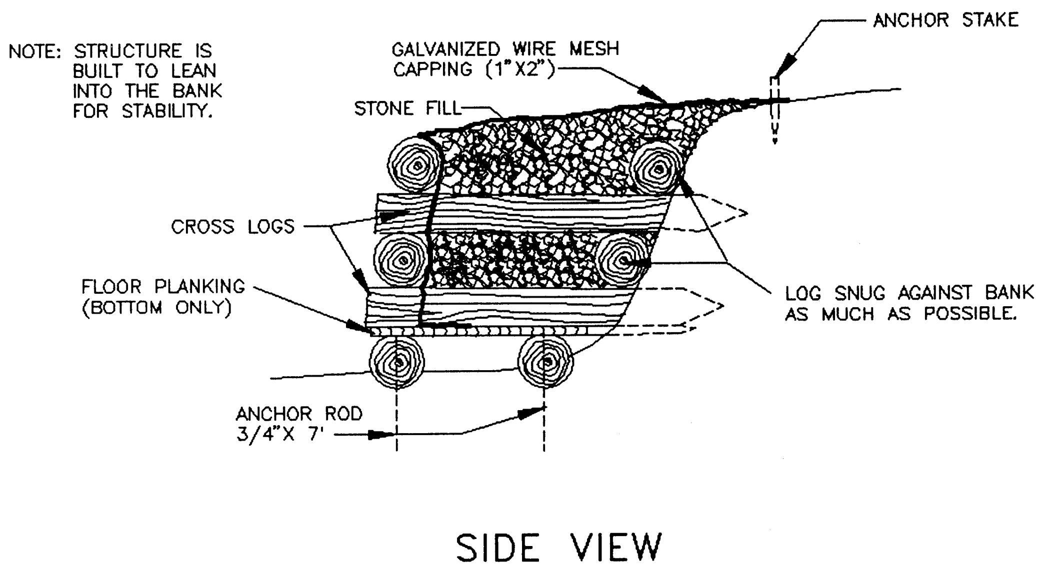


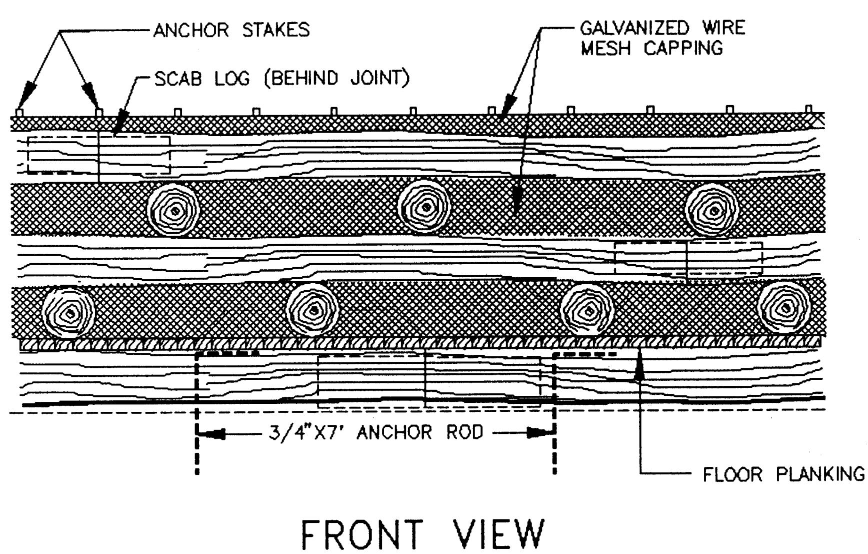
TYPICAL GABION DEFLECTOR

Source: Adapted from product literature of Bekaert Gabions

Plate 3.23-2

LOG CRIBBING

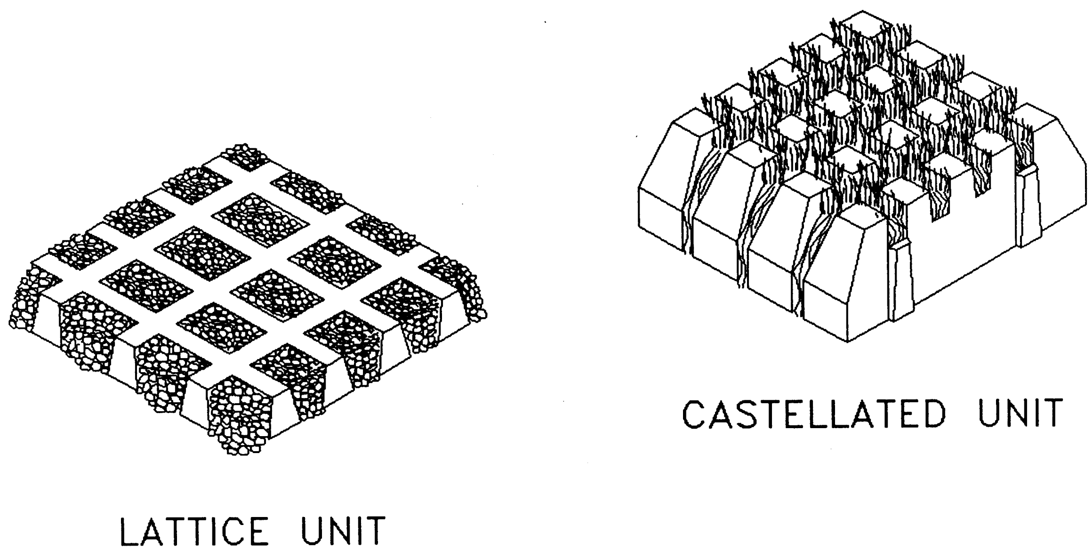


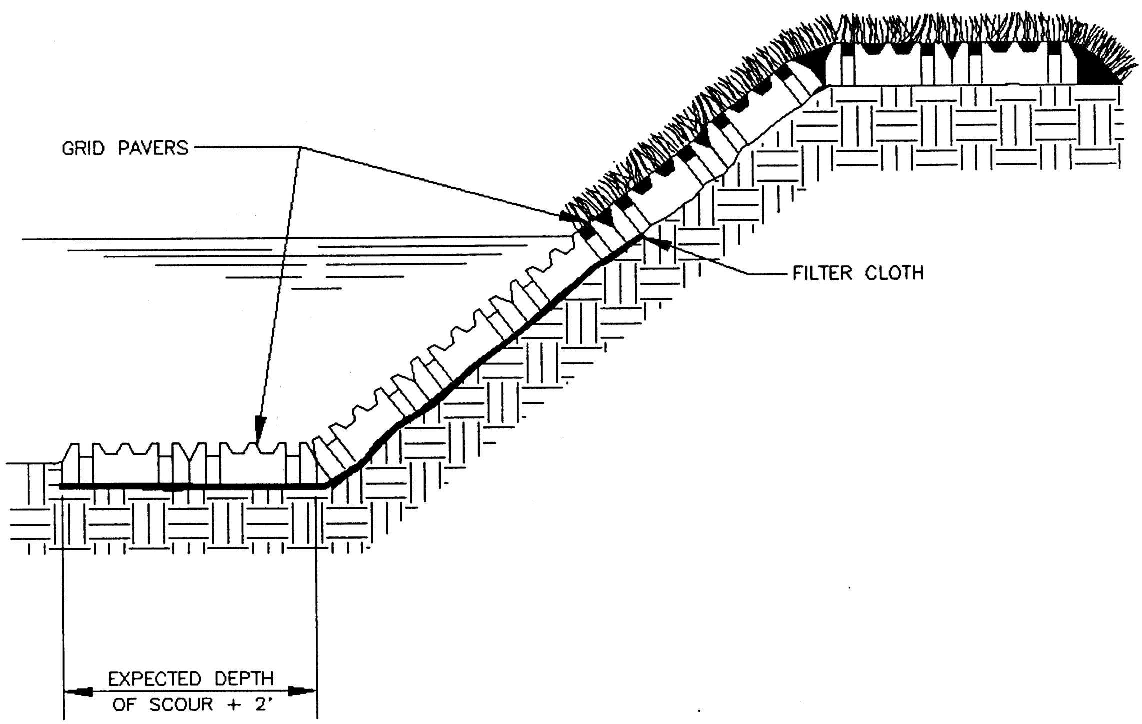


Source: Introductory Guide to Stream Improvement

Plate 3.23-3

GRID PAVERS





Source: Va. DSWC

Plate 3.23-4

STD & SPEC 3.24

TEMPORARY VEHICULAR STREAM CROSSING

SC

Definition

A temporary structural span installed across a flowing watercourse for use by construction traffic. Structures may include bridges, round pipes, pipe arches, or oval pipes.

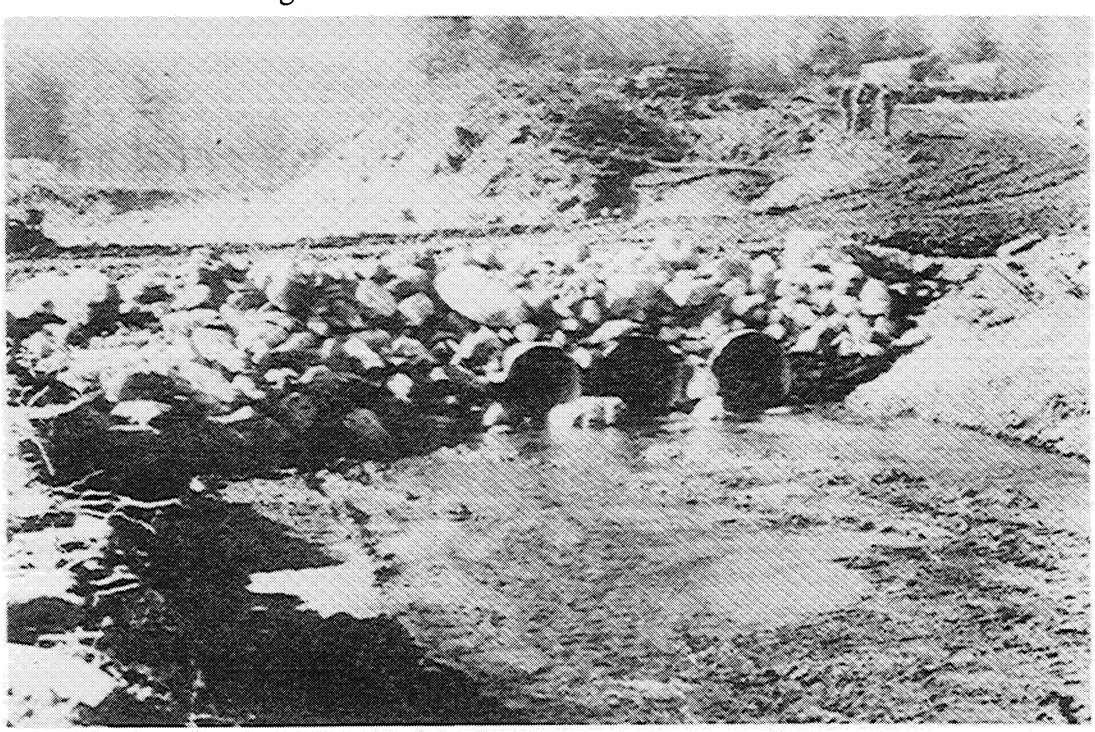
Purposes

1. To provide a means for construction traffic to cross flowing streams without damaging the channel or banks.

2. To keep sediment generated by construction traffic out of the stream.

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than 1 square mile. Structures which must handle flow from larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.



Planning Considerations

Temporary stream crossings are necessary to prevent construction vehicles from damaging streambanks and continually tracking sediment and other pollutants into the flow regime. These structures are, however, also undesirable in that they represent a channel constriction which 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 section 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 construction equipment which will cross the structure. The designer must also be aware that such structures are subject to the rules and regulations of the U. S. Army Corps of Engineers for in-stream modifications (404 permits).

A temporary bridge crossing is a structure made of wood, metal, or other materials which provides access across a stream or waterway. It is the preferred method for temporary waterway crossings. Normally, bridge construction causes the least amount of disturbance to the stream bed and banks when compared to the other types of crossings. They can also be quickly removed and reused. In addition, temporary bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings. A temporary culvert crossing is a structure consisting of stone and a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossings. Temporary culverts are used where the channel is too wide for normal bridge construction or the anticipated loading of construction vehicles may prove unsafe for single span bridges. There is some disturbance within the stream during construction and removal of the temporary culvert crossing. The stone, along with the temporary culverts, can be salvaged and reused.

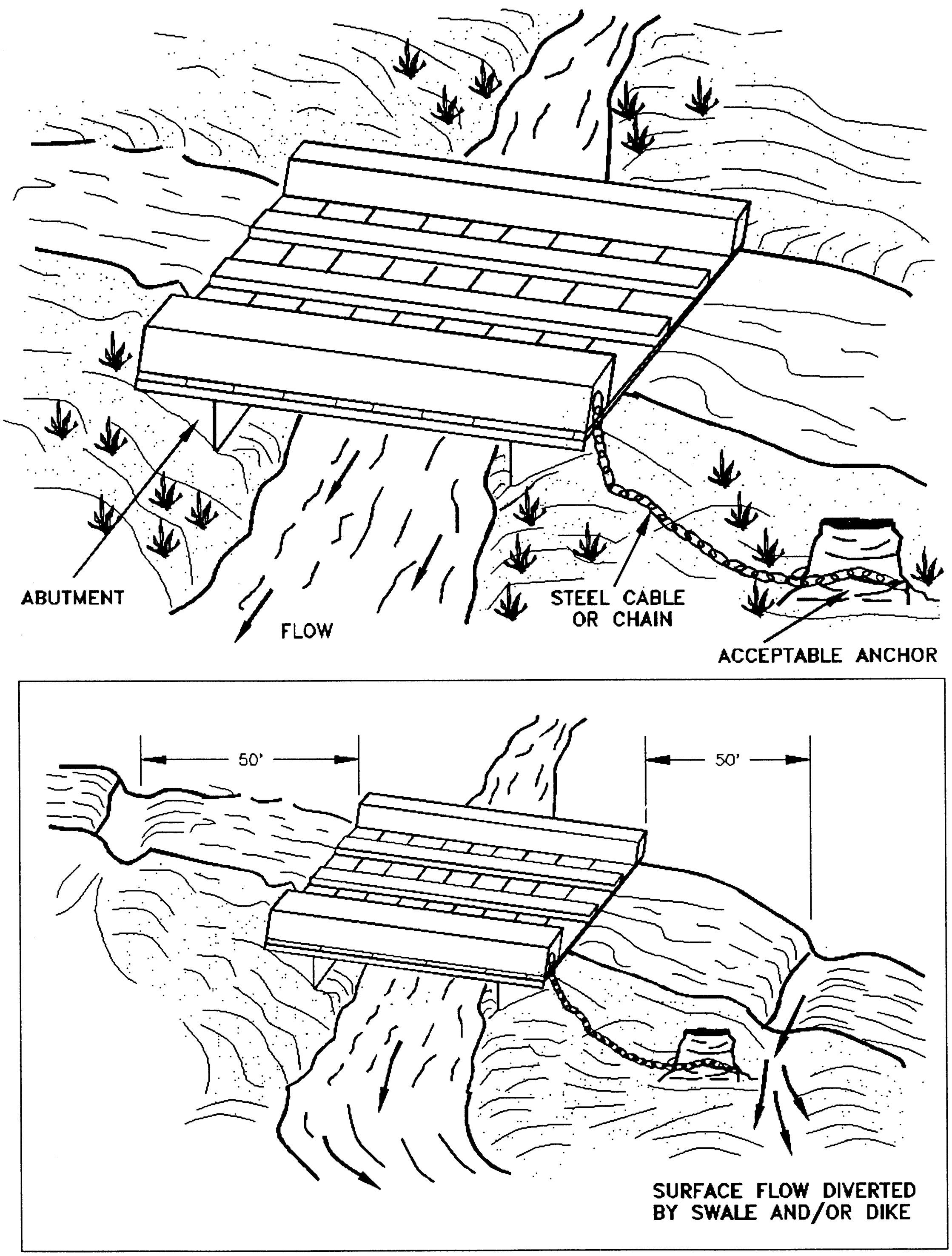
Design Criteria

1. Temporary Bridge Crossing

    a. Structures may be designed in various configurations. However, the materials used to construct the bridge must be able to withstand the anticipated loading of the construction traffic. Plate 3.24-1 shows on example of such a crossing.

    b. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15° from a line drawn perpendicular to the center line of the stream at the intended crossing location.

TEMPORARY BRIDGE CROSSING



Source: 1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control

Plate 3.24-1

c. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.

d. A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Std. & Spec. 3.11, TEMPORARY RIGHT OF WAY DIVERSION or Std. & Spec. 3.09, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

e. Appropriate perimeter controls such as SILT FENCE (Std. & Spec. 3.05) or TURBIDITY CURTAIN (Std. & Spec. 3.27) must be employed when necessary along banks of stream parallel to the same.

f. All crossings shall have one traffic lane. The minimum width shall be 12 feet with a maximum width of 20 feet.

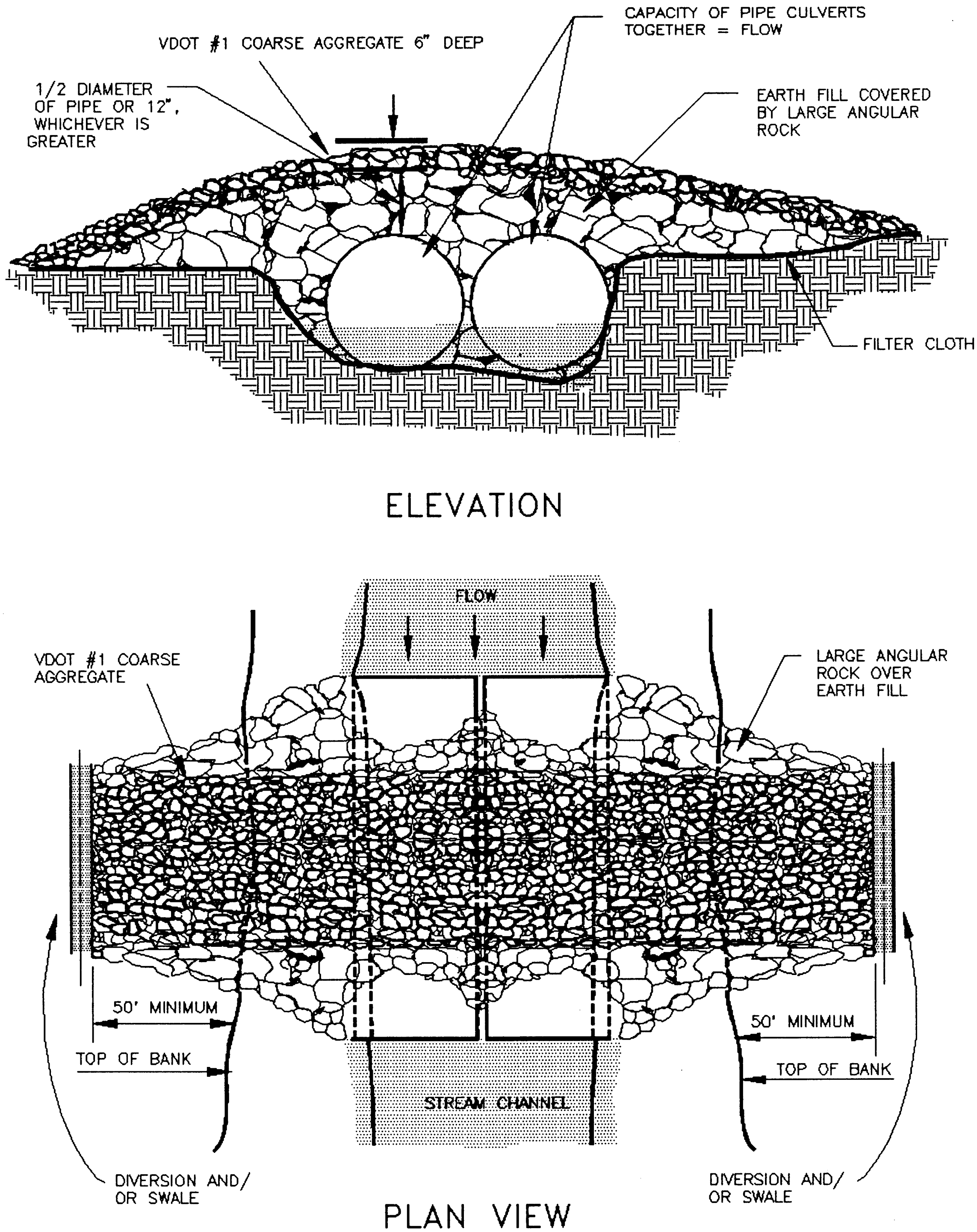
g. Further design/construction recommendations for temporary bridge construction may be found in Construction Specifications.

2. <u>Temporary Culvert Crossing</u>

a. Where culverts are installed, VDOT #1 Coarse Aggregate <u>or larger</u> will be used to form the crossing. The depth of stone cover over the culvert shall be equal to one-half the diameter of the culvert or 12 inches, whichever is greater. To protect the sides of the stone from erosion, riprap shall be used and designed in accordance with Std. & Spec. 3.19, RIPRAP (see Plate 3.24-2).

b. If the structure will remain in place for <u>up to 14 days</u>, the culvert shall be large enough to convey the flow from a 2-year frequency storm without appreciably altering the stream flow characteristics. See Table 3.24-A for aid in selecting an appropriate culvert size (note all assumptions). If the structure will remain in place <u>14 days to 1 year</u>, the culvert shall be large enough to convey the flow from a 10-year frequency storm. In this case, the hydrologic calculation and subsequent culvert size must be done for the specific watershed characteristics. If the structure must remain in place over 1 year, it must be designed as a permanent measure by a qualified professional.

TEMPORARY CULVERT CROSSING



Source: Va. DSWC

Plate 3.24-2

c. 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 18 inches.

d. All culverts shall be strong enough to support their cross-sectioned area under maximum expected loads.

e. The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.

f. The slope of the culvert shall be at least 0.25 inch per foot.

g. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15° from a line drawn perpendicular to the centerline of the stream at the intended crossing location.

h. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.

i. The approaches to the structure shall consist of stone pads meeting the following specifications:

1) Stone: VDOT #1
2) Minimum thickness: 6 inches
3) Minimum width: equal to the width of the structure

j. A water diverting structure such as a swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with Std. & Spec. 3.11, TEMPORARY RIGHT OF WAY DIVERSION or Std. & Spec. 3.09, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

TABLE 3.24-A
PIPE DIAMETER (INCHES) FOR STREAM CROSSINGS[a]

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
301 - 350	42	48	60	60
351 - 400	42	54	60	60
451 - 500	42	54	60	72
501 - 550	48	60	60	72
551 - 600	48	60	60	72
601 - 640	48	60	72	72

[a] Note: Table is based on USDA-SCS Graphical Peak Discharge Method for 2-year frequency storm event, CN = 65; Rainfall depth = 3.5 inches (average for Virginia).

Source: Va. DSWC

Construction Specifications

1. Temporary Bridge Crossing (see Plate 3.24-1)

    a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

b. The temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.

c. Abutments shall be placed parallel to and on stable banks.

d. Bridges shall be constructed to span the entire channel. If the channel width exceeds 8 feet (as measured from top-of-bank to top-of-bank), then a footing, pier or bridge support may be constructed within the waterway. One additional footing, pier or bridge support will be permitted for each additional 8-foot width of the channel. No footing, pier or bridge support, however, will be permitted within the channel for waterways which are less than 8 feet wide.

e. Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.

f. Decking materials shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.

g. Run planking (optional) shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.

h. Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.

i. Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

j. All areas disturbed during installation shall be stabilized within 7 calendar days of that disturbance in accordance with MS #1.

k. When the temporary bridge is no longer needed, all structures including abutments and other bridging materials should be removed immediately.

l. Final clean-up shall consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials shall be stored outside flood plain of the stream. Removal of the bridge and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.

2. Temporary Culvert Crossing

a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

b. The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration.

c. Filter cloth shall be placed on the streambed and streambanks prior to placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum of six inches and a maximum of one foot beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability. See Std. & Spec. 3.19, RIPRAP, for required physical qualities of the filter cloth.

d. The culvert(s) shall extend a minimum of one foot beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet in length.

e. The culvert(s) shall be covered with a minimum of one foot of aggregate. If multiple culverts are used, they shall be separated by at least 12 inches of compacted aggregate fill. At a minimum, the bedding and fill material used in the construction of the temporary access culvert crossings shall conform with the aggregate requirements cited in part "i" under "Temporary Culvert Crossing."

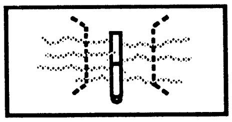
f. When the crossing has served its purpose, all structures including culverts, bedding and filter cloth materials shall be removed. Removal of the structure and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.

g. Upon removal of the structure, the stream shall immediately be shaped to its original cross-section and properly stabilized.

Maintenance

Both structures shall be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately.

STD & SPEC 3.25



UTILITY STREAM CROSSING

USC

Definition

A strategy for crossing small waterways when in-stream utility construction is involved.

Purposes

1. To help protect sediment from entering the stream from construction within approach areas.

2. To minimize the amount of disturbance within the stream itself.

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than one square mile. Structures or methodology for crossing streams with larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

A *Diversion Channel* may be utilized to allow "work in the dry".

Planning Considerations

Utility construction, by virtue of its sprawling, linear nature, frequently crosses and impacts live streams. There is a potential for excessive sediment loss into a stream by both the disturbance of the approach areas and by the work with the stream-bed and banks.

It is often a difficult task to decide what type of control to use as a utility stream crossing. A method such as the "boring and jacking" of pipe below a streambed, which would prevent disturbance within the watercourse, is a preferred method if it is practical. However, in cases where in-stream work is unavoidable, consideration must be given to providing adequate mitigation of sediment loss while minimizing the amount of encroachment (MS #12) and time spent working in the channel. There is some "give and take" as far as the installation of controls - sometimes there is less damage to the environment created by providing substantial controls for the approach areas and refraining from installing extensive measures in the stream itself. However, when the installation of the utility line within streambed and banks will take an extended period of construction time, consideration should be given to substantial in-stream controls or stream diversion in order to prevent excessive sedimentation damage.

As a result of the difficulty in choosing the right method for a utility stream crossing, designers and plan reviewers should always make site visits of proposed crossing to ensure that the most appropriate method is chosen. The designer and plan reviewer should also be aware that such modifications are subject to other state and federal construction permits.

The following are several methods for dealing with utility stream crossings (with varying construction time and stream size scenarios) which allow for "work in the dry" to prevent excessive sedimentation damage. By no means are these methods all-inclusive. As with other control measures, site-specific design and innovative variations are encouraged.

Design Criteria (All methods)

1. The drainage area should be no greater than one square mile (640 acres).

2. All filter cloth used in the construction of the utility crossing must conform to physical requirements noted in Std. & Spec. 3.19, RIPRAP.

3. Water diverting structures should be used at all trenching and/or construction road approaches (50 feet on either side of the crossing) as per Std. & Spec. 3.24, VEHICULAR STREAM CROSSING.

4. Design criteria more specific to each particular crossing can be found in Plates 3.25-1 through 3.25-4.

Construction Specifications

1. Diversion Channel Crossing - Preferred method if construction will remain in area of stream for an extended period (longer than 72 hours) and site conditions (such as width of stream) make diversion practical.

   a. The diversion channel crossing must be operational before work is done in the stream (construction will be performed "in the dry").

   b. Minimum width of bottom shall be six feet or equal to bottom width of existing streambed, whichever is less. Refer to Plates 3.25-1 and 3.25-2.

   c. Maximum steepness of side slopes shall be 2:1. Depth and grade may be variable, dependent on site conditions, but shall be sufficient to ensure continuous flow of water in the diversion.

   d. There are three types of diversion channel linings which can be used, based upon expected velocity of bankfull flow. Refer to Plate 3.25-2 and the following table:

TABLE 3.25-A

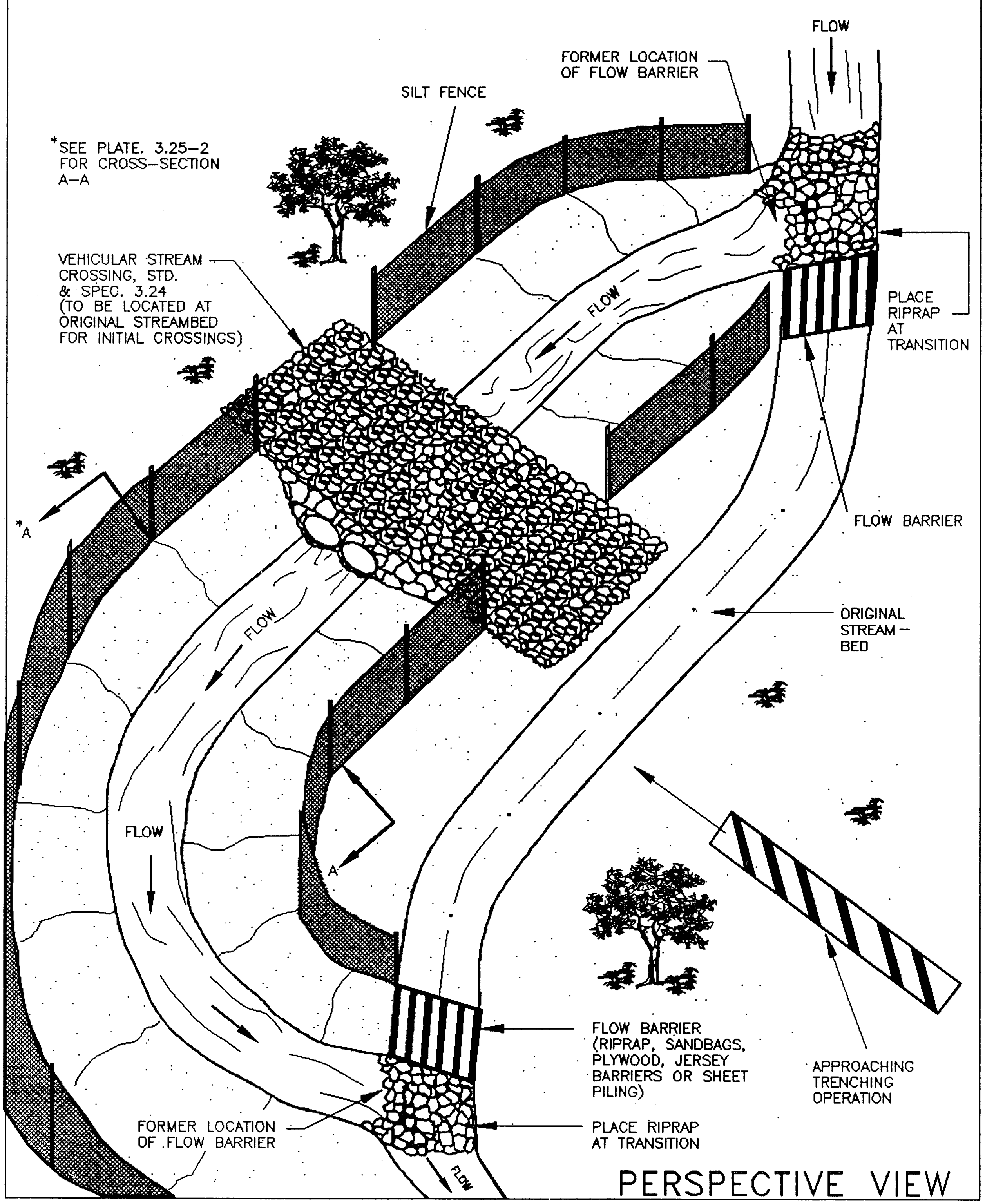
DIVERSION CHANNEL LININGS

Lining Material	Classification	Acceptable Velocity Range
Filter Cloth*, Polyethylene or Grass	TYPE A	0 - 2.5 f.p.s.
Filter Cloth*	TYPE B	2.5 - 9.0 f.p.s.
Class I Riprap and Filter Cloth*	TYPE C	9.0 - 13.0 f.p.s.

* Filter Cloth must meet the minimum physical requirements noted in Std. & Spec. 3.19, RIPRAP.

Source: VDOT Standard Sheets

DIVERSION CHANNEL CROSSING

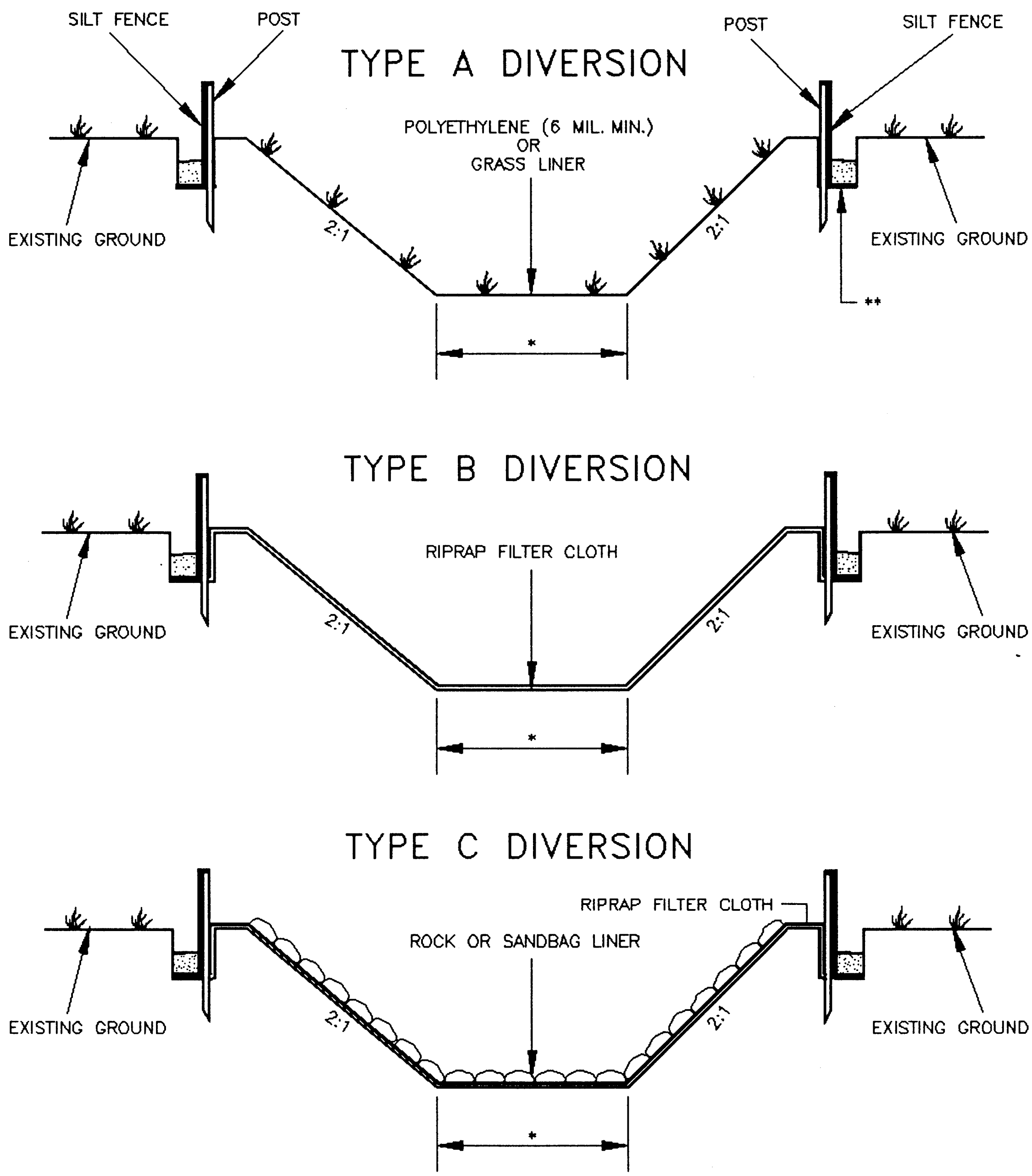


Source: Va. DSWC

Plate 3.25-1

DIVERSION CHANNEL CROSSING

ACCEPTABLE LININGS
(CROSS SECTION A-A OF PLATE 3.25-1)



* 6' MINIMUM OR WIDTH OF EXISTING STREAM WHICHEVER IS LESS

** ENTRENCH SILT FENCE AND FILTER CLOTH IN SAME TRENCH

Source: Adapted from VDOT Standard Sheets

Plate 3.25-2

e. Type A stream diversions may be seeded with a standard seed mix for the type of soils encountered and the time of year seed is sown. An average growth of two inches in height shall be achieved throughout the diversion with an 85% cover before water is turned through it.

f. Stream diversion liners shall be secured at the upstream and downstream sides with non-erodible weights such as riprap. These weights shall allow normal flow of the stream. Soil shall not be mixed in with stream diversion weights. Weights may also be needed along the stream diversion's length to secure liner.

g. Stream diversion liners should be overlapped when a single or continuous liner is not available or is impractical. Overlaps should be such that continuous flow of the steam is maintained. An upstream section should overlap a downstream section by a <u>minimum of 18 inches</u>. Overlaps along the cross-section should be made such that a liner is placed in the steam diversion bottom first and additional pieces of liner on the slopes overlap the bottom piece by a minimum of 18 inches.

h. Stream diversion liners shall be entrenched at the top of the diversion slopes (slopes breaks) along with a line of silt fence. Silt fence may be excluded if the diversion liner is extended to such a point that siltation of the stream will not occur. If silt fence is excluded, the diversion liner must be secured. Liners shall extend from slope break to slope break as shown in Plate 3.25-2.

i. Staples used in securing SOIL STABILIZATION BLANKETS AND MATTING (see Std. & Spec. 3.36) or non-erodible weights (riprap) shall be used as necessary to anchor stream diversion liners to the side slopes of the diversion. Wooden stakes should not be used on the diversion's bottom or side slopes.

j. Non-erodible materials such as riprap, jersey barriers, sandbags, plywood, or sheet piling, shall be used as flow barriers to divert the stream away from its original channel and to prevent or reduce water backup into a construction area.

k. The downstream flow barrier is to be removed prior to the upstream barrier when opening a stream diversion for the transport of water.

l. Streams should be rediverted upon completion of the utility crossing for which the diversion was built. Prior to rediversion, any materials (flow barrier) used to prevent water backup into the downstream end of the original streambed shall be removed. This material should not be placed in the downstream end of the diversion until after water has been rediverted to the original waterway. The stream should then be rediverted by removing all of the materials damming the upstream end of the original streambed and then placing it in the upstream end of the stream diversion. The diversion should be sealed off at the downstream end and then backfilled.

Once started, any work to relocate a stream shall not be discontinued until it is completed.

m. Stream should be rediverted <u>only</u> <u>after</u> backfilling and restabilization of original streambed and banks is completed. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur <u>immediately</u> following the attainment of final grade.

n. Any dewatering discharge from this operation shall be placed into an approved DEWATERING STRUCTURE (see Std. & Spec. 3.26).

2. <u>Flume Pipe Crossing</u> - To be used when in-stream construction will last less than 72 hours and stream is narrow (less than 10 feet wide), making "cofferdam" construction impractical.

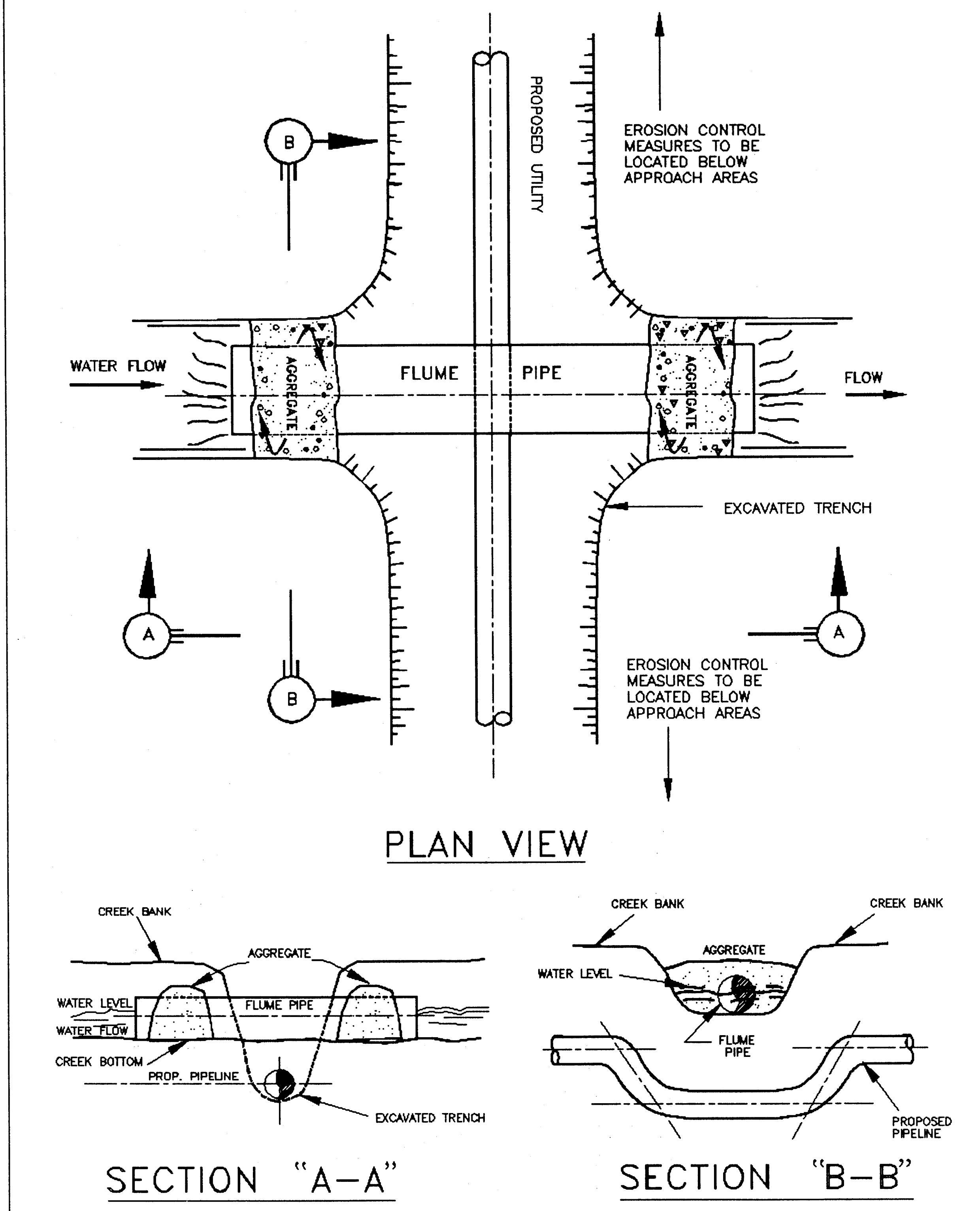
a. The flume pipe crossing must be made operational prior to the start of construction in the stream.

b. The materials used (culvert(s), stone and filter fabric) must meet the physical constraints of those used in VEHICULAR STREAM CROSSING, Std. & Spec. 3.24.

c. A large flume pipe (or culvert) of an adequate size to support normal water channel flow (see Table 3.24-A) shall then be installed in the stream bed across the proposed pipeline trench centerline. VDOT #1 Coarse Aggregate (minimum size) or riprap shall be placed close to each end of the flume pipe so as to dam off the creek forcing the water to flow through the flume pipe (see Plate 3.25-3).

d. The entrapped water can then be pumped from the creek within the dammed-off area and in the proposed trench centerline into an approved DEWATERING STRUCTURE (see Std. & Spec. 3.26). The trench can then be dug under the flume pipe. The pipe sections will then be installed to the proper depth under the flume pipe. After pipe sections are installed, the ditch will be backfilled and restabilization shall be carried out.

FLUME PIPE CROSSING



Source: Va. DSWC

Plate 3.25-3

e. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of the utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.

f. After completion of backfilling operation and restoration of stream/creek banks and leveling of stream bed, the flume pipe can then be removed. The gravel can be removed or spread in the stream bed depending on permit requirements. Sediment control in approach areas shall not be removed until all construction is completed in stream/creek crossing area. All ground contours shall be returned to their original condition.

3. Cofferdam Utility Crossing - To be used when stream diversion is not practical and stream is wide enough (10 feet or wider) to make cofferdam installation practical.

a. Construction is to be performed in low flow periods.

b. Crossing shall be accomplished in a manner that will not prohibit the flow of the stream. (See Plate 3.25-4).

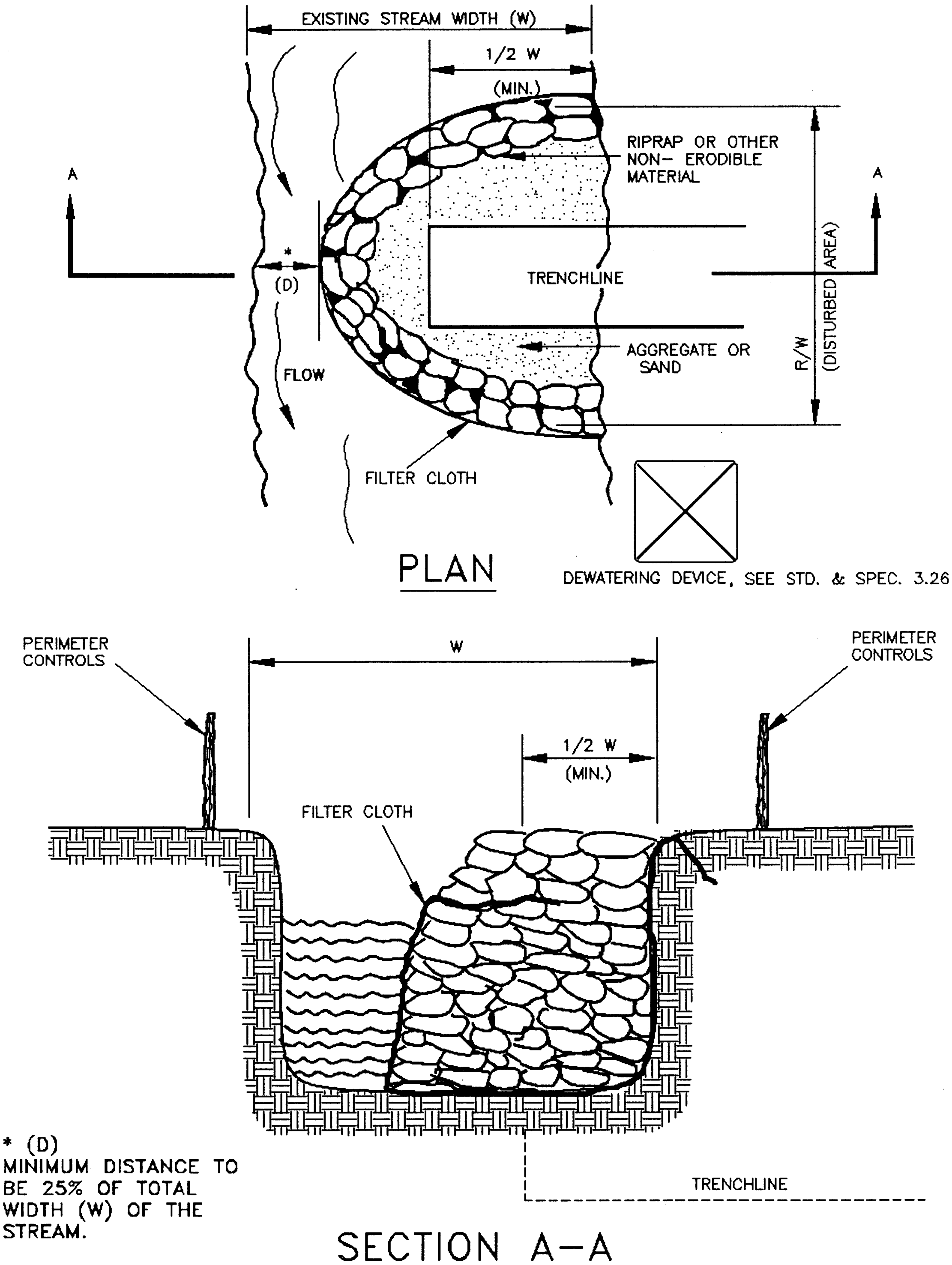
c. As with all utility line crossings, approach areas must be controlled with perimeter measures such as silt fence or straw bales.

d. Remove large rocks, woody vegetation, or other material from the streambed and banks that may get in the way of placing the riprap, sandbags, sheet metal, or wood planks or installing the utility pipe or line.

e. Form a cofferdam by placing the riprap (or other non-erodible materials) in a semicircle along the side of the stream in which the utility installation will begin. It must be surrounded and underlain with filter cloth as shown in Plate 3.25-4. The height of and area within the dam will depend upon the size of the work area and the amount of steam flow. Stack materials as high as will be necessary to keep water from overtopping the dam and flooding the work area. When the stream flow is successfully diverted by the cofferdam, dewater the work area and stabilize it with aggregate (VDOT #57 or #68 Coarse Aggregate) or sand. Make sure to discharge the water into a sediment trapping device (see DEWATERING STRUCTURE, Std. & Spec. 3.26).

g. Install the utility pipe or line in half the streambed as noted in Plate 3.25-4. Remove the riprap or other materials and begin placing them on the other side of the stream.

COFFERDAM CROSSING



* (D)
MINIMUM DISTANCE TO BE 25% OF TOTAL WIDTH (W) OF THE STREAM.

Source: Va. DSWC

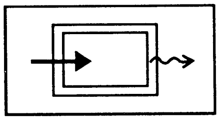
Plate 3.25-4

h. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to Std. & Spec. 3.19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.

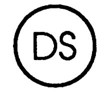
Maintenance

Care must be taken to inspect any steam crossing area at the end of each day to make sure that the construction materials are positioned securely. This will ensure that the work area stays dry and that no construction materials float downstream.

STD & SPEC 3.26



DEWATERING STRUCTURE



Definition

A temporary settling and filtering device for water which is discharged from dewatering activities.

Purpose

To filter sediment-laden water prior to the water being discharged off-site.

Conditions Where Practice Applies

Wherever sediment-laden water must be removed from a construction site by means of pumping.

Planning Considerations

Water which is pumped from a construction site usually contains a large amount of sediment. A dewatering structure is designed to remove the sediment before water is released off-site.

This practice includes several types of dewatering structures which have different applications dependent upon site conditions and types of operation. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the Plan-Approving Authority.

A dewatering structure may not be needed if there is a well- stabilized, vegetated area on-site to which water may be discharged. The area must be stabilized so that it can filter sediment and at the same time withstand the velocity of the discharged water without eroding. A minimum filtering length of <u>75 feet</u> must be available in order for such a method to be feasible.

Design Criteria

1. A dewatering structure must be sized (and operated) to allow pumped water to flow through the filtering device <u>without overtopping</u> the structure.

2. Material from any required excavation shall be stored in an area and protected in a manner that will prevent sediments from eroding and moving off-site.

3. An excavated basin (applicable to "Straw Bale/Silt Fence Pit") may be lined with filter fabric to help reduce scour and to prevent the inclusion of soil from within the structure.

4. Design criteria more specific to each particular dewatering device can be found in Plates 3.26-1 through 3.26-3.

Construction Specifications

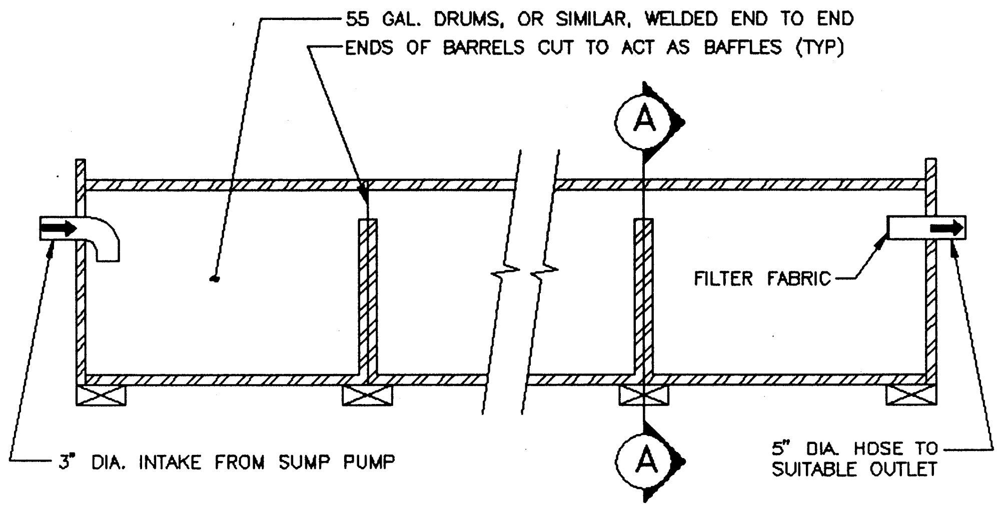
1. <u>Portable Sediment Tank</u> (see Plate 3.26-1)

    a. The structure may be constructed with steel drums, sturdy wood or other material suitable for handling the pressure exerted by the volume of water.

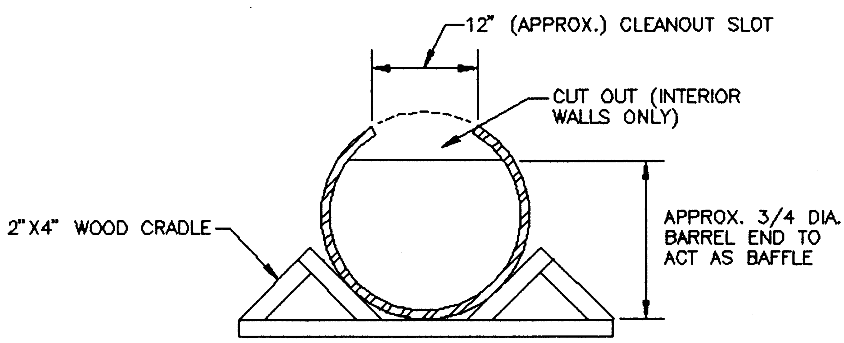
    b. Sediment tanks will have a minimum depth of two feet.

    c. The sediment tank shall be located for easy clean-out and disposal of the trapped sediment and to minimize the interference with construction activities.

PORTABLE SEDIMENT TANK



ELEVATION



CROSS-SECTION A-A

Source: USDA-SCS

Plate 3.26-1

d. The following formula shall be used to determine the storage volume of the sediment tank:

Pump discharge (g.p.m.) x 16 = cubic feet of storage required

e. Once the water level nears the top of the tank, the pump must be shut off while the tank drains and additional capacity is made available.

f. The tank shall be designed to allow for emergency flow over top of the tank.

g. Clean-out of the tank is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.

2. Filter Box (see Plate 3.26-2)

a. The box selected should be made of steel, sturdy wood or other materials suitable to handle the pressure requirements imposed by the volume of water. Fifty-five gallon drums welded top to bottom are normally readily available and, in most cases, will suffice.

b. Bottom of the box shall be made porous by drilling holes (or some other method).

c. VDOT #3 Coarse Aggregate shall be placed over the holes at a minimum depth of 12 inches (metal "hardware" cloth may need to be placed between the aggregate and the holes if holes are drilled larger than the majority of the stone).

d. As a result of the fast rate of flow of sediment-laden water through the aggregate, the effluent must be directed over a well-vegetated strip of at least 50 feet after leaving the base of the filter box.

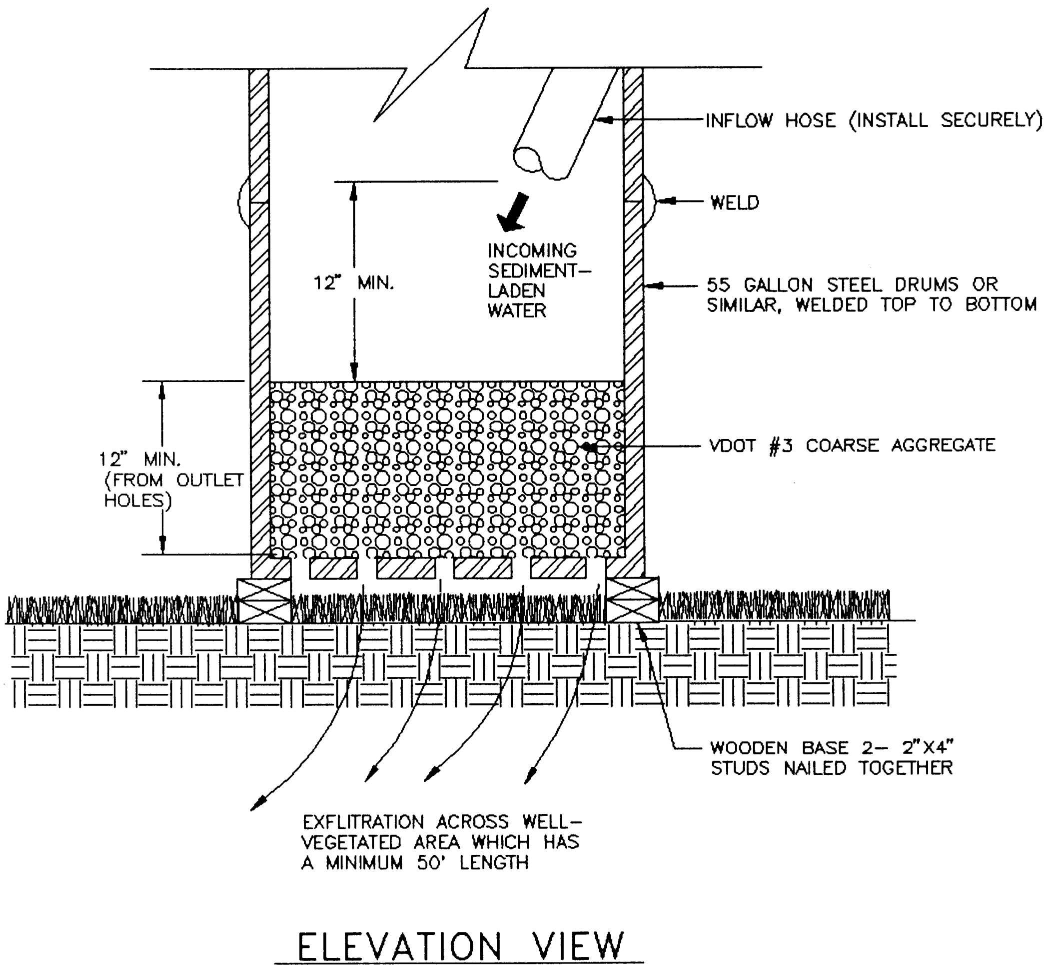
e. The box shall be sized as follows:

Pump discharge (g.p.m.) x 16 = cubic feet of storage required

f. Once the water level nears the top of the box, the pump must be shut off while the box drains and additional capacity is made available.

g. The box shall be designed/constructed to allow for emergency flow over the top of this box.

FILTER BOX



Source: Va. DSWC

Plate 3.26-2

h. Clean-out of the box is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.

i. If the stone filter does become clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and replaced.

Note: Using a filter box only allows for minimal settling time for sediment particles; therefore, it should only be used when site conditions restrict the use of the other methods.

3. Straw Bale/Silt Fence Pit (see Plate 3.26-3)

a. Measure shall consist of straw bales, silt fence, a stone outlet (a combination of VDOT Class AI Riprap and VDOT #25 or #26 Aggregate) and a wet storage pit oriented as shown in Plate 3.26-3.

b. The structure must have a capacity which is dictated by the following formula:

Pump discharge (g.p.m.) x 16 = cubic feet of storage required

In calculating the capacity, one should include the volume available from the floor of the excavation to the crest of the stone weir.

c. In any case, the excavated area should be a minimum of 3 feet below the base of the perimeter measures (straw bales or silt fence).

d. The perimeter measures must be installed as per the guidelines found in Std. & Spec. 3.04, STRAW BALE BARRIER and Std. & Spec. 3.05, SILT FENCE.

e. Once the water level nears the crest of the stone weir (emergency overflow), the pump must be shut off while the structure drains down to the elevation of the wet storage.

f. The wet storage pit may be dewatered only after a minimum of 6 hours of sediment settling time. This effluent should be pumped across a well-vegetated area or through a silt fence prior to entering a watercourse.

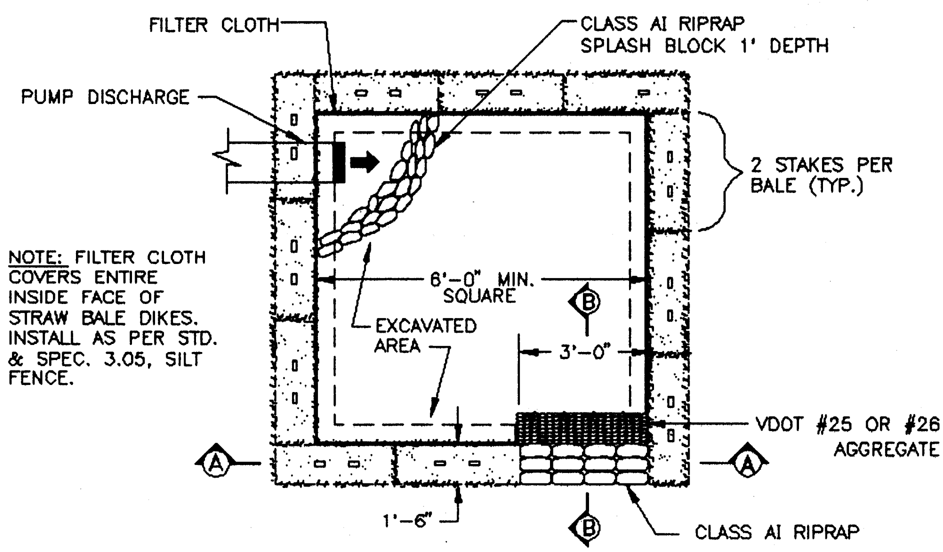
g. Once the wet storage area becomes filled to one-half of the excavated depth, accumulated sediment shall be removed and properly disposed of.

h. Once the device has been removed, ground contours will be returned to original condition.

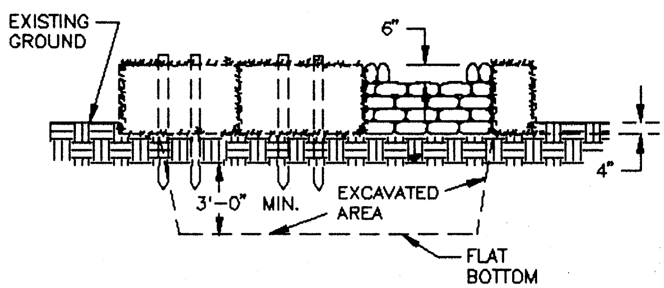
Maintenance
(All dewatering structures)

1. The filtering devices must be inspected frequently and repaired or replaced once the sediment build-up prevents the structure from functioning as designed.

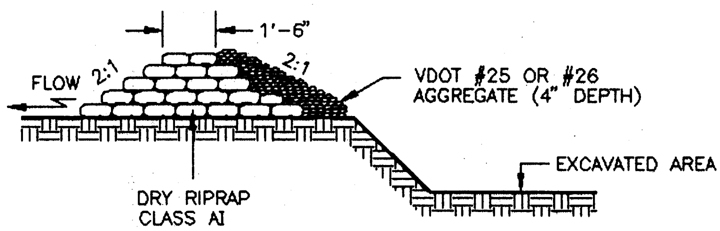
STRAW BALE/SILT FENCE PIT



PLAN VIEW



CROSS-SECTION A-A



CROSS-SECTION B-B

Source: Va. DSWC Plate 3.26-3

2. The accumulated sediment which is removed from a dewatering device must be spread on-site and stabilized or disposed of at an approved disposal site as per approved plan.

STD & SPEC 3.27

TURBIDITY CURTAIN

TC

Definition

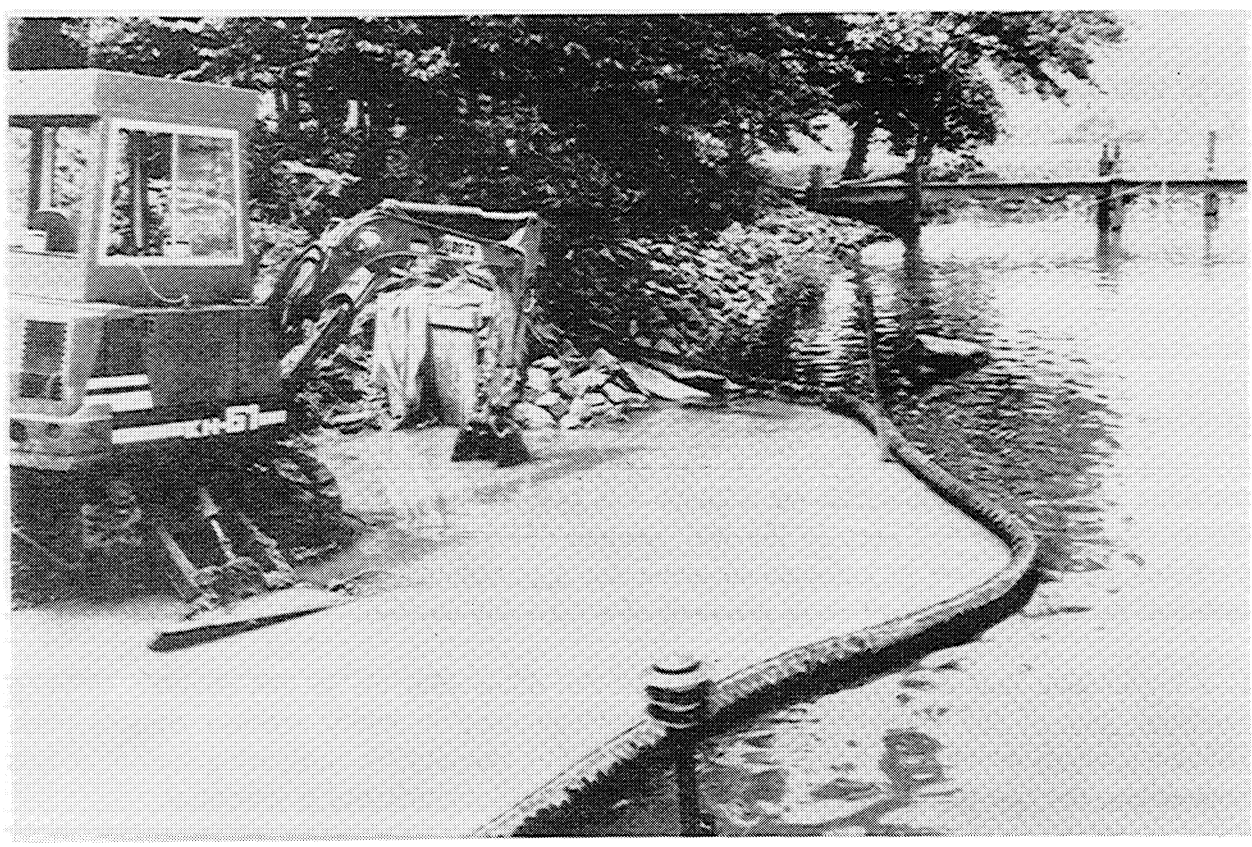
A floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water.

Purpose

To provide sedimentation protection for a watercourse from up-slope land disturbance or from dredging or filling within the watercourse.

Conditions Where Practice Applies

Applicable to non-tidal and tidal watercourses where intrusion into the watercourse by construction activities and subsequent sediment movement is unavoidable.



Planning Considerations

Soil loss into a watercourse results in long-term suspension of sediment. In time, the suspended sediment may travel large distances and affect wide-spread areas. A turbidity curtain is designed to deflect and contain sediment within a limited area and provide enough residence time so that soil particles will fall out of suspension and not travel to other areas.

Turbidity curtain types must be selected based on the flow conditions within the water body - whether it be a flowing channel, lake, pond, or a tidal watercourse. The specifications contained within this practice pertain to minimal and moderate flow conditions where the velocity of flow may reach 5 feet per second (or a current of approximately 3 knots). For situations where there are greater flow velocities or currents, a qualified engineer and product manufacturer should be consulted.

Consideration must also be given to the direction of water movement in channel flow situations. Turbidity curtains are not designed to act as water impoundment dams and can not be expected to stop the flow of a significant volume of water. They are designed and installed to trap sediment, not to halt the movement of the water itself. In most situations, <u>turbidity curtains should not be installed across channel flows</u>.

In tidal or moving water conditions, provisions must be made to allow the volume of water contained within the curtain to change. Since the bottom of the curtain is weighted and external anchors are frequently added, the volume of water contained within the curtain will be much greater at high tide verses low tide and measures must be taken to prevent the curtain from submerging. In addition to allowing for slack in the curtain to rise and fall, water must be allowed to flow through the curtain if the curtain is to remain in roughly the same spot and to maintain the same shape. Normally, this is achieved by constructing part of the curtain from a heavy woven filter fabric. The fabric allows the water to pass through the curtain, but retains the sediment pollutants. Consideration should be given to the volume of water that must pass through the fabric and sediment particle size when specifying fabric permeability.

Sediment which has been deflected and settled out by the curtain <u>may be removed</u> if so directed by the on-site inspector or the Plan-Approving Authority. However, consideration must be given to the probable outcome of the procedure - <u>will it create more of a sediment problem by resuspension of particles and by accidental dumping of the material by the equipment involved</u>? It is, therefore, recommended that the soil particles trapped by a turbidity curtain only be removed if there has been a significant change in the original contours of the affected area in the watercourse. Regardless of the decision made, soil particles should always be allowed to settle for <u>a minimum of 6-12 hours</u> prior to their removal by equipment or prior to removal of a turbidity curtain.

It is imperative that the intended function of the other controls in this chapter, to <u>keep sediment out of the watercourse</u>, be the strategy used in every erosion control plan. However, when proximity to the watercourse makes successfully mitigating sediment loss impossible, the use of the turbidity curtain during land disturbance is essential.

Design Criteria

1. Type I configuration (see Plate 3.27-1) should be used in protected areas where there is no current and the area is sheltered from wind and waves.

2. Type II configuration (see Plate 3.27-1) should be used in areas where there may be small to moderate current running (up to 2 knots or 3.5 feet per second) and/or wind and wave action can effect the curtain.

3. Type III configuration (see Plate 3.27-2) should be used in areas where considerable current (up to 3 knots or 5 feet per second) may be present, where tidal action may be present and/or where the curtain is potentially subject to wind and wave action.

4. Turbidity curtains should extend the entire depth of the watercourse whenever the watercourse in question is not subject to tidal action and/or significant wind and wave forces.

5. In tidal and/or wind and wave action situations, the curtain should never be so long as to touch the bottom. A minimum 1-foot "gap" should exist between the weighted lower end of the skirt and the bottom at "mean" low water. Movement of the lower skirt over the bottom due to tidal reverses or wind and wave action on the flotation system may fan and stir sediments already settled out.

6. In tidal and/or wind and wave action situations, it is seldom practical to extend a turbidity curtain depth lower than 10 to 12 feet below the surface, even in deep water. Curtains which are installed deeper than this will be subject to very large loads with consequent strain on curtain materials and the mooring system. In addition, a curtain installed in such a manner can "billow up" towards the surface under the pressure of the moving water, which will result in an effective depth which is significantly less than the skirt depth.

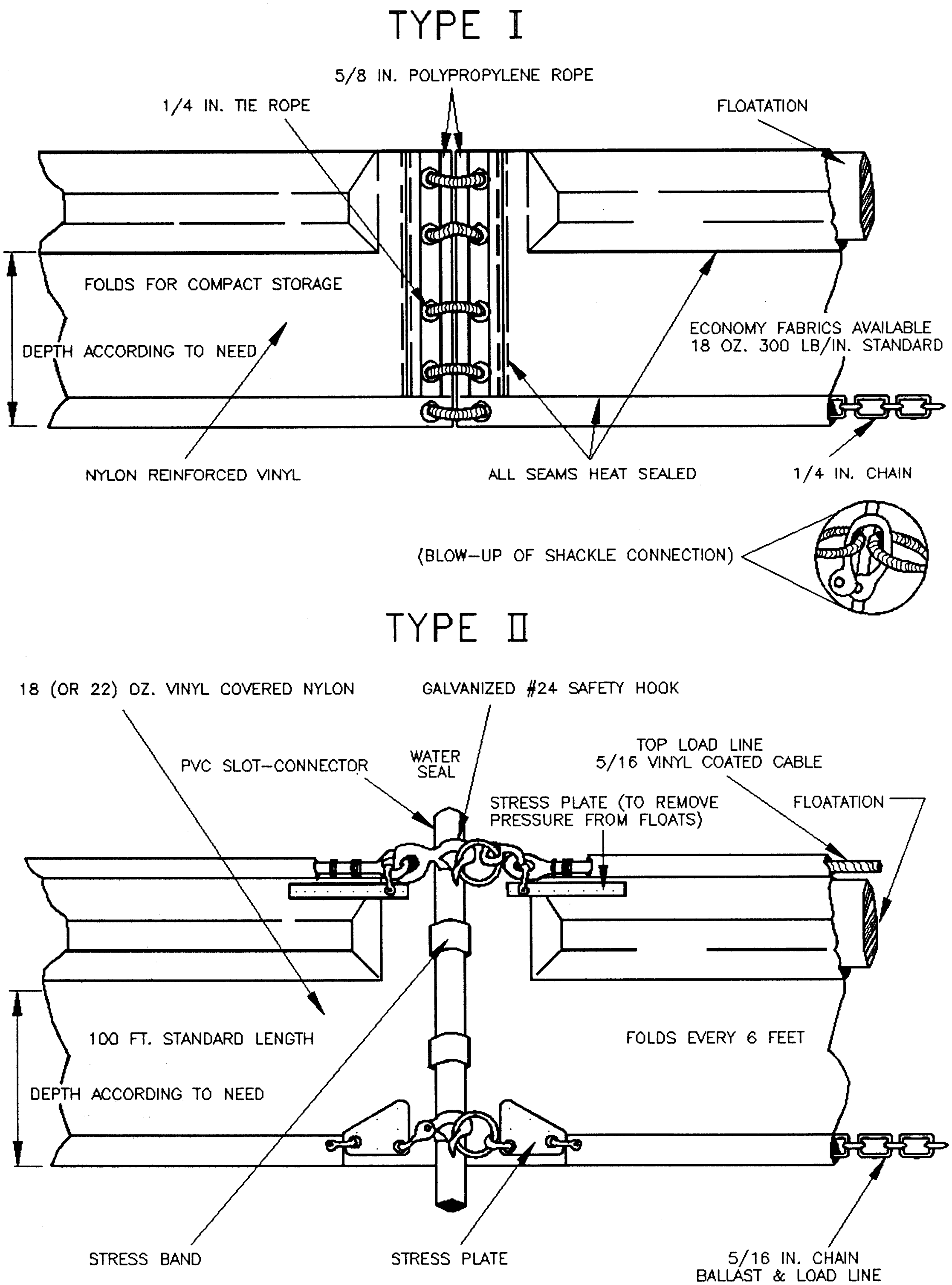
7. Turbidity curtains should be located parallel to the direction of flow of a moving body of water. Turbidity Curtain should not be placed across the main flow of a significant body of moving water.

8. When sizing the length of the floating curtain, allow an additional 10-20% variance in the straight line measurements. This will allow for measuring errors, make installing easier and reduce stress from potential wave action during high winds.

9. An attempt should be made to avoid an excessive amount of joints in the curtain; a minimum continuous span of 50 feet between joints is a good "rule of thumb."

10. For stability reasons, a maximum span of 100 feet between joints (anchor or stake locations) is also a good rule to follow.

TURBIDITY CURTAIN

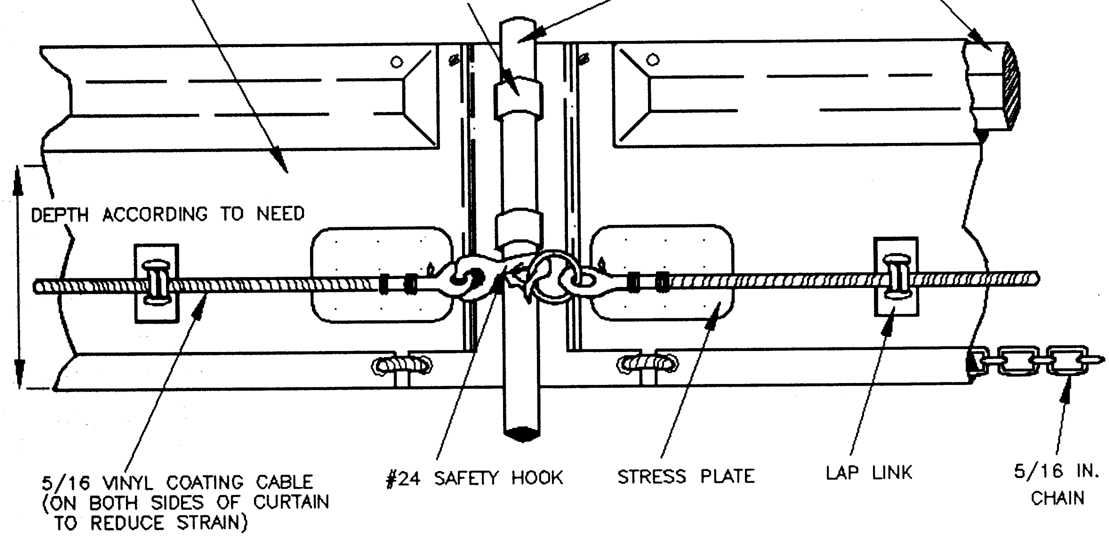


Source: American Boom and Barrier Corp. product literature

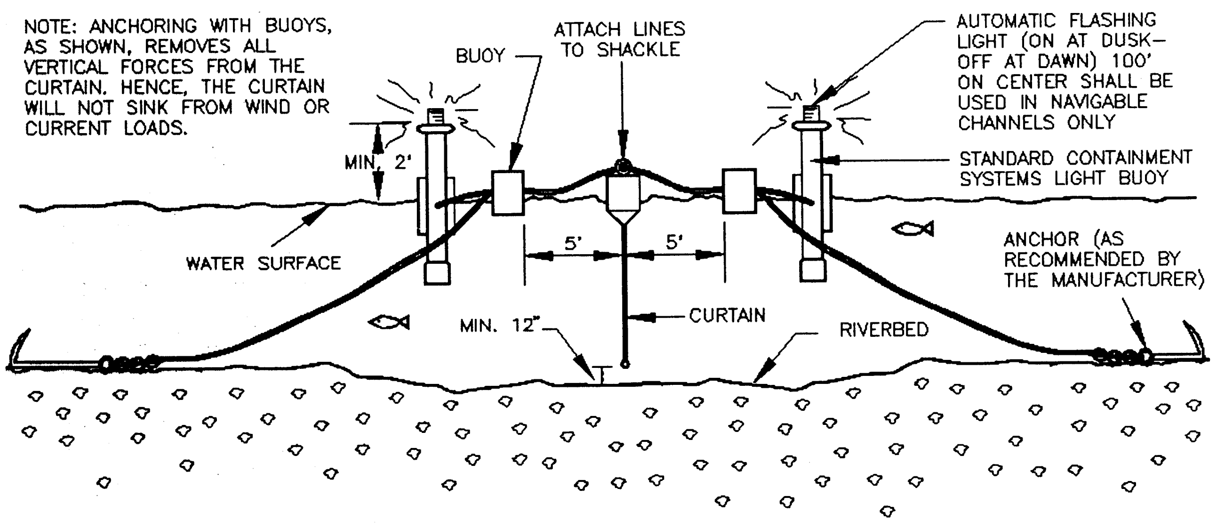
Plate 3.27-1

TURBIDITY CURTAIN

TYPE III



ORIENTATION WHEN INSTALLED (TIDAL SITUATION – TYPE III)



Source: Adapted from American Boom and Barrier Corp. and VDOT Standard Sheets

Plate 3.27-2

11. The ends of the curtain, both floating upper and weighted lower, should extend well up into the shoreline, especially if high water conditions are expected. The ends should be secured firmly to the shoreline (preferably to rigid bodies such as trees or piles) to fully enclose the area where sediment may enter the water.

12. When there is a specific need to extend the curtain to the bottom of the watercourse in tidal or moving water conditions, a heavy woven pervious filter fabric may be substituted for the normally recommended impervious geotextile. This creates a "flow-through" medium which significantly reduces the pressure on the curtain and will help to keep it in the same relative location and shape during the rise and fall of tidal waters.

13. Typical alignments of turbidity curtains can be seen in Plate 3.27-3. The number and spacing of external anchors may vary depending on current velocities and potential wind and wave action; manufacturer's recommendations should be followed.

Construction Specifications

Materials

1. Barriers should be a bright color (yellow or "international" orange are recommended) that will attract the attention of nearby boaters.

2. The curtain fabric must meet the minimum requirements noted in Table 3.27-A.

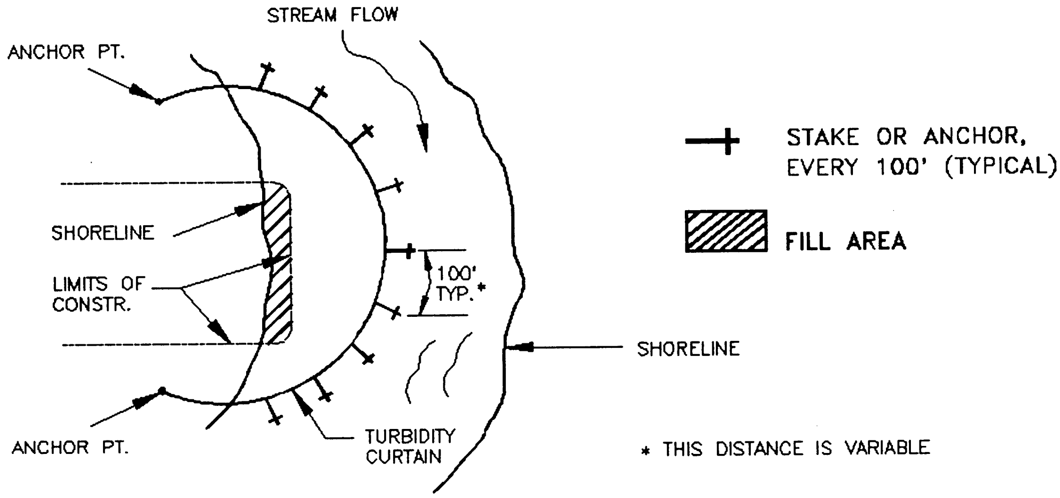
3. Seams in the fabric shall be either vulcanized welded or sewn, and shall develop the full strength of the fabric.

4. Floatation devices shall be flexible, buoyant units contained in an individual floatation sleeve or collar attached to the curtain. Buoyancy provided by the floatation units shall be sufficient to support the weight of the curtain and maintain a freeboard of at least 3 inches above the water surface level (see Plate 3.27-2).

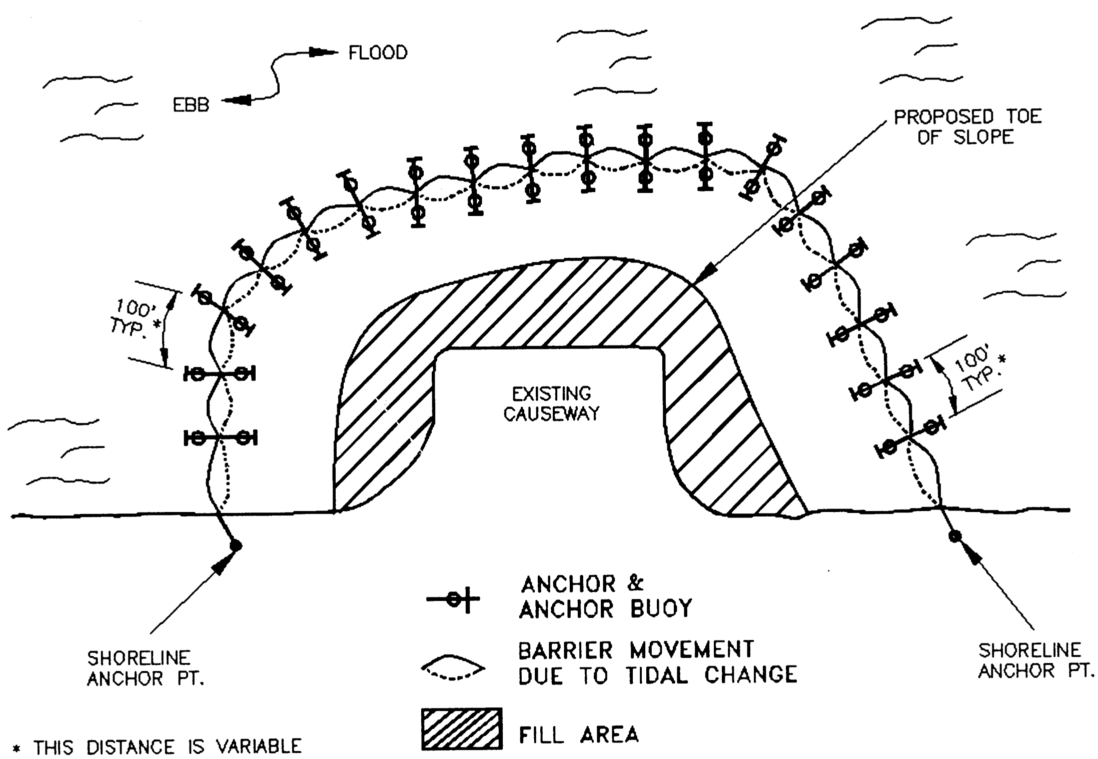
5. Load lines must be fabricated into the bottom of all floating turbidity curtains. Type II and Type III must have load lines also fabricated into the top of the fabric. The top load line shall consist of woven webbing or vinyl-sheathed steel cable and shall have a break strength in excess of 10,000 pounds. The supplemental (bottom) load-line shall consist of a chain incorporated into the bottom hem of the curtain of sufficient weight to serve as ballast to hold the curtain in a vertical position. Additional anchorage shall be provided as necessary. The load lines shall have suitable connecting devices which develop the full breaking strength for connecting to load lines in adjacent sections (see Plates 3.27-1 and 3.27-2 which portray this orientation).

TURBIDITY CURTAIN

TYPICAL LAYOUTS:
STREAMS, PONDS & LAKES (PROTECTED & NON-TIDAL)



TIDAL WATERS AND/OR HEAVY WIND & WAVE ACTION



Source: Adapted from Florida Department of
Transportation Road and Design Specifications

Plate 3.27-3

TABLE 3.27-A

PHYSICAL PROPERTIES OF TURBIDITY CURTAIN FABRIC

Physical Property	Requirement
Thickness, mils	45
Weight/oz./sq. yd.:	
Type I	18
Type II	18 or 22
Type III	22
Grab Tensile Strength, lbs.	300
UV Inhibitor	Must be included

Source: Adapted from The Ralph Lemon Company product literature

6. External anchors may consist of wooden or metal stakes (2- x 4-inch or 2½-inch minimum diameter wood or 1.33 pounds/linear foot steel) when Type I installation is used; when Type II or Type III installations are used, bottom anchors should be used.

7. Bottom anchors must be sufficient to hold the curtain in the same position relative to the bottom of the watercourse without interfering with the action of the curtain. The anchor may dig into the bottom (grappling hook, plow or fluke-type) or may be weighted (mushroom type) and should be attached to a floating anchor buoy via an anchor line. The anchor line would then run from the buoy to the top load line of the curtain. When used with Type III installations, these lines must contain enough slack to allow the buoy and curtain to float freely with tidal changes without pulling the buoy or curtain down and must be checked regularly to make sure they do not become entangled with debris. As previously noted, anchor spacing will vary with current velocity and potential wind and wave action; manufacturer's recommendations should be followed. See orientation of external anchors and anchor buoys for tidal installation in Plate 3.27-2.

Installation

1. In the calm water of lakes or ponds (Type I installation) it is usually sufficient to merely set the curtain end stakes or anchor points (using anchor buoys if bottom anchors are employed), then tow the curtain in the furled condition out and attach it to these stakes or anchor points. Following this, any additional stakes or buoyed anchors required to maintain the desired location of the curtain may be set and these anchor points made fast to the curtain. Only then, the furling lines should be cut to let the curtain skirt drop.

2. In rivers or in other moving water (Type II and Type III installations) it is important to set all the curtain anchor points. Care must be taken to ensure that anchor points are of sufficient holding power to retain the curtain under the existing current conditions, prior to putting the furled curtain into the water. Again, anchor buoys should be employed on all anchors to prevent the current from submerging the flotation at the anchor points. If the moving water into which the curtain is being installed is tidal and will subject the curtain to currents in both directions as the tide changes, it is important to provide anchors on both sides of the curtain for two reasons:

   a) Curtain movement will be minimized during tidal current reversals.

   b) The curtain will not overrun the anchors and pull them out when the tide reverses.

   When the anchors are secure, the furled curtain should be secured to the upstream anchor point and then sequentially attached to each next downstream anchor point until the entire curtain is in position. At this point, and before unfurling, the "lay" of the curtain should be assessed and any necessary adjustments made to the anchors. Finally, when the location is ascertained to be as desired, the furling lines should be cut to allow the skirt to drop.

3. Always attach anchor lines to the flotation device, not to the bottom of the curtain. The anchoring line attached to the floatation device on the downstream side will provide support for the curtain. Attaching the anchors to the bottom of the curtain could cause premature failure of the curtain due to the stresses imparted on the middle section of the curtain.

4. There is an exception to the rule that turbidity curtains should not be installed across channel flows; it occurs when there is a danger of creating a silt build-up in the middle of a watercourse, thereby blocking access or creating a sand bar. Curtains have been used effectively in large areas of moving water by forming a very long-sided, sharp "V" to deflect clean water around a work site, confine a large part of the silt-laden water to the work area inside the "V" and direct much of the silt toward the shoreline. Care must be taken, however, not to install the curtain perpendicular to the water current.

5. See Plate 3.27-3 for typical installation layouts.

Removal

1. Care should be taken to protect the skirt from damage as the turbidity curtain is dragged from the water.

2. The site selected to bring the curtain ashore should be free of sharp rocks, broken cement, debris, etc. so as to minimize damage when hauling the curtain over the area.

3. If the curtain has a deep skirt, it can be further protected by running a small boat along its length with a crew installing furling lines before attempting to remove the curtain from the water.

Maintenance

1. The developer/owner shall be responsible for maintenance of the filter curtain for the duration of the project in order to ensure the continuous protection of the watercourse.

2. Should repairs to the geotextile fabric become necessary, there are normally repair kits available from the manufacturers; manufacturer's instructions must be followed to ensure the adequacy of the repair.

3. When the curtain is no longer required as determined by the inspector, the curtain and related components shall be removed in such a manner as to minimize turbidity. Remaining sediment shall be sufficiently settled before removing the curtain. Sediment may be removed and the original depth (or plan elevation) restored. Any spoils must be taken to upland area and be stabilized.

STD & SPEC 3.28

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SUBSURFACE DRAIN

SD

Definition

A perforated conduit such as pipe, tubing or tile installed beneath the ground to intercept and convey ground water.

Purposes

1. To prevent sloping soils from becoming excessively wet and subject to sloughing.
2. To improve the quality of the growth medium in excessively wet areas by lowering the water table.
3. To drain stormwater detention areas or structures.

Conditions Where Practice Applies

Wherever excess water must be removed from the soil. The soil must be deep and permeable enough to allow an effective system to be installed. Either a gravity outlet must be available or pumping must be provided. These standards do no apply to foundation drains.

Planning Considerations

Subsurface drainage systems are of two types, relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation, or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern (see Plate 3.28-1).

Interceptor drains are used to remove water as it seeps down a slope to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout (see Plate 3.28-2).

Design Criteria

Location

Tree roots can often clog subsurface drain systems. Consequently, sub-surface drains should be located such that there are no trees within 50 feet of the drain.

Relief Drains - Relief drains should be located through the center of wet areas. They should drain in the same direction as the slope.

Interceptor drains - Interceptor drains should be located on the uphill side of wet areas . They should be installed across the slope and drain to the side of the slope.

Capacity of Drains

The required capacity of a subsurface drain depends upon its use.

Relief drains- Relief drains installed in a uniform pattern should remove a minimum of 1 inch of groundwater in 24 hours (0.042 cfs/acre). The design capacity must be increased accordingly to accommodate any surface water which enters directly into the system (see Plate 3.28-4).

Interceptor drains or relief drains in a random pattern- Interceptor drains or relief drains installed in a random pattern should remove a minimum of 1.5 cfs/1000 feet of length. This value should be increased for sloping land according to the values in Table 3.28-A. In addition, if a flowing spring or surface water enters directly into the system, this flow must be accommodated and the design capacity must be increased accordingly to take care of this flow (see Plate 3.28-4).

TABLE 3.28-A

WATER REMOVAL RATES FOR SLOPING LAND*

Land Slope	Water Removal Rates
2 - 5%	1.65 cfs/1000 ft.
6 - 12%	1.80 cfs/1000 ft.
> 12%	1.95 cfs/1000 ft.

* These rates depend on the soil types where the drains are installed. Heavier soils may result in slower water removal rates.

Source: Va. DSWC

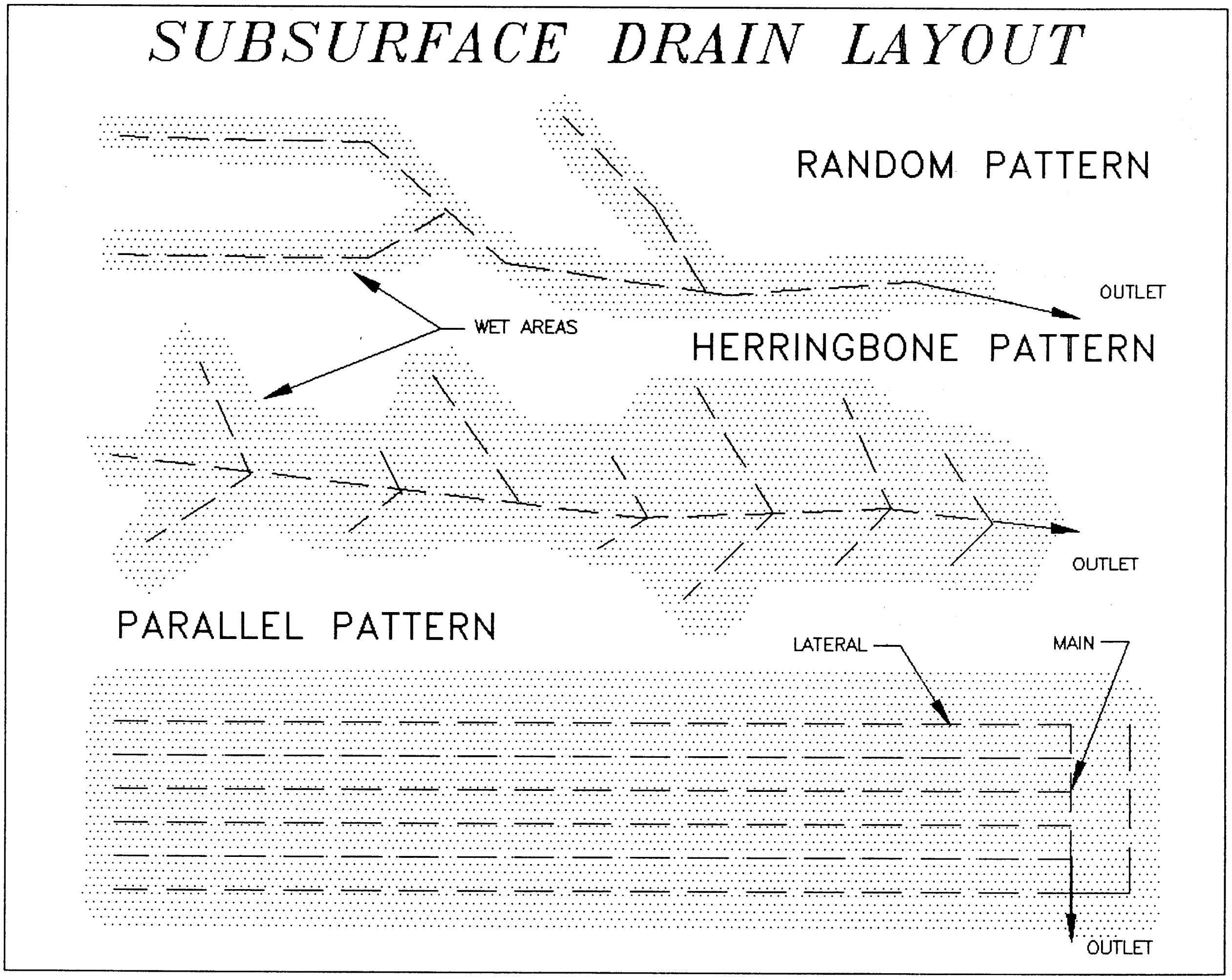
Size of Drains

Subsurface drains should be sized for the required capacity using Plates 3.28-6 and 3.28-7 in Appendix 3.28-a. The minimum diameter for a subsurface drain shall be 4 inches.

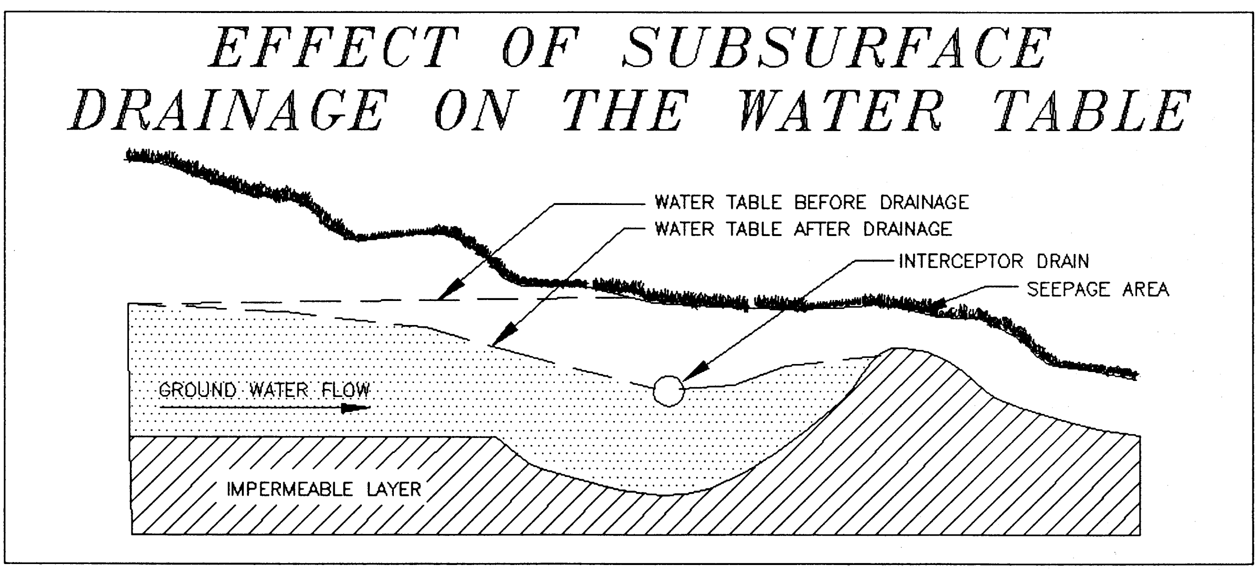
Depth and Spacing

Relief Drains - Relief drains installed in a uniform pattern should have equal spacing between drains and the drains should be at the same depth. Maximum depth is limited by the allowable load on the pipe, depth to impermeable layers in the soil, and outlet requirements. The minimum depth is 24 inches under normal conditions. Twelve inches is acceptable where the drain will not be subject to equipment loading or frost action. Spacing between drains is dependent on soil permeability and the depth of the drain. In general, however, a depth of 3 feet and a spacing of 50 feet will be adequate. A more economical system may be designed., if the necessary information is available, by using the equations found in Appendix 3.28-a.

Interceptor drain - The depth of installation of an interceptor drain is influenced mainly by the depth to which the water table is to be lowered. The maximum depth is limited by the allowable load on the pipe and the depth to an impermeable layer. Minimum depth should be the same as for relief drains.



Source: USDA-SCS Plate 3.28-1



Source: USDA-SCS Plate 3.28-2

One interceptor drain is usually sufficient. However, if multiple drains are to be used, determining the required spacing can be difficult. The best approach is to install the first drain - then if seepage or high water table problems occur downslope, install an additional drain a suitable distance downslope. This distance can be calculated from equations found in Appendix 3.28-a.

Velocity and Grade

The minimum velocity required to prevent silting is 1.4 ft./sec. The line should be graded to achieve at least this velocity. Steep grades should be avoided, however. Table 3.28-B lists maximum velocities for various soil textures.

TABLE 3.28-B

MAXIMUM VELOCITIES FOR VARIOUS SOIL TEXTURES

Soil Texture	Maximum Velocity (ft./sec.)
Sandy and Sandy Loam	3.5
Silt and Silt Loam	5.0
Silty Clay Loam	6.0
Clay and Clay Loam	7.0
Coarse Sand or Gravel	9.0

Source: Va. DSWC

Envelopes

Envelopes shall be used around all drains for proper bedding and improved flow of groundwater into the drain. The envelope shall consist of 3 inches of VDOT #68 aggregate placed completely around the drain. The stone shall be encompassed by a filter cloth separator in order to prevent the migration of surrounding soil particles into the drain (see Plate 3.28-3). Filter cloth must meet the physical requirements noted in Std. & Spec. 3.19, RIPRAP.

Surface Water

Plate 3.28-4 shows two types of surface water inlets. The grated inlet should not be used where excessive sedimentation might be a problem.

Outlet

The outlet of the subsurface drain shall empty into a channel or some other watercourse which will remove the water from the outlet. It shall be above the mean water level in the receiving channel. It shall be protected from erosion, undermining, damage from periods of submergence, and the entry of small animals into the drain.

The outlet shall consist of a 10-foot section of corrugated metal, cast iron, steel or schedule 40 PVC pipe without perforations. No envelope material shall be used around the pipe. At least two-thirds of the outlet pipe length shall be buried.

Materials

Acceptable materials for subsurface drains include perforated, continuous closed-joint conduits of corrugated plastic, concrete, corrugated metal, asbestos cement, and bituminous fiber. The strength and durability of the pipe shall meet the requirements of the site in accordance with the manufacturer's specifications.

Construction Specifications

1. The trench shall be constructed on a continuous grade with no reverse grades or low spots.

2. Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.

3. Deformed, warped, or otherwise unsuitable pipe shall not be used.

4. Envelopes or filter material shall be placed as specified with at least 3 inches of material on all sides of the pipe.

5. Backfilling shall be done immediately after placement of the pipe. No sections of pipe should remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.

6. The outlet section of the drain shall consist of at least 10 feet of non-perforated corrugated metal, cast iron, steel or schedule 40 PVC pipe. At least two-thirds of its length shall be buried.

Maintenance

1. Subsurface drains should be checked periodically to ensure that they are free-flowing and not clogged with sediment.

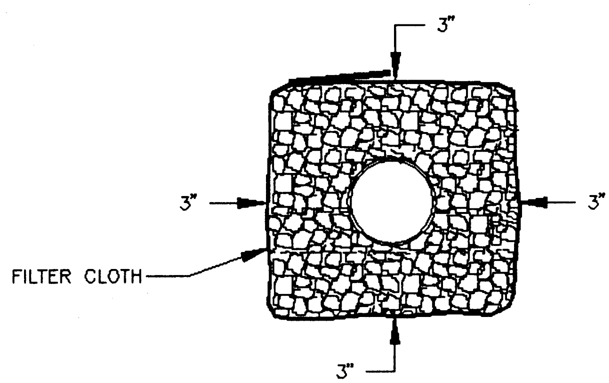
2. The outlet should be kept clean and free of debris.

3. Surface inlets should be kept open and free of sediment and other debris.

4. Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees.

5. Where drains are crossed by heavy vehicles, the line should be checked to ensure that it is not crushed.

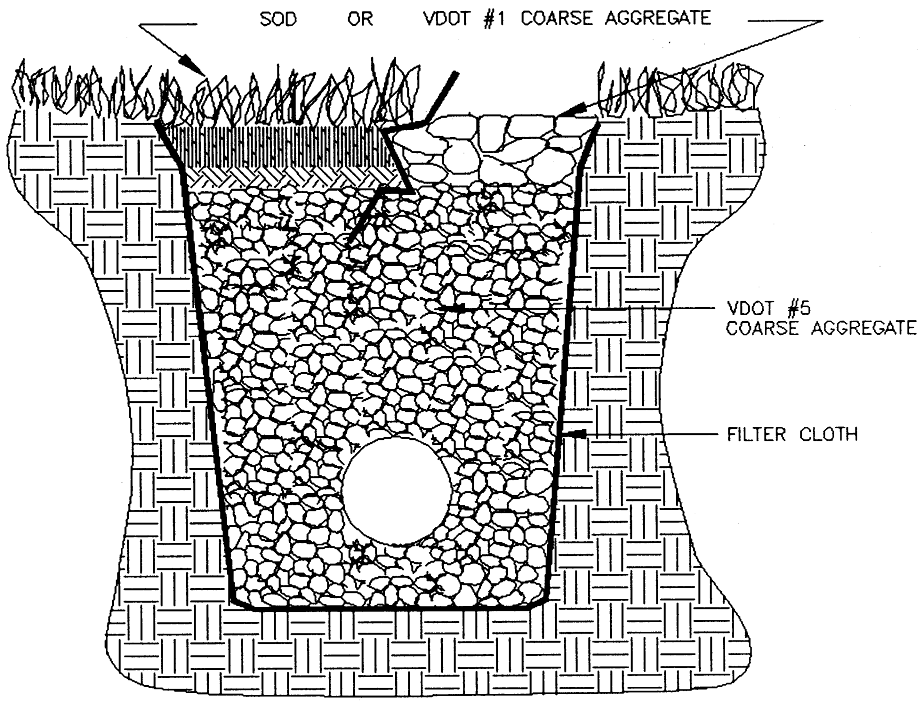
DRAINAGE ENVELOPE



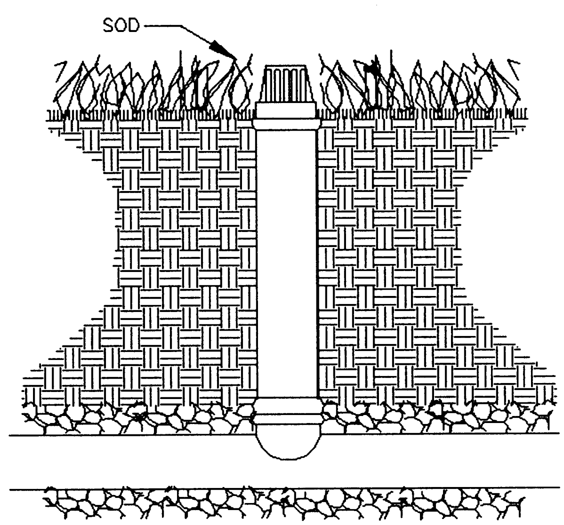
Source: USDA-SCS

Plate 3.28-3

SURFACE INLETS



NATURAL INLET



GRATED INLET

Source: USDA-SCS

Plate 3.28-4

APPENDIX 3.28-a

Subsurface drains are not generally designed to flow under pressure and the hydraulic gradient is parallel with the grade line. Consequently, the flow is considered to be open channel and Manning's Equation can be used. The required drain size can be determined by the following procedure:

1. Determine the flow the drain must carry.
2. Determine the gradient of the drain
3. From Table 3.28-C, determine "n" for the type of drain pipe to be used. Choose the correct Plate (3.28-5 through 3.28-7) for the "n" just determined.
4. Enter the appropriate plate with the gradient of the pipe and the flow in the pipe. The intersection of the two lines must be to the right of the line for 1.4 ft./sec. If it is not, increase the gradient or flow capacity or both.

Example 1

Given:

A random subsurface drain is to be installed on a 1.0% grade, 700 feet in length, and using corrugated plastic pipe.

Calculate:

The required size of the drain pipe.

Solution:

From the Std. & Spec., the required capacity of the pipe is:

$$1.5\ ft.^3/\text{sec.}/1000\ ft.$$

$$Capacity = \frac{700}{1000}\ x\ 1.5\ ft.^3/\text{sec.} = 1.05\ ft.^3/\text{sec.}$$

* From Table 3.28-C, n = 0.015 for corrugated plastic pipe.

* From Plate 3.28-6, choose an 8-inch pipe.

Example 2

Given:

A relief drain installed in a gridiron pattern of 8 laterals, 500 feet long, 0.5% grade, and 50 feet on centers. A main 400 feet in length on a 0.5% grade will connect to the laterals. Use bituminized fiber pipe for the main and laterals.

Calculate:

The required size of the drain pipe.

Solution:

The drainage area for each lateral is 25 feet on either side of the pipe times the length. Therefore:

$$\frac{50\ ft.\ \ x\ \ 500\ ft.}{43{,}560\ ft.^2/acre} = 0.57\ acre$$

From the Std. & Spec., the drains must remove 1 inch of water in 24 hours or 0.042 $ft.^3$/sec./acre.

$$0.042\ ft.^3/\text{sec.}/acre\ \ x\ \ 0.57\ acre = 0.02\ ft.^3/\text{sec.}$$

From Table 3.28-C, n = 0.013 for bituminized fiber pipe.

From Plate 3.28-5, a 4-inch pipe must be used for the laterals.

The first 25 feet of the main will drain 25 feet on either side of the pipe. The remaining 375 feet will drain only 25 feet on the side opposite from the laterals. In addition, the main will drain the laterals.

Drainage from main:

$$\frac{25\ ft.\ \ x\ \ 50\ ft.}{43{,}560\ ft.^2/acre} + \frac{375\ ft.\ \ x\ \ 25\ ft.}{43{,}560\ ft.^2/acre} = 0.24\ acre$$

Drainage from laterals:

$$8 \quad x \quad 0.57 \; acre \quad = \quad 4.56 \; acre$$

$$Total \quad = \quad 0.24 \quad + \quad 4.56 \quad = \quad 4.8 \; acre$$

Required capacity:

$$0.042 \; ft.^3/\text{sec.}/acre \quad x \quad 4.8 \; acre \quad = \quad 0.20 \; ft.^3/\text{sec.}$$

From Plate 3.28-5, choose a 5-inch pipe for the main.

TABLE 3.28-C

"n" VALUES FOR SUBSURFACE DRAIN PIPES

Composition of Pipe or Tubing	"n" Values
Asbestos Cement	0.013
Bituminized Fiber	0.013
Concrete	0.015
Corrugated Plastic	0.015
Corrugated Metal	0.025

Source: Va. DSWC

Spacing of Relief Drains

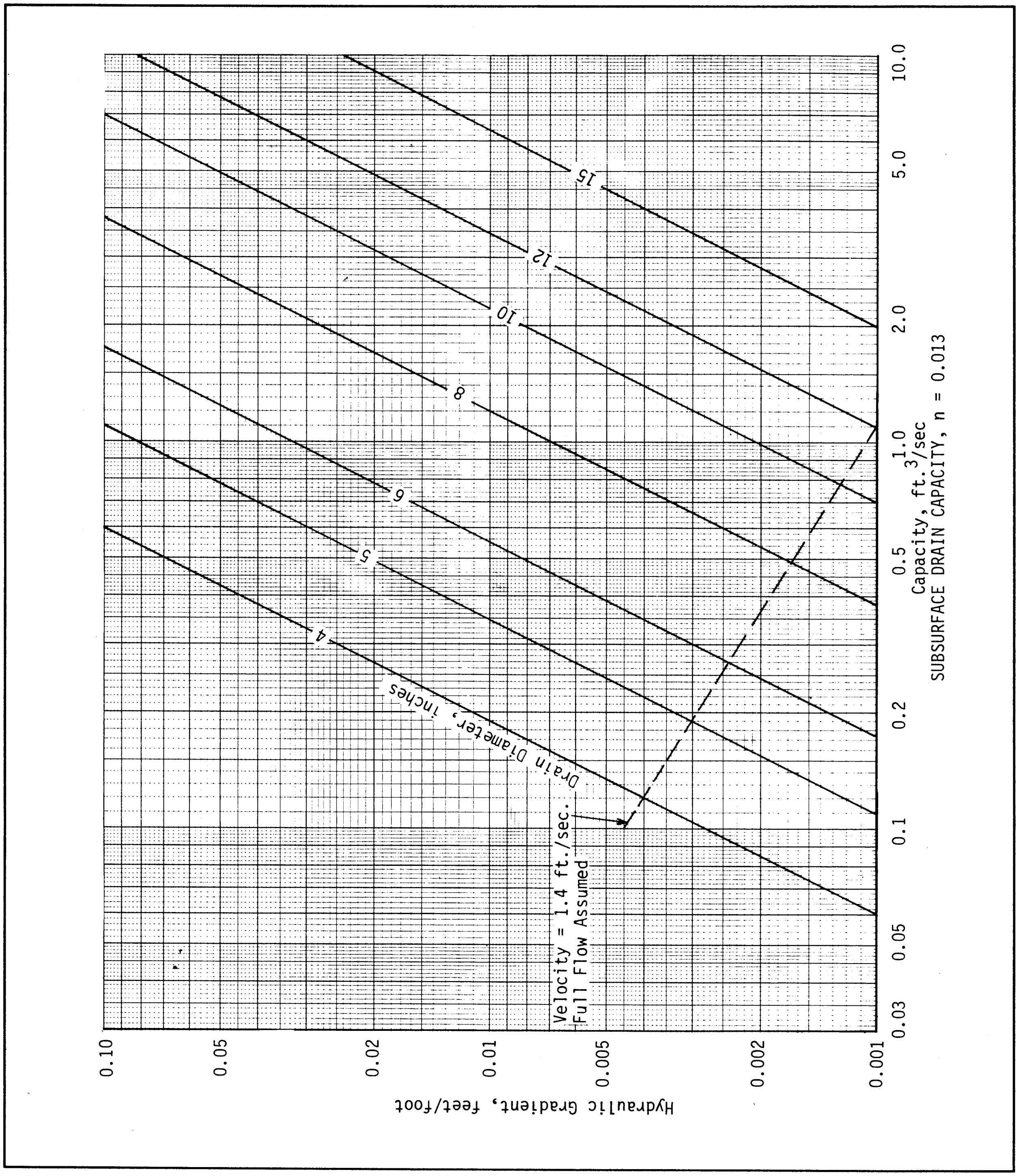
If the necessary information is known, the following equation can be used to calculate drain spacing in lieu of the recommended standard:

$$S \quad = \quad \sqrt{\frac{4k \; (M^2 \; + \; 2 \; AM)}{q}}$$

Where,

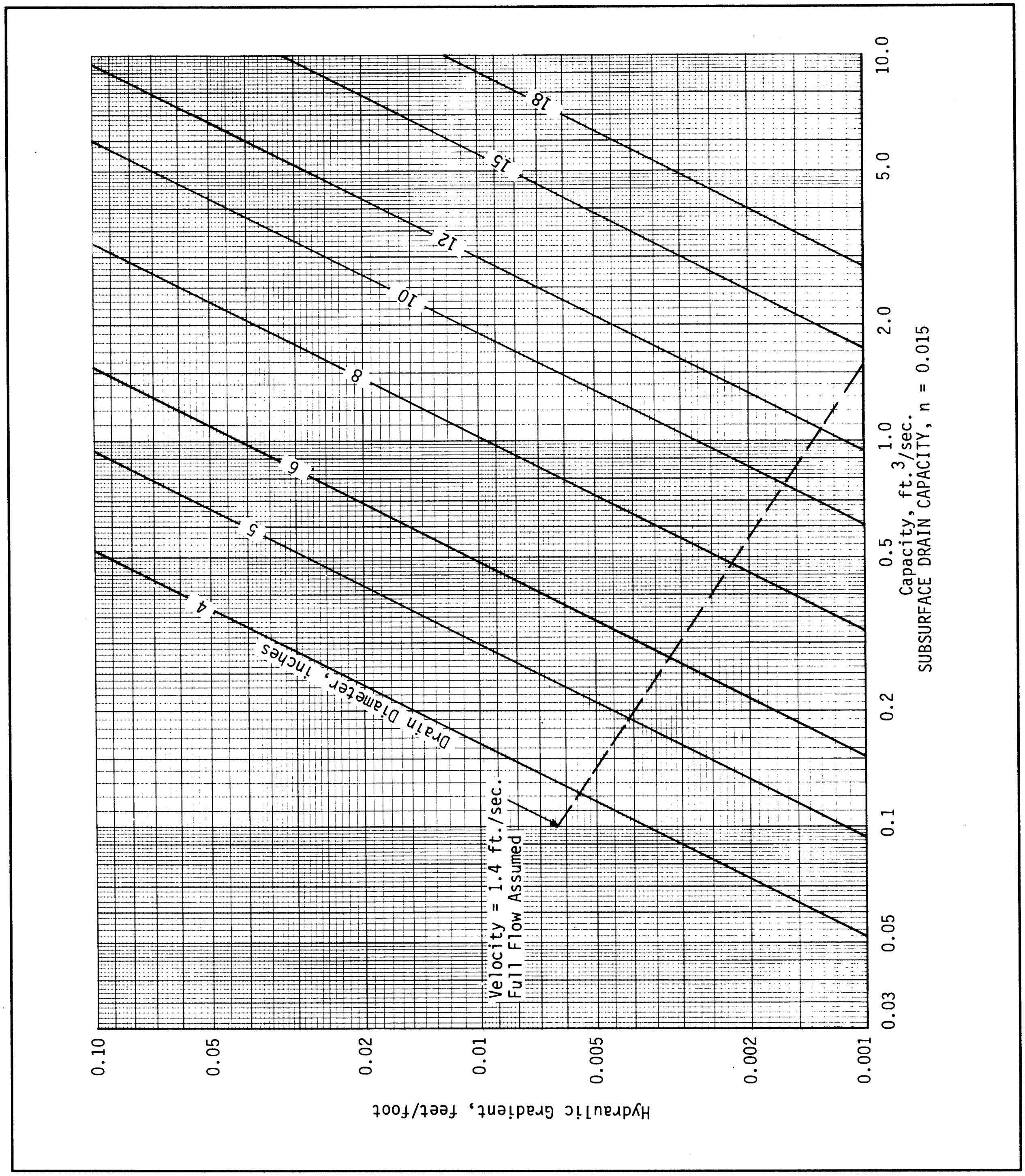
S = drain spacing, feet

k = average hydraulic conductivity, in./hr. (for practical purposes, hydraulic conductivity is equal to permeability).



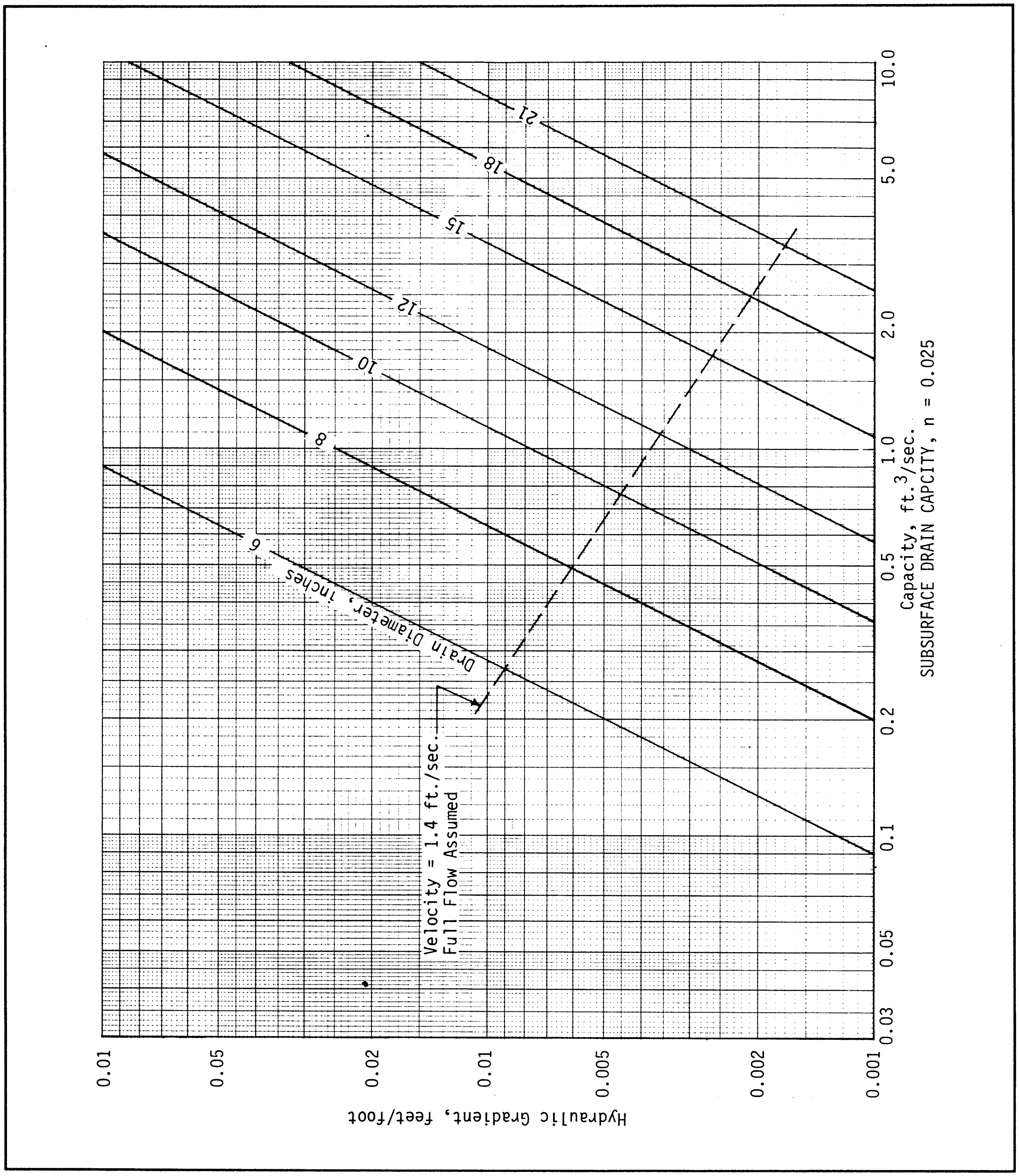
Source: USDA-SCS

Plate 3.28-5



Source: USDA-SCS

Plate 3.28-6



Source: USDA-SCS

Plate 3.28-7

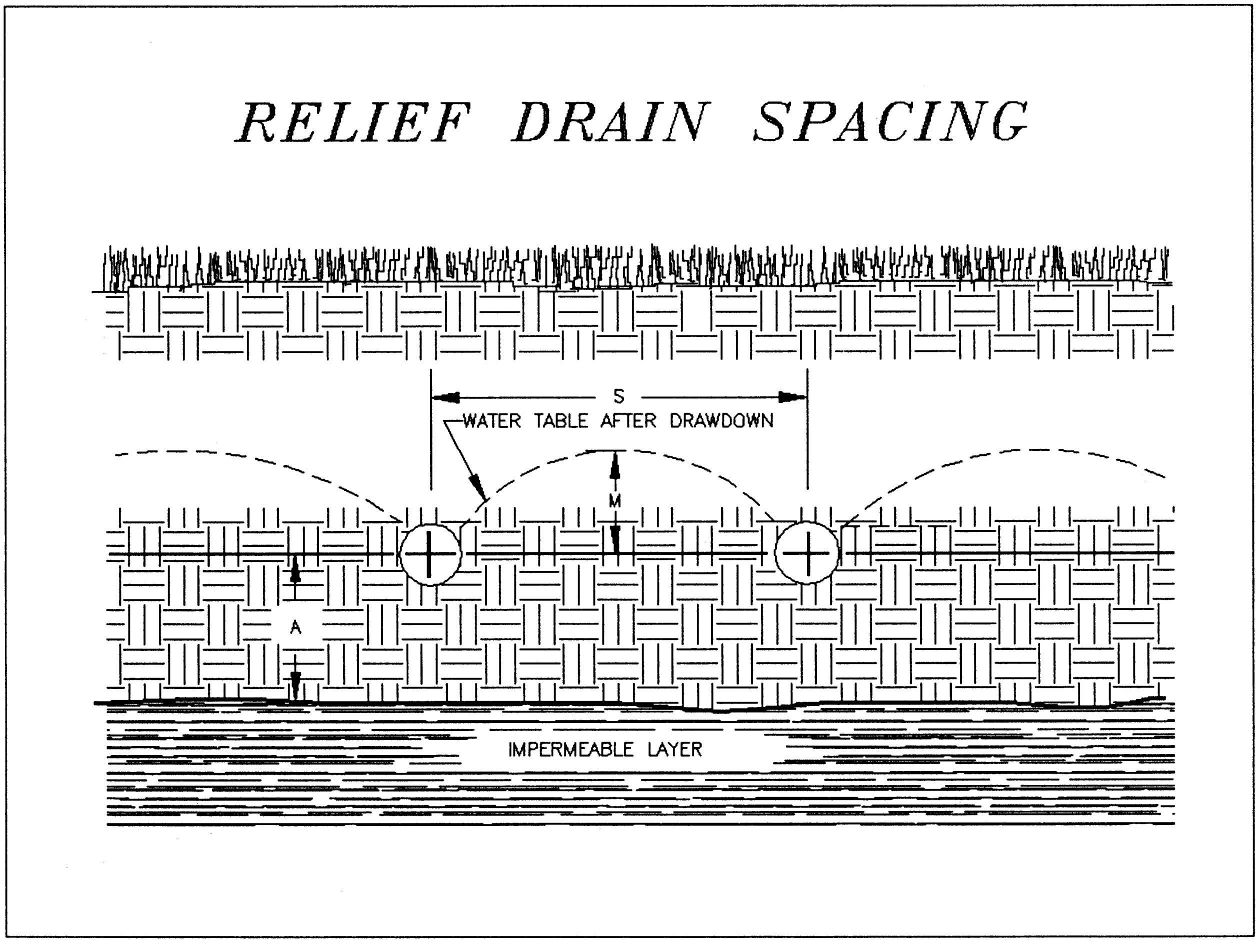
M = vertical distance, after drawdown, of water table above drain at mid-point between lines, feet.

A = depth of barrier below drain, feet.

q = drainage coefficient, rate of water removal, inch/hr.

Also, see Plate 3.28-8.

This equation is applicable to most areas in Virginia. Limitations of the equation are listed in the SCS National Engineering Handbook, Section 16, Drainage of Agricultural Land (66).



Source: USDA-SCS

Plate 3.28-8

Spacing of Interceptor Drains

If one interceptor drain is not sufficient, the spacing of multiple drains can be calculated by the following equation:

$$Le = \frac{k\,i}{q}\,(de - dw + W_2)$$

Where,

Le = the distance downslope from the drain to the point where the water table is at the desired depth after drainage, feet. The second drain should be located at this point.

k = the average hydraulic conductivity of the subsurface profile to the depth of the drain, in./hr.

q = drainage coefficient, rate of water removal, in./hr.

i = the hydraulic gradient of the water table before drainage, feet/foot.

de = the effective depth of the drain, feet.

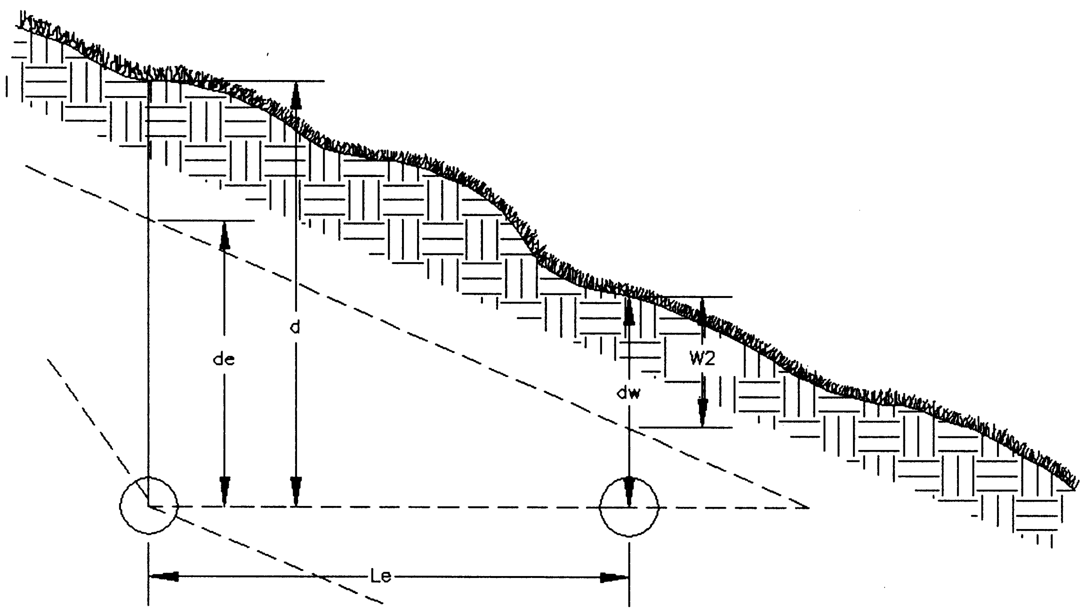
dw = the desired minimum depth to water table after drainage, feet.

W_2 = the distance from the ground surface to the water table, before drainage, at the distance (Le) downslope from the drain, feet.

Also, see Plate 3.28-9.

Further information on the equation can be obtained from the SCS National Engineering Handbook, Section 16, Drainage of Agricultural Land (66).

INTERCEPTOR DRAIN SPACING



Source: USDA-SCS

Plate 3.28-9

STD & SPEC 3.29

SURFACE ROUGHENING

SR

Definition

Providing a rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine-grading them.

Purposes

1. To aid in establishment of vegetative cover with seed.
2. To reduce runoff velocity and increase infiltration.
3. To reduce erosion and provide for sediment trapping.

Conditions Where Practice Applies

1. All slopes steeper than 3:1 require surface roughening, either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.

2. Areas with grades less steep than 3:1 should have the soil surface lightly roughened and loose to a depth of 2 to 4 inches prior to seeding.

3. Areas which have been graded and will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.

4. Slopes with a stable rock face do not require roughening or stabilization.

Planning Considerations

Graded areas with smooth, hard surfaces give a false impression of "finished grading" and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity.

Rough loose soil surfaces give lime, fertilizer and seed some natural coverage. Niches in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

1. Disturbed areas which will not require mowing may be stair-step graded, grooved, or left rough after filling.

2. Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material which sloughs from above, and provides a level site where vegetation can become established.

3. Areas which will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by discing, harrowing, raking, or seed-planting machinery operated on the contour.

4. It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all, but is not as

effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.

Specifications

Cut Slope Applications For Areas Which Will Not Be Mowed

Cut slopes with a gradient steeper than 3:1 shall be stair-step graded or grooved (Plates 3.29-1 and 3.29-2).

1. Stair-step grading may be carried out on any material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.

   The ratio of the vertical cut distance to the horizontal distance shall be less than 1:1 and the horizontal portion of the "step" shall slope toward the vertical wall.

   Individual vertical cuts shall not be more than 30 inches on soft soil materials and not more than 40 inches in rocky materials.

2. Grooving consists of using machinery to create a series of ridges and depressions which run perpendicular to the slope (on the contour).

   Grooves may be made with any appropriate implement which can be safely operated on the slope and which will not cause undue compaction. Suggested implements include discs, tillers, spring harrows, and the teeth on a front-end loader bucket. Such grooves shall not be less than 3 inches deep nor further than 15 inches apart.

Fill Slope Applications For Areas Which Will Not Be Mowed

Fill slopes with a gradient steeper than 3:1 shall be grooved or allowed to remain rough as they are constructed. Method (1) or (2) below may be used.

1. Groove according to #2 above.

2. As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface (see Plate 3.29-3).

Colluvial materials (soil deposits at the base of slopes or from old stream beds) shall not be used in fills as they flow when saturated.

At no time shall slopes be bladed or scraped to produce a smooth, hard surface.

Cuts, Fills, and Graded Areas Which Will Be Mowed

Mowed slopes should not be steeper than 3:1. Excessive roughness is undesirable where mowing is planned. These areas may be roughened with shallow grooves such as remain after tilling, discing, harrowing, raking, or use of a cultipacker-seeder. The final pass of any such tillage implement shall be on the contour (perpendicular to the slope).

Grooves formed by such implements shall be not less than 1-inch deep and not further than 12-inches apart. Fill slopes which are left rough as constructed may be smoothed with a dragline or pickchain to facilitate mowing.

Roughening With Tracked Machinery (see Plate 3.29-4)

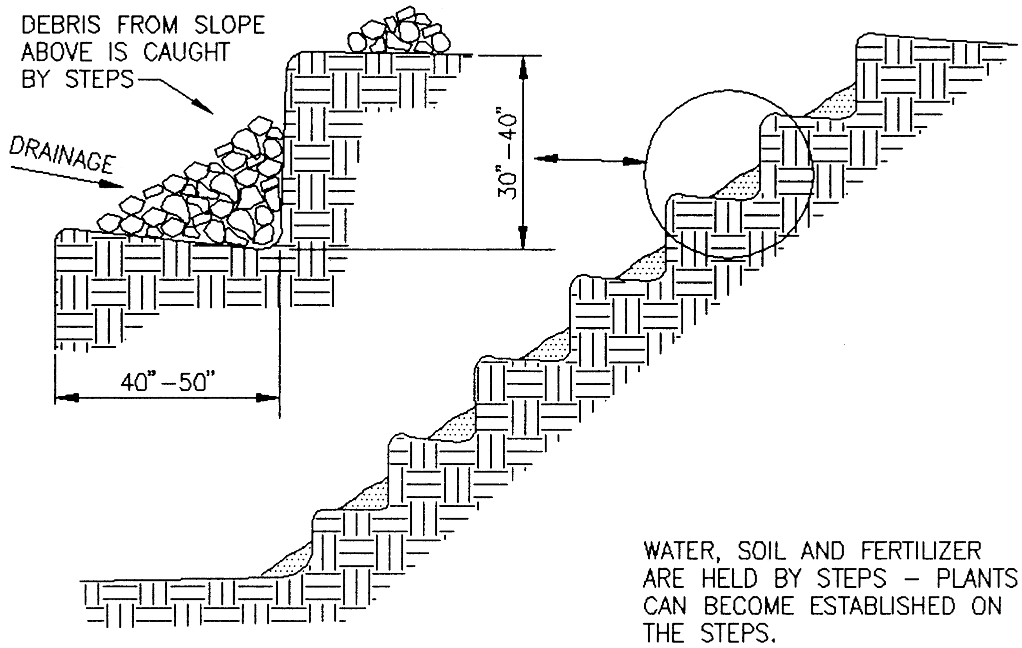
Roughening with tracked machinery on clayey soils is not recommended unless no alternatives are available. Undue compaction of surface soil results from this practice. Sandy soils do not compact severely, and may be tracked. In no case is tracking as effective as the other roughening methods described.

When tracking is the chosen surface roughening technique, it shall be done by operating tracked machinery up and down the slope to leave horizontal depressions in the soil. As few passes of the machinery should be made as possible to minimize compaction.

Seeding

Roughened areas shall be seeded and mulched as soon as possible to obtain optimum seed germination and seedling growth.

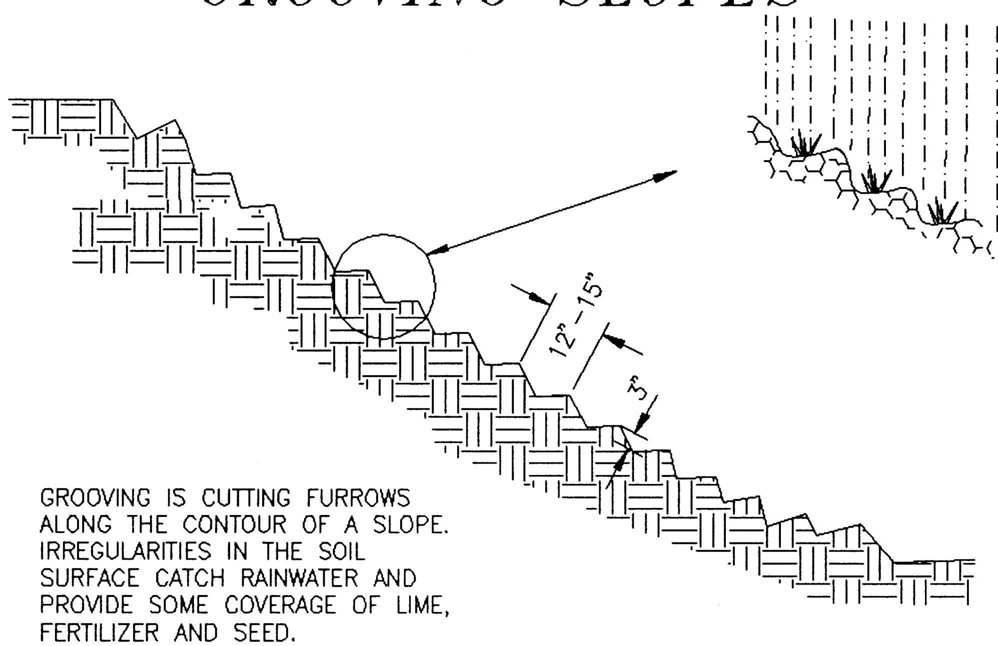
STAIR STEPPING CUT SLOPES



Source: Va. DSWC

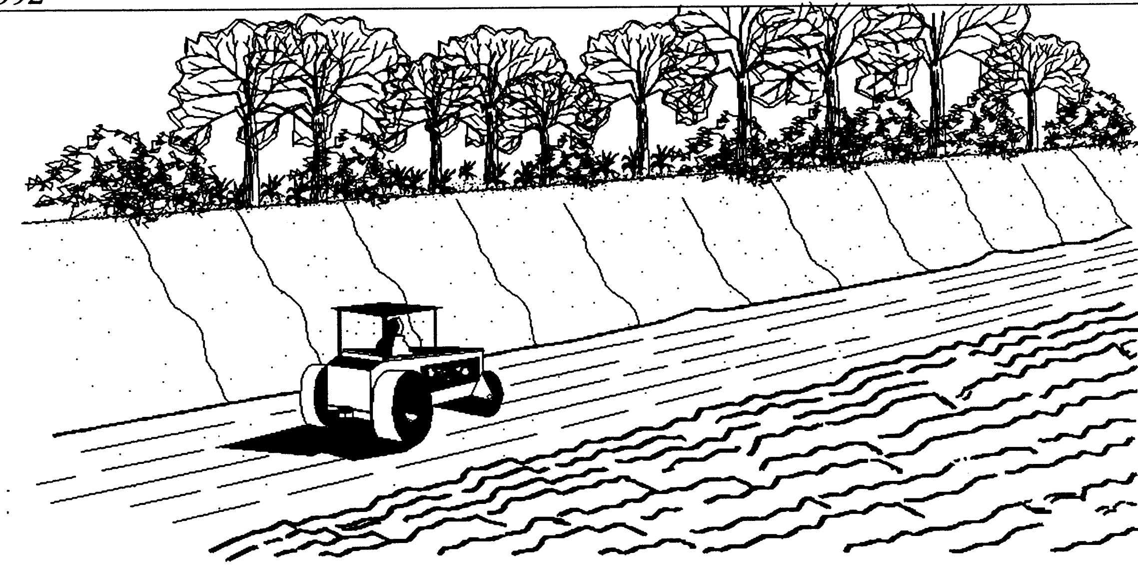
Plate 3.29-1

GROOVING SLOPES



Source: Va. DSWC

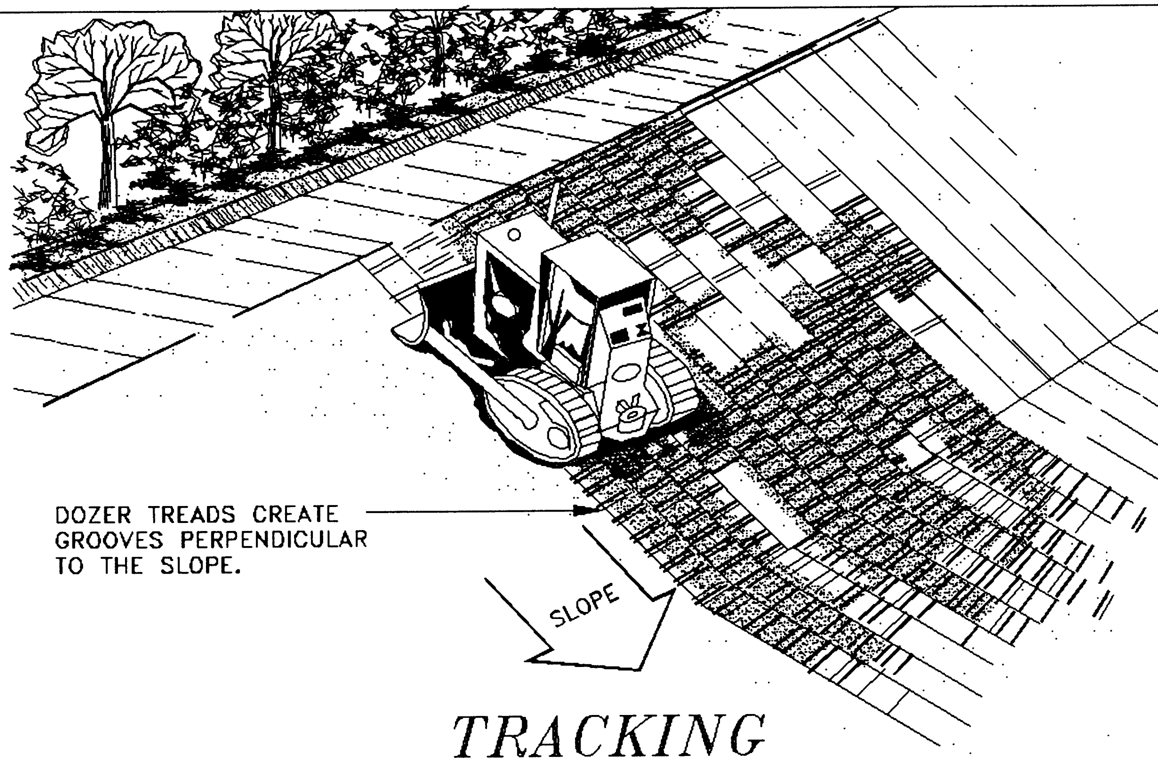
Plate 3.29-2



EACH LIFT OF THE FILL IS COMPACTED, BUT THE OUTER FACE OF THE SLOPE IS ALLOWED TO REMAIN LOOSE SO THAT THE ROCKS, CLODS, ETC. REACH THE NATURAL ANGLE OF REPOSE.

FILL SLOPE TREATMENT

Source: Va. DSWC — Plate 3.29-3



TRACKING

Source: <u>Michigan Soil Erosion and Sedimentation Guide</u> — Plate 3.29-4

STD & SPEC 3.30

TOPSOILING

TO

Definition

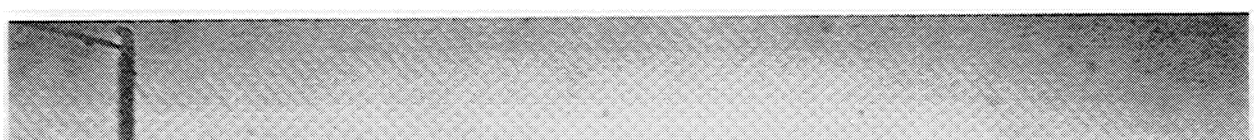
Methods of preserving and using the surface layer of undisturbed soil, often enriched in organic matter, in order to obtain a more desirable planting and growth medium.

Purpose

To provide a suitable growth medium for final site stabilization with vegetation.

Conditions Where Practice Applies

1. Where the preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium.



2. Where the subsoil or existing soil presents the following problems:

    a. The texture, pH, or nutrient balance of the available soil cannot be modified by reasonable means to provide an adequate growth medium.

    b. The soil material is too shallow to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth.

    c. The soil contains substances potentially toxic to plant growth.

3. Where high-quality turf is desirable to withstand intense use or meet aesthetic requirements.

4. Where ornamental plants will be established.

5. Only on slopes that are <u>2:1 or flatter</u> unless other measures are taken to prevent erosion and sloughing.

Planning Considerations

Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants, and supplying a large share of the water used by plants.

Although topsoil provides an excellent growth medium, there are disadvantages to its use. Stripping, stockpiling, and reapplying topsoil, or importing topsoil, may not always be cost-effective. Topsoiling can delay seeding or sodding operations, increasing the exposure time of denuded areas. Most topsoil contains weed seeds, and weeds may compete with desirable species.

Advantages of topsoil include its high organic matter content and friable consistence, water-holding capacity, and nutrient content.

In site planning, the option of topsoiling should be compared with that of preparing a seedbed in subsoil. The clay content of subsoils does provide high moisture availability and deter leaching of nutrients and, when properly limed and fertilized, subsoils may provide a good growth medium which is generally free of weed seeds. In many cases topsoiling may not be required for the establishment of less demanding, lower maintenance plant material. Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a required procedure when establishing vegetation on shallow soils, soils containing potentially toxic materials, and soils of critically low pH (high acid) levels.

If topsoiling is to be done, the following items should be considered:

1. Whether an adequate volume of topsoil exists on the site. Topsoil will be spread at a compacted depth of 2 to 4 inches (depths closer to 4 inches are preferred).

2. Location of the topsoil stockpile so that it meets specifications and does not interfere with work on the site.

3. Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding, or planting.

4. Care must be taken not to apply topsoil to subsoil if the two soils have contrasting textures. Clayey topsoil over sandy subsoil is a particularly poor combination, as water may creep along the junction between the soil layers, causing the topsoil to slough. Sandy topsoil over a clay subsoil is equally as likely to fail.

5. If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. Topsoiling of steep slopes should be discouraged unless good bonding of soils can be achieved.

Specifications

Materials

Field exploration of the site shall be made to determine if there is sufficient surface soil of good quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). It shall be free of debris, trash, stumps, rocks, roots, and noxious weeds, and shall give evidence of being able to support healthy vegetation. It shall contain no substance that is potentially toxic to plant growth.

All topsoil shall be tested by a recognized laboratory for the following criteria:

Organic matter content shall be not less than 1.5% by weight.

pH range shall be from 6.0-7.5. If pH is less than 6.0, lime shall be added in accordance with soil test results or in accordance with the recommendations of the vegetative establishment practice being used.

Soluble salts shall not exceed 500 ppm.

If additional off-site topsoil is needed, it must meet the standards stated above.

Stripping

Topsoil operations should not be performed when the soil is wet or frozen. Stripping shall be confined to the immediate construction area. A 4-to 6-inch stripping depth is common, but depth may vary depending on the particular soil. All perimeter dikes, basins, and other sediment controls shall be in place prior to stripping.

Stockpiling

Topsoil shall be stockpiled in such a manner that natural drainage is not obstructed and no off-site sediment damage shall result. Stabilize or protect stockpiles in accordance with MS #2.

Side slopes of the stockpile shall not exceed 2:1.

Perimeter controls must be placed around the stockpile immediately; seeding of stockpiles shall be completed within 7 days of the formation of the stockpile, in accordance with Std. & Spec. 3.31, TEMPORARY SEEDING if it is to remain dormant for longer than 30 days (refer to MS #1 and MS #2).

Site Preparation Prior to and Maintenance During Topsoiling

Before topsoiling, establish needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, waterways, sediment basins, etc. These practices must be maintained during topsoiling.

Grading: Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.

Liming: Where the pH of the subsoil is 6.0 or less, or the soil is composed of heavy clays, agricultural limestone shall be spread in accordance with the soil test or the vegetative establishment practice being used.

Bonding: After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by discing or scarifying to a depth of at least 2 inches to ensure bonding of the topsoil and subsoil.

Applying Topsoil

Topsoil shall not be placed while in a frozen or muddy condition, when topsoil or subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding or seeding. The topsoil shall be uniformly distributed to a minimum compacted depth of 2 inches on 3:1 or steeper slopes and 4 inches on flatter slopes. (See Table 3.30-A to determine volume of topsoil required for application to various depths). Any irregularities in the surface, resulting from topsoiling or other operations, shall be corrected in order to prevent the formation of depressions or water pockets.

It is necessary to compact the topsoil enough to ensure good contact with the underlying soil and to obtain a level seedbed for the establishment of high maintenance turf. However, undue compaction is to be avoided as it increases runoff velocity and volume, and deters seed germination. Special consideration should be given to the types of equipment used to place topsoil in areas to receive fine turf. Avoid unnecessary compaction by heavy machinery whenever possible. In areas which are not going to be mowed, the surface should be left rough in accordance with SURFACE ROUGHENING (Std. & Spec. 3.29).

Soil Sterilants

No sod or seed shall be placed on soil which has been treated with soil sterilants until sufficient time has elapsed to permit dissipation of toxic materials.

TABLE 3.30-A

CUBIC YARDS OF TOPSOIL REQUIRED FOR APPLICATION TO VARIOUS DEPTHS

Depth (inches)	Per 1,000 Square Feet	Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	537
5	15.5	672
6	18.6	806

Source: Va. DSWC

STD & SPEC 3.31

TEMPORARY SEEDING

TS

Definition

The establishment of a temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.

Purposes

1. To reduce erosion and sedimentation by stabilizing disturbed areas that will not be brought to final grade for a period of more than ~~30~~ 14 days. RWE; DEQ-OTS 3-12-14

2. To reduce damage from sediment and runoff to downstream or off-site areas, and to provide protection to bare soils exposed during construction until permanent vegetation or other erosion control measures can be established.

Conditions Where Practice Applies

Where exposed soil surfaces will not be at final grade for more than 14 days. ~~are not to be fine-graded for periods longer than 30~~ days. Such areas include denuded areas, soil stockpiles, dikes, dams, sides of sediment basins, temporary roadbanks, etc. (see MS #1 and MS #2). A permanent vegetative cover shall be applied to areas that will be left dormant for a period of more than 1 year.

Planning Considerations

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

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

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

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

Specifications

Prior to seeding, install necessary erosion control practices such as dikes, waterways, and basins.

Plant Selection

Select plants appropriate to the season and site conditions from Tables 3.31-B and 3.31-C. Note that Table 3.31-B presents plants which can be used without extensive evaluation of site conditions; Table 3.31-C presents more in-depth information on the plant materials.

Seedbed Preparation

To control erosion on bare soil surfaces, plants must be able to germinate and grow. Seedbed preparation is essential.

1. Liming: An evaluation should be conducted to determine if lime is necessary for temporary seeding. In most soils, it takes up to 6 months for a pH adjustment to occur following the application of lime. Therefore, it may be difficult to justify the cost of liming a temporary site, especially when the soil will later be moved and regraded. The following table may be used to determine the actual need along with suggested application rates.

TABLE 3.31-A

LIMING REQUIREMENTS FOR TEMPORARY SITES

pH Test	Recommended Application of Agricultural Limestone
below 4.2	3 tons per acre
4.2 to 5.2	2 tons per acre
5.2 to 6	1 ton per acre

Source: Va. DSWC

2. Fertilizer: Shall be applied as 600 lbs./acre of 10-20-10 (14 lbs./1,000 sq. ft.) or equivalent nutrients. Lime and fertilizer shall be incorporated into the top 2 to 4 inches of the soil if possible.

3. Surface Roughening: If the area has been recently loosened or disturbed, no further roughening is required. When the area is compacted, crusted, or hardened, the soil surface shall be loosened by discing, raking, harrowing, or other acceptable means (see SURFACE ROUGHENING, Std. & Spec. 3.29).

4. Tracking: Tracking with bulldozer cleats is most effective on sandy soils. This practice often causes undue compaction of the soil surface, especially in clayey soils, and does not aid plant growth as effectively as other methods of surface roughening.

Seeding

Seed shall be evenly applied with a broadcast seeder, drill, cultipacker seeder or hydroseeder. Small grains shall be planted no more than 1½ inches deep. Small seeds, such as Kentucky Bluegrass, should be planted no more than 1/4 inch deep. Other Grasses and Legumes should be planted from 1/4 inch to 1/2 inch deep.

Mulching

1. Seedings made in fall for winter cover and during hot and dry summer months shall be mulched according to MULCHING, Std. & Spec. 3.35, except that hydromulches (fiber mulch) will not be considered adequate. Straw mulch should be used during these periods.

2. Temporary seedings made under favorable soil and site conditions during optimum spring and fall seeding dates may not require mulch.

Re-seeding

Areas which fail to establish vegetative cover adequate to prevent rill erosion will be re-seeded as soon as such areas are identified.

TABLE 3.31-B

ACCEPTABLE TEMPORARY SEEDING PLANT MATERIALS

"QUICK REFERENCE FOR ALL REGIONS"

Planting Dates	Species	Rate (lbs./acre)
Sept. 1 - Feb. 15	50/50 Mix of Annual Ryegrass (Lolium multi-florum) & Cereal (Winter) Rye (Secale cereale)	50 - 100
Feb. 16 - Apr. 30	Annual Ryegrass (Lolium multi-florum)	60 - 100
May 1 - Aug 31	German Millet (Setaria italica)	50

Source: Va. DSWC

TABLE 3.31-C

TEMPORARY SEEDING PLANT MATERIALS, SEEDING RATES, AND DATES

SPECIES	SEEDING RATE		NORTH[a]			SOUTH[b]			PLANT CHARACTERISTICS
	Acre	1000 ft²	3/1 to 4/30	5/1 to 8/15	8/15 to 11/1	2/15 to 4/30	5/1 to 9/1	9/1 to 11/15	
OATS (Avena sativa)	3 bu. (up to 100 lbs., not less than 50 lbs.)	2 lbs.	X	-	-	X	-	-	Use spring varieties (e.g., Noble).
RYE[d] (Secale cereale)	2 bu. (up to 110 lbs., not less than 50 lbs.)	2.5 lbs.	X	-	X	X	-	X	Use for late fall seedings, winter cover. Tolerates cold and low moisture.
GERMAN MILLET (Setaria italica)	50 lbs.	approx. 1 lb.	-	X	-	-	X	-	Warm-season annual. Dies at first frost. May be added to summer mixes.
ANNUAL RYEGRASS[c] (Lolium multi-florum)	60 lbs.	1½ lbs.	X	-	X	X	-	X	May be added in mixes. Will mow out of most stands.
WEEPING LOVEGRASS (Eragrostis curvula)	15 lbs.	5½ ozs.	-	X	-	-	X	-	Warm-season perennial. May bunch. Tolerates hot, dry slopes and acid, infertile soils. May be added to mixes.
KOREAN LESPEDEZA[c] (Lespedeza stipulacea)	25 lbs.	approx. 1½ lbs.	X	X	-	X	X	-	Warm season annual legume. Tolerates acid soils. May be added to mixes.

[a] Northern Piedmont and Mountain region. See Plates 3.22-1 and 3.22-2.
[b] Southern Piedmont and Coastal Plain.
[c] May be used as a cover crop with spring seeding.
[d] May be used as a cover crop with fall seeding.
X May be planted between these dates.
\- May not be planted between these dates.

STD & SPEC 3.32

PERMANENT SEEDING

PS

Definition

The establishment of perennial vegetative cover on disturbed areas by planting seed.

Purposes

1. To reduce erosion and decrease sediment yield from disturbed areas.

2. To permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials.

3. To improve wildlife habitat.

4. To enhance natural beauty.

Conditions Where Practice Applies

1. Disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil.

2. Rough-graded areas which will not be brought to final grade for a year or more.

Planning Considerations

Vegetation controls erosion by reducing the velocity and the volume of overland flow and protecting the bare soil surface from raindrop impact.

Areas which must be stabilized after the land has been disturbed require vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes. Permanent vegetative covers must meet the requirements of Minimum Standard #3.

Advantages of seeding over other means of establishing plants include the small initial establishment cost, the wide variety of grasses and legumes available, low labor requirement, and ease of establishment in difficult areas.

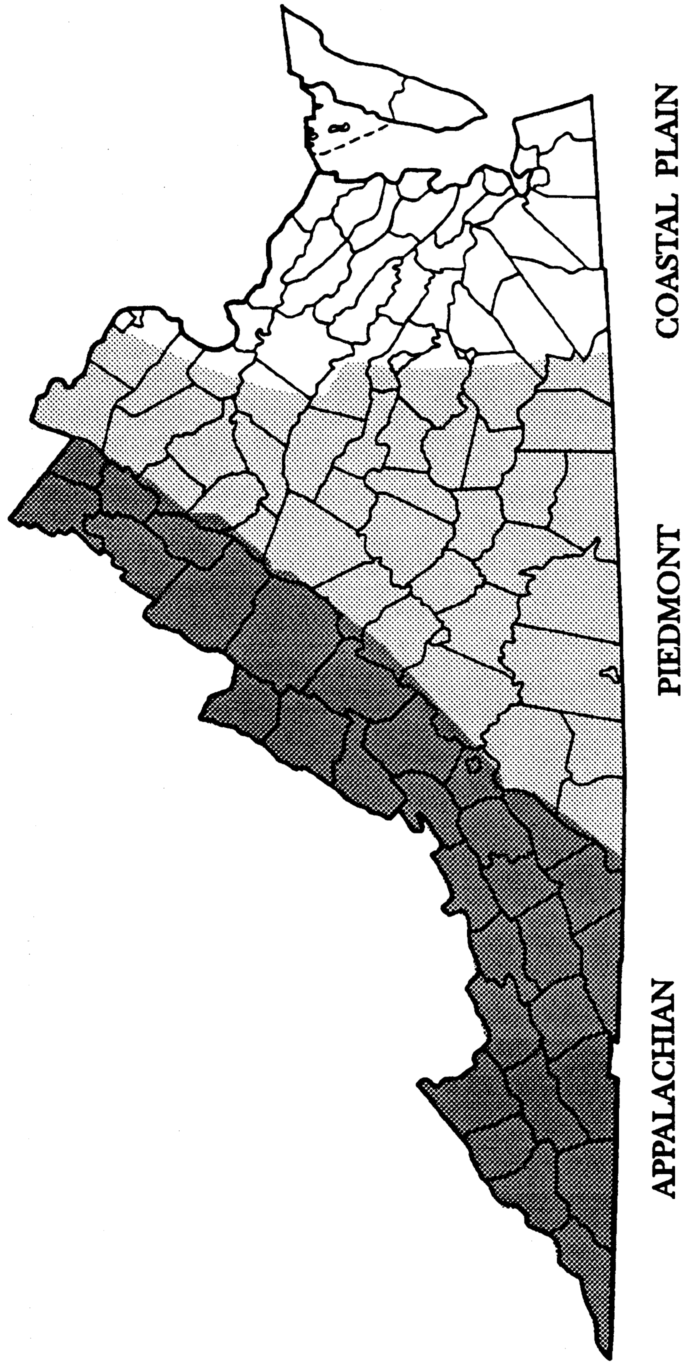
Disadvantages which must be dealt with are the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding, the potential need for weed control during the establishment phase, and a need for water and appropriate climatic conditions during germination.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done in the planning stages to increase the chances for successful seeding. Selection of the right plant materials for the site, good seedbed preparation, and conscientious maintenance are important.

SELECTING PLANT MATERIALS: The factors affecting plant growth are climate, soils, and topography. In Virginia, there are three major physiographic regions that reflect changes in soil and topography. In selecting appropriate plant materials, one should take into account the characteristics of the physiographic region in which the project is located (see Plate 3.32-1).

PHYSIOGRAPHIC REGIONS:

Coastal Plain - Soils on the Coastal Plain are deeply weathered, stratified deposits of sand and clay. They are generally acidic and low in plant nutrients. The sandy soils are hot and droughty in summer. This region receives more rain and is warmer than the other regions of the state. The land is fairly level, and many areas are poorly drained. Warm season grasses traditionally perform well in these areas.



PHYSIOGRAPHIC PROVINCES IN VIRGINIA

Source: Va. DSWC

Plate 3.32-1

<u>Piedmont</u> - Soils on the Piedmont plateau are highly variable. They tend to be shallow, with clayey subsoils. Piedmont soils are low in phosphorus. Soils derived from mica schist are highly erodible. Topography is rolling and hilly. The southern Piedmont has much the same climate as the Coastal Plain. Often referred to as the "transition zone" in planting. Contains areas that will support both warm or cool season grasses.

<u>Appalachian and Blue Ridge Region</u> - This region is divided into plateaus, mountains, and narrow valleys. Soils tend to be shallow and acid, and may erode rapidly on steep slopes. Shaley slopes are often unstable and droughty. This area is colder and drier than the rest of the State. The rugged topography makes plant establishment difficult. Cool season grasses are normally specified in this region.

<u>SOILS</u>: On the whole, soils in Virginia always require some nitrogen (N) fertilization to establish plants. Phosphorus (P) and potassium (K) are usually needed. Except for some small pockets of shallow limestone soils, lime is universally needed.

Soils can be modified with lime and fertilizer, but climate cannot be controlled. For this reason, the State has been divided into two major climatic regions, referred to as the Northern Piedmont and Mountain Region and the Southern Piedmont and Coastal Plain Region, for grass and legume selection (see map, Plate 3.32-2).

Microclimate, or localized climate conditions, can affect plant growth. A south-facing slope is drier and hotter than a north-facing slope, and may require drought-tolerant plants. Shaded areas require shade-tolerant plants; the windward side of a ridge will be drier than the leeward, etc.

<u>LAND USE</u>: A prime consideration in selecting which plants to establish is the intended use of the land. All of these uses - residential, industrial, commercial, recreational - can be separated into two major categories: high-maintenance and low-maintenance.

<u>High-maintenance areas</u> will be mowed frequently, limed and fertilized regularly, and will either receive intense use (e.g., athletics) or require maintaining to an aesthetic standard (home lawns). Grasses used for these situations must be fine-leaved and attractive in appearance, able to form tight sod, and be long-lived perennials. They must be well-adapted to the geographic area where they are planted, because constant mowing puts turf under great stress. Sites where high-maintenance vegetative cover is desirable include homes, industrial parks, schools, churches, athletic playing surfaces as well as some recreational areas.

<u>Low-maintenance areas</u> will be mowed infrequently or not at all; lime and fertilizer may not be applied on a regular basis; the areas will not be subjected to intense use, nor required to have a uniform appearance. These plants must be able to persist with little maintenance over long periods of time. Grass and legume mixtures are favored for these sites because legumes are capable of fixing nitrogen from the air for their own use, and the use of the plants around them. Such mixed stands are better able to withstand adverse conditions.

Sites that would be suitable for low-maintenance vegetation include steep slopes, stream or channel banks, some commercial properties, and "utility turf" areas such as roadbanks.

Seedbed Preparation - The soil on a disturbed site must be modified to provide an optimum environment for seed germination and seedling growth. The surface soil must be loose enough for water infiltration and root penetration. The pH (acidity and alkalinity) of the soil must be such that it is not toxic and nutrients are available, usually between pH 6.0-7.0. Sufficient nutrients (added as fertilizer) must be present. After seed is in place, it must be protected with a mulch to hold moisture and modify temperature extremes, and to prevent erosion while seedlings are growing.

The addition of lime is equally as important as applying fertilizer. Lime is best known as a pH, or acidity, modifier, but it also supplies calcium and magnesium which are plant nutrients. Its effect on pH makes other nutrients more available to the plant. It can also prevent aluminum toxicity by making aluminum less soluble in the soil. Many soils in Virginia are high in aluminum, which stunts the growth of plant roots.

MAINTENANCE: Even with careful, well-planned seeding operations, failures can occur. When it is clear that plants have not germinated on an area or have died, these areas must be reseeded immediately to prevent erosion damage. However, it is extremely important to determine for what reason germination did not take place and make any corrective action necessary prior to reseeding the area. Healthy vegetation is the most effective erosion control available.

Specifications

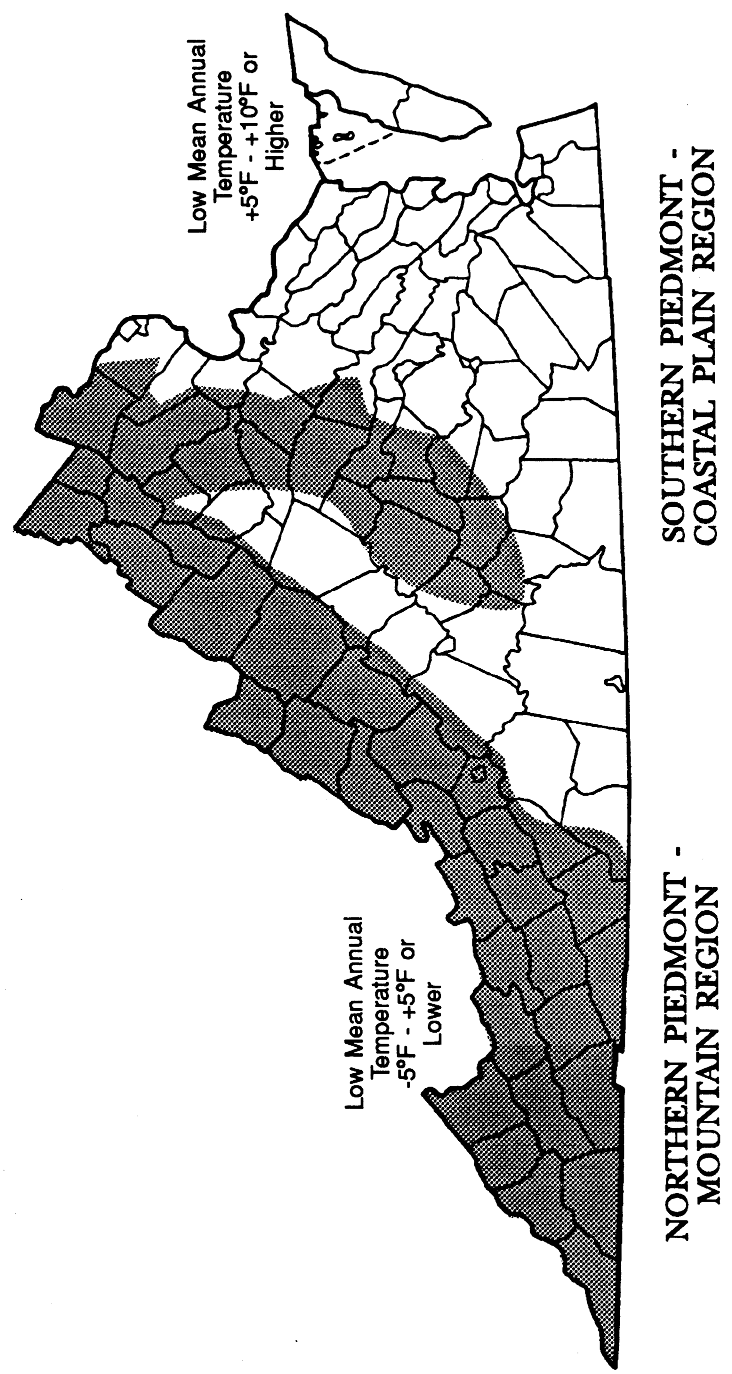
Selection of Plant Materials

1. Selection of plant materials is based on climate, topography, soils, land use, and planting season. To determine which plant materials are best adapted to a specific site, use Tables 3.32-A and 3.22-B which describe plant characteristics and list recommended varieties.

2. Appropriate seeding mixtures for various site conditions in Virginia are given in Tables 3.32-C, 3.32-D and 3.32-E. These mixtures are designed for general use, and are known to perform well on the sites described. Check Tables 3.32-A and 3.32-B for recommended varieties.

3. A more extensive description of plant materials (grasses and legumes), their usage and pictorial representation can be found in Appendix 3.32-c.

4. When using some varieties of turfgrasses, the Virginia Crop Improvement Association (VCIA) recommended turfgrass mixtures may also be used. Consumer protection programs have been devised to identify quality seed of the varieties recommended by the Virginia Cooperative Extension Service. These will bear a label indicating



PLANT HARDINESS ZONES IN VIRGINIA FOR GRASSES AND LEGUMES

Source: Adapted from <u>Virginia Climate Advisory</u>, 1979. Plate 3.32-2 that they are approved by the Association. Mixtures may be designed for a specific physiographic region or based on intended use. Special consideration is given to plant characteristics, performance, etc.

TABLE 3.32-A
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
TALL FESCUE (Festuca arundinacea)	P	C	5.5-6.2	10-14	60-85	F	F	M	SPD	225K	Low when used for erosion control; high when used in lawn	Better suited for erosion control and rough turf application.	Ky 31
TALL FESCUES (Improved)	P	C	5.5-6.2	10-14	60-85	F	G	M	SPD	220K	Responds well to high maintenance.	Excellent for lawn and fine turf.	See current VCIA list.
KENTUCKY BLUEGRASS (Poa pratense)	P	C	6.0-6.5	14	60-75	G	P	M	SPD	2.2m	Needs fertile soil, favorable moisture. Requires several years to become well established.	Excellent for fine turfs-takes traffic, mowing. Poor drought/heat tolerance.	See current VCIA list.
PERENNIAL RYEGRASS (Lolium perenne)	P	C	5.8-6.2	7-10	60-75	F	F	M-H	SPD	227K	Will tolerate traffic.	May be added to mixes. * Improved varieties will perform well all year.	See current VCIA list.

KEY

A = Annual P = Perennial C = Cool Season Plant W = Warm Season Plant G = Good F = Fair P = Poor VP = Very Poor H = High
M = Medium L = Low SPD = Somewhat Poorly Drained MPD = Moderately Poorly Drained PD = Poorly Drained VPD = Very Poorly Drained

TABLE 3.32-A (Continued)
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)		Life Cycle	Season	pH Range	Germination Time, In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
FINE FESCUES	HARD FESCUE (Festuca Longifolia)	P	C	5.0-6.2	10-14	60-80	VG	G	L	MWD	400K	Grows well in sun or shade and will tolerate infertile soils; improved disease resistance.	Exceeds all fine fescues in most tests. Excellent for low-maintenance situations.	Reliant, Spartan, Aurora
	CHEWINGS FESCUE	P	C	5.0-6.2	10-14	60-80	VG	G	L	MWD	400K	Tolerates shade, dry infertile soils.	Poor traffic tolerance, less thatch than other fine fescues.	Flyer
	RED FESCUE (Festuca Rubra)	P	C	5.0-6.2	10-14	60-80	VG	G	L	MWD	400K	Low to medium fertility requirements. Requires well-drained soil.	Spreads by rhizomes, tillers and stolons. Will not take traffic - very shade tolerant.	Long-fellow, Victory
REED CANARYGRASS (Phalaris arundinacea)		P	C	5.8-6.2	21	70-85	G	G	M-H	VPD	530K	Do not mow closely or often.	Conservation cover in wet areas.	No named varieties

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TABLE 3.32-A (Continued)
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time, In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
REDTOP (Agrostis alba)	P	C	5.8-6.2	10	65-85	G	F	L	PD	5m	Will tolerate poor, infertile soils; deep rooted.	Does well in erosion control mixes - not for lawns.	No named varieties.
WEEPING LOVEGRASS (Evagrostis curvula)	P	W	4.5-6.2	14	65-85	F-P	G	L-M	SPD	1.5m	Low-fertility requirements; excellent drought tolerance.	Fast-growing, warm-season bunch grass. Excellent cover for erosion control.	No named varieties.
BERMUDAGRASS (Cynodon dactylon)	P	W	5.8-6.2	21	70-95	P	G	M-H	SPD	1.8m hulled	High nitrogen utilization, excellent drought tolerance. Some varieties adapted to western VA.	Common varieties used for erosion control. Hybrids used for fine turf.	See current VCIA list.
ORCHARDGRASS (Dactylis glomerata)	P	C	5.8-6.2	18	60-75	F	F	M	SPD	625K	Does best on well-drained, loamy soil.	Good pasture selection - may be grazed.	Virginia origin or Potomac

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TABLE 3.32-A (Continued)
CHARACTERISTICS OF COMMONLY SELECTED GRASSES

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
ANNUAL RYEGRASS (Lolium multiflorum)	A	C	5.8-6.2	7	60-70	G	P	M-H	SPD	227K	Will grow on most Virginia Soils. Do not use in fine-turf areas.	May be added into mixes or established alone as temporary cover in spring and fall.	No named varieties.
RYE (Secale cereale)	A	C	5.8-6.2	7	55-70	VG	G	L-M	SPD	18K	Will establish in most all Virginia soils. Do not use in fine-turf areas.	May be added into mixes or established alone for late fall/winter cover.	Abruzzi, Balboa
FOXTAIL MILLET (Setaria italica)	A	W	5.8-6.2	10	65-85	VP	G	M	MWD	220K	Establishes well during summer. Very low moisture requirements.	May be added to erosion-control mixes or established alone.	Common, German

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TABLE 3.32-B
CHARACTERISTICS OF LEGUMES APPROPRIATE FOR EROSION CONTROL

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
CROWNVETCH (Coronilla varia)	P	C	6.0-6.5	14-21	70	G	VG	M	MWD	110K	Does best on well-drained soils. Minimum maintenance when established. May need phosphorus. Inoculation is essential.	Excellent for steep, rocky slopes. Produces colorful blooms in May/June. Slow to establish. Does best when seeded in spring.	Penngift Chemung Emerald
SERICEA LESPEDEZA (Lespedeza cuneata)	P	W	5.8-6.2	21-28	70-85	F	VG	L	MWD	335K	Grows in most well-drained soils. Low fertility requirements. Inoculation is essential.	Use hulled seed in spring; unhulled in fall. Very deep-rooted legume. Excellent choice for eastern Va.	Serecia Interstate
FLATPEA (Lathyrus silvestrus)	P	C	5.0-7.0	14-28	65-75	G	G	L	PD	15K	Needs lime and high phosphorus. Good shade tolerance.	Tolerates acidic and wetter soils better than other legumes.	Lathco
BIRDSFOOT TREFOIL (Lotus corniculatus)	P	C	6.0-6.5	7	65-70	G	F	M	SPD	375K	Inoculation is essential. Grows in medium-fertile, slightly acid soils.	Grows better on poorly drained soils than most legumes. Poor drought/heat tolerance.	No named varieties.

KEY

A = Annual   P = Perennial   C = Cool Season Plant   W = Warm Season Plant   G = Good   F = Fair   P = Poor   VP = Very Poor   H = High
M = Medium   L = Low   SPD = Somewhat Poorly Drained   MPD = Moderately Poorly Drained   PD = Poorly Drained   VPD = Very Poorly Drained

TABLE 3.32-B (Continued)
CHARACTERISTICS OF LEGUMES APPROPRIATE FOR EROSION CONTROL

COMMON NAME (Botanical Name)	Life Cycle	Season	pH Range	Germination Time In Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seeds Per Pound	MAINTENANCE REQUIREMENTS	REMARKS	Suggested Varieties for Virginia
ANNUAL LESPEDEZAS (Lespedeza striata, L. stipulacea)	A	W	5.8-6.2	14	70-85	F	VG	L	MWD	200K	Will grow on almost any well-drained soil.	Choose Kobe for southeastern Va.; needs almost no nitrogen to survive.	Kobe, Korean
RED CLOVER (Trifolium pratense)	P	C	6.0-6.5	7-14	70	G	F	M	SPD	275K	Needs high levels of phosphorus and potassium.	Acts as a biennial. Can be added to low-maintenance mixes.	Kenstar, Kenland
WHITE CLOVER (Trifolium repens)	P	C	6.0-6.5	10	70	G	P	M	PD	700K	Requires favorable moisture, fertile soils, high pH.	Spreads by soil surface stolons, white flowers.	Common, White Dutch

KEY

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M = Medium   L = Low   SPD = Somewhat Poorly Drained   MPD = Moderately Poorly Drained   PD = Poorly Drained   VPD = Very Poorly Drained

TABLE 3.32-C
SITE SPECIFIC SEEDING MIXTURES
FOR APPALACHIAN/MOUNTAIN AREA

	Total Lbs. Per Acre
Minimum Care Lawn	
- Commercial or Residential	200-250 lbs.
- Kentucky 31 or Turf-Type Tall Fescue	90-100%
- Improved Perennial Ryegrass *	0-10%
- Kentucky Bluegrass	0-10%
High-Maintenance Lawn	
Minimum of three (3) up to five (5) varieties of bluegrass from approved list for use in Virginia.	125 lbs.
General Slope (3:1 or less)	
- Kentucky 31 Fescue	128 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop **	20 lbs.
	150 lbs.
Low-Maintenance Slope (Steeper than 3:1)	
- Kentucky 31 Fescue	108 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop **	20 lbs.
- Crownvetch ***	20 lbs.
	150 lbs.

* Perennial Ryegrass will germinate faster and at lower soil temperatures than fescue, thereby providing cover and erosion resistance for seedbed.

** Use seasonal nurse crop in accordance with seeding dates as stated below:

March, April through May 15th	Annual Rye
May 16th through August 15th	Foxtail Millet
August 16th through September, October	Annual Rye
November through February	Winter Rye

*** If Flatpea is used, increase to 30 lbs./acre. All legume seed must be properly inoculated. Weeping Lovegrass may also be included in any slope or low-maintenance mixture during warmer seeding periods; add 10-20 lbs/acre in mixes.

TABLE 3.32-D
SITE SPECIFIC SEEDING MIXTURES FOR PIEDMONT AREA

	Total Lbs. Per Acre
Minimum Care Lawn	
- Commercial or Residential	175-200 lbs.
- Kentucky 31 or Turf-Type Tall Fescue	95-100%
- Improved Perennial Ryegrass	0-5%
- Kentucky Bluegrass	0-5%
High-Maintenance Lawn	200-250 lbs.
- Kentucky 31 or Turf-Type Tall Fescue	100%
General Slope (3:1 or less)	
- Kentucky 31 Fescue	128 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
	150 lbs.
Low-Maintenance Slope (Steeper than 3:1)	
- Kentucky 31 Fescue	108 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
- Crownvetch **	20 lbs.
	150 lbs.

* Use seasonal nurse crop in accordance with seeding dates as stated below:

February 16th through April . . . . Annual Rye
May 1st through August 15th . . . . Foxtail Millet
August 16th through October . . . . Annual Rye
November through February 15th . . . . Winter Rye

** Substitute Sericea lespedeza for Crownvetch east of Farmville, Va. (May through September use hulled Sericea, all other periods, use unhulled Sericea). If Flatpea is used in lieu of Crownvetch, increase rate to 30 lbs./acre. All legume seed must be properly inoculated. Weeping Lovegrass may be added to any slope or low-maintenance mix during warmer seeding periods; add 10-20 lbs./acre in mixes.

TABLE 3.32-D

SITE SPECIFIC SEEDING MIXTURES FOR COASTAL PLAIN AREA

	Total Lbs. Per Acre
Minimum Care Lawn	
- Commercial or Residential	
- Kentucky 31 or Turf-Type Tall Fescue	175-200 lbs.
or	
- Common Bermudagrass **	75 lbs.
High-Maintenance Lawn	
- Kentucky 31 or Turf-Type Tall Fescue	200-250 lbs.
or	
- Hybrid Bermudagrass (seed) **	40 lbs. (unhulled)
or	30 lbs. (hulled)
- Hybrid Bermudagrass (by other vegetative establishment method, see Std. & Spec. 3.34)	
General Slope (3:1 or less)	
- Kentucky 31 Fescue	128 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
	150 lbs.
Low Maintenance Slope (Steeper than 3:1)	
- Kentucky 31 Tall Fescue	93-108 lbs.
- Common Bermudagrass **	0-15 lbs.
- Red Top Grass	2 lbs.
- Seasonal Nurse Crop *	20 lbs.
- Sericea Lespedeza **	20 lbs.
	150 lbs.

* Use seasonal nurse crop in accordance with seeding dates as stated below:

February, March through April	Annual Rye
May 1st through August	Foxtail Millet
September, October through November 15th	Annual Rye
November 16th through January	Winter Rye

** May through October, use hulled seed. All other seeding periods, use unhulled seed. Weeping Lovegrass may be added to any slope or low-maintenance mix during warmer seeding periods; add 10-20 lbs./acre in mixes.

Seedbed Requirements

Vegetation should not be established on slopes that are unsuitable due to inappropriate soil texture, poor internal structure or internal drainage, volume of overland flow, or excessive steepness, until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. The existing soil must have these characteristics:

1. Enough fine-grained material to maintain adequate moisture and nutrient supply.

2. Sufficient pore space to permit root penetration. A bulk density of 1.2 to 1.5 indicates that sufficient pore space is present. A fine granular or crumb-like structure is also favorable.

3. Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans shall be 12 inches or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.

4. A favorable pH range for plant growth. If the soil is so acidic that a pH range of 6.0-7.0 cannot be attained by addition of pH-modifying materials, then the soil is considered an unsuitable environment for plant roots and further soil modification would be required.

5. Freedom from toxic amounts of materials harmful to plant growth.

6. Freedom from excessive quantities of roots, branches, large stones, large clods of earth, or trash of any kind. Clods and stones may be left on slopes steeper than 3:1 if they do not significantly impede good seed soil contact.

If any of the above criteria cannot be met, i.e., if the existing soil is too coarse, dense, shallow, acidic, or contaminated to foster vegetation, then topsoil shall be applied in accordance with TOPSOILING, Std. & Spec. 3.30.

Necessary structural erosion and sediment control practices will be installed prior to seeding. Grading will be carried out according to the approved plan.

Surfaces will be roughened in accordance with SURFACE ROUGHENING, Std. & Spec. 3.29.

Soil Conditioners

In order to modify the texture, structure, or drainage characteristics of a soil, the following materials may be added to the soil:

1. Peat is a very costly conditioner, but works well. If added, it shall be sphagnum moss peat, hypnum moss peat, reed-sedge peat or peat humus, from fresh-water sources. Peat shall be shredded and conditioned in storage piles for at least six months after excavation.

2. Sand shall be clean and free of toxic materials. Sand modification is ineffective unless you are adding 80 to 90% sand on a volume basis. This is extremely difficult to do on-site. If this practice is considered, consult a professional authority to ensure that it is done properly.

3. Vermiculite shall be horticultural grade and free of toxic substances. It is an impractical modifier for larger acreage due to expense.

4. Raw manure is more commonly used in agricultural applications. However, when stored properly and allowed to compost, it will stabilize nitrogen and other nutrients. Manure, in its composted form, is a viable soil conditioner; however, its use should be based on site-specific recommendations offered by a professional in this field.

5. Thoroughly rotted sawdust shall have 6 pounds of nitrogen added to each cubic yard and shall be free of stones, sticks, and toxic substances.

6. The use of treated sewage sludge has benefitted from continuing advancements in its applications in the agricultural community. When composted, it offers an alternative soil amendment. Limitations include a potentially undesirable pH (because of lime added during the treatment process) and the possible presence of heavy metals. This practice should be thoroughly evaluated by a professional and be used in accordance with any local, state, and federal regulations.

Lime and Fertilizer

Lime and fertilizer needs should be determined by soil tests. Soil tests may be performed by the Cooperative Extension Service Soil Testing Laboratory at VPI&SU, or by a reputable commercial laboratory. Information concerning the State Soil Testing Laboratory is available from county extension agents. Reference Appendix 3.32-d for liming applications (in lbs.) needed to correct undesirable pH for various soil types.

Under unusual conditions where it is not possible to obtain a soil test, the following soil amendments will be applied:

Lime

Coastal Plain: 2 tons/acre pulverized agricultural grade limestone (90 lbs./1000 ft.^{2}).

Piedmont and Appalachian Region: 2 tons/acre pulverized agricultural grade limestone (90 lbs./1000 ft.^{2}).

Note: An agricultural grade of limestone should always be used.

Fertilizer

Mixed grasses and legumes: 1000 lbs./acre 10-20-10 or equivalent nutrients (23 lbs./1000 ft.^{2}).

Legume stands only: 1000 lbs./acre 5-20-10 (23 lbs./ 1000 ft.^{2}) is preferred; however, 1000 lbs./acre of 10-20-10 or equivalent may be used.

Grass stands only: 1000 lbs./acre 10-20-10 or equivalent nutrients, (23 lbs./1000 ft.^{2}).

Other fertilizer formulations, including slow-release sources of nitrogen (preferred from a water quality standpoint), may be used provided they can supply the same amounts and proportions of plant nutrients.

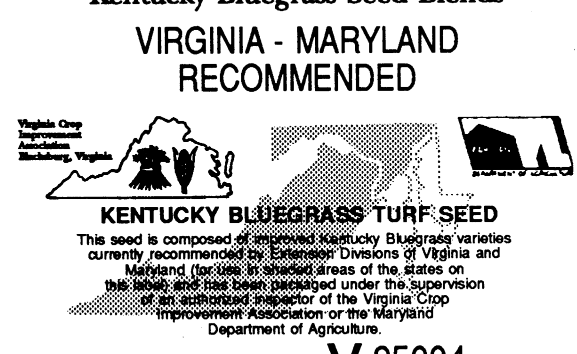
Incorporation - Lime and fertilizer shall be incorporated into the top 4-6 inches of the soil by discing or other means whenever possible. For erosion control, when applying lime and fertilizer with a hydroseeder, apply to a rough, loose surface.

Seeding

1. Certified seed will be used for all permanent seeding whenever possible. Certified seed is inspected by the Virginia Crop Improvement Association or the certifying agency in other states. The seed must meet published state standards and bear an official "Certified Seed" label (see Appendix 3.32-a).

Kentucky Bluegrass Seed Mixtures

Kentucky Bluegrass Seed Blends



2. Legume seed should be inoculated with the inoculant appropriate to the species. Seed of the Lespedezas, the Clovers and Crownvetch should be scarified to promote uniform germination.

3. Apply seed uniformly with a broadcast seeder, drill, culti-packer seeder, or hydroseeder on a firm, friable seedbed. Seeding depth should be 1/4 to 1/2 inch.

4. To avoid poor germination rates as a result of seed damage during hydroseeding, it is recommended that if a machinery breakdown of 30 minutes to 2 hours occurs, 50% more seed be added to the tank, based on the proportion of the slurry remaining in the tank. Beyond 2 hours, a full rate of new seed may be necessary.

   Often hydroseeding contractors prefer not to apply lime in their rigs as it is abrasive. In inaccessible areas, lime may have to be applied separately in pelletized or liquid form. Surface roughening is particularly important when hydroseeding, as a roughened slope will provide some natural coverage of lime, fertilizer and seed.

   Legume inoculants should be applied at five times the recommended rate when inoculant is included in the hydroseeder slurry.

Mulching

All permanent seeding must be mulched immediately upon completion of seed application. Refer to MULCHING, Std. & Spec. 3.35.

Maintenance of New Seedings

In general, a stand of vegetation cannot be determined to be fully established until it has been maintained for one full year after planting.

Irrigation: New seedings should be supplied with adequate moisture. Supply water as needed, especially late in the season, in abnormally hot or dry weather, or on adverse sites. Water application rates should be controlled to prevent excessive runoff. Inadequate amounts of water may be more harmful than no water.

Re-seeding: Inspect seeded areas for failure and make necessary repairs and re-seedings within the same season, if possible.

a. If vegetative cover is inadequate to prevent rill erosion, over-seed and fertilize in accordance with soil test results.

b. If a stand has less than 40% cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. The soil must be tested to determine if acidity or nutrient imbalances are responsible. Re-establish the stand following seedbed preparation and seeding recommendations.

Fertilization: Cool season grasses should begin to be fertilized 90 days after planting to ensure proper stand and density. Warm season fertilization should begin at 30 days after planting.

Apply maintenance levels of fertilizer as determined by soil test. In the absence of a soil test, fertilization should be as follows:

Cool Season Grasses

4 lbs. nitrogen (N)

1 lb. phosphorus (P) Per 1000 $ft.^2$ per year

2 lbs. potash (K)

Seventy-five percent of the total requirements should be applied between September 1 and December 31st. The balance should be applied during the remainder of the year. **More than 1 lb. of soluble nitrogen per 1000 $ft.^2$ should not be applied at any one time.**

Warm Season Grasses

Apply 4-5 lbs. nitrogen (N) between May 1 and August 15th per 1000 $ft.^2$ per year.

Phosphorus (P) and Potash (K) should only be applied according to soil test.

Note: The use of slow-release fertilizer formulations for maintenance of turf is encouraged to reduce the number of applications and the impact on groundwater.

Additional Information on the Successful Establishment of Grasses and Legumes

See Appendix 3.32-b for "helpful hints" in achieving high success rates in grass or legume plantings.

APPENDIX 3.32-a

SEED QUALITY CRITERIA

Where certified seed is not available, the minimum requirements for grass and legume seed used in vegetative establishment are as follows:

a. All tags on containers of seed shall be labeled to meet the requirements of the State Seed Law.

b. All seed shall be subject to re-testing by a recognized seed laboratory that employs a registered seed technologist or by a state seed lab.

c. All seed used shall have been tested within twelve (12) months.

d. Inoculant - the inoculant added to legume seed in the seed mixtures shall be a pure culture of nitrogen-fixing bacteria prepared for the species. Inoculants shall not be used later than the date indicated on the container. Twice the supplier's recommended rate of inoculant will be used on dry seedings; five times the recommended rate if hydroseeded.

e. The quality of the seed used shall be shown on the bag tags to conform to the guidelines in Table 3.32-E.

TABLE 3.32-E

QUALITY OF SEED*

	Minimum Seed Purity (%)	Minimum Germination (%)
Legumes		
Crownvetch	98	65**
Lespedeza, Korean	97	85**
Lespedeza, Sericea	98	85**
Grasses		
Bluegrass, Kentucky	97	85
Fescue, Tall (Improved, Turf-Type Cultivars)	98	85
Fescue, Tall (Ky-31)	97	85
Fescue, Red	98	85
Redtop	94	80
Reed Canarygrass	98	80
Perennial Ryegrass	98	90
Weeping Lovegrass	98	87
Annuals		
Annual Ryegrass	97	90
German Millet	98	85
Oats	98	80
Cereal Rye	98	85

* Seed containing prohibited or restricted noxious weeds should not be accepted. Seed should not contain in excess of 0.5% weed seed. To calculate percent pure, live seed, multiply germination times purity and divide by 100.

Example: Ky-31 Tall Fescue with a germination of 85 percent and a purity of 97 percent.

97 x 85 = 8245. 8245 ÷ 100 = 82.45 percent pure live seed.

** Includes "hard seed"

APPENDIX 3.32-b

KEYS TO SUCCESSFUL ESTABLISHMENT OF GRASSES AND LEGUMES

Planning

Where feasible, grading operations should be planned around optimal seeding dates for the particular region. The most effective times for establishing perennial grass in Virginia generally extend from March through May and from August through October. Outside these dates, the probability of failure is much higher. If the time of year is not suitable for seeding a permanent cover (perennial species), a temporary cover crop should be planted. Temporary seeding of annual species (small grains, ryegrasses or millets) often succeeds during periods of the year that are unsuitable for seeding permanent (perennial) species.

Variations in weather and local site conditions can modify the effects of regional climate on seeding success. For this reason, mixtures including both cool and warm season species are preferred for low-maintenance cover, particularly in the Coastal Plain. Such mixtures promote cover which can adapt to a range of conditions. Many of these mixtures are not desirable, however, for high quality lawns, where variation in texture of the turf is inappropriate. It is important to note that in Virginia the establishment of 100% warm season grasses in a high quality lawn is limited to the extreme eastern portions of the Coastal Plain.

Selection

Species selection should be considered early in the process of preparing an erosion and sediment control plan. A variety of vegetation can be established in Virginia due to the diversity in both soils and climate. However, for practical, economical stabilization and long-term protection of disturbed sites, species selection should be made judiciously.

Seasonality must be considered when selecting species. Grasses and legumes are usually classified as warm or cool season in reference to their season of growth. Cool season plants realize most of their growth during the spring and fall and are relatively inactive or dormant during the hot summer months. Therefore, fall is the most favorable time to plant them. Warm season plants "green-up" late in the spring, grow most actively during the summer, and go dormant at the time of the first frost in fall. Spring and early summer are preferred planting times for warm season plants.

Seed Mixtures

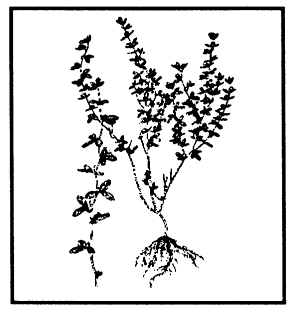
As previously noted, the establishment of high quality turf frequently involves planting one single species. However, in seedings for erosion control purposes, the inclusion of more than one species should always be considered. Mixtures need not be excessive in poundage or seed count. The addition of a quick-growing annual provides early protection and facilitates establishment of one or two perennials in a mix. More complex mixtures might include a quick-growing annual, one or two legumes and more than one perennial grass.

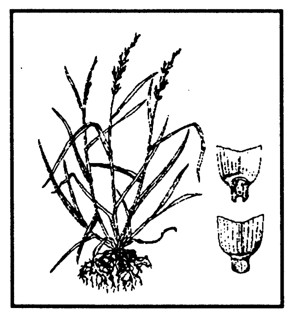
The addition of a "nurse" crop (quick-growing annuals added to permanent mixtures) is a sound practice for soil stabilization, particularly on difficult sites - those with steep slopes; poor, rocky, erosive soils; those seeded out the optimum seeding periods; or in any situation where the development of permanent cover is likely to be slow. The nurse crop germinates and grows rapidly, holding the soil until the slower-growing perennial seedlings become established.

APPENDIX 3.32-c

PLANT INFORMATION SHEETS

Contents:



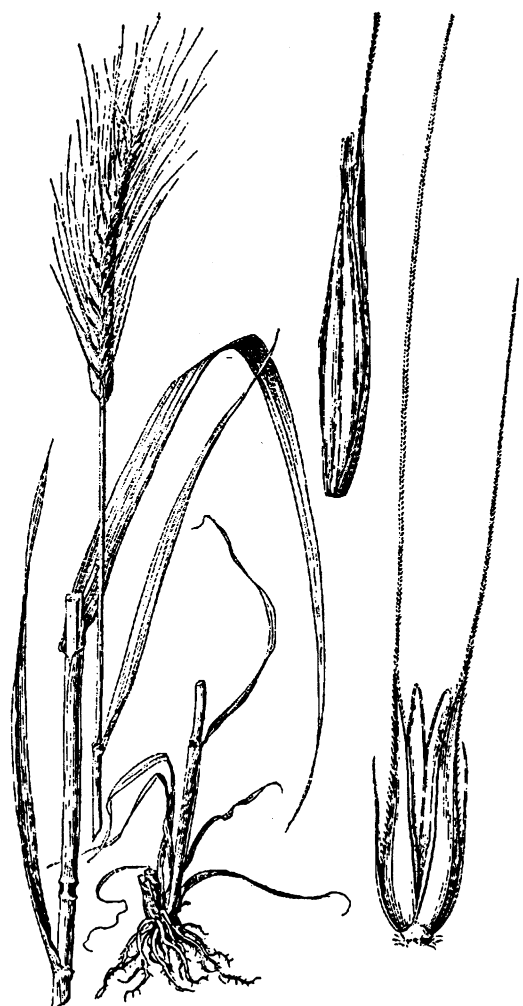


ANNUAL GRASSES AND GRAINS

Small grains are cool season annual grasses primarily grown for animal feed and human consumption. In Virginia, the grains used for soil stabilization are primarily Rye and Oats. Foxtail Millet, which is sometimes considered a small grain, is becoming a very popular and successful planting for soil stabilization.

1. Oats (Avenasativa): A cool season annual grass primarily grown for animal feed and human consumption, but also used for soil stabilization. Oats are seeded in early spring in the western part of the state (winter oats may be sown in the Coastal Plain). Seeding rates are 3 bushels (100 lbs.) per acre bare ground or 2-1/2 lbs. per 1000 square feet.

2. Rye (Secale cereale): Often referred to as Winter Rye because of its winter hardiness, Rye is the most common small grain used for soil stabilization. It is also the most productive grain on dry, infertile, acid or sandy soils. It may be seeded in the fall for winter ground cover. By maturing early, it offers less competition during the late spring period, a critical time in the establishment of perennial species. Rye grain germinates quickly and is tolerant of poor soils. Including Rye grain in fall-seeded mixtures is almost always advantageous, but it is particularly helpful on difficult and erodible soils, erodible slopes or when seeding is late. Rates up to 100 lbs. for bare ground. Overly thick stands of Rye grain will suppress the growth of perennial seedlings. Approximately 50 lbs. per acre is the maximum for this purpose and, where lush growth is



Rye (Secale cereale)

expected, that rate should either be cut in half, or Rye grain should be totally eliminated from the mixture.

3. Foxtail Millet (Setaria italica): A warm season annual grass which may be used for temporary cover. German Millet (variety commonly used in Virginia) germinates quickly and goes to seed quickly. These features make it an excellent companion grass for summer seedlings. It dies at first frost. Seeding rates are up to 50 lbs. per acre for temporary cover. Use 10 to 20 lbs. per acre in mixes.

4. Annual Rye (Lolium multiflorum): A cool season annual grass used for temporary cover or as a nurse grass to allow for germination of permanent stands. Most commonly used in mixes for erosion control. Performs well throughout the state in neutral to slightly acid soils. Rates up to 100 lbs. per acre for temporary cover. Use 10 to 20 lbs. per acre in mixes.

Foxtail Millet (Setaria italica)

Annual Rye (Lolium multiflorum)

ANNUAL LEGUMES

1. Annual Lespedezas (Lespedeza striata)

Uses: Pasture, hay, erosion control, soil improvement, wildlife food.

Description: Annual warm season legumes. Korean Lespedeza is larger and coarser than Common Lespedeza and grows to about 12 inches. Seed of Korean is shiny and black, while seed of Common is stippled. Kobe is the most desirable variety of Common Lespedeza.

Adaptation: Throughout Virginia. Optimum pH range is 6.0 to 6.5; will grow from 5.5 to 7.0. Will grow in soil textures ranging from sands to clays and through a wide range of fertility conditions.

Establishment: Seed should always be inoculated. May be seeded alone or mixed with grasses or small grains. Requires a firm seedbed; may be broadcast or drilled. Should be seeded in early spring at 25 to 40 lbs. per acre or one-half to 1 lb. per 1000 square feet, depending on use. (Use lower figure as half the seeding rate of any spring seeding with grass or grain.) Should not be mowed at less than three inches. Lespedeza will not make a large contribution in sod grasses like Bluegrass; they do best in open sod grasses like tall fescue.

Sources: Seed of common variety (Kobe) and Korean varieties (Climax, Harbin and Rowan) are commercially available.

Annual Lespedezas (Lespedeza striata)

PERENNIALS

1. Tall Fescue (Festuca arundinacea)

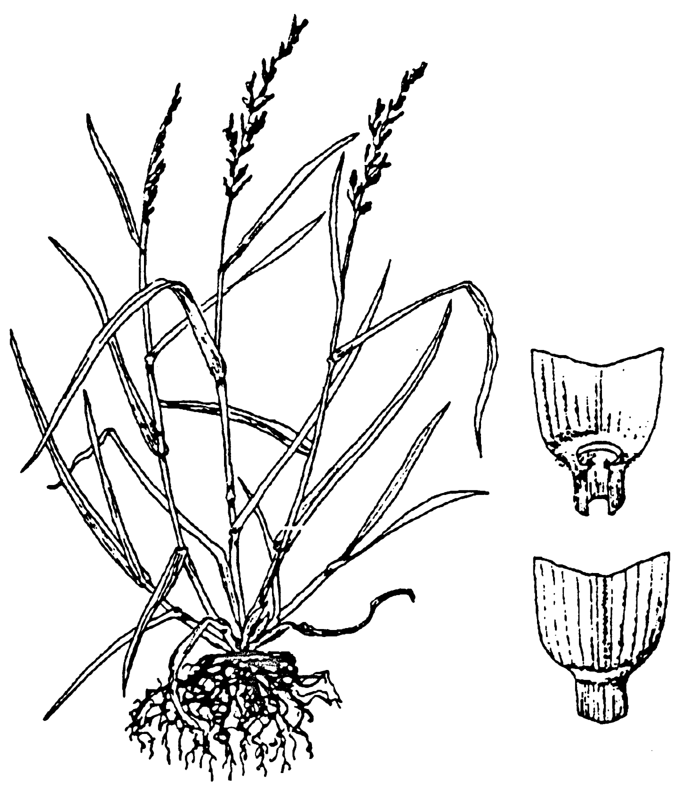
Uses: Pasture, hay, recreation areas, lawns and stabilization of waterways, banks, slopes, cuts, fills, and spoils. It is the most widely used grass at this time for stabilizing large disturbed areas.

Description: A robust, cool season, long-lived, deep-rooted bunchy grass which may have short rhizomes (underground stems). Kentucky 31 is the best-known variety. A number of new varieties of Tall Fescue are becoming available for lawn and other fine-turf uses, and several offer definite improvements. However, their higher cost over the old standby, KY 31, is seldom justified when used for purposes of stabilization and erosion control. Tall Fescue tolerates a wide range of seeding dates; however, with the possible exception of high mountain elevation, it is most dependable when planted in fall.

Adaptation: Adapts well to both high and low maintenance uses throughout Virginia. Adapted to a wide range of climatic conditions. Optimum pH range is 6.0 to 7.0; will tolerate from 3.0 to 8.0. Will grow on shallow and claypan soils if they are moist. Growth is limited more by moisture than by temperature extremes, but it will tolerate drought, infertile soils and moderate shade.

Establishment: Requires a firm seedbed. Hydroseeding is successful. Seeding rates vary from 100 lbs. per acre for erosion control to 250 lbs. per acre for lawns. Plant in early spring or from the middle of August through September. Legumes may not thrive in fescue stands due to the aggressive growth habits of this grass. Mowing is desirable on critical areas at least once every two years; lack of periodic mowing will encourage clumpiness.

Sources: Readily available as seed and sod.



Tall Fescue (Festuca arundinacea)

2. Kentucky Bluegrass (Poa pratense)

Uses: Pasture, turf for lawns, athletic fields, golf courses, and playgrounds. Also used to stabilize waterways, slopes, cuts and fills. Choice food for grouse, turkeys, deer and rabbits.

Description: Long-lived, cool season perennial grass which forms a dense sod. Becomes dormant in the heat of summer since its growing season is spring and fall.

Adaptation: Best adapted to well-drained, fertile soils of limestone origin and the climate of northern and western Virginia. Optimum pH range is 6.0 to 7.0. Bluegrasses are better suited to high maintenance situations in the transition zone. Essentially dormant during dry or hot weather; however, it will normally survive severe drought.


Kentucky Bluegrass (Poa pratense)

Establishment: Requires a firm, weed-free seedbed and adequate fertilization (liberal phosphorus) and lime are important. Can be used with Tall Fescues at low rates. Minimum mowing height is 1-1/2 inches. Critical erosion areas may be mowed only once per year, if desired. This grass is usually seeded with a mixture of other grasses or legumes; several varieties of Bluegrass should be used together to ensure good stand survival. Bare ground rates are 120 lbs. per acre. Overseed 1 to 1-1/2 per 1000 square feet.

Sources: Readily available as seed and sod.

3. <u>Perennial Ryegrass</u> (Lolium perrenne)

Uses: Erosion control, soil improvement, lawns, pasture, and hay; newer varieties are excellent for high-traffic areas.

Description: Perennial Ryegrasses are an excellent selection where rapid establishment is desired. Cool season. Ryegrasses cross-pollinate freely so "Common Ryegrass" may be a mixture of annual and perennial species. Certified seed of Perennial Ryegrass varieties is produced: Blaser, Palmer, Goalie, Fiesta II, Ranger, Regal and Pennfine may be used in Virginia.

Perennial Ryegrass (Lolium perrenne)

Adaptation: Throughout Virginia. Grows best on dark, rich soils in mild climates. Newer varieties have good drought tolerance but may require irrigation if under drought stress or heavy traffic. Will tolerate wet soils with good surface drainage.

Establishment: A firm, mellow surface over compact subsoils gives good results. Seed in fall or spring. Perennial Ryegrass may also be seeded in mid-August to early September. For turf, use a rate of 5 to 8 lbs. per 1000 square feet, if seeded alone; lesser amounts are suitable in mixtures, depending on the characteristics of the companion species. Generally not seeded alone except on athletic fields with intensive use. Perennial Ryegrass does best when used with bluegrass as 20 percent or less of the mixture. Ryegrasses germinate rapidly which makes them particularly suited to disturbed-area stabilization and temporary seeding. They will, however, tend to dominate stands in mixtures if percentage is too high.

Sources: Readily available commercially. Care should be taken to buy seed appropriate to the needs of the project.

4. Fine Fescues

* Red Fescue
* Hard Fescue
* Chewings Fescue

Uses: Excellent for shady, low maintenance areas and north-facing slopes. May be used to stabilize waterways, slopes, banks, cuts, fills, and as a cover crop in orchards.

Description: Red Fescue is a cool season perennial that occurs in two forms: bunch-type and creeping. Creeping Red Fescue forms a tight sod. The leaves of Red Fescue are narrow and wiry. Hard Fescues are slow-growing with excellent shade tolerance.

Adaptation: Shade tolerant and somewhat drought-resistant once established. Grows well in sandy and acidic soils. Optimum pH range is 4.5 to 6.0. Prefers well-drained soils but requires adequate moisture for establishment. In areas of high temperature and humidity (such as southeastern Virginia), some Fine Fescues may turn brown or deteriorate during the summer. Newer varieties of Hard Fescue are more drought tolerant.

Establishment: Rarely seeded in pure stands. Seedbed preparation and fertility adjustments are usually dictated by the other grasses in the mixture. Red Fescues may comprise 25 to 60% by weight of a seeding mixture. In shaded areas red fescue may be the key grass in the mixture. Mowing consistently below 1-1/2 is not recommended.

Sources: Readily available commercially. New Hard Fescues may be in short supply.

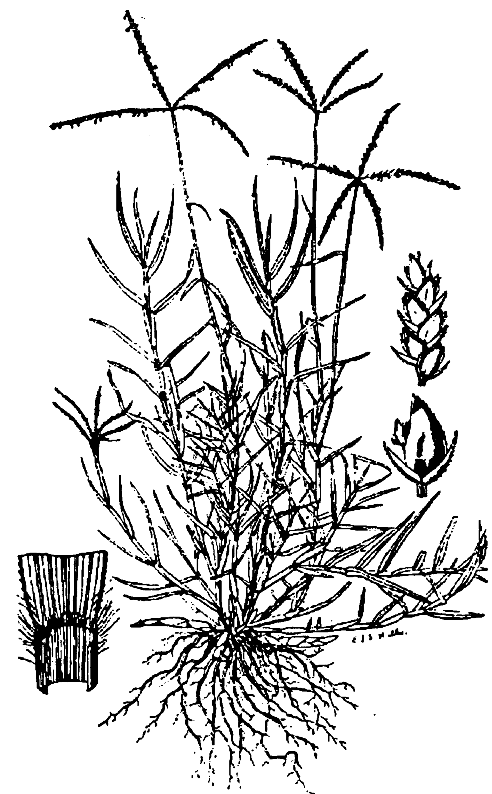
Red Fescue (Festuca rubra)

5. Bermudagrass (Cynodon dactylion)

Uses: Soil and water conservation, pasture, hay, silage, lawns, both high maintenance and general purpose turf, and stabilization of grassed waterways.

Description: A long-lived, warm season perennial that spreads by stolons and rhizomes (runners and underground stems). Height of stems of Common Bermudagrass may be 12 inches. The stems are short-jointed and the leaves flat and spreading. Common Bermudagrass may be established vegetatively with sprigs (sections of stems) or from seeds; however, it has the potential to develop into a weed problem because it spreads vigorously. Cold-tolerant hybrids are usually specified. These are traditionally established from sprigs or sod, but seed is now available.

Adaptation: Southern Piedmont and Coastal Plain in Virginia and some southern appalachian ridges and valleys. Check Std. & Spec. 3.34 for regional adaptations of varieties. Makes its best growth when average daily temperatures are above 75 degrees. Grows on a wide range of soils from heavy clays to deep sands. Optimum pH is 6.0 to 6.5. It is drought-resistant and salt-tolerant. Tolerates floods of short duration but will not thrive on waterlogged soils; does not persist under heavy shade. For rough areas, the varieties Midland (a forage hybrid) and Coastal are recommended. For fine-turf areas, Tufcote (a fine-leaved turf hybrid), Midiron, Tifway, and Vamont are used in Virginia.


Bermudagrass (Cynodon dactylion)

Establishment: By sodding or planting sprigs. Sprigs should be planted (by hand or machine) when soil is warm in a well-prepared, moist seedbed. One end of the sprig should extend above ground, and the other should be covered by firmly packed soil.

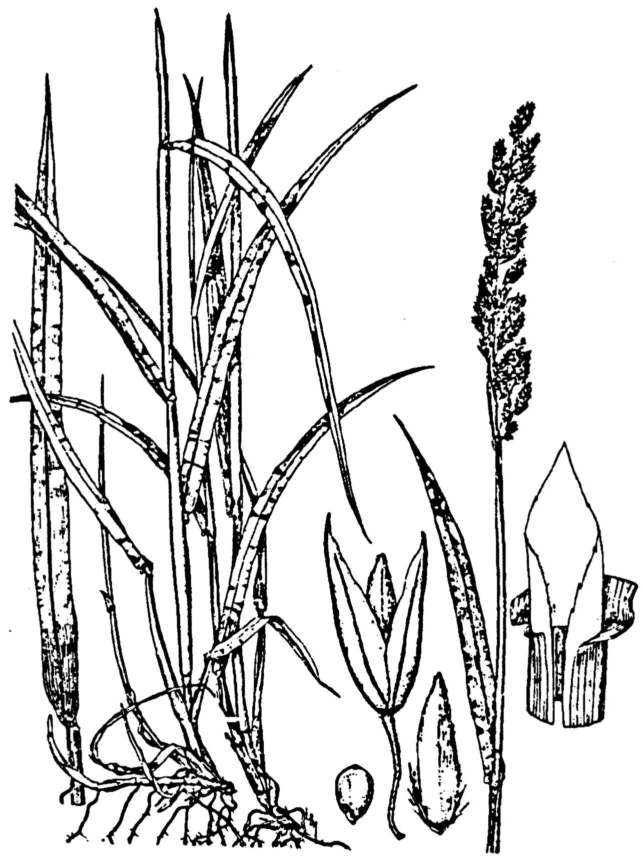
Sources: Readily available as seed, sprigs, and sod.

6. Reed Canarygrass (Phalaris arundinacea)

Uses: Pasture, hay silage, and erosion control. An excellent grass for stabilizing waterways, healing and controlling gullies, and protecting shorelines of ponds and reservoirs from wave action. Also provides good cover for shooting preserves. Can be used in deep gullies and drainage ditches where streamflow is rapid. Vigorous growth may impede flow in small, low velocity channels.

Description: A long-lived, cool season, clumpy perennial with coarse rhizomes (underground stems). Grows 4 to 7 feet tall. Most widely used variety is Ioreed.

Adaptation: Throughout Virginia. Does best in a cool, moist climate. Makes best growth on fertile, moist, medium to fine soils; but will grow in a wide range of soil moisture conditions. Will also grow well on swampy or floodplain soils consisting of peat, muck or sand. Will withstand flooding, yet is quite drought-tolerant when mature. Optimum pH range 5.0 to 7.5.



Reed Canarygrass (Phalaris arundinacea)

Establishment: Requires a well-prepared seedbed that is firm and weed free. Seed in spring or late summer; drill seed alone or with a legume. Seed must be fresh - it should be labeled as having at least 70% germination tested within the last 6 months. Normally, pure stands should be established because this grass is not very compatible with other plants. Mowing should not occur more than twice a year on stabilized critical erosion areas or waterway as this will result in reduced stands.

Sources: Available commercially.

MISCELLANEOUS EROSION CONTROL GRASSES

1. Weeping Lovegrass (Eragrostis curvula)

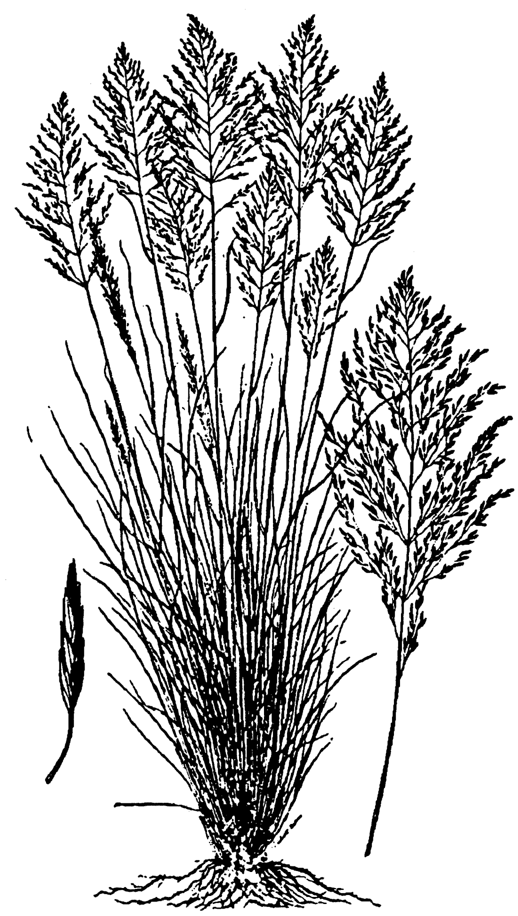
Uses: Fast-growing cover for erosion control. In the northeast, weeping lovegrass acts as a summer annual. The normal life of 3 to 5 years may be foreshortened by low winter temperatures. May provide permanent cover on southern exposure.

Description: A rapid-growing, warm season bunch grass introduced from East Africa. The long, narrow leaves are numerous, very fine, and droop over to the ground, hence the name. Leaf height is rarely above 12 inches.

Adaptation: Prefers light-textured, well-drained soil; will thrive on soil of low fertility. Low winter temperatures may deplete stand.

Establishment: Easy to establish by seed; germinates rapidly and grows quickly. Lime and fertilizer needs are similar to those of Tall Fescue and Ryegrass. Requires pH of 5.5 or higher. May be planted any time after danger of frost and throughout the summer. Very fine seed, commonly added to erosion control seed mixtures. Use of hydroseeders is successful if the seeding rate is increased to compensate for the lack of a firm seedbed. Normal seeding rates are 5 to 20 lbs. per acre in mixes.

Sources: Readily available from large seed companies.



Weeping Lovegrass (Eragrostis curvula)

2. Redtop (Agrostis alba)

Uses: Erosion control, pasture, companion grass in turf seedings and stabilizing ditch and channel banks, grassed waterways, and other disturbed areas.

Description: A coarse, cool season perennial grass with rhizomes (underground stems). Grows to 30 to 40 inches.

Adaptation: Throughout Virginia; does better in the cool, humid areas. Will grow under a wide variety of soil and moisture conditions. Grows on very acid soils (pH 4.0 to 7.5) and poor, clay soils of low fertility. While drought-resistant, it is also a useful wetland grass.

Establishment: Has very small seed and requires a compact seedbed. May be sown in early spring or late summer. Seldom seeded alone except as temporary turf. Adequate fertilization is essential on critical areas to obtain good cover rapidly. Most commonly added to mixes, usually 2 to 3 lbs. per acre. Redtop will disappear from a stand under frequent low mowing.

Sources: Available from commercial sources.

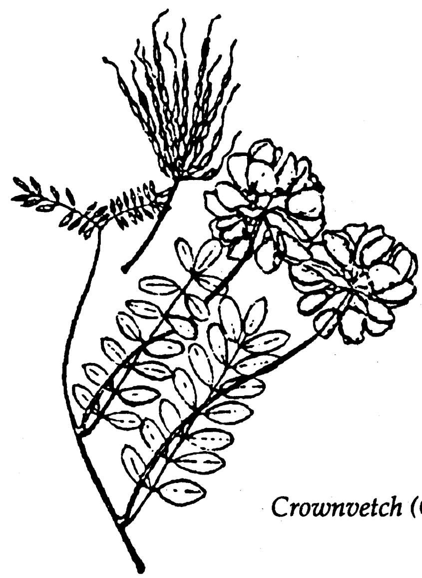
Redtop (Agrostis alba)

LEGUMES

1. Crownvetch (Coronilla varia)

Uses: For erosion control of critical areas such as steep roadbanks, surface mine spoil and industrial waste areas. It is also useful as a residential ground cover. It provides high-quality forage for ruminant animals and serves as a wildlife food and cover plant.

Description: A deep-rooted, cool season, perennial, herbaceous legume with a semi-reclining growth habit. It reaches 2 to 3 feet in height, and does not climb or twine. It fixes nitrogen in the soil and makes a dense mat of vegetative cover.



Crownvetch (Coronilla varia)

Adaptation: Best adapted to the northern Piedmont and Mountain regions of Virginia. It grows best on well-drained soils with a pH range of 5.5 to 8.3. It will persist on more acid soils for a prolonged period once established. It is not adapted to soils with poor drainage. Crownvetch is winter-hardy and drought-tolerant. Varieties commonly used are Chemung, Penngift and Emerald.

Establishment: Only inoculated seed should be used. Requires at least 500 lbs. per acre of 5-10-10 fertilizer (or the area should be fertilized according to soil test results). Soil acidity must be raised above a pH of 5.5. Crownvetch requires mulch and can be hydroseeded successfully. Seeding in the spring is most successful. Frost-seeding may be used on steep or stony sites (seed in late winter, and allow frost action to work the seed into soil). Crownvetch often takes 2 to 3 years to establish a dense stand. A companion grass such as Perennial Ryegrass or Redtop needs to be mixed into the initial planting, but the Crownvetch will eventually crowd out the companion plants. It will not persist under frequent mowing.

Sources: Available commercially.

2. Flatpea (Lathyrus sylvestris)

Uses: Flatpea is an erosion control plant that provides a thick mat of vegetative cover, fixes nitrogen in the soil, and can be maintained with a minimum of management. It is useful on roadbanks, dams, borrow area, gravel pits, surface mine spoil, and industrial waste areas. It is an ideal plant for stabilizing logging roads and utility right-of-ways since it will restrict the invasion of many woody species. It also provides good wildlife cover and food.

Description: A cool season perennial legume. It will climb to a height of 6 to 7 feet if support is available, but the normal height is 2 to 3 feet.

Flatpea (Lathyrus sylvestris)

Adaptation: Flatpea is adaptable to a wide variety of soil conditions. It is drought-tolerant, cold-hardy, and does well on low-fertility sites such as sands, gravels, and soils from acid sandstones. It is not adapted to wet sites, but it will grow on somewhat poorly drained soils. It will tolerate minor shade and a minor degree of flooding. The optimum pH range is from 6.0 to 6.5. The only available variety is Lathco, developed by the USDA-Soil Conservation Service.

Establishment: Use only inoculated seed. The seedbed should be scarified, if possible. The seed is normally drilled or band seeded, but on rough sites or steep slopes, it can be broadcast and then worked into the soil by light dragging. Where possible, a light application of mulch, properly anchored, will assure a good stand. Lime is essential if the soil is below a pH of 5.0. Fertilize according to a soil test or apply 400 lbs. per acre of 10-20-10. Work lime and fertilizer into soil when preparing the seedbed. For a primary stand, use a seeding rate of 30 to 40 lbs. in a mixture with 8 to 10 lbs. of Perennial Ryegrass or 10 to 15 lbs. of Tall Fescue. Flatpea is slow to germinate, so grasses are needed to provide quick cover. Early spring seedings in April or May are best; June seedings are less desirable. Grass seedings may be overseeded with Flatpea from November through March. Flatpea is usually not winter-hardy if seeded in mid or late summer; therefore, dormant seedings are recommended. Mulch with straw at a minimum rate of 1-1/2 tons per acre on all critical sites, and anchor. Little management is required. Remove woody vegetation if the site is invaded. Mowing is acceptable once the stand is established. Mow after full bloom at a 6-inch minimum height.

Sources: Lathco is commercially available.

3. Sericea Lespedeza (Lespedeza cuneata)

Uses: Hay, pasture, erosion control, cover crop, wildlife food.

Description: Warm season perennial legume with upright woody stems 12 to 18 inches tall. Roots widely branched penetrating soil 3 feet or more.

Adaptation: Well adapted to all parts of Virginia. Best on well-drained, deep soils of medium texture. Will also grow on sandy, rather acidic, infertile soils. Most often the legume of choice for eastern Virginia. Optimum pH range is 6.0 to 6.5, but will tolerate a range of 5.0 to 7.0. It is drought-tolerant. Common varieties in Virginia are Serala and Interstate.

Sericea Lespedeza (Lespedeza cuneata)

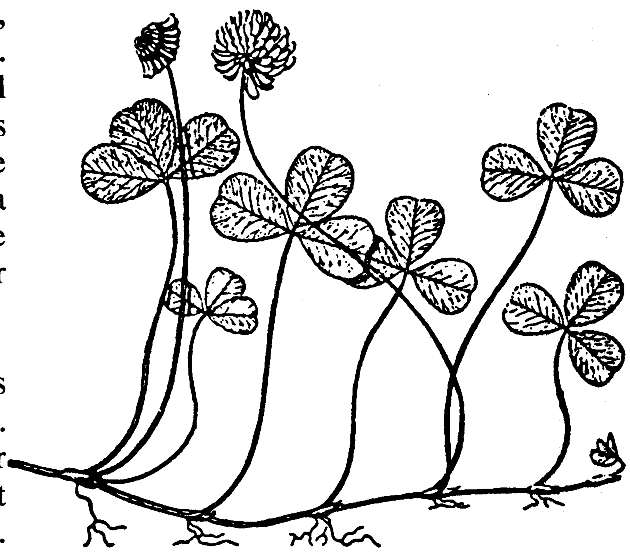
Establishment: Seed from April to June. Requires a firm seedbed. Use only inoculated seed. Rates vary from 20 to 30 lbs. of unhulled seed per acre. Requires phosphate and potash. Will not persist under frequent mowing (once a year recommended).

Sources: Seed of common varieties is commercially available.

4. White Clover (Trifolium repens)

Uses: Common White Clover is used mostly for pastures. Ladino clover, a giant white clover, is also used for hay and silage in mixtures with a grass. The thick-growing, spreading characteristics of the common type make it ideal for erosion control.

Description: A cool season perennial legume. The common type has a prostrate type of growth, while the Ladino is more upright. Both spread by stolons (horizontal branches along ground) and by roots at the nodes. Representative common varieties used in Virginia are Tillman, Common and White Dutch. Ladino is the only cultivar for the large type.



White Clover (Trifolium repens)

Adaptation: Thrives in cool climates and on moist, rich soils with full sun. Will not tolerate extremes of cold or drought. Where soil moisture is not adequate, Ladino is short-lived. Optimum soil pH is 6.5, but it will grow in a range of 5.0 to 7.5. Common White Clover volunteers readily in Bluegrass mixtures where moderate to high fertility is maintained. Stands are persistent.

Establishment: Ladino Clover requires inoculation, fertilizing, and liming for successful growth. Phosphorus and potash are the key fertilizer elements required. Ladino makes a good companion crop with grasses such as Orchardgrass, Bromegrass, Tall Fescue and Timothy. These grasses will normally crowd out the Ladino after 2 to 3 years. Seed should be planted (drilled or broadcast) at shallow depths, and a firm seedbed is desirable.

Sources: Available commercially.

APPENDIX 3.32-d

TABLE 3.32-F

LBS. OF GROUND AGRICULTURAL LIMESTONE* PER THOUSAND SQUARE FEET NEEDED TO CORRECT pH LEVEL OF ACID SOILS TO 6.5

Existing pH	Soil Texture		
	Sandy Loam	Loam	Clay Loam
6.2	20	35	40
6.0	40	55	70
5.8	55	65	85
5.6	70	80	105
5.4	90	100	125
5.2	105	120	140
5.0	120	140	160
4.8	125	180	205
4.6	155	210	230
4.0	200	250	300

* Lime should always be applied in accordance with the results of a soil test, such as may be obtained through the soil testing laboratory at VPI&SU or through a reputable commercial laboratory.

Source: DSWC's Basic Urban E&S in Virginia

STD & SPEC 3.35

MULCHING

MU

Definition

Application of plant residues or other suitable materials to the soil surface.

Purposes

1. To prevent erosion by protecting the soil surface from raindrop impact and reducing the velocity of overland flow.

2. To foster the growth of vegetation by increasing available moisture and providing insulation against extreme heat and cold.

Conditions Where Practice Applies

1. Areas which have been permanently seeded (see Std. & Spec. 3.32, PERMANENT SEEDING) should be mulched immediately following seeding.

2. Areas which cannot be seeded because of the season should be mulched to provide some protection to the soil surface. An organic mulch should be used, and the area then seeded as soon weather or seasonal conditions permit. It is not recommended that fiber mulch be used alone for this practice; at normal application rates it just simply does not provide the protection that is achieved using other types of mulch.

3. Mulch may be used together with plantings of trees, shrubs, or certain ground covers which do not provide adequate soil stabilization by themselves.

4. Mulch shall be used in conjunction with temporary seeding operations as specified in TEMPORARY SEEDING, Std. & Spec. 3.31.

Planning Considerations

Mulches are applied to the soil surface to conserve a desirable soil property or to promote plant growth. A surface mulch is one of the most effective means of controlling runoff and erosion on disturbed land.

Mulches can increase the infiltration rate of the soil, reduce soil moisture loss by evaporation, prevent crusting and sealing of the soil surface, modify soil temperatures, and provide a suitable microclimate for seed germination.

Organic mulch materials, such as straw, wood chips, bark, and fiber mulch have been found to be the most effective.

Chemical soil stabilizers or soil binders should not be used alone for mulch. These materials are useful to bind organic mulches together to prevent displacement.

A variety of manufactured SOIL STABILIZATION BLANKETS AND MATTING (see Std. & Spec. 3.36) have been developed for erosion control in recent years. Some of these products can be used as mulches, particularly in critical areas such as waterways. They also may be used to hold other mulches to the soil surface.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season and economics. It is especially important to mulch liberally in mid-summer and prior to winter, and on cut slopes and southern slope exposures.

Organic Mulches

Straw - The mulch most commonly used in conjunction with seeding. The straw should come from wheat or oats (free of troublesome weed seeds) and may be spread by hand or machine. Straw can be windblown and must be anchored down by an acceptable method.

<u>Hay</u> - May be used in lieu of straw where volunteers will not present a problem, and may be spread by hand or machine. Hay can be windblown and must also be anchored or tacked down.

<u>Corn Stalks</u> - These should be shredded into 4- to 6-inch lengths. Stalks decompose slowly and are resistant to displacement.

<u>Wood Chips</u> - Suitable for areas that will not be closely mowed, and around ornamental plantings. Chips decompose slowly and do not require tacking. They must be treated with 12 pounds of nitrogen per ton to prevent nutrient deficiency in plants; however, can be a very inexpensive mulch if chips are obtained from trees cleared on the site.

<u>Bark Chips, Shredded Bark</u> - These are by-products of timber processing which are used in landscaped plantings. Bark is also a suitable mulch for areas planted to grasses and not closely mowed. It may be applied by hand or mechanically and is not usually toxic to grasses or legumes; additional nitrogen fertilizer is not required.

<u>Fiber Mulch</u> - Used in hydroseeding operations and applied as part of the slurry. It creates the best seed-soil contact when applied over top of (as a separate operation) newly seeded areas. These fibers do not require tacking, although tacking agents or binders are sometimes used in conjunction with the application of fiber mulch. This form of mulch does <u>not</u> provide sufficient protection to highly erodible soils. <u>Additionally, fiber mulch will not be considered adequate mulch when used during the dry summer months or when used for late fall mulch cover. Use straw mulch during these periods</u>. Fiber mulch may be used to tack (anchor) straw mulch. This treatment is well suited for steep slopes, critical areas, and areas susceptible to displacement.

There are other organic materials which make excellent mulches but are only available locally or seasonally. Creative use of these materials can reduce costs.

<u>Chemical Mulches and Soil Binders</u>

A wide range of synthetic, spray-on materials are marketed to stabilize and protect the soil surface. These are emulsions or dispersions of vinyl compounds, rubber or other substances which are mixed with water and applied to the soil. They may be used alone in some cases as temporary stabilizers, or in conjunction with fiber mulches or straw.

When used alone, chemical mulches do not have the capability to insulate the soil or retain soil moisture that organic mulches have. This soil protection is also easily damaged by traffic. Application of these mulches is usually more expensive than organic mulching, and the mulches decompose in 60-90 days.

<u>Blankets and Matting</u>

Field experience has shown that plastic netting, when used alone, does not retain soil moisture or modify soil temperature. In some cases it may stabilize the soil surface while grasses are being established, but is primarily used in grassed waterways and on slopes to hold straw or similar mulch in place.

Jute mesh and other soil stabilization blankets are good choices for mulching on difficult slopes and in minor drainage swales. Most of the soil stabilization mattings (used to create a permanent matrix for root growth within the soil) must receive mulching in order to properly stabilize an area. Notably, some manufacturers have recently developed permanent mattings which include self-contained, temporary mulching materials; however, these measures will have to meet the requirements noted in Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS AND MATTING, before they can be recommended for use on steep slopes and in channel flow situations.

The most critical aspect of installing blankets and mats is obtaining firm, continuous contact between the material and the soil. Without such contact, the material may fail and thereby allow erosion to occur. It is important to use an adequate number of staples and make sure the material is installed properly in order to maximize soil protection. These products are discussed in more detail in Std. & Spec. 3.36, SOIL STABILIZATION BLANKETS & MATTING.

Specifications

Organic Mulches

Organic mulches may be used in any area where mulch is required, subject to the restrictions noted in Table 3.35-A.

Materials: Select mulch material based on site requirements, availability of materials, and availability of labor and equipment. Table 3.35-A lists the most commonly used organic mulches. Other materials, such as peanut hulls and cotton burs, may be used with the permission of the local Plan-Approving Authority.

Prior to mulching: Complete the required grading and install needed sediment control practices.

Lime and fertilizer should be incorporated and surface roughening accomplished as needed. Seed should be applied prior to mulching except in the following cases:

a. Where seed is to be applied as part of a hydroseeder slurry containing fiber mulch.

b. Where seed is to be applied following a straw mulch spread during winter months.

TABLE 3.35-A

ORGANIC MULCH MATERIALS AND APPLICATION RATES

MULCHES:	RATES:		NOTES:
	Per Acre	Per 1000 sq. ft.	
Straw or Hay	1½ - 2 tons (Minimum 2 tons for winter cover)	70 - 90 lbs.	Free from weeds and coarse matter. Must be anchored. Spread with mulch blower or by hand.
Fiber Mulch	Minimum 1500 lbs.	35 lbs.	Do not use as mulch for winter cover or during hot, dry periods.* Apply as slurry.
Corn Stalks	4 - 6 tons	185 - 275 lbs.	Cut or shredded in 4-6" lengths. Air-dried. Do not use in fine turf areas. Apply with mulch blower or by hand.
Wood Chips	4 - 6 tons	185 - 275 lbs.	Free of coarse matter. Air-dried. Treat with 12 lbs nitrogen per ton. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand.
Bark Chips or Shredded Bark	50 - 70 cu. yds.	1-2 cu. yds.	Free of coarse matter. Air-dried. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand.

* When fiber mulch is the only available mulch during periods when straw should be used, apply at a minimum rate of 2000 lbs./ac. or 45 lbs./1000 sq. ft.

Source: Va. DSWC

Application: Mulch materials shall be spread uniformly, by hand or machine.

When spreading straw mulch by hand, divide the area to be mulched into approximately 1,000 sq. ft. sections and place 70-90 lbs. (1½ to 2 bales) of straw in each section to facilitate uniform distribution.

Mulch Anchoring: Straw mulch must be anchored immediately after spreading to prevent displacement. Other organic mulches listed in Table 3.35-A do not require anchoring. The following methods of anchoring straw may be used:

1. Mulch anchoring tool (often referred to as a Krimper or Krimper Tool): This is a tractor-drawn implement designed to punch mulch into the soil surface. This method provides good erosion control with straw. It is limited to use on slopes no steeper than 3:1, where equipment can operate safely. Machinery shall be operated on the contour.

2. Fiber Mulch: A very common practice with widespread use today. Apply fiber mulch by means of a hydroseeder at a rate of 500-750 lbs./acre over top of straw mulch or hay. It has an added benefit of providing additional mulch to the newly seeded area.

3. Liquid mulch binders: Application of liquid mulch binders and tackifiers should be heaviest at edges of areas and at crests of ridges and banks, to prevent displacement. The remainder of the area should have binder applied uniformly. Binders may be applied after mulch is spread or may be sprayed into the mulch as it is being blown onto the soil.

   The following types of binders may be used:

   a. Synthetic binders - Formulated binders or organically formulated products may be used as recommended by the manufacturer to anchor mulch.

   * b. Asphalt - Any type of asphalt thin enough to be blown from spray equipment is satisfactory. Recommended for use are rapid curing (RC-70, RC-250, RC-800), medium curing (MC-250, MC-800) and emulsified asphalt (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2).

      Apply asphalt at 0.10 gallon per square yard (10 gal./1000 sq. ft. or 430 gal./acre). Do not use heavier applications as it may cause the straw to "perch" over rills. All asphalt designations are from the Asphalt Institute Specifications.

* Note: This particular method is not used as commonly today as it once was in the past. The development of hydraulic seeding equipment promoted the industry

to turn to synthetic or organically based binders and tackifiers. When this method is used, environmental concerns should be addressed to ensure that petroleum-based products do not enter valuable water supplies. Avoid applications into waterways or channels.

4. Mulch nettings: Lightweight plastic, cotton, or paper nets may be stapled over the mulch according to manufacturer's recommendations.

5. Peg and twine: Because it is labor-intensive, this method is feasible only in small areas where other methods cannot be used. Drive 8- to 10-inch wooden pegs to within 3 inches of the soil surface, every 4 feet in all directions. Stakes may be driven before or after straw is spread. Secure mulch by stretching twine between pegs in a criss-cross-within-a square pattern. Turn twine 2 or more times around each peg.

Chemical Mulches

Chemical mulches* may be used alone only in the following situations:

a. Where no other mulching material is available.

b. In conjunction with temporary seeding during the times when mulch is not required for that practice.

c. From March 15 to May 1 and August 15 to September 30, provided that they are used on areas with slopes no steeper than 4:1, which have been roughened in accordance with SURFACE ROUGHENING, Std. & Spec. 3.29. If rill erosion occurs, another mulch material shall be applied immediately.

* Note: Chemical mulches may be used to bind other mulches or with fiber mulch in a hydroseeded slurry at any time. Manufacturer's recommendations for application of chemical mulches shall be followed.

Maintenance

All mulches and soil coverings should be inspected periodically (particularly after rainstorms) to check for erosion. Where erosion is observed in mulched areas, additional mulch should be applied. Nets and mats should be inspected after rainstorms for dislocation or failure. If washouts or breakage occur, re-install netting or matting as necessary after repairing damage to the slope or ditch. Inspections should take place up until grasses are firmly established. Where mulch is used in conjunction with ornamental plantings, inspect periodically throughout the year to determine if mulch is maintaining coverage of the soil surface; repair as needed.

STD & SPEC 3.36

Treat. - 1
or
Treat. - 2

SOIL STABILIZATION BLANKETS & MATTING

Definition

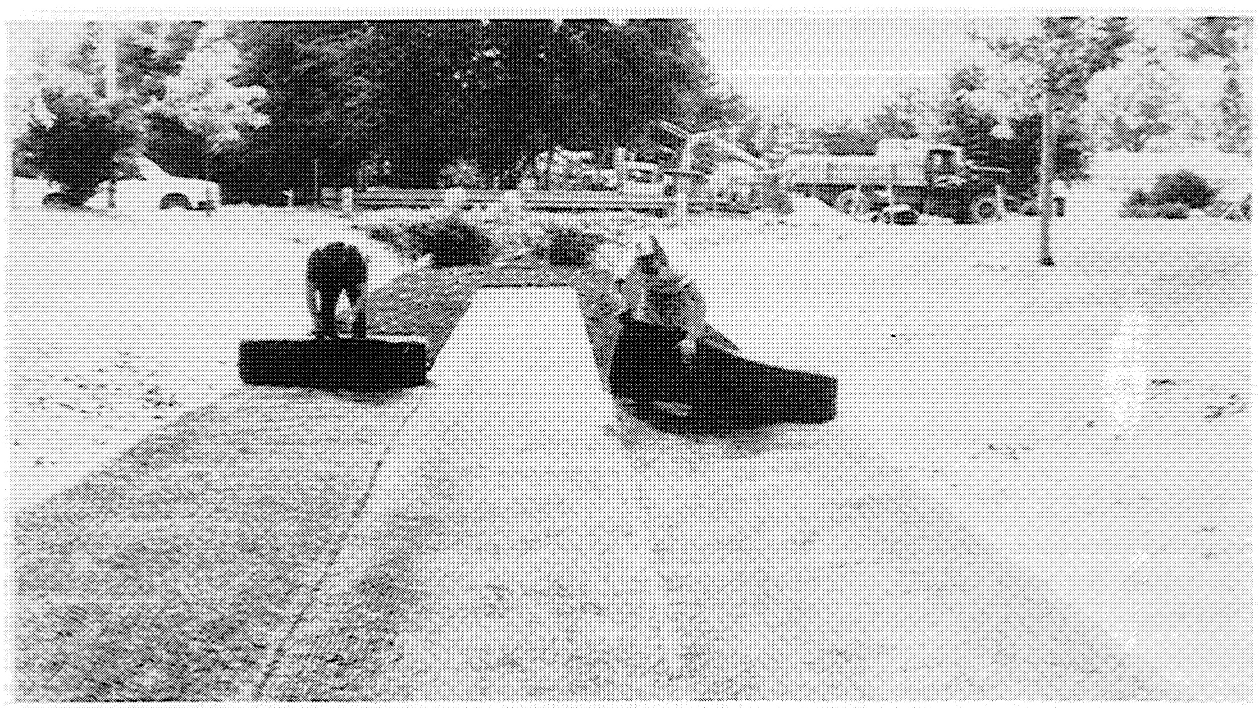
The installation of a protective covering (blanket) or a soil stabilization mat on a prepared planting area of a steep slope, channel or shoreline.

Purpose

To aid in controlling erosion on critical areas by providing a microclimate which protects young vegetation and promotes its establishment. In addition, some types of soil stabilization mats are also used to raise the maximum permissible velocity of turf grass stands in channelized areas by "reinforcing the turf" to resist the forces of erosion during storm events.

Conditions Where Practice Applies

On short, steep slopes where erosion hazard is high and planting is likely to be too slow in providing adequate protective cover; in vegetated channels where the velocity of design flow exceeds "allowable" velocity; on streambanks or tidal shorelines where moving water is likely to wash out new plantings; or in areas where the forces of wind prevent standard mulching practices from remaining in place until vegetation becomes established.



Planning Considerations

Soil stabilization blankets and mats can be applied to problem areas to supplement nature's erosion control system (vegetation) in its initial establishment and in providing a safe and "natural" conveyance for high velocity stormwater runoff. They are being used today in many applications were previously a structural lining would have been required. Care must be taken to choose the type of blanket or matting which is most appropriate for the specific needs of a project. Two general types of blankets and mats are discussed within this specification. However, with the abundance of soil stabilization products available today, it is impossible to cover all the advantages, disadvantages and specifications of all manufactured blankets and mats. Therefore, as with many erosion control-type products, there is no substitute for a thorough understanding of the manufacturer's instructions and recommendations and a site visit by a designer or plan reviewer to verify a product's appropriateness.

Treatment-1 is a degradable soil stabilization blanket which includes "combination" blankets consisting of a plastic netting which covers and is intertwined with a natural organic or man-made mulch; or, a jute mesh which is typically homogeneous in design and can act alone as a soil stabilization blanket.

It should be used to help establish vegetation on previously disturbed slopes - normally problem slopes of 3:1 or greater. Since the materials which compose the soil stabilization blankets will deteriorate over time, they should be used in permanent conveyance channels with the realization that the system's resistance to erosion is based on the type of vegetation planted and the existing soil characteristics. During the establishment of vegetation, **Treatment-1** should not be subjected to shallow or deep concentrated flows moving at greater than 4 feet/second.

Treatment-1 provides the following benefits in the achievement of vegetative stabilization when properly applied over seed and required amendments:

1. Protection of the seed and soil from raindrop impact and subsequent displacement.

2. Thermal consistency and moisture retention for seedbed area.

3. Stronger and faster germination of grasses and legumes.

4. Planing off excess stormwater runoff.

5. Prevention of sloughing of topsoil added to steeper slopes.

Treatment-2 is a soil stabilization matting which consists of a non-degradable, 3-dimensional plastic structure which can be filled with soil prior to planting. This configuration provides a matrix for root growth where the matting becomes entangled and penetrated by roots, forming continuous anchorage for surface growth and promoting enhanced energy dissipation. **Treatment-2** can be used on problem slopes (normally 3:1 or greater), and in stormwater conveyance channels.

In addition to those benefits noted for **Treatment-1**, **Treatment-2** provides the following benefits in the achievement of vegetative stabilization and in the replacement of more traditional channel linings such as concrete and riprap:

1. Causes soil to drop out of stormwater and fill matrix with fine soils which become the growth medium for the development of roots.

2. When embedded in the soil within stormwater channels, it acts with the vegetative root system to form an erosion resistant cover which resists hydraulic lift and shear forces.

Since **Treatment-2** is non-degradable, it can be used in permanent conveyance channels and can withstand higher velocities of flow than the vegetation and soil would normally allow. However, a 10 feet/second velocity of flow should be the maximum allowed in a conveyance system which utilizes **Treatment-2**.

VDOT Nomenclature and Product Information

The Virginia Department of Transportation has its own nomenclature for many of the standards and specifications found in this handbook; this is true in the case of soil stabilization blankets and matting. The following relationship exists between the two methods of naming the practice:

Va. E&S-C Handbook		VDOT Specifications
Treatment-1	(is equivalent to)	EC-2
Treatment-2	(is equivalent to)	EC-3

It is recommended that most current VDOT "Approved Products List" for these products be consulted prior to installation of a particular blanket or mat. Importantly, the list names those products approved for a certain range of flow velocities when **Treatment-2** (VDOT's EC-3) installation is contemplated.

TREATMENT-1: SOIL STABILIZATION BLANKET

(Allowable Velocity Range During Vegetation Establishment: 0 - 4 f.p.s.)

Materials

1. Combination Blankets - They shall consist of a photo-degradable plastic netting which covers and is entwined in a natural organic or man-made mulching material.

The mulching material shall consist of wood fibers, wood excelsior, straw, coconut fiber, or man-made fibers, or a combination of the same. The blanket shall be of consistent thickness with the mulching material/fibers evenly distributed over its entire length. The mulching material/fibers must interlock or entwine to form a dense layer which not only resists raindrop impact, but will allow vegetation to penetrate the blanket.

The blanket shall be nontoxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. At a minimum, the plastic netting must cover the top side of the blanket and possess a high web strength. The netting shall be entwined with the mulching material/fiber to maximize strength and provide for ease of handling.

2. <u>Jute Mesh</u> - It shall be of a uniform, open, plain weave, of undyed and unbleached single jute yarn. The yarn shall be of loosely twisted construction and shall not vary in thickness by more than one half of its normal diameter. Jute mesh shall be new and shall conform to the following:

   a. Length of jute mesh shall be marked on each roll.

   b. There shall be 0.60-inch openings (± 25%) between strands, lengthwise.

   c. There shall be 0.90-inch openings (± 25%) between strands, lengthwise.

   d. Weight shall average 0.90 lbs./square yard with a tolerance of 5%.

   As previously noted, jute mesh provides such good coverage (large surface area of strands) and contains such small openings that it can be used alone as a blanket.

3. <u>Other **Treatment-1** Products</u> - These shall conform to manufacturer's specifications and be approved by the Plan-Approving Authority prior to being specified for a particular application. These products should be installed in accordance with manufacturer's recommendations, <u>provided those recommendations are at least as stringent as this specification</u>. Again, it is recommended that VDOT's "Approved Products List" be consulted. In no case shall these products cover less than 30% of the soil surface.

4. <u>Staples</u> - Staples for anchoring Treatment-1 shall be No. 11-gauge wire or heavier. Their length shall be a minimum of 6 inches. A larger staple with a length of up to 12 inches should be used on loose, sandy, or unstable soils.

Installation Requirements

Site Preparation - After site has been shaped and graded to approved design, prepare a friable seedbed relatively free from clods and rocks more than 1½ inches in diameter and any foreign material that will prevent uniform contact of the protective covering with the soil surface.

Planting - Lime, fertilize, and seed in accordance with seeding or other type of planting plan. When using jute mesh on a seeded area, apply approximately one-half the seed after laying the mat. The protective covering can be laid over sprigged areas where small grass plants have been inserted into the soil. Where ground covers are to be planted, lay the protective covering first and then plant through the material as per planting design.

When open-weave nets are used, lime, fertilizer, seed and mulch should be applied before laying the net. When a combination blanket (such as an "excelsior" blanket) is used, seed and soil amendments must also be applied before the blanket is laid.

Orientation - See Plate 3.36-1 for orientation of **Treatment-1** for different topographic conditions.

Laying and Stapling (see Plate 3.36-2) - If instructions have been followed, all needed check slots will have been installed, and the protective covering will be laid on a friable seedbed free from clods, rocks, roots, etc. that might impede good contact.

1. Start laying the protective covering from the top of the channel or top of slope and unroll down-grade.

2. Allow to lay loosely on soil - do not stretch.

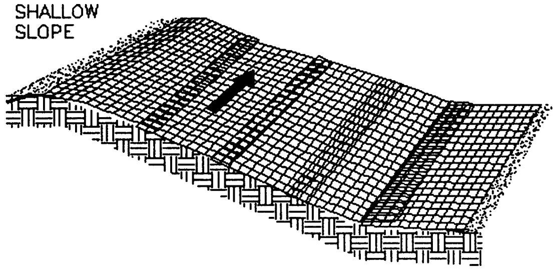
3. Upslope ends of the protective covering should be buried in a anchor slot no less than 6-inches deep. Tamp earth firmly over the material. Staple the material at a minimum of every 12 inches across the top end.

4. Edges of the material shall be stapled every 3 feet. Where multiple widths are laid side by side, the adjacent edges shall be overlapped a minimum of 2 inches and stapled together.

5. Staples shall be placed down the center, staggered with the edges at 3 foot intervals.

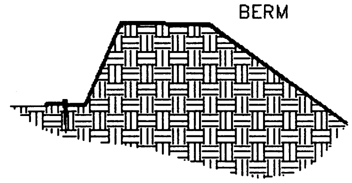
Check slots - On highly erodible soils and on slopes steeper than 4:1, erosion check slots should be made every 50 feet (see Plate 3.36-2). Insert a fold of the material (separate piece) into a 6-inch trench and tamp firmly. Staple fold to "main" blanket at minimum 12-inch intervals across the upstream and downstream portion of the blanket.

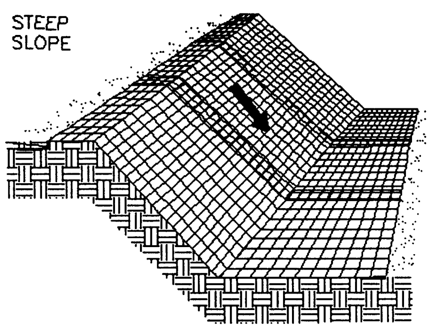
TYPICAL ORIENTATION OF TREATMENT – 1 (SOIL STABILIZATION BLANKET)



ON SHALLOW SLOPES, STRIPS OF NETTING PROTECTIVE COVERINGS MAY BE APPLIED ACROSS THE SLOPE.

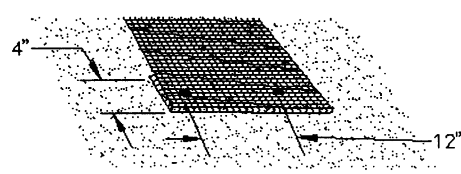
WHERE THERE IS A BERM AT THE TOP OF THE SLOPE, BRING THE MATERIAL OVER THE BERM AND ANCHOR IT BEHIND THE BERM.

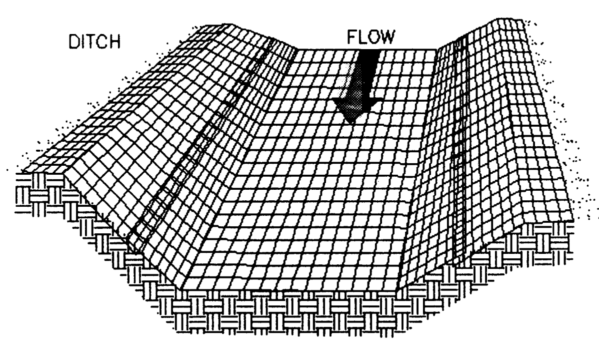




ON STEEP SLOPES, APPLY PROTECTIVE COVERING PARALLEL TO THE DIRECTION OF FLOW AND ANCHOR SECURELY.

BRING MATERIAL DOWN TO A LEVEL AREA BEFORE TERMINATING THE INSTALLATION. TURN THE END UNDER 4" AND STAPLE AT 12" INTERVALS.



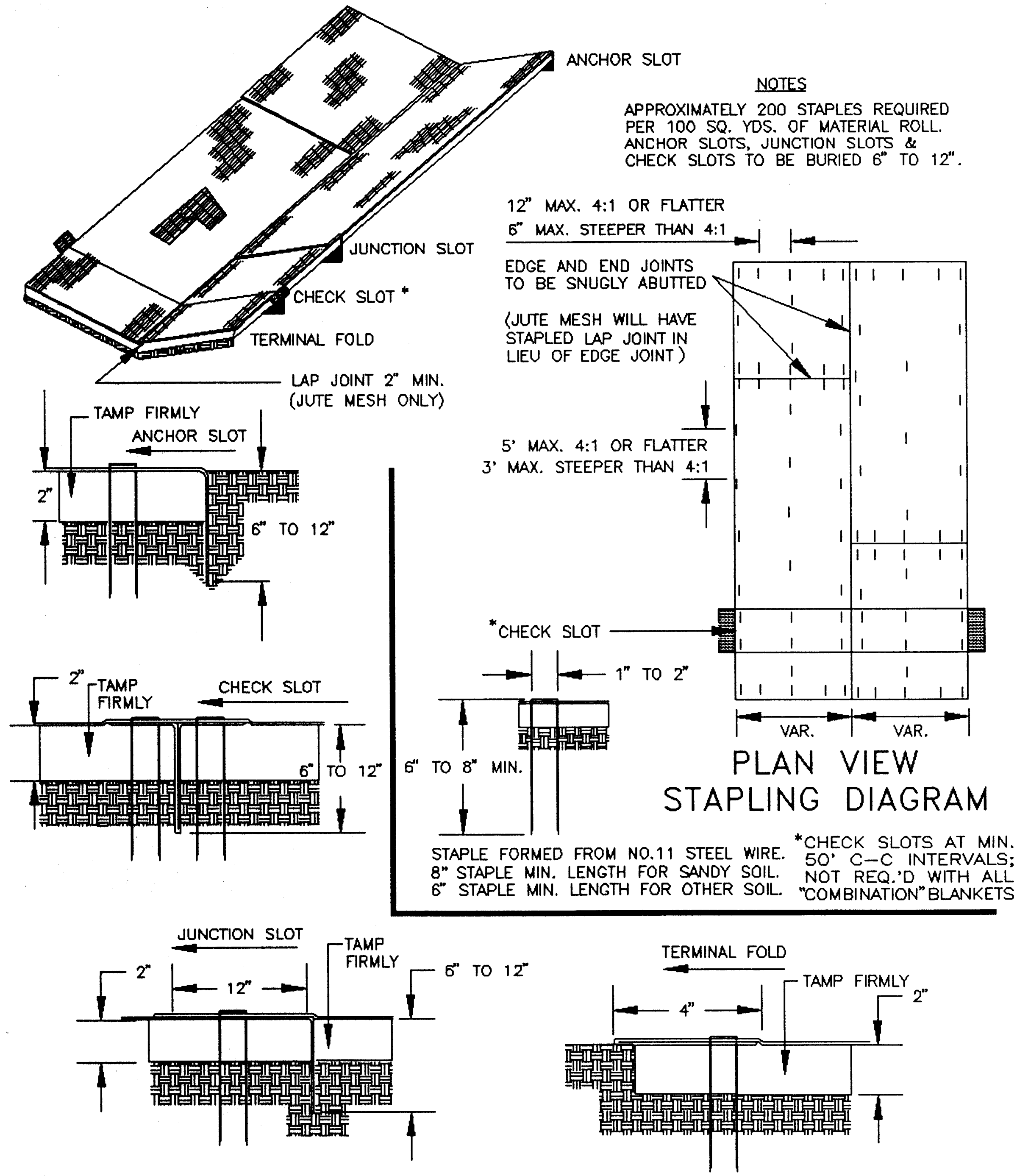


IN DITCHES, APPLY PROTECTIVE COVERING PARALLEL TO THE DIRECTION OF FLOW. USE CHECK SLOTS AS REQUIRED. AVOID JOINING MATERIAL IN THE CENTER OF THE DITCH IF AT ALL POSSIBLE.

Source: Adapted from Ludlow Products Brochure

Plate 3.36-1

TYPICAL TREATMENT – 1 (SOIL STABILIZATION BLANKET) INSTALLATION CRITERIA



Source: VDOT Road and Bridge Standards

Plate 3.36-2

Note: Many combination blankets are designed and manufactured to resist movement and uplift to a point which check slots may not be required. Plan designers and review authorities are urged to study manufacturers' recommendations and site conditions.

Joining Protective Coverings - Insert a new roll of material into an anchor slot, as with upslope ends. Overlap the end of the previous roll a minimum of 12 inches, and staple across the end of the roll just below the anchor slot and across the material every 12 inches.

Terminal End - At the point at which the material is discontinued, or at which time the protective covering meets a structure of some type, fold 4 inches of the material underneath and staple every 12 inches (minimum).

At bottom of slopes - Lead net out onto a level area before anchoring. Turn ends under 4 inches, and staple across end every 12 inches.

Final Check - These installation techniques must be adhered to:

1. Protective blanket is in uniform contact with the soil.
2. All lap joints are secure.
3. All staples are driven flush with the ground.
4. All disturbed areas have been seeded.

TREATMENT-2: SOIL STABILIZATION MATTING

(Allowable velocity range after vegetative establishment: 0 - 10 f.p.s.)

Materials

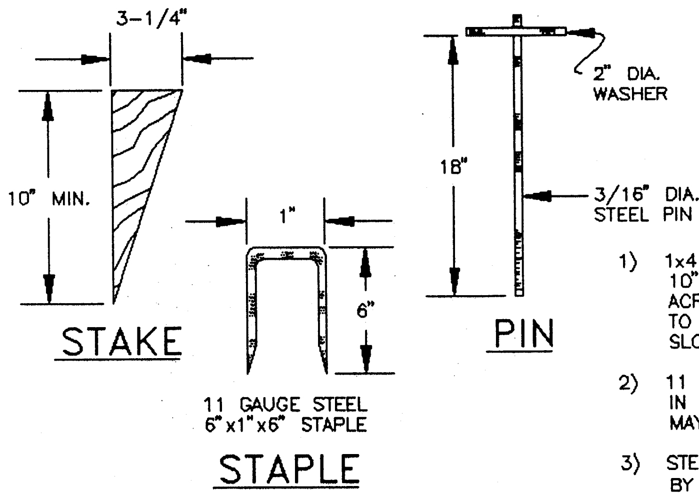
Matting - The majority of these products provide a three dimensional geomatrix of nylon, polyethylene, or randomly oriented monofilaments, forming a mat. These products contain ultra violet (UV) inhibiting stabilizers, added to the compounds to ensure endurance and provide "permanent root reinforcement."

The three dimensional feature creates an open space which is allowed to fill with soil. The roots of the grass plant become established within the mat itself, forming a synergistic root and mat system. As the grass becomes established, the two actually "reinforce" each other, preventing movement or damage to the soil. Allowable velocities are increased considerably over natural turf stands.

Selection of the appropriate matting materials along with proper installation become critical factors in the success of this practice. VDOT's "Approved Products List" can be a real asset in the selection process. Consultation with the supplier or the manufacturer and thorough evaluation of performance data to ensure proper selection of a soil stabilization matting are also essential. Although many manufacturers claim their products may inhibit erosion associated with channel velocities of up to 20 ft./sec., it is recommended that any velocities that exceed 10 ft./sec. be properly protected with some form of structural lining (see Std. & Spec. 3.17, STORMWATER CONVEYANCE CHANNEL).

Staples - Staples or anchoring methods and recommendations vary by manufacturers. The expectation of high velocities should dictate the use of more substantial anchoring. Some of the typically recommended stakes, staples and pins are depicted in Plate 3.36-3

STAKES, STAPLES, & PINS FOR INSTALLATION OF TREATMENT - 2 SOIL STABILIZATION MATTING



1) 1x4 TRIANGULAR SURVEY STAKE – MINIMUM 10" IN LENGTH. PLACEMENT OF THE STAKE ACROSS THE FLOW OF THE WATER IS THOUGHT TO PROVIDE A "PINBALL EFFECT" TO HELP SLOW THE VELOCITY.

2) 11 GAUGE STEEL – MINIMUM 1" WIDE BY 6" IN LENGTH STEEL STAPLE – 2"x8" STAPLE MAY BE REQUIRED IN CERTAIN SOIL CONDITIONS.

3) STEEL PINS – 3/16 DIAMETER STEEL PIN BY 18" IN LENGTH WITH A 2" DIAMETER WASHER ON TOP. (SEE ILLUSTRATION)

Source: Product literature from Greenstreak, Inc. Plate 3.36-3

Installation Requirements

Site Preparation - After site has been shaped and graded to approved design, prepare a friable seedbed relatively free from clods and rocks more than 1 inch in diameter, and any foreign material that will prevent contact of the soil stabilization mat with the soil surface. If necessary, redirect any runoff away from the ditch or slope during installation.

Planting - Lime, fertilize and seed in accordance with MS #1 and the approved plan, paying special attention to the plant selection that may have been chosen for the matted area. If the area has been seeded prior to installing the mat, make sure and reseed all areas disturbed during installation.

Mulching - Mulch (normally straw) should be applied following installation of **Treatment-2** at rates noted in Std. & Spec. 3.35, MULCHING.

Laying and Securing - See Plates 3.36-4, 3.36-5 and 3.36-6. Similar to installing **Treatment-1,** but Plan Approving Authority's requirements or manufacturer's recommendations must be followed as detailed. The key to achieving desired performance is dependent upon proper installation.

Check Slots - See Plate 3.36-4. Matting manufacturers vary significantly in their check slot requirements. Similar to the installation of **Treatment-1,** a check slot may be required when laying **Treatment-2** to "correct" the flow of water if it has the potential to undermine the matting. Most authorities (including VDOT) require that the sides of the matting also be entrenched, creating a slope shelf for the material to rest on, preventing water from entering under the mat on the sides.

Securing the Material and Joining Mats - Again, product specifications vary - upstream and downstream terminal slots, new roll overlaps and multiple width installations differ by various products and manufacturers.

Final Check - These installation techniques must be adhered to:

1. Soil stabilization mat is in uniform contact with the soil.

2. All required slots and lapped joints are in place.

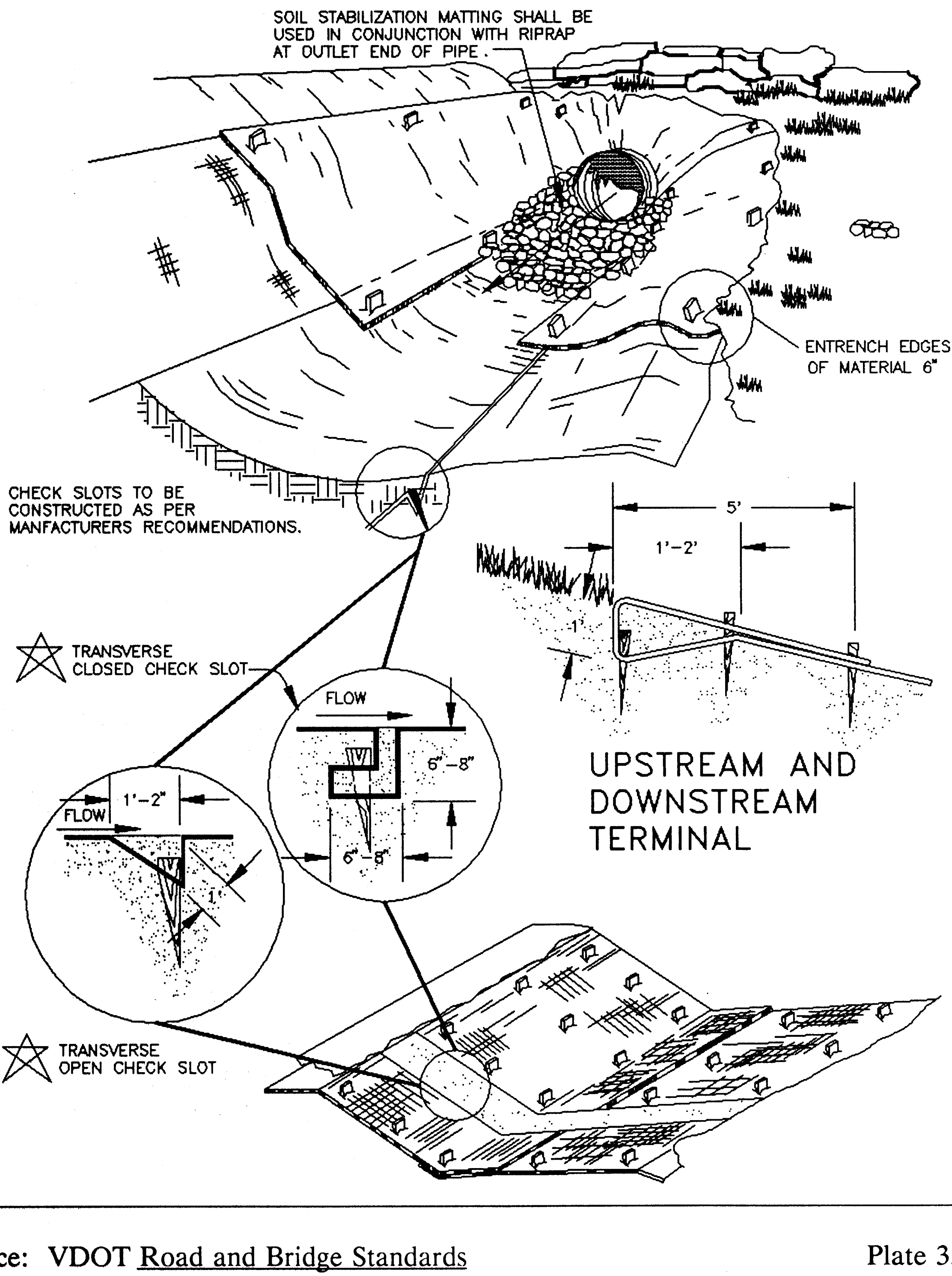
3. The material is properly anchored.

4. All disturbed areas are seeded.

Maintenance

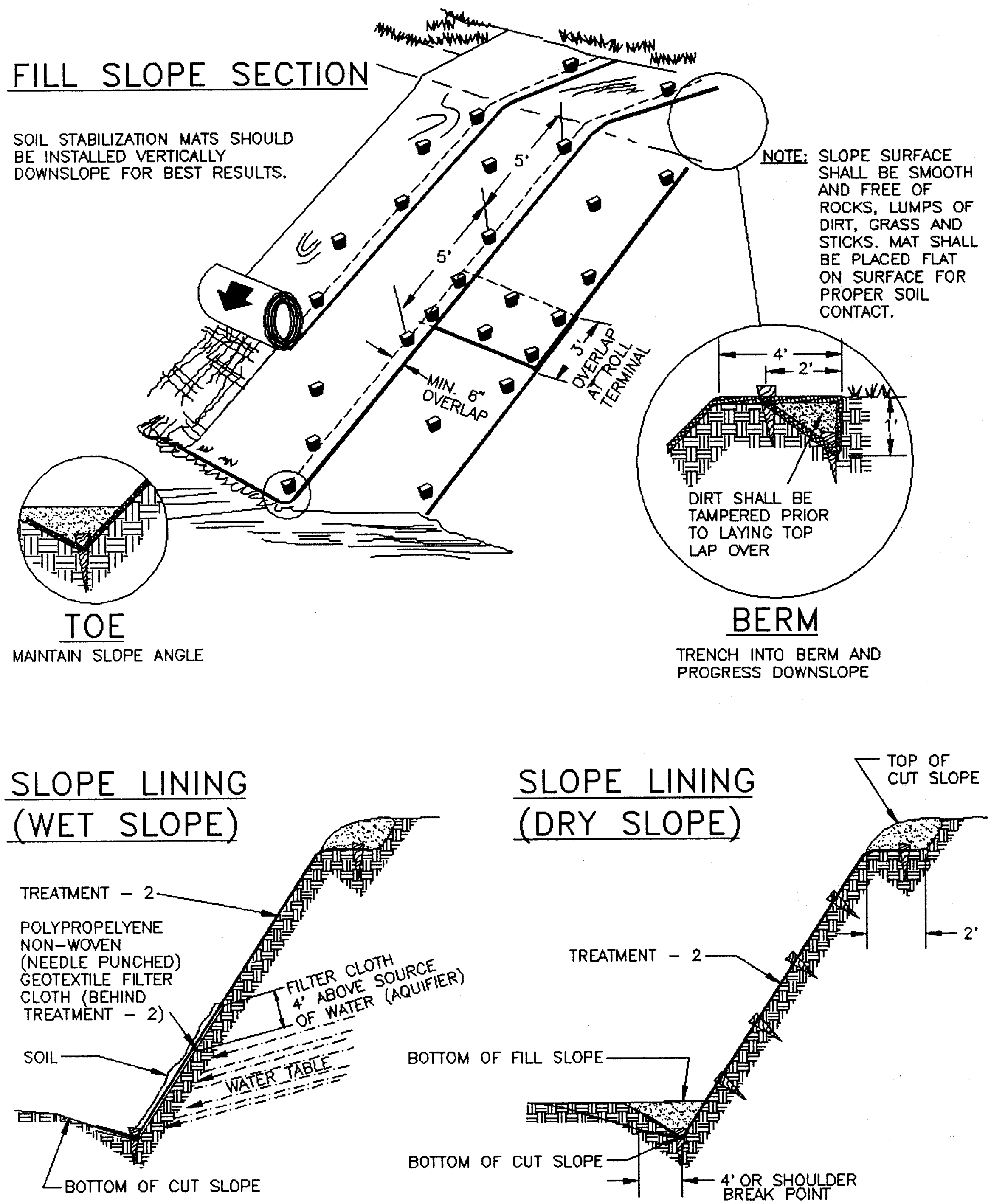
All soil stabilization blankets and matting should be inspected periodically following installation, particularly after rainstorms to check for erosion and undermining. Any dislocation or failure should be repaired immediately. If washouts or breakage occurs, re-install the material after repairing damage to the slope or ditch. Continue to monitor these areas until which time they become permanently stabilized; at that time an annual inspection should be adequate.

TYPICAL TREATMENT-2 SOIL STABILIZATION MATTING INSTALLATION



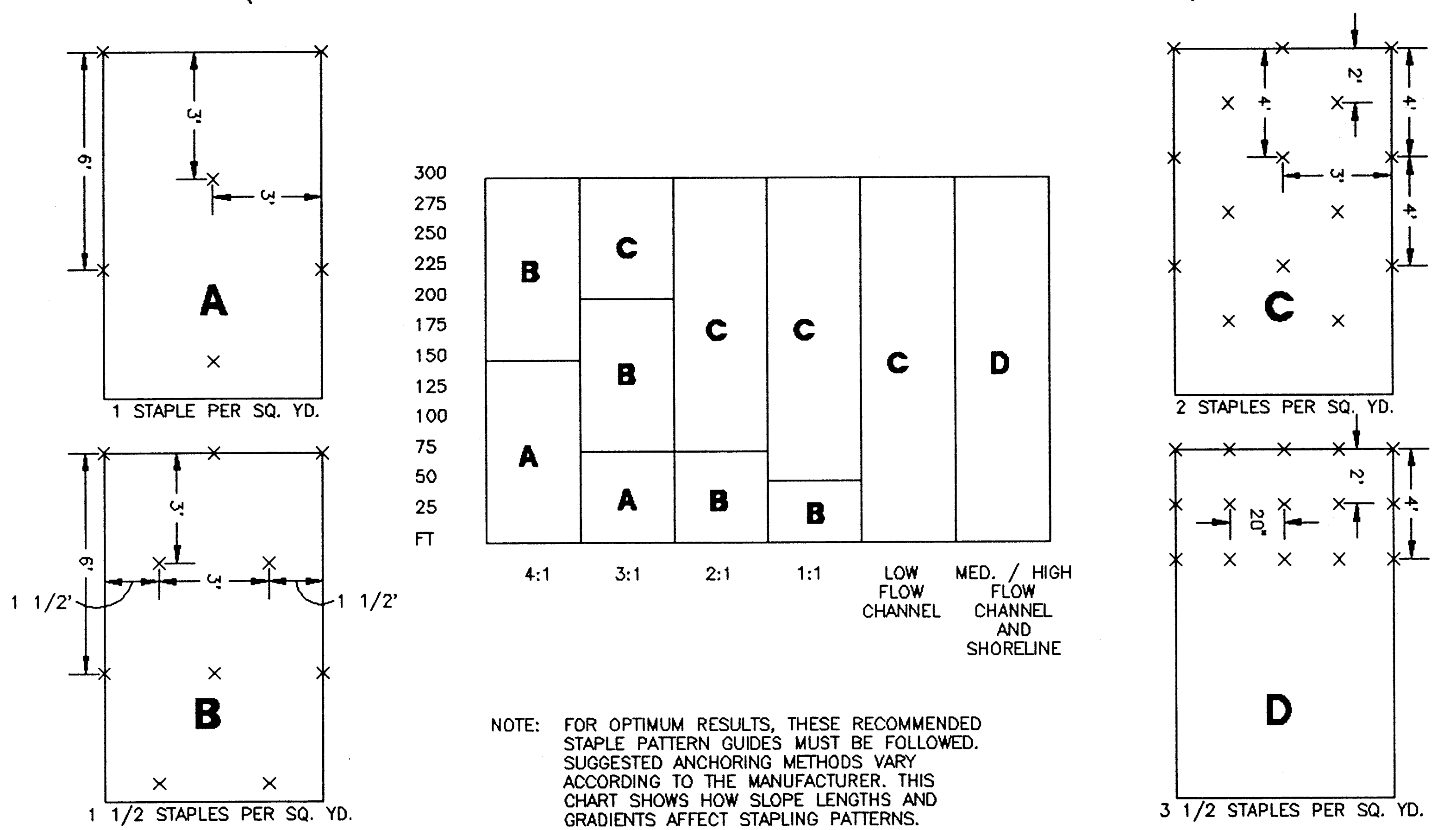
Source: VDOT Road and Bridge Standards Plate 3.36-4

TYPICAL TREATMENT – 2
SOIL STABILIZATION MATTING
SLOPE INSTALLATION



Source: VDOT Road and Bridge Standards Plate 3.36-5

GENERAL STAPLE PATTERN GUIDE AND RECOMMENDATIONS FOR TREATMENT – 2 (SOIL STABILIZATION MATTING)



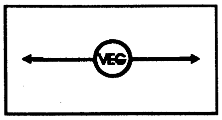
NOTE: FOR OPTIMUM RESULTS, THESE RECOMMENDED STAPLE PATTERN GUIDES MUST BE FOLLOWED. SUGGESTED ANCHORING METHODS VARY ACCORDING TO THE MANUFACTURER. THIS CHART SHOWS HOW SLOPE LENGTHS AND GRADIENTS AFFECT STAPLING PATTERNS.

Source: Product literature from North American Green

Plate 3.36-6

STD & SPEC 3.37

TREES, SHRUBS, VINES & GROUND COVERS



Definition

Stabilizing disturbed areas by establishing vegetative cover with trees, shrubs, vines, or ground covers.

Purposes

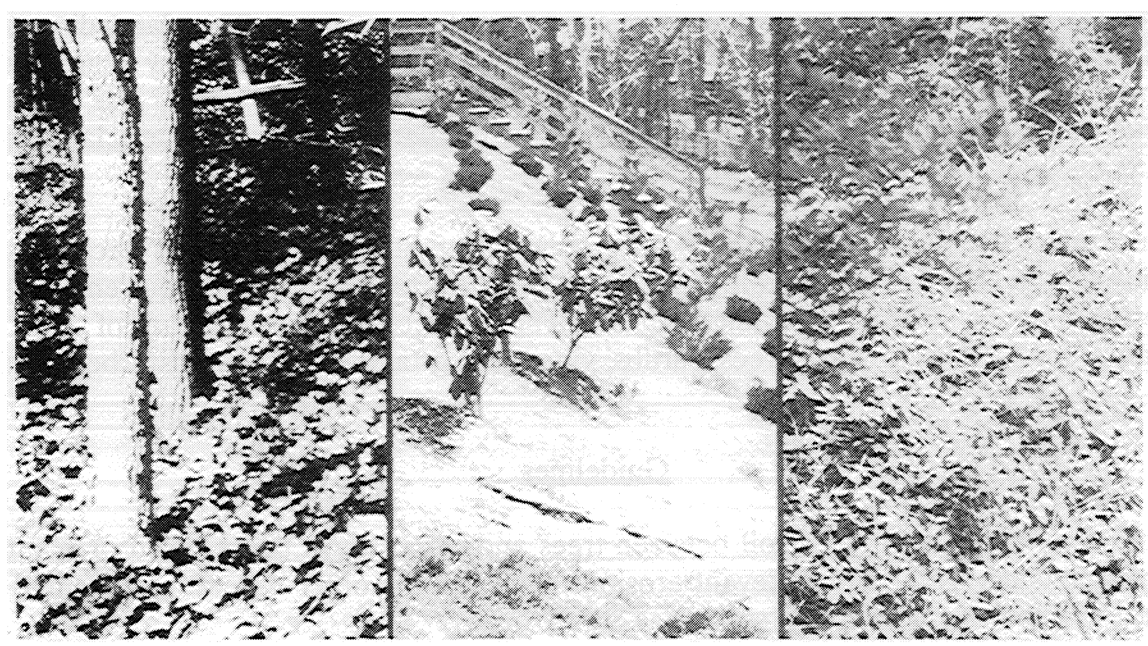
1. To aid in stabilizing soil in areas where vegetation other than turf is preferred.

2. To provide food and shelter for wildlife where wildlife habitat is desirable.

Conditions Where Practice Applies

1. In areas where turf establishment is difficult.

2. On steep or rocky slopes, where mowing is not feasible.



3. Where ornamentals are desirable for landscaping purposes.

4. Where woody plants are desirable for soil conservation, or to establish wildlife habitat.

Planning Considerations

Disturbed areas may be stabilized in many different ways. Most frequently, a permanent vegetative cover of grasses and legumes is established. There are locations, however, where other types of vegetation are preferred. The following situations are examples of ways in which trees, shrubs, vines, and ground covers may be used:

1. On cut and fill slopes adjacent to paved areas of shopping centers, schools, industrial parks, or other non-residential projects: woody plants and ground covers can be used on these slopes to control erosion. They will also help to control foot traffic, will not require as much maintenance as mowed lawns, and will be more attractive than unmowed grass cover.

2. In residential areas, slopes too steep to be mowed and areas along rights-of-way or easements may be planted in trees, shrubs, vines or ground covers to reduce maintenance and improve appearance.

3. The interested homeowner or small project developer may choose to use ornamental plants in problem areas - shade, steep slopes, inaccessible places - as alternatives to grass. Ground covers may be used to reduce or eliminate the need for mowing grass on level areas.

There are vast numbers of plants that may be used for these purposes. The plants discussed in this practice are those which are known to be adapted to Virginia, fairly easy to grow, and commonly available from commercial nurseries. Many plants suitable for use are not mentioned here. Information on such plants can be obtained from nurserymen, landscape architects, and extension agents.

Because many types of woody plants and ground covers are discussed, and because site conditions and land use vary so widely, it is not practical to give specific requirements for the establishment of every plant mentioned. This practice consists, instead, of a set of general guidelines for growing trees, shrubs, vines, and ground covers on disturbed land.

Guidelines

As noted in MS #1, disturbed soil between trees and shrubs must be mulched or planted with permanent vegetation to prevent erosion. Refer to the other vegetative practices to select a method for stabilizing these areas.

Trees

Selecting the Right Trees - In the urban and suburban environment, trees may be exposed to insufficient light and water; high velocity winds; salt from highway ice control programs; heat radiation from roads and buildings; pollutants from cars and industry; root amputation for water, sewer, and gas lines; topping to prevent interference with power lines; and covering of roots by pavement. New species and varieties of trees are being selected for the modern environment on the basis of their ability to withstand those difficult conditions and still provide the benefits associated with having trees (see Plate 3.37-1).

Selection of trees depends on the desired function of the tree, whether it be shade, privacy screening, noise screening, appearance, enhancement of wildlife habitat, or a combination of these. The following characteristics of the tree should be considered when making choices:

1. Hardiness - "Hardiness zones" are based on average annual minimum temperature. Virginia contains 3 such zones (Plate 3.37-2) to which different trees are adapted.

2. Mature height and spread - The eventual height of a tree must be considered in relation to planting location to avoid future problems with power lines and buildings (see Plate 3.37-3).

3. Growth rate - Some trees attain mature height at an early age, others take many years. If "instant shade" is desired, rapid growth is needed. Slow-growing trees are usually less brittle and live longer.

4. Root system - Some trees obstruct underground pipelines with fibrous roots.

5. Cleanliness - Maintenance problems can be avoided by not selecting trees that drop seedpods, flowers, or twigs in large amounts.

6. Moisture and fertility requirements - If good soil and drainage are not available, trees tolerant of poor growing conditions must be planted.

7. Ornamental effects - If a tree is unusually attractive in appearance, some other shortcomings may be overlooked.

8. Evergreen vs. deciduous - Evergreens retain their leaves throughout the year, and so are useful for privacy screens and noise screens. Deciduous trees drop their leaves in fall. They are preferable for shade trees.

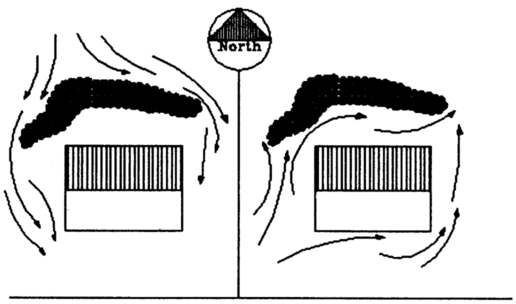
Some of these characteristics are given in Table 3.37-B for trees commonly grown in Virginia.

At the same time as trees are being selected, the site where they will be planted should be evaluated. Consider the prior use of the land; adverse soil conditions, such as poor drainage

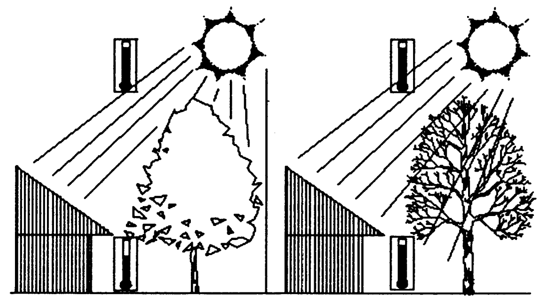
BENEFITS OF TREES

TEMPERATURE MODIFICATION

TREES AFFECT WIND SPEED AND DIRECTION, AND THUS TEMPERATURE. FOR EXAMPLE, AN EVERGREEN PLANTING ON THE NORTHWEST SIDE OF A BUILDING WILL REDUCE THE EFFECTS OF HARSH WINTER WINDS AND DIRECT COOL SUMMER BREEZES THROUGH THE AREA. TREES PROTECT THE SOIL FROM DRYING SUN AND WIND, REDUCING EVAPORATION AND MAINTAINING COOLER TEMPERATURES UNDER TREES. WHEN PROPERLY PLACED NEAR BUILDINGS, TREES OF PROPER SIZE WILL INSULATE BUILDINGS FROM EXTREME TEMPERATURE CHANGES IN WINTER AND SUMMER, HELPING REDUCE COSTS OF HEATING AND COOLING. DECIDUOUS TREES BLOCK OUT THE HOT SUMMER SUN, KEEPING THE HOME COOLER, AND ALLOW WARMTH OF WINTER SUN TO PASS THROUGH.



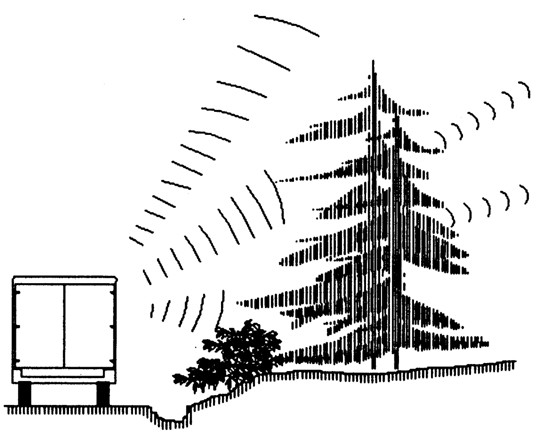
WINTER SUMMER



SUMMER WINTER

SOUND CONTROL

NOISES FROM NEARBY SOURCES CAN BE REDUCED THROUGH PROPER PLACEMENT OF TREES. THE DEGREE OF CONTROL DEPENDS ON THE DENSITY OF THE PLANTING AND INTENSITY AND DIRECTION OF SOUND WAVES. BOTH DECIDUOUS AND EVERGREEN TREES SHOULD BE USED FOR BEST EFFECT.

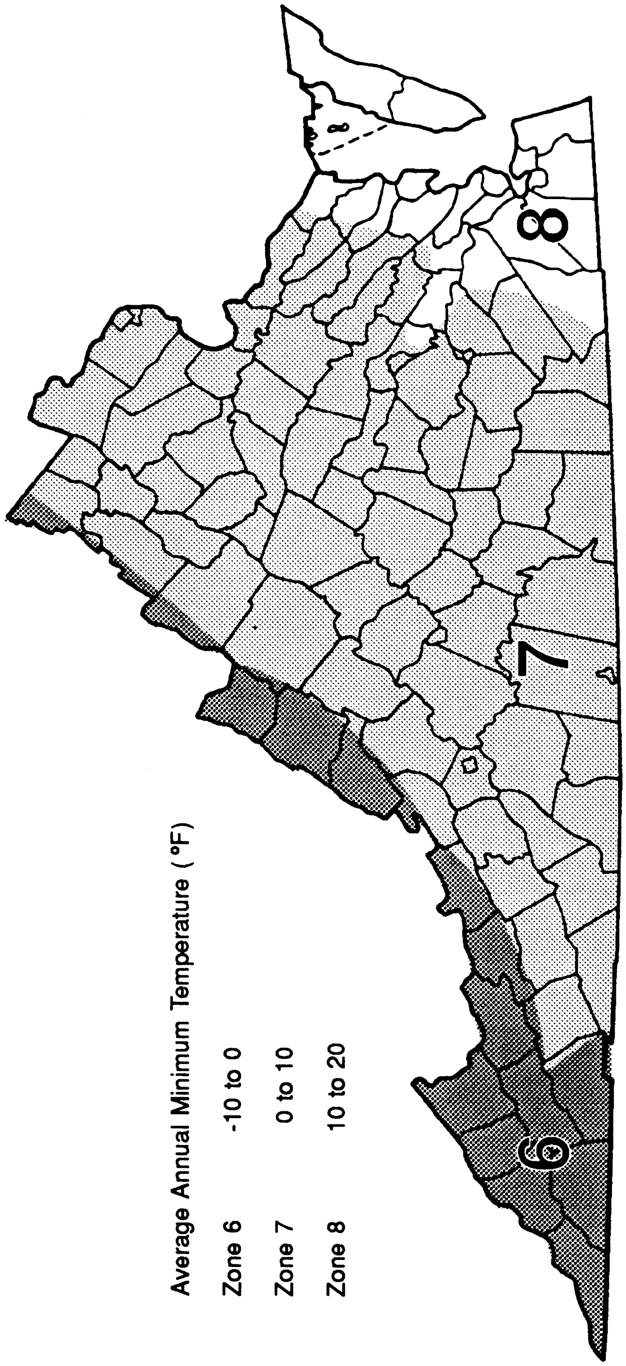


EROSION CONTROL

COARSE LEAF TEXTURES, HORIZONTAL BRANCHING HABITS, FIBROUS ROOT STSTEMS, AND ROUGH BARK ARE TREE CHARACTERISTICS MOST EFFECTIVE IN SLOWING WATER MOVEMENT AND WIND SPEED, THUS REDUCING EROSION PROBLEMS.

Source: Va. DSWC

Plate 3.37-1

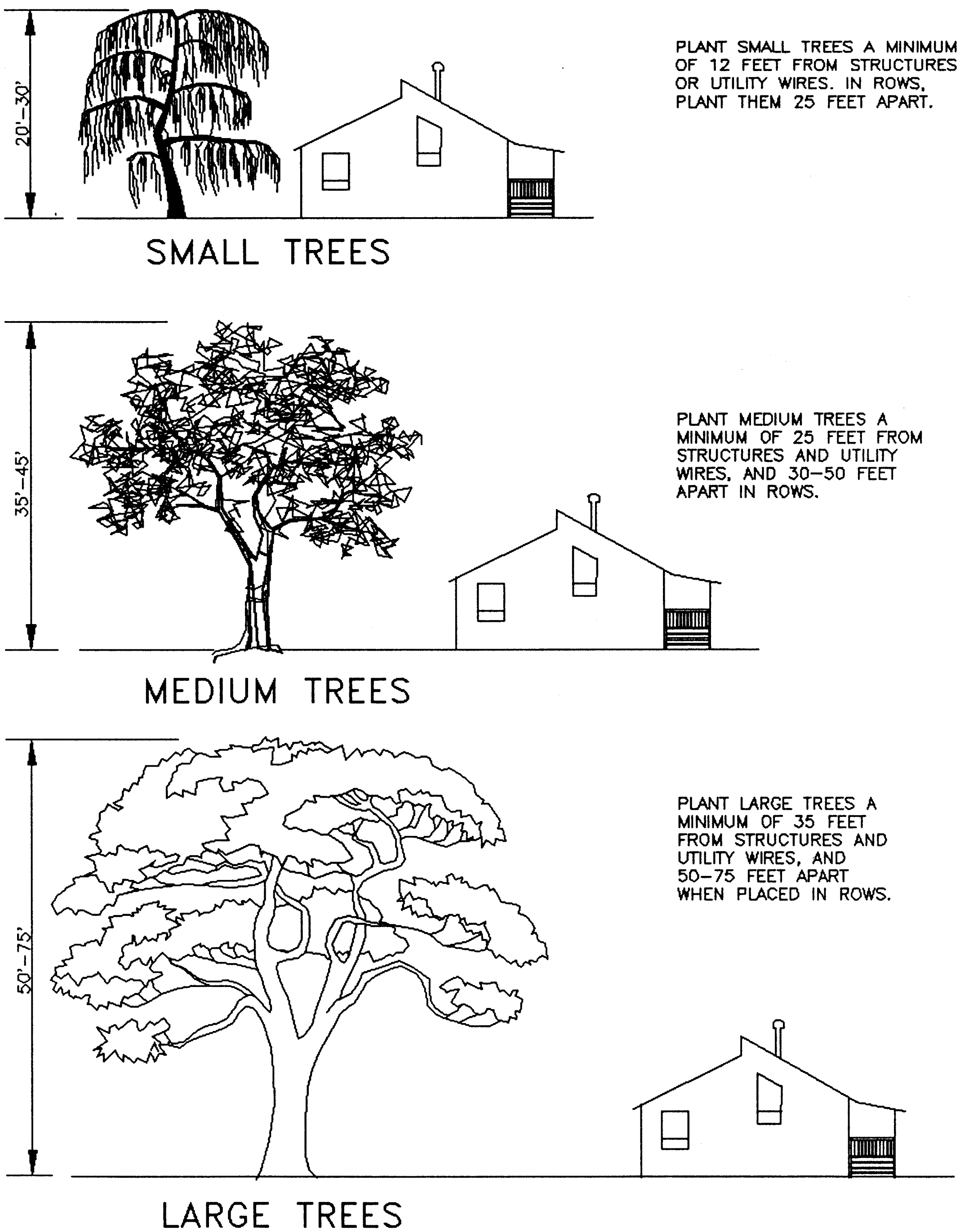


PLANT HARDINESS ZONES IN VIRGINIA FOR TREES, SHRUBS, VINES AND GROUND COVER

Source: <u>Conservation Plants for the Northeast</u>, USDA-SCS

Plate 3.37-2

SPACING TREES FOR SAFETY AND EFFECTIVE LANDSCAPING



Source: Va. DSWC

Plate 3.37-3

or acidity, exposure to wind; temperature extremes; location of utilities, paved areas, and security lighting; and traffic patterns.

Sources of trees and how they may be bought - The trees listed in Table 3.37-A are usually available at commercial nurseries as container-grown trees or as balled and burlapped trees. Container-grown trees can be planted at any time of year that the ground is not frozen, if sufficient water is provided. They should be purchased and planted when quite young (less than 2" diameter trunk) to avoid dealing with root-bound plants.

Balled and burlapped trees are usually larger; check to be sure that soil around roots was dug with the tree and not just packed around bare roots. The soil should have been kept moist.

Tree seedlings are available commercially and are also sold in lots of 50, 100, 500, or 1000 by the state forest nurseries. State nurseries are located in New Kent, Augusta, and Cumberland. About 20 species of trees are usually available during the height of the planting season, at nominal prices. These seedlings are not to be used as ornamentals or for fine landscaping; they are intended to be used as conservation plantings for erosion control, reforestation, and development of wildlife habitat. Since 50 seedlings will only plant an area of 3000 square feet, it is permissible to plant fairly small areas as long as the purpose is conservation. More information about this program is available through the Virginia Department of Forestry.

Planting Bare-Rooted Tree Seedlings

When - Trees to be planted as bare-rooted seedlings should be handled only while dormant in spring, or after leaf fall in autumn. Refer to Plate 3.37-4 for planting instructions.

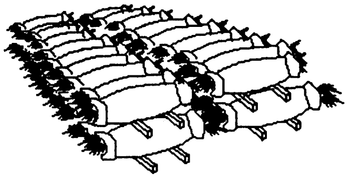
When stabilizing the disturbed area between tree plantings, do not use grasses or legumes which will overshade the new seedlings. Where possible, a circle of mulch around seedlings will help them to compete successfully with herbaceous plants.

Transplanting Trees (Planting Balled-and-Burlapped and Container-Grown Trees)

When - Hardwoods should be transplanted in the late fall following their leaf drop. There is a single exception to this rule: "Willow" Oaks seem to survive at a greater rate when they are transplanted in the spring. Evergreens may be transplanted beginning with the fall cool-down period (normally September) and may continue into spring prior to elongation of the new growth.

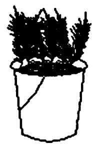
Tree preparation - Proper digging of a tree includes the conservation of as much of the root system as possible, particularly the fine roots. Soil adhering to the roots should be damp when tree is dug, and kept moist until planting. The soil (or "root") ball should be 12 inches in diameter for each inch of diameter of the trunk. The tree should be carefully excavated and the soil ball wrapped in burlap and tied with rope. Use of a mechanical tree spade is also acceptable.

PLANTING BARE-ROOTED SEEDLINGS



CARE OF SEEDLINGS UNTIL PLANTED

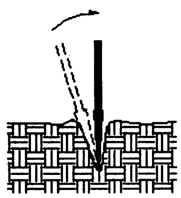
SEEDLINGS SHOULD BE PLANTED IMMEDIATELY. IF IT IS NECESSARY TO STORE MOSS-PACKED SEEDLINGS FOR MORE THAN 2 WEEKS, ONE PINT OF WATER PER PKG. SHOULD BE ADDED. IF CLAY-TREATED, DO NOT ADD WATER TO PKG. PACKAGES MUST BE SEPERATED TO PROVIDE VENTILATION TO PREVENT "HEATING". SEPARATE PACKAGES WITH WOOD STRIPS AND STORE OUT OF THE WIND IN A SHADED, COOL (NOT FREEZING) LOCATION.



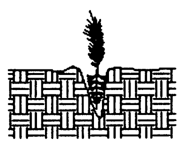
CARE OF SEEDLINGS DURING PLANTING

WHEN PLANTING, ROOTS MUST BE KEPT MOIST UNTIL TREES ARE IN THE GROUND. DO NOT CARRY SEEDLINGS IN YOUR HAND EXPOSED TO THE AIR AND SUN. KEEP MOSS-PACKED SEEDLINGS IN A CONTAINER PACKED WITH WET MOSS OR FILLED WITH THICK MUDDY WATER. COVER CLAY-TREATED SEEDLINGS WITH WET BURLAP ONLY.

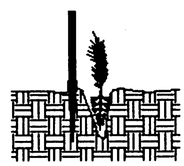
HAND PLANTING



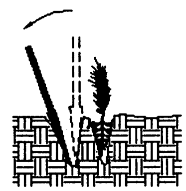
INSERT BAR AT ANGLE SHOWN AND PUSH FORWARD TO UPRIGHT POSITION.



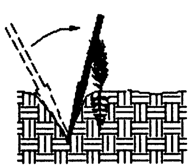
REMOVE BAR AND PLACE SEEDLING AT CORRECT DEPTH.



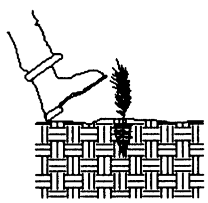
INSERT BAR TWO INCHES TOWARD PLANTER FROM SEEDLING.



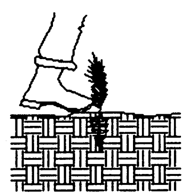
PULL BAR TOWARD PLANTER FIRMING SOIL AT BOTTOM OF ROOTS.



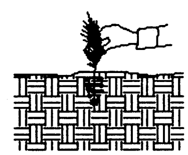
PUSH BAR FORWARD FROM PLANTER FIRMING SOIL AT TOP OF ROOTS.



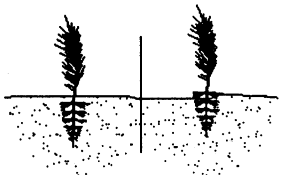
FILL IN LAST HOLE BY STAMPING WITH HEEL.



FIRM SOIL AROUND SEED-LING WITH FEET.



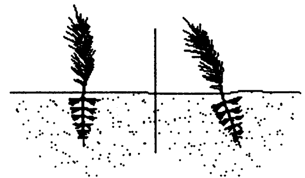
TEST PLANTING BY PULLING LIGHTLY ON SEEDLING.



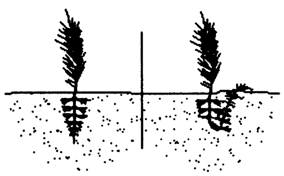
RIGHT WRONG

DON'T EXPOSE ROOTS TO AIR DURING FREEZE OR PLANT IN FROZEN GROUND.

PLANT SEEDLINGS UPRIGHT – NOT AT AN ANGLE.

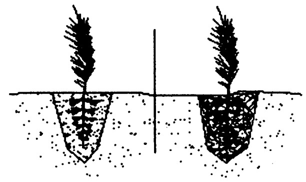


RIGHT WRONG



DO NOT BEND ROOTS SO THAT THEY GROW UPWARDS OUT OF THE GROUND.

ALWAYS PLANT IN SOIL – NEVER LOOSE LEAVES OR DEBRIS. PACK SOIL TIGHTLY.



Source: Va. Department of Forestry

Plate 3.37-4

Evergreens, or any trees which are to be transported for a distance, should have the branches bound with soft rope to prevent damage.

Site Preparation - Rather than digging a planting hole, rototill or loosen with a shovel, a shallow area the depth (height) of the soil ball and the width of five times the diameter of the soil ball or container. Organic material can be added to the loosened soil as long as the new material is used uniformly throughout the area.

Heavy or poorly drained soils are not good growth media for trees. When it is necessary to transplant trees into such soils, extra care should be taken. Properly installed drain tile will improve drainage.

Setting the tree - At the center of the prepared area, dig a shallow hole to set the tree. The hole should allow the root ball to sit on solid ground rather than loose soil. The upper surface of the root ball should be level with the existing soil. The tree may be set just a few inches higher than its former location, especially if soil is poorly drained. Do not set the tree lower than it was previously positioned. Soil to be placed around the root ball should be moist but not wet (see Plate 3.37-5).

Set the tree in the hole and remove the rope which holds the burlap. Cut away the burlap or, at a minimum, push it back into the bottom of the excavation. Do not break the soil of the root ball. Fill the hole with soil half-way, and tamp firmly around the root ball. Add water to settle the soil and eliminate air pockets. When the water has drained off, fill the hole the remainder of the way and tamp as before.

Use extra soil to form a shallow basin around the tree, somewhat smaller than the diameter of the root ball (Plate 3.37-5). This will be for holding water when the tree is irrigated.

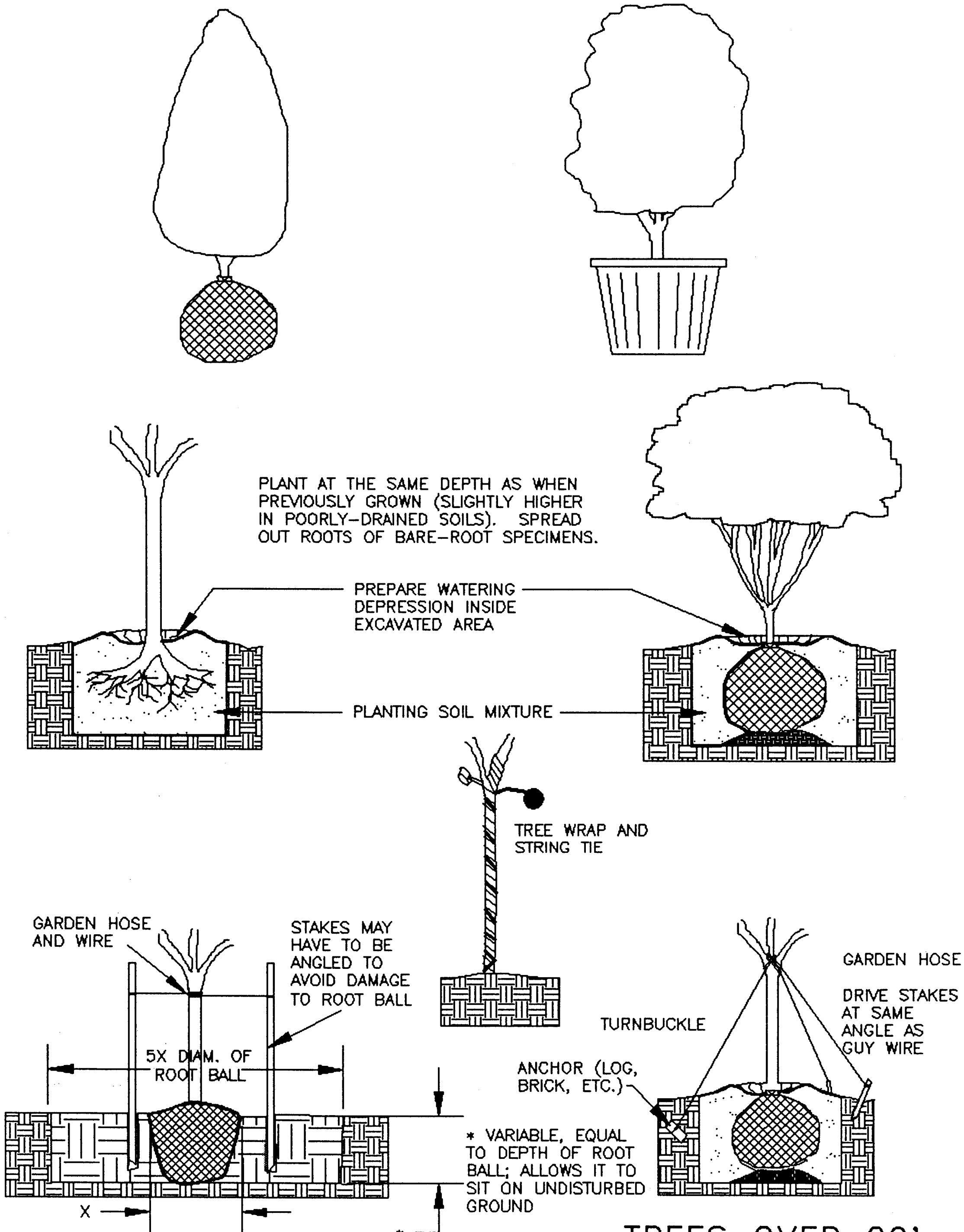
Note: Level the ground and eliminate these basins when winter sets in, as ice forming in the basin might injure the trunk.

Supporting the tree - Newly planted trees may need artificial support, especially in windy areas, to prevent excessive swaying. Stakes or guy wires may be used (see Plate 3.37-4). Use rubber hose and allow some slack in the guy to encourage strengthening of the plant. Remove all supports within six months of planting.

Watering - Soil around the tree should be thoroughly watered after the tree is set in place. When the soil becomes dry, the tree should be watered deeply but not too often. Mulching around the base of the tree is helpful in preventing roots from drying out.

Maintenance of Tree Plantings - Like all plants, trees require water and fertilizer to grow. Ideally, young trees should receive an inch of water each week for the first two years after planting. When rain does not supply this need, the tree should be watered deeply but not any more frequent than once per week.

PLANTING BALLED-&-BURLAPPED & CONTAINER-GROWN TREES



Source: Va. Department of Forestry

Plate 3.37-5

Transplanted trees should be fertilized one year or so after planting. There are many sophisticated ways to supply fertilizer to trees, but some simple methods are adequate. The best material for small trees is well-rotted stable manure, if it can be obtained. Add it as a 2-inch layer of mulch around the tree annually. If chemical fertilizers are to be used, a formulation such as 10-8-6 or 10-6-4 is preferred. Use about 2 lbs. per inch of trunk diameter measured 4 feet from the ground. Thus, if the trunk diameter at 4 feet was 5 inches, 10 lbs. of fertilizer would be applied.

Note: Evergreens - use one-half the recommended amount of chemical fertilizer or use only organic fertilizers such as cottonseed meal, bone meal, or manure.

Fertilizer must come in contact with the roots to benefit the tree. A simple way to insure this is to make holes in the tree's root area with a punchbar, crowbar, or augur. Holes should be 18-inches deep, spaced about 2 feet apart, and located around the drip line of the tree. Distribute the necessary fertilizer evenly into these holes, and close the holes with the heel of the shoe or by filling with topsoil or peat moss.

Fertilize trees in late fall or in early spring, before leaves emerge.

Shrubs

Much of what has been said about trees also applies to shrubs. A shrub is an erect, woody plant less than 15 feet tall, usually with several trunks rising from a common base. Some have the appearance of small trees, and some lie close to the ground.

Selecting appropriate shrubs - There are so many ornamental shrubs available that advising on the choice of any one is difficult. Table 3.37-B gives the basic characteristics of shrubs commonly available at commercial nurseries in Virginia, which are recommended for conservation planting because they enrich or hold the soil or encourage development of wildlife habitat. Information on other shrubs is available from nurserymen and extension agents.

Follow the general procedure for tree planting when planting shrubs.

Maintenance

Proper pruning, watering, and application of fertilizer every three years or so will keep shrubs, healthy. Maintain the mulch cover or turf cover surrounding the shrubs. A heavy layer of mulch reduces weeds and retains moisture.

VINES AND GROUND COVERS

Low-growing plants that sprawl, trail, spread, or send out runners come in many leaf types, colors and growth habits. Some are suitable only as part of a maintained landscape, and some can stabilize large areas with little care.

In addition to stabilizing disturbed soil, vines and ground covers can perform the following functions:

1. Maintain cover in areas where turf will not thrive.

2. Provide attractive cover that does not need mowing.

3. Help to define traffic areas and control pedestrian movement. People are more likely to walk on the grass than to walk on a thick bed of ivy or a prickly planting of juniper.

Table 3.37-C gives the characteristics of some commonly used vines and ground covers suitable for Virginia. Information on others is available from nurserymen.

Most all ground covers perform best when planted in the spring. Container-grown plants can be planted throughout the growing season if adequate water is provided.

Site preparation - Ground covers are plants that naturally grow very close together, causing severe competition for space, nutrients, and water. Soil for ground covers should be well-prepared. A well-drained soil high in organic matter is best.

If the area to be planted is so large that adding amendments to the soil as a whole would be impractical, organic matter may be added only to each planting hole.

Lime and fertilize according to soil test, or add 5 lbs. or 10-10-10 and 10 lbs. of ground agricultural limestone to every 100 square feet. Incorporate into the top 4 to 6 inches of the soil. Add organic matter up to one-third of the total soil volume, either over the whole area (a layer 2 inches deep mixed into the top 6 inches) or in each planting hole, if the area is large.

Plants such as ivy, pachysandra, and periwinkle should be planted on 1-foot centers; large plants such as juniper can be spaced on 3-foot centers.

Mulching - The soil between trees and shrubs must be planted with cover vegetation or must be mulched. When establishing ground covers, it is not desirable to plant species that will compete strongly with the ground cover or will make maintenance difficult. A thick, durable mulch such as shredded bark or wood chips is recommended to prevent erosion and reduce weed problems. Pre-emergent herbicides may be necessary where weeding is not practical.

On slopes where erosion may be a problem, jute mesh or excelsior blankets may be installed prior to planting, and plants tucked into the soil through slits in the net. Such plants should be put in a staggered pattern to minimize erosion.

Maintenance

Trim old growth as needed to improve the appearance of ground covers. Most covers need once-a-year trimming to promote growth. Maintain mulch cover with additions of mulch where needed. Fertilize as described above, every 3 to 4 years.

TABLE 3.37-A
TREES FOR LANDSCAPING, EROSION CONTROL AND SOIL CONSERVATION IN VIRGINIA

COMMON NAME (Botanical Name)	Leaf Type	Zones in Va.	Mature Size (in feet)	SOIL MOISTURE PREFERRED			pH Range	USES			Disease/Pest Resistance	Salt Tolerance	POLLUTION TOLERANCE			REMARKS (Suggested Varieties)
				Dry	Med	Wet		Lawns	Street	Seashore			O_3	SO_2	F	
BEECH (Fagus grandifolia)	D	6 7 8	70 - 120		X		6.5 - 7.5	X			fair	S	-	S	-	Long-lived. Has edible nuts. Needs lots of space.
BIRCH, RIVER (Betula nigra)	D	7 8	50 - 80	X	X		4.0 - 5.0	X			good	-	S	S	-	Prefers deep, moist soils such as streambanks. Graceful form.
CEDAR, EASTERN RED (Juniperus virginiana)	E	7 8	20 - 50	X	X	X	6.0 - 6.5	x			good	-	T	T	T	Long-lived.
CHERRY, JAPANESE (Prunus serrulata)	D	6 7 8	15 - 20		X		6.5 - 7.5	X	X		good	-	-	-	T	Very showy pink or white flowers. Usually grafted on 6-7 foot stem. (Kwanzan)
CRABAPPLE (Malus spp.)	D	6 7 8	15 - 20		X		6.5 - 7.5	X	X	X	fair	I	S	S	-	White or pink flowers. Many varieties, some with edible fruit.
CUCUMBER TREE (Magnolia acuminata)	D	6 7	50 - 80	X	X		4.0 - 7.0	X			good	-	-	-	-	Grows rapidly. Green flowers; scarlet fruits in fall.
DOGWOOD, FLOWERING (Cornus florida)	D	6 7 8	30 - 40		X		5.0 - 6.5	X	X		good	-	T	T	T	Ideal street tree. White or pink flowers. Has poor drought resistance.
GINKGO (Ginkgo biloba)	D	6 7 8	to 100		X	X	6.0 - 6.5	x	x		very good	-	T	T	T	Plant male trees only - fruit has an offensive odor.

Sheet 1 of 6

TABLE 3.37-A (continued)
TREES FOR LANDSCAPING, EROSION CONTROL AND SOIL CONSERVATION IN VIRGINIA

COMMON NAME (Botanical Name)	Leaf Type	Zones in Va.	Mature Size (in feet)	SOIL MOISTURE PREFERRED			pH Range	USES			Disease/Pest Resistance	Salt Tolerance	POLLUTION TOLERANCE			REMARKS (Suggested Varieties)
				Dry	Med	Wet		Lawns	Street	Seashore			O_3	SO_2	F	
GOLDEN RAIN TREE (Koelreutaria paniculata)	D	6 7 8	20 - 30		X	X	6.0 - 6.5	X	X		good	-	-	-	-	Clusters of yellow flowers. Tolerant of parking lot conditions.
HACKBERRY, SOUTHERN (Celtis Mississippiensis)	D	6 7 8	80 - 90	X	X	X	6.5 - 7.5	X	X		good	T	T	T	-	Resembles elm in appearance. European hackberry also a good street tree. Tolerant of parking lot conditions.
HAWTHORNE (Crataegus spp.)	D	6 7 8	15 - 25		X		6.0 - 7.5	X	X		good	I	-	S	-	Thorny, Washington, and Lavalle types are good ornamentals. Tolerant of parking lot conditions.
HOLLY (Ilex opaca)	E	6 7 8	40 - 50	X	X	X	4.0 - 6.0	X	X	X	good	I	-	T	T	Slow-growing. Shade tolerant. Red berries appear only on female trees.
HORNBEAM (IRONWOOD) (Carpinus spp.)	D	6 7 8	10 - 30	X	X	X	6.5 - 7.5	X	X		good	S	-	T	I	Prefers low, moist bottomlands. Will tolerate shade. Yeddo hornbeam and European hornbeam preferred.
LINDEN, LITTLE LEAF (Tilia cordata)	D	6 7 8	40 - 50		X		6.5 - 7.5	X	X	X	fair	S	S	I	T	Best streetside linden. (Rancho, Greenspire, Chancellor)
LOCUST, BLACK (Robinia pseudo-acacia)	D	6 7 8	30 - 50		X	X	5.0 - 7.5			X	fair	I	S	T	I	Suited only to erosion control on seriously disturbed areas.

Sheet 2 of 6

TABLE 3.37-A (continued)
TREES FOR LANDSCAPING, EROSION CONTROL AND SOIL CONSERVATION IN VIRGINIA

COMMON NAME (Botanical Name)	Leaf Type	Zones in Va.	Mature Size (in feet)	SOIL MOISTURE PREFERRED			pH Range	USES			Disease/Pest Resistance	Salt Tolerance	POLLUTION TOLERANCE			REMARKS (Suggested Varieties)
				Dry	Med	Wet		Lawns	Street	Seashore			O_3	SO_2	F	
LOCUST, HONEY (Gleditsia triacanthos inermis)	D	6 7	50 - 75	X	X	X	6.5 - 7.5	X	X	X	good	T	S	-	-	Sturdy, wind-firm tree. (Moraine, Sunburst, Shademaster)
MAGNOLIA, SOUTHERN (Magnolia grandiflora)	E	7 8	60 - 80	X	X		4.0 - 7.0	X		X	good	-	-	-	-	Prefers moist, rich soil. Large, glossy leaves and 6-8" white flowers. Tolerant of parking lot conditions.
MAPLE, HEDGE (Acer campestre)	D	6 7 8	20 - 30		X	X	6.5 - 7.5	X	X		good	-	T	T	I	Prefers well-drained, deep, fertile soil. May be used in clipped hedges.
MAPLE, NORWAY (Acer platanoides)	D	6 7 8	50 - 60		X	X	6.5 - 7.5	X	X	X	good	T	I	T	I	Rapid growing. Provides extremely dense shade (kills grass). (Cavalier, Summer Shade)
MAPLE, RED (Acer rubrum)	D	6 7 8	50 - 80	X	X		4.5 - 7.5	X	X	X	good	S	T	T	-	Grows rapidly when young. Good tree for suburbs, but not city. (Gerling, Tilford)
MAPLE, SUGAR (Acer saccharum)	D	6	50 - 70	X	X	X	6.5 - 7.5	X			fair	I	T	T	-	Outstanding fall foliage. Suburban, but not city, tree. Slow-growing and shapely. (Green Mountain)
OAK, CHESTNUT (Quercus montana)	D	6	60 - 70		X	X	6.0 - 6.5	X			good	T	S	T	I	Grows well in sandy, gravelly or rocky soils.

Sheet 3 of 6

TABLE 3.37-A (continued)
TREES FOR LANDSCAPING, EROSION CONTROL AND SOIL CONSERVATION IN VIRGINIA

COMMON NAME (Botanical Name)	Leaf Type	Zones in Va.	Mature Size (in feet)	SOIL MOISTURE PREFERRED			pH Range	USES			Disease/Pest Resistance	Salt Tolerance	POLLUTION TOLERANCE			REMARKS (Suggested Varieties)
				Dry	Med	Wet		Lawns	Street	Seashore			O_3	SO_2	F	
OAK, PIN (Quercus palustris)	D	6 7 8	60 - 80	X	X	X	5.5 - 6.5	X	X		good	T	S	S	I	Most easily transplanted of the oaks. (Sovereign)
OAK, RED, NORTHERN (Quercus rubra borealis)	D	6 7 8	70 - 90		X	X	4.5 - 6.0	X	X	X	good	T	T	T	I	Most rapid-growing oak. Needs plenty of space.
OAK, RED, SOUTHERN (Quercus falcata)	D	7 8	70 - 80			X	4.0 - 5.0			X	good	-	T	T	I	Characteristically an upland tree. Prefers dry, infertile soils.
OAK, SCARLET (Quercus coccinea)	D	6 7	60 - 80			X	6.0 - 6.5	X	X		good	T	S	T	I	Prefers sandy or gravelly soils.
OAK, WHITE (Quercus alba)	D	6 7 8	60 - 80		X	X	6.5 - 7.5	X	X	X	fair	T	S	S	I	Long-lived, stately tree. Grows slowly.
OAK, WILLOW (Quercus phellos)	D	7 8	40 - 50	X	X	X	4.0 - 6.5	X			good	T	S	T	I	Long-lived, but grows quickly. Easy to transplant. Prefers fertile, acid soil.
PAGODATREE, JAPANESE (Sophora japonica)	D	7 8	30 - 40		X	X	6.0 - 7.5	X	X		good	-	-	-	-	Tolerates parking lot conditions. White flowers.

Sheet 4 of 6

TABLE 3.37-A (continued)
TREES FOR LANDSCAPING, EROSION CONTROL AND SOIL CONSERVATION IN VIRGINIA

COMMON NAME (Botanical Name)	Leaf Type	Zones in Va.	Mature Size (in feet)	SOIL MOISTURE PREFERRED			pH Range	USES			Disease/Pest Resistance	Salt Tolerance	POLLUTION TOLERANCE			REMARKS (Suggested Varieties)
				Dry	Med	Wet		Lawns	Street	Seashore			O_3	SO_2	F	
PEAR, CALLERY (Pyrus Calleryana)	D	6 7 8	40 - 50		X	X	6.5 - 7.5	X	X		good	I	-	S	-	Tolerates parking lot conditions. White flowers. (Bradford, Chanticleer)
PINE, AUSTRIAN (Pinus nigra)	E	6 7 8	30 - 50		X	X	4.0 - 6.5	X		X	good	T	-	-	-	Very hardy and rapid-growing. Will tolerate shallow soil and drought.
PINE, JAPANESE BLACK (Pinus thunbergi)	E	7 8	30 - 50		X	X	4.0 - 6.5	X		X	good	T	-	-	-	Popular ornamental selection for Virginia.
PINE, LOBLOLLY (Pinus taeda)	E	7 8	90 - 120	X	X		4.0 - 6.5			X	good	-	-	S	S	Use only for conservation plantings, not as an ornamental.
PINE, SHORTLEAF (Pinus echinata Miller)	E	6 7 8	80 - 100		X	X	4.0 - 6.5	X			good	-	-	-	-	Attractive shape. Prefers well-drained, sandy or gravelly soil.
PINE, SCOTCH (Pinus sylvestris)	E	6 7	60 - 90			X	4.0 - 6.5	X			good	I	S	S	S	Moderate growth. Very hardy and disease resistant.
PINE, VIRGINIA (Pinus virginiana)	E	6 7	30 - 40		X	X	4.0 - 6.5	X			good	I	S	S	-	Tolerates poor soil. Use for conservation plantings, not as an ornamental. Shallow-rooted.

Sheet 5 of 6

TABLE 3.37-A (continued)
TREES FOR LANDSCAPING, EROSION CONTROL AND SOIL CONSERVATION IN VIRGINIA

COMMON NAME (Botanical Name)	Leaf Type	Zones in Va.	Mature Size (in feet)	SOIL MOISTURE PREFERRED			pH Range	USES			Disease/Pest Resistance	Salt Tolerance	POLLUTION TOLERANCE			REMARKS (Suggested Varieties)
				Dry	Med	Wet		Lawns	Street	Seashore			O_3	SO_2	F	
PINE, WHITE (Pinus strobus)	E	6	80 - 100			X	4.0 - 6.5	X			fair	S	S	S	S	Very attractive, rapid-growing tree. Prefers deep, sandy loam. Subject to white pine blister rust.
PLANE-TREE, LONDON (Platanus acerifolia)	D	6 7 8	50 - 70		X		6.5 - 7.5	X	X	X	good	-	-	T	T	Good city tree. Does shed bark.
SWEETGUM (Liquidambar styraciflua)	D	7 8	80 - 120	X	X	X	6.0 - 7.5	X	X		good	-	S	S	T	Disease-prone in Washington, D.C. area. Splendid fall color. Needs deep soil and full sunlight. (Festival, Burgundy)
TUPELO (BLACKGUM) (Nyssa sylvatica)	D	6 7 8	60 - 80	X	X		5.0 - 6.0	X		X	good	I	T	T	-	Scarlet fall foliage. Suitable for swampy areas.
YEW, JAPANESE (Taxus cuspidata)	E	6 7 8	15 - 20		X		6.0 - 6.5	X			good	-	T	-	I	Can be used as an ornamental.
ZELKOVA (Zelkova serrata)	D	6 7 8	70 - 80		X		6.0 - 6.5	X	X		good	-	-	-	-	Recommended as replacement for American Elm. Hardy, fast-growing. Tolerates parking lot conditions.

Note: 1. For hardiness zones in Virginia, see Plate 3.37-2.

2. "E" - Evergreen
"D" - Deciduous

3. Pollution tolerance: "S" - sensitive. Will show physical damage.
"T" - tolerant.
"I" - intermediate. Damage depends on growing conditions.
"-" - no information at this time.

Sheet 6 of 6

TABLE 3.37-B
SHRUBS FOR VEGETATING DISTURBED AREAS

COMMON NAME (Botanical Name)	Leaf Type	DRAINAGE TOLERANCE					Shade Tolerance	pH Range	Mature Height (in feet)	Flowers	FRUIT	USES
		Droughty	Well-Drained	Moderately Well-Drained	Somewhat Poorly Drained	Poorly Drained						
AMERICAN CRANBERRY BUSH (Viburnum trilobum)	D			X	X	X	fair	6.5 - 7.5	6 - 7	--*	red berries	Hedges and borders. Winter food for birds. Fruits in 4 - 5 years.
AMUR HONEYSUCKLE "Rem Red" (Lonicera maackii)	D	X	X	X	X		good	6.5 - 8.0	8 -12	white	red berries	Erect shrubs for borders and hedges. Fall and winter food for birds.
CALIFORNIA PRIVET (Ligustrum ovalifolium)	E		X	X			fair	6.0 - 7.0	12 -18	--	--	Hedges and wind-breaks. Grows rapidly. Do not use in Mountain Region.
AUTUMN OLIVE (Eleagnus umbrellata)	D	X	X	X			poor	4.5 - 7.0	12	fragrant	red berries	Reclaiming mined land, screening; abundant food for wildlife. Fixes nitrogen. Attractive silvery foliage.
BAYBERRY (Myrica pennsylvanica)	E	X	X	X			poor	5.0 - 6.0	6 - 8	--	waxy, gray berries	Revegetating sand dunes; ornamental for droughty areas; fixes nitrogen in soil.
BEACH PLUM (Prunus maritima)	D	X	X	X			fair	6.0 - 8.0	7	white	edible, purple plum-like fruits	Revegetating sand dunes/droughty areas. Fruit used for jelly and baking, also favored by wildlife.
BICOLOR LESPEDEZA "Natob" (Lespedeza bicolor)	D	X	X	X			fair	4.5 - 6.5	12	purple	--	Rapid-growing shrub, provides food and cover for quail and wild turkey. Fixes nitrogen. Holds soil on slopes.

E = Evergreen D = Deciduous * Where no comment is made, fruit or flowers are inconspicuous.

Sheet 1 of 3

TABLE 3.37-B (continued)
SHRUBS FOR VEGETATING DISTURBED AREAS

COMMON NAME (Botanical Name)	Leaf Type	DRAINAGE TOLERANCE					Shade Tolerance	pH Range	Mature Height (in feet)	Flowers	FRUIT	USES
		Droughty	Well-Drained	Moderately Well-Drained	Somewhat Poorly Drained	Poorly Drained						
BRISTLY LOCUST "Arnot" (Robinia fertilis)	D	X	X	X			fair	5.0 - 7.5	6	pink	pods	Steep slopes, gravelly infertile areas. Fixes nitrogen. Spreads by sprouting from roots.
ELDERBERRY (Sambucus canadensis)	D		X	X	X	X	fair	6.0 - 7.5	12	white	edible purple berries	Provides food for birds and deer. Fruit in 4-5 yrs.
FIRETHORN (Pyracantha coccinea)	E	X	X	X			fair	6.0 - 8.0	10 - 15	white	orange or red berries	Screens, barriers. Food for songbirds. Low-growing and upright types available.
HORIZONTAL JUNIPER (Juniperus spp.)	E	X	X				poor	5.0 - 6.0	1 - 2	--	--	Used as ground cover or ornamental. Set plants 2 feet apart for cover in 2-3 years.
JAPANESE YEW (Taxus cuspidata)	E			X	X		good	6.0 - 7.0	12 - 16	--	--	Used for hedges and screens.
RUGOSA ROSE (Rosa rugosa)	D	X	X	X			fair	6.0 - 7.0	3 - 5	white, pink	red hips in 1-2 yrs.	Stabilizing sand dunes and landscaping. Food and cover for songbirds and rabbits. Sprawling growth habit, but not aggressive.
SHORE JUNIPER "Emerald Sea" (Juniperus conferta)	E	X	X				fair	5.0 - 6.0	1	--	--	Stabilizing sand dunes and sandy road banks.

E = Evergreen D = Deciduous * Where no comment is made, fruit or flowers are inconspicuous.

Sheet 2 of 3

TABLE 3.37-B (continued)
SHRUBS FOR VEGETATING DISTURBED AREAS

COMMON NAME (Botanical Name)	Leaf Type	DRAINAGE TOLERANCE					Shade Tolerance	pH Range	Mature Height (in feet)	Flowers	FRUIT	USES
		Droughty	Well-Drained	Moderately Well-Drained	Somewhat Poorly Drained	Poorly Drained						
SWEET FERN (Comptonia peregrina)	D	X	X				poor	5.0 - 6.0	2 - 4	--	--	Pleasantly scented. Fixes nitrogen. Spreads by underground stems. Stabilizes droughty areas. Do not use in Coastal Plain.
TATARIAN HONEYSUCKLE (Lonicera tatarica)	D		X	X			fair	6.5 - 8.0	6 - 9	pink, showy	red berries in 3-4 yrs	Erect shrub; hedges, borders, summer food for birds.
WINTERBERRY (Ilex verticillata)	D		X	X	X	X	fair	5.0 - 6.0	10	--	red berries in 3-4 years	Ornamental screens. Winter food for songbirds.

E = Evergreen D = Deciduous * Where no comment is made, fruit or flowers are inconspicuous.

Sheet 3 of 3

TABLE 3.37-C
GROUND COVERS AND VINES FOR EROSION CONTROL

COMMON NAME (Botanical Name)	Leaf Type	DRAINAGE TOLERANCE					Shade Tolerance	pH Range	FLOWERS	CHARACTERISTICS
		Droughty	Well-Drained	Moderately Well-Drained	Somewhat Poorly Drained	Poorly Drained				
BEARBERRY (Arctostaphylos uva-ursi)	E	X	X				good	4.5 - 6.0	--*	Trailing shrub. Low-fertility sandy areas, dunes. Set plants 18 in. apart for cover in 2-4 yrs.
BUGLEWEED (Ajuga reptans)	E		X	X			excellent	6.0 - 7.5	blue, white or red spikes	Small, low-growing herbaceous plants, in bronze or green. Set plants 1 ft. apart for cover in 1 year.
DAYLILY (Hemerocallis spp.)	D	X	X	X	X	X	fair	6.0 - 8.0	various/showy	Grass-like foliage. Unusually adaptable and free of pests and disease.
DUSTY MILLER "Beach Wormwood" (Artemisia stelleriana)	D	X	X	X			poor	6.0 - 7.5	--	Silvery foliage, 1-2 ft. tall. Spreads by underground stems. Stabilizing groundcover on coastal dunes. Set plants 2 ft. apart for cover in 2 years.
ENGLISH IVY (Hedera helix)	E	X	X	X			good	6.0 - 8.0	--	Low-maintenance vine for large areas. Will climb on trees, walls, etc. Set plants or rooted cutting 1 ft. apart for cover in 2 yrs.
HALL'S JAPANESE HONEYSUCKLE (Lonicera japonica halliana)	sE	X	X	X	X		good	6.0 - 7.5	white, fading to yellow; fragrant	Aggressively spreading vine. Excellent cover for large sloping areas such as road banks. Set clumps or plants 18 in. apart for cover in 2 years.

E = Evergreen D = Deciduous sE = Semi-evergreen * Where no comment is made, flowers are inconspicuous.

Sheet 1 of 2

TABLE 3.37-C (continued)
GROUND COVERS AND VINES FOR EROSION CONTROL

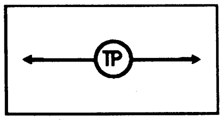
COMMON NAME (Botanical Name)	Leaf Type	DRAINAGE TOLERANCE: Droughty	Well-Drained	Moderately Well-Drained	Somewhat Poorly Drained	Poorly Drained	Shade Tolerance	pH Range	FLOWERS	CHARACTERISTICS
JAPANESE SPURGE "Pachysandra" (Pachysandra terminalis)	E		X	X			excellent	4.5 - 5.5	small white spikes	Low-growing, attractive cover for borders and as lawn substitute under trees and other shady areas. Set plants 1 ft. apart for cover in 2 years.
LILY-OF-THE-VALLEY (Convallaria majalis)	E	X	X	X	X		excellent	4.5 - 6.0	fragrant white bells on short stalks	Low-maintenance cover for partial or full shade. Set plants 1 ft. apart for cover in 2-3 years.
LILY-TURF (Liriope spp.)	E	X	X	X	X		good	4.5 - 6.0	white, lavender, or purple spikes	Grass-like, low-maintenance cover for droughty, infertile soils. Spreads by underground stems. Available in variegated form. Set plants 6-12 inches apart for cover in 2 years.
PERIWINKLE "Vinca" (Vinca Minor)	E		X	X			excellent	6.0 - 7.5	small, blue flowers	Lawn substitute for shady areas. Spreads by stolons; not aggressive. Grows in full sun as well as shade. Set plants 1 ft. apart for cover in 1-2 years.
SMALL-LEAVED COTONEASTER (Cotoneaster microphylla)	E		X	X			fair	6.0 - 7.0	tiny, white flowers	Prostrate shrub. Informal cover for large areas. Set plants 2 ft. apart for cover in 2 years.
VIRGINIA CREEPER (Quinquefolia parthenocissus)	D	X	X				fair	5.0 - 7.5	--*	Ground cover for dunes and other dry areas; will climb trees. Attractive crimson foliage in fall. Berries eaten by songbirds. Set plants 18 in. apart for cover in 1-2 years.

E = Evergreen D = Deciduous * Where no comment is made, flowers are inconspicuous.

Sheet 2 of 2

STD & SPEC 3.38

TREE PRESERVATION & PROTECTION



TP

Definition

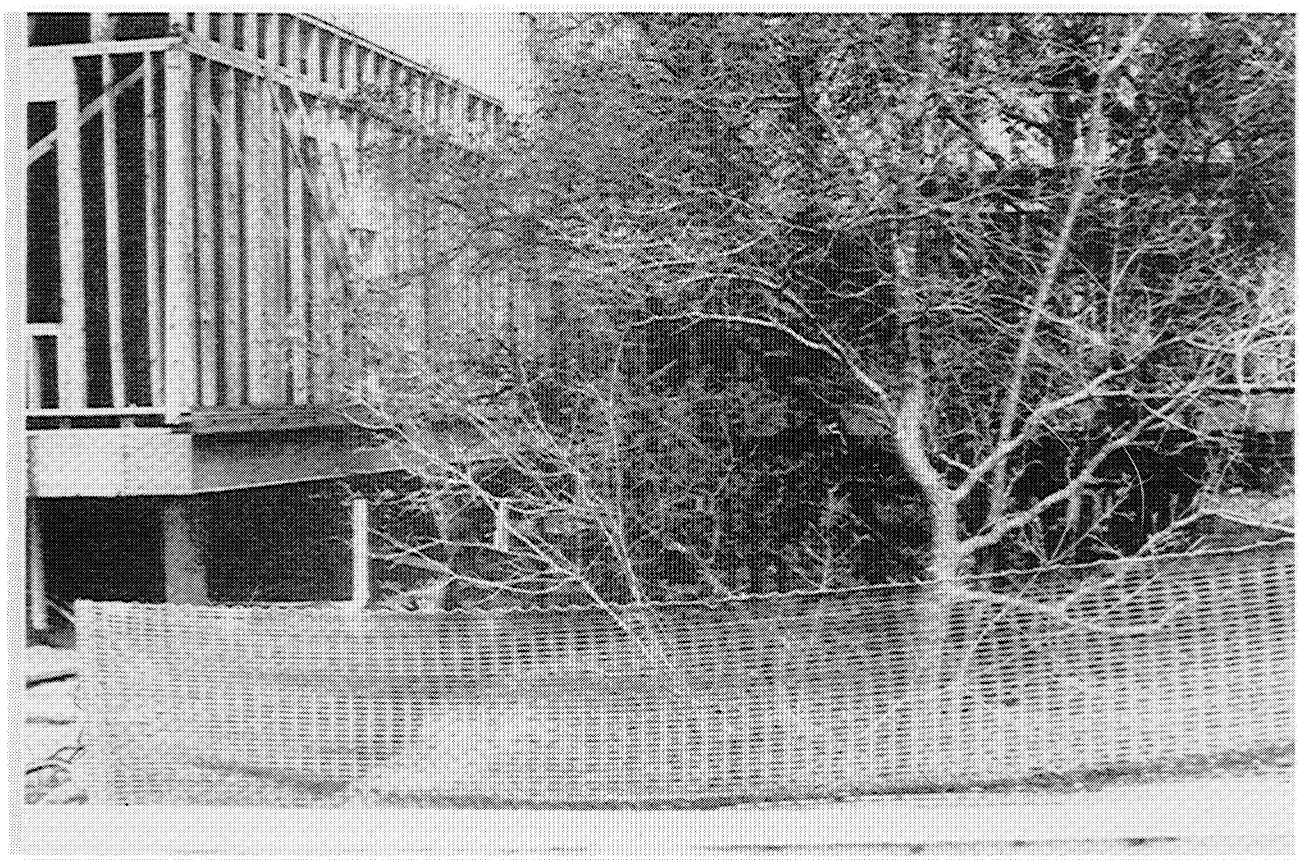
Protection of desirable trees from mechanical and other injury during land disturbing and construction activity.

Purpose

To ensure the survival of desirable trees where they will be effective for erosion and sediment control, watershed protection, landscape beautification, dust and pollution control, noise reduction, shade and other environmental benefits while the land is being converted from forest to urban-type uses.

Conditions Where Practice Applies

Tree-inhabited areas subject to land disturbing activities.



Planning Considerations

New development often takes place on tracts of forested land. In fact, building sites are often selected because of the presence of mature trees. However, unless sufficient care is taken and planning done in the interval between buying the property and completing construction, much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and ground cover. This responsibility is usually exercised by agents-the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which we value trees so highly. Trees perform the following functions on a site:

1. Assist in stabilizing the soil and preventing erosion.
2. Help to decrease stormwater runoff through canopy interception and root zone absorption.
3. Moderate temperature changes and provide shade.
4. Moderate the effects of sun and wind.
5. Provide buffers and screens against noise.
6. Filter pollutants from the air.
7. Help to remove carbon dioxide from the air and release oxygen.
8. Provide a haven for animals and birds, which help to control insect populations.
9. Conserve and increase property values.
10. Provide psychological and aesthetic counterpoints to the man-made urban setting.

Stresses of Construction

Trees may appear to be inanimate objects, but they are living organisms that are constantly involved in the process of respiration, food processing, and growth. Construction activities expose trees to a variety of stresses resulting in injury ranging from superficial wounds to death. An understanding of these stresses is helpful in planning for tree protection.

1. Surface Impacts: Natural and man-related forces exerted on the tree above the ground can cause significant damage to trees.

    a. Wind damage - Removal of some trees from groups will expose those remaining to greater wind velocities. Trees tend to develop anchorage where it is most needed. Isolated trees develop anchorage rather equally all around, with stronger root development on the side of the prevailing winds. The more a tree is protected from the wind, the less secure is its anchorage. The result of improper thinning is often wind-thrown trees. Selective removal in favor of a single tall tree may also create a lightning hazard.

b. Excessive pruning - Unprotected trees are often "topped" or carelessly pruned to prevent interference with utility wires or buildings. If too many branches are cut, the tree may not be able to sustain itself. If the pruning is done without considering the growth habit, the tree may lose all visual appeal. If the branches are not pruned correctly, decay may set in.

c. Trunk damage - Tree trunks are often nicked or scarred by trucks and construction equipment. Such superficial wounds provide access to insects and disease.

2. Root Zone Impacts: Disturbing and delicate relationship between soil, roots, and the rest of the tree can damage or kill a tree. The roots of an existing tree are established in an area where essential materials (water, oxygen, and nutrients) are present. The mass of the root system is the correct size to balance the intake of water from the soil with the transpiration of water from the leaves.

a. Raising the grade as little as 6 inches can retard the normal exchange of air and gases. Roots may suffocate due to lack of oxygen, or be damaged by toxic gases and chemicals released by soil bacteria.

b. Raising the grade may also elevate the water table. This can cause drowning of the deeper roots.

c. Lowering the grade is not usually as damaging as raising it. However, even shallow cuts of 6 to 8 inches will remove most of the topsoil, removing some feeder roots and exposing the rest to drying and freezing.

d. Deep cuts may sever a large portion of the root system, depriving the tree of water and increasing the chance of wind-throw.

e. Lowering the grade may lower the water table, inducing drought. This is a problem in large roadway cuts or underdrain installations.

f. Trenching or excavating through a tree's root zone can eliminate as much as 40 percent of the root system. Trees suffering such damage usually die within 2 to 5 years.

g. Compaction of the soil within the drip line (even a few feet beyond the drip line) of a tree by equipment operation, materials storage, or paving can block off air and water from roots.

h. Construction chemicals or refuse disposed of in the soil can change soil chemistry or be toxic to trees. Most damage to trees from construction activities is due to the invisible root zone stresses.

Design Criteria

No formal design is required. However, in planning for the development of a wooded site where some trees will be preserved, a number of criteria must be considered.

Selecting Trees to be Retained

The proper development of a wooded site requires completion of a plan for tree preservation before clearing and construction begins. Trees should be identified by species, and located on a topographical map, either as stands or as individuals, depending on the density and value of the trees. Base decisions on which trees to save on the following considerations:

1. Life expectancy and present age: Preference should be given to trees with a long life span, such as white oak, beech, and maple. Long-lived specimens that are past their prime may succumb to the stresses of construction, so smaller, younger trees of desirable species are preferred; they are more resilient and will last longer. However, if the cost of preservation is greater than the cost of replacement with a specimen of the same age and size, replacement may be preferred.

2. Health and disease susceptibility: Check for scarring caused by fire or lightning, insect or disease damage, and rotted or broken trunks or limbs. Pest- and pollution-resistant trees are preferred.

3. Structure: Check for structural defects that indicate weakness or reduce the aesthetic value of a tree: trees growing from old stumps, large trees with overhanging limbs that endanger property, trees with brittle wood (such as silver maple), misshapen trunks or crowns, and small crowns at the top of tall trunks. Open grown trees often have better form than those grown in the woods. Trees with strong tap or fibrous root systems are preferred to trees with weak rooting habits.

4. Cleanliness: Some trees such as elm and black locust are notoriously "dirty", dropping twigs, bark, fruit, or plant exudates. A clean tree is worth more than a dirty one. Trees which seed prolifically or sucker profusely are generally less desirable in urban areas. Thornless varieties are preferred.

5. Aesthetic values: Handsome bark and leaves, neat growth habit, fine fall color, and attractive flowers and fruit are desirable characteristics. Trees that

provide interest during several seasons of the year enhance the value of the site.

6. Comfort: Trees help relieve the heat of summer and buffer strong winds throughout the year. Summer temperatures may be 10 degrees cooler under hardwoods than under conifers. Deciduous trees drop their leaves in winter, allowing the sun to warm buildings and soil. Evergreens are more effective wind buffers.

7. Wildlife: Preference should be given to trees that provide food, cover, and nesting sites for birds and game.

8. Adaptability to the proposed development:

    a. Consider the mature height and spread of trees; they may interfere with proposed structures and overhead utilities. Roots may interfere with walls, walks, driveways, patios, and other paved surfaces; or water lines, septic tanks, and underground drainage.

    b. Trees must be appropriate to the proposed use of the development; select trees which are pollution-tolerant for high-traffic and industrial areas, screen and buffer trees for noise or objectionable views, salt-tolerant species for areas exposed to deicing salts or ocean spray.

    c. Consider location of landfills. Gases generated in them can travel long distances underground, to injure distant trees. Choose species tolerant of anaerobic soil conditions.

    d. Determine the effect of proposed grading on the water table. Grading should not take place within the drip line of any tree to be saved.

9. Survival needs of the tree: Chosen trees must have enough room to develop naturally. They will be subject to injury from increased exposure to sunlight, heat radiated from buildings and pavement, and wind. It is best to retain groups of trees rather than individuals. As trees mature, they can be thinned gradually.

10. Relationship to other trees: Individual species should be evaluated in relation to other species on the site. A species with low value when growing among hardwoods will increase in value if it is the only species present. Trees standing alone generally have higher landscape value than those in a wooded situation. However, tree groups are much more effective in preventing erosion and excess stormwater runoff.

Site Planning for Tree Protection

1. If lot size allows, select trees to be saved before siting the building. No tree should be destroyed or altered until the design of buildings and utility systems is final.

2. Critical areas, such as flood plains, steep slopes, and wetlands, should be left in their natural condition or only partially developed as open space.

3. Locate roadways to cause the least damage to valuable stands. Follow original contours, where feasible, to minimize cuts and fills.

4. Minimize trenching by locating several utilities in the same trench. Excavations for basements and utilities should be kept away from the drip line of trees.

5. Construction material storage areas and worker parking should be noted on the site plan, and located where they will not cause compaction over roots.

6. When retaining existing trees in parking areas, leave enough ground ungraded beyond the drip line of the tree to allow for its survival.

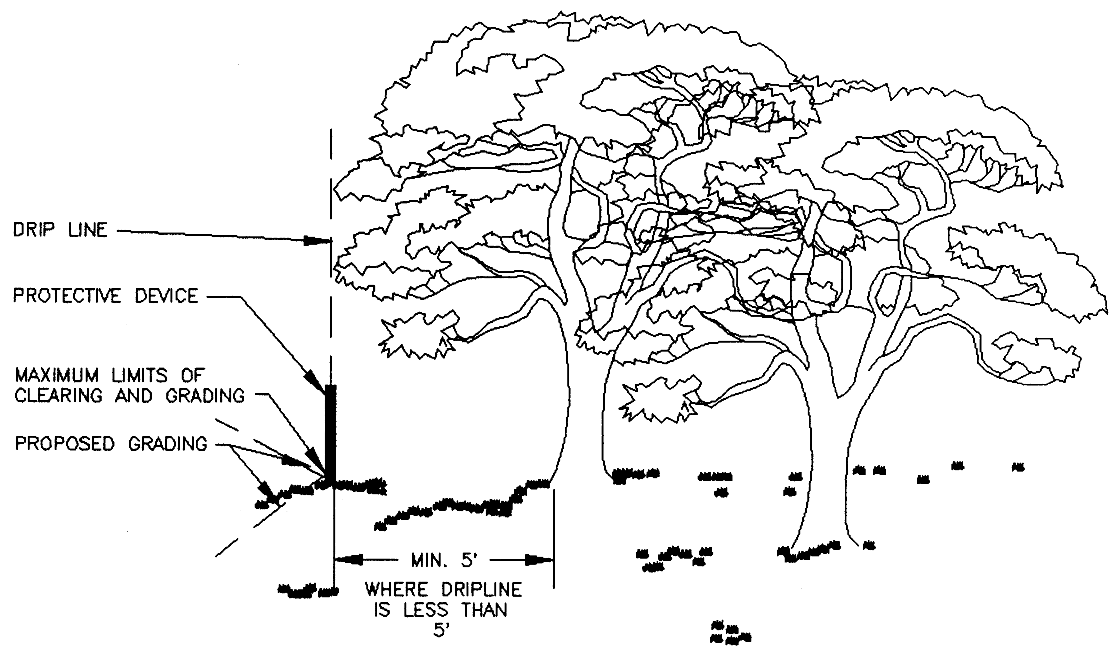
7. Locate erosion and sediment control measures at the limits of clearing and not in wooded areas, to prevent deposition of sediment within the drip line of trees being preserved. Sediment basins should be constructed in the natural terrain, if possible, rather than in locations where extensive grading and tree removal will be required.

Specifications

1. Groups of trees and individual trees selected for retention shall be accurately located on the plan and designated as "tree(s) to be saved." Individual specimens that are not part of a tree group shall also have their species and diameter noted on the plan.

2. At a minimum, the limits of clearing shall be located outside the drip line of any tree to be retained and, in no case, closer than 5 feet to the trunk of any tree (Plate 3.38-1).

3. Marking: Prior to construction and before the preconstruction conference, individual trees and stands of trees to be retained within the limits of clearing shall be marked at a height visible to equipment operators. According to the Virginia Department of Forestry, a diagonal slash of brightly colored paint approximately 8 to 10 inches in length is a common practice in areas where an accidental or purposeful alteration of the proper markings is a concern. In most situations, such as an area which is supposed to receive formal landscaping, a surveyor's ribbon or a similar material applied at a reasonable height encircling the tree will suffice.



CONSTRUCTION OPERATIONS RELATIVE TO THE LOCATION OF PROTECTED TREES

Source: Public Facilities Manual, Vol. III, Fairfax Co., Va., 1976 Plate 3.38-1

4. Pre-Construction Conference: During any preconstruction conference, tree preservation and protection measures should be reviewed with the contractor as they apply to that specific project.

5. Equipment Operation and Storage: Heavy equipment, vehicular traffic, or stockpiles of any construction materials (including topsoil) shall not be permitted within the drip line of any tree to be retained. Trees being removed shall not be felled, pushed or pulled into trees being retained. Equipment operators shall not clean any part of their equipment by slamming it against the trunks of trees to be retained.

6. Fires: Fires shall not be permitted within 100 feet from the drip line of any trees to be retained. Fires shall be limited in size to prevent adverse effects on trees, and kept under surveillance.

7. Storage and Disposal of Toxic Materials: No toxic materials shall be stored closer than 100 feet to the drip line of any trees to be retained. Paint, acid, nails, gypsum board, wire, chemicals, fuels, and lubricants shall not be disposed of in such a way as to injure vegetation.

8. Fencing and Armoring (Plate 3.38-2): Any device may be used which will effectively protect the roots, trunk and tops of trees retained on the site. However, trees to be retained within 40 feet of a proposed building or excavation shall be protected by fencing. Personnel must be instructed to honor protective devices. The devices described are suggested only, and are not intended to exclude the use of other devices which will protect the trees to be retained.

   a. Snow Fence - Standard 40-inch high snow fence shall be placed at the limits of clearing on standard steel posts set 6 feet apart.

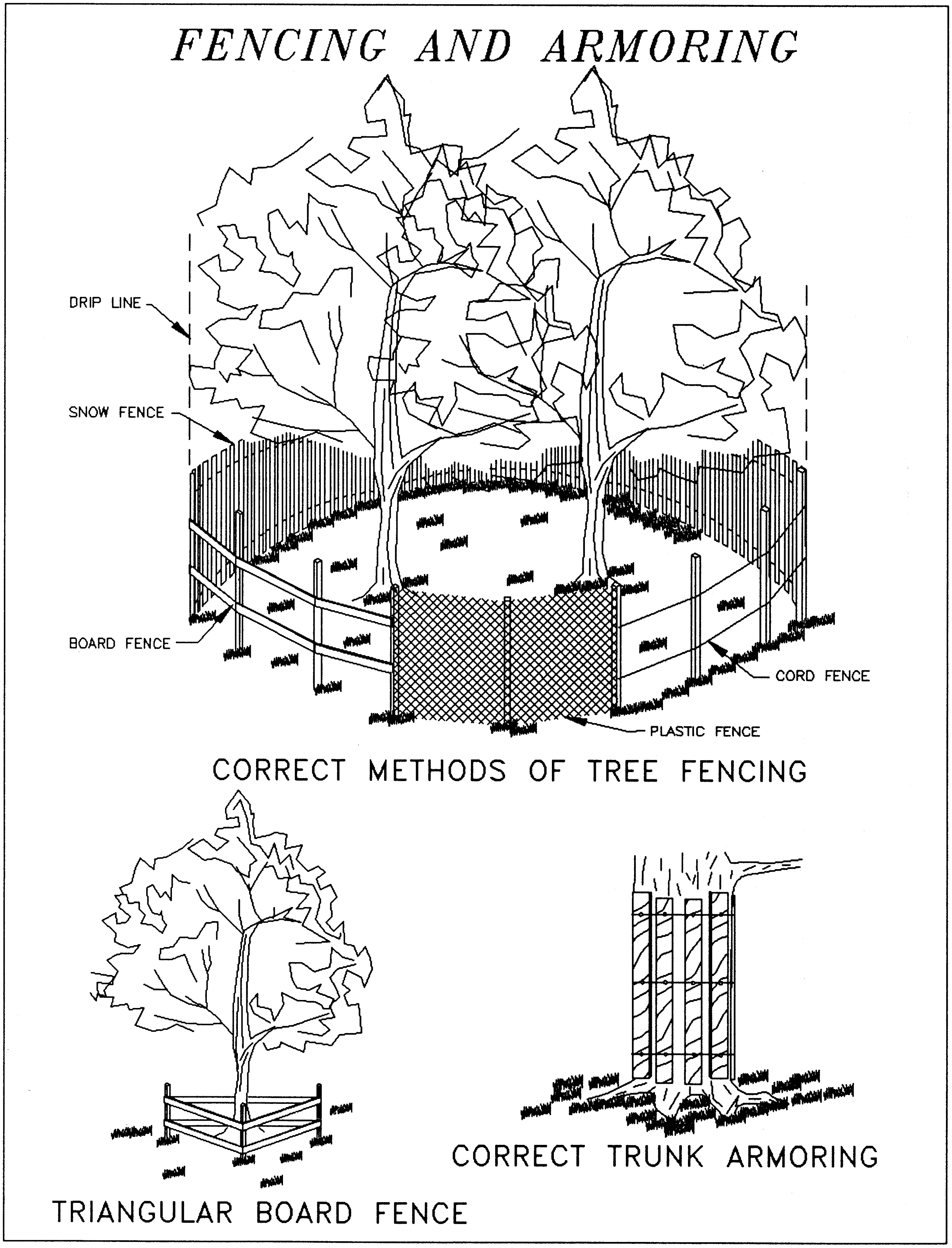
   b. Board Fence - Board fencing consisting of 4-inch square posts set securely in the ground and protruding at least 4 feet above the ground shall be placed at the limits of clearing with a minimum of two horizontal boards between posts. If it is not practical to erect a fence at the drip line, construct a triangular fence nearer the trunk. The limits of clearing will still be located at the drip line, since the root zone within the drip line will still require protection.

   c. Cord Fence - Posts with a minimum size of 2 inches square or 2 inches in diameter set securely in the ground and protruding at least 4 feet above the ground shall be placed at the limits of clearing with two rows of cord 1/4-inch or thicker at least 2 feet apart running between posts with strips of colored surveyor's flagging tied securely to the string at intervals no greater than 3 feet.

   d. Plastic Fencing - 40-inch high "international orange" plastic (polyethylene) web fencing secured to conventional metal "T" or "U" posts driven to a minimum depth of 18 inches on 6-foot minimum centers shall be installed at the limits of clearing. The fence should have the following minimum physical qualities:

Tensile yield:	Average 2,000 lbs. per 4-foot width (ASTM D638)
Ultimate tensile yield:	Average 2,900 lbs. per 4-foot width (ASTM D638)
Elongation at break (%):	Greater than 1000% (ASTM D638)
Chemical resistance:	Inert to most chemicals and acids

   e. Earth Berms - Temporary earth berms shall be constructed according to specifications for a TEMPORARY DIVERSION DIKE (Std. & Spec. 3.9) with the base of the berm on the tree side located along the limits of clearing. Earth berms may not be used for this purpose if their presence will conflict with drainage patterns.



Source: Va. DSWC

Plate 3.38-2

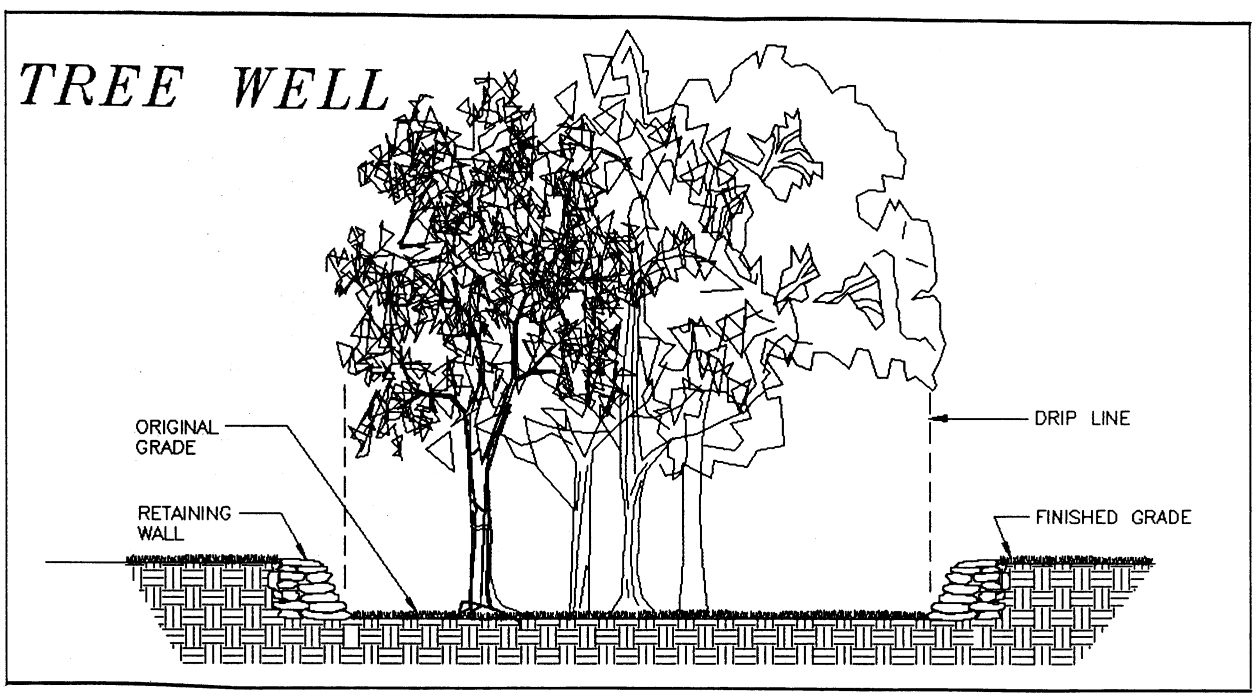
f. Additional Trees - Additional trees may be left standing as protection between the trunks of the trees to be retained and the limits of clearing. However, in order for this alternative to be used, the trunks of the trees in the buffer must be no more than 6 feet apart to prevent passage of equipment and material through the buffer. These additional trees shall be reexamined prior to the completion of construction and either be given sufficient treatment to ensure survival or be removed.

g. Trunk Armoring - As a last resort, a tree trunk can be armored with burlap wrapping and 2-inch studs wired vertically no more than 2 inches apart to a height of 5 feet encircling the trunk. If this alternative is used, the root zone within the drip line will still require protection. Nothing should ever be nailed to a tree.

Fencing and armoring devices shall be in place before any excavation or grading is begun, shall be kept in good repair for the duration of construction activities, and shall be the last items removed during the final cleanup after the completion of the project.

9. Raising the grade: When the ground level must be raised around an existing tree or tree group, the following considerations shall be made and steps taken to adequately care for the affected tree.

a. A well may be created around the tree(s) slightly beyond the drip line to retain the natural soil in the area of the feeder roots (Plate 3.38-3).



Source: Va. DSWC Plate 3.38-3

b. In the case of an individual tree, when the above alternative is not practical or desirable, the following method is recommended to ensure survival of the tree (Plate 3.38-4).

1) Before making the fill, remove the green vegetation, sod, leaf litter, and other organic matter from beneath the tree or trees to a distance of 3 feet beyond the drip line and loosen the surface soil to a depth of approximately 3 inches without damaging the roots.

2) Apply fertilizer in the root area of the tree to be retained. Fertilizer formulations and application rates and methods shall conform to the guidelines provided in Table 3.38-A.

3) The dry well shall be constructed so as to allow for tree trunk diameter growth. A space of at least 1 foot between the tree trunk and the well wall is adequate for large, old, slow-growing trees. Clearance for younger trees shall be at least 2 feet.

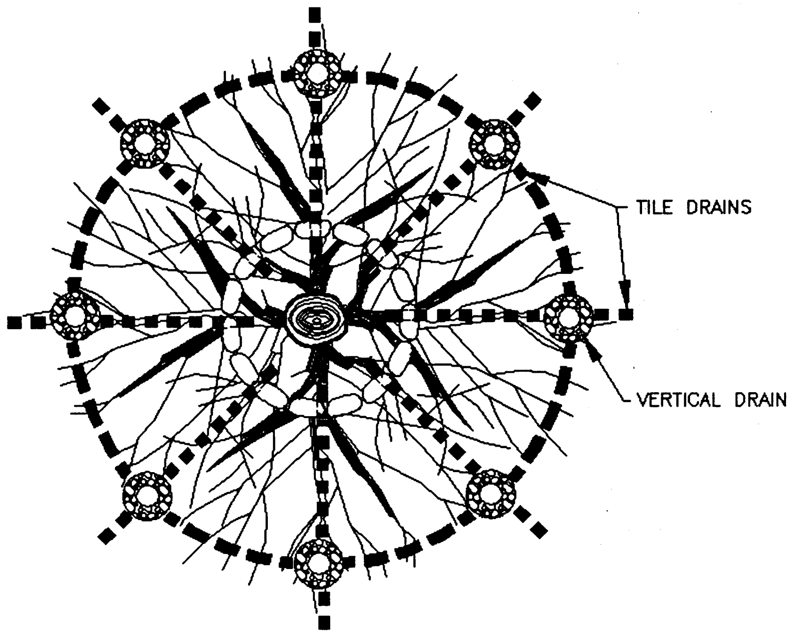
4) The well shall be high enough to bring the top just above the level of the proposed fill. The well wall shall taper slightly away from the tree trunk at a rate of 1 inch per foot of wall height.

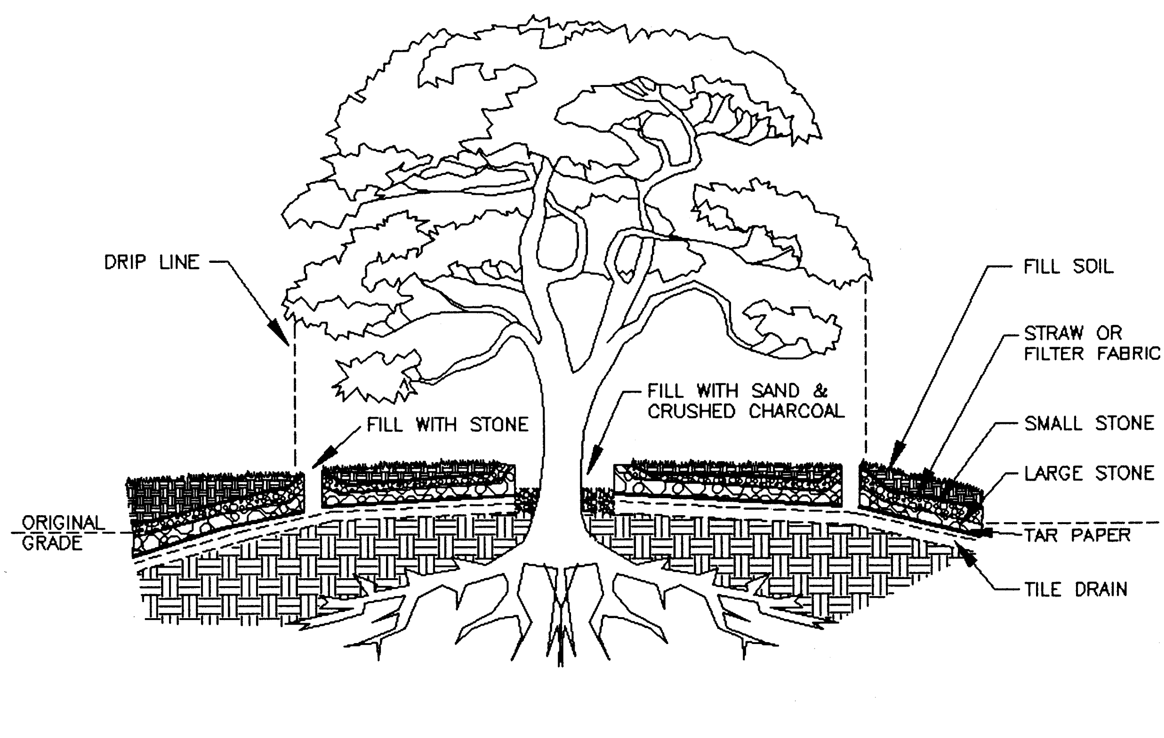
5) The well wall shall be constructed of large stones, brick, building tile, concrete blocks, or cinder blocks with care being taken to ensure that ample openings are left through the wall of the well to allow for free movement of air and water. Mortar shall only be used near the top of the well and only above the porous fill.

6) Drain lines composed of 4-inch, high-quality drain tiles shall begin at the lowest point inside the well and extend outward from the tree trunk in a wheel-and-spoke pattern with the trunk as the hub. These radial drain lines shall slope away from the well at a rate of 1/8 inch per foot. The circumferential line of tiles should be located beneath the drip line of the tree. Vertical tiles or pipes shall be placed over the intersections of the two tile systems if a fill of more than 2 feet is contemplated. These vertical tiles shall be held in place with stone fill. Tile joints shall be tight. A few radial tiles shall extend beyond each intersection and shall slope sharply downward to ensure good drainage.

7) Tar paper or its approved equivalent shall be placed over the tile and/or pipe joints to prevent clogging, and large stone shall be placed around and over drain tiles and/or pipes for protection.

TREE WELL DETAIL





Source: Adapted from Tree Maintenance, 5th ed., Pirone, 1978. Plate 3.38-4

TABLE 3.38-A
TREE FERTILIZATION FOR PROTECTION FROM CONSTRUCTION ACTIVITY

TREE TYPE	SPECIAL CONDITIONS	APPLICATION RATE & METHOD		FORMULATION
Broad-Leaf Deciduous	Greater than 6 inches dbh* except American Beeches and Crabapples	Normal	2-4 lbs. per inch dbh; broadcast	Commercial 10-8-6 or 10-6-4
		Grade Change	4-5 lbs. per inch dbh; broadcast	Commercial 10-6-4
	Smaller than 6 inches dbh, including all American Beeches and Crabapples	Normal	1-2 lbs. per inch dbh; broadcast	Commercial 10-8-6 or 10-6-4
		Grade Change	2-3 lbs. per inch dbh; broadcast	Commercial 10-6-4
Narrow-Leaf Evergreen	Greater than 6 inches dbh, located in groups	2-4 lbs per 100 sq. ft. of bed area; broadcast		Commercial 10-6-4
	Greater than 6 inches dbh, single specimens in open area	2 lbs. per inch dbh; broadcast		Commercial 10-6-4
	Smaller than 6 inches dbh	5 lbs. per 100 sq. ft. of bed area; incorporated into soil		Tankage or Cottonseed Meal
Broad-leaf Evergreen	Where nitrogen in soil is sufficient	Liberal quantities incorporated into soil and applied as mulch		Acid Peat Moss or Rotted Oak Leaf Mold
	Where additional nitrogen is necessary	Also add 5 lbs. per 100 sq. ft. of bed area incorporated into soil		Tankage or Cottonseed Meal

* dbh : Diameter at breast height (4.5 feet above ground level).

Source: Information taken from Tree Maintenance, P. P. Pirone, 1978.

8) A layer of 2- to 6-inches of stone shall be placed over the entire area under the tree from the well outward at least as far as the drip line. For fills up to 2-feet deep, a layer of stone 8- to 12-inches thick should be adequate. A thicker layer of this stone, not to exceed 30 inches, will be needed for deeper fills.

9) A layer of 3/4-inch to 1-inch stone covered by straw, fiber-glass mat or a manufactured filter fabric shall be used to prevent soil from clogging the space between stones. Cinders shall not be used as fill material.

10) Filling shall be completed with porous soil such as topsoil until the desired grade is reached. This soil shall be suitable to sustain specified vegetation.

11) To prevent clogging of the drain lines, crushed stone shall be placed inside the dry well over the openings of the radial tiles. Vertical tiles shall also be filled with crushed rock and may also be covered with a screen.

12) To prevent anyone from falling into the dry well and leaves and debris from accumulating there, the area between the trunk and the well wall shall either be covered by an iron grate or filled with a 50-50 mixture of crushed charcoal and sand. (This will also prevent rodent infestation and mosquito breeding.)

c. Where water drainage through the soil is not a problem, coarse gravel in the fill may be substituted for the tile. This material has sufficient porosity to ensure air drainage. Instead of the vertical tiles or pipes in the system, stones, crushed rock, and gravel may be added so that the upper level of these porous materials slants toward the surface in the vicinity below the drip line (Plate 3.38-5).

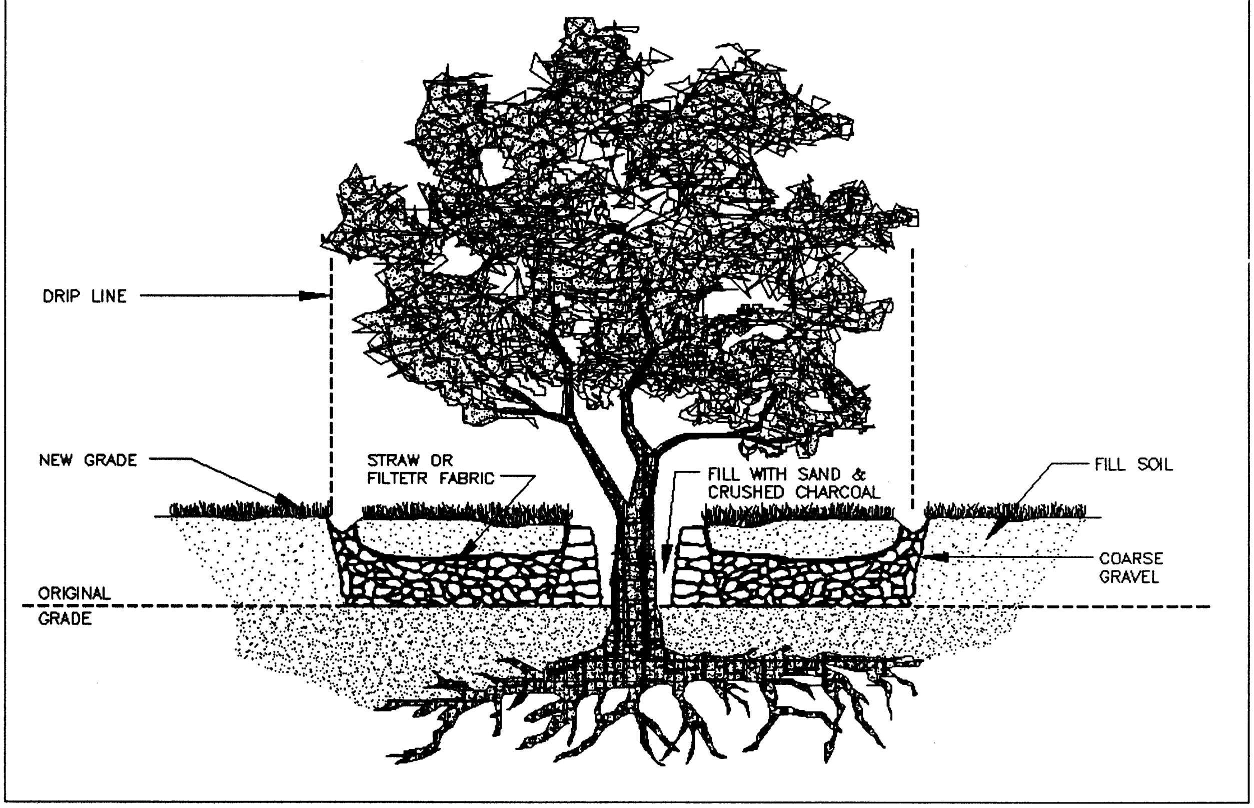
d. Raising the grade on only one side of a tree or group of trees may be accomplished by constructing only half of one of these systems.

10. Lowering the grade: Trees shall be protected from harmful grade cuts by the construction of a tree wall (Plate 3.38-6).

a. Following excavation, all tree roots that are exposed and/or damaged shall be trimmed cleanly, painted with tree paint, and covered with moist peat moss, burlap, or other suitable material to keep them from drying out.

b. The wall shall be constructed of large stones, brick, building tile, or concrete block or cinder block in accordance with the detail in Plate 3.38-6.

TREE WELL WITHOUT DRAIN TILES



Source: Va. DSWC — Plate 3.38-5

c. Backfill with peat moss or other organic material or with topsoil to retain moisture and aid in root development.

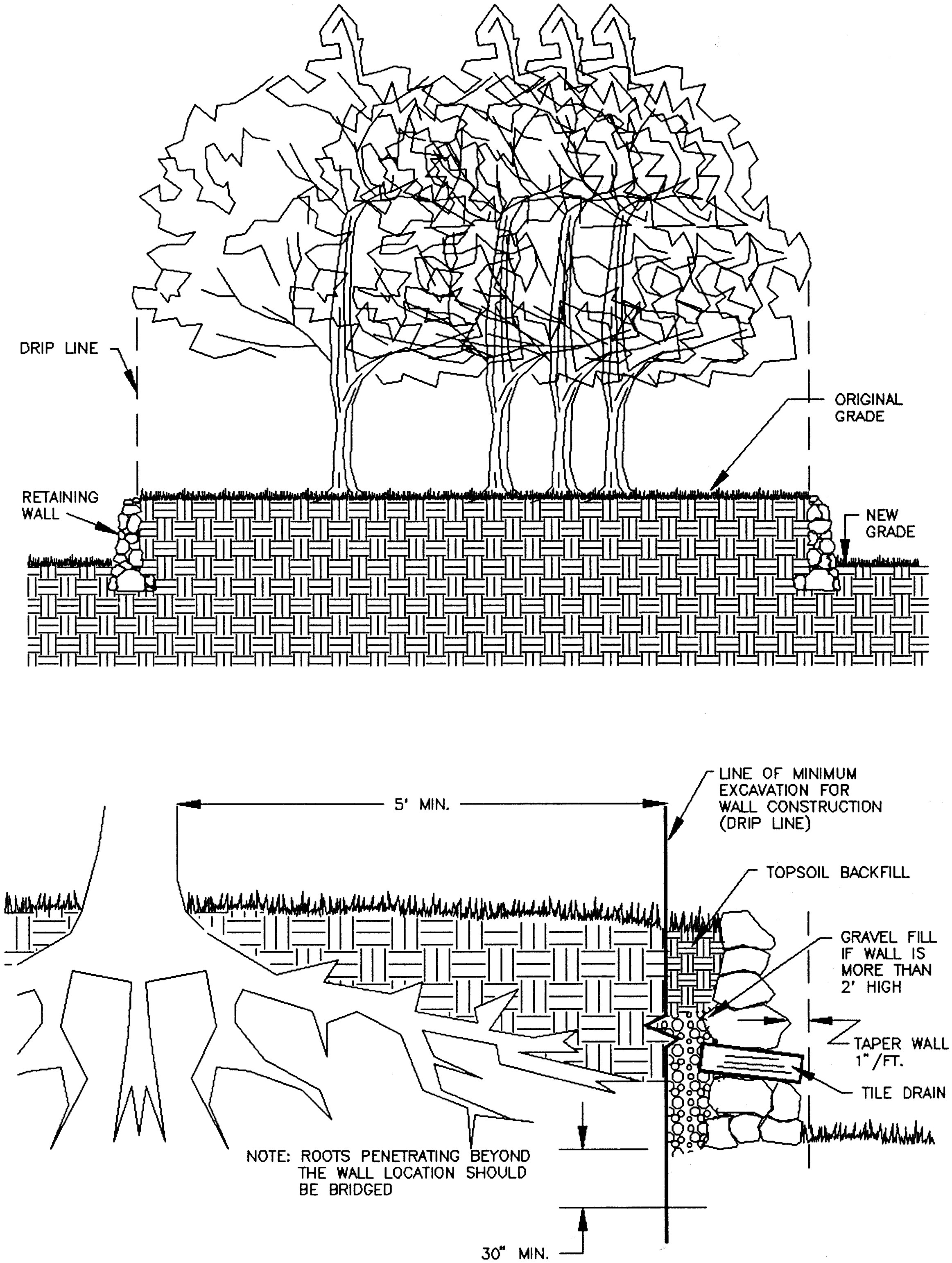
d. Apply fertilizer and water thoroughly. Fertilizer formulations and application rates and methods shall conform to the guidelines provided in Table 3.38-A.

e. Prune the tree crown, reducing the leaf surface in proportion to the amount of root loss.

f. Provide drainage through the wall so water will not accumulate behind the wall.

g. Lowering the grade on only one side of a tree or group of trees may be accomplished by constructing only half of this system.

TREE WALL DETAIL



Source: Adapted from Trees for Architecture and the Landscape, Zion, 1968.

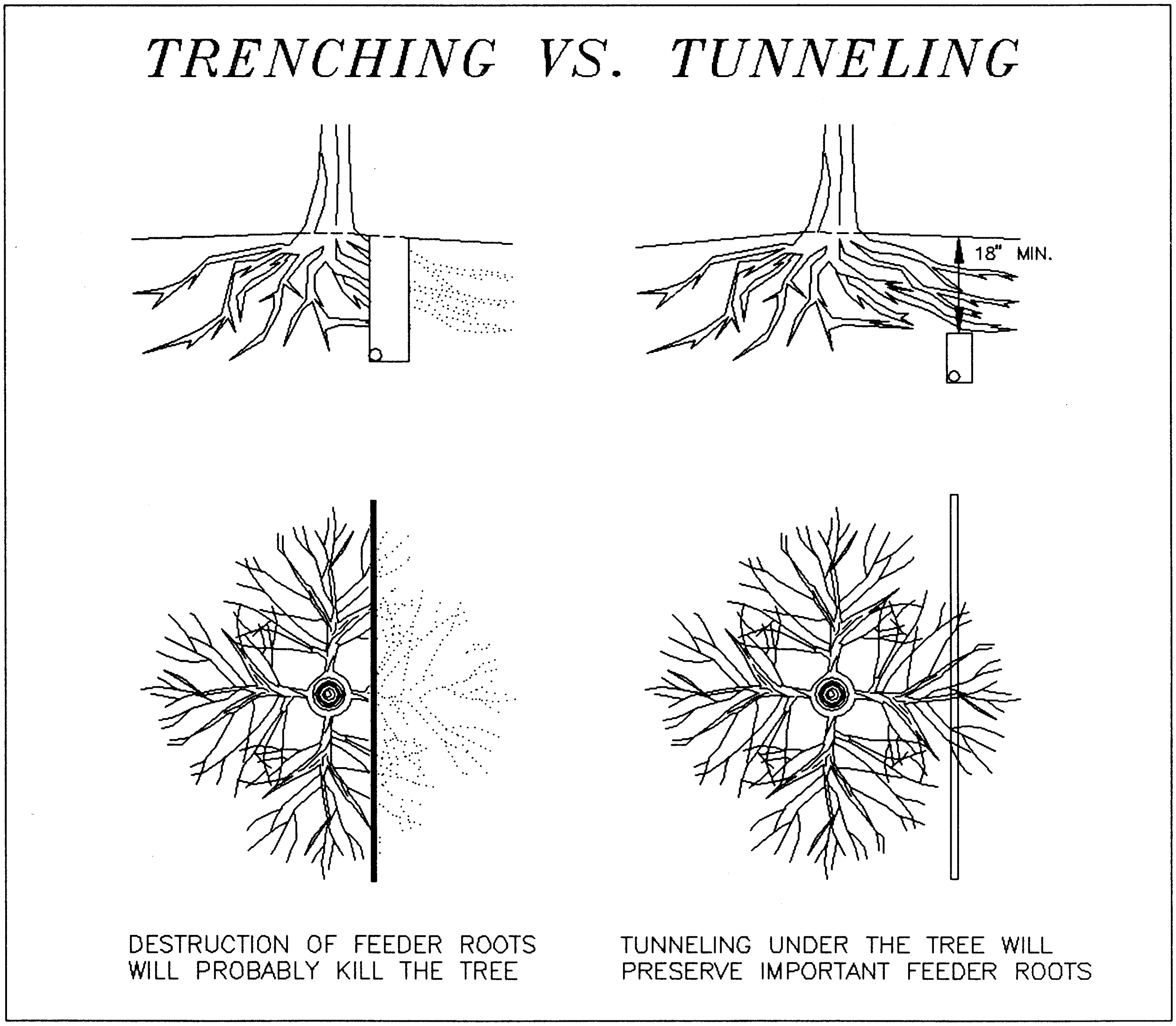
Plate 3.38-6

11. Trenching and Tunnelling:

a. Trenching shall be done as far away from the trunks of trees as possible, preferably outside the branches or crown spreads of trees, to reduce the amount of root area damaged, or killed by trenching activities.

b. Wherever possible, trenches should avoid large roots or root concentrations. This can be accomplished by curving the trench or by tunnelling under large roots and areas of heavy root concentration.

c. Tunnelling is more expensive initially, but it usually causes less soil disturbance and physiological impact on the root system (Plate 3.38-7). The extra cost may offset the potential cost of tree removal and replacement should the tree die.



Source: Tree Maintenance, Pirone, 1979. Plate 3.38-7

Tunnelling is almost always preferred over the trenching method. The tunnel should be 18 inches or greater below the ground surface and should not be located under the center of the tree (an off-center tunnel has the least impact on the roots).

d. Roots shall not be left exposed to the air. They shall be covered with soil as soon as possible or protected and kept moistened with wet burlap or peat moss until the trench or tunnel can be filled.

e. The ends of damaged and cut roots shall be cut off smoothly and protected by painting promptly with a tree-wound dressing.

f. Trenches and tunnels shall be filled as soon as possible. Air spaces in the soil shall be avoided by careful filling and tamping.

g. Peat moss or other suitable material shall be added to the fill material as an aid to inducing and developing new root growth.

h. The tree shall be mulched and fertilized to conserve moisture, stimulate new root growth, and enhance general tree vigor.

i. If a large amount of the root system has been damaged and killed, the crown leaf surface shall be proportionately reduced to balance the reduced root system. This may be accomplished by pruning 20 to 30 percent of the crown foliage. If roots are cut during the winter, pruning shall be accomplished before the next growing season. If roots are cut during the growing season, pruning shall be done immediately.

12. <u>Removal and Replacement of Damaged Trees</u>: Should a tree intended and marked to be retained be damaged seriously enough that survival and normal growth are not possible, the tree shall be removed. If replacement is desirable and/or required, the replacement tree shall be of the same or similar species, 2-inch to 2½-inch (minimum) caliper balled and burlapped nursery stock. However, today, with the aid of a "tree spade," the same caliper tree may be required as a replacement.

13. <u>Clean-Up</u>: Clean-up after a construction project can be a critical time for tree damage. Trees protected throughout the development operation are often destroyed by carelessness during the final clean-up and landscaping. Fences and barriers shall be removed last, after everything else is cleaned-up and carried away.

14. <u>Maintenance</u>: In spite of precautions, some damage to protected trees may occur. In such cases, the following maintenance guidelines should be followed:

a. <u>Soil Aeration</u> - If the soil has become compacted over the root zone of any tree, the ground shall be aerated by punching holes with an iron bar. The bar shall be driven 1-foot deep and then moved back and forth until the soil is loosened. This procedure shall be repeated every 18 inches until all of the compacted soil beneath the crown of the tree has been loosened.

b. Repair of Damage

1) Any damage to the crown, trunk, or root system of any tree retained on the site shall be repaired immediately.

2) Whenever major root or bark damage occurs, remove some foliage to reduce the demand for water and nutrients.

3) Damaged roots shall immediately be cut off cleanly inside the exposed or damaged area. Cut surfaces shall be painted with approved tree paint, and moist peat moss, burlap, or top-soil shall be spread over the exposed area.

4) To treat bark damage, carefully cut away all loosened bark back into the undamaged area, taper the cut at the top and bottom, and provide drainage at the base of the wound (Plate 3.38-8).

5) All tree limbs damaged during construction or removed for any other reason shall be cut off above the collar at the preceding branch junction (Plate 3.38-8).

6) Care for serious injuries shall be prescribed by a forester or a tree specialist.

c. Fertilization: Broadleaf trees that have been stressed or damaged shall receive a heavy application of fertilizer to aid their recovery.

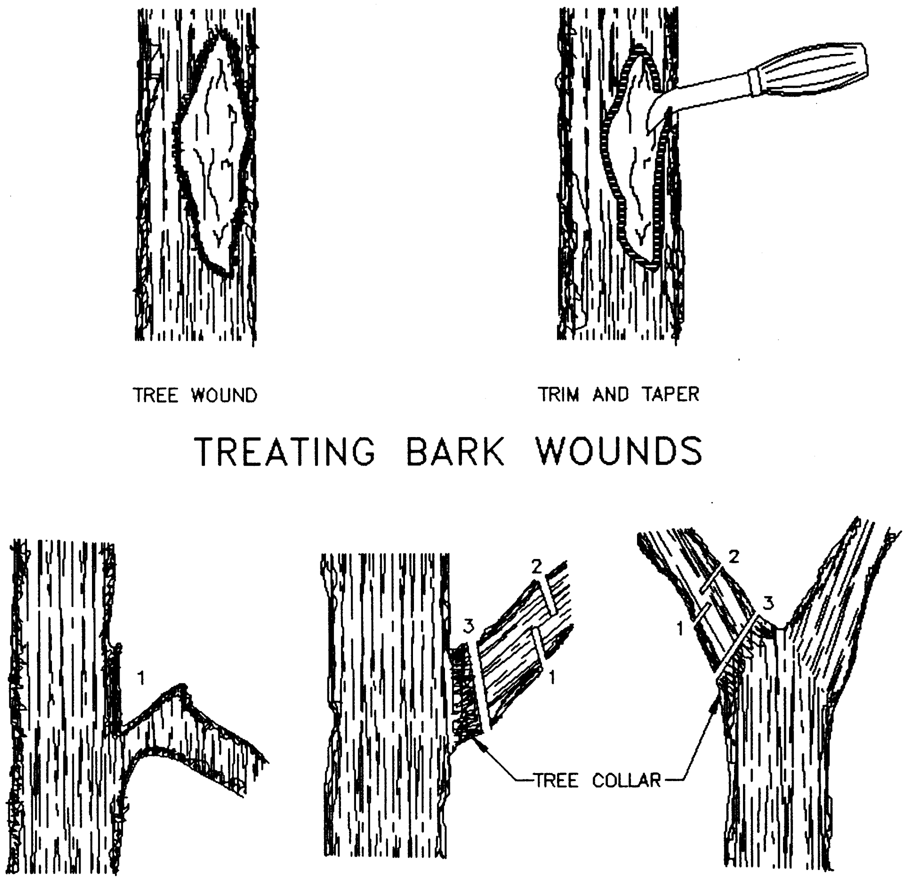
1) Trees shall be fertilized in the late fall (after October 1) or the early spring (from the time frost is out of the ground until May 1). Fall applications are preferred, as the nutrients will be made available over a longer period of time.

2) Fertilizer shall be applied to the soil over the feeder roots (see Plate 3.38-9). In no case should it be applied closer than 3 feet to the trunk.

The root system of conifers extends some distance beyond the drip line. Increase the area to be fertilized by one fourth the area of the crown.

3) Fertilizer shall be applied using approved fertilization methods and equipment.

TREE CARE



TREE WOUND TRIM AND TAPER

TREATING BARK WOUNDS

INCORRECT CORRECT CORRECT

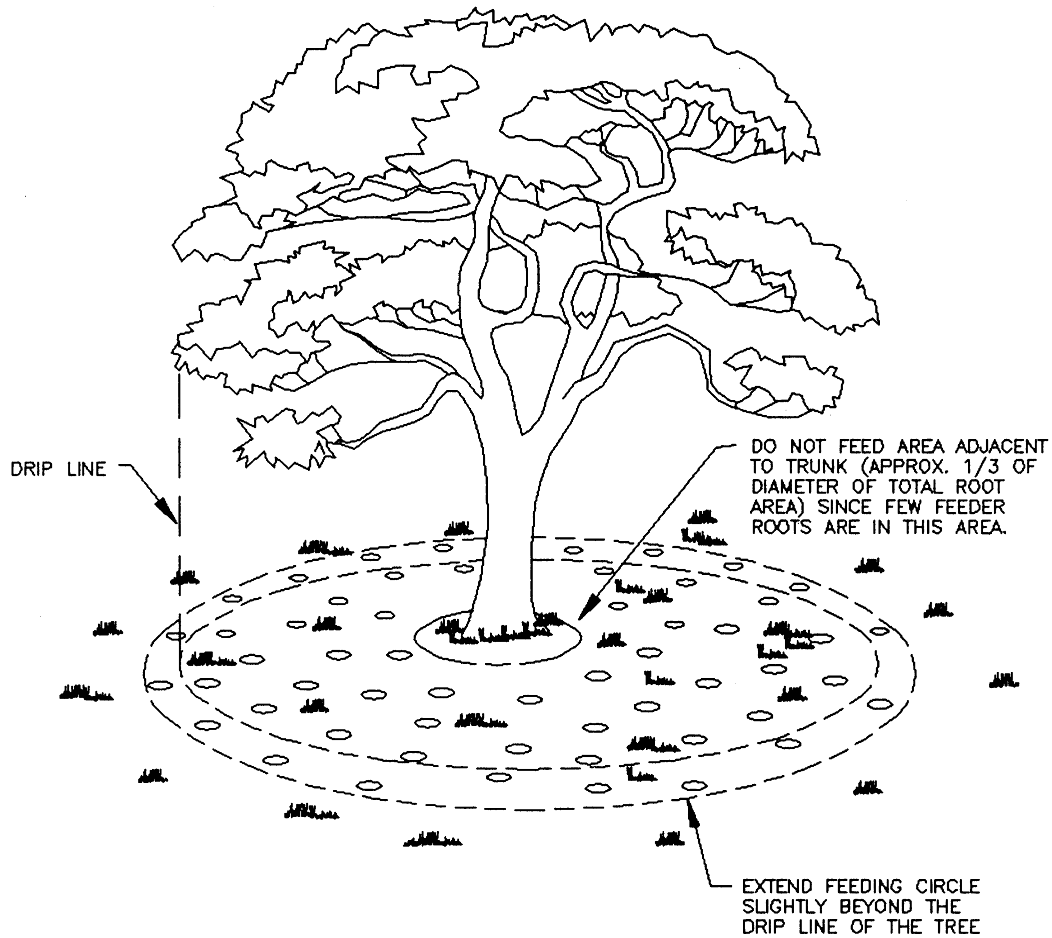
PRUNING DAMAGED BRANCHES

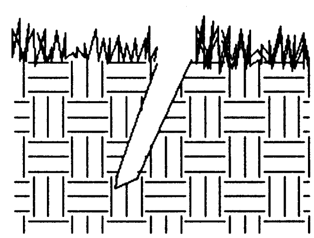
Source: Public Facilities Manual, Vol. III, Fairfax Co., Va., 1976. Plate 3.38-8

4) Formulations and application rates shall conform to the guidelines given in Table 3.38-A.

Maintain a ground cover of organic mulch around trees that is adequate to prevent erosion, protect roots, and hold water.

TREE FERTILIZATION





HOLES SHOULD BE APPROXIMATELY 18" DEEP AND 2' APART, AND THEY SHOULD SLANT TOWARD THE TRUNK.

Source: Tree Maintenance, Pirone, 1979.

Plate 3.38-9

STD & SPEC 3.39

DUST CONTROL

DC

Definition

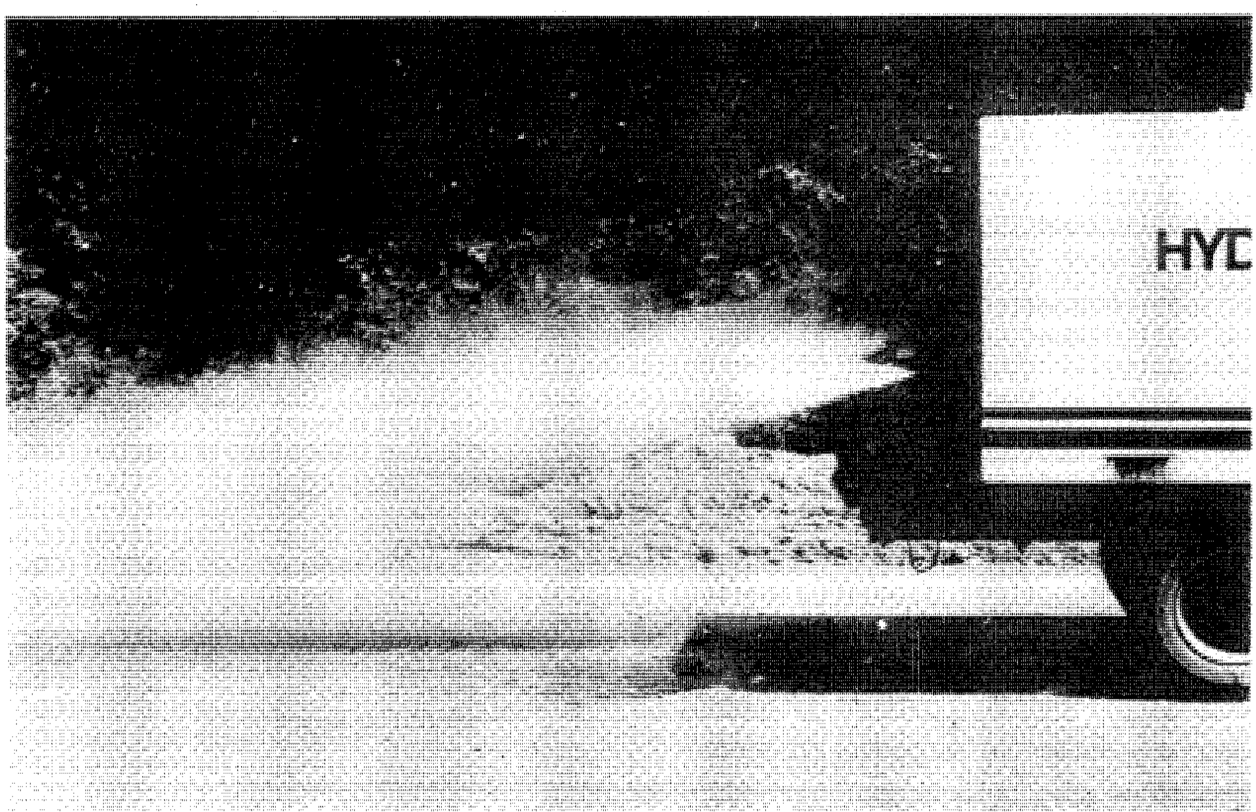
Reducing surface and air movement of dust during land disturbing, demolition and construction activities.

Purpose

To prevent surface and air movement of dust from exposed soil surfaces and reduce the presence of airborne substances which may present health hazards, traffic safety problems or harm animal or plant life.

Conditions Where Practice Applies

In areas subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventive measures are not taken.



Planning Considerations

Construction activities inevitably result in the exposure and disturbance of soil. Fugitive dust is emitted both during the activities (i.e., excavation, demolition, vehicle traffic, human activity) and as a result of wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in "heavy" construction activities, such as road and street construction and subdivision, commercial or industrial development, which involve disturbance of significant areas of the soil surface. Research of construction sites has established an average dust emission rate of 1.2 tons/acre/month for active construction. Earth-moving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions.

In planning for dust control, limiting the amount of soil disturbance at any one time should be a key objective. Therefore, phased clearing and grading operations and the utilization of temporary stabilization in accordance with MS #1 can significantly reduce dust emissions. Undisturbed vegetative buffers (minimum 50-foot widths) left between graded areas and protected areas can also be very helpful in dust control.

Temporary Measures Used During Construction

1. Vegetative Cover - In areas subject to little or no construction traffic, a vegetatively stabilized surface will reduce dust emissions (see TEMPORARY SEEDING, Std. & Spec. 3.31).

2. Mulch - When properly applied, mulch offers a fast, effective means of controlling dust. Not recommended for areas within heavy traffic pathways. Binders or tackifiers should be used to tack organic mulches (see MULCHING, Std. & Spec. 3.35).

3. Tillage - This practice is designed to roughen and bring clods to the surface. It is an emergency measure which should be used before wind erosion starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 inches apart, spring-toothed harrows, and similar plows are examples of equipment which may produce the desired effect.

4. Irrigation - This is the most commonly used dust control practice. Site is sprinkled with water until the surface is wet. Repeat as needed. It offers fast protection for haul roads and other heavy traffic routes.

5. Spray-On Adhesives - Tremendous progress has been made in recent years in the development of products of this type. Most are effective on "mineral" soils and are ineffective on "muck" soils. These coherics are derived from a variety of compounds, both organic and synthetic based. Many of the adhesives will withstand heavy traffic loads. The organics include derivatives from pine tar and vegetable gum; synthetics may be acrylic or petroleum based.

The following table list various adhesives and provides corresponding information on mixing and application:

TABLE 3.39-A

ADHESIVES USED FOR DUST CONTROL

Adhesive	Water Dilution (Adhesive: Water)	Type of Nozzle	Application Rate Gallons/Acre
Anionic Asphalt Emulsion	7:1	Coarse Spray	1,200
Latex Emulsion	12.5:1	Fine Spray	235
Resin in Water	4:1	Fine Spray	300
Acrylic Emulsion (Non-Traffic)	7:1	Coarse Spray	450
Acrylic Emulsion (Traffic)	3.5:1	Coarse Spray	350

Source: Va. DSWC

6. Stone - Stone can be used to stabilize roads or other areas during construction using crushed stone or coarse gravel (see CONSTRUCTION ROAD STABILIZATION, Std. & Spec. 3.3).

7. Barriers - A board fence, wind fence, sediment fence, or similar barrier can help to control air currents and blowing soil. Place barriers perpendicular to prevailing air currents at intervals of about 15 times the barrier height. Where dust is a known problem, existing windbreak vegetation should be preserved.

8. Calcium Chloride - This chemical may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage. Application rates should be strictly in accordance with suppliers' specified rates.

Permanent Methods

1. Permanent Vegetation - The application of PERMANENT SEEDING (see Std. & Spec. 3.32) and saving existing trees and large shrubs can help reduce soil and air movement from construction sites.

2. Stone - Crushed stone or coarse gravel can be used as a permanent cover which will provide control of soil emissions.