CHAPTER 7

Soil Stabilization

Soil Stabilization is the most effective means to minimize erosion and off-site sediment from development sites. Stabilized soils have vegetative or other types of cover left during construction or replaced following disturbance in order to prevent wind or water. Maintaining stabilization involves taking key steps at planning and continuing until the end of construction.

During project planning all efforts should especially be made to retain existing vegetation. This can be accomplished by phasing construction activity, using 'open space' design concepts, and minimizing corridor widths for road and utility construction. Special emphasis on preserving natural vegetation should be made near sensitive areas such as wetlands, stream corridors, steep slopes, and woodlots. Ideally, natural areas should be set aside permanently; however even delaying disturbance of portions of a site through phasing will prevent significant erosion from occurring. Areas not to be disturbed must be shown on construction plans and clearly marked in the field.

Once clearing and grading begins, erosion will occur until the site is re-stabilized. This occurs as rough or finish grading operations become idle or finished and are seeded and mulched as soon as possible, during any season. The most common methods, seeding and mulching are relatively inexpensive, easy to implement, and requires minimum maintenance. No matter which method is used, all stabilization practices significantly reduce off-site pollution and reliance on more costly and less reliable sediment treatment practices.

7.1 Minimized Phased Disturbance

Description

Phased disturbance limits the total amount of grading at any one time and sequences operations so that at least half the site is either left as undisturbed vegetation or re-stabilized prior to additional grading operations. This approach actively monitors and manages exposed areas, so that erosion is minimized and sediment controls can be more effective in protecting aquatic resources and downstream landowners.

Condition Where Practice Applies

This practice can be applied anywhere development occurs and is well suited to protect critical areas on and off site, such as wetlands, streams, ponds and highly erodible areas subject to high erosion rates. The practice is applicable where natural vegetation can act as a soil stabilizer during development and perhaps as a water quality feature after construction.

Planning Considerations

Two planning principles should be applied for phased disturbance. First, developments should be fit around the natural site conditions (e.g. topography, drainage, vegetation and setting) and thus involve less grading and fewer offsite impacts than conventional development patterns. Practically this means retaining undisturbed green space around water resources and on critical areas like steep slopes.

The second planning principle is focused on managing active construction, so that at least 50% of the land area is maintained in vegetation. By anticipating the timing and extent each grading and construction operation, along with erosion and sediment controls, exposed ground does not sit idle. This management principle is applied by developing phases of a project that can be brought to completion quicker than the entire parcel; and by utilizing

an effective construction sequence to assist project managers to anticipate the next step towards stabilization and completion.

Ideally with phasing and effective sequencing, a parcel is divided between vegetated inactive areas and active areas where work is continuous from clearing operations, through grading, drainage and construction until final re-stabilization with vegetation. A realistic construction sequence is an essential planning tool for this practice with the goal that only areas under active construction have exposed soils.

Construction Operation	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
PHASE 1: Roadway, Storm & Utilities	◄	—	—	—	—	—	►												
Install construction site entrance	•																		
Fence natural & tree protection area	•																		
Install SW/sed basin, diversion and silt F.		•																	
Seed SW/Sed basin areas		•																	
Clear ROW		•																	
Grading, install storm, San. and utilties		•	•																
Place inlet protection on storm sewers			•																
Grade road swales and stabilize			•	•															
Road construction				•	•														
Seed/mulch graded areas					•	•													
PHASE 1: Home Construction					◄	—	—	—	—	►									
Clear home sites					•	•	•												
Install silt fence & filter berms					•														
Basement excavation & rough grading					•	•	•	•											
Temporary seeding on lots						•	•	•	•										
Final yard grading								•	•	•									
Permanent seed and mulch								•	•	•									
PHASE 2: Roadway, Storm & Utilities								◄	—	—	►								
Install sediment trap, silt F. and filter B.								•											
Seed sediment trap								•											
Grading, install storm, San. and utilties									•	•									
Place inlet protection on storm inlets										•									
Erosion control matting on swales										•									
Road construction											•								
Winterization- Seed/mulch graded areas										•	•								
PHASE 2: Home Construction												◄	—	—	—	—	—	—	►
Clear home sites												•	•						
Install filter berms													•						
Basement excavation														•	•				
Temporary seeding on lots															•	•	•		
Final yard grading																	•	•	
Permanent seeding and mulching																		•	•
Remove temp riser, clean out SW pond																			•
Adapt SW pond outlet for permanent configuration																			•

Figure 7.1.1 Sample Sequence of Construction Operations

Design Criteria

Specify all major construction operations including erosion and sediment controls with the estimated time for completion in a sequence of operations (see Figure 7.1.1). The sequence of operations shall be noted on construction drawings. Changes should be made to the construction sequence as work is completed or delayed.

Divide site work into major phases so that no more than 50% of the site is exposed at any one time. Within each phase, operations such as clearing can also be divided to keep from removing all the vegetation at once. For example, clearing for a roadway and infrastructure can be effectively separated from clearing operations required for homebuilding rather than removing all vegetation at once.

All areas that are disturbed shall be provided with appropriate controls such as sediment basins, traps or barriers to prevent sediment from impacting water resources or offsite areas. Disturbed areas that are expected to be inactive (idle) for 21 days or longer will be temporarily stabilized until the subsequent construction operations begin or permanent seeding and mulching can be completed.

Maintenance

Monitoring is essential to ensure that phasing and sequencing occur properly. This includes making sure only the areas that need to be exposed are exposed, and all other BMP practices are in good working order.

Routinely verify that work is progressing in accordance with the project's construction sequence. If progress deviates, take corrective actions.

When changes to the project schedule are unavoidable, amend the construction sequence schedule on drawings and plans well in advance to anticipate potential problems and maintain control.

Common Problems/Concerns

Proper planning not conducted – more than 50% of the site is bare at any one time. Areas may be too large and may need to be managed in smaller increments.

Active disturbance of the entire site does not allow portions to reach stages of completion so that temporary or permanent seeding and mulching can be employed. A failure to limit work areas to phases will result in erosion and sediment control being less effective.

Failure to anticipate completion dates for final or temporary grading stages can leave disturbed areas unprotected during winter months.

Failure to follow the construction sequence or maintain may result in erosion and sediment control items being delayed.

Temporary seeding and revegetation of graded areas is delayed as other work slows. Some areas such as slopes should proceed with seedings even though delays in other operations are occurring.

7.2 Clearing and Grubbing

Description

Clearing and grubbing is the removal of trees, brush and other unwanted material in order to develop land for other uses or provide access for site work. Clearing generally describes the cutting and removal of above ground material while grubbing is the removal of roots, stumps, and other unwanted material below existing grade.

Clearing and grubbing includes the proper disposal of materials and the implementation of best management practices in order to minimize exposure of soil to erosion and causing downstream sedimentation.

Condition Where Practice Applies

This practice may be applied anywhere existing trees and other material must be removed for development to occur. The potential for erosion and sedimentation increases as: the vegetation removed; area disturbed or watercourses encountered increases.

Planning Considerations

Site assessment, selection and marking

Sites should be assessed to determine areas to be left undisturbed as well as trees or vegetated areas to be saved (see tree preservation area). These areas need to be clearly marked on plans and in the field. Land clearing activities should not begin until the site assessment and the field marking is concluded.

Timing and Phasing

Large-scale sites should be cleared in phases, with initiation of each phase delayed until actual construction is scheduled for that area of the site.

Erosion, sediment and stream instability potential

Clearing in some areas should be avoided or delayed due to the potential for destabilization. Cleared sites on heavy soils and steep slopes are subject to excessive erosion and may require additional practices to keep the soil in place. Land clearing during dry or frozen times will decrease compaction and potential water quality problems from runoff.

Stream corridors should be left in tact unless and until plans have been made to immediately restore stable conditions. These areas are subject to rapid erosion once vegetation is removed and soon become a source of sediment downstream. Alternatively naturally vegetated stream corridors help protect water resources from pollution generated during grubbing and grading operations.

Design Criteria

Timber Salvage – Develop plans specifying the kind and location of timber to be salvaged, the location of haul roads and skid trails, location and width of natural buffer zones around water bodies, and the location and methods of stream crossings. The method of disposing of all material that will not be salvaged should also be specified. Plans should also include the best management practices that will be used to protect the cleared area from erosion.

Identify and protect healthy trees following specifications in the **Tree and Natural Area Preservation** practice. Where possible, preserve a natural buffer/filter strip adjacent to all water bodies. Avoid clearing to the water bodies' edge.

1. Where it is necessary to clear to the water's edge, appropriate sediment control should be used and seeding and other stabilization should be initiated within 2 days of work becoming idle.
2. Phase work so that only part of the site is being cleared at any given time. This will reduce the amount of time soil is exposed to erosive forces. Follow examples in the **Phased Disturbance** practice.
3. Install earth diversions to intercept and divert runoff to stable outlets and appropriate sediment ponds.
4. All debris should be kept out of surface water resources. If possible, leave mulch or vegetation on the ground to decrease runoff and potential runoff. See the "Disposal Options" section, below.
5. Exposed areas not planning for immediate earthwork should be temporarily seeded to prevent further erosion at the site. See the **Temporary Seeding** practice. Additional stabilization or sediment control practices may be necessary to keep soil on the site.

Grubbing – Grubbing removes roots and stumps by digging or pushing over with earth moving equipment. Grubbing should be carefully monitored near lakes and streams to protect the water's edge. Removing root systems near the banks of streams and lakes make cause the area to become unstable and erode. If possible, avoid grubbing at all near the water's edge.

Tree Removal –

1. Where trees and stumps are removed in separate operations, trees may be used for commercial purposes such as lumber, firewood, or mulch.

2. Trees and stumps may be removed in one operation. This method leaves materials that can be useful in stream restoration and stabilization (e.g rootwads, vanes). may be used as a rootwads for streambank restoration work. Be certain that sufficient trunk is left for effective anchoring in the bank. Tops of trees should be removed and chipped for mulch.
3. Operating heavy equipment too close to trees will result in damage or loss due to soil disruption, compaction and trunk damage. It is recommended that all heavy equipment operations be limited to outside the drip line of all trees to be preserved. The drip line is the area from the trunk of the tree outward to a point at which there is no longer any overhanging vegetation.
4. In forested wetlands, shallow–rooted species are protected by each other from potential wind damage. Whenever trees are removed from a forested wetland, the possibility of blow downs or windthrow increases. Shallow rooted species are also protected by edge trees, which shield the prevailing wind side of the woodlot. It is helpful to leave as many edge trees as possible on the prevailing wind side of the cleared area.

Disposal Options –

Where possible, all stumps, roots, logs, brush, limbs, tops and other debris resulting from the clearing or thinning operation should be disposed of by processing through a chipping machine. The chips can then be utilized as mulch (see Mulching practice), as part of a site stabilization or final landscaping plan. Organic material may also be disposed of at an approved composting facility.

Note that treetops, stumps and field stone which are cleared and piled/windrowed in suitable areas can improve habitat for wildlife such as rabbits, raccoons, snakes, salamanders, toads and frogs.

Maintenance

Land clearing itself requires no maintenance except maintenance of the equipment used in the land clearing operation. Tree protection that utilizes fencing and signage should be maintained throughout the clearing stages. It is also important to maintain all other temporary and permanent practices that are used in conjunction with the land clearing to prevent soil erosion and sedimentation.

Common Problems / Concerns

Clearing of areas planned for preservation may occur and desirable species may be damaged, therefore preservation areas should be well marked.

During construction, naturally vegetated banks of stream and lakes may become destabilized. Clearly mark areas where natural vegetation must be maintained, and immediately implement stabilization plans of denuded areas.

As large areas are disturbed, site erosion potential drastically increases until cover is re-established. Establish temporary seedings as soon as clearing/grubbing and grading activities stop or become idle.

7.3 Tree and Natural Area Reservation

Description

Tree and natural area preservation insures that important vegetated areas existing on-site prior to development will survive the construction process. Tree protection areas prevent the losses and damages to trees that are common as a result of construction. This practice is useful to protect individual trees, and areas of forest or natural vegetation in stream corridors, or open space.

Conditions Where Practice Applies

This practice is applicable to any tree, forested or naturally vegetated area planned for long-term survival and subject to construction impacts. Existing trees provide valuable benefits during and after construction including: reduced erosion, reduced runoff rates and volume, reduced cooling costs, sound and visual barriers and higher property values.

Planning Considerations

Preservation of important natural areas must begin before the location of buildings, roads and utilities is determined. Early site planning should include delineating forested areas and significant trees and creating an inventory of the existing trees on-site. These should influence the placement of roads, buildings, and parking areas in the same manner as topography, streams and wetlands.

Tree Stand Delineation – Useful information for the delineation may include:

- Stands of trees to be preserved
- Individual trees of significance due to age, size, history, or aesthetic value

- Hazard trees to be removed
- Open areas
- Sensitive areas such as wetlands, riparian corridors, important wildlife habitat
- Other important natural or historic features.

Tree Survey (Inventory) – A tree inventory or survey provides more detailed information about tree resources. Key to this step is outlining, on the engineering plans, the root zone of trees that may be impacted during construction. A method to calculate the root zone is to allow one-foot of radius for each inch of trunk diameter at breast height. Alternatively drip line or outline of the furthest hanging branches can be used (see the figure). Information to include in the tree survey includes:

- All trees to be impacted by proposed construction and critical root zone
- Diameter of tree
- Species of tree
- Health of tree
- Notes on crown or root condition

Note regarding tree survival: A tree's root zone is critical to its ability to survive. Damaging the root zone during construction will lead to the tree's decline and ultimately its death within 1 to 10 years. Ninety-five percent of a tree's roots are in the upper 12-18 inches of soil, and the majority of the roots supplying nutrients are found just below the soil surface. The critical root zone extends at least to the drip zone of a tree and must be protected from soil compaction, grubbing, filling activities, and other disturbances.

Design Criteria

Site Plan - With the tree survey data and high value natural areas clearly shown on a base map, site designers can plan the location of roads, utilities, and other improvements to minimize impacts. Regarding trees, the plan identifies tree preservation areas as well as those trees that will be severely impacted by development, and which may need to be removed.

The following should be shown on the erosion and sediment control plans and clearly marked on site:

- Limits of clearing and grubbing
- Natural preservation areas including the specimens (detail extent and type)
- Construction roads and stockpile areas outside of preservation areas
- Notes and drawings detailing measures to protect preservation areas during construction,
- Notes and drawings detailing protect preservation areas following construction,
- Areas for planting.

Protection During Construction for Tree Preservation Areas - Construction administration is the on-site protection and care of trees selected to remain. The following are necessary activities for adequate protection:

- **Prevent any filling, compaction, storage, or excavation within the tree protection zone.** Weight and traffic on a tree's root zone cause soil compaction. This reduces air and water movement to the tree's root system and is a major cause of tree decline.

- **Fence out construction traffic.** Tree protection areas must be made visible during construction. A physical barrier of a fence and signage must be in place prior to clearing and remain in place throughout construction.
- **Delineate parking, material storage, and cement washout areas to prevent inappropriate areas from being utilized.**
- **Supervise clearing activities to insure "save" areas are preserved.**

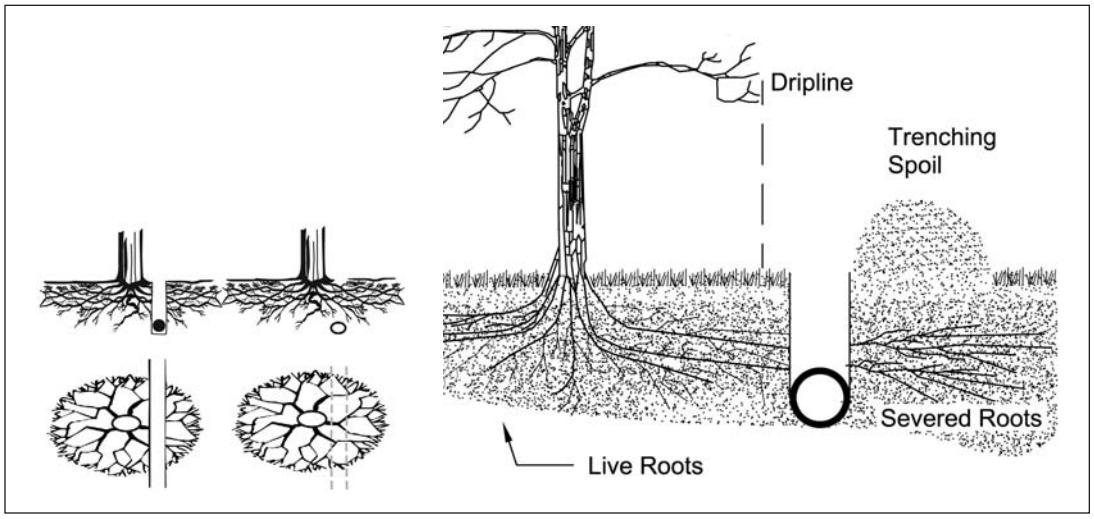

Figure 7.3.1 Inappropriate trenching (40% root loss) versus Tunneling (no significant root loss) and more appropriate trenching.

- **Supervise trenching, excavation and tunneling near trees to be saved.** Trenching near trees effectively cuts off large portions of a tree's root system (see figure). Ideally trenching should stay beyond the drip zone of a tree. A better alternative is to tunnel beneath the root zone at a depth greater than 2 feet.
- **Care for damaged trees.** Cutting damaged root systems clean and removing damaged branches may aid slightly damaged trees.

Provide a permanent visual barrier - Protecting forest vegetation permanently requires visual barriers to encroachment. It is not enough to protect areas with conservation easements, deed restrictions or even separate ownership. Forested stream buffers, parks and valuable wood lots are often severely degraded by mowing, removal of the understory and ground cover plants, and dumping of yard waste. Permanent signs or fences should identify the area and describe allowable uses.

Common Concerns

The following consequences can result from tree damage during construction activities:

- Loss of individual or groups of trees
- Long term decline of tree health
- Increased personal property damage
- Reduced property values
- Increased cost of removal once the project is complete

References:

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Koehler, C. S., R. H. Hunt., D. F. Lobel, and J. Geiger. 1984. *Protecting Trees When Building on Forested Land.* University of California Cooperative Extension, Berkeley, CA 94720.

Fazio, J. 1992. *Trenching and Tunneling Near Trees.* The National Arbor Day Foundation, 100 Arbor Avenue, Nebraska City, NE 68410.

Miller, L. M., D. Rathke, and G. Johnson. 1993. *Protecting Trees from Construction Damage*. Minnesota Extension Service, 20 Coffey Hall, Saint Paul, MN 55108-6064.

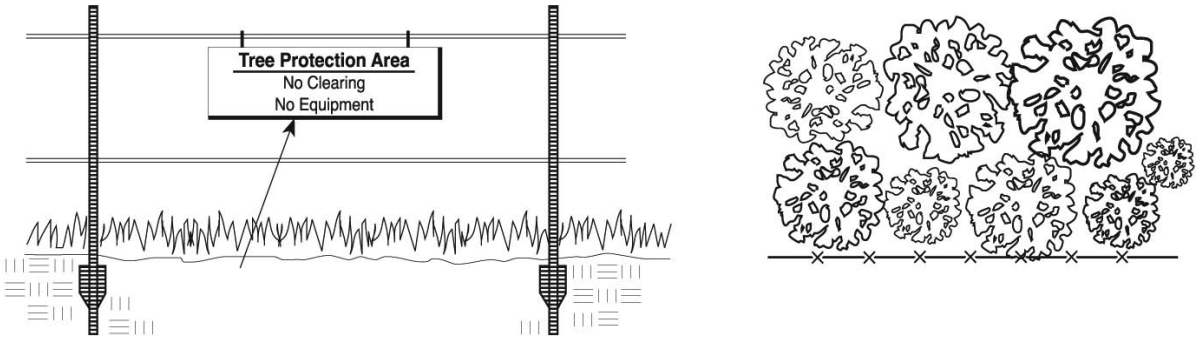
The National Arbor Day Foundation. *Tree City USA Bulletins. The National Arbor USA Bulletins.* The National Arbor Day Foundation, 100 Arbor Avenue, Nebraska City, NE 68410.

Penn State University. A Guide to preserving trees in Development projects. The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. http://pubs.cas.psu.edu/FreePubs/pdfs/uh122.pdf

International Society of Arboriculture. *Avoiding Tree Damage During Construction.* http://www.treesaregood.com/treecare/avoiding_construction.asp

Specifications
for

Tree and Natural Area Preservation

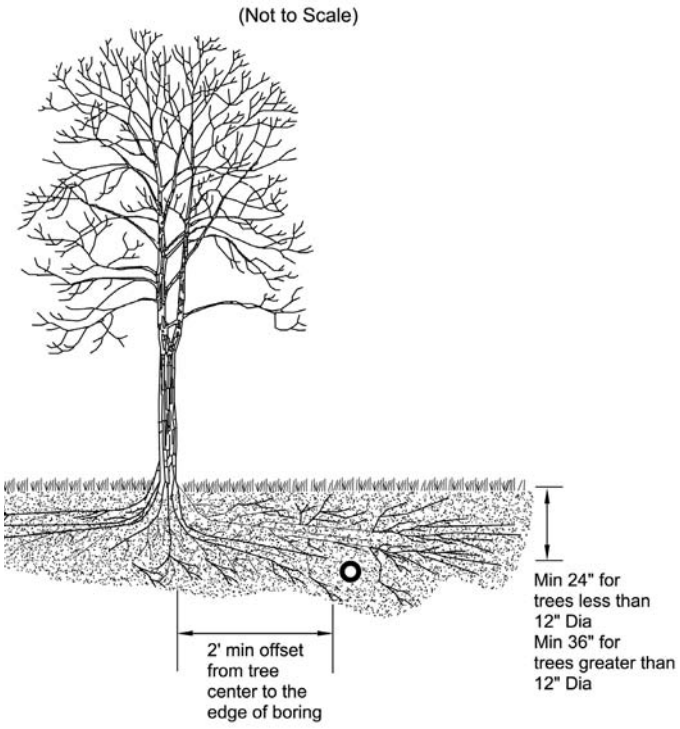


1. Tree and natural area preservation shall be fenced prior to beginning clearing operations.
2. Fence materials shall be metal fence posts with two strands of high tensile wire, plastic fence or snow fence.
3. Signage shall clearly identify the tree and natural preservation area and state that no clearing or equipment is allowed within it.
4. Fence shall be placed as shown on plans and beyond the drip line or canopy of trees to be protected.
5. If any clearing is done around specimen trees it shall be done by cutting at ground level with hand held tools and shall not be grubbed or pulled out. No clearing shall be done in buffer strips or other preserved forested areas.
6. No filling or stockpiling of materials shall occur within the tree protection area, including deposition of sediment.

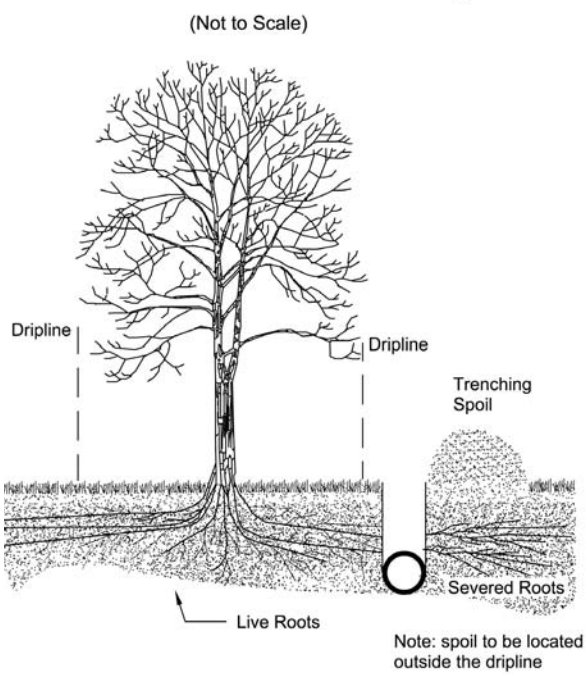
Specifications
for

Protection During Utility Installation

Boring



Trenching



1. Where utilities must run through a tree's dripline are, tunneling should be used to minimize root damage. Tunneling should be performed at a minimum depth of 24 inches for trees less than 12 inches in diameter or at a minimum depth of 36 inches for larger diameter trees.
2. Where tunneling will be performed within the dripline of a tree, the tunnel should be placed a minimum of 2 feet away from the tree trunk to avoid taproots.
3. Minimize excavation or trenching within the dripline of the tree. Route trenches around the dripline of trees.
4. Roots two inches or larger that are severed by trenching should be sawn off neatly in order to encourage new growth and discourage decay.
5. Soil excavated during trenching shall be piled on the side away from the tree.
6. Roots shall be kept moist while trenches are open and refilled immediately after utilities are installed or repaired

7.4 Construction Entrance

Description

A construction entrance is a stabilized pad of stone underlain with a geotextile and is used to reduce the amount of mud tracked off-site with construction traffic. Located at points of ingress/egress, the practice is used to reduce the amount of mud tracked off-site with construction traffic.

Conditions Where Practice Applies

A construction entrance is applicable where:

- Construction traffic leaves active construction areas and enters public roadways or areas unchecked by effective sediment controls;
- Areas where frequent vehicle and equipment access is expected and likely to contribute sediment to runoff, such as at the entrance to individual building lots.

Planning Considerations

Construction entrances address areas that contribute significant amounts of mud to runoff by providing a stable area for traffic. Although they allow some mud to be removed from construction vehicle tires before they enter a public roads, they should not be the only practice relied upon to manage off-site tracking. Since most mud is flung from tires as they reach higher speeds, restricting traffic to stabilized construction roads, entrances and away from muddy areas is necessary.

If a construction entrance is not sufficient to remove the majority of mud from wheels or there is an especially sensitive traffic situation on adjacent roads, wheel wash areas may be necessary. This requires an extended width pad to avoid conflicts with traffic, a supply of wash water and sufficient drainage to assure runoff is captured in a sediment pond or trap.

Proper installation of a construction entrance requires a geotextile and proper drainage to insure construction site runoff does not leave the site. The use of geotextile under the stone helps to prevent potholes from developing and will save the amount of stone needed during the life of the practice. Proper drainage may include culverts to direct water under the roadway or water bars to direct muddy water off the roadway toward sediment traps or ponds.

Design Criteria

The area of the entrance must be cleared of all vegetation, roots, and other objectionable material. Geotextile will then be placed the full width and length of the entrance.

Stone shall be placed to a depth of at least 6 inches. Roads subject to heavy duty loads should be increased to a minimum of 10 inches. Surface water shall be conveyed under the entrance, through culverts, or diverted via a water bars or mountable berms (minimum 5:1 slopes) so as to convey sediment laden runoff to sediment control practices or to allow clean water to pass by the entrance.

The stabilized construction entrance shall meet the specifications that follow.

Maintenance

The entrance shall be maintained in a condition that 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.

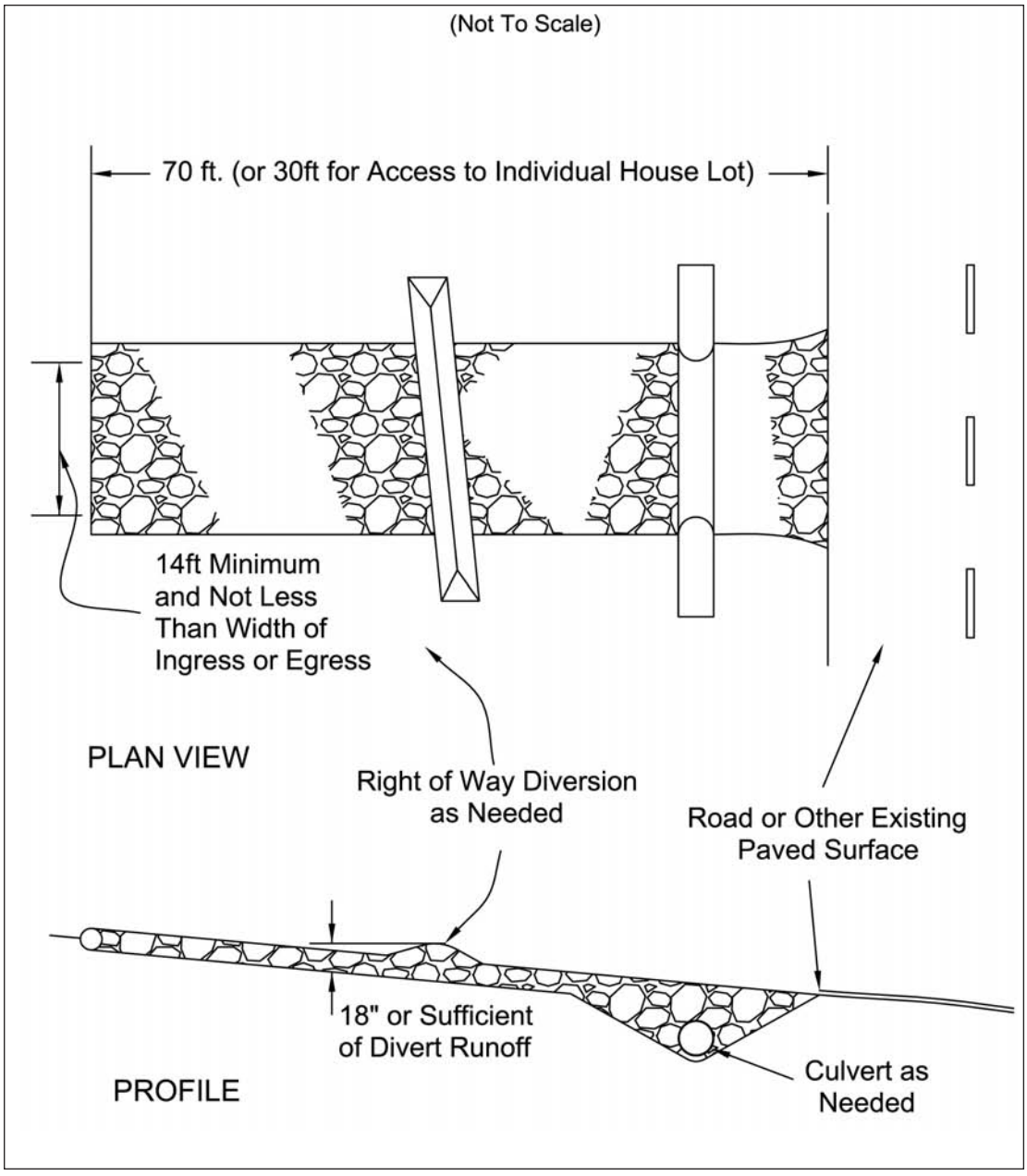
Common Problems / Concerns

Mud is allowed to accumulate and is tracked on to public right-of-ways. The entrance and associated construction roads may need dressing with additional stone.

Soft depression areas develop in entrance area. Stone may not have been underlain with geotextile or insufficient stone base has been provided.

Specifications
for

Construction Entrance



Specifications
for

Construction Entrance

1. Stone Size—ODOT # 2 (1.5-2.5 inch) stone shall be used, or recycled concrete equivalent.
2. Length—The Construction entrance shall be as long as required to stabilize high traffic areas but not less than 70 ft. (exception: apply 30 ft. minimum to single residence lots).
3. Thickness -The stone layer shall be at least 6 inches thick for light duty entrances or at least 10 inches for heavy duty use.
4. Width -The entrance shall be at least 14 feet wide, but not less than the full width at points where ingress or egress occurs.
5. Geotextile -A geotextile shall be laid over the entire area prior to placing stone. It shall be composed of strong rot-proof polymeric fibers and meet the following specifications:

Figure 7.4.1

Geotextile Specification for Construction Entrance	
Minimum Tensile Strength	200 lbs.
Minimum Puncture Strength	80 psi.
Minimum Tear Strength	50 lbs.
Minimum Burst Strength	320 psi.
Minimum Elongation	20%
Equivalent Opening Size	EOS < 0.6 mm.
Permittivity	1×10-3 cm/sec.

6. Timing—The construction entrance shall be installed as soon as is practicable before major grading activities.
7. Culvert -A pipe or culvert shall be constructed under the entrance if needed to prevent surface water from flowing across the entrance or to prevent runoff from being directed out onto paved surfaces.
8. Water Bar -A water bar shall be constructed as part of the construction entrance if needed to prevent surface runoff from flowing the length of the construction entrance and out onto paved surfaces.
9. Maintenance -Top dressing of additional stone shall be applied as conditions demand. Mud spilled, dropped, washed or tracked onto public roads, or any surface where runoff is not checked by sediment controls, shall be removed immediately. Removal shall be accomplished by scraping or sweeping.
10. Construction entrances shall not be relied upon to remove mud from vehicles and prevent off-site tracking. Vehicles that enter and leave the construction-site shall be restricted from muddy areas.
11. Removal—the entrance shall remain in place until the disturbed area is stabilized or replaced with a permanent roadway or entrance.

7.5 Dust Control

Description

Dust control involves preventing or reducing dust from exposed soils or other sources during land disturbing, demolition and construction activities to 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 results from both construction activities 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 construction and subdivision, commercial or industrial development, which involve disturbing 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.

Planning for dust control involves limiting the amount of soil disturbance at any one time as a key objective. Therefore, phased clearing and grading operations (minimize disturbance-phasing) and the utilization of other stabilization practices 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 by providing windbreaks and non-erosive areas.

Design Criteria

A number of measures can be utilized to limit dust either during or between construction stages or once construction is complete. Generally the same methods that are used to limit erosion by limiting exposure of soils to rainfall can be used to limit dust including: stabilizing exposed soils with mulch, vegetation or permanent cover. Additional methods particular to dust control include managing vehicles and construction traffic, road treatment and treatment of exposed soil with chemical stabilizers.

Vegetative Cover – The most effective way to prevent dust from exposed soil is to provide a dense cover of vegetation. In areas subject to little or no construction traffic, vegetative stabilization reduces dust drastically. Timely temporary and permanent seedings must be utilized to accomplish this. See TEMPORARY SEEDING & PERMANENT SEEDING.

Mulch - When properly applied, mulch offers a fast, effective means of controlling dust. Mulching is not recommended for areas within heavy traffic pathways. Binders or tackifiers should be used to tack organic mulches. See MULCHING.

Rough Graded Soils – Leaving the soil in a temporary state of rough grade, where clods rather than flattened soils predominate the surface can reduce the amount of dust generated from areas during periods of higher winds. This must be balanced by the need to reach a stage where the soil can be stabilized and may be only be necessary when high winds are predicted.

Watering - This is the most commonly used dust control practice. The site is sprinkled with water until the surface is wet before and during grading and is repeated as needed. It offers fast protection for haul roads and other heavy traffic routes. Watering should be done at a rate that prevents dust but does not cause soil erosion. Wetting agents are also available to increase the effectiveness of watering and must follow manufacturers instructions.

Chemical Stabilizers/Wetting Agents – Many products of this type are available and are usually most effective on typical mineral soils but may not be on predominantly organic soils such as muck. Users are advised to pay attention to the limitations and instructions regarding each product. The following table lists various adhesives and provides corresponding information on mixing and application:

Table 7.5.1 Adhesives for Dust Control

Adhesive	Water Dilution (Adhesive: Water)	Nozzle Type	Application Rate Gallon/Acre
Latex Emulsion	12.5:1	Fine	235
Resin in Water	4:1	Fine	300
Acrylic Emulsion (No-traffic)	7:1	Coarse	450
Acrylic Emulsion (Traffic)	3.5:1	Coarse	350

Stone - Stone can be used to stabilize roads or other areas during construction using crushed stone or coarse gravel. Research has shown the addition of bentonite to limestone roads (not igneous gravel) has shown benefits in reducing dust.

Windbreaks and Barriers – Where dust is a known problem, existing windbreak vegetation should be preserved. Maintaining existing rows of trees or constructing a 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.

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. Liquid application of a 35% calcium chloride solution is common. Note: application rates should be strictly in accordance with suppliers' specified rates.

Street Cleaning - Paved areas that have accumulated sediment from construction sites should be cleaned daily, or as needed, utilizing a street sweeper or bucket -type loader or scraper.

Operation and Maintenance

Most dust control measures, such as applications of water or road treatments will require monitoring and repeat applications as needed to accomplish good control.

Common Problems / Concerns

Vegetation is removed from large areas of the construction site and left barren for long periods of time.

Continuous, scheduled monitoring of the construction site conditions is not made.

Specifications
for

Dust Control

1. Vegetative Cover and/mulch – Apply temporary or permanent seeding and mulch to areas that will remain idle for over 21 days. Saving existing trees and large shrubs will also reduce soil and air movement across disturbed areas. See Temporary Seeding; Permanent Seeding; Mulching Practices; and Tree and Natural Area Protection practices.
2. Watering – Spray site with water until the surface is wet before and during grading and repeat as needed, especially on haul roads and other heavy traffic routes. Watering shall be done at a rate that prevents dust but does not cause soil erosion. Wetting agents shall be utilized according to manufacturers instructions.
3. Spray-On Adhesives – Apply adhesive according to the following table or manufacturers' instructions.

Table 7.5.1 Adhesives for Dust Control

Adhesive	Water Dilution (Adhesive: Water)	Nozzle Type	Application Rate Gal./Ac.
Latex Emulsion	12.5:1	Fine	235
Resin in Water Acrylic Emulsion (No-traffic)	4:1	Fine	300
Acrylic Emulsion (No-traffic)	7:1	Coarse	450
Acrylic Emulsion (Traffic)	3.5:1	Coarse	350

4. Stone – Graded roadways and other suitable areas will be stabilized using crushed stone or coarse gravel as soon as practicable after reaching an interim or final grade. Crushed stone or coarse gravel can be used as a permanent cover to provide control of soil emissions.
5. Barriers – Existing windbreak vegetation shall be marked and preserved. Snow fencing or other suitable barrier may be placed perpendicular to prevailing air currents at intervals of about 15 times the barrier height to control air currents and blowing soil.
6. 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.
7. Operation and Maintenance - When Temporary Dust Control measures are used; repetitive treatment should be applied as needed to accomplish
control.

   Street Cleaning - Paved areas that have accumulated sediment from construction should be cleaned daily, or as needed, utilizing a street sweeper or bucket -type endloader or scraper.

7.6 Grade Treatment (Surface Roughening)

Description

Grade Treatment or surface roughening creates horizontal depressions in the soil surface that help to reduce erosion by reducing runoff velocity and increasing infiltration. These depressions aid in the establishment of vegetative cover and provide localized trapping of sediments. Grade Treatment is typically created by operating tillage implements on the contour or by running tracked equipment up and down a slope without fine grading the surface.

Conditions Where Practice Applies

1. All slopes steeper than 3:1 require grade treatment, 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 that have been graded and will not be seeded 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

A grading plan should be developed to establish drainage areas, direct drainage patterns, and decrease runoff velocities. The plan should coordinate the grading with the erosion/sedimentation control plan and the stormwater management plan. Grading should be done in stages according to the implementation schedule, thus limiting the amount of surface

area left in a disturbed, unstable condition. When grading, leave a natural buffer between the disturbed areas and the water body (50 ft. minimum width recommended.) If a natural buffer cannot be left, construct a berm or install other appropriate sediment control BMPs (i.e. sediment trap, silt fence) adjacent to the water body.

Prior to placing fill, topsoil and organic materials should be removed. To prevent differential settlement, fill should be free of objectionable materials such as logs, rocks and stumps. Frozen fill or organic (muck) materials should not be used.

Spoil and topsoil piles shall not be located in or near drainageways and shall be stabilized as soon as possible by seeding and mulching. Placing piles adjacent to channel banks where it may create bank failure or result in deposition of sediment downstream should be avoided.

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 that generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

Design Criteria

Grade Treatment is to be performed only after all cuts and fills are made and brought to the final shape and grade.

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. Grading methods include stair-step grading, grooving, and tracking.

Stair-step grading. This method should be done on slopes steeper than 3:1 with material soft enough to be bulldozed and which will not be mowed. The vertical cut should be less than the horizontal distance and should not exceed 2 feet in soft material and 3 feet in rocky material. The horizontal position of the "step" should be sloped toward the vertical up-hill wall.

Grooving. This method can be done on any area, which can safely accommodate disks, tillers, spring harrow, or the teeth of a front-end loader bucket. In areas, which will not be mowed, use equipment to create grooves perpendicular to the slope. Grooves should not be less than 3 inches deep, nor more than 15 inches apart. In cuts, fills, and areas that will be mowed, grooves should be less than 10 inches apart and not less than 1 inch deep.

Tracking. This method is done by running tracked machinery (such as bulldozers) up and down slopes to leave horizontal depressions in the soil. Back-blading should not be done during the final grading operation.

Tracking or roughening with tracked machinery is not recommended on clayey soils unless other alternatives are unavailable due to its likelihood of causing compaction of the surface soil. Sandy soils do not compact severely, and may be tracked. In no case is tracking as effective as the other roughening methods described. To roughen with tracked machinery, operate the equipment up and down the slope to leave horizontal depressions in the soil with as few passes of the machinery as possible to minimize compaction.

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, tracked, 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 shed from above, and provides a level site where vegetation can become established.
3. Areas that will be mowed (these areas should have slopes 3:1 or flatter) may have small furrows left by discing, harrowing, raking, or seed-planting machinery operated on the contour.
4. Avoid excessive compacting of the soil surface when scarifying. Tracking with bull-dozer treads is preferable to not roughening at all, but is not as effective as other forms of roughening, as the soil surface may be compacted and runoff increased.

Maintenance

Roughened areas shall be seeded and mulched within seven (7) days of last disturbance to obtain optimum seed germination and seedling growth.

Common Problems / Concerns

Severe compaction due to equipment operation – results in unsuitable seedbed and poor vegetation establishment.

Rough areas difficult to mow – caused by cutting grooves too deep or excessive erosion from grooves not being on the contour.

Grooving done perpendicular, rather than parallel to slope – results in accelerated erosion.

Specifications
for

Grade Treatment

Cut Slopes-Greater than 3:1 Slopes

1. Stair-step grading may be carried out on any material soft enough to be ripped with a bulldozer. The ratio of the horizontal distance to the vertical cut distance shall be flatter than 1:1 and the horizontal portion of the "step" shall slope toward the vertical wall. Individual vertical cuts shall not be more than 24 inches on soft soil materials and not more than 36 inches in rocky materials.
2. Grooving 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 Slopes-Greater than 3:1 Slopes

Fill slopes steeper than 3:1 shall be grooved or allowed to remain rough as they are constructed utilizing method (1) or (2) below.

1. Grooving may be made with any appropriate implement which can be safely operated on the slope and which will not cause undue compaction such as discs, tillers, spring harrows, and the teeth on a front-end loader bucket. Grooves left shall not be less than 3 inches deep nor further than 15 inches apart.
2. As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface. At no time shall slopes be bladed or scraped to produce a smooth, hard surface.

Cuts, Fills, and Graded Areas Which Will Be Mowed

1. Mowed slopes should not be steeper than 3:1 and shall avoid excessive roughness. These areas may be roughened with shallow grooves such as those, which 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).
2. Grooves formed by implements shall be not less than 1 inch deep and not further than 12 inches apart. Fill slopes that are left rough during construction may be smoothed with a chain harrow or similar implement to facilitate mowing.

Roughening With Tracked Machinery

1. Avoid tracking clayey soils if possible, due to their potential for compaction. Conversely sandy soils will have low potential for compaction.
2. Operate 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.

7.7 Topsoiling

Description

Topsoiling occurs during grading operations as the upper most organic layer of soil is stripped and stockpiled from areas being graded and subsequently replaced on the newly graded areas. Topsoil provides a more suitable growing medium than subsoil or on areas with poor moisture, low nutrient levels, undesirable pH, or in the presence of other materials that would inhibit establishment of vegetation. Replacing topsoil helps plant growth by improving the water holding capacity and nutrient content and consistency of the soils.

Conditions Where Practice Applies

This practice applies anywhere a good stand of vegetation is desired, whether turf, ornamental plants, and/ or vegetative cover especially in areas where high-quality turf is desirable to withstand intense use or meet aesthetic requirements, although it may not be appropriate for areas with slopes greater than 2:1.

This practice is especially applicable to areas where:

- existing soil structure, pH, or nutrient balance cannot be easily improved with soil amendments to be a suitable growth medium.
- existing soils are too shallow to provide adequate rooting depth or;
- the existing soil contains substances toxic to the desired vegetation.

Planning Considerations

Topsoil is the upper layer of natural soil (A horizon), which is typically darker and more fertile than the subsoil due to increased amounts of organic material. This layer is typically very evident as a person excavates through soil horizons. Project sites will have varying degrees of topsoil resources prior to construction, with some historically eroded sites having limited topsoil resources. These sites may have less justification for moving, stockpiling and re-spreading the top horizon of soil. If in question, assistance by a trained soils professional should be sought to determine the extent of topsoil resources on the project site.

Although replacing topsoil is critical to establishing good vegetation and limiting runoff from development sites, it comes with additional costs. Stripping, stockpiling and reapplying topsoil or importing topsoil will require greater work in grading operations and therefore will increase costs. Topsoiling will also add time to grading operations and may increase the exposure time of denuded areas. Additionally, depending on the original vegetative cover, topsoil often contains weed seeds that may compete with desirable species.

In site planning, the option of topsoiling should be compared with that of preparing a seedbed in subsoil. The clay content of subsoil does provide high moisture availability and deters leaching of nutrients. When adjusted for optimal pH and nutrient availability, subsoil may provide an adequate growth medium that is generally free of weeds. Topsoiling may not be required to establish less demanding, lower maintenance plants, although runoff will be increased due to the lack of topsoil from the site.

If topsoiling is planned, locations for topsoil stockpiles must be determined where drainage and site work will not be encumbered. Construction scheduling must be adjusted to allow sufficient time for moving, stockpiling and spreading topsoil between grading and re-vegetation operations.

Design Criteria

These are provided in the specifications that follow.

Maintenance

Topsoil stockpiles should be stabilized with temporary vegetation and provided sufficient sediment controls. Sediment Controls will need regular inspection and appropriate repairs as needed.

Common Problems / Concerns

- 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, leading to sloughing of the topsoil. Sandy topsoil over clay subsoil is equally likely to fail.
- 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 is highly discouraged, unless good bonding of soils can be achieved.
- Topsoil should not be applied in excessively wet/moist conditions.

Specifications
for

Topsoiling

Salvaging and Stockpiling

1. Determine the depth and suitability of topsoil at the site. (For help, contact your local SWCD office to obtain a county soil survey report).
2. Prior to stripping topsoil, install appropriate downslope erosion and sedimentation controls such as sediment traps and basins.
3. Remove the soil material no deeper than what the county soil survey describes as “surface soil” (ie. A or Ap horizon).
4. Construct stockpiles in accessible locations that do not interfere with natural drainage. Install appropriate sediment controls to trap sediment such as silt fence immediately adjacent to the stockpile or sediment traps or basins downstream of the stockpile. Stockpile side slopes shall not exceed a ratio of 2:1.
5. If topsoil is stored for more than 21days, it should be temporary seeded, or covered with a tarp.

Spreading the Topsoil

1. Prior to applying topsoil, the topsoil should be pulverized.
2. To ensure bonding, grade the subsoil and roughen the top 3-4 in. by disking.
3. Do not apply when site is wet, muddy, or frozen, because it makes spreading difficult, causes compaction problems, and inhibits bonding with subsoil.
4. Apply topsoil evenly to a depth of at least 4 inches and compact slightly to improve contact with subsoil.
5. After speading, grade and stabilize with seeding or appropriate vegetation.

7.8 Temporary Seeding

Description

Temporary seedings establish temporary cover on disturbed areas by planting appropriate rapidly growing annual grasses or small grains. Temporary seeding provides erosion control on areas in between construction operations. Grasses, which are quick growing, are seeded and usually mulched to provide prompt, temporary soil stabilization. It effectively minimizes the area of a construction site prone to erosion and should be used everywhere the sequence of construction operations allows vegetation to be established.

Conditions Where the Practice Applies

Temporary seeding should be applied on exposed soil where additional work (grading, etc.) is not scheduled for more than 21 days. Permanent seeding should be applied if the areas will be idle for more than one year.

Planning Considerations

This practice has the potential to drastically reduce the amount of sediment eroded from a construction site. Erosion control efficiencies greater than 90% will be achieved with proper applications of temporary seeding. Because practices used to trap sediment are usually much less effective, temporary seeding is to be use even on areas where runoff is treated by sediment trapping practices. Because temporary seeding is highly effective and practical on construction sites, its liberal use is highly recommended.

Design Criteria

Specifications follow these explanations of important aspects of temporary seeding.

Plant Selection: Select the plants appropriate from the table in the Specifications for Temporary seeding. Choose varieties of tall fescue that are endophyte free or have non-toxic endophytes. Seeding rates for dormant seedings are increased by 50 percent. More information on dormant seedings is given in the permanent seeding section.

The length of time the area will idle and the season in which seeding occurs should influence the selection of seeding species. For areas remaining idle for over a year, a mixture containing perennial ryegrass is recommended. Cereal grains (rye, oats and wheat) are included in some of the mixtures as cover crops. These are annual plants that will die after producing seed. Realize that oats will not over-winter and continue to grow as wheat and rye do.

Site preparation: Temporary seeding is best done on a prepared soil seedbed of loose pulverized soil. However, seedings should not be delayed, if additional grading operations are not possible. At a minimum, remove large rock or debris that will interfere with seeding operations. If the ground has become crusted, a disk or a harrow should be used to loosen the soil. Overall the best soil conditions will exist immediately after grading operations cease, when soils remain loose and moist.

Soil amendments: A soil test is necessary to adequately predict the need for lime and fertilizer. Seedings that are expected to be long lasting (over 1-3 months), should have lime and fertilizer applied as recommended by a soil test. In lieu of a soil test, fertilizer can be broadcast and worked into the top inch of soil at the rate of 6 pounds/1000 ft2 or 250 pounds per acre of 10-10-10 or 12-12-12.

Seeding Methods: Seed shall be applied uniformly with a cyclone spreader, drill, cultipacker seeder, or hydroseeder. When feasible, seed that has been broadcast shall be covered by raking or dragging and then lightly tamped into place using a roller or cultipacker. If hydroseeding is used, the seed and fertilizer will be mixed on-site and the seeding shall be done immediately and without interruption.

Maintenance

Areas failing to establish vegetative cover adequate to prevent erosion shall be reseeded as soon as such areas are identified.

Seeding performed during hot and dry summer months shall be watered at a rate of 1 inch per week.

Common Problems / Concerns

- Insufficient topsoil or inadequately tilled, limed, and/ or fertilized seedbed results in poor establishment of vegetation.
- An overly high seeding rate of nurse crop (oat, rye or wheat) in the seed mixture results in over competition with the perennials.
- Seeding outside of seeding dates results in poor vegetation establishment and a decrease in plant hardiness.
- An inadequate rate of mulch results in poor germination and failure.

Specifications
for

Temporary Seeding

Table 7.8.1 Temporary Seeding Species Selection

Seeding Dates	Species	Lb./1000 ft2	Lb/Acre
March 1 to August 15	Oats Tall Fescue Annual Ryegrass	3 1 1	128 (4 Bushel) 40 40
	Perennial Ryegrass Tall Fescue Annual Ryegrass	1 1 1	40 40 40
	Annual Ryegrass Perennial Ryegrass Creeping Red Fescue Kentucky Bluegrass	1.25 3.25 0.4 0.4	55 142 17 17
	Oats Tall Fescue Annual Ryegrass	3 1 1	128 (3 bushel) 40 40
August 16th to November	Rye Tall Fescue Annual Ryegrass	3 1 1	112 (2 bushel) 40 40
	Wheat Tall Fescue Annual Ryegrass	3 1 1	120 (2 bushel) 40 40
	Perennial Rye Tall Fescue Annual Ryegrass	1 1 1	40 40 40
	Annual Ryegrass Perennial Ryegrass Creeping Red Fescue Kentucky Bluegrass	1.25 3.25 0.4 0.4	40 40 40
November 1 to Feb. 29	Use mulch only or dormant seeding		

Note: Other approved species may be substituted.

1. Structural erosion and sediment control practices such as diversions and sediment traps shall be installed and stabilized with temporary seeding prior to grading the rest of the construction site.
2. Temporary seed shall be applied between construction operations on soil that will not be graded or reworked for 21 days or greater. These idle areas shall be seeded within 7 days after grading.
3. The seedbed should be pulverized and loose to ensure the success of establishing vegetation. Temporary seeding should not be postponed if ideal seedbed preparation is not possible.
4. Soil Amendments—Temporary vegetation seeding rates shall establish adequate stands of vegetation, which may require the use of soil amendments. Base rates for lime and fertilizer shall be used.
5. Seeding Method—Seed shall be applied uniformly with a cyclone spreader, drill, cultipacker seeder, or hydroseeder. When feasible, seed that has been broadcast shall be covered by raking or dragging and then lightly tamped into place using a roller or cultipacker. If hydroseeding is used, the seed and fertilizer will be mixed on-site and the seeding shall be done immediately and without interruption.

Specifications
for

Temporary Seeding

Mulching Temporary Seeding

1. Applications of temporary seeding shall include mulch, which shall be applied during or immediately after seeding. Seedings made during optimum seeding dates on favorable, very flat soil conditions may not need mulch to achieve adequate stabilization.

2. Materials:

- Straw—If straw is used, it shall be unrotted small-grain straw applied at a rate of 2 tons per acre or 90 lbs./ 1,000 sq. ft. (2-3 bales)
- Hydroseeders—If wood cellulose fiber is used, it shall be used at 2000 lbs./ ac. or 46 lb./ 1,000-sq.-ft.
- Other—Other acceptable mulches include mulch mattings applied according to manufacturer's recommendations or wood chips applied at 6 ton/ ac.

3. Straw Mulch shall be anchored immediately to minimize loss by wind or water. Anchoring methods:

- Mechanical—A disk, crimper, or similar type tool shall be set straight to punch or anchor the mulch material into the soil. Straw mechanically anchored shall not be finely chopped but left to a length of approximately 6 inches.
- Mulch Netting—Netting shall be used according to the manufacturers recommendations. Netting may be necessary to hold mulch in place in areas of concentrated runoff and on critical slopes.
- Synthetic Binders—Synthetic binders such as Acrylic DLR (Agri-Tac), DCA-70, Petroset, Terra Track or equivalent may be used at rates recommended by the manufacturer.
- Wood-Cellulose Fiber—Wood-cellulose fiber binder shall be applied at a net dry wt. of 750 lb./ac. The wood-cellulose fiber shall be mixed with water and the mixture shall contain a maximum of 50 lb. / 100 gal.

7.9 Mulching

Description

A protective layer of mulch, usually of straw, applied to bare soil is used to abate erosion by shielding it from raindrop impact. Mulch also helps establish vegetation by conserving moisture and creating favorable conditions for seeds to germinate.

Conditions Where Practice Applies

Mulch should be used liberally throughout construction to limit the areas that are bare and susceptible to erosion. Mulch can be used in conjunction with seeding to establish vegetation or by itself to provide erosion control when the season does not allow grass to grow. Mulch and other vegetative practices must be applied on all disturbed portions of construction-sites that will not be re-disturbed for more than 21 days.

Design Criteria

See specifications for Mulching.

Maintenance

Additional mulching is necessary to cover exposed soil conditions when observed during routine maintenance inspections.

Common Problems / Concerns

The application of synthetic binders must be conducted in such a manner as to not be introduced into watercourses.

Weather considerations must be addressed to ensure the application of synthetic binders are not washed away and introduced into watercourses.

The use of a mulch cover is not recommended for areas, which will exhibit higher velocities than 3.5 feet/second. An erosion control matting is recommended for areas which will exhibit higher velocities.

Areas which have been mulched should be inspected and maintained if necessary every 7 days or within 24 hours of a rain event greater than or equal to 0.5 inches to ensure adequate protection.

Specifications
for

Mulching

1. Mulch and other appropriate vegetative practices shall be applied to disturbed areas within 7 days of grading if the area is to remain dormant (undisturbed) for more than 21 days or on areas and portions of the site which can be brought to final grade.
2. Mulch shall consist of one of the following:

- Straw - Straw shall be unrotted small grain straw applied at the rate of 2 tons/ac. or 90 lb./1,000 sq. ft. (two to three bales). The straw mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. For uniform distribution of hand-spread mulch, divide area into approximately 1,000 sq.ft. sections and place two 45-lb. bales of straw in each section.
- Hydroseeders - Wood cellulose fiber should be used at 2,000 lb./ac. or 46 lb./1,000 sq. ft.
- Other - Acceptable mulches include mulch mattings and rolled erosion control products applied according to manufacturer's recommendations or wood mulch/chips applied at 10-20 tons/ac.

3. Mulch Anchoring - Mulch shall be anchored immediately to minimize loss by wind or runoff. The following are acceptable methods for anchoring mulch.

- Mechanical - Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil. Straw mechanically anchored shall not be finely chopped but be left generally longer than 6 inches.
- Mulch Nettings - Use according to the manufacturer's recommendations, following all placement and anchoring requirements. Use in areas of water concentration and steep slopes to hold mulch in place.
- Synthetic Binders - For straw mulch, synthetic binders such as Acrylic DLR (Agri-Tac), DCA-70, Petroset, Terra Tack or equal may be used at rates recommended by the manufacturer. All applications of Sythetic Binders must be conducted in such a manner where there is no contact with waters of the state.
- Wood Cellulose Fiber - Wood cellulose fiber may be used for anchoring straw. The fiber binder shall be applied at a net dry weight of 750 lb./acre. The wood cellulose fiber shall be mixed with water and the mixture shall contain a maximum of 50 lb./100 gal. of wood cellulose fiber.

7.10 Permanent Seeding

Description

Perennial vegetation is established on areas that will not be re-disturbed for periods longer than 12 months. Permanent seeding includes site preparation, seedbed preparation, planting seed, mulching, irrigation and maintenance.

Permanent vegetation is used to stabilize soil, reduce erosion, prevent sediment pollution, reduce runoff by promoting infiltration, and provide stormwater quality benefits offered by dense grass cover.

Conditions Where Practice Applies

Permanent seeding should be applied to:

- Any disturbed areas or portions of construction sites at final grade. Permanent seeding should not be delayed on any one portion of the site at final grade while construction on another portion of the site is being completed. Permanent seeding shall be completed in phases, if necessary.
- Areas subject to grading activities but will remain dormant for a year or more.

Planning Considerations

Vegetation controls erosion by reducing the velocity and the volume of overland flow and protects bare soil surface from raindrop impact. A healthy, dense turf promotes infiltration and reduces the amount of runoff. The establishment of quality vegetation requires selection of the right plant materials for the site, adequate soil amendments, careful seedbed preparation, and maintenance.

Soil Compaction— Storm water quality and the amount of runoff both vary significantly with soil compaction. Non-compacted soils improve stormwater infiltration by promoting:

- dense vegetative growth;
- high soil infiltration & lower runoff rates;
- pollutant filtration, deposition & absorption; and
- beneficial biologic activity in the soil.

Construction activity creates highly compacted soils that restrict water infiltration and root growth. The best time for improving soil condition is during the establishment of permanent vegetation. It is highly recommended that subsoilers, plows, or other implements are specified as part of final seedbed preparation. Use discretion in slip-prone areas.

Minimum Soil Conditions— Vegetation cannot be expected to stabilize soil that is unstable due to its texture, structure, water movement or excessively steep slope. The following minimum soil conditions are needed for the establishment and maintenance of a long-lived vegetative cover. If these conditions cannot be met, see the standards and specifications for Topsoiling.

- Soils must include enough fine-grained material to hold at least a moderate amount of available moisture.
- The soil must be free from material that is toxic or otherwise harmful to plant growth.

Design Criteria

See specifications for permanent seeding below.

Maintenance

1. Expect emergence within 4 to 28 days after seeding, with legumes typically following grasses. Check permanent seedlings within 4 to 6 weeks after planting. Look for:
   - Vigorous seedlings;
   - Uniform ground surface coverage with at least 30% growth density;
   - Uniformity with legumes and grasses well intermixed;
   - Green, not yellow, leaves. Perennials should remain green throughout the summer, at least at the plant bases.

2. Permanent seeding shall not be considered established for at least 1 full year from the time of planting. Inspect the seeding for soil erosion or plant loss during this first year. Repair bare and sparse areas. Fill gullies. Re-fertilize, re-seed, and re-mulch if required. Consider no-till planting. A minimum of 70% growth density, based on a visual inspection, must exist for an adequate permanent vegetative planting.

- If stand is inadequate or plant cover is patchy, identify the cause of failure and take corrective action: choice of plant materials, lime and fertilizer quantities, poor seedbed preparation, or weather. If vegetation fails to grow, have the soil tested to determine whether pH is in the correct range or nutrient deficiency is a problem.
- Depending on stand conditions, repair with complete seedbed preparation, then over-seed or re-seed.
- If it is the wrong time of year to plant desired species, over-seed with small grain cover crop to thicken the stand until timing is right to plant perennials or use temporary seeding. See Temporary Seeding standard.

3. Satisfactory establishment may require re-fertilizing the stand in the second growing season.
   - Do not fertilize cool season grasses in late May through July (i.e. Kentucky Bluegrass, Orchardgrass, Perrenial Ryegrass, Smooth Brome, Fescues, Timothy, Reed Canarygrass and Garrison Grass)
   - Grass that looks yellow may be nitrogen deficient. In lieu of a soil test, an application of 50 lbs. of N-P-K per acre in early spring will help cool season grasses compete against weeds or grow more successfully.
   - Do not use nitrogen fertilizer if the stand contains more than 20 percent legumes.

4. Long-term maintenance fertilization rates shall be established by following soil test recommendations or by using the rates shown in Table 2.

Table 7.10.1 Maintenance for Permanent Seedings Fertilization and Mowing

Mixture	Formula	Lbs./ Acre	Lbs./1,000 sq.ft.	Time	Mowing
Creeping Red Fescue Ryegrass Kentucky Bluegrass	10-10-10	500	12	Fall, yearly or as needed	Not closer than 3”
Tall Fescue	10-10-10	500	12		Not closer than 4”
Turf-type Fescue	10-10-10	500	12		
Crown Vetch Fescue	0-20-20	400	10	Spring, yearly following establishment and every 4-7 years thereafter	Do not mow
Flat Pea Fescue	0-20-20	400	10		Do not mow

Note: Following soil test recommendations is preferred to fertilizer rates shown above.

5. Consider mowing after plants reach a height of 6 to 8 inches. Mow grasses tall, at least 3 inches in height and minimize compaction during the mowing process. Vegetation on structural practices such as embankments and grass-lined channels need to be mowed only to prevent woody plants from invading the stand.

Common Problems / Concerns

- Insufficient topsoil or inadequately tilled, limed, and/or fertilized seedbed - results in poor establishment of vegetation.
- Unsuitable species or seeding mixture - results in competition with the perennials.
- Nurse crop rate too high in the mixture - results in competition with the perennials.
- Seeding done at the wrong time of year - results in poor establishment of vegetation, also plant hardiness is significantly decreased.
- Mulch rate inadequate - results in poor germination and failure.

Specifications
for

Permanent Seeding

Site Preparation

1. Subsoiler, plow, or other implement shall be used to reduce soil compaction and allow maximum infiltration. (Maximizing infiltration will help control both runoff rate and water quality.) Subsoiling should be done when the soil moisture is low enough to allow the soil to crack or fracture. Subsoiling shall not be done on slip-prone areas where soil preparation should be limited to what is necessary for establishing vegetation.
2. The site shall be graded as needed to permit the use of conventional equipment for seedbed preparation and seeding.
3. Topsoil shall be applied where needed to establish vegetation.

Seedbed Preparation

1. Lime—Agricultural ground limestone shall be applied to acid soil as recommended by a soil test. In lieu of a soil test, lime shall be applied at the rate of 100 pounds per 1,000-sq. ft. or 2 tons per acre.
2. Fertilizer—Fertilizer shall be applied as recommended by a soil test. In place of a soil test, fertilizer shall be applied at a rate of 25 pounds per 1,000-sq. ft. or 1000 pounds per acre of a 10-10-10 or 12-12-12 analyses.
3. The lime and fertilizer shall be worked into the soil with a disk harrow, spring-tooth harrow, or other suitable field implement to a depth of 3 inches. On sloping land, the soil shall be worked on the contour.

Seeding Dates and Soil Conditions

Seeding should be done March 1 to May 31 or August 1 to September 30. If seeding occurs outside of the above-specified dates, additional mulch and irrigation may be required to ensure a minimum of 80% germination. Tillage for seedbed preparation should be done when the soil is dry enough to crumble and not form ribbons when compressed by hand. For winter seeding, see the following section on dormant seeding.

Dormant Seedings

1. Seedings should not be made from October 1 through November 20. During this period, the seeds are likely to germinate but probably will not be able to survive the winter.
2. The following methods may be used for “Dormant Seeding”:

- From October 1 through November 20, prepare the seedbed, add the required amounts of lime and fertilizer, then mulch and anchor. After November 20, and before March 15, broadcast the selected seed mixture. Increase the seeding rates by 50% for this type of seeding.
- From November 20 through March 15, when soil conditions permit, prepare the seedbed, lime and fertilize, apply the selected seed mixture, mulch and anchor. Increase the seeding rates by 50% for this type of seeding.
- Apply seed uniformly with a cyclone seeder, drill, cultipacker seeder, or hydro-seeder (slurry may include seed and fertilizer) on a firm, moist seedbed.
- Where feasible, except when a cultipacker type seeder is used, the seedbed should be firmed following seeding operations with a cultipacker, roller, or light drag. On sloping land, seeding operations should be on the contour where feasible.

Mulching

1. Mulch material shall be applied immediately after seeding. Dormant seeding shall be mulched. 100% of the ground surface shall be covered with an approved material.
2. Materials

- Straw—If straw is used it shall be unrotted small-grain straw applied at the rate of 2 tons per acre or 90 pounds (two to three bales) per 1,000-sq. ft. The mulch shall be spread uniformly by hand or mechanically applied so the soil surface is covered. For uniform distribution of hand-spread mulch, divide area into approximately 1,000-sq.-ft. sections and spread two 45-lb. bales of straw in each section.
- Hydroseeders—If wood cellulose fiber is used, it shall be applied at 2,000 lb./ac. or 46 lb./1,000 sq. ft.
- Other—Other acceptable mulches include rolled erosion control mattings or blankets applied according to manufacturer’s recommendations or wood chips applied at 6 tons per acre.

3. Straw and Mulch Anchoring Methods

Straw mulch shall be anchored immediately to minimize loss by wind or water.

- Mechanical—A disk, crimper, or similar type tool shall be set straight to punch or anchor the mulch material into the soil. Straw mechanically anchored shall not be finely chopped but, generally, be left longer than 6 inches.
- Mulch Netting—Netting shall be used according to the manufacturer's recommendations. Netting may be necessary to hold mulch in place in areas of concentrated runoff and on critical slopes.
- Asphalt Emulsion—Asphalt shall be applied as recommended by the manufacture or at the rate of 160 gallons per acre.
- Synthetic Binders—Synthetic binders such as Acrylic DLR (Agri-Tac), DCA-70, Petroset, Terra Tack or equivalent may be used at rates specified by the manufacturer.
- Wood Cellulose Fiber—Wood cellulose fiber shall be applied at a net dry weight of 750 pounds per acre. The wood cellulose fiber shall be mixed with water with the mixture containing a maximum of 50 pounds cellulose per 100 gallons of water.

Irrigation

Permanent seeding shall include irrigation to establish vegetation during dry weather or on adverse site conditions, which require adequate moisture for seed germination and plant growth.

Irrigation rates shall be monitored to prevent erosion and damage to seeded areas from excessive runoff.

Table 7.10.2 Permanent Seeding

Seed Mix	Seeding Rate		Notes:
	Lbs./acre	Lbs./1,000 Sq. Feet	
General Use			
Creeping Red Fescue Domestic Ryegrass Kentucky Bluegrass	20-40 10-20 20-40	1⁄2-1 1⁄4-1⁄2 1⁄2-1	For close mowing & for waterways with <2.0 ft/sec velocity
Tall Fescue	40-50	1-1 1⁄4	
Turf-type (dwarf) Fescue	90	2 1⁄4	
Steep Banks or Cut Slopes			
Tall Fescue	40-50	1-1 1⁄4	
Crown Vetch Tall Fescue	10-20 20-30	1⁄4-1⁄2 1⁄2-3⁄4	Do not seed later than August
Flat Pea Tall Fescue	20-25 20-30	1⁄2-3⁄4 1⁄2-3⁄4	Do not seed later than August
Road Ditches and Swales			
Tall Fescue	40-50	1-11⁄4	
Turf-type (Dwarf) Fescue Kentucky Bluegrass	 90 5	 2 1⁄4 0.1	
Lawns			
Kentucky Bluegrass Perennial Ryegrass	100-120	2 2	
Kentucky Bluegrass Creeping Red Fescue	100-120	2 1-1/2	For shaded areas

Note: Other approved seed species may be substituted.

7.11 Sodding

Description

Sodding utilizes rolls or mats of turf grass to provide immediate stabilization to bare soils. It is especially useful in highly erosive areas such as drainage ways and on slopes that will be mowed.

Conditions Where Practice Applies

Sod may be used where immediate cover is required or preferred, and where vegetation will be adequate stabilization such as minor swales, around drop inlets, and lawns.

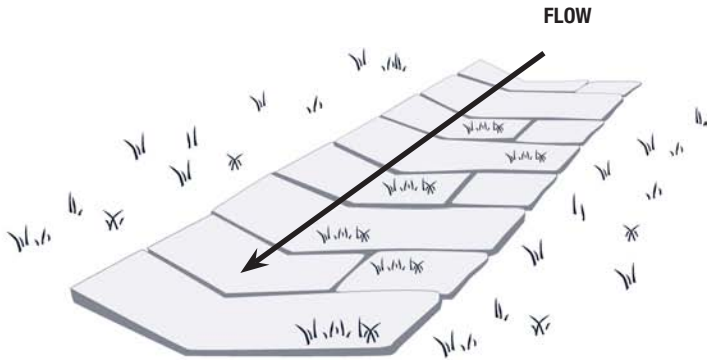
Design Criteria

These are provided in the specifications that follow.

Maintenance

Adequate moisture is the most important factor to establishing sod. Sod must be watered immediately after installation, daily during first week and as necessary for the remainder of the initial rooting period, usually 2-4 weeks. An adequate watering will moisten to a depth of 4-6 inches. Although watering needs and frequency may taper off after this period, sodded areas are not often independent of watering until their second season of growth. Most foot traffic should be limited and mowing withheld until the sod is firmly rooted.

Lay sod in a staggered brick like pattern



Utilizing sod in waterways

Common Problems / Concerns

- An inadequately prepared site or soils can cause inadequate rooting and establishment. Hard soils can cause runoff to occur between the sod and soil layers and poor establishment of the root system. The area should be adequately cleared of clods, debris, have sufficient topsoil and be moistened during dry periods.
- The placement of sod on frozen soil, or in freezing temperatures will result in failure to establish grass.
- Drying of sod during and immediately following the placement of sod will result in death of the sod.

References

Pound W., Street J., 1991. *Lawn Establishment Bulletin 546.* The Ohio State University.

Specifications
for

Sodding

Materials

1. Sod shall be harvested, delivered and installed within a period of 48 hours. Sod not transplanted within this period shall be inspected and approved prior to installation.
2. The sod shall be kept moist and covered during hauling and preparation for placement.
3. Sod shall be machine cut at a uniform soil thickness of 0.75 inches, plus or minus 0.25 inches, at the time of cutting. Measurements for thickness shall exclude top growth and thatch.

Site Preparation

1. A subsoiler, plow or other implement shall be used to reduce soil compaction and allow maximum infiltration. Maximizing infiltration will help control both runoff rate and water quality. Subsoiling shall not be conducted on slip-prone areas where soil preparation should be limited only to what is necessary for establishing vegetation.
2. The area shall be graded and topsoil spread where needed. (see Topsoiling)
3. Soil Amendments:

   Lime—Agricultural ground limestone shall be applied to acidic soils as recommended by a soil test. In lieu of a soil test, lime shall be applied at the rate of 100 lb./1,000 sq. ft. or 2 tons/ac.

   Fertilizer—Fertilizer shall be applied as recommended by a soil test. In lieu of a 2soil test fertilizer shall be applied at a rate of 12 lb./1,000 sq. ft. or 500 lb./ac. of 10-10-10 or 12-12-12 analysis.

   The lime and fertilizer shall be worked into the soil with a disk harrow, spring-tooth harrow, or other suitable field implement to a depth of 3 inches.
4. Before laying sod, the surface shall be uniformly graded and cleared of all debris, stones and clods larger than 3-in. diameter.

Sod Installation

1. During periods of excessively high temperatures, the soil shall be lightly irrigated immediately before laying the sod.
2. Sod shall not be placed on frozen soil.
3. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and tightly wedged against each other. Lateral joints shall be staggered in a brick-like pattern. Ensure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids that would dry the roots.
4. On sloping areas where erosion may be a problem, sod shall be laid with the long edge parallel to the contour and with staggered joints. The sod shall be secured with pegs or staples.
5. As sodding is completed in any one section, the entire area shall be rolled or tamped to ensure solid contact of roots with the soil surface. Sod shall be watered immediately after rolling or tamping until the sod and soil surface below the sod are thoroughly wet. The operations of laying, tamping and irrigating for any piece of sod shall be completed within 8 hours.

Maintenance

1. In the absence of adequate rainfall, watering shall be performed daily or as often as necessary during the first week with sufficient quantities to maintain moist soil to a depth of 4-6 inches.
2. After the first week, sod shall be watered as necessary to maintain adequate moisture and ensure establishment.
3. The first mowing shall not be attempted until sod is firmly rooted.

7.12 Temporary Rolled Erosion Control Products (Erosion Control Matting)

Description

A Temporary Rolled Erosion Control Product (TRECP) is a degradable manufactured material used to stabilize easily eroded areas while vegetation becomes established. Temporary Rolled Erosion Control Products are degradable products composed of biologically, photo chemically or otherwise degradable materials. Temporary RECPs consist of erosion control netting, open weave textiles, and erosion control blankets and mattings. These products reduce soil erosion and assist vegetative growth by providing temporary cover from the erosive action of rainfall and runoff while providing soil-seed contact.

Condition where practice applies:

Temporary rolled erosion control products (matting or blankets) should be used on:

- Areas where erosion potential is high or a failure to establish vegetation is costly such as slopes greater than 3:1, constructed channels or stream banks
- Areas where establishing vegetation is difficult such as southern exposures or areas prone to drying
- Areas of concentrated flow, especially where flows exceeds 3.5 feet per second (e.g near culverts)
- Problem areas with highly erosive soils
- Areas where mulch is difficult to hold in place due to wind or water

Planning Considerations:

Temporary RECPs can be applied to critical or problem areas to enhance the erosion control as vegetation is being established. Although these materials add cost, they insure more immediate stability following construction reducing grading repairs and a faster greening of projects. Permanent non-degradable rolled erosion control products (turf reinforcement mats) are beyond the scope of this practice, but may be useful where design discharges or runoff exert velocities and shear stresses exceeding the ability of mature vegetation to withstand.

Temporary RECPs provide stable and rapid greening for areas conveying stormwater runoff. Care must be taken to choose the type of RECP, which is most appropriate for the specific needs of a project. Designers must take into account the vegetated and unvegetated velocities and sheer stresses in channel applications. With the abundance of soil stabilization products available, it is impossible to cover all the advantages, disadvantages and specifications of all manufactured RECPs. 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 product's designer or plan reviewer to verify appropriateness.

Temporary RECPs should be used to help establish vegetation on previously disturbed slopes - especially slopes of 3:1 or greater. The materials that compose the RECP will deteriorate over time. If used in permanent conveyance channels, designers should consider the system's resistance to erosion as it relates to the type of vegetation planted and the existing soil characteristics. As much as possible during establishment of vegetation, soil stabilization blankets should not be subjected to concentrated flows moving at greater than 3.5 feet/second.

Design Criteria

Choose a product that will provide the appropriate time period of protection. Allowable velocity range during vegetation establishment should be 3.5 feet per second or less.

Erosion Control Blankets - shall consist of photodegradable plastic netting or biodegradable natural fiber netting that 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. Mulching material/fibers must interlock or entwine to form a dense layer, which not only resists raindrop impact, but also will allow vegetation to penetrate the blanket. The mulching material degradation rate must be consistent with the designers desired slope protection time. Temporary Rolled Erosion Control Products (or erosion control blankets) shall meet the specifications that follow.

Table 7.12.1

Material	Maximum Length Of Protection
Straw	10-12 Months
Straw/Coconut	24 Months
Coconut	36 Months
Excelsior	36 Months

Erosion Control Netting - shall consist of a woven natural fiber or extruded geosynthetic mesh used as a component in the manufacture of RECPs, or separately as a temporary RECP to anchor loose fiber mulches.

Open Weave Textile - shall consist of processed natural or polymer yarns woven into a matrix, used to provide erosion control and facilitate vegetation establishment.

Maintenance:

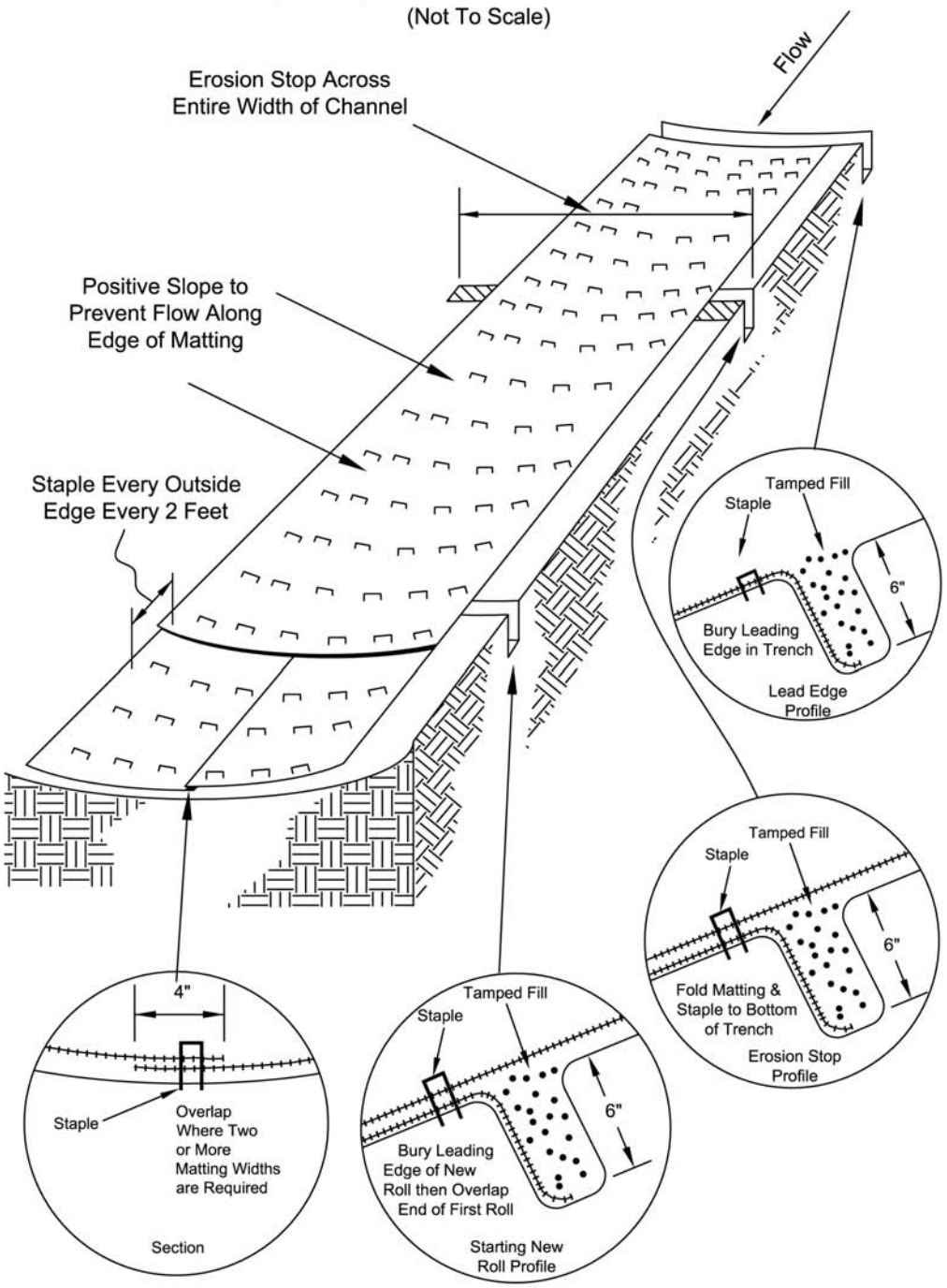
All RECPs should be inspected regularly after installation, especially after storms to check for erosion or undermining of the product. Make needed repairs immediately, addressing rills or gullies that have developed prior to replacing the RECP. In the case erosion repairs, assure that subsequent runoff across the area is dispersed or adequately spread.

Common Problems/Concerns:

- Manufacturer's selection and installation recommendations not followed. Results in failure of the RECP.
- Poor contact between soil and the RECP. Results in erosion below the RECP and lower seed germination rates, causing failure.
- Proper stapling guidelines not followed. Results in movement or displacement of RECP.
- Erosion check slots are not used. Results in erosion under the RECP, causing failure.
- Unstable slopes that result in RECP or slope failure. Determine cause of slope failure, correct, and reinstall RECP
- In channels, the width of RECP used is not sufficient, this causes water to flow along the sides of RECP causing erosion. Install RECP up side slopes of ditch line as well as the bottom.

Specifications
for

Temporary Rolled Erosion Control Product



Specifications
for

Temporary Rolled Erosion Control Product

1. Channel/Slope Soil Preparation Grade and compact area of installation, preparing seedbed by loosening 2”-3” of topsoil above final grade. Incorporate amendments such as lime and fertilizer into soil. Remove all rocks, clods, vegetation or other debris so that installed RECP will have direct contact with the soil surface.
2. Channel/Slope Seeding Apply seed to soil surface prior to installation. All check slots, anchor trenches, and other disturbed areas must be reseeded. Refer to the Permanent Seeding specification for seeding recommendations.

Slope Installation

3. Excavate top and bottom trenches (12”x6”). Intermittent erosion check slots (6”x6”) may be required based on slope length. Excavate top anchor trench 2’ x 3’ over crest of the slope.
4. If intermittent erosion check slots are required, install RECP in 6”x6” slot at a maximum of 30’ centers or the mid point of the slope. RECP should be stapled into trench on 12” centers.
5. Install RECP in top anchor trench, anchor on 12” spacings, backfill and compact soil.
6. Unroll RECP down slope with adjacent rolls overlapped a minimum of 3”. Anchor the seam every 18”. Lay the RECP loose to maintain direct soil contact, do not pull taught.
7. Overlap roll ends a minimum of 12” with upslope RECP on top for a shingle effect. Begin all new rolls in an erosion check slot if required, double anchor across roll every 12”.
8. Install RECP in bottom anchor trench (12”x6”), anchor every 12”. Place all other staples throughout slope at 1 to 2.5 per square yard dependant on slope. Refer to manufacturer’s anchor guide.

Channel Installation

9. Excavate initial anchor trench (12”x6”) across the lower end of the project area.
10. Excavate intermittent check slots (6”x6”) across the channel at 30’ intervals along the channel.
11. Excavate longitudinal channel anchor slots (4”x4”) along both sides of the channel to bury the edges. Whenever possible extend the RECP 2’-3’ above the crest of channel side slopes.
12. Install RECP in initial anchor trench (downstream) anchor every 12”, backfill and compact soil.
13. Roll out RECP beginning in the center of the channel toward the intermittent check slot. Do not pull taught. Unroll adjacent rolls upstream with a 3” minimum overlap (anchor every 18”) and up each channel side slope.
14. At top of channel side slopes install RECP in the longitudinal anchor slots, anchor every 18”.
15. Install RECP in intermittent check slots. Lay into trench and secure with anchors every 12”, backfill with soil and compact.
16. Overlap roll ends a minimum of 12” with upstream RECP on top for a shingling effect. Begin all new rolls in an intermittent check slot, double anchored every 12”.
17. Install upstream end in a terminal anchor trench (12”x6”); anchor every 12”, backfill and compact.
18. Complete anchoring throughout channel at 2.5 per square yard using suitable ground anchoring devices (U shaped wire staples, metal geotextile pins, plastic stakes, and triangular wooden stakes). Anchors should be of sufficient length to resist pullout. Longer anchors may be required in loose sandy or gravelly soils.

7.13 Turf Reinforcement Matting (Permanent Rolled Erosion Control Products)

Description

Turf reinforcement matting (TRM) is a permanent, non-degradable rolled erosion control product used to reinforce natural soil and vegetated growth with synthetic materials to prevent erosion and maintain the durability of vegetated areas. Turf reinforcement is generally an interwoven material applied to areas where natural vegetation alone is not sufficient to withstand expected flow conditions or to provide sufficient long-term erosion protection.

Condition where practice applies

Turf reinforcement matting (TRM) is applicable on:

- Critical areas or slopes (up to 1:1) where erosion potential is high
- Water conveyances subject to higher shear stresses and velocities (> 3.5 fps) than normally advisable for vegetated channels
- Area subject to limited scour
- slopes areas where vegetation has been disturbed and soil replaced

Turf reinforcement matting is not appropriate for areas which will be constantly inundated with water and therefore unable to establish adequate vegetation.

Planning Considerations

Turf reinforcement matting provides 3-dimensional matrix for root growth that increases the vegetation's ability to resist the shear forces of moving water. TRMs are commonly

used in channels designed to carry stormwater runoff. Site designers should follow manufacturer's recommendations on maximum permissible shear stresses and flow velocities. These recommendations change according to the development of the vegetation. They should be considered for at least these three stages during design: 1) no vegetation (soil and TRM); vegetation at 50% cover; and fully established vegetation.

During establishment velocities should not exceed 10 feet per second. Depending upon the manufacturer's recommendations, velocities may be increased up to 18 fps and 8 pounds of shear stress, or greater, once completely vegetated. Specific guidance regarding product limitations for turf reinforcement mats designed for permanent application must be sought from the manufacturers. While velocity may be useful for slope applications, calculating permissible shear stress is necessary and more appropriate for channel applications.

With many manufacturers' products available, it is impossible to cover all the advantages, disadvantages and specifications of each. Therefore, as with many erosion control products, there is no substitute for a thorough understanding of the manufacturer's instructions and recommendations and site visits by the designer to verify appropriateness.

Design Criteria

Turf reinforcement matting generally has an allowable velocity range during vegetation establishment of less than or equal to 0 – 10 feet per second, although this will vary according to each manufacturer's product.

Materials – shall consist of a 100% non-degradable synthetic material with a three-dimensional geomatrix of nylon, polyethylene, or randomly oriented monofilaments, forming a mat. The product should contain an ultra violet (UV) stabilizer to ensure longevity. Selection of appropriate matting materials along with proper installation and vegetation establishment are critical factors in the success of this practice.

Soil shall be prepared Make the soil surface is stable, firm, and free of rocks and other obstructions. Install the turf reinforcement matting according to the manufacturer's published installation guidelines or the following specifications contains in this practice whichever is more restrictive.

Turf reinforcement matting applications require the TRM material first, applying seed the TRM is required. If soil in-filling is required, install TRM, apply seed, and lightly brush or rake 0.3 to 0.7 in. (8 to 18 mm) of topsoil into the voids in the TRM to fill the product thickness.

Maintenance

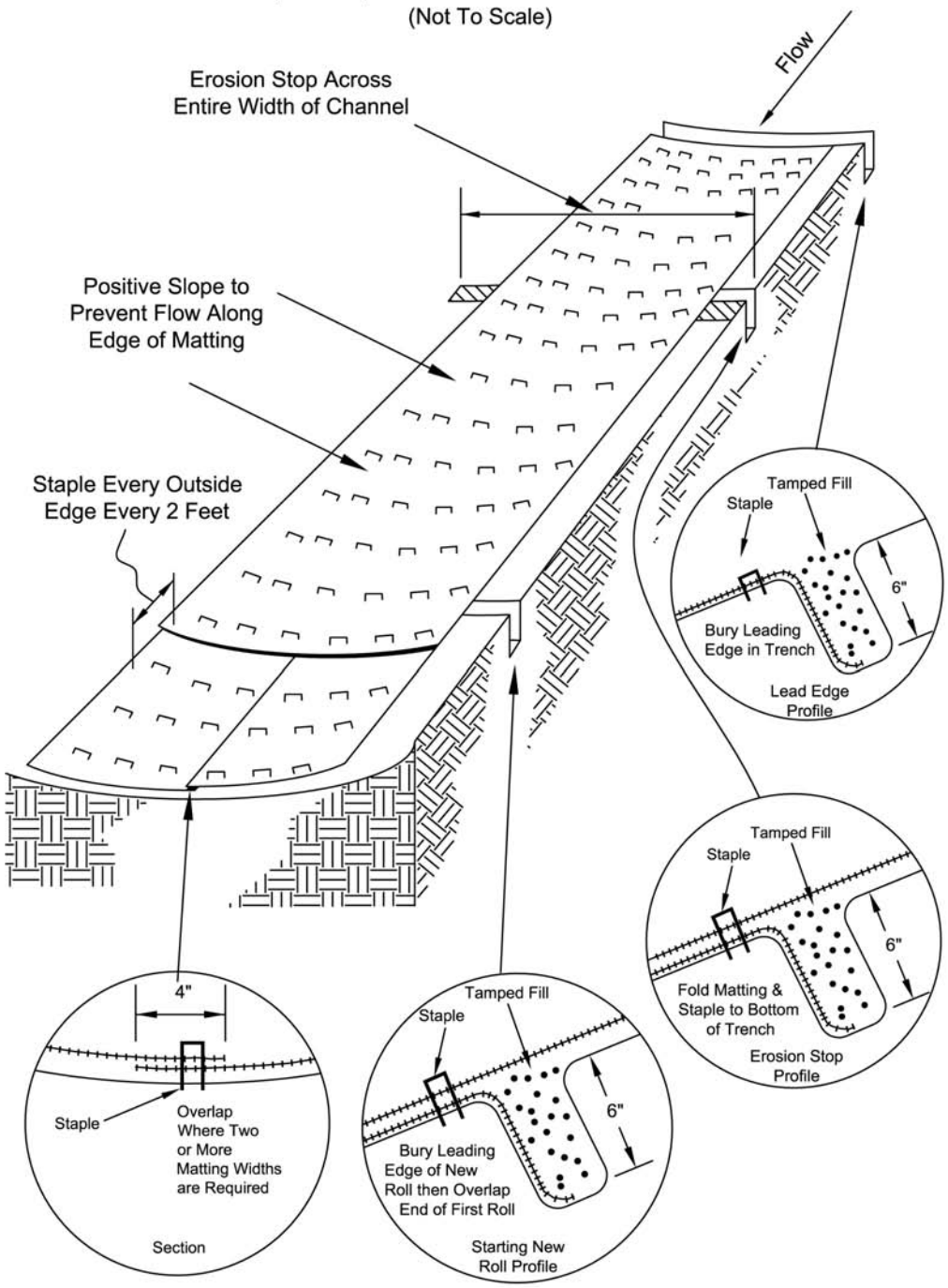
All TRMs should be inspected regularly after installation, especially after storms to check for erosion or undermining of the product. Make needed repairs immediately, addressing rills or gullies that have developed prior to replacing the TRM. In the case erosion repairs, assure that subsequent runoff across the area is dispersed or adequately spread.

Common Problems / Concerns

- Manufacturer's installation recommendations not followed. Results in failure of the TRM.
- Poor contact between soil and the TRM. Results in erosion below the TRM and lower seed germination rates, causing failure.
- Proper stapling guidelines not followed. Results in movement or displacement of TRM.
- Erosion check slots are not used. Results in erosion under the TRM, causing failure.
- Unstable slopes that result in TRM or slope failure. Determine cause of slope failure, correct, and reinstall TRM
- In channels, the width of TRM used is not sufficient, this causes water to flow along the sides of TRM causing erosion. Install TRM up side slopes of ditch line as well as the bottom.

Specifications
for

Turf Reinforcement Matting



Specifications
for

Turf Reinforcement Matting

1. Channel/Slope Soil Preparation Grade and compact area of installation, preparing seedbed by loosening 2”-3” of topsoil above final grade. Incorporate amendments such as lime and fertilizer into soil. Remove all rocks, clods, vegetation or other debris so that installed TRM will have direct contact with the soil surface.
2. Channel/Slope Seeding Apply seed to soil surface prior to installation. All check slots, anchor trenches, and other disturbed areas must be reseeded. Refer to the Permanent Seeding specification for seeding recommendations.

Slope Installation

3. Excavate top and bottom trenches (12”x6”). Intermittent erosion check slots (6”x6”) may be required based on slope length. Excavate top anchor trench 2’ x 3’ over crest of the slope.
4. If intermittent erosion check slots are required install TRM in 6”x6” slot at a maximum of 30’ centers or the mid point of the slope. TRM should be stapled into trench on 12” centers.
5. Install TRM in top anchor trench, anchor on 12” spacings, backfill and compact soil.
6. Unroll TRM down slope with adjacent rolls overlapped a minimum of 3”. Anchor the seam every 18”. Lay the TRM loose to maintain direct soil contact, do not pull taught.
7. Overlap roll ends a minimum of 12” with upslope TRM on top for a shingle effect. Begin all new rolls in an erosion check slot if required, double anchor across roll every 12”.
8. Install TRM in bottom anchor trench (12”x6”), anchor every 12”. Place all other staples throughout slope at 1 to 2.5 per square yard dependant on slope. Refer to manufacturer’s anchor guide.

Channel Installation

9. Excavate initial anchor trench (12”x6”) across the lower end of the project area.
10. Excavate intermittent check slots (6”x6”) across the channel at 30’ intervals along the channel.
11. Excavate longitudinal channel anchor slots (4”x4”) along both sides of the channel to bury the edges. Whenever possible extend the TRM 2’-3’ above the crest of channel side slopes.
12. Install TRM in initial anchor trench (downstream) anchor every 12”, backfill and compact soil.
13. Roll out TRM beginning in the center of the channel toward the intermittent check slot. Do not pull taught. Unroll adjacent rolls upstream with a 3” minimum overlap (anchor every 18”) and up each channel side slope.
14. At top of channel side slopes install TRM in the longitudinal anchor slots, anchor every 18”.
15. Install TRM in intermittent check slots. Lay into trench and secure with anchors every 12”, backfill with soil and compact.
16. Overlap roll ends a minimum of 12” with upstream TRM on top for a shingling effect. Begin all new rolls in an intermittent check slot, double anchored every 12”.
17. Install upstream end in a terminal anchor trench (12”x6”); anchor every 12”, backfill and compact.
18. Complete anchoring throughout channel at 2.5 per square yard using suitable ground anchoring devices (U shaped wire staples, metal geotextile pins, plastic stakes, and triangular wooden stakes). Anchors should be of sufficient length to resist pullout. Longer anchors may be required in loose sandy or gravelly soils.