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June 1, 2006

A cooperative effort between the North Carolina Sedimentation Control Commission, the North Carolina Department of Environment and Natural Resources, and the North Carolina Agricultural Extension Service.

Erosion and Sediment Control Planning and Design Manual

Disclaimer

The contents of this publication were prepared by the authors and should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations. Additional information from professionals, agencies, organizations and institutions with expertise in a particular area may be useful in selecting, designing, and installing certain practices.

The mention of trade names, products or companies does not constitute an endorsement.

This manual is intended for periodic update. Therefore sections of the manual may be changed as practices for erosion and sedimentation control evolve.

Preface

Thousands of acres of land are exposed each year in North Carolina for the construction of subdivisions, shopping centers, office centers, highways and other developments. Without protective measures these exposed areas are vulnerable to accelerated erosion and sedimentation that damages adjoining properties, streams and other water resources of the state.

The North Carolina Sedimentation Pollution Control Act of 1973 established a statewide program to control soil erosion and sedimentation. The law covers all land-disturbing activities in North Carolina, except those involving agriculture, forestry and mining.

The Act sets basic performance standards backed by rules and regulations. The law and the rules do not specify a rigid set of practices. Rather, they require the land developer to prepare an erosion and sedimentation control plan and employ appropriate measures to meet the performance standards.

As part of the educational requirements of the Act, the Commission is pleased to have sponsored the development of this manual. The manual is a basic reference for the preparation of a comprehensive erosion and sedimentation control plan and for the design, construction and maintenance of individual practices. It is intended to help land developers comply with the Act.

This manual is the "state of the art" and provides useful information for the implementation of a sound erosion control program that can be tailored to specific site conditions. The Commission will continue to support education and training to ensure sound and economical sedimentation control procedures to protect the streams, lakes, and estuaries of the state.

Kyle Sonnenberg,

Kyle R Sonnenberg

Chairman
Sedimentation Control Commission

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1

North Carolina Sedimentation Control Law

1

North Carolina Sedimentation Control Law

The purpose of this section is to highlight the portions of the North Carolina Sedimentation Pollution Control Act of 1973 that may affect individuals involved in construction or other land-disturbing activities. The full text of the law is included in *Appendix 8.08*. Address specific questions regarding the interpretation of this law to your regional office of the Land Quality Section of the Department of Environment and Natural Resources (DENR).

This law is performance oriented: it prohibits visible off-site sedimentation from construction sites but permits the owner and developer to determine the most economical, effective methods for erosion and sedimentation control. This flexibility in the law allows for innovation and considers the uniqueness of each construction site; however, it also requires the developer to plan his activities carefully in light of their erosion potential. To control erosion and sedimentation and satisfy the intent of the law, the developer should employ an integrated system of control measures and management techniques. An effective control system is based on an understanding of the processes of erosion and sedimentation and the basic principles for their control. *Chapter 2* discusses these processes and principles.

Who is affected?

The law governs all land-distrubing activities except agriculture and mining, which is regulated by the Mining Act of 1971. *Erosion and sedimentation control are required regardless of the size of the disturbance.* The law requires land developers to plan and implement effective temporary and permanent control measures to prevent accelerated erosion and off-site sedimentation. Further, if the installed protective measures do not work, additional measures must be taken.

What does the law require?

The law requires installation and maintenance of sufficient erosion control practices to retain sediment within the boundaries of the site. It also requires that surfaces be non-erosive and stable within 15 working days or 90 calendar days after completion of the activity, whichever period is shorter. In certain High Quality watersheds this stabilization must be achieved within 15 working days or 60 calendar days after completion of the activity, whichever is shortest.

An erosion and sedimentation control plan must be submitted at least 30 days before land disturbance begins on any site 1 acre or larger. The erosion and sedimentation control plan must be approved by the regulatory agency before any land-disturbing activities are begun. The erosion control plan requires a thorough evaluation of the site and the proposed land-disturbing activities in the planning phase of the development. The details and requirements for this plan are found in *Chapter 4, Preparing the Erosion and Sedimentation Control Plan*. Primary requirements are as follows:

- A sufficient buffer zone must be retained or established along any natural watercourse or lake to contain all visible sediment to the first 25% of the buffer strip nearest the disturbed area. An undisturbed 25 foot buffer must be maintained along trout waters.
- The angle of cut-and-fill slopes must be no greater than that sufficient for proper stabilization. Graded slopes must be vegetated or otherwise stabilized within 21 calendar days of completion of a phase of grading.
- Off-site sedimentation must be prevented, and a ground cover sufficient to prevent erosion must be provided within 15 working days or 90 calendar days, whichever is shorter.

What are the performance standards?

Erosion and sedimentation control measures must be designed to provide protection from a rainfall event equivalent in magnitude to the 10-year peak runoff. In areas where High Quality Waters (HOW's) are a concern, the design requirement is the 25 year storm.

Runoff velocities must be controlled so that the peak runoff from the 10-year frequency storm occurring during or after construction will not damage the receiving stream channel at the discharge point. The velocity must not exceed the greater of:

- the maximum non-erosive velocity of the existing channel, based on soil texture (Table 8.05d, *Appendix 8.05*), or
- peak velocity in the channel prior to disturbance.

If neither condition can be met, then protective measures must be applied to the receiving channel.

Who is responsible for maintenance?

During construction, the person financially responsible for site development is responsible for maintenance of the erosion and sedimentation control practices installed. The landowner may also be held responsible.

After construction is complete and the surface is permanently stabilized, responsibility passes to the landowner or the person managing the land.

Who enforces the law?

The Sedimentation Pollution Control Act provides authority to the State or authorized local agencies to inspect land-disturbing activities and to prosecute violators. Citizens damaged by violations of the Act may also take action through the courts.

What are the penalties?

Civil penalties assessed by the state or authorized localities carry a maximum fine of $5000/day per violation for each day that the site in violation.

Criminal penalties for knowing or willful violations may be imposed to a maximum of 90 days in jail and a $5,000 fine.

Administrative stop-work orders or injunction issued by the courts.

Who is the governing/ responsible agency?

The law created the Sedimentation Control Commission to develop and administer North Carolina's sedimentation and erosion control program. This program is implemented by the DENR, Land Quality Section under the Commission's direction. Authorized local governments or agencies may adopt their own ordinances; however, local programs must be approved by the Commission and must meet or exceed the minimum standards set by the state. If their programs are approved, local governments administer and enforce them. Because these programs vary widely in content and scope, consult the administering agency to avoid violations of local ordinances.

What other activities does the state's program include?

The state assists and encourages local governments and other state agencies to develop their own erosion and sedimentation control programs. The DENR reviews local programs as needed to assure uniform enforcement of the Act.

The state develops educational and instructional materials to demonstrate methods and practices for erosion and sedimentation control.

The state has developed a set of rules pertinent to sedimentation and erosion control. These rules were adopted as Title 15A, Chapter 4 of the North Carolina Administrative Code. The complete text of these rules is provided in *Appendix 8.08 and 8.09.*

2

Processes and Principles of Erosion and Sedimentation

2

Processes and Principles of Erosion and Sedimentation

When land is disturbed at a construction site, the erosion rate accelerates dramatically. Since ground cover on an undisturbed site protects the surface, removal of that cover increases the site's susceptibility to erosion. Disturbed land may have an erosion rate 1,000 times greater than the pre-construction rate. Even though construction requires that land be disturbed and left bare for periods of time, proper planning and use of control measures can reduce the impact of man-induced accelerated erosion.

The major problem associated with erosion on a construction site is the movement of soil off the site and its impact on water quality. Millions of tons of sediment are generated annually by the construction industry in the United States. The rate of erosion on a construction site varies with site conditions and soil types but is typically 100 to 200 tons per acre and may be as high as 500 tons per acre. In N.C., 15% to 32% of eroded soil is transported to valuable water resources (SCS, 1977).

Identifying erosion problems at the planning stage and noting highly erodible areas, helps in selecting effective erosion control practices and estimating storage volumes for sediment traps and basins. This manual focuses primarily on the prevention of sedimentation problems associated with water-generated soil erosion.

THE EROSION AND SEDIMENTATION PROCESS

Types of Erosion

Erosion is a natural process by which soil and rock material is loosened and removed. Erosion by the action of water, wind, and ice has produced some of the most spectacular landscapes we know. Natural erosion occurs primarily on a geologic time scale, but when man's activities alter the landscape, the erosion process can be greatly accelerated. Construction-site erosion causes serious and costly problems, both on-site and off-site.

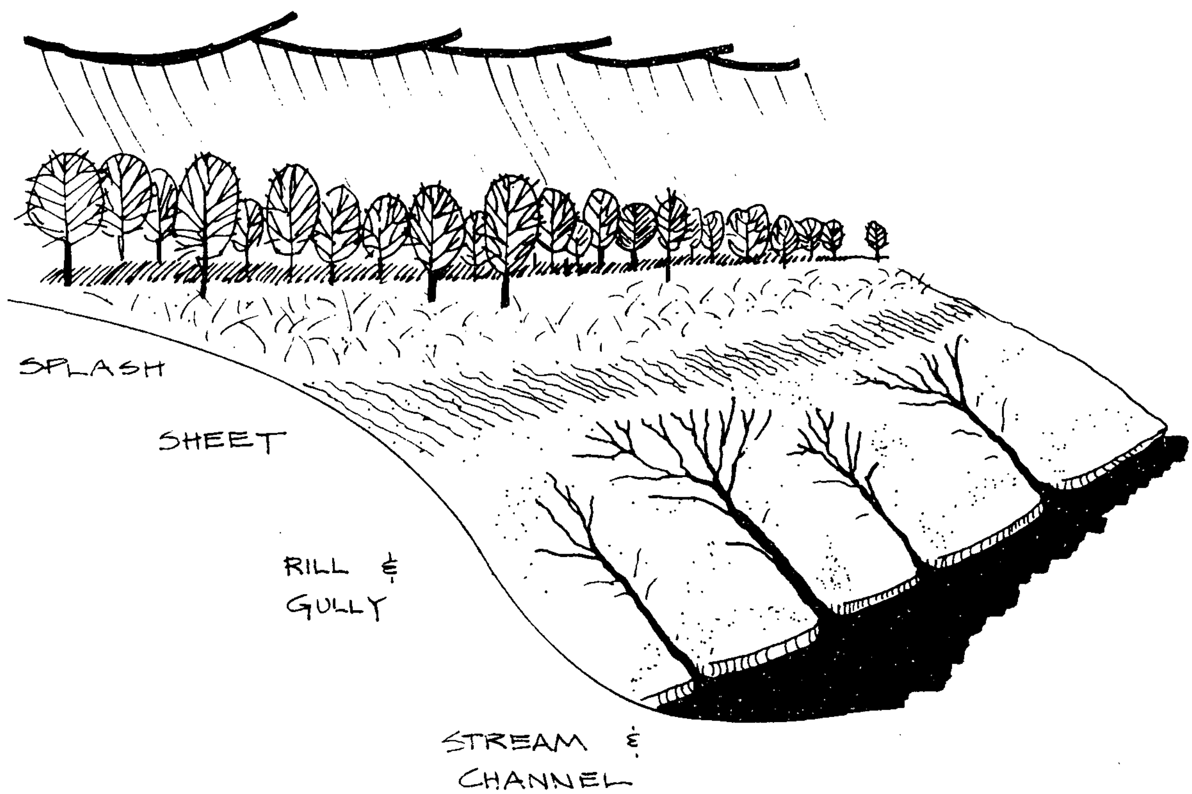


Figure 2.1 The four types of soil erosion on an exposed slope.

The soil erosion process begins by water falling as raindrops and flowing on the soil surface. Figure 2.1 illustrates the four types of soil erosion on exposed terrain: **splash, sheet, rill, and gully**, and **stream and channel**. Splash erosion results when the force of raindrops falling on bare or sparsely vegetated soil detaches soil particles. Sheet erosion occurs when these soil particles are easily transported in a thin layer, or sheet, by water flowing. If this sheet runoff is allowed to concentrate and gain velocity, it cuts rills and gullies as it detaches more soil particles. As the erosive force of flowing water increases with slope length and gradient, gullies become deep channels and gorges. The greater the distance and slope, the more difficult it is to control the increasing volume and velocity of runoff and the greater the resultant damage.

Sedimentation

Sedimentation is the deposition of soil particles that have been transported by water and wind. The quantity and size of the material transported increases with the velocity of the runoff. Sedimentation occurs when the water in which the soil particles are carried is sufficiently slowed for a long enough period of time to allow particles to settle out. Heavier particles, such as gravel and sand, settle out sooner than do finer particles, such as clay. The length of time a particle stays in suspension increases as the particle size decreases. The colloidal clays stay in suspension for very long periods and contribute significantly to water turbidity.

Factors that Influence Erosion

The potential for an area to erode is determined by four principal factors: soils, surface cover, topography, and climate. These factors are interrelated in their effect on erosion potential. The variability in North Carolina's terrain, soils, and vegetation makes erosion control unique to each development.

Understanding the factors that effect the erosion process enables us to make useful predictions about the extent and consequences of on-site erosion. An empirical model developed for agricultural applications, the Universal Soil Loss Equation (USLE), predicts soil loss resulting from sheet and rill erosion. It considers both the effects of erosion control practices and the factors that influence erosion, so it is useful for evaluating erosion problems and potential solutions. The factors that influence erosion are soil characteristics, surface cover, topography, and climate.

Soils

A soil is a product of its environment. The vulnerability of a soil to erosion, known as its erodibility, is a result of a number of soil characteristics, which can be divided into two groups: those influencing infiltration, the movement of water into the ground; and those affecting the resistance to detachment and transport by rainfall and runoff. The soil erodibility factor (K) is a measure of a soil's susceptibility to erosion by water. Key factors that affect erodibility are soil texture, content of organic matter, soil structure, and soil permeability.

Soil texture is described by the proportions of sand, silt, and clay in the soil. High sand content gives a coarse texture, which allows water to infiltrate readily, reducing runoff. A relatively high infiltration rate coupled with resistance to transport by runoff results in a low erosion potential. Soils containing high proportions of silt and very fine sand are most erodible. Clay acts to bind particles and tends to limit erodibility; however, when clay erodes, the particles settle out very slowly.

Because **organic matter**, such as plant material, humus, or manure, improves soil structure, increases water-holding capacity, and may increase the infiltration rate, it reduces erodibility and the amount of runoff.

Soil structure is determined by the shape and arrangement of soil particles (Figure 2.2). A stable, sharp, granular structure absorbs water readily, resists erosion by surface flow, and promotes plant growth. Clay soils or compacted soils have slow infiltration capacities that increase runoff rate and create severe erosion problems.

Soil permeability refers to a soil's ability to transmit air and water. Soils that are least subject to erosion from rainfall and shallow surface runoff are those with high permeability rates, such as well-graded gravels and gravel-sand mixtures. Loose, granular soils reduce runoff by absorbing water and by providing a favorable environment for plant growth.

Surface Cover

Vegetation is the most effective means of stabilizing soils and controlling erosion. It shields the soil surface from the impact of falling rain, reduces flow velocity, and disperses flow. Vegetation provides a rough surface that slows the runoff velocity and promotes infiltration and deposition of sediment.

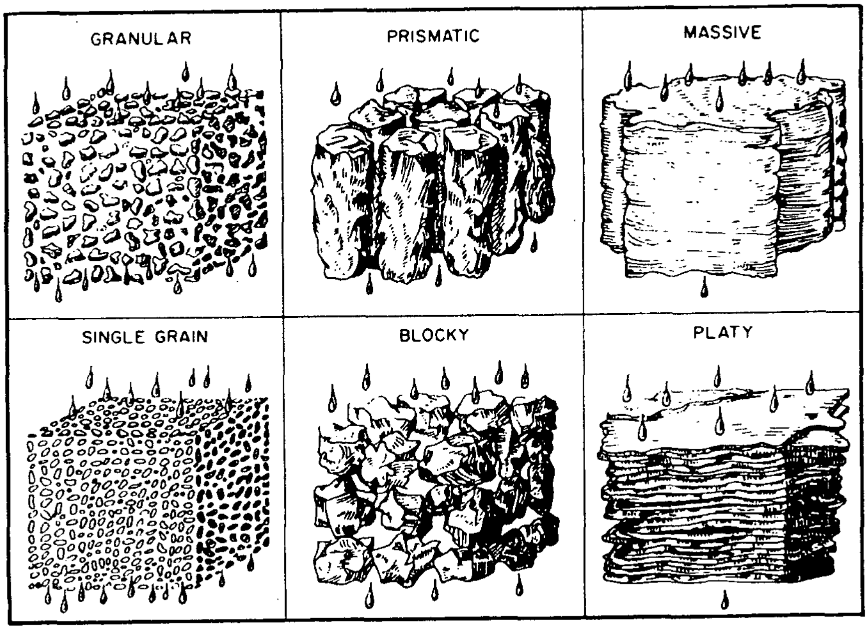


Figure 2.2 Soil structure influences the *infiltration rate and movement of water in* a soil. (Source: USDA and U.S. Department of the Interior, Agr. Inf. Bul. No. 199, 1959)

Plants remove water from the soil and thus increase the soil's capacity to absorb water. Plant leaves and stems protect the soil surface from the impact of raindrops, and the roots help maintain the soil structure.

The type and condition of ground cover influence the rate and volume of runoff. Although impervious surfaces protect the area covered, they prevent infiltration and thereby decrease the time of concentration for runoff. The result is high peak flow and increased potential for stream and channel erosion (Figure 2.3).

Nonvegetative covers such as mulches, paving, and stone aggregates also protect soils from erosion.

Topography

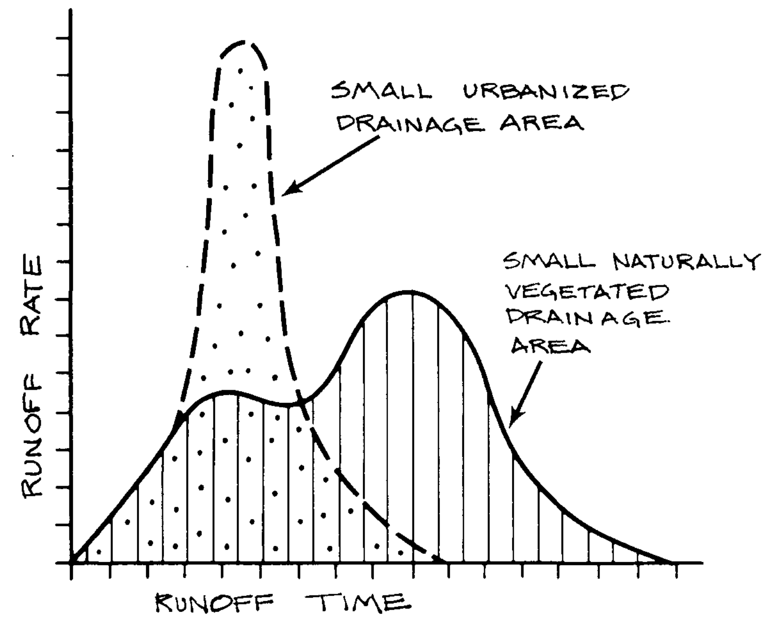
Topographic features distinctly influence erosion potential. Watershed size and shape, for example, affect runoff rates and volumes. Long, steep slopes increase runoff flow velocity. Swales and channels concentrate surface flow, which results in higher velocities. Exposed south-facing soils are hotter and drier, which makes vegetation more difficult to establish.

Climate

North Carolina has considerable diversity of climate. A hurricane season along the coastal region and snow and ice in the mountains are examples of the extremes in weather. High-intensity storms that are common in North Carolina produce far more erosion than low-intensity, long-duration storms with the same runoff volume.

The frequency, intensity, and duration of rainfall and the size of the area on which the rain falls are fundamental factors in determining the amount of runoff produced. Seasonal temperature changes also define periods of high erosion risk. For example, precipitation as snow creates no erosion, but repeated freezing and thawing breaks up soil aggregates, which can be transported readily in runoff from snowmelt.

Figure 2.3 Comparison of runoff in natural and urbanized drainage areas.



Impacts of Erosion and Sedimentation

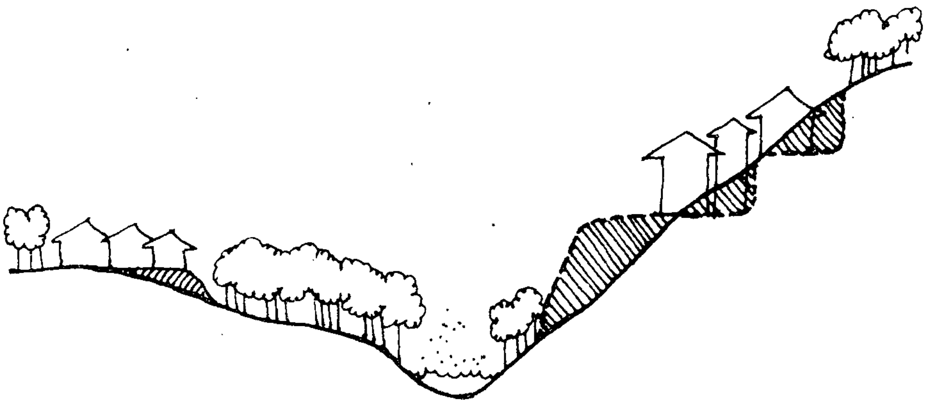
Damage from sedimentation is expensive both economically and environmentally. Sediment deposition destroys fish spawning beds, reduces the useful storage volume in reservoirs, clogs streams, may carry toxic chemicals, and requires costly filtration for municipal water supplies. Suspended sediment can reduce in-stream photosynthesis and alter a stream's ecology. Many environmental impacts from sediment are additive, and the ultimate results and costs may not be evident for years. The consequences of off-site sedimentation can be severe and should not be considered as just a problem to those immediately affected.

On-site erosion and sedimentation can cause costly site damage and construction delays. Lack of maintenance often results in failure of control practices and expensive cleanup and repairs.

PRINCIPLES OF EROSION AND SEDIMENTATION CONTROL

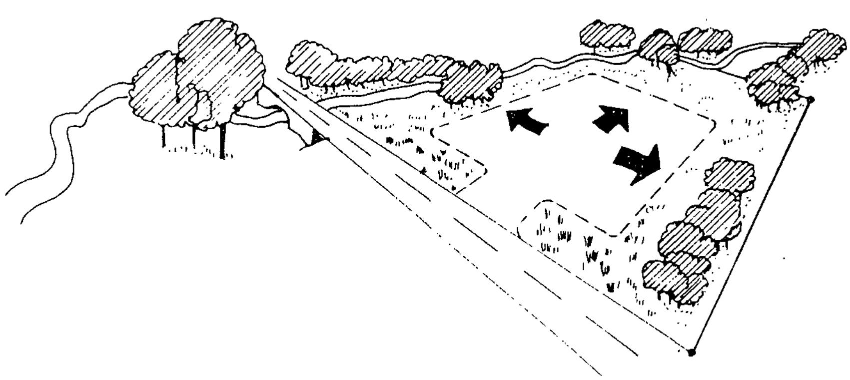
Effective erosion and sedimentation control requires first that the soil surface be protected from the erosive forces of wind, rain, and runoff, and second that eroded soil be capture on-site. The following principles are not complex but are effective. They should be integrated into a system of control measures and management techniques to control erosion and prevent off-site sedimentation.

Fit the Development to Existing Site Conditions



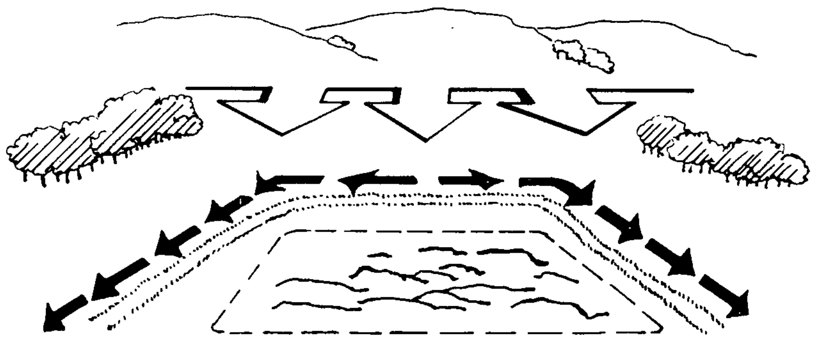
Review and consider all existing conditions in the initial site selection for the project. Select a site that is suitable rather than force the terrain to conform to development needs. Ensure that development features follow natural contours. Steep slopes, areas subject to flooding, and highly erodible soils severely limit a site's use, while level, well-drained areas offer few restrictions. **Any modifications of a site's drainage features or topography requires *protection from erosion and sedimentation.***

Minimize the Extent and Duration of Exposure



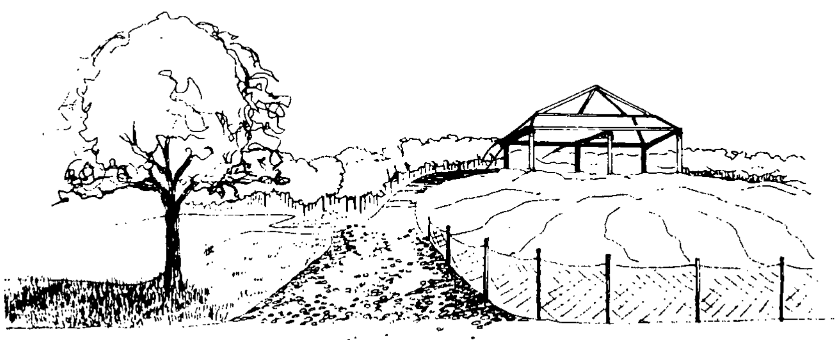
Scheduling can be a very effective means of reducing the hazards of erosion. Schedule construction activities to minimize the exposed area and the duration of exposure. In scheduling, take into account the season and the weather forecast. Stabilize disturbed areas as quickly as possible.

Protect Areas to be Disturbed from Stormwater Runoff



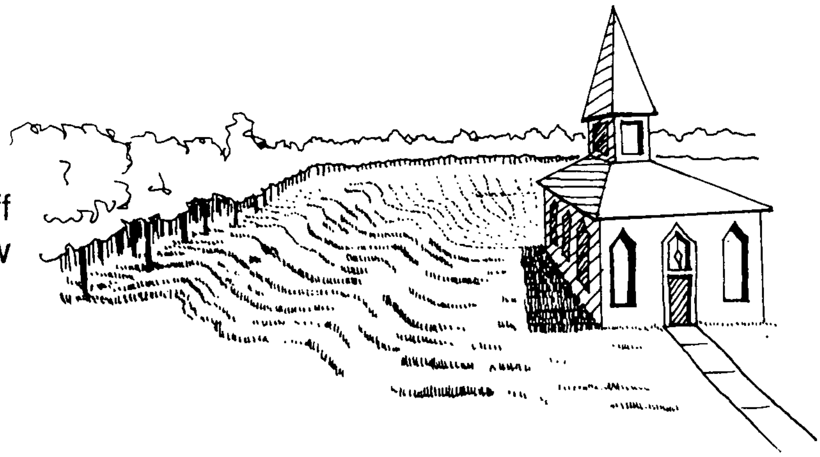
Use dikes, diversions, and waterways to intercept runoff and divert it away from cut-and-fill slopes or other disturbed areas. To reduce on-site erosion, install these measures before clearing and grading.

Stabilize Disturbed Areas



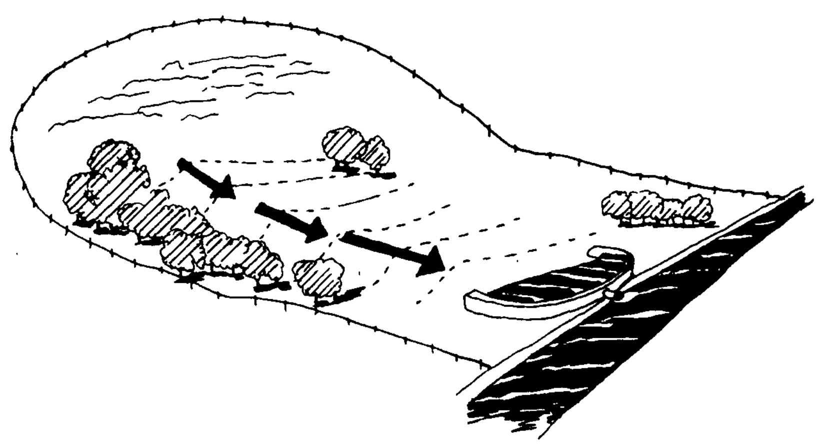
Removing the vegetative cover and altering the soil structure by clearing, grading, and compacting the surface increases an area's susceptibility to erosion. Apply stabilizing measures as soon as possible after the land is disturbed. Plan and implement temporary or permanent vegetation, mulches, or other protective practices to correspond with construction activities. Protect channels from erosive forces by using protective linings and the appropriate channel design. Consider possible future repairs and maintenance of these practices in the design.

Keep Runoff Velocities Low



Clearing existing vegetation reduces the surface roughness and infiltration rate and thereby increases runoff velocities and volumes. Use measures that break the slopes to reduce the problems associated with concentrated flow volumes and runoff velocities. Practical ways to reduce velocities include conveying stormwater runoff away from steep slopes to stabilized outlets, preserving natural vegetation where possible, and mulching and vegetating exposed areas immediately after construction.

Retain Sediment on the Site



Even with careful planning some erosion is unavoidable. The resulting sediment must be trapped on the site. Plan the location where sediment deposition will occur and maintain access for cleanout. Protect low points below disturbed areas by building barriers to reduce sediment loss. **Whenever possible, plan and construct sediment traps and basins before other land-disturbing activities.**

Inspect and Maintain Control Measures

Inspection and maintenance is vital to the performance of erosion and sedimentation control measures. If not properly maintained, some practices may cause more damage than they prevent. Always evaluate the consequences of a measure failing when considering which control measure to use, since failure of a practice may be hazardous or damaging to both people and property. For example, a large sediment basin failure can have disastrous results; low points in dikes can cause major gullies to form on a fill slope. It is essential to inspect all practices to determine that they are working properly and to ensure that problems are corrected as soon as they develop. Assign an individual responsibility for routine checks of operating erosion and sedimentation control practices.

3

Vegetative Considerations

3

Vegetative Considerations

EFFECTS OF VEGETATION ON EROSION, SEDIMENTATION, AND PROPERTY VALUE

Dense, vigorous vegetation protects the soil surface from raindrop impact, a major force in dislodging soil particles and moving them downslope. It also shields the soil surface from the scouring effect of overland flow and decreases the erosive capacity of the flowing water by reducing its velocity.

The shielding effect of a plant canopy is augmented by roots and rhizomes that hold the soil, improve its physical condition, and increase the rate of infiltration, further decreasing runoff. Plants also reduce the moisture content of the soil through transpiration, thus increasing its capacity to absorb water (Figure 3.1)

Suitable vegetative cover affords excellent erosion protection and sedimentation control and is essential to the design and stabilization of many structural erosion control devices. Vegetative cover is relatively inexpensive to achieve and tends to be self-healing; it is often the only practical, long-term solution to stabilization and erosion control on most disturbed sites in North Carolina.

Planning from the start for vegetative stabilization reduces its cost, minimizes maintenance and repair, and makes structural erosion control measures more effective and less costly to maintain. Post-construction landscaping is also less costly where soils have not been eroded, slopes are not too steep, and weeds are not allowed to proliferate. Natural areas—those left undisturbed—can provide low-maintenance landscaping, shade, and screening. Large trees increase property value if they are properly protected during construction.

Besides preventing erosion, healthy vegetative cover provides a stable land surface that absorbs rainfall, cuts down on heat reflectance and dust, restricts weed growth, and complements architecture. The result is a pleasant environment for employees, tenants and customers, and an attractive site for homes. Property values can be increased dramatically by small investments in erosion control. Even the final landscaping represents only a small fraction of total construction costs and contributes greatly to the marketing potential of a development.

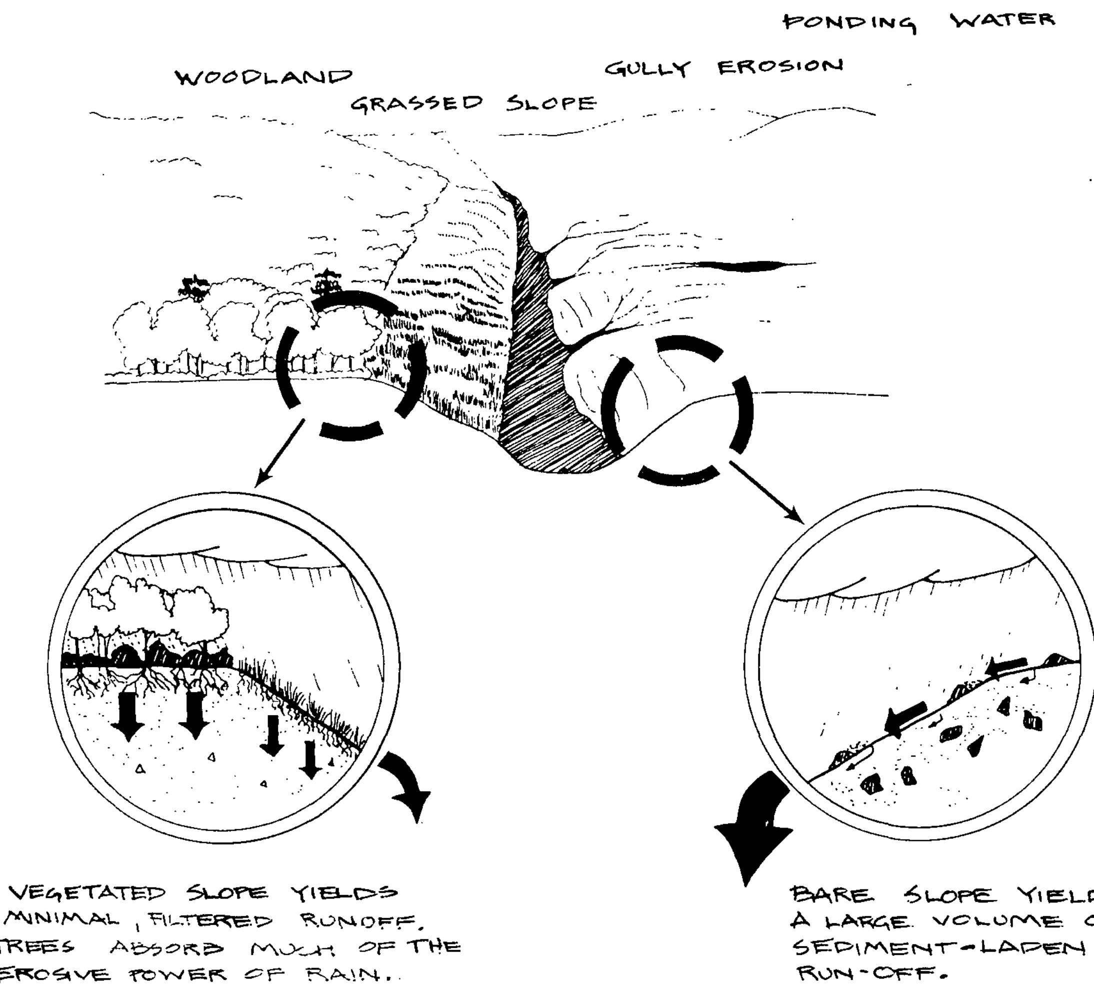


Figure 3.1 Effects of vegetation on erosion.

SITE CONSIDERATIONS

Species selection, establishment methods, and maintenance procedures should be based on site characteristics including soils, slope, aspect, climate, and expected management.

Slope

The steeper the slope, the more essential is a vigorous vegetative cover. Good establishment practices, including seedbed preparation, quality seed, lime, fertilizer, mulching and tacking are critical. The degree of slope may limit the equipment that can be used in seedbed preparation, planting, and maintenance; steep slopes also increase costs.

Aspect

Aspect affects soil temperature and available moisture. South-and west-facing slopes tend to be warmer and drier, and often require special treatment. For example, mulch is essential to retain moisture, and drought-tolerant plant

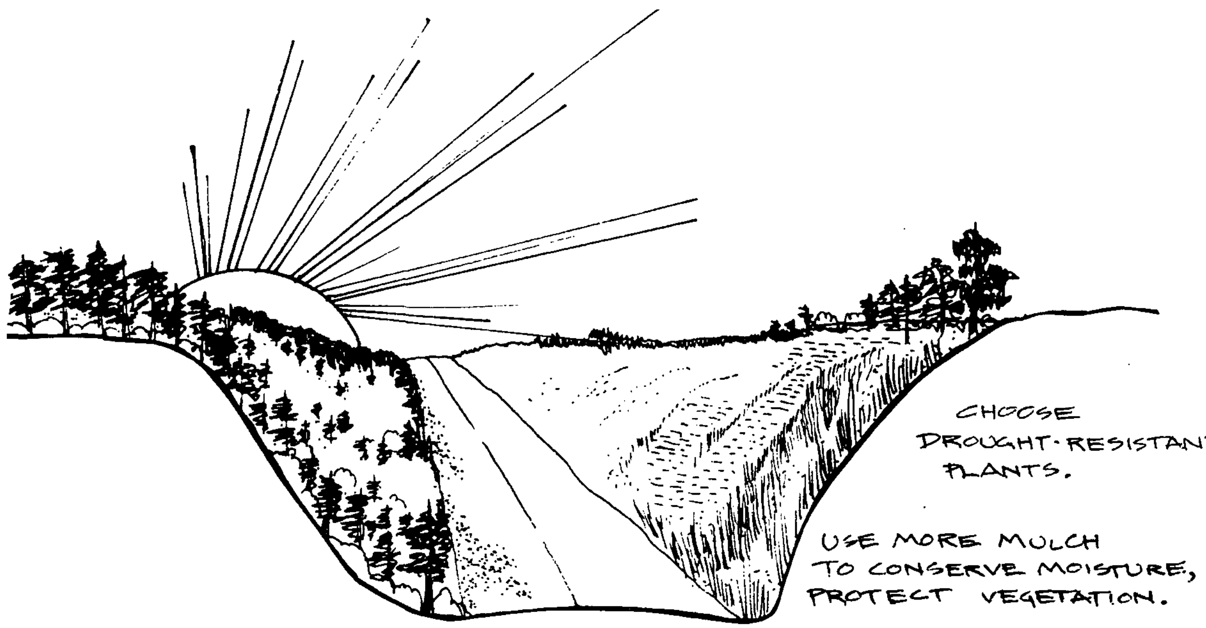


Figure 3.2 South- and west-facing slopes are hot and dry.

species should be added to the seed mixture (Figure 3.2). South- and west-facing slopes also may be subject to more frost heaving due to repeated cycles of freezing and thawing.

Climate

The regional climate must be considered in selecting well-adapted plant species. North Carolina recommendations are usually based on three broad physiographic regions: Mountain, Piedmont, and Coastal Plain. Climatic differences determine the appropriate plant selections based on such factors as cold-hardiness, tolerance to high temperatures and high humidity, and resistance to disease.

Management

When selecting plant species for stabilization, consider post-construction land use and the expected level of maintenance. In every case, future site management is an important factor in plant selection.

Where a neat appearance is desired, use plants that respond well to frequent mowing and other types of intensive maintenance. Likely choices for quality turf in the west are tall fescue, Kentucky bluegrass, and Bermudagrass, or in the east, Bermudagrass, centipedegrass, zoysiagrass, and Bahiagrass.

At sites where low maintenance is desired, longevity is particularly important. Sericea lespedeza, tall fescue, annual lespedeza, and, in some cases, Bermudagrass, redtop, or crownvetch are likely choices. Other species may be appropriate to intermediate levels of maintenance.

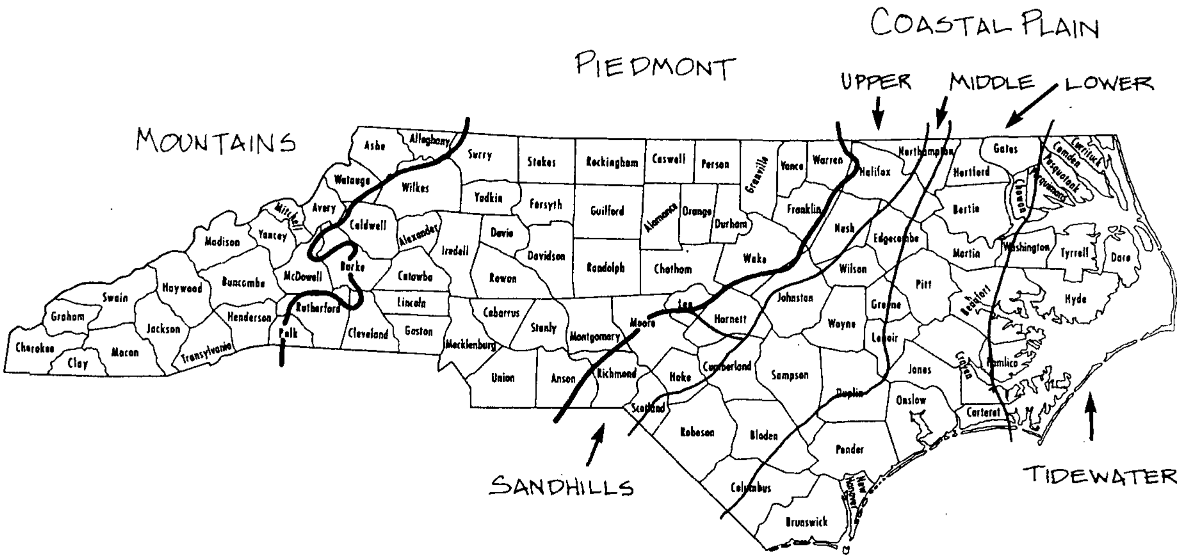


Figure 3.3 Major physiographic regions of North Carolina differ in relief, geology, climate, elevation, and major soil systems.

Soils

Many soil characteristics— including texture, organic matter, fertility, acidity, moisture retention, drainage, and slope—influence the selection of plants and the steps required for their establishment. The following is a very general description of North Carolina soils with respect to characteristics that affect stabilization of disturbed sites. Soil formation in North Carolina has been influenced primarily by parent materials and relief. As a result, soils differ among the major physiographic regions shown in Figure 3.3.

Mountain Region

Surface soils of the Mountain Region vary from sandy loam to clay loam, with shallow subsoils varying from silt loams to sandy loams. Steep slopes with shallow, stony, droughty soils are common. Many mountain soils have been severely eroded. On more level topography, deeper profiles provide greater water-storage capacity and room for root growth. Shallow, stony soils and steep slopes present major problems for vegetation establishment in this region. Permanent vegetation is normally selected from cool-season, winter-hardy perennials.

Piedmont Region

Piedmont soils are similar to those of the Mountains but, in general, are deeper, lower in organic matter, and have subsoils higher in clay. Deeper subsoils are typically silts, silt loams, and sandy loams. Surface soils vary from sandy loam to clay loam, and subsoils are commonly thick with heavy clay texture. While topography is gentler than in the Mountains, it is mostly rolling to hilly, with well-developed drainage patterns. Soils are generally well to excessively drained.

The sloping terrain and silty subsoils often result in severe erosion potential. As a result of previously poor management practices, many areas are moderately to severely eroded.

Piedmont soils generally support a wide variety of plants, including both cool- and warm-season species. Sites that are steep, shallow, stony, droughty, or severely eroded present problems for establishment of vegetation.

Coastal Plain Region

Coastal Plain soils include some of the easiest and some of the most difficult soils to vegetate. The Coastal Plain region has several different subregions to consider.

The Sand Hills region of the Coastal Plain is dominated by coarse, deep, excessively drained sand and rolling topography. These soils are extremely low in organic matter and plant nutrients. When disturbed, they are subject to both wind and water erosion. These are some of the most erodible soils in the State and need to be treated with the utmost caution. Due to their low water-holding capacity, revegetation requires highly drought-resistant species.

Upper and Middle Coastal Plain soils generally have well-drained sandy loam surface horizons underlain by sandy clay loam subsoils. Topography is undulating to nearly level. These soils retain more moisture and nutrients than the sands of the Sand Hills and coastal dunes, and support a wider variety of vegetation. However, they are still quite erodible when disturbed. The region also includes some poorly drained soils and some excessively drained "Sand Hills" soils.

Lower Coastal Plain soils vary from well-drained to poorly drained and from sand to silt loam in texture. The coarser soils are extremely erodible. Poorly drained soils ranging from sands to organics are limited in extent. Along the southern coast both old and young dune sands occur. Choice of species for revegetation is largely determined by moisture retention and drainage conditions. Dune sands require a unique group of species.

The Tidewater Region is dissected by sounds and numerous wide rivers. Soils may be wet and mostly organic or mineral soils with high clay content. Draining these soils can be difficult. The organic mucks and peats are most often underlain by sand, but may have silt or clay subsoils.

Nature of Disturbed Soils

Throughout the State, most disturbed sites end up, after grading, with a surface consisting of acid, infertile subsoil materials that are toxic to most plants (Figure 3.4). Such soils may not be capable of supporting the dense growth necessary to prevent erosion. Construction activities further decrease soil productivity by increasing compaction, making slopes steeper, and altering drainage patterns. Topsoiling, soil amendments, and special seedbed preparation are generally required to offset these problems.

Soil Sampling

A good sedimentation control plan should include thorough soil sampling in the area of planned construction. Different soils should be sampled separately. Containers for soil samples and instructions for sampling may be obtained from any local Agricultural Extension office or from the North Carolina Department of Agriculture. Analysis of soil samples is available from the NCDA soil testing lab. Test results include lime and fertilizer recommendations. Fertilizing

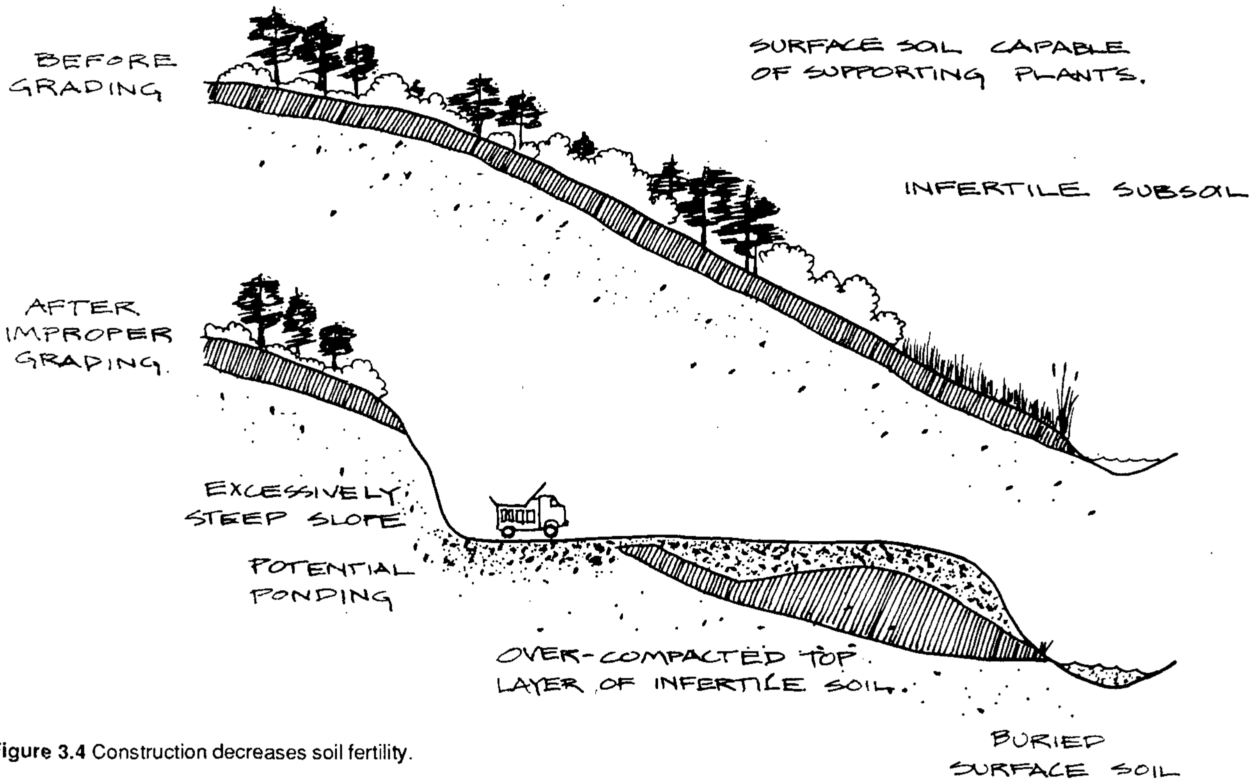


Figure 3.4 Construction decreases soil fertility.

according to the soil test ensures the most efficient expenditure of money for fertilizer and a minimum of excess fertilizer to pollute streams or groundwater. Soil sampling should begin well in advance of planting because 1 to 6 weeks are required to obtain soil test results.

Soil Limitations

Certain soil factors are difficult to modify and can impose severe limitations on plant growth. These include such things as depth, stoniness, texture, and properties related to texture such as water- and nutrient-holding capacity. Extremely coarse textures result in droughtiness and nutrient deficiencies. Fine textures, on the other hand, impede infiltration and decrease permeability, thereby increasing the volume of runoff. Toxic levels of elements such as aluminum, iron, and manganese are limiting to plant growth. However, these become less soluble as the pH is raised, so that toxicity problems can usually be eliminated by liming. Toxicities from industrial waste could also make the soil unsuitable for plant growth.

Portions of this manual refer to "poor" , "severe", "droughty", and "adverse" soils. These are subjective terms that require judgement based on experience in revegetating disturbed soils. They refer to soils that require special treatment beyond routine tillage and fertilization. *Appendix 8.01* provides guidance for identifying soils and predicting their characteristics.

SEASONAL CONSIDERATIONS

Newly constructed slopes and other unvegetated areas should be seeded and mulched, or sodded, as soon as possible after grading. Where feasible, grading operations should be planned around optimal seeding dates for the particular region. The most effective times for planting perennials generally extend from March through May and from August through October. Outside these dates the probability of failure is higher. If the time of year is not suitable for seeding permanent cover (perennial species), a temporary cover crop should be planted. Otherwise, the area must be stabilized with gravel or mulch. Temporary seeding of annual species (small grains, Sudangrass, or German millet) often succeeds at times of the year that are unsuitable for seeding permanent (perennial) species. Some annual species may be recommended for late winter through spring, summer, or late summer late fall. Planting dates differ with physiographic region.

Seasonality must be considered when selecting species. Grasses and legumes are usually classified as warm- or cool-season in reference to their season of growth. Cool-season plants produce most of their growth during the spring and fall and are relatively inactive or dormant during the hot summer months. Therefore fall is the most dependable time to plant them. Warm-season plants greenup late in the spring, grow most actively during the summer, and go dormant at the first frost in fall. Spring and early summer are preferred planting times for warm-season plants.

Variations in weather and local site conditions can modify the effects of regional climate. For this reason, mixtures including both cool- and warm-season species are preferred for low-maintenance cover, particularly in the Piedmont. Such mixtures promote cover adapted over a range of conditions. These mixtures are not desirable, however, for high-quality lawns, where variation in texture of the turf is inappropriate.

SELECTION OF VEGETATION

Species selection should be considered early in the process of preparing the erosion and sedimentation control plan. A diversity of vegetation can be grown in North Carolina, due to the variation in both soils and climate. However, for practical, economical stabilization and long-term protection of disturbed sites, species selection should be made with care. Many widely occurring plants are inappropriate for soil stabilization because they do not protect the soil effectively, or because they are not quickly and easily established. Plants that are preferred for some sites may be poor choices for others; a few can become troublesome pests.

Initial stabilization of most disturbed sites requires grasses and legumes that grow together without gaps. This is true even where part or all of the site is planted to trees or shrubs. In landscape plantings, disturbed soil between trees and shrubs must also be protected either by mulching or by permanent grass-legume mixtures. Although mulching alone is an alternative, it requires continuing maintenance.

Mixture vs Single-Species Plantings

Single-species plantings are warranted in many cases, but they are more susceptible than mixtures to damage from disease, insects, and weather extremes. In addition, mixtures tend to provide protective cover more quickly. Consequently, the inclusion of more than one species should always be considered for soil stabilization and erosion control. Mixtures need not be elaborate. The addition of a quick-growing annual provides early protection and facilitates establishment of one or two perennials. More complex mixtures might include a quick-growing annual, one or two legumes, and one or two perennial grasses (*Practice Standards and Specifications: 6.11, Permanent Seeding*).

Companion or "Nurse" Crops

The addition of a "nurse" crop (quick-growing annuals added to permanent mixtures) is a sound practice for soil stabilization, particularly on difficult sites—those with steep slopes; poor, stony, erosive soils; late seedings, etc.—or in any situation where the development of permanent cover is likely to be slow. The nurse crop germinates and grows rapidly, holding the soil until the slower-growing perennial seedlings become established (Figure 3.5). Nurse crop recommendations are included in *Practice Standards and Specifications: 6.11, Permanent Seeding.*

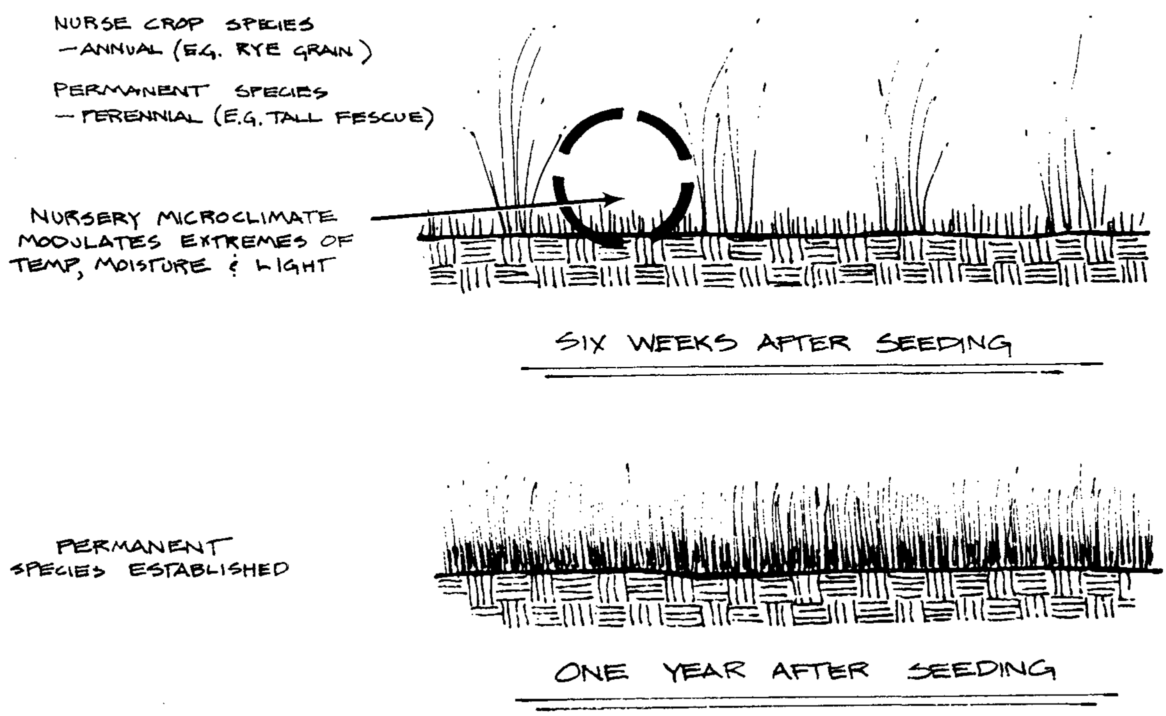


Figure 3.5 Nurse crops promote the establishment of permanent species.

Seeding rate of the nurse crop must be limited to avoid crowding, especially under optimum growing conditions. Seeding rates recommended in this manual are designed to avoid overcrowding. **Do not exceed the recommended rate.**

Plants Species Selection

Table 3.1 is a summary of the major plant species available for stabilization use in North Carolina. This summary is based on research and many years of field experience. Using this information makes plant selection straightforward for most situations. Recommended plants and some of more limited application are listed in Table 8.02a, *Appendix 8.02*, along with their botanical names. Specific seeding rates are given in *Practice Standards and Specifications: 6.10, Temporary Seeding*, and *6.11, Permanent Seeding.*

Annuals

Annual plants grow rapidly and then die in one growing season. The are useful for quick, temporary cover or as nurse crops for slower-growing perennials.

Winter rye (grain) is usually superior to other winter annuals (wheat, oats, crimson clover, etc.) both for temporary seeding and as a nurse crop in permanent mixtures. It has more cold-hardiness than other annuals and will germinate and grow at lower temperatures. By maturing early, it offers less competition during the late spring period. a critical time in the establishment of perennial species. Rye grain germinates quickly and is tolerant of poor soils. Including rye grain in fall-seeded mixtures is almost always advantageous. but it is particularly helpful on difficult soils and erodible slopes or when seeding is late. Overly thick stands of rye grain will suppress the growth of perennial seedlings. **Limit seeding rates to the suggested level.** About 50 lb/acre is the maximum for this purpose, and where lush growth is expected, that rate should either be cut in half, or rye grain should be eliminated from the mixture.

Table 3.1 Plants Recommended for Revegetating Disturbed Soils in North Carolina

	Annuals	Perennials
Cool-season grasses	Winter rye (grain)	Tall fescue Kentucky bluegrass Redtop
Warm-season grasses	German millet Sudangrass	Bermudagrass Bahiagrass Centipedegrass
Legumes	Annual lespedeza	Crownvetch Sericea lespedeza
Marsh plants		Smooth cordgrass Saltmeadow cordgrass Giant cordgrass
Dune plants		American beachgrass Sea oats Bitter panicum Saltmeadow cordgrass

Annual ryegrass is **not recommended** for use in North Carolina (Figure 3.6). It provides dense cover rapidly, but may be more harmful than beneficial in areas that are to be permanently stabilized. Annual ryegrass is highly competitive, and if included in mixtures, it crowds out most other species before it matures in late spring or early summer, leaving little or no lasting cover. It can be effective as a temporary seeding, but if allowed to mature the seed volunteers and seriously interferes with subsequent efforts to establish permanent cover. Winter rye (grain) is preferable in most applications.

German millet is a fine-stemmed summer annual, useful for temporary seeding, as a nurse crop, and for tacking mulch. It is better adapted to sandy soils than are the Sudangrasses. Normal seeding dates are between the last frost in spring and the middle of August.

Sudangrass—Only the small-stemmed varieties of Sudangrass should be used. Like German millet, Sudangrass is useful for temporary seeding and as a nurse crop, but it is adapted to soils higher in clay content. Seed for common Sudangrass is not always available, but other small-stemmed types may be used, such as the hybrid Trudan. **The coarse-stemmed sorghum-Sudangrass hybrids are not satisfactory as nurse plants and are not appropriate for erosion control**. Seeding dates are similar to those for German millet.

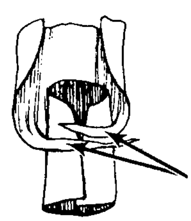


Figure 3.6 Annual ryegrass is recognized by flowers directly attached to a central stem and claw-like auricles at the leaf attachment.

Annual lespedeza is a warm-season, self-reseeding annual legume that is tolerant of low fertility and is adapted to climate and most soils throughout the state. It is an excellent nurse crop in the spring, filling in weak or spotty stands the first season without suppressing the perennial seedlings. It is often seeded with sericea lespedeza. Annual lespedeza can heal damaged areas in the perennial cover for several years after initial establishment. Two varieties of annual lespedeza are generally available: Kobe and Korean. Kobe is superior on sandy soils and generally preferable in the Coastal Plain. Both Kobe and Korean are satisfactory in the Piedmont. Korean is better in the mountains as the seeds mature earlier.

The preferred seeding dates for annual lespedeza are in late winter to early spring. It can be mixed with fall seedings. In which case some seeds remain dormant over the winter and germinate the following spring. However, it is more effective to overseed with lespedeza in February or March.

Cool-Season Perennials

Perennial plants remain viable over winter and initiate new growth each year. Stands of perennials persist indefinitely under proper management and environmental conditions. They are the principal components of permanent vegetative cover.

Cool-season perennials produce most of their growth during the spring and fall and are more cold-hardy than most warm-season species. Descriptions of the species recommended for vegetating disturbed soils follow.

Tall fescue, a cool-season grass, is the most widely used species in the state for erosion control (Figure 3.7). It is well-adapted to all but the most droughty soils of the Sand Hills and Coastal Plain. It thrives in full sun to partial shade and is easy to establish. If seeded in the fall, it provides stabilization early in the first growing season. Because of tall fescue's bunchy growth habit, it is best used in mixtures. It does not fill in well where areas are damaged by disease or weather; however, short rhizomes enable individual plants to expand substantially in thin stands.

A number of new varieties of tall fescue are becoming available for lawn and other fine turf use and several offer definite improvements. However, their higher cost over the old standby, KY31, is seldom justified solely for purposes of stabilization and erosion control. Tall fescue tolerates a wide range of seeding dates, but, with the possible exception of high mountain elevations, it is most dependable when fall-planted. It is adapted to both high- and low-maintenance uses, tolerating frequent or no mowing. Liberal fertilization and proper liming are essential for prompt establishment of tall fescue, but once firmly in place it can tolerate minimal maintenance almost indefinitely.

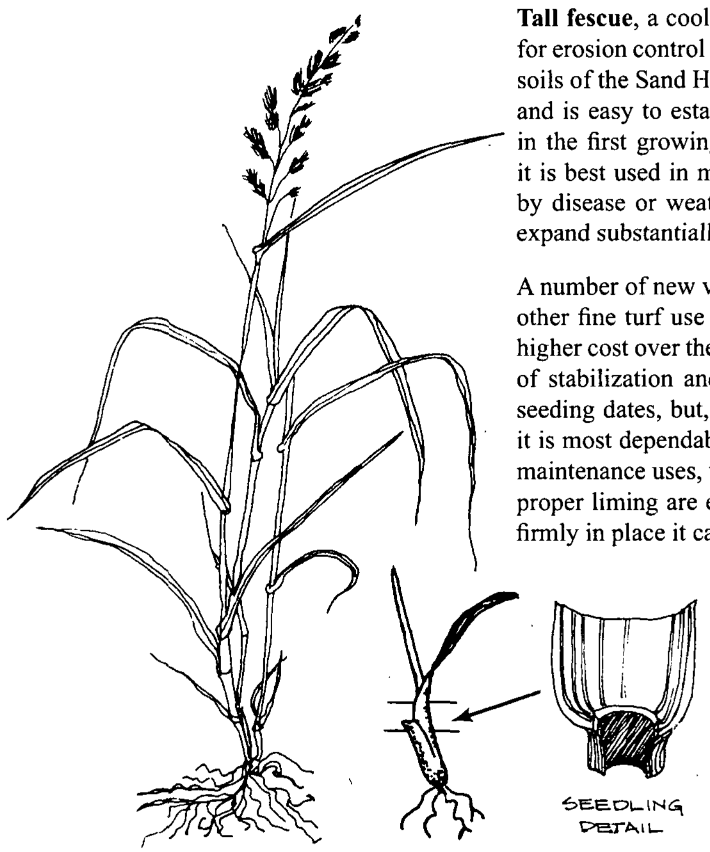


Figure 3.7 Tall fescue is a common perennial easily confused with ryegrass. Seedhead is branched, loose and open. Auricles are absent in young plants (compare with Figure 3.6).

Kentucky bluegrass is the dominant lawn grass in the Mountains and Upper Piedmont. It has higher lime and fertility requirements than the other perennial grasses used in these regions. Bluegrass spreads by strong rhizomes and, where adapted, is an excellent soil stabilizer, readily filling in damaged spots. As with tall fescue, it has been the subject of intensive breeding activity in recent years, resulting in varieties with more heat tolerance and resistance to hot-weather diseases. Mixtures of these new varieties with improved types of tall fescue are becoming popular, particularly for Piedmont lawns, where they can be used in both sun and partial shade.

Redtop is a tough, cool-season perennial grass tolerant of infertile, droughty, somewhat acid soils. It can be a useful component of mixtures on dry, stony slopes in the western half of the state, particularly in the Mountain region.

Warm-Season Perennials

Warm-season perennials initiate growth later in the spring than cool-season species and experience their greatest growth during the hot summer months. Warm-season species are not generally used in the Mountains; most species thrive only in areas on the Coastal Plain. The following grasses have proven the most useful for soil stabilization.

Bermudagrass is an aggressive, sod-forming warm-season perennial adapted to a wide range of well-drained to excessively drained soils throughout the Piedmont and Coastal Plain. It is very drought-resistant, has considerable salt-tolerance, and can be very useful for erosion control, particularly on deep sands in the Sand Hills and near the coast. Bermudagrass is not at all shade tolerant.

Figure 3.8 Common Bermudagrass.

Common Bermudagrass (Figure 3.8) should be used with **extreme care** as it quickly becomes a pest in croplands, gardens, and landscape plantings, spreading rapidly both vegetatively and by seed. It is difficult to control and almost impossible to eradicate.

The turf- and hay-type hybrids do not produce viable seed and are less aggressive. Therefore, they are much easier to control, and are less likely to become pests. However, hybrid Bermudas are more costly to establish because they must be planted from sprigs or plugs. In fact, the cost involved in establishing turf-type hybrids makes them generally practical only for fine turf use.

Common Bermudagrass is normally seeded in late spring using "hulled" seed (seed from which the outer covering or bracts have been removed). Unhulled seed may be used in fall-seeded mixtures because it lies dormant over winter and germinates in the spring. Hybrid varieties are planted in early spring, while soil moisture is still adequate. They may be planted later if water is available for irrigation.

Bahiagrass is a warm-season perennial grass adapted to the lower Piedmont and Coastal Plain. It tolerates dry, acid, low-fertility soils. Bahiagrass produces a fairly dense sod suitable for low-maintenance lawns, were it not for the production of unsightly seedheads (1-2 feet high) throughout the growing season.

Unfortunately, the strain of Bahiagrass generally available, Pensacola, is occasionally subject to winter-kill at this latitude. Consequently, it should not be relied upon in pure stands. The Wilmington strain is more cold-tolerant, but seed is not generally available.

Centipedegrass is adapted to well-drained, medium- to coarse-textured soils in the eastern Piedmont and Coastal Plain. Generally used as a low- to moderate-maintenance turf, it is tolerant of infertile, low pH soils, heat, drought, and cold.

A serious problem with centipedegrass is its slow growth rate. Also, when grown on dry sands, irrigation is required to avoid severe pest injury (pearl bug). It is not tolerant to traffic or compaction.

Centipedegrass can be established from seeds or sprigs, but a nurse crop must be used to provide initial erosion control. The best planting months are March through July.

Weeping lovegrass seeds often germinate and become established under drier conditions than most other cultivated grasses, and it is quite drought-resistant.

It is a bunch grass, forming distinct clumps that spread very little. This makes perfect stands essential, otherwise erosion between clumps may become serious. Further, this species is usually rather short-lived in North Carolina. Lovegrass is sometimes mixed with sericea lespedeza, which fills in between the clumps and persists after the weeping lovegrass declines. However, it can be too competitive as a nurse crop. Where permanent cover is desired, it is usually best to start with species that provide more complete cover of a more permanent nature.

Weeping lovegrass is not recommended because its clumping growth habit and lack of persistence reduce its value for erosion control under North Carolina conditions.

Perennial Legumes

Crownvetch is a deep-rooted, perennial legume with spreading rootstocks, adapted to the Mountain region and to the cool slopes (north and east exposures) in the Piedmont. It is useful on steep slopes and rocky areas that are likely to be left unmowed. Crownvetch requires a specific *Rhizobium* inoculant, which may have to be obtained by special order. It can be seeded in the spring or fall. Crownvetch does not respond well to mowing.

Sericea lespedeza is a deep-rooted, drought-resistant perennial legume, adapted to all but the poorly drained soils of the state. It is long-lived, tolerant of low-fertility soils, pest free, and it fixes nitrogen. It can be a valuable component in most low-maintenance mixtures. Sericea is a slow starter and should not be expected to contribute much to prevention of soil erosion the first year; however, it strengthens rapidly and persists indefinitely on suitable sites. Seedings that include sericea require mulch and should include nurse plants such as German millet, Sudangrass, or annual lespedeza. "Scarified," or roughened, seed should be used for spring seeding of sericea because it germinates more readily. Un-scarified seed is recommended for fall-seed mixtures because many of the seeds will lie dormant over winter and germinate early the next spring.

Sericea does not tolerate frequent mowing and may be considered unsightly because the old top growth breaks down slowly.

Coastal Dune Vegetation

Revegetation of construction sites on the barrier islands of North Carolina requires special attention to selection of plant species. In the foredune area there are only a few plants that tolerate the stresses of the beach environment. They must be able to survive salt spray, sand blasting, burial by sand, saltwater flooding, drought, heat, and low nutrient supply. The species commonly planted in this environment is American beachgrass. Other well-suited plants are sea oats, bitter panicum, and coastal panicgrass. In areas behind the foredune, coastal Bermudagrass has been used effectively for stabilization. In low, moist areas saltmeadow cordgrass may be transplanted.

American beachgrass is a cool-season perennial dune grass. It is the principal species presently planted in North Carolina for dune building and as a stabilizer in the foredune zone. Easy to propagate, it establishes and grows rapidly, and is readily available from commercial nurseries. It is an excellent sand trapper capable of growing upward with 4 feet of accumulating sand in one season. New plantings are usually effective at trapping wind-blown sand by the middle of the first growing season.

While extremely valuable for initial stabilization and dune building in disturbed areas, this grass has several serious problems under North Carolina conditions. It is a northern species, probably occurring naturally only as far south as Currituck Banks. It is severely affected by heat and drought and tends to deteriorate and die behind frontal dunes as the sand supply declines. Also, it is susceptible to a fungal disease (Marasmius blight) and a soft scale insect (*Eriococcus carolinae*). Consequently, beachgrass plantings should be reinforced by the inclusion of sea oats and bitter panicum. Dead patches should be replanted to sea oats, bitter panicum, or seashore elder. Sea oats and bitter panicum may be planted without beachgrass, but these plants are more expensive.

The selection of adapted strains is important, as the southern limit of adaptation for this species is approached along the North Carolina coast. Hatteras, a North Carolina selection, has been used effectively for many years. Cape is a northern strain that looks good at first, but does not persist well here. Bogue is a more recent selection, better than Cape, but not as thoroughly tested as Hatteras.

Figure 3.9 Sea oats.

Sea oats (Figure 3.9) is the primary native dune builder from Currituck Banks southward to Mexico. It is a warm-season grass, vigorous, drought- and heat-tolerant, and an excellent sand trapper once fully established. The seed heads, borne on 3 to 4 feet stalks, are quite decorative, This plant is much more tolerant of reduced sand and nutrient supply than American beachgrass, and may persist in backdune areas indefinitely.

Sea oats is limited in commercial availability. Pot-grown seedlings may be transplanted to the dunes when 12 to 16 inches in height.

Early growth in the dunes is generally slower than American beachgrass, and transplants are not effective in trapping sand the first season. This, and the scarcity of commercial supplies, make planting in pure stands generally impractical. However, on the North Carolina coast enough sea oat plants should be included in American beachgrass plantings to assure a future seed supply if there is not already one nearby. This will provide for gradual replacement as the beachgrass stand weakens.

Bitter panicum is a warm-season, perennial grass occurring on and near sand dunes from New England southward to Mexico. It rarely, if ever, produces viable seed and must be propagated vegetatively. It is also highly palatable to grazing animals. These characteristics probably account for its scarcity on many beaches.

Bitter panicum is most useful for inclusion in American beachgrass plantings to encourage long-term stability. It is relatively pest-free, both under nursery conditions and on the dunes. Commercial supplies are limited, but could be readily expanded to meet demand.

When buried, this grass will root at most nodes. Place runners in trenches, leaving several inches of the tip exposed, or set small plants, as with American beachgrass. Stands respond vigorously to nitrogen fertilization.

Saltmeadow cordgrass is a warm-season perennial useful for transplanting on low areas subject to saltwater flooding. It is a heavy seed producer and is often the first plant on moist sand flats. It collects and accumulates blowing sand, creating an environment suitable for dune plants.

Saltmeadow cordgrass is easy to transplant on moist sites, but does not survive on dry dunes. Plants should be dug from young, open stands. Survival of transplants from older, thick stands is poor. Nursery production from seed is relatively easy, and the pot-grown seedlings transplant well. Propagation by seed is possible, but the percentage of viable seed varies.

Intertidal Vegetation

There is often a need to transplant vegetation in the intertidal zone of estuaries to reduce shoreline erosion, to stabilize dredged material, or for mitigation of wetland impact.

In saltwater areas, smooth cordgrass is transplanted in the intertidal zone from mean sea level to mean high water, and saltmeadow cordgrass from mean high water to the storm tide level. In brackish water areas (10 parts per thousand or less of soluble salts), giant cordgrass may be used in the intertidal zone. Greenhouse-grown seedlings of these plants can be obtained from commercial sources, but usually only on special order. Transplants may also be dug from young, open natural stands in the case of smooth and saltmeadow cordgrass.

Smooth cordgrass is the dominant plant in the regularly flooded intertidal zone of saltwater estuaries along the Atlantic and Gulf Coast of North America. The plant is adapted to anaerobic, saline soils that may be clayey, sandy, or organic. It will tolerate salinities of 35 parts per thousand (ppt) but grows best from 10 to 20 ppt. Plant height varies from 1 to 7 feet depending on environmental conditions and nutrient supply. It produces a dense root and rhizome mat that helps prevent soil movement. Transplants can be obtained by digging from new, open stands of the grass or may be grown from seed in pots. Seeds are collected in September and stored, covered with seawater, and refrigerated. The plants and seedlings grow rapidly when transplanted on favorable sites.

Saltmeadow cordgrass is a fine-leaved grass, 1 to 3 feet in height, that grows just above the mean high tide line in regularly flooded marshes, and throughout irregularly flooded marshes. It can be propagated in the same way as smooth cordgrass except that seed may be stored dry under refrigeration. A stand of saltmeadow cordgrass provides good protection from storm wave erosion.

Giant cordgrass grows in brackish, irregularly-flooded areas. Stems are thicker and taller than in the other cordgrasses, growing to a height of 9 to 10 feet. Seedlings are easy to produce in pots and these can be successfully transplanted, but survival of plants dug from existing stands is poor.

Topsoiling

The surface layer of an undisturbed soil is often enriched in organic matter and has physical, chemical, and biological properties that make it a desirable planting and growth medium. These qualities are particularly beneficial to seedling establishment. Consequently, **where practical, topsoil should be stripped off prior to construction and stockpiled for use in final revegetation of the site**. Planning such stabilization measures from the beginning of the project may eliminate costly amendments and repair measures later. Topsoiling may not be required for the establishment of less demanding, lower maintenance plants, but it is essential on sites having critically shallow soils or soils with other severe limitations. It is essential for establishing fine turf and ornamentals.

The need for topsoiling should be evaluated, taking into account the amount and quantity of available topsoil, and weighing this against the difficulty of preparing a good seedbed on the existing subsoil. Where a limited amount of topsoil is available, it should be reserved for use on the most critical areas. In many cases, topsoil has already been eroded away or, as in wooded sites, it may be too trashy.

Site Preparation

The soil on a disturbed site must be modified to provide an optimum environment for germination and growth. Addition of topsoil, soil amendments, and tillage are used to prepare a good seedbed. At planting, the soil must be loose enough for water infiltration and root penetration, but firm enough to retain moisture for seedling growth. Tillage generally involves disking, harrowing, raking, or similar method. Lime and fertilizer should be incorporated during tillage.

Soil Amendments

Liming is almost always required on disturbed sites to decrease the acidity (raise pH), reduce exchangeable aluminum, and supply calcium and magnesium. Even on the best soils, some fertilizer is required. Suitable rates and types of soil amendments should be determined through soil tests. Limestone and fertilizer should be applied uniformly during seedbed preparation and mixed well with the top 4 to 6 inches of soil.

Organic amendments, in addition to lime and fertilizer, may improve soil tilth, structure, and water-holding capacity—all of which are highly beneficial to seedlings establishment and growth. Some amendments also provide nutrients. Examples of useful organic amendments include well-rotted sawdust, well-rotted animal manure and bedding, crop residue, peat, and sludge from municipal sewage or industrial waste.

Organic amendments are particularly useful where topsoil is absent, where soils are excessively drained, and where soils are high in clay. The application of several inches of topsoil usually eliminates the need for organic amendments.

Sludge is an inexpensive amendment that can be very beneficial to plant growth, but proper planning and careful management are essential to its use. Sludge adds nutrients, primarily nitrogen and phosphorus, improves soil structure, and increases organic matter. Types of sludge available include municipal sewage, and waste from textile, wood processing, and fermentation industries. Nutrient content of the sludge depends on the source, but is much lower than that of commercial fertilizers. Sewage sludge may be used in reclamation of disturbed sites, **but always check local or State regulations before attempting to use sewage sludge.**

Sludges may sometimes be high in heavy metals such as nickel and cadmium. North Carolina has published guidelines for the use of sludges which must be followed to maximize effectiveness and avoid pollution of streams. Runoff and erosion control are essential where sludge has been applied. Near residential areas, odors can also be a problem. Sludge is available in either solid or liquid forms. Solid or semi-solid forms are broadcast on sod or soil and may or may not be incorporated. Liquid sludge is irrigated, broadcast, broadcast and incorporated, or injected directly beneath the surface.

Surface Roughening

A rough surface is especially important to seeding sloped areas. Contour depressions and loose surface soil help retain lime, fertilizer, and seed. A rough surface also reduces runoff velocity and increases infiltration.

Because slopes steeper than 3:1 are not usually mowed, they can be left quite rough by grooving, furrowing, tracking, or stairstep grading (*Practice Standards and Specifications: 6.03, Surface Roughening*). Stairstep grading is particularly helpful where there are large amounts of soft rock, because each step catches material in which vegetation can become established.

Slopes flatter than 3:1, which may be mowed, should be grooved by disking, harrowing, raking, or operating planting equipment on the contour. On gentle slopes with sufficient mulch, this is sufficient to retain seed and soil amendments and promote infiltration. Seed should be broadcast soon after surface roughening, before the surface is sealed by rainfall.

Planting Methods

Seeding is by far the fastest and most economical method that can be used with most species. However, some grasses do not produce seed and must be planted vegetatively. Seedbed preparation, liming, and fertilization are essentially the same regardless of the method chosen.

Seeding

Uniform seed distribution is essential. This is best obtained using a cyclone seeder (hand-held), drop spreader, conventional grain drill, cultipacker seeder, or hydraulic seeder. The grain drill and cultipacker seeders (also called grass seeder packer or Brillion drill) are pulled by a tractor and require a clean, even seedbed.

On steep slopes, hydro-seeding may be the only effective seeding method. Surface roughening is particularly important when preparing slopes for hydroseeding. In contrast to other seeding methods, a rugged and even trashy seedbed gives the best result.

The "insurance" effect of extra seed has been taken into account in arriving at the rates recommended in this manual. **Rates exceeding those given are not recommended because over-dense stands are more subject to drought and competitive interference.**

Because uniform distribution is difficult to achieve with hand-broadcasting, it should be considered only as a last resort. When hand-broadcasting of seed is necessary, uneven distribution may be minimized by applying half the seed in one direction and the other half at right angles to the first. Small seed should be mixed with sand for better distribution.

A "sod seeder" (no-till planter) is used to restore or repair weak cover. It can be used on moderately stony soils and uneven surfaces. It is designed to penetrate the sod, open narrow slits, and deposit seed with a minimum of surface disturbance. Fertilizer is applied in the same operation.

Inoculation of legumes—Legumes have bacteria, rhizobia, which invade the root hairs and form gall-like "nodules." The host plant supplies carbohydrates to the bacteria, which supply the plant with nitrogen compounds fixed from the atmosphere. A healthy stand of legumes, therefore, does not require nitrogen fertilizer. *Rhizobium* species are host specific—a given species will inoculate some legumes but not others. Successful establishment of legumes, therefore, requires the presence of specific strains of nodule-forming, nitrogen-fixing bacteria on their roots. In areas where a legume has been growing, sufficient bacteria may be present in the soil to inoculate seeded plants, but in other areas the natural *Rhizobium* population may be too low.

In acid subsoil material, if the specific *Rhizobium* is not already present, it must be supplied by mixing it with the seed at planting. Cultures for this purpose are available through seed dealers.

Among the legumes suggested here, crownvetch is the only one generally requiring inoculation under North Carolina conditions. Lespedeza nodule bacteria are widely distributed in the soils of this state.

Sprigging and Plugging

Sprigging refers to planting stem fragments consisting of runners (stolons) or lateral, below-ground stems (rhizomes), which are sold by the bushel. This method can be used with most warm-season grasses and with some ground covers, such as periwinkle. Certain dune and marsh grasses are transplanted using vertical shoots with attached roots or rhizomes. Sprigs can be broadcast or planted in furrows using a tobacco transplanter. Under favorable conditions, the hay-type, hybrid Bermudagrasses will cover-over in one growing season from sprigs spaced on 6 feet centers. Lawn-type plants are usually sprigged much more thickly.

Broadcasting is easier, but requires more planting material—3 to 10 bu/1,000 ft^2 for Bermudagrass. Broadcast sprigs must be pressed into the top 1/2 to 1 inch of soil by hand or with a smooth disk set straight, special planter, cultipacker, or roller.

Plugging differs from sprigging only in the use of plugs cut from established sod, in place of sprigs. It is usually used to introduce a superior grass into an old lawn. It requires more planting stock, but usually produces a complete cover more quickly than sprigging.

Sodding

In sodding, the soil surface is completely covered by laying cut section of turf. It is practiced in this region with turf-type Bermudas, Kentucky bluegrass, tall fescue, and blugrass-tall fescue mixtures, and is limited primarily to lawns, steep slopes, and sod waterways. A commercial source of high-quality turf is required and water must be available. Plantings must be wet down immediately after planting, and kept well watered for a week or two thereafter.

Sodding, though quite expensive, is warranted where immediate establishment is required, as in stabilizing drainage ways and steep slopes, or in the establishment of high-quality turf. If properly done, it is the most dependable method and the most flexible in seasonal requirements. Sodding is feasible almost any time the soil is not frozen.

Irrigation

Irrigation, though not generally required, can extend seeding dates into the summer and insure seedling establishment. Damage can be caused by both under- and over-irrigating. If the amount of water applied penetrates only the first few inches of soil, plants may develop shallow root systems that are prone to desiccation. **If supplementary water is used to get seedlings up, it must be continued until plants become firmly established.**

Irrigation requirements depend upon current weather conditions—rainfall, temperature, humidity, etc. A statewide weather forecast including information on planting and growing conditions is available through the North Carolina Agricultural Extension Service by calling "Teletip" (1-800-662-7301). This can be used to determine day-to-day watering needs.

Mulching

Mulch is essential to the revegetation of most disturbed sites, especially on difficult sites such as southern exposures, channels, and excessively dry soils. The steeper the slope and the poorer the soil, the more valuable it becomes. In addition, mulch fosters seed germination and seedling growth by reducing evaporation, preventing soil crusting, and insulating the soil against rapid temperature changes.

Mulch may also protect surfaces that cannot be seeded. Mulch prevents erosion in the same manner as vegetation, by protecting the surface from raindrop impact and by reducing the velocity of overland flow. There are a number of organic and a few chemical mulches that may be useful, as well as nets and tacking materials (*Practice Standards and Specifications: 6.14, Mulching*).

Grain straw (wheat, oats, barley, rye) is the most widely used and one of the best mulches. However, there are other materials that work well but may be only locally available. Mulching materials covered in this manual have their respective advantages and appropriate applications, and a material should not be selected on the basis of cost alone.

MAINTENANCE

Satisfactory stabilization and erosion control requires a complete vegetative cover. Even small breaches in vegetative cover can expand rapidly and, if left unattended, can allow serious soil loss from an otherwise stable surface. A single heavy rain is often sufficient to greatly enlarge bare spots, and the longer repairs are delayed, the more costly they become. Prompt action will keep sediment loss and repair cost down. New seedlings should be inspected frequently and maintenance performed as needed. If rills and gullies develop, they must be filled in, re-seeded, and mulched as soon as possible. Diversions may be needed until new plants take hold (Figure 3.10).

Maintenance requirements extend beyond the seeding phase. Damage to vegetation from disease, insects, traffic, etc., can occur at any time. Herbicides and regular mowing may be needed to control weeds—dusts and sprays may be needed to control insects. Herbicides should be used with care where desirable plants may be killed. **Weak or damaged spots must be relimed, fertilized, mulched, and reseeded as promptly as possible**. Refertilization may be needed to maintain productive stands.

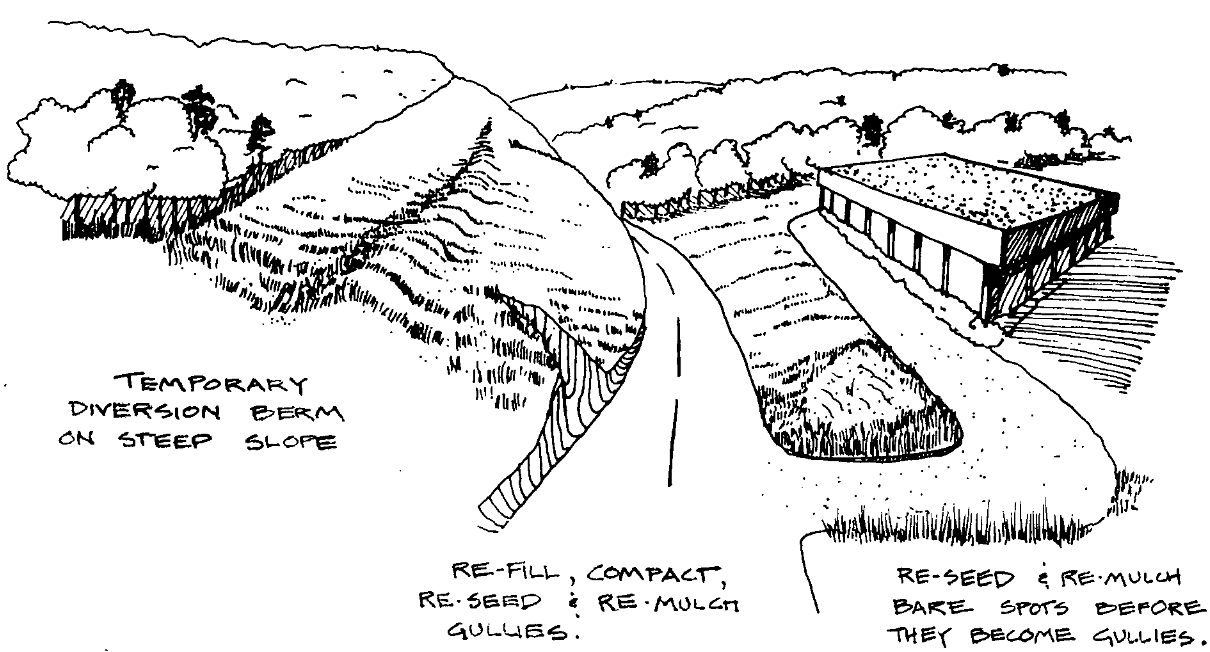


Figure 3.10 Maintenance of vegetative cover.

Vegetation established on disturbed soils often requires additional fertilization. Frequency and amount of fertilization can best be determined through periodic soil testing. Fertilization guidelines are also given in the seeding specifications (*Practice Standards and Specifications: 6.11, Permanent Seeding*). A fertilization program is required for the maintenance of fine turf and sod that is mowed frequently. Maintenance requirements should always be considered when selecting plant species for revegetation.

3

4

Preparing the Erosion and Sedimentation Control Plan

4

Preparing the Erosion and Sedimentation Control Plan

GENERAL CONSIDERATIONS

Before preparing an erosion and sedimentation control plan, the designer should have a sound understanding of the requirements of the North Carolina Sedimentation Control Law (*Chapter 1*), erosion and sedimentation control principles (*Chapter 2*), the role of vegetation and other surface protection in the erosion process (*Chapter 3*), and the appropriate uses of the principal erosion and sedimentation control practices (*Chapter 5*).

Developers and builders can minimize erosion, sedimentation, and other construction problems by selecting areas appropriate for the intended use. Tracts of land vary in suitability for development. Knowing the soil type, topography, natural landscape values, drainage patterns, flooding potential, and other pertinent data helps identify both beneficial features and potential problems of a site.

Purpose of the Plan

The purpose of an erosion and sedimentation control plan is to establish clearly which control measures are intended to prevent erosion and off-site sedimentation. The plan should serve as a blueprint for the location, installation, and maintenance of practices to control all anticipated erosion and prevent sediment from leaving the site.

The approved erosion and sedimentation control plan—showing the location, design, and construction schedule for all erosion and sedimentation control practices—should be a part of the general construction contract. State specifically the method of payment for implementing this plan in the contract, and consider erosion and sedimentation control an early pay item.

Elements of the Plan

An erosion and sedimentation control plan must contain sufficient information to describe the site development and the system intended to control erosion and prevent off-site damage from sedimentation. As a minimum, include in the plan:

- a site location or vicinity map,
- a site development drawing,

- a site erosion and sedimentation control drawing,
- drawings and specifications of practices designated with supporting calculations and assumptions,
- vegetation specifications for temporary and permanent stabilization,
- a construction schedule,
- a financial/ownership form, and
- a brief narrative.

Although a narrative is not specifically required by the law, it can clarify details of the plan as an aid for the inspector and the contractor. The narrative should be concise, but should describe:

- the nature and purpose of the proposed development,
- pertinent conditions of the site and adjacent areas, and
- the proposed erosion and sedimentation control measures.

The designer should assume that the plan reviewer has not seen the site, and is unfamiliar with the project. Map scales and drawings should be appropriate for clear interpretation.

Data Collection and Preliminary Analysis

The base map for the erosion control plan is prepared from a detailed topographic map. If available, a soil map should be obtained from the local office of the USDA Soil Conservation Service. Transferring the soil survey information to the topographic map is helpful for site evaluation.

The design engineer responsible for the plan should inspect the site to verify the base map with respect to natural drainage patterns, drainage areas, general soil characteristics, and off-site factors.

The base map should reflect such characteristics as:

- soil type and land slopes,
- natural drainage patterns,
- unstable stream reaches and flood marks,
- watershed areas,
- existing vegetation (noting special vegetative associations),
- critical areas such as steep slopes, eroding areas, rock outcroppings, and seepage zones,
- unique or noteworthy landscape values to protect,
- adjacent land uses—especially areas sensitive to sedimentation or flooding, and
- critical or highly erodible soils that should be left undisturbed.

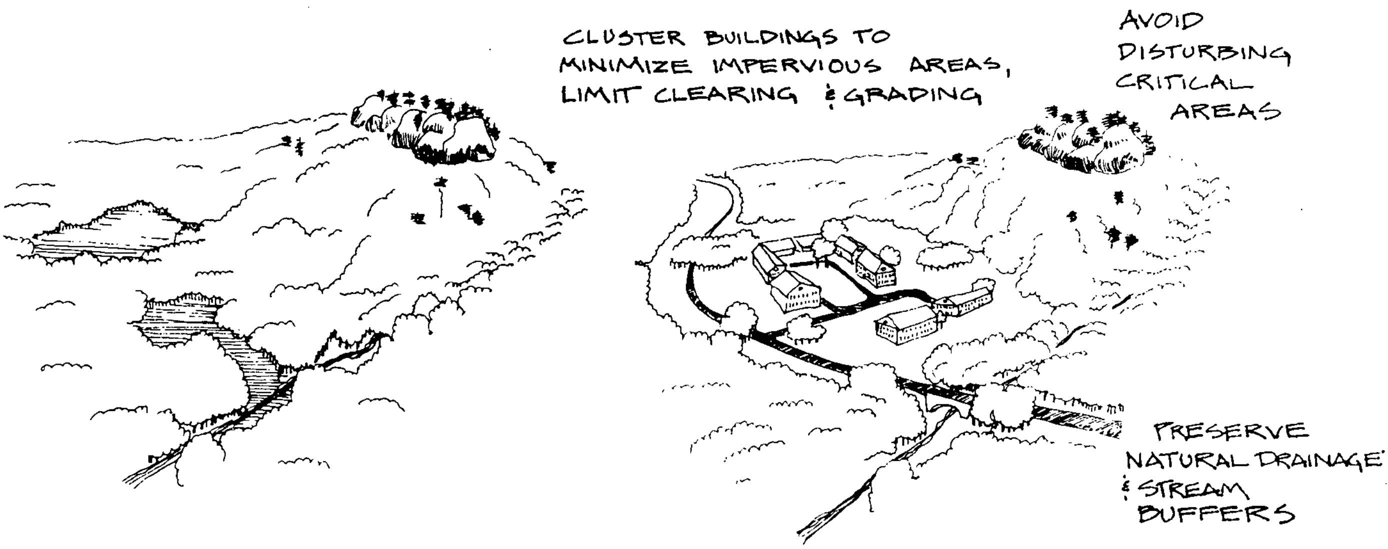


Figure 4.1 Site evaluation.

In the analysis of these data, identify:

- buffer zones,
- suitable stream crossing areas,
- access routes for construction and maintenance of sedimentation control devices,
- borrow and waste disposal areas, and
- the most practical sites for control practices.

The analysis of the topography, soils, vegetation, and hydrology should define the limitations of the site and identify locations suitable for development.

Principles of Site Development

The site evaluation data and the information shown on the field map serve as the basis for both the site development plan and the erosion and sedimentation control plan (Figure 4.1). Plan development to fit the proposed site, recognizing constraints determined in the site analysis. To determine the best layout of the site, observe the following principles:

Fit the development to the site—Follow natural contours as much as possible. Preserve and use natural drainage systems.

Limit clearing and grading—Clearly define work limit lines. Grade to minimize cut-and-fill slopes, preserve natural buffer areas, and limit the time that bare soil is exposed.

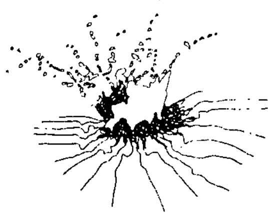
Minimize impervious areas—Build in clusters to provide more open space, minimize parking areas, and reduce disturbance for utility line construction. Use porous paving materials when practical. Maintain existing vegetation where possible.

Avoid disturbing critical areas—Identify and avoid areas vulnerable to concentrated runoff.

Maintain and enhance existing site values—Retain significant trees and other plant groups. Avoid disturbing unique land forms, very steep slopes, and rock outcroppings.

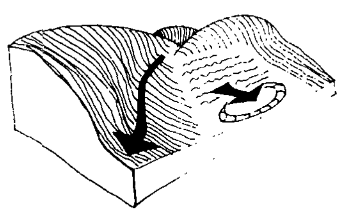
Strategy

The erosion and sedimentation control plan should seek to protect the soil surface from erosion, control the amount and velocity of runoff, and capture all sediment on-site during each phase of the construction project. Strategies for controlling erosion and sedimentation should consider the following elements:

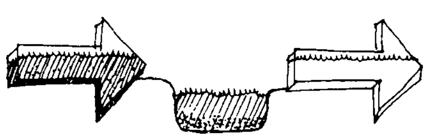


Schedule activities—Coordinate the installation of erosion and sedimentation control practices to coincide with the construction activities as the most cost-effective control strategy. Many sedimentation control practices should precede grading activities.

Protect the soil surface—Limit the extent of disturbance, and stabilize the soil surface immediately. Once the surface has been disturbed, it is subject to accelerated erosion, and should be protected with appropriate cover, such as mulch or vegetation, in an expedient manner.



Control surface runoff—Divert water from undisturbed areas to avoid disturbed areas. Break up long slopes with temporary diversions to reduce the velocity of runoff. Divert sediment-laden water to sediment impoundments. Make all outlets and channels stable for the intended flow.



Capture sediment on-site—Divert runoff that transports sediment to an adequate sediment-trapping device to capture sediment on the site.

Chapter 5 provides a practice selection guide (Table 5.1) for the selection of appropriate control practices. *Chapter 6* contains standards and specifications for the implementation of recommended erosion and sedimentation control practices.

WRITING THE PLAN

Phase I: Runoff-Erosion Analysis

Development of the erosion and sedimentation control plan can be viewed as a series of phases that occur in approximate chronological order. The phases overlap considerably and so are not presented as steps.

Landscape—Evaluate proposed changes in the landscape to determine their effect on runoff and erosion. Note all physical barriers to surface runoff, such as roads, buildings, and berms. Check slope grades and lengths for potential erosion problems. Designate intended collection points for concentrated flow and specify controls to dissipate energy or stabilize the surface. Designate areas to be protected or used as buffer zones in this phase (Figure 4.2).

Runoff yield—Evaluate surface runoff for the entire contributing drainage area—on-site and off-site. Delineate small subwatersheds on-site, and estimate peak runoff rates and volumes at selected collection points identified. Base runoff determinations on the peak discharge from the 10-year storm with site conditions during and after development—**not predisturbance conditions.** See *Appendix 8.03* for procedures for estimating peak runoff.

Sediment yield—Estimate sediment yield by subwatersheds. This aids in identifying preferred locations for sediment traps and barriers, and can be used to estimate the expected cleanout frequency. An area that is subject to excessive erosion may call for extra storage capacity in traps or additional precautions during construction.

Phase II: Sediment Control

Erosion control practices reduce the amount of sediment generated, but they do not eliminate the need for sediment control devices such as barriers and traps. Sediment control practices operate by reducing flow velocity, and creating shallow pools that reduce the carrying capacity of runoff. Thus, sedimentation occurs on-site rather than off-site. Sediment is generally not controlled by filtering, but by deposition. The designer should locate all traps and barriers

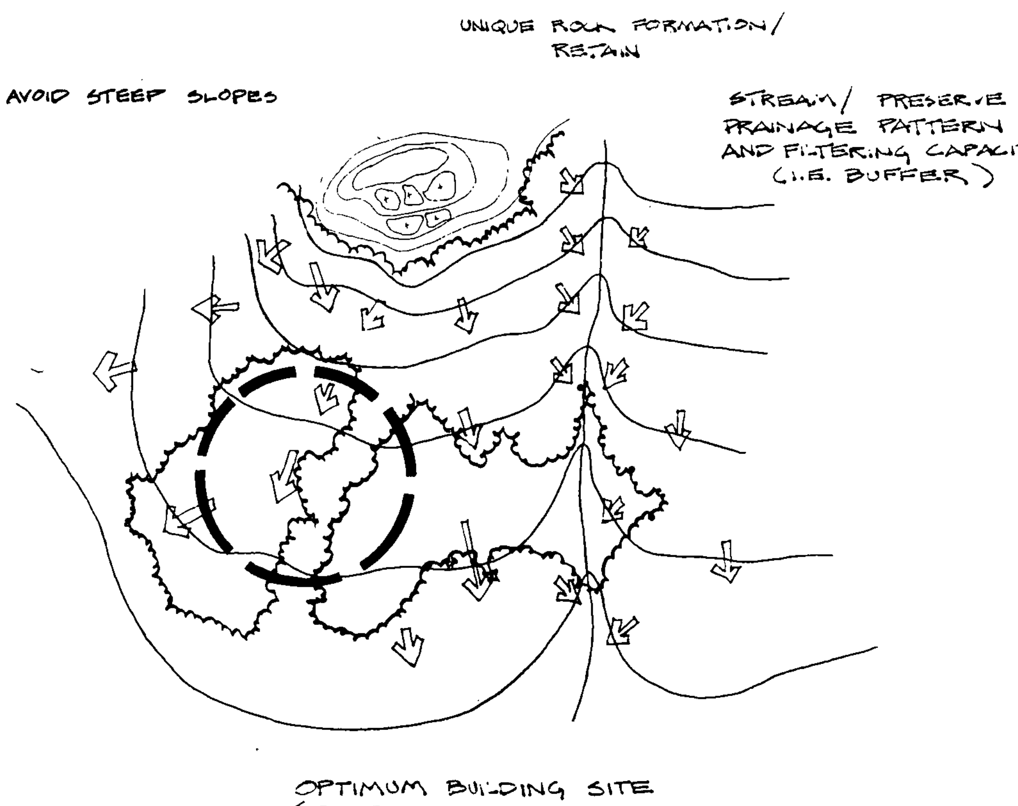
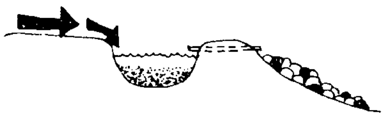


Figure 4.2 Landscape evaluation.

recognizing that they represent deposition points where access for maintenance will be necessary.

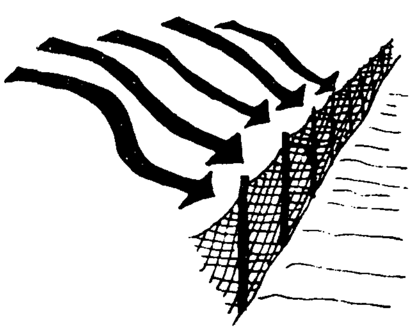
Sediment basins and traps—Select sites and install sediment basins and traps before other construction activities are started. Also consider locations for diversions, open channels, and storm drains at this time so that all sediment-laden runoff can be directed to an impoundment structure before leaving the construction site.



Divert sediment-free water away from sediment basins, and release it through stable outlets. This reduces construction costs, and improves basin efficiency.

This plan should show access points for cleanout of all traps and basins and indicate sediment disposal areas. Maintenance of storage capacity is essential throughout the construction period.

Practice standards in *Chapter 6* provide design criteria and construction specifications for sediment traps (Practice 6.60), sediment basins (Practice 6.61), rock dams (Practice 6.63), and skimmer sediment basins (Practice 6.64). Procedures for the design of sediment basins are contained in *Appendix 8.07.*



Sediment fences—Sediment fences (Practice 6.62) provide effective control of sediment carried in sheet flow. They are particularly useful where there is limited space to work such as near property lines, among trees, or near sidewalks or streets.

Sediment fences should never be used across streams, ditches, channels, or gullies.

The sediment fence operates primarily by reducing flow velocity and causing a shallow pool to form. If filtering action is required, the designer should assume that the barrier will clog rapidly so that all runoff must be retained behind the fence or released through a designated outlet. Any outlet points must be reinforced and stabilized, and should be designated in the plan.

Place sediment fences on relatively flat ground with sufficient area for a pool to develop without putting unnecessary strain on the fence. If a level area is not available at the fence location, excavate a trench directly upslope from the fence.

Show sediment fences on the topographic map, and clearly indicate deposition areas and needed overflow or bypass outlet points. Also show access routes for maintenance.

Inlet protection—Inlet protection devices for storm sewers, conduits, slope drains, or other structures make effective, low-cost deposition areas for trapping and holding sediment. A shallow excavation in conjunction with a sediment barrier can be effective at many locations. In the plan, show where these measures will be located, what type of device will be used, and how these devices will be constructed and maintained. Practice standards for the design of several types of inlet protection devices are included in *Chapter 6* (Practices 6.50, 6.51, 6.52, 6.53, 6.54, and 6.55).

Phase III: Protection of Disturbed Areas

Once an area is disturbed, it is subject to accelerated erosion. In the plan, show how erosion will be controlled on these disturbed areas. Erosion control can be achieved by:

- limiting the size of clearing and time of exposure by proper scheduling,
- reducing the amount of runoff over the disturbed surface,
- limiting grades and lengths of slopes, and
- re-establishment protective cover immediately after land-disturbing activities are completed or when construction activities are delayed for 30 or more working days.

Cut-and-fill slopes—Steep cut or fill slopes are particularly vulnerable to erosion. Protect such slopes by temporary or permanent diversions just above the proposed slope before it is disturbed. Provide a stable channel, flume, or slope drain, where it is necessary to carry water down a slope. Flow conveyances may have vegetative, mechanical, or combined vegetative and mechanical liners, depending on slope and soil conditions.

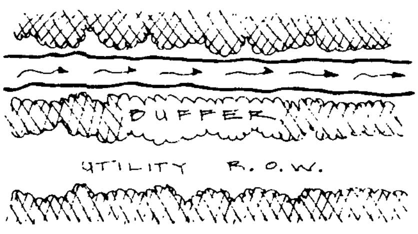
Shorten long slopes by installing temporary diversions across the slope to reduce flow velocity and erosion potential. Install permanent diversions with slope drains and protected outlets on long steep slopes (over 20%) as the slopes are constructed.

Finish final slope grades without delay, and apply the appropriate surface stabilization measures as soon as possible. Roughen slope surfaces to improve the success of vegetative stabilization. Consider both the stabilization measures and how they will be maintained before planning the steepness of the finished slope. For example, if the finished slope is to have smooth grass cover, it should be constructed on a grade of 3:1 or flatter to allow mowing.

Surface covers—Riprap, gravel, straw and other land covers can provide immediate surface protection to disturbed soil areas. Riprap is especially useful where concentrated runoff over steep slopes occurs. Riprap should be installed on a gravel or filter fabric bed.

Construction traffic—Carefully plan stabilization of construction access areas, construction roads, and parking areas. Ensure that traffic patterns follow site contours, and limit the length of routes up steeper slopes. Generally, road grades should not exceed 12%. Controlling surface runoff is necessary to prevent serious roadside erosion. Proper grading of the road surface, stable channel design, the use of water bars, other diversions, and culverts help prevent erosive flows. Where water tables are high, subsurface drainage may be needed to stabilize the sub-grade. Storm drains should be considered for water disposal where channel grade exceeds 5%. Plans should show all stabilization measures needed to control surface runoff from all roads.

Borrow and waste disposal areas—Clear borrow and waste disposal areas only as needed and protect them from surface runoff. Maintain berms as fill slopes are constructed to reduce slope length and control runoff. Slope all areas to provide positive drainage, and stabilize bare soil surfaces with permanent vegetation or mulch as soon as final grades are prepared. Direct all runoff that contains sediment to a sediment-trapping device. In large borrow and disposal sites, shape and deepen the lower end to form an in-place sediment trap, if site conditions warrant it. Off-site borrow areas may be governed by the N.C. Mining Act.



Utilities—Use the spoil from utility trench excavations to divert flow from upslope areas, but use care in spoil placement to avoid blocking natural surface outlets. Diversions and water bars can reduce erosion when properly spaced across utility rights-of-way. When utilities are located near a stream, maintain an undisturbed buffer zone wherever possible. If site dewatering is necessary, pump or divert muddy water to sediment traps before discharging it to the stream. If streams must be crossed, make sure all necessary materials and equipment are on-site before construction begins, and complete work quickly. Finish all disturbed surfaces to design grade and immediately stabilize them with permanent vegetation or other suitable means. When utilities cross the stream, you must specify the plans to prevent sedimentation.

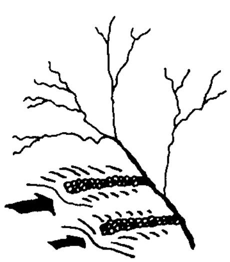
Perimeter protection—Consider diversion dikes for perimeter protection for all proposed developments, and install them where appropriate before clearing the site. Exercise care not to create flooding or erosion by blocking the natural drainage pattern. Be sure to provide an adequate outlet.

Dust control—Exposed soil surfaces that are nearly level have little potential for runoff erosion, but may be subject to severe wind erosion. Keeping the disturbed surface moist during windy periods is an effective control measure, especially for construction haul roads.

Preserving vegetation—Preserve existing vegetation on the site as long as possible as a cost-effective way to prevent on-site erosion and off-site sedimentation.

Phase IV: Runoff Conveyance

The safe conveyance of runoff water from a construction site is achieved by: (1) utilizing and supplementing existing stable watercourses, (2) designing and constructing stable open channels, or (3) installing storm drains with stable outlets. The plan should indicate locations and designs for these facilities. Complete and stabilize outlets for channels, diversions, slope drains, or other structures before installing the conveyance measure.

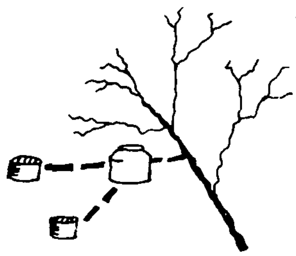


Existing watercourses—When using existing watercourses, either show that flow velocities are acceptable for increased runoff conditions, or indicate how necessary stabilization will be achieved.

Excavated channels—When channels are to be excavated, base a stability analysis on allowable velocity, or tractive force procedures. Include all calculations as part of the plan documentation.

Wide, shallow channels with established grass linings are usually stable on slopes up to 5%. These channels must be protected with temporary liners until grass is established. If channel gradients are too steep to use vegetation, riprap or concrete linings may be required, and in some instances grade stabilization structures may be needed.

Storm drains—Where the site plan calls for a system of storm drains, the drains may be used effectively in the erosion and sedimentation control plan. Build junction boxes or inlets early in the construction sequence, and grade the adjacent area to drain toward the inlet. Install an inlet protection device at all open pipe inlets, and excavate a shallow basin in the approach to the inlet for sediment storage. The storm drain flow from the protected inlets may be diverted to a sediment basin for additional sediment control. Restrict the drainage area for inlets to less than 1 acre, and frequently inspect inlet protections for needed maintenance.



Standards for runoff conveyance (Practices 6.30, 6.31, 6.32, and 6.33) and outlet protection measures (Practices 6.40 and 6.41) in *Chapter 6* provide the criteria necessary for the design of these practices. Design procedures for channels and outlet structures are contained in *Appendices 8.05, 8.06,* and *8.07.* Standards for the design of storm drains are not included.

Phase V: Stream Protection

Streambanks, streambeds, and adjoining areas are susceptible to severe erosion if not protected. Include sufficient detail to show that streams are stable for the increased velocities expected from the development activity. At a minimum, all streams should be stable for flows from the peak runoff from the 10-year storm.

When stability analysis shows that the stream requires protection, vegetation is usually the preferred approach because it maintains the stream nearest to its natural state. When flow velocities approach 4-6 ft/sec, or if frequent periods of bankful flows are expected, structural measures such as riprap lining or grade stabilization structures are usually necessary. In the plan, show where stream protection is needed, and how it will be accomplished.

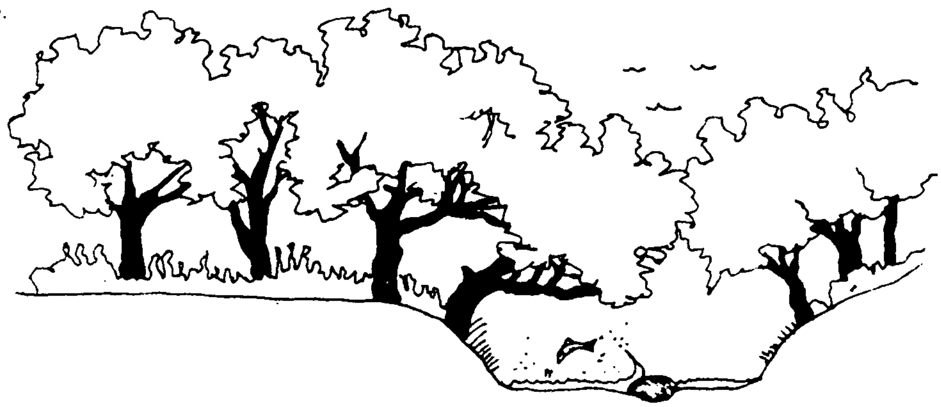
Runoff into stream—Only sediment-free runoff may be discharged from construction sites directly into streams. Ensure that all other flows enter from desilting pools formed by sediment traps or barriers.

Velocity control—Keep the velocity of flow discharged into a stream within acceptable limits for site conditions. Control velocity by installing an appropriate outlet structure. Standards for two types of outlet protection devices are given in *Chapter 6* (Practices 6.40 and 6.41). Design procedures for riprap outlet structures are contained in *Appendix 8.06.*

Buffer zone—Areas adjoining streams should be left undisturbed as buffers (Figure 4.3). Existing vegetation, if dense and vigorous, will reduce flow velocities and trap sediment from sheet flow. However, the principal benefit of leaving natural buffer zones along streams is that they prevent excessive erosion in these sensitive areas. Maintaining stream canopies also protects fish and wildlife habitats; provides shade, wind breaks and noise barriers; protects the bank from out-of-bank flood flows; and generally preserves natural site aesthetics.

Indicate stream buffer zones in plans that involve natural streams. The width is determined by site conditions, but generally should not be less than 25 feet on each side of the stream. Where natural buffers are not available, provide artificial buffers. **Where work is required along a stream, you must provide a mechanical or artificial buffer.**

Figure 4.3 Wooded buffer zone.



Off-site stream protection—Increased rate and volume of runoff from development activities may cause serious erosion at points some distance downstream. The developer should work with downstream property owners to stabilize sensitive downstream channel areas.

Stream crossing—Minimize the number of stream crossings. Construct crossings during dry periods; if necessary, divert water during construction. The plan should show the type of crossing to be used and the associated control measures to minimize erosion from surface runoff such as diversions, outlet structures, riprap stabilization, etc. Design guidelines are given in *Chapter 6* (Practices 6.70, 6.71, 6.72, 6.73, and 6.74) for stream protection practices.

Phase VI: Construction Scheduling

Appropriate sequencing of construction activities can be the most effective means for controlling erosion and sedimentation. Consequently, present the construction activity schedule of the general contract as part of the erosion and sedimentation control plan. **Put into place the primary erosion and sedimentation control practices for the site, i.e., sediment basins and traps, and a water conveyance system before undertaking major land-disturbing activities.**

Install sediment basins and primary sedimentation control practices as the first structural measures. Next install the overall water disposal outlet system for the site.

Stabilize all construction access routes, including the construction entrance/ exit and the associated drainage system, as the roads are constructed. Install storm drains early in the construction sequence, and incorporate them in the sedimentation control plan. Then install low-cost inlet protection devices for efficient sedimentation control in the area around the inlets. This allows early use of the inlets and the drain system.

Install diversions above areas to be disturbed and, where appropriate, locate diversion dikes along boundaries of areas to be graded before grading takes place.

After all principal erosion and sedimentation control measures are in place, perform the land clearing and rough grading. Clear areas only as needed.

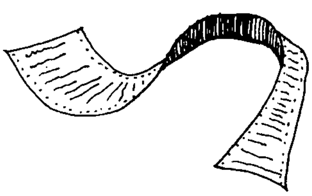
Complete final grading and surface stabilization in an expedient manner and within the construction schedule. Minimize the time of exposure, and select temporary ground cover according to the location and season. Temporary surfaces should be stabilized as soon as active grading is suspended, and graded slopes and fills must be stabilized within 21 calendar days, regardless of the time of year.

Phase VII: Maintenance

In the erosion and sedimentation control plan, indicate who is responsible for maintenance and when it will be provided. The maintenance schedule should be based on site conditions, design safeguards, construction sequence, and anticipated weather conditions. Specify the amount of allowable sediment accumulation, design cross-section, and required freeboard for each practice and what will be done with the sediment removed. The plans should also state when temporary practices will be removed and how these areas and waste disposal areas will be stabilized.

Phase VIII: Performance Requirement

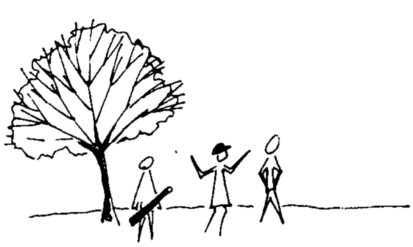
Even though the developer may have an approved plan that is properly installed and maintained, he/she is not relieved of responsibility for off-site sediment damage resulting from his/her construction activities. Therefore, frequently inspect the property boundary for evidence of sedimentation. If off-site damage occurs, the developer may be responsible for immediate corrective measures. Modification of the plan and re-approval may also be necessary.



The erosion and sedimentation control plan should be flexible enough to allow for modification to correct problems. It is common for unanticipated events or construction changes to occur during project development that may require major alterations in the plan. Resubmit significant changes for approval before they are implemented.

Phase IX: Preconstruction Conference

A preconstruction conference with the owner, contractor, and erosion control personnel at the site is recommended as a means of assuring proper implementation of the erosion and sedimentation control plan. This conference is required by some local ordinances. A preconstruction conference allows all parties to meet, review the plans and construction schedule, and agree on responsibility and degree of control expected. Discuss maintenance requirements, phasing of operations, and plan revisions at this time.



A preconstruction meeting is especially important for large, complex jobs or when the contractor and/or developer has had little experience in this type of work.

If the job foreman assigned responsibility for on-site sediment control cannot be present at the conference, give his/her name to the erosion control representative at this time.

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