Turf Establishment and Erosion Control

In cooperation with the Local Road Research Board
"Sponsoring research for county and municipal roads and streets"
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- Conducting a program for the monitoring and implementation of research results.

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Accelerated soil erosion and the sedimentation caused by it pose serious problems for the construction industry and state and local agencies. Runoff from construction sites has high sediment loads which may contain various pollutants, including oil, chemicals, and soil wastes. Natural erosion in ditches and along roadways may result in sedimentation that may result in costly damage to water and land. Drainage channels, culverts, and storm sewers may be filled and plugged by sediment, resulting in frequent and costly maintenance.

This report addresses those problems and outlines methods for controlling erosion both during and after construction. Structural and vegetative practices for reducing sedimentation are given, and turf establishment techniques for native grasses and wildflowers are discussed. Information regarding the National Pollution Discharge Elimination System (NPDES) Storm Water Permit Requirements is also given.
Turf Establishment and Erosion Control

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Introduction

Accelerated soil erosion, the process by which the land surface is worn away by wind, water, ice and gravity due to human use, and the sedimentation that is caused by it, pose serious problems for the construction industry and state and local agencies. Run-off from construction sites has high sediment loads which may contain petroleum products, phosphorus, nitrogen, construction chemicals, or solid wastes. Natural erosion that occurs in ditches and along roadways can cause sedimentation that may result in costly damage to water and public and private lands. Obstruction of stream channels and rivers by masses of deposited sediment reduces their hydraulic capacity. Sediment also fills drainage channels, plugs culverts and storm sewers, resulting in costly and frequent maintenance.

In a short period of time, construction sites can contribute more sediment to surface waters than was previously deposited over several decades. Construction site run-off rates are estimated to be 100 times that of cropland, two hundred times that of grassland, and two thousand times that of forest land. Without erosion control during construction, land and water suffer permanent and severe damage. Sediment has two main effects on the environment: it depletes land resources and impairs water quality.

Erosion can be controlled, and it is important and now required that agencies make an effort to do so. The amount of erosion in an area is affected by several factors, including the soil characteristics, vegetative cover, topography and climate. Soil characteristics that affect its permeability, resistance to detachment, and susceptibility to being carried away by water influence the amount of erosion potential. Soil texture, percent fines and silt, organic content and soil structure are important factors in determining erodibility. Soils high in organic matter have a more stable structure, which improves their permeability. Clean, well-drained soils and well-graded gravels are the least erodible.

The amount and type of vegetative cover are also important factors in the amount of erosion in an area. Vegetation protects the surface from the impact of rain, holds soil particles in place, and increases its ability to absorb water. Ground cover also acts to slow the run-off velocity and helps remove sub-surface water between rainfalls. By reducing the removal of ground cover during construction and decreasing the duration and area of exposure, erosion potential is greatly reduced.

The size, shape and slope of the area also affect the amount and rate of erosion. Flatter grades and rounded surfaces will reduce the susceptibility for sedimentation. Considering these factors in the design and construction of a project, and taking action to reduce the vulnerability of the area to erosion will prevent the unnecessary loss of valuable soil.

This report was written to accomplish five objectives:

- Survey local Minnesota agencies to determine current practices, why they were implemented, and their success or failure.
- Study previous projects conducted by MnDOT, and outline their findings.
- Present what is being done to provide aesthetics for erosion control.
- Explain new regulations and construction specifications, and outline their requirements for local agencies.
- Evaluate current policies with respect to Contractor’s Working Days, and present general guidelines for policy improvement.
Survey Results

To evaluate current problems and erosion control practices, the Local Road Research Board conducted a survey of county and city agencies in Minnesota. Surveys were sent to 203 agencies, and 79 (39 percent) were returned. Agencies were asked to detail erosion control devices commonly used, turf establishment methods, factors affecting their choice of construction methods, specifications used, and successes or failures experienced with new products or techniques.

Erosion Control

The respondents were almost equally divided when asked whether erosion was a significant problem for their agency. The most commonly used method to control erosion is bale checks. Silt fence and erosion mats are also used by many agencies, as shown in Figure 1:

Survey respondents stated that hay bale checks work the best of all methods, which explains their popularity. Silt fence, excelsior blankets, and seeding as soon as possible after construction were also preferred by many respondents as the best way to control erosion. Polypropylene plastic has been used by 46 percent of the respondents, and 72 percent have used a wood fiber blanket to control erosion.

Most agencies (95 percent) consider erosion control in their design and specifications, and most (78 percent) also use MnDOT Standard Specifications in construction. Of the 22 percent that write their own specifications, both Red Wing and Chanhassen require that an erosion control plan be submitted and approved prior to construction. Chanhassen has a separate policy for erosion control, which requires that the erosion control plan be implemented, inspected, and approved by the City before any rough grading may begin. All disturbed areas must be reseeded immediately after work is completed in each area, and seed is to be used to provide a temporary ground cover as soon as possible.
The City also requires that catch basins, gutters, and streets be kept clean throughout construction, and allows the City to halt work if the contractor does not comply. According to the policy, the contractor is solely responsible for all sediment and erosion control, which is considered an incidental cost to the project. Development Contracts with the City state:

The parties recognize that time is of the essence in controlling erosion. If the developer does not comply with the erosion control plan and schedule of supplementary instructions received from the City, the City may take such action as it deems appropriate to control erosion at the developer’s expense.

The City of Chanhassen recognizes the importance of erosion control, and has taken action to include it in construction specifications. No development is allowed and building permits are not issued unless the plat is in full compliance with the erosion control requirements. Erosion control must be maintained until the vegetative cover has been restored, even if the construction has been completed and accepted. The City authorizes removal of erosion control procedures only after the site has been stabilized.1

Turf Establishment
Almost all of the respondents (96 percent) also use MnDOT Standard Specifications for turf establishment. The most common seed mix used in Minnesota is Mix No. 500, for several reasons. The most important factor for all respondents was erosion control capability, followed by hardiness, maintenance, aesthetics, climatic conditions of the area, and density of the grown vegetation. Figure 2 shows the actual response for each factor.

![Figure 2. Factors Affecting Seed Mix Selection.](image-url)
Native grasses have been used by about 29 percent of the respondents. Reasons for not using them include excessive costs, poor performance, and slow growth. Only 16 percent of the respondents have used wildflowers on roadway projects and most of them stated that the flowers were difficult to grow or did not grow at all. Several stated that it was too soon after planting to measure or evaluate success.

Testing soil prior to seeding is not a common practice, with only 10 percent of the agencies saying that they did as a regular part of construction. However, most of the agencies (80 percent) do fertilize prior to seeding. The importance of salvaging or conserving topsoil for future use is recognized by 80 percent of the respondents, who do so as a standard practice. Many of the items addressed in the survey are discussed later in this report. These include erosion control both during construction and long-term.

**Previous Research and Current Practice**

**Erosion Control During Construction**

Construction is one of the main causes of accelerated erosion. In addition to high sediment loads, construction sites also generate other pollutants such as phosphorus, nitrogen, petroleum products, construction chemicals and solid wastes. Although agriculture creates more total sediment than construction due to the large acreage of exposed soils, increased regulations have been imposed on the construction industry for the following reasons:

- Erosion rates are much greater on construction sites due to steeper slopes, smoother surfaces, and increased impervious areas.
- In urban areas where land costs are higher, erosion is more costly and visible.
- Unlike farmers, whose source of income is directly affected by erosion, the construction industry has no incentive to preserve the soil.

Most erosion occurs between land clearing, grading and stabilization of the new soil surface. Therefore, erosion control during construction is extremely important.\(^3\)

Minnesota Statutes Chapter 40, regulations adopted by the Minnesota Pollution Control Agency and DNR, and the MnDOT Standard Specifications make erosion control during construction mandatory. Construction erosion can be controlled by limiting the area under construction at one time, using erosion control devices, and reestablishing turf on areas that have been graded at the earliest possible time.

The project engineer is given authority in the MnDOT Standard Specifications to limit the area of a project open to erosion at one time. To determine the appropriate area size, the engineer should consider equipment, topography, soil, ditch and slope grades, and weather. The engineer may also require the contractor to maintain all graded areas in a well-drained condition, and to place all aprons, rip rap, flumes and sod as soon as possible to control erosion. Temporary seeding may also be required as part of the staging plans.\(^4\) The AASHTO Guide states that less than 750,000 square feet of erodible soil may be exposed at any one time during construction. This figure is based on average conditions found on a typical rural 4-lane divided highway grading project, and can be decreased according to local conditions.\(^5\)
Construction Methods

Many things can be done to reduce the erosion potential and the amount of sedimentation on a site. Before plans are developed, the soil should be examined to determine its erodibility, and methods to reduce the effect of running water on the more erodible soils should be developed and incorporated into the plans. Common Minnesota soils are listed below in order of their erosion potential:

<table>
<thead>
<tr>
<th>Most Erodible</th>
<th>Least Erodible</th>
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</thead>
<tbody>
<tr>
<td>Silty Clay Loam</td>
<td>Loamy Sand</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>Nonplastic</td>
</tr>
<tr>
<td>Silty Loam</td>
<td>Sandy Loam</td>
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<tr>
<td>Silt</td>
<td>Plastic</td>
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<td>Sandy Loam</td>
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<td></td>
<td>Clay Loam</td>
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<tr>
<td></td>
<td>Peat</td>
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<tr>
<td></td>
<td>Muck</td>
</tr>
<tr>
<td></td>
<td>Sand</td>
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<tr>
<td></td>
<td>Gravel</td>
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<tr>
<td></td>
<td>Rock</td>
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<tr>
<td></td>
<td>Pavements</td>
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</tbody>
</table>

To reduce erosion potential, appropriate structural and construction methods must be selected based on the soil type. Typical structural methods for controlling erosion are listed below.

- **Temporary Gravel Construction Entrances** - located at site entrances to reduce the amount of mud transported onto public roads.

- **Stabilization of Haul Roads** - temporary stabilization with gravel immediately after grading to reduce erosion caused by vehicles during wet conditions.

- **Hay Bale Barriers** - temporary hay barrier placed across or at toe of slope to intercept sediment and decrease flow velocities. Bales must be well anchored to prevent runoff flow from uplifting them. This can be done by staking each bale with 2x2-inch stakes or rebars. Bale barriers should be used when additional protection is required, such as when drainage flows off the ROW into lakes and streams, when the flow is intermittent, or its normal depth is less than six inches.

- **Silt Fence** - a temporary sediment barrier constructed of posts, filter fabric and wire support fence, placed across or at the toe of slope to catch sediment and decrease flow velocities.

- **Brush Barriers** - temporary barrier made of limbs, weeds, vines, roots, rock and other cleared materials pushed together to form a berm, located across or at the toe of a slope to catch sediment and decrease flow velocities.

- **Temporary Diversion Dikes** - a ridge of compacted soil located at the top or base of a slope to divert off-site runoff away from an unprotected slope. Also used to direct runoff to a sediment basin.

- **Temporary Fill Diversion** - a channel with a supporting ridge or the lower side cut along the top of a fill area to divert runoff away from the unprotected fill slope to a sediment basin or stabilized outlet.

- **Temporary Right-of-Way Diversion** - a ridge of compacted soil or loose gravel placed across a disturbed right-of-way of similar sloping area to shorten the flow length within the disturbed strip and divert runoff to a stabilized outlet. Use soil in areas where there is no construction traffic, and gravel where vehicular traffic is present.
Temporary Sediment Trap - a small ponding area, formed by constructing an earthen embankment with a gravel outlet across a drainage swale, to detain sediment-filled runoff from small disturbed areas for enough time to allow most of the sediment to settle out. Typical trap locations are at the foot of embankments, at the downgrade end of a cut section, in ditch bottoms steeper than three percent, in medians, and in depressions within the ROW. The dimensions of the trap can be varied according to each project, and are limited to areas of 15 acres or less. Traps should be spaced less than 300 feet apart when placed in a series, and all traps must be fenced to prevent unwanted access.

Temporary Sediment Basin - a basin with a controlled stormwater release structure, formed by forming an embankment of compacted soil across a drainageway, to detain sediment-filled runoff from disturbed areas greater than five acres for enough time for the sediment to settle out. Requires sufficient space and appropriate topography.

Temporary Slope Drain - a flexible tube or conduit, used before permanent drainage structures are installed, intended to move concentrated runoff from top to bottom of slope without causing erosion. The inlet end of a drain must be properly constructed to channel water into the conduit, and metal aprons should be provided. The outlet ends should have some means of dissipating the energy to control erosion. In addition, temporary drains must be securely anchored to the slope.

Outlet Protection - installation of a paved rip rap channel sections and/or stilling basins below storm drain outlets to reduce erosion from scouring at outlets and to reduce flow velocities before stormwater enters channels below the outlet.

Rip Rap - permanent, erosion-resistant ground cover of large, loose, angular stone installed at ends of culverts, on steep slopes, or elsewhere to prevent erosion.

Level Spreader - an outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope to convert concentrated, sediment-free runoff to sheet flow.

Subsurface Streams - a perforated conduit installed beneath the ground to catch and direct ground water. Prevents sloping soils from becoming saturated and subject to sloughing, and improves the quality of soil in wet areas by lowering the water table.

These methods and descriptions were obtained from the NACE Action Guide Volume III-8, Soil Erosion and Pollution Prevention.6
Shaping, seeding, and mulching techniques also affect the erosion potential of a soil, as illustrated in Figure 4. During construction, grades should be kept smooth with no abrupt changes. Ditch cuts should be smooth and rounded in the initial grading. Both seeding and mulching should be done, which will reduce the erosion potential to almost zero. 7

![Figure 3. Effect of Treatment on the Erosion Potential of a Soil. (Source: MnDOT Construction Manual)](image)

Construction erosion can be reduced and controlled with correct planning and use of the following techniques:

1. Minimize the extent of an area exposed at one time, and the duration of exposure. Develop a staging plan that includes temporary seeding as one area is finished, and enables grading of an area to be completed as soon as possible after it is started.

2. Apply erosion control practices to prevent excessive on-site damage. Keep soil covered as much as possible, and specify grading techniques that minimize erosion, including roughening a slope on the contour or tracking with a cleated dozer.

3. Apply perimeter control practices to protect the disturbed areas from off-site runoff, and prevent damage to the areas below the site by controlling sediment once it is produced and preventing it from leaving the site. Diversions, dikes, sediment traps, vegetation filters and sediment basins are collection techniques that work well by filtering runoff as it flows through an area or impounding the runoff for a period to allow sediment to settle out.

4. Keep runoff velocity low and retain the runoff on-site by flattening and reducing slope lengths, and preserving the natural vegetation cover. Consider the installation of detention structures to prevent damage to downstream areas.
5. Stabilize disturbed areas immediately after the final grading is complete by placing temporary or permanent vegetation. Also, place gravel base immediately after subcut grading is completed.

6. Implement a thorough maintenance and follow-up program with periodic checks of erosion control practices.

Local Erosion-Control Programs

Erosion prevention procedures provided by agencies should stipulate the following:

- Adequacy and type of materials which will be provided during construction.
- Procedures for sampling soil for fertility, erodibility, and texture.
- Correlation of results with general soil surveys.
- Mixes for fertilizing, liming, seeding, mulching, and slope dressing materials.
- Provision in design for special problems.
- Provisions and method for monitoring the entire process.

Perhaps the most important information regarding erosion control design and construction is the availability of technical assistance through the Department of Transportation. They are willing to review plans and details, and offer valuable suggestions. Technical assistance is available from the Mn/DOT Soils Unit or Hydraulics Unit, District Materials Engineers, Mn/DOT district hydraulics personnel, and MnDOT Environmental Services.

Four major elements are necessary for the administration of a local erosion-control program. They are:

1) Plan Submittal Establish and inform public of the requirements for plan submittal.

2) Plan Review and Approval Establish criteria for the review and approval of erosion and sediment control plans.

3) Inspection Establish a program of regular and thorough on-site inspections. Hold preconstruction conference to inform contractors of all erosion control and staging requirements.

4) Enforcement Establish procedures for enforcing the erosion and sediment-control ordinance.
Design Considerations for Permanent Erosion Control

It is important that permanent erosion control has been designed into the project so that once temporary erosion control has served its useful life, the soil can be preserved and ditch and slope grades maintained. Erosion control issues should be examined as early as in the preliminary site analysis. Project layout should attempt to blend the alignment with the area topography, to avoid long grades or deep cuts. Slopes less than 7 percent pose little erosion hazard, 7 to 15 percent grades pose a moderate erosion hazard and slopes greater than 15 percent should be avoided, as they provide a high potential for erosion. In addition, long slope lengths should be avoided. Slopes less than 75 feet long should always have grades less than 15 percent. Those between 75 and 150 feet long should be graded at 7 to 15 percent, and slopes greater than 300 feet should be designed with less than 7 percent grades.

Where possible, natural drainage patterns should be followed to avoid erosion and the cost of artificial drainage (culverts, underground piping, etc.). After the initial drainage layout is complete, the estimated runoff should be calculated and checked to insure that the increased amount will not erode or flood existing drainage systems downstream.

Ground cover is the most important factor in preventing erosion. Every attempt should be made to save existing vegetation, as trees and other vegetation protect the soil and beautify the area. Staged construction with temporary seeding and mulching will greatly help to reestablish turf and reduce erosion potential, by reducing the area that is without cover at any time. On adjacent areas, specifically downstream, it is also important to check for sediment pollution and damage from increased volume, velocity and flow of runoff.

When completing the final design and erosion calculations, shoulders are the most important roadway area to consider. Shoulder erosion leads to exposure of the base and subgrade which results in weaker shoulders and overall pavement. Fill-slope surfaces protect the road core and are subject to slipping erosion, which can be prevented by the use of deep-rooted plants, such as alfalfa. Any concentrated flow is hard on fill areas. Berms, curbs and drainage structures, as described previously can also be used for permanent erosion control. Compared to other slopes, a concave slope erodes less, and results in less sediment and slope changes over time.

When determining the horizontal and vertical alignment, ditches should be sloped to obtain a low flow velocity, and designed with smooth grades, gradual changes, and longer lengths. Generally, it is easier to establish permanent turf on fill areas than on cut sections. In-place stabilized steep slopes of rock debris, soil, or streambanks should be left undisturbed. When designing the profile, the length of cut sections should be minimized, and vertical depth of cuts maximized to obtain larger quantities of material from a single location. Borrow pits should be shaped to match the natural contours of the surrounding area, then fertilized and seeded.

Surface channels are usually the most economical means of collecting water. Ditch bottoms should be flat to control the flow of water, since a V-cross section concentrates the water and results in greater erosion. The MnDOT Road Design Manual recommends a trapezoidal shaped channel, and has adopted this shape as its standard for roadside ditches. The Manual also states that backslopes at roadside ditches are to be as flat as practical for both safety and erosion reasons.
Ditch sodding should be wide enough to line the entire ditch bottom, otherwise water will flow along the edge of the sod and cause erosion. Ditches should be sodded to accommodate one foot of flow depth. Glass roving, jute netting, wood excelsior blankets, replacement with less erodible soil such as clay, or bituminous, stone, concrete, or metal or wood fiber with pitch may also be used as a protective lining. At channel changes, the surface should be protected with riprap, sod, pavement, or metal end sections. The designer should check that the flowline profile does not result in accelerated flow velocity beyond the end of the channel change. Table 1 lists ditch gradients that require a liner.

When aligning the ditches and culverts, abrupt changes of direction should be avoided, as should short 90 degree culverts. Longer, skewed culverts that follow the drainage line are more expensive, but require less maintenance over time. Ditch erosion can also be controlled by installing a series of dams or weirs across the ditch to reduce the flow velocity and amount of sediment. Ditch checks can be used when the ditch carries a high velocity flow, has a high grade, or results in deep flow. Ditch checks consist of earth, concrete, stone, timber, or steel placed in a pile directly in the flow line to slow the water speed.  

In general, water should not be allowed to concentrate where it cannot be controlled. Water concentrations from roadways and backslopes cause gullies when allowed to flow over easily erodible slopes. Improper disposal of soil from construction projects may cause a moderate runoff flow to concentrate and damage soil; the most severe erosion occurs in ditches and medians where the water velocity is greater than 3 to 4 feet per second. Therefore, all previously listed steps should be taken to reduce the runoff speed and resulting erosion. Details of rounding lengths and sodding layout, and erosion control devices are given in the MnDOT Road Design Manual, Chapter 8.

<table>
<thead>
<tr>
<th>Soils</th>
<th>Grade (%)</th>
<th>Maximum Permissible Velocity With Sod (ft/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loamy Sand Sands</td>
<td>&gt; 2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Silty Loam Sandy Loam</td>
<td>&gt; 2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Firm Loam</td>
<td>&gt; 2.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>&gt; 2.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

The ditch gradients listed are to be used as a guide under normal conditions in design and treatment of ditches. It is accepted that there are several variables in flow quantities and velocities that may affect the sod design determination as given. Sodding should not be used when the flow velocity exceeds the maximum permissible given above. When exceeded, consult with MnDOT Hydraulics Unit for recommendations concerning design of special liners or energy dissipators.
Turf Establishment

In addition to good design, establishing good vegetative cover on finished grading acts as the best means for permanent erosion control. A study was conducted by the State Department of Transportation (now MnDOT) to determine the relationship between vegetative cover and erosion control. The study identified five major items as significant in the establishment of good vegetative cover and erosion control:15

- Controlling water flow
- Slope preparation and topsoiling
- Seeding and fertilizing
- Mulches and erosion control products
- Mowing

The goal of vegetative stabilization is quick establishment of self-perpetuating plants that stabilize the soil, protect the roadway structure and enhance the aesthetic value of the road. Plants should be chosen for their growth performance under constraints of the local weather and native soils. Many factors contribute to their successful stabilization, including analyzing soil samples and considering the soil conditions when specifying the ground cover, and grading and contouring smooth slopes that blend in with the natural topography.16

Slope Preparation and Topsoiling

Methods of controlling water flow have been discussed in the previous section. Slope preparation and topsoiling involve placing materials on the finished construction slopes to improve the growing conditions or reduce the erosion potential. Occasionally, topsoil may not be available, and the subsoil may be required as a slope dressing or extender for the topsoil. The soil may also be seeded directly, without slope dressing.

It is better to use topsoil over subsoil because topsoil usually contains more organic matter and available nutrients, and may also have a better structure for plant growth. Placement of topsoil over subsoils helps to saturate subsoils with micro-organisms faster than if under normal conditions, in which dust, debris, and flowing water inoculate the subsoils. Plastic subsoils used for slope dressing over granular soils may increase the ability of a subsoil to hold nutrients and moisture, reducing the erosion potential. Before specifying subsoils or mulch for use in topsoiling, the District Soils Engineer should be consulted.

If topsoil is readily available, a depth of six inches should be used for slope dressing in rural areas, and six inches in urban and rest areas. If topsoil is in short supply, a minimum depth of three inches may be used. Topsoil borrow may be necessary on some projects to obtain this minimum three-inch depth. Poor subsoils may be insulated with heavier lifts of topsoil. Excess topsoil should be stockpiled for future use.17

Seeding and Ground Cover Selection

When selecting the type of ground cover to specify, the vegetative zone of that the project should be considered, as some plants perform well in some zones and poorly in others. In addition to the vegetative zone, soil, temperature effects, water relationships, effects of slope direction, and sunlight also affect vegetation growth. The physical, chemical and biological components of a soil determines the natural vegetation of an area. The northeast coniferous zone in Minnesota contains fine to medium, often peaty organic forest soils. The central hardwood forest area contains either sandy soils in the oak savanna area or heavier clay soils in the maple-basswood zone. In the prairies of south and west Minnesota, soils are mostly silt and clay loams.
Temperature is another major factor affecting the types of plants that will flourish in an area. Based on the average winter minimum temperature, the state is divided into additional vegetative zones. Plant species are rated for hardiness in a particular zone, and these ratings serve as a guide to where a particular species may be planted with expectation of survival. Various areas of the state differ greatly in the amount of precipitation they receive. Prairie grasses, found mainly in the southwest areas are noteworthy for their ability to withstand heat and drought, and are therefore excellent candidates for roadside planting.

Vegetation that works best for various soil types in Minnesota are listed in Table 2.

<table>
<thead>
<tr>
<th>Soil</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic pH 7.0 to 8.5</td>
<td>Legumes, Prairie Grasses</td>
</tr>
<tr>
<td>Sandy loams, loam soils pH &lt; 6.5</td>
<td>Grasses</td>
</tr>
<tr>
<td>Loamy sand, and sand soils Dry sites</td>
<td>Grasses with sand dropseed, hairy vetch added</td>
</tr>
<tr>
<td>Wet ditch bottoms</td>
<td>Seaside Bentgrass, Redtop</td>
</tr>
<tr>
<td>Urban areas not sodded, but will be mowed (flatter than 3:1)</td>
<td>Bluegrass, Red Fescue, and Buffalo Grass</td>
</tr>
<tr>
<td>Urban areas not sodded, and difficult to mow</td>
<td>Crownvetch, Bromegrass</td>
</tr>
<tr>
<td>Rural areas with either steep slopes and/or seepage areas on a slope</td>
<td>Crownvetch, Alfalfa, Bromegrass, and Redtop</td>
</tr>
</tbody>
</table>

Highway test plots were planted by the State for the purpose of evaluating ground cover establishment procedures, planting methods, and cultural practices. Those covers rated with good or excellent performance are as follows:

**Woody Ground Covers**

- bush cinquefoil
- Japanese trailing raspberry
- cutleaf stephanandra
- dwarf wormwood
- creeping juniper
- Hughes juniper
- oldfield juniper
- skandra juniper
- prostate black locust

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19
Herbaceous Perennials

- crowvetch
- cicer milkvetch
- birdsfoot trefoil
- Alaska phlox
- fringed sage

MnDOT recommends that groundcovers be planted in prepared beds to eliminate the competition from turf grasses and weeds. Prior to seeding, the soil must be fertilized, at a rate determined from soil testing and analysis. Plants should be spaced at 1.5 to 2-foot intervals. Fertilizing, watering, and mulching of the beds can improve growing conditions, and weeds may be controlled with wood chips, commercial wood fibers, or straw and mulches. All seeded areas should be mulched with the exception of level swamp disposal areas. A wood fiber blanket is to be used on critical cut or fill slopes, and crowvetch is a good choice for groundcover in those areas.

Vegetative Erosion Control Methods
Ways to control erosion through vegetative practices are listed below. These are also taken from the NACE Action Guide Volume III-8.

- **Vegetative Streambank Stabilization** - establishing vegetation on streambanks to protect them from erosion.
- **Surface Roughening** - leaving slopes in a rough condition to reduce runoff velocity, provide sediment trapping and increase infiltration.
- **Topsoiling** - preserving topsoil to provide suitable growth medium for vegetation, but not recommended for slopes greater the 2:1.
- **Temporary Seeding** - establishing temporary vegetation on disturbed areas by seeding with fast-growing plants for areas where final grade will not be established for 30 days to one year.
- **Permanent Seeding** - establishing perennial vegetative cover by planting seed on rough-graded areas that will not be fine-graded for a year or more.
- **Sodding** - stabilizing fine-graded areas by establishing permanent grass stands with sod.
- **Bermudagrass Sprigging** - establishing vegetative cover with hybrid Bermudagrass by planting sprigs or plugs to stabilize areas where sod is not appropriate.
- **Mulching** - applying plant residues to disturbed surfaces to prevent erosion and reduce overland flow velocities. Increases moisture in the soil and provides insulation, thereby increasing plant growth.
- **Planting Trees, Shrubs, Vines and Grass Covers** - stabilizes disturbed areas where turf is not appropriate. Effective in areas where turf maintenance is difficult.
- **Tree Preservation and Protection** - protecting existing trees during construction.
The Department of Transportation erosion control study conducted in 1962 recommended improvements to turf establishment and erosion control methods. Several of the recommendations are still applicable:

- Sodded or lined ditches, dikes and flumes should be used more where the water flow is concentrated.
- The seedbed should be prepared with agricultural equipment and operated on the contour to provide shallow ridges or furrows.
- Seed should be selected for maximum compatibility with the fertility level of the available topsoil and should be sown with equipment that will not nullify or damage the prep work that has been done.
- Mowing should be made to a height of greater than 4 inches to make the turf more resistant to growth and weed infestation.

Erosion Control Fabrics

The long-term solution to erosion control is the establishment of permanent vegetation. However, time is needed for plants to develop sufficient size to adequately control erosion, and the quick cover obtained by grasses is needed before that. The use of natural or synthetic erosion control material to ensure a stable soil surface may be required to accommodate seed germination. The primary attribute of synthetic or permanent materials is their ability to withstand higher flow rates or steeper slopes, but they are more expensive, harder to install and do not look as nice as natural materials.

Three new erosion control product types are currently available, and include mats and blankets, roving, and soil-confinement systems.

Mats and Blankets

Natural mats and blankets are machine or hand-woven, and consist of wood excelsior, straw or other natural materials, bound together with photo-degradable plastic mesh. They retain soil moisture, control surface temperature fluctuations of the soil, conform to the surface topography, protect against sun burnout, and break up the impact of rain drops to minimize erosion. These mats and blankets typically are composed of a web of continuous or staple monofilaments bound or stitched between netting to provide dimensional stability.

These erosion control blankets are thick enough to provide cover and shading, resulting in improved soil moisture and enhanced seedling germination, and are porous enough to allow a uniform and dense stand of vegetation to grow through the mat. Whether they are placed in a slope or channel, the site must be shaped and free of soil clods, clumps, rocks or tire imprints of any significant size that prevents the material from lying flush with the soil surface. The material is to be placed starting downstream, and progressing upstream. The first roll is to be centered longitudinally in mid-channel and pinned with temporary stakes to maintain the alignment. Subsequent rolls should follow in a staggered sequence behind the first roll, and work should proceed outward from the channel center. A minimum four-inch overlap should be placed, and material should be staked or stapled at intervals as directed by the manufacturer along the seams.
Roving

Roving uses fiberglass or polypropylene materials to form a continuous strand for erosion control protection. Fiberglass roving is formed from fibers drawn from molten glass, gathered in strands to form a single ribbon. The roving is flexible and allows for any width or thickness of material to be applied. It serves to protect soil loss as a root reinforcement matrix that becomes a permanent erosion control structure. The installation of roving in either a drainageway or on a steep slope is relatively easy. Standard highway maintenance equipment is required, and includes an air compressor capable of producing 90 cfm at 100 psi, and either an emulsified asphalt tank, or any type of tank with a pump attached that can pump emulsified asphalt through a handgun.

After the soil surface is prepared and seed and fertilizer applied, the roving is installed using a special nozzle connected to the air compressor. The roving is spread over the area to form a random mat of continuous fibers. After completing the application, a tack coat of emulsified asphalt is applied to assure adhesion of the fibers to one another and to the soil. The roving application rate is 0.25 to 0.50 lb/sy, and depends on the amount of erosion control required. The recommended application rate for the emulsified asphalt is 0.25 to 0.33 gal/sy.

Soil-confinement Systems

Soil-confinement systems generally consist of a series of honeycomb-shaped cells formed into a spreadable sheet or blanket. Sheets of the material are anchored and filled with soil, creating a solid surface in areas of poor soil stability. The products generally are made from a high-density polyethylene or nonwoven polyester material. These systems are designed to be used in the most demanding excavation projects, such as slope surface reinforcement, highway embankments, headwalls and wingwalls, pipeline and culvert installations, and excessive drainage slopes.

To install these systems, manufacturers directions should be followed. The surface should be leveled and debris removed. The soil-confinement material should be spread across and down slopes, with edges anchored. The honeycomb sections are then filled with appropriate material to be left in place permanently.24

Salt Effects

One item mentioned as a concern by respondents to the LRRB survey was salt effects on roadside vegetation. High concentrations of sodium and chloride in soils may adversely affect plant growth. Treating the soil with gypsum appears to successfully return the soil condition resulting from years of salting and sodium accumulation to correct conditions.

Salt can also cause problems with drainage and erosion control, as soils with a high sodium content often develop poor drainage characteristics. Most salt damage occurs within 30 feet of the roadway. To reduce this problem, salt tolerant species should be planted in this area, and trees and bushes should be planted at least 30 feet from the pavement edge. Many turf grasses are salt-tolerant. Alkali grass resembles Kentucky bluegrass and actually thrives on roadways that receive high quantities of salt. Kentucky 31 fescue has the highest salt tolerance of turf grasses tested.25
Other salt-tolerant grasses and wildflowers are listed below:

**Native Grasses**
- Canadian wild rye
- Indian grass
- Little bluestem
- Blue grama
- Side oats grama

**Wildflowers**
- Black-eyed Susan
- Purple prairie clover
- Yarrow
- Bush clover

New Regulations

National Pollution Discharge Elimination System Storm Water Permit Requirements

Agencies are now required by law to address erosion control issues in their construction projects. The 1987 amendments to the federal Clean Water Act required the Environmental Protection Agency (EPA) to develop regulations for storm water discharges. The EPA’s storm water regulations and Minnesota’s Construction Activity Program were designed to reduce the amount of erosion and pollutants from leaving the construction site during and after construction.

Any construction project which disturbs five or more acres that begins after October 1, 1992 must be covered by a National Pollutant Discharge Elimination Discharge System (NPDES) Storm Water Permit. Construction projects that were started before October 1, 1992, but are not completed until after that date also require an NPDES permit. The Construction Activity Program is currently on hold until the Pollution Control Agency develops a strategy for best implementing it. To comply with the permit requirements while the program is on hold, agencies seeking coverage may do so by either filing a Notice of Intent (NOI) form with the MPCA, or by completing a permit application, EPA form "2F". The operator (owner, developer, or general contractor) is responsible for applying for the permit. The owner may submit an application if the operator has not yet been identified.

Construction work covered under this regulation includes the following:

**Clearing**
- Grading
- Excavation
- Road Building
- Demolition Activity

**Construction of:**
- Residential Houses
- Commercial Facilities
- Industrial Buildings
- Office Buildings

Until the guidelines are determined, the MPCA recommends preventing erosion through the use of Best Management Practices (BMPs) for any construction activity, regardless of its size. The BMPs should address the following issues:

1) Tracking soil and other sediment from the construction site onto impervious surfaces.
2) On-site erosion during construction prior to the establishment of final grade.
3) Storm water runoff from the site after construction.

Contact Mr. Scott Thompson or Mr. Dan Sullivan at the MPCA with any questions.26
Contractor Working Days

One issue that was addressed in the survey of Minnesota agencies was charging working days for turf establishment. Over half of the respondents (54 percent) stated that they continue to charge working days to contractors after the remainder of the project is completed. Of those that do not charge working days, 70 percent said they did not experience problems persuading the contractor to complete the turfing in a timely manner. Some respondents recommended requiring contractors to turf each section of the project as it is completed. Others stated that retaining five percent of the payment encourages the contractor to complete the project soon, as does a penalty for late work. Other good suggestions for getting the turfing completed include:

> specify that the contractor is responsible for repairing all erosion damage until the project is closed out;
> specify a separate schedule and completion dates for staged turfing;
> remove turf establishment from the contract, and make it the agency’s responsibility;
> specify that the Owner may contract to have turfing done by someone else if work is not competed on time; and
> charge working days until turfing is completed.

MnDOT Standard Specifications do allow working days to be charged until the turfing is completed. Informing the Contractor at the preconstruction conference that they will be charged for these days will help reduce misunderstandings and delays in completing turf establishment.
Aesthetic Improvements

The State of Minnesota spends $8 million a year to mow approximately one million acres of roadway grasses. One way to reduce the amount of mowing is to plant meadows or wildflowers in their place. Ground cover plants and non-grasses may also be used where mowing is difficult. Meadows and wildflowers have three benefits over grasses:

1) Ecological benefits from more diverse, self-sustaining planting without chemicals or mowing.
2) Dramatic reductions in mowing costs.
3) Aesthetic improvements in the roadside.

The ecological benefits of planting wildflowers are many. A more diverse plant community provides habitat for many species of wildlife, and also provides a vegetational buffer between the highway and forest. Also, there is reduced environmental impacts with the maintenance of meadows as compared to turfgrass. The impact on water quality is significant, in that reduced mowings also reduces the amount of pesticides, oil, lead, gasoline, and sediments that are added to surface runoff. Wildflowers can trap and filter airborne pollutants, which are then more likely to leach into the soil instead of running off with surface water.

Economic benefits are seen mainly in the reduction of the amount of mowing required, as meadows only require one mowing per year. Aesthetic benefits include increased color and more interesting textures along the roadway.

Several LRRB survey respondents stated difficulty in stabilizing wildflower growth. There is often a perception that native grasses and wildflower planting may be a failure during the first growing season, when they are actually establishing well. This is because native grasses use most of their energy to develop roots during the first season, and many do not begin growing until late spring or early summer. Several years are needed for a stand of native grasses to become established, and until then the plantings may appear unkept and weedy. When they are fully established, few weeds are able to compete with the native grasses for water and nutrients, and they are eventually starved out. A split-block experimental planting was installed in 1989 to test the effects of tilling, fertilizing, and herbicide treatments. It showed that the key to successful wildflower growth is stopping the spread of invasive grasses and broad-leaved weeds. There are three ways to achieve good stabilization of flower beds. They include mowing, grazing, and burning. Mowing plants just before flowers mature will exhaust their energy and prevent seeding. It is much better to mow in the late fall or early spring, after the seeds have matured and planted.

Two years of study found the following:

- tilling permitted better establishment of wildflowers than no tilling;
- pre-emergent treatments showed a significant decrease in grasses, and more flowers;
- fertilization did not improve the growth of wildflowers, grasses, or broadleaf weeds;
- monocot-specific herbicide was effective for controlling invasive grasses.

Wildflower growth and establishment are more successful when competition for light, space, water, and nutrients by invasive grasses is reduced. Fertilization does not appear to improve the growth of the wildflowers and may actually increase the number of weeds.
Summary

Erosion control and sediment reduction should be considered in every aspect of design. As the majority of erosion occurs during construction of a project, a construction erosion control plan is very important and should be required. New regulations require this plan to be submitted in order to obtain an NPDES Storm Water Permit, mandatory for all construction projects which disturb five or more acres of land. Knowledge of temporary and permanent methods of controlling erosion are crucial for every designer.

During layout of the project, the designer should attempt to blend the alignment and drainage patterns with the area topography. Long grades and deep cuts should be avoided, and changes in slope should be rounded to reduce erosion potential. Areas downstream should also be considered, by calculating all runoff generated from the project, and analyzing its affect on the downstream area. Vegetative cover on finished areas should be established as soon as possible. When selecting the seed mix or groundcover for an area, the vegetative zone, temperature, soil, water and slope direction should be considered. After the seed is selected, many vegetative practices can be used to further enhance plant growth.

Although erosion control is most important during the design and construction of a project, it is very important that effective maintenance continue indefinitely. Without effective erosion control, we risk the loss of soil, a very valuable resource.
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7  MnDOT, p.5-591.581.
8  *Soil*, p.4-1.
9  *Soil*, p.5-1.
11  *Soil*, p.3-1.
12  *Soil*, p.3-2.
13  *Soil*, p.3-3.
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16  *Soil*, p.4-13.
17  *Soil*, p.5-3.
19  Johnson, p.8.
20  Johnson, p.50.
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