Water Quality Enhancement Program
Design Manual

South Dakota Department of Transportation
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1.1 Introduction

This section provides an overview of the authorities and regulations that govern the South Dakota Department of Transportation (SDDOT) Water Quality Enhancement Program, as well as the rules and statutes that govern the requirements for managing erosion and sediment control for construction sites. The rules for implementation of the National Pollutant Discharge Elimination System (NPDES), as published in the Federal Register, comprise over 300 pages of text and numerous pages in the state code for implementation of the South Dakota program. As appropriate, references to specific sections have been provided in this document. However, this section focuses on the primary authorities governing the requirement for erosion and sediment control for construction sites and how erosion and sediment control can be implemented within the requirements of the law and the unique needs of SDDOT.

1.2 Clean Water Act

The authority for the current requirements for erosion and sediment control on construction sites is based on the Federal Water Pollution Control Act as amended in 1972 and again in 1977. These revisions essentially established the current structure for regulating the discharge of pollutants into U.S. waters and gave the Environmental Protection Agency (EPA) the authority to implement pollution control programs. This body of legislation has become known as the Clean Water Act (CWA).

The sections of the CWA that bear most directly on SDDOT are contained in Title IV Permits and Licenses:

- Section 401 Certification,
- Section 402 National Pollutant Discharge Elimination System (NPDES), and
- Section 404 Permits for Dredge or Fill Material.

Section 401 of the CWA requires permitting for the discharge into waters of the U.S. Section 402 establishes the NPDES and gives the EPA the authority to promulgate and enforce rules. Section 404 requires permits for dredging or filling of navigable waters and has subsequently been interpreted to govern the infringement upon all wetlands of the U.S.

Further revisions to the act, in 1981 and 1987, mandated efforts to reduce polluted runoff considered the primary source of nonpoint source pollution. These revisions specifically targeted runoff from urban storm sewers, industrial facilities, and construction sites. The initial implementation of the program commonly referred to as Phase I of the Municipal Separate Storm Sewer System (MS4) occurred in November of 1990. About this time, the EPA established permitting requirements for storm water discharges from “large” and “medium” MS4s.

By definition a “large” MS4 is an urban population center of 250,000 or more and a “medium” MS4 is a population of 100,000 and greater. Phase II of the program was implemented in December of 1999 and extended the coverage to include storm water discharges from “small” MS4s.
A “small” MS4 is defined in the rules as a separate storm sewer system that is owned or operated by a Federal, state, city, town, county, association, district, sanitary district, or other public body with jurisdiction over the disposal of sewerage industrial wastes or other wastes. The rule also defines a “small” MS4 as an incorporated place that serves a population of less than 100,000 or is located in one or more counties with unincorporated urbanized populations serving less than 100,000. The rules specifically designate transportation departments as “small” MS4s.

1.3 Historic Resources and Endangered Species Legislation Impacting Erosion and Sediment Control Requirements

Other legislation that impacts the selection of erosion and sediment controls includes the Archeological and Historic Preservation Act of 1974 (AHPA PL 93-291; 16 U.S.C. 469), the National Historic Preservation Act as amended (NHPA, PL 89-665; 16 U.S.C. 470), and the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884). While not directly associated with physical erosion and sediment controls used in construction, compliance with provisions of these acts must be addressed when preparing the construction general permit, Storm Water Pollution Prevention Plan (SWPPP). Special situations covered in the requirements of these acts may require that special additional measures be taken to avoid impacting historic resources and threatened or endangered species and their habitat.

1.4 Code of Federal Regulation

The Code of Federal Regulations (CFR) require permits for storm water discharges associated with industrial activity, and construction projects that disturb one or more acres of land, and designated MS4 (40CFR 122.26). Storm water discharge permits require temporary and permanent controls on storm water discharges to reduce the transport of sediment and other pollutants that may be picked up and transported into adjacent waters.

1.5 South Dakota Code

The general authority for the South Dakota rules is found in the South Dakota Codified Laws (SDCL) 34A-2-93.,(17). This section requires the state “To establish a delegated national pollutant discharge elimination system program as provided for in the U.S. Code of Federal Regulations (CFR) under 40 CFR Part 123 as amended to January 1, 1993” The specific requirements of 40 CFR Part 123 State Program Requirements also references other parts of the following rules: 40 CFR Parts: 9 OMB Approvals under the Paperwork Reduction Act; 122 EPA Administered Permit Programs: The National Pollutant Discharge Elimination System; and 124 Procedures for Decision Making.
In December 1993, the South Dakota Department of Agriculture and Natural Resources (SD DANR) was delegated the permitting authority for the South Dakota's storm water program. The SD DANR incorporated the Federal storm water regulations by reference into the Administrative Rules of South Dakota (ARSD), Chapters 74:52:01 through 74:52:11. The parts of the South Dakota Code that specifically impact on the erosion and sediment control practices are found in the rules of the SD DANR. The applicable section is 74:52:02:36 which designates discharges subject to surface water discharge permit regulations.

1.6 SDDOT Storm Water Management Program

This program should not be confused with the obligations of the department to implement erosion and sediment control best management practices (BMPs) on construction sites. This is a separate program and has different requirements.

Since SDDOT is a designated "small" Municipal Separate Storm Sewer System, the department has to meet the requirements outlined in 40CFR 123 for implementation of the NPDES. This rule requires the preparation and submission of a Storm Water Management Program (SWMP). This requirement has been completed by the department.

1.7 Storm Water General Construction Permit

Normal construction projects, those that do not have special requirements due to special site conditions such as endangered species covered by the Endangered Species Act (ESA), or historic, archaeological, or cultural resources covered by the National Historic Preservation Act (NHPA), or are Indian lands or lands that remain under Federal jurisdiction, are covered under the South Dakota “General Permit for Storm Water Discharges Associated with Construction Activities." The General Permit requires the use of Best Management Practices (BMPs) for erosion and sediment control on construction sites. The permit relies on the installation and maintenance of appropriate
BMPs to affect acceptable storm water discharge quality and does not set any specific constituent loading standards for storm water discharges.

1.7.1 Requirements of the General Construction Permit for Storm Water Discharges Associated with Industrial or Construction Activities

Three documents are necessary to meet the requirements of the South Dakota and the U.S. EPA General Permits:

- Notice of Intent (NOI),
- Storm Water Pollution Prevention Plan (SWPPP), and
- Notice of Termination (NOT).

The NOI and the SWPPP are required prior to beginning construction activities. The NOT is completed upon final stabilization of all the disturbed areas affected by construction activities.

1.7.1.1 The Notice of Intent (NOI)

Since administration of the NPDES program has been delegated to the state of South Dakota, the program for lands under the State’s jurisdiction is administered by the SD DANR. The NOI required by SD DANR must be filed 15 days prior to beginning construction. SD DANR has developed their own form for filing the NOI for storm water discharges associated with industrial and construction activities. For lands that remain under Federal jurisdiction (e.g. Indian lands) the U.S. EPA remains the permitting authority. U.S. EPA requires that the NOI be filed on the Federal forms. This can be done electronically at [https://www.epa.gov/npdes/electronic-notice-intent-enoi](https://www.epa.gov/npdes/electronic-notice-intent-enoi). The contact for Region 8 storm water issues is:

Amy Clark  
US EPA, Region 08  
Stormwater Coordinator  
1595 Wynkoop St.  
Mail Code: 8WD-CWW  
Denver, CO 80202-1129  
Phone: (303) 312-7014  
Email: clark.amy@epa.gov
1.7.1.2 The Storm Water Pollution Prevention Plan (SWPPP)

The SWPPP is the primary instrument for ensuring compliance with the requirements of both the State and Federal General Permits for storm water discharges associated with construction activities. The SWPPP is a construction document and included in the plans for every project that will disturb one or more acres. This site size criterion must be applied with judgment. Sites less than one acre that are a part of a larger effort, though not on the same site, and are adjacent to sensitive habitat or water bodies should be protected even though they may be below the one acre threshold.

Regardless of the formal jurisdiction, Federal or State, the SWPPP has ten (10) sections that must be addressed in detail. For SDDOT projects, this information has been integrated into the Section D general plan notes. This was formerly the Sediment and Erosion Control Plan and is now designated as the SWPPP. This section serves as a standalone document to satisfy the regulatory requirements, as well as being an integral part of the project document set. The preparation of these materials are discussed in detail in the training materials and other sections of the Design Manual.

1.7.1.3 The Notice of Termination (NOT)

The NOT is required upon completion of permanent stabilization of the construction site. Stabilization is complete when the vegetation cover of the surface reaches a cover equal to seventy percent (70%) of adjacent vegetation cover. This is sometimes misinterpreted to be seventy percent (70%) of surface cover, but it means that the cover of the site is generally uniform, and the cover is equal to 70 percent (70%) of the cover for a typical mature stand of vegetation for the soils, climate, and species mix.
1.8 SWPPP Preparation Process Diagram

1. Does Project Disturb One Acre or More?
   - No: SWPPP Not Required
   - Yes: SWPPP Required

2. Are There Special Environmental Issues?
   - Yes: Individual Review or Special Provisions Required
   - No: The Construction General Permit

3. Implement Special Provisions

4. Prepare the SWPPP

5. Prepare the NOI Submit to SD DANR

6. Receive Letter of Acceptance

7. Construction Begins

8. Field revisions needed to meet unforeseen conditions
   - Revise the SWPPP Documents

9. 70% of Adjacent Cover Reached, File NOT
1.8  Maintenance of the SWPPP

The SWPPP is different than most construction documents in that the regulations require that it be revised and kept up to date during the construction of the project. If erosion and sediment control methods are changed or added due to unforeseen site conditions or if there are changes in the work that significantly change the erosion and sediment control measures, the SWPPP must be revised.

1.8.1  Inspections

Revisions are usually based on changes made as the result of regular site inspections. The construction site must be inspected every 7 days and after every rainfall event of 0.5 inches (12mm) of depth or greater. Inspections are recorded on form DOT-298 and maintained for inspection by SD DANR or U.S. EPA. If construction activities or excessive rainfall damage erosion and sediment controls, this damage is to be noted and appropriate corrections made as soon as possible but no greater than 7 days. There is often confusion about the 24 hour stipulation. In some cases, an area needing repair may be inaccessible due to standing water or saturated soils. In these cases, it is important that actions be taken to prevent any transport of sediment from the site and to perform maintenance activities within 24 hours of the site becoming accessible.

1.8.2  Plan Revisions

When on-site changes are made in erosion and sediment control methods and materials, they have to be noted on the SWPPP plan and drawings. The SWPPP has two parts, Section D plan notes, and the erosion and sediment control plan sheets used for construction. Depending on the type of change, it is generally satisfactory to note the changes on the field drawing set located on the job site. The inspection forms, DOT-298, provide the necessary backup information for the notes made on the drawings. The appropriate text section of the SWPPP should be revised as needed to correspond to the plans. It is important that changes be made in a neat and timely manner, generally immediately after the required inspection has been completed.

1.9  Conclusion

Sediment, which is primarily soil, is the primary pollutant in surface water. The sediment and erosion control measures SDDOT uses to revegetate construction projects are most all proven technologies and will continue to be used. What is different from previous practices is the requirement to control erosion and sedimentation during the construction process rather than waiting until construction is complete. In essence, the requirement is that no sediment generated during the construction period be allowed to leave the construction site. To accomplish this goal there is a large palette of effective temporary erosion and sediment control tools available that will effectively control erosion when properly installed and maintained. While there are costs associated with implementing these controls, the costs are insignificant when compared to the costs of cleaning drainage structures and streams, restoring fisheries, or cleaning silted farmlands.
## Section 2: Principles of Erosion and Sediment Control

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2.1 Introduction

Erosion is the process by which soil particles are detached by rainfall, wind, ice, gravity, or any other action on the soil surface. Once the soil particles are detached, they become sediment suspended in water or wind and are then available for transport. When the water or wind velocity has slowed sufficiently, and for a long enough period of time, soil particles fall from suspension the process of settling out of suspension is called sedimentation. Heavier soil particles, such as sand and gravel, settle more quickly than finer silt and clay particles. For example, coarse sand with a particle size of 0.3 mm may settle one meter in 30 seconds. However, clay with a particle size of 0.0015 may take almost 80 hours to settle one meter. Turbidity is the presence of suspended solids in water, i.e., muddy looking water. This creates a negative environment for water dwelling animals and plant life. Since water erosion is the concern of current regulations, it will be the primary erosive force discussed.

2.2 Types and Causes of Erosion

There are several ways in which the surface of the soil erodes. With water caused erosion, the process begins with the initial soil particle detachment caused by energy impact of raindrops. This is referred to as splash or raindrop erosion Because water is cohesive, or affixes to itself, it will accumulate as a collective force. This collective force flows downstream, eroding the soil in many different ways. As sheet flow, the water accumulates as a thin, broad layer of water. This causes sheet erosion which is generally less destructive than concentrated flows because it usually has less energy or velocity. Sheet flow and sheet erosion usually occur on surfaces that have a relatively flat slope. On steeper slopes, this generally occurs at the top of the slope prior to the water collecting into concentrated flow.

As the water gains velocity and collects in greater quantities, it forms rills or small eroded channels in the soil surface. These rills collect water and as more water collects, the rill grows to form a gully. The difference between a rill and a gully is size and duration. If the soil surface is reshaped, as in tilling, blading, or re-grading, the rills do not form in the exact the same location. However, rills may reform in the area due to water flowing across the surface. With a gully, unless the water above the gully location is redirected, it is likely that the gully will reform in the same location. If gullies are left in place, they can continue eroding the soil until the slope bank fails and creates in-stream damages and stream bed erosion.

Streambank or channel erosion is as natural as all other erosion. It is caused by sediment deposition that accumulates on one side and pushes the water to the opposing side thereby eroding the bank. This process is what makes streams and rivers meander. The water system handles natural sediment deposition by covering the soil with vegetation and thereby stabilizing the new soil area. However, channels may become unstable due to increased flows or changes in upstream sediment load.
2.2.1 Runoff Factors

Runoff quantities are going to impact the amount of erosion one can anticipate. The basic factors that are going to influence runoff quantities are:

- Precipitation
- Soil Permeability
- Antecedent Moisture
- Watershed Area
- Land Cover
- Adjacent Land Use

2.2.1.1 Precipitation

Precipitation or annual rainfall for an area will affect erosion. In areas that have relatively low annual precipitation, there may be times during the year that construction activities see no significant rainfall. However, in many arid areas, annual rainfall may be comprised of a few, short duration, but very intense storms.

2.2.1.2 Soil Permeability

Soil permeability or soil characteristics help determine how much runoff will percolate into the soil. Looser soils such as sand will allow the runoff to percolate into the soil. Tighter soils, such as clays, do not allow for much infiltration into the soil. Storm water that does not enter the soil, remains as runoff, and therefore an erosive force. Soil infiltration rates are decreased and runoff volumes are increased when the soil is frozen, regardless of the soil group. Soils, as classified by the Natural Resource Conservation Service (NRCS) fall into four basic Hydrologic Soil Groups based on the soil's runoff potential and are as follows:

**Group A** has *low runoff potential and high infiltration rates* even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands, gravels, loamy sand, or sandy loam types of soils and have a high rate of water transmission.

**Group B** has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures such as a silt loam or loam.

**Group C** has a low infiltration rate when thoroughly wetted and consists chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structures such as a sandy clay loam.

**Group D** has *the highest runoff potential* because they have *very low infiltration rates* when thoroughly wetted and consists chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils are usually clay loam, silty clay loam, sandy clay, silty clay, or clay.
2.2.1.3 Antecedent Moisture

The antecedent moisture or existing moisture in the soil will influence the amount of runoff infiltration. If a soil has a high water content or high water table, there is little room for additional water. If a soil has a loose structure and is relatively dry, there is greater water infiltration and storage capacity within the soil structure.

2.2.1.4 Watershed Characteristics

The size of the surrounding watershed and location within a watershed area will influence the amount of runoff, and therefore the amount of erosion potential. A site with a surrounding large watershed that drains to the site can anticipate greater quantities of runoff than a site that is at the top of a watershed area or with a small surrounding watershed area.

2.2.1.5 Land Cover

Land cover is an essential component of generated runoff. Vegetation will reduce the runoff velocity, promote infiltration, and capture sediment. However, lack of vegetation or impermeable surfaces will tend to increase runoff velocities and the potential for erosion (See Figure 2-1).

2.2.1.6 Land Use

An erosion potential analysis will include an evaluation of adjacent land use. If the surrounding project site has established vegetation, then one can anticipate that much of adjacent storm water will be assimilated by the adjacent land cover. If the project site is next to vast areas of impervious surface, such as a large, paved parking lot, then one can anticipate that there will not only be high velocity flows, but the runoff may include litter, debris, and parking lot surface pollutants. Another consideration of paved surface runoff is thermal pollution. As the pavement heats in the summer season, the water flowing into adjacent property and receiving waters is usually a higher temperature than other runoff.

2.2.2 Accelerated Erosion

Natural erosion is generally considered to be due to the influence of climatic forces on the surface of the earth. However, accelerated erosion is natural erosion multiplied by human activity such as construction. Sediment enters receiving waters more rapidly and at far greater concentrations through accelerated erosion. When nature is unable to assimilate the quantities of pollutants, impairment occurs.

Common construction related activities that can accelerate erosion include:

- Unrestricted or non-phased development
- Removal of surface cover or vegetation
- Increased surface imperviousness (i.e., paving.)

Phasing construction activities can decrease erosion by leaving existing vegetation in place until construction activity necessitates removal. This requires coordination of land clearing schedules with the installation of erosion control measures. The objective is to minimize the amount of disturbed area at any one time.
Leaving existing vegetation in place helps reduce runoff and erosion because it:

- Protects the soil from raindrop impact
- Reduces the velocity of runoff
- Anchors soil in place through the plant root system
- Intercepts soil particles during runoff
- Increases the infiltration rate of the soil

However, an increase in impervious surfaces can increase the amount of runoff. According to the Environmental Protection Agency, as little as 10 percent impervious cover in a watershed can result in stream degradation. Figure 2-1 shows the relationship between impervious cover and surface runoff. If sensitive receiving waters are adjacent to paved areas, there is the possibility of thermal pollution from runoff that has been heated by impervious surfaces. The increase in impervious surfaces also increases the peak discharge rates due to minimal infiltration.

![Figure 2-1: Relationship between Impervious Surfaces and Runoff](Source: U.S. EPA)

2.3 Erosion Control versus Sediment Control

The terms erosion and sediment control are often misused as if the terms are interchangeable. In fact, they are quite different in both concept and management requirements. Sediment is a product of erosion. Erosion control is any practice that protects the soil surface and minimizes the amount soil particles detached and transported by rainfall or wind. Erosion control is implemented as a source control. Soil is a natural resource that has a significant value, especially in the structural integrity of a highway system. Sediment control is any practice that traps the soil particles after they have been detached and transported. Sediment control begins with erosion control by minimizing the potential sources of sediment. The emphasis should be placed on providing a protective cover on the soil surface, diverting runoff so that it does not flow across disturbed areas, and preserving existing vegetation to maximize soil infiltration and capture sediment.
Erosion controls work in conjunction with sediment controls. Areas under active construction often cannot have immediate erosion control in place. Sediment control measures, such as silt fence, are then used to capture and contain the sediment. A commonly misdirected approach to erosion control is the use of sediment controls, such as silt fence and wattles, without any erosion controls in place. Sediment controls are secondary to erosion controls. Sediment control measures often require more maintenance than erosion control. The sediment build-up needs to be removed routinely to assure proper performance of the control measure. If adequate erosion controls are in place, less sediment will be transported; and therefore, less sediment will need to be captured. Protecting the soil surface and keeping the soil in place should be the primary goal in storm water management.

2.3.1 Impacts of Sediment on Water Resources

The EPA has determined that sediment is the number one pollutant being discharged from construction activities. Sediment entering receiving waters is more than just a little soil in the water. Storm water runoff carries contaminants that lie on the soil and pavement surfaces such as pesticides, herbicides, bacteria, and other toxic substances. Many of these substances are transported with soil particles and can negatively impact water resources. These impacts may include:

- Destruction of spawning areas, food sources, and habitat
- Direct toxicity to wildlife
- Lake degradation
- Sediment deposition of adjacent land
- Siltation of navigation channels
- Impacts to commercial fisheries
- Reduction of storm water conveyance systems and water storage capacities
- Turbidity from suspended sediment contributes to a decline in water quality. It can reduce available sunlight which reduces photosynthesis and plant growth in aquatic species. This can lead to the destruction of habitat through pollutant laden sedimentation.

Sediment pollution has an impact on natural systems within the water bodies, the adjacent land uses such as agriculture, and the surrounding ecosystems. It also has an economic impact. Siltation or sediment deposition within waterways directly affects the navigation ability of vessels using that waterway. Fish habitat, and therefore, sport fishing and the tourism industry is affected by the degradation of water resources. Reduction in water storage capacity in natural systems and infrastructure can increase flooding. There are also costs associated with removal of sediment from storm water conveyance systems and water treatment. Many of these impacts and associated costs are directly related to erosion and the sedimentation that occurs.
2.4 Principles of Erosion and Sediment Control

Ineffective erosion and sediment control measures is not usually the result of a lack of effort. Instead, ineffective controls can usually be attributed to placing BMPs in the wrong application, sediment control placed instead of erosion control, and/or erosion control used where a runoff management tool was needed or simply improper installation. This misapplication usually results in failure of the BMP. The most common problem is using sediment control devices, such as silt fence, as a cure for erosion problems where no erosion control device was implemented. This creates a high maintenance situation for the silt fence as there is no BMP in place to reduce the quantity of soil that is being detached and transported.

The first step in choosing a proper BMP is to decide its function within the strategy for controlling erosion and sediment. Understanding the function an erosion or sediment control BMP is to perform is the first step in achieving cost effective control. In general erosion controls function in the following three ways:

- Surface Protection
- Run-on Management
- Velocity Control

Sediment controls function by removing any suspended material in storm water runoff before it can leave the site and be transported to adjacent water bodies or courses. Most often sediment controls are designed to capture a predetermined volume of storm water runoff and then remove a significant portion of the Total Suspended Solids (TSS). Sediment controls function in three ways:

- Extended detention or extended in-channel residence time
- Filtration
- Chemical Flocculants

2.4.1 Erosion Control

Erosion controls are the most effective means of ensuring that adjacent properties are protected from sediment damage during construction. The objective of all erosion control BMPs is to retain soil particles and other pollutants in place by preventing them from being suspended in storm water runoff. The materials and technologies employed to accomplish this function by protecting the surface, managing storm water run-on and by controlling the velocity of flow over the surface.

2.4.1.1 Surface Protection

Surface protection works by covering the surface of the bare soil in a way that accomplishes two objectives. First, the material must absorb the energy of rain drops impacting the unprotected soil surface. Second, to be effective the material or method must trap and hold in place any soil particles that are dislodged by rain drop impact. There are numerous materials available to provide this function and should be selected based on a detailed knowledge of the site conditions, soil texture, slope, slope length and climatic variables.
2.4.1.2 Run-on Management

Run-on management tools are designed to utilize proper grading, diversions, barriers, or interceptor ditches to minimize concentrated flows and divert runoff away from denuded slopes or other critical areas. This can be done by minimizing slope steepness and length through the use of benches, terraces, contour furrows, interceptor swales or diversion ditches. The concept is to divert clean runoff before it becomes sediment-laden and convey it down the slope in pipes or lined channels until it can be released into an appropriate undisturbed conveyance.

2.4.1.3 Velocity Control

Velocity reduction is a key component of BMP strategies. Control measures such as rock check dams, wattles, etc., are placed perpendicular to the direction of flow, whether sheet flow or concentrated flow, to slow the velocity of the water by interrupting the flow and helping maintain sheet flow. Concentrated flows generate more energy and velocity than sheet flows. Greater depths of flow and increased velocity results in more erosion and suspension of eroded materials. If concentrated flows develop, control measures, such as check dams, can be used to reduce the velocity. Where concentrated flows are directed to uniform surfaces, level spreaders can be used to reestablish sheet flows. Level spreaders can also improve the efficiency of other facilities, such as vegetated swales, filter strips, or infiltration devices which are dependent on sheet flow to operate efficiently. The BMP type must be selected based on the anticipated depth of flow, velocity, and frequency of flows over the surface or in the channel.

2.4.2 Sediment Control

Effective sediment control measures are designed and implemented to capture suspended materials by extending the residence time in channels or physically capturing a predetermined volume of water in order to remove the suspended sediment material. The removal of suspended solids can be affected in three ways; extending the detention time of storm water run of in a channel or basin, filtering the sediment from the water through some type of filtration medium, or by using chemical flocculants.

2.4.2.1 Extended Detention

Detention is the most common means of providing sediment control on construction sites. Extended detention can be affected by interrupting flows or by actually capturing a water volume in a basin or sediment trap. Current regulations require that a volume of one acre-inch (3,600cf or 102cm) be provide for each acre of watershed contributing to an outlet. Table 1 provides some accepted rates of settling for solids based on particle size.
Table 1 Settling Rates of Sediment Materials by Particle Size

<table>
<thead>
<tr>
<th>Diameter of Particle (mm)</th>
<th>Order of Size</th>
<th>Settling Velocity (mm/sec)</th>
<th>Time Required to Settle One Meter (3.28 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>Gravel</td>
<td>1000</td>
<td>1.0 seconds</td>
</tr>
<tr>
<td>1.0</td>
<td></td>
<td>100</td>
<td>9.8 seconds</td>
</tr>
<tr>
<td>0.6</td>
<td>Coarse Sand</td>
<td>63</td>
<td>15 seconds</td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td>32</td>
<td>30 seconds</td>
</tr>
<tr>
<td>0.15</td>
<td>Fine Sand</td>
<td>15</td>
<td>67 seconds</td>
</tr>
<tr>
<td>0.015</td>
<td></td>
<td>0.35</td>
<td>47.6 minutes</td>
</tr>
<tr>
<td>0.010</td>
<td>Silt</td>
<td>0.154</td>
<td>107 minutes</td>
</tr>
<tr>
<td>0.003</td>
<td></td>
<td>0.0138</td>
<td>20.1 hours</td>
</tr>
<tr>
<td>0.0015</td>
<td>Clay</td>
<td>0.0035</td>
<td>79 hours</td>
</tr>
<tr>
<td>0.0010</td>
<td></td>
<td>0.00154</td>
<td>180 days</td>
</tr>
<tr>
<td>0.0001</td>
<td></td>
<td>0.0000154</td>
<td>754 days</td>
</tr>
<tr>
<td>0.00001</td>
<td>Colloidal Particles</td>
<td>0.000000154</td>
<td>207 years</td>
</tr>
</tbody>
</table>

NOTE: temperature 50° C; all particles assumed to have specific gravity of 2.65

2.4.2.2 Filtration

Filtration is also used to as a means of sediment control on construction sites. Silt fence is usually considered a filtration BMP because it is supposed to slow the flow of water and filter the suspended materials from the storm water stream. However, silt fence fabrics are easily filled by solids and usually end up functioning as detention structure rather than a filter. Research is demonstrating that the most effective filtration devices are rock check dams, filter socks or rolled materials such as coir wattles and sediment bags. Simple rock check dams or rock checks that include cores of some type of filter material such as sand, activated charcoal or compost. Filter socks are synthetic fiber tubes filled with a filter medium of compost, mixed compost and wood chips or some other friable filtration medium. Rolled products or wattles also provide some filtration when used in channels and on slopes. Sediment bags are large bags fabricated from synthetic fabrics similar to silt fence. Storm water is usually pumped into the fabric bag which allows the storm water to drain slowly trapping the sediment in the bag. These have achieved some popularity in sensitive areas where workspace is limited.

2.4.2.3 Chemical Flocculants

Chemical flocculants are being employed to remove suspended materials form storm water. The greatest benefit seems to be in removing very fine particulate matter from suspension when draw down times are limited. These are specialized materials and do not have broad application for sediment control on transportation construction sites.
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### 3.1 Introduction

Temporary erosion and sediment controls whether structural or passive are collectively termed “Best Management Practices” or BMPs. When discussing erosion and sediment controls it is important to draw a distinction between permanent and temporary erosion and sediment controls. Permanent erosion control for most all situations involves reestablishing a vegetative cover of native and adapted species of grasses, forbs, and other herbaceous materials. Permanent structural erosion controls are only required when changes are made to the existing natural systems that require reinforcing or armoring of the surface to prevent erosion. Common examples of conditions that require some type of permanent structural erosion control are:

- Bridge approaches and abutments that must resist high tractive forces
- Construction or modified channels that have tractive forces greater than those recommended for vegetated channels
- Structures in or crossing streams that are actively migrating
- Cut or fill slopes that have long, steep slopes of unstable or highly erosive materials

Conditions other than those above rarely need any treatment other than reestablishment of vegetative cover.

Temporary erosion control methods and materials have two purposes:

1. To protect the surface from erosive forces until permanent vegetative cover is established.
2. To foster the establishment and growth of permanent vegetative cover by moderating soil temperatures, conserving soil moisture, and protecting developing seedlings.

Permanent sediment controls are structures used to treat storm water runoff from transportation facilities. These include a wide range of structural types such as: extended detention ponds, wet ponds, constructed wetlands, bio-retention areas, porous pavements, filters, etc. Temporary sediment controls used for construction sites are usually simple detention structures, filters, and traps made of synthetic materials and products such as sediment bags.

There are numerous methods, materials, and technologies to assist with accomplishing temporary erosion and sediment controls for transportation construction sites. Each material, method or combination of methods must be selected based on a thorough knowledge of the site, its soils, hydrologic and hydraulic properties, and climate.

### 3.2 Permanent Erosion Control

Permanent erosion control reestablishes vegetative cover with native or adapted species appropriate to the geographic region and includes any structural modifications needed to ensure long term sustainability. For a majority of transportation sites, reestablishment of adapted grass species is the primary means of permanently controlling both erosion and sediment. However, in some cases, additional controls may be needed to permanently control erosion of stream beds and banks, cut or fill embankments, or where special soil conditions are encountered.
Under the National Pollutant Discharge Elimination System (NPDES) rules, it is often
difficult to separate permanent erosion and sediment controls from storm water quantity
and quality controls. Erosion control is really the first line of defense in ensuring good
water quality. Other controls tend to be downstream practices to control runoff or
remove materials that become suspended in storm water runoff. Storm water controls
range from simple grass-lined channels or earth-formed extended detention basins to
very sophisticated wetlands, wet ponds, and filters.

The following subsections briefly discuss some of the permanent erosion control and
storm water quality measures in common use. This discussion is intended as a guide
only and not intended to be an exhaustive discussion of all the available storm water
quality and permanent erosion and sediment control technologies.

3.2.1 Vegetation

Vegetation is the primary means of controlling erosion and sedimentation on all
unpaved surfaces of the roadside. For roadsides, unpaved shoulders, in-slopes, back
slopes, borrow ditches, and cut and fill embankments; the preferred vegetative cover is
made up of herbaceous species, grasses, forbs, wildflowers, etc.

Woody species are generally confined to use in very specialized situations where
stronger, deeper rooted plants are needed to increase the structural integrity of the
native soil conditions. On the roadside, woody species should not be used or allowed to
colonize within the clear zone recommended for the design speed and road edge
conditions. In most cases, trees with woody trunks are considered a hazard when they
encroach on the clear zone. In addition, most grasses and herbaceous species are not
shade tolerant and will not survive under a tree canopy.

3.2.2 Native and Adapted Vegetation Species

There has been a great deal of discussion about using native grass species on the
roadside to replace what are often called exotic or invasive species. Anytime native
grass species are considered, there are significant issues that must be considered also.
Many parts of the roadside are an integral part of the highway structure, shaped,
compacted and sealed to prevent moisture from entering the road base materials. In the
areas immediately adjacent to the pavement, many native species are not well adapted
to these droughty, compacted soil conditions. In these situations, the preferred species
are those adapted to those conditions and quite frequently these adapted species are
not natives.

The scale of the seeding operation must be considered because this often impairs using
all native species on the roadside. The revegetation of a roadside may involve several
hundred acres, and native seed is seldom available in quantities sufficient to meet these
needs. For this reason, available commercial seed sources must be used.

Eventually, more native seed may become available at reasonable cost. However, until
seed sources are developed, and varieties are developed that tolerate the harsh
growing conditions of the roadside, non-invasive adapted species provide the most
environmentally sound approach to permanent erosion control and maintaining water
quality.
3.2.3 Soils and Soil Testing

There is no substitute for soil tests conducted on areas to be revegetated. Once again it is important to understand that the roadside is part of a structure and in no way related to the adjacent farm field, wood lot, or pasture, although they are neighbors, and the vegetation community of the roadside must be sensitive to that.

For the most part, the soils that compose the roadside are, by design, non-organic. Therefore, additional basic plant nutrients are necessary to achieve a suitable vegetation cover. In order to know what nutrients are actually needed, soil tests are recommended for at least, Nitrogen (N), Phosphorous (P), Potassium (K) and soil pH.

Simply looking at the soil does not tell how much and what type of nutrients need to be added. The soils at the surface of the roadside may have been transported to the site from some distance; likewise, the lower horizons of the soil profile do not necessarily match the properties of the surface soil. It is not at all uncommon to encounter extreme changes in pH or unusually high levels of either potassium or phosphorous and only soil testing will identify these differences.

Nutrients are one of the leading pollutants in storm water and contribute significantly to conditions including low available oxygen. Therefore, adding the right nutrients is an important consideration in managing water quality. If soils are already rich in potassium or phosphorous, adding more by simply specifying a balanced fertilizer may result in increases in the chemical nutrient pollutant loading of receiving waters.

Commercial fertilizers are often cited as a culprit in contributing to nutrient pollution. However, because of the scale of roadside planting, commercial fertilizers are the effective means of supplying these nutrients. The key to proper use of commercial fertilizers is to use soil tests to select the appropriate fertilizer analysis for specific site conditions.

An alternative method that has been gaining widespread popularity is the use of organic compost. Composts have been demonstrated to provide some nutrient benefits depending on the type of composted material. However, composts do not provide the control of nutrient amounts that can be achieved with chemical fertilizers, and it has been demonstrated that some types of compost, particularly animal manures, can have very high concentrations of phosphorous and ammonia that will create nitrogen spikes in the runoff. In most cases the nitrogen is not a major concern, but the phosphorous can be a problem in areas that have high background phosphorous levels in the soil. The most beneficial use of compost seems to be in helping replenish the organic content of the topsoil and in helping rebuild mature topsoil. This is a major benefit, particularly in areas of very shallow, rocky soils.
3.3 Matching Vegetation to Soil and Climate

It is important to match the seed mixes to the season and the climatic conditions of the region. The Department has developed seven (7) standard seed mixture for South Dakota.

- Two (2) seed mixtures are designated for use east of the Missouri River.
- Two (2) seed mixtures are designated for use west of the Missouri River (outside of the Black Hills).
  - In each case, there is a mixture that contains a nurse/cover crop, and a mixture that does not contain a nurse/cover crop. The mixtures containing the nurse/cover crop should be considered for sites with steep grades, long backslopes, or highly erosive soils.
- One (1) seed mixture contains wildflowers and is designed specifically for use within the Black Hills, or adjacent to US Forest Service, National Park Service, or SD Game Fish and Parks properties.
- One (1) mixture is for urban applications and replacing turf lawns.
- One (1) mixture is for use on small projects with less than five (5) acres of disturbed ground.

Deviations from these recommended mixes should only occur in circumstances where special soil conditions are encountered, where extreme climatic differences such as high elevation are encountered, or if drought or other environmental conditions persist long enough to greatly effect seed supplies.

3.3.1 Seeding

Seeding is covered by Section 730 of the SDDOT Standard Specification for Roads & Bridges. The specifications cover the materials and methods to be used for seeding including the planting seasons, bed preparation and planting methods. These specifications are supplemented by the standard notes pages for erosion and sediment control which are available on-line.

3.3.2 Sodding

Sodding, or solid sodding, is an effective way of achieving immediate, permanent erosion control. Depending on the location of a project, soil, and slope conditions, sod can often provide a cost-effective alternative to the use of seeding with erosion control blankets. The primary consideration is the availability of a suitable water supply, which may be a municipal water supply, an available well, or an accessible surface water body of sufficient size to supply the establishment irrigation needs for the required four (4) week watering period. Sod quality, site preparation, and laying sod are covered in Section 733, Sodding in the Standard Specifications for Roads & Bridges.
3.4 Wood Materials in Erosion Control

Woody plant materials are primarily used in biotechnical stabilization applications or in areas where reforestation is to be used (usually on back slopes), as the primary erosion control or in ornamental planting. Ornamental planting is not usually part of a permanent erosion control plan and will not be discussed further here. The two types of woody material used in erosion control are tree or shrub seedlings, and live cuttings or live stakes.

Seedlings are planted bare root, and planting should conform to the same planting season as for grasses and herbaceous materials. Live cuttings and stakes must be harvested while the parent plants are fully dormant. The cuttings and stakes must be stored in a moist condition and planted prior to the cuttings or stakes breaking dormancy.

3.5 Structural Supplemental Controls

Structural supplemental controls are any devices or materials used with or without vegetation to prevent surface, bank, channel, or stream bed erosion. Permanent controls are only necessary where natural conditions have been modified to the point that the pre-existing vegetative cover will no longer prevent erosion, or where natural processes, or upstream modifications have created unstable conditions that cannot be mitigated by vegetation alone. Examples of supplemental erosion and sediment controls include:

- concrete riprap and energy dissipaters
- gabions and gabion mattresses,
- rock riprap,
- turf reinforcement mats (TRMs).

When the need for permanent structural controls arises, the selection and design of permanent structural erosion and sediment controls must be based on good engineering practice. Preparation usually involves hydrologic, hydraulic, and geotechnical analysis of the site as the basis for determining the design of permanent controls. One size does not fit all, and over-design in an effort to be on the safe side, can sometimes lead to unforeseen downstream consequences. Therefore, no further discussion of permanent structural controls is appropriate in this context.

3.6 Biotechnical Controls

Biotechnical is a term applied to the use of live vegetation to achieve permanent structural erosion controls. These solutions have the greatest applications where unstable slopes are encountered such as in rock cuts and cut slopes in mountainous terrain, steep fill slopes, and for the stabilization of rapidly eroding stream banks. The most common types of biotechnical stabilization techniques include:

- Branch packing
- Brush mattresses
- Brush layering
- Coconut fiber rolls
- Dormant post plantings
- Joint planting
- Live cribwalls
- Live fascines
- Live stakes
- Log and root wad revetment
- Tree revetment
- Vegetated geogrids

A more detailed discussion of these methods and their applications is provided in a special section on biotechnical techniques.

3.7 Temporary Erosion and Sediment Control for Construction

The discussion of temporary erosion and sediment control is divided into subsections that cover basic categories of temporary controls used in construction based upon their function:

- Surface protection for slopes and channels
- Velocity reduction
- Sediment capture
- Run-on management

Erosion controls are placed on the surface to dissipate the energy of rainfall and minimize soil particle detachment. Sediment controls are corrective measures that trap sediment and other suspended materials carried in runoff before it can enter an adjacent water body. Sediment controls are backup measures and should never be used in lieu of good erosion control measures. Good erosion control will minimize the need for sediment controls.

However, even the best erosion controls are only about 80%-85% efficient; therefore, some sediment control backup is needed for every site. Regulations currently require that a sediment capture volume equivalent to 3600 cubic feet, or one acre inch, for every disturbed acre of contributing drainage area be provided ahead of the downstream discharge point(s). It is recommended that the required volume be viewed as insurance and that more localized sediment controls be provided up stream of the required sediment catchment(s).

The BMP data sheets provide descriptions of the wide range of sediment controls that are available and the wide variety of applications. For convenience they have been grouped into five broad categories:

- Perimeter protection
- In-channel detention materials and methods
- In-stream detention materials
- Drainage inlet
- Drainage outlet protections
To avoid repetition, some methods and materials have been placed in the group that characterizes the most common application even though they may have application in more than one category.

A group of BMP data sheets occurring within each category describe the various methods and materials used to achieve a particular type of erosion control. Each BMP sheet includes the information outlined below.

**Material Name**

The material or method name used is the term generally accepted by erosion and sediment control professionals and the industry. The two organizations cited as the authority for terms used, are the International Erosion Control Association (IECA) and the Erosion Control Technology Council (ECTC). The IECA is an international trade organization of erosion and sediment control professionals. The ECTC is an association of manufacturers and other erosion and sediment control professionals whose purpose is developing, marketing, and establishing quality standards for the industry. ECTC receives most of its support from material manufacturers and suppliers.

**Other Terms**

Other terms list any names or titles that may also be used regionally for a material or method name listed

**Inspection Form Number**

The construction site inspection for lists BMPs by number for reference within the document. If there is a coinciding number, it is listed on the BMP sheets.

**SDDOT Specification**

If there is a standard SDDOT specification for the application of the material, a hyperlinked reference to that specification is provided. Simply click the highlighted link and the document will go to that specification.

**SDDOT Standard Plate**

If there is a standard SDDOT plate for the application of the material, a hyperlinked reference to that plate is provided. Simply click the highlighted link and the document will go to the appropriate plate.

**Description**

This section includes a general description of the BMP, its function as a BMP, and other descriptive information that would assist a designer with choosing the proper BMP.

**Applications**

This section briefly lists the site conditions and situations where the material or method has application. Other sections of the manual will provide more detail about the design criteria for specific situations.
Considerations

The design considerations provide a brief synopsis of the things that should be considered when selecting the material or method. For example, many rolled erosion control products have different longevity characteristics that will be magnified by climatic conditions. Therefore, regional climatic variables might be listed as a design consideration.

Where temporary erosion control materials and methods are concerned, one size does not fit all. This section will list the limitations of use.

Any specific training needs, equipment or any special skills needed to design or specify a particular material or method will be discussed. For example, gabions and stone riprap must be designed for specific flow conditions. Therefore, design should be handled by an engineer qualified to estimate flow characteristics and the resulting stresses that would have to be resisted by the materials used.

Inspection and Maintenance

This section discusses the quality control issues associated with a proper application of a material or method, such as proper depth of cover or lack of bare spots, etc. Issues related to periodic inspections and special maintenance considerations are also noted.

Common Problems

Most all materials and methods have weaknesses or common problems in their installation. This includes issues such as materials not being properly anchored or healed in, non-uniformity of cover, or migration of cover material in a blanket or mat. For each material, common problems will be noted to facilitate selection and inspection.

BMP Ratings

The BMP data sheet will also have indicators that include the following:

- Effectiveness Index – rates BMP performance relative to bare soil
- Functional Longevity – rates BMP longevity from one season to over three years or duration of project with consideration of factors such as weather, material degradability and consistent material quality
- Ease of Installation – rates BMP based upon labor, necessary equipment and mobilization, access, and availability
- Ease of Maintenance – rates BMP based upon frequency, labor, equipment, and mobilization, repair, and replacement, access, and availability

Some ratings may indicate that there is no data available (NDA) or not applicable (NA).
3.7.1 Surface Protections – Slopes

Slopes surface protection methods and materials are intended to perform four functions:

- Protect the soil surface from forces that will detach soil particles and make them available for transport in wind or water
- Preserve soil moisture to foster seed germination and vegetation establishment
- Moderate soil temperatures to foster seed germination and vegetation establishment
- Reduce runoff velocities to capture and hold detached soil particles

There are numerous materials and methods that are available to provide slope surface protection. Each material and method have specific applications depending on the site, soils, slope, climatic factors, and the length of the construction period. Refer to Section 3.5 BMP Selection Tool.

3.7.2 Surface Protection – Channels

The level of surface protection in a channel or ditch is based upon the shear stress or tractive force of the water entering the channel. This can be calculated using the SDDOT Chapter 9 Drainage Manual. Shear stress is rated in pounds per square foot (psf). The higher the psf, the more protection is needed. Channel protection is necessary in hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation. In cases where there are deep, concentrated flows that may generate tractive forces of 1.5 psf and greater, a combination of surface protection and velocity reduction are needed. Refer to Section 3.5 BMP Selection Tool.

3.7.3 Surface Protection – Outlets

Surface protection at an outlet may require the same shear stress calculations from Chapter 9 Drainage Manual as with channels. High velocity, high flow discharges exert tractive forces on the soil surface that may require heavy reinforcement for protection. Refer to Section 3.5 BMP Selection Tool.

3.7.4 Velocity Reduction – Slopes

Velocity reduction BMPs on slopes promote infiltration and thereby reduce runoff. They can break up a long slope length to reduce the sheet flow velocity, thereby reducing the possibility of it gathering into concentrated flows. Refer to Section 3.5 BMP Selection Tool.

3.7.5 Velocity Reduction – Channels

Velocity reduction BMPs in channels are used to promote infiltration and lessen the quantity of runoff. Reducing the velocity decreases the destructive power of the flowing water. Refer to Section 3.5 BMP Selection Tool.
3.7.6 Sediment Capture – Perimeter Control

Perimeter protection includes those materials that can be used to prevent sheet flow sediment discharges from the site. The most common material used for perimeter protection is geotextile silt fence but there are some other effective alternatives that can be used in the appropriate conditions.

Another category of perimeter protection is sediment capture materials and methods that capture and hold runoff until materials settle out of suspension. These devices can be earthen structures, temporary holding tanks, or geosynthetic materials. Refer to Section 3.5 BMP Selection Tool.

3.7.7 Sediment Capture – In-channel Detention

In-channel detention is a form of check that will detail a certain volume of flow providing sufficient residence time to remove some of the silt load from the flow. Many of these materials and methods also double as velocity controls as well. Refer to Section 3.5 BMP Selection Tool.

3.7.8 Sediment Capture – In-stream Detention

In-stream sediment devices are used to contain sediment when working in water. These are in place to confine sediment suspended by activity in the water to a specific area. They are not to be used to capture upstream sediment-laden runoff. Upstream runoff must be captured with additional sediment controls such as silt fence prior to entering the receiving water. Refer to Section 3.5 BMP Selection Tool.

3.7.9 Sediment Capture – Drainage Inlet Protection

During the course of construction, inlets to the storm sewer system and entrances to culverts should be protected to prevent siltation in the pipe which will be conveyed to the connecting water body during succeeding storm events. Some methods simply block the inlet allowing the storm water to pond temporarily around the inlet. However, care must be exercised when choosing this type of solution in order to be sure that water will not flood an active road or highway. Other inlet protection methods are essentially pervious barriers that use a combination of filtration and detention to remove suspended materials from the runoff. Refer to Section 3.5 BMP Selection Tool.

3.7.10 Sediment Capture – Drainage Outlet Protection

Drainage outlets often have high velocity, high flow water. With this comes great erosion potential. Many BMPs serve to capture sediment from these discharge areas. Caution must be used in choosing and placing a BMP at a drainage outlet as to not block the outlet and create flooding upstream. Refer to Section 3.5 BMP Selection Tool.
3.7.11 Sediment Capture – Construction Entrance

Loose soil on construction sites will adhere to vehicle tires and tracks and will be tracked onto adjacent streets and highways if some provision is not made to remove the loose material before the vehicle leaves the site. For this reason, it is important on linear projects, like highways, to limit ingress and egress to specific points along the route. At each point of egress there should be a means of removing the loose soil material from vehicles before they leave the site. Refer to Section 3.5 BMP Selection Tool.

3.8 Run-On Management

Storm water flowing on a site consists of three parts: run-on, run across, and run-off. Management of the water that enters the construction site can minimize the amount of sediment-laden runoff. The BMPs linked below are designed to minimize concentrated flows and divert runoff away from denuded slopes or other critical areas. Runoff management techniques minimize slope steepness and length, and intercept and divert flows. It is an effective method to intercept clean run-on and divert it to a stabilized area before it becomes sediment laden. This protects the soil surface and assists in maintenance of sediment trapping devices by reducing the quantity of sediment-laden water. The key concept is to keep the clean water clean. Refer to Section 3.5 BMP Selection Tool.

3.9 Biotechnical Techniques

The intent of this section is to introduce an environmentally sensitive approach to soil erosion control so that project designers can be aware of solutions that are not structurally based. Biotechnical control is a specialized field and requires a comprehensive knowledge of hydraulics, geotechnical engineering, horticulture, and fluvial geomorphology. Traditionally trained engineers would need additional training in order to apply this technique.

3.9.1 Material Properties

Biotechnical engineering or soil bioengineering is the use of live, woody cuttings combined with inert materials such as dead wood, rock or geosynthetics to stabilize slopes or streambanks. This application takes a great deal of coordination and scheduling because the effectiveness of stabilization depends highly on whether live cuttings are harvested and installed during dormant periods. Because vegetation is the primary stabilization material and mechanism, biotechnical controls are best used when environmental sensitivity is an issue. The selection of plant materials depends on local plant communities. Related information of plants should be available from local U.S. Department of Agriculture (USDA)-NRCS plant material centers. Biotechnical measures are good alternatives and can serve as both temporary and permanent BMPs. The combined use of different techniques on the same project site is common and encouraged.
Typical biotechnical techniques rely on woody plant materials by taking advantage of their deep root system, which reinforces the soil and other structures. Herbaceous plant materials such as grasses should also be included so that more fine soil particles can be held in place. The reinforcement strength increases over time, which is one of the benefits from the use of biotechnical stabilization.

Common slope and streambank erosion problems that can be stabilized by biotechnical methods include unstable slopes such as rock cuts and cut slopes in mountainous terrain, steep fill slopes, and rapidly eroding streambanks. USDA-NRCS lists 12 common types of biotechnical stabilization techniques including:

- branch packing,
- brush mattress,
- brush layering,
- coconut fiber rolls,
- dormant post plantings,
- joint planting,
- live crib walls,
- live fascines,
- live stakes,
- log and root wad revetment,
- tree revetment,
- vegetated geogrids.

### 3.10 Endangered Species

#### 3.10.1 Provisions for the Topeka Shiner

See the special provision for "Construction Practices in Streams Inhabited by the Topeka Shiner". This special provision describes several conditions that are to be met by the project contractors during in-stream activities when the stream is inhabited by the Topeka Shiner.

#### 3.11 BMP Selection Tool

This section provides a selection tool to guide the selection of an appropriate temporary sediment or erosion control BMP for a specific condition. The tool is essentially a decision tree that will guide the user through a series of site conditions. Simply follow the diagram below by clicking on the appropriate box. The process is repeated until you reach a list of appropriate BMPs for the site conditions cited. The list of BMPs is linked to the appropriate data sheet for each BMP type that can be used for the site conditions entered.
Erosion Control Measure

Temporary Controls
- Surface Protection
- Velocity Reduction
- Sediment Capture
- Run-on Management

Permanent Controls
- Surface Protection
- Channel Protection
- Sediment Control
Section 4: Managing the Construction Site

4.1 Mobilization
   4.1.1 Posting the SWPPP
   4.1.2 Initial Installation of BMPs
   4.1.3 Mobilization Checklist for Initial Installation

4.2 Maintaining the SWPPP in the Field
   4.2.1 Procedure for Revising the SWPPP
   4.2.2 Storm Water Pollution Prevention Plan Modification Form

4.3 Inspection
   4.3.1 Inspection Requirements
   4.3.2 SWPPP Site Inspection Form
   4.3.3 Final Inspection Checklist
4.1 Mobilization

4.1.1 Posting the Storm Water Pollution Prevention Plan (SWPPP)

The SWPPP and its supporting documents must remain on the construction site or at a location posted at the job site. The materials must be available during business hours at all times throughout the project. All records and documents are to be compiled together in an orderly fashion. These provisions are in place to ensure that all records are available in the event a legal situation arises. The location of the SWPPP must be posted on the construction sign located on the perimeter of the project. The sign must be placed in a location where the general public can read the sign without entering the jobsite; this avoids liability and trespassing issues.

The SWPPP is comprised of two parts:

- Narrative Sheets in the SWPPP, Section D General Plan Notes
- SWPPP plan sheets

By reference, the SWPPP also incorporates the construction documents cover sheet which describes the project and location as required for the SWPPP. This format is recommended because it keeps all the SWPPP documentation plans and forms together in a single package. This information can be used as a standalone document for meeting the requirements of the SD DANR General Permit for Storm Water Discharges Associated with Construction Activities (April 1, 2018).

The first several pages of Section D – General Notes for Erosion and Sediment Control have been set up to provide the boilerplate information needed for the SWPPP. Issues such as maintenance, inspections, spill management, etc., have been addressed and provided there. However, every project will have to be reviewed to be sure that the general statements apply. Use the SWPPP Checklist to ensure that all SWPPP requirements are completed.

4.1.2 Initial installation of BMPs

When the SWPPP has been completed and posted and the Notice of Intent (NOI) accepted by SD DANR, the construction project may commence. Prior to the beginning of construction all temporary erosion and sediment controls must be installed according to the SWPPP. In order to ensure a successful plan, all stabilization measures should be installed in the order listed in the sequence of major events. Effort should be taken to ensure that all personnel involved with the installation of the controls are adequately trained. Improperly installed controls may actually increase the in-storm water pollution.
4.1.3 Mobilization Checklist for Initial Installation

Before construction begins, all temporary erosion and sediment controls are to be in place in accordance with the provisions of the SWPPP and the NOI. The mobilization checklist should be used to inspect the site to be sure all appropriate BMPs are in place just prior to commencement of any grading or surface disturbing activities. It is recommended that the completed checklist be maintained with the required SWPPP project records. While it is not a required checklist, it documents that all appropriate preparations were in place prior to beginning work. No construction activities should take place until all items on this list have been completed. Mobilization Checklist.

4.2 Maintaining the SWPPP in the Field

4.2.1 Procedure for Revising the SWPPP

Use Form – DOT-298 to record changes made to the SWPPP and to correct any deficiencies or unanticipated erosion and sediment control needs. Based on the information recorded on the form, revise the SWPPP document text or drawings to reflect the changes noted on the form. Changes can be accomplished by symbols and notes on the plan sheets. Notes should reference the date and the form on which the changes are based.

4.2.2 SWPPP Modification Form

For full compliance with the National Pollutant Discharge Elimination System (NPDES) storm water permit, and to ensure SDDOT is in compliance, the SWPPP must be consistent with the General Permit for Storm Water Discharges Associated with Construction Activities (General Permit) and must accurately reflect existing field conditions. If field conditions require changes, the SWPPP must be revised to reflect the necessary changes. These documents should be current at all times and available for inspection by SD DANR or U.S. EPA inspectors. This is important because the SWPPP is developed according to site specific features. When the site conditions change, there is a possibility of a significant effect on the potential for discharging pollutants into the storm water.

Deficiencies noted in regular inspections must be corrected in a timely matter but in no case more than 7 days after the discovery. In the event that site conditions limit access, action should be taken immediately to replace, repair or install an alternate BMP to ensure that no sediment is discharged from the site. Any condition that prevents completing the repair in the 24 hour period along with the actions taken to prevent any sediment discharge must be documented. Any changes required by the permitting authority will be made within 7 days of the notification. Document the changes on the SWPPP Modification Form – DOT-298 and submit it to the permitting agency.
4.3 Inspections

No BMPs are maintenance free. Without regular, consistent inspections and maintenance, BMPs will not successfully control potential spills, erosion, and sediment. Once construction activities begin, SD DANR requires regular inspections of all erosion and sediment controls. It is important to remember that these inspections include all facets of the SWPPP. This includes all materials storage areas, vehicle storage and maintenance areas, as well as all structural BMPs used for erosion and sediment control. The results of these inspections will determine the extent of maintenance required.

4.3.1 Inspection Requirements

SD DANR requires that site inspections be conducted at least once every 7 days and within 24 hours following a rainfall event of 0.5 inch or significant snowmelt that could cause surface erosion. During winter freezing conditions where runoff is unlikely, inspections can be conducted once per month. These inspections should be done by personnel who are familiar with permit conditions and the proper installation and operation of pollution prevention measures.

As noted in the previous section the inspections must include disturbed areas of the construction site that have not been finally stabilized (70% adjacent cover), areas used to store materials, structural control measures (erosion and sediment control BMPs), and locations where vehicles enter and exit the construction site.

When conducting inspections, the inspector must address three critical areas of concern:

- Is there any evidence of, or the potential for, pollutants (sediment) leaving the site?
- Are the erosion and sediment control BMPs identified in the plan operating correctly?
- Is sediment being tracked off the site?

An inspection report must be completed that summarizes the results of the inspection and should include the name and title of the person making the inspection, date of the inspection, major observations, and any corrective measures taken. These reports must be retained as part of the plan for at least three years after the site has reached final stabilization, and coverage under the permit has been terminated. These inspection reports must include any incidents of noncompliance.

Based on the results of the inspection, the plan must be revised and implemented no later than 7 calendar days following the inspection. In the event that no incidents of noncompliance are identified, the inspection report should contain a certification that the site is in compliance with the plan and the permit. The inspection report must be signed in accordance with signature authority guidelines included in the SD DANR General Permit for Storm Water Discharges Associated with Construction Activities.
There is no better time to determine if a BMP is working correctly than immediately after a rainfall event. During this period, you can see if everything is working properly and can often identify a potential problem even before it starts. In the event of flooding or other situations which prohibit access, it is important to document the situation that prevents access or taking corrective action and noting any additional corrective actions taken to prevent possible discharges from the site. Corrective actions should then be taken as soon as access is possible.

SDDOT requires that all of its project engineers and inspectors, as well as the contractor’s project superintendents complete the SDDOT Erosion and Sediment Control Certification Course to ensure that inspectors understand the requirements for erosion and sediment control on construction sites. Inspectors and other project management personnel must be familiar with the project SWPPP, as well as the proper selection, installation, operation, and maintenance of erosion and sediment control measures.

4.3.2 SWPPP Site Inspection Form

Use the SWPPP Site Inspection Form DOT-298 to record required site inspections during the course of constructing a project. It is the primary tool for ensuring compliance with SD DANR’s General Permit for Storm Water Discharges Associated with Construction Activities. Complete the forms and maintain them with the other SWPPP documentation.

4.3.3 Final Inspection Checklist

Use the Final Inspection Checklist for the final inspection of the site, leading up to filing the Notice of Termination (NOT). Prior to filing the NOT, all temporary erosion and sediment controls are to be removed from the site. This checklist focuses on the issues related to filing the NOT. While it is not specifically required by SD DANR, it does document the critical issues needed to close out the project and file the NOT. If used as recommended, the completed checklist should be filed with the other SWPPP documents for the project and maintained for the required three year period.
5.1 Introduction

This section describes the plan sheets and documentation needed to meet the SD DANR requirements for coverage under the General Permit for Storm Water Discharges Associated with Construction Activities (General Permit). Erosion and sediment control design considerations, the BMP selection process, engineering design methods, and permit submissions related to the Storm Water Pollution Prevention Plan (SWPPP) submissions are discussed here. The documents and procedures covered in this section are related to available standard plates, and revised Section D Plan Notes which are now the template for the SWPPP.

5.2 South Dakota Department of Transportation Policy

SDDOT has adopted policies and conventions to be used in the preparation of the SWPPP. Those charged with preparation of the plan must be familiar with these policies, as well as the requirements of the SD DANR General Permit.

5.2.1 The Plan

The SWPPP consists of the Section D SWPPP (formerly the Sediment and Erosion Control Plans) and the SWPPP plan sheet. This set includes the project cover sheet and may include other drawings in the construction document set. Together, these sheets fully describe the erosion and sediment control work to be performed for the project.

The SWPPP is bound with the construction documents to ensure that they are clearly considered part of the work to be performed. However, the package is also designed so that the SWPPP materials can be detached and used as a standalone document to meet the permit filing requirements. In so far as possible, all repetitive items that apply to every construction project have been included in the new SWPPP as boiler plate. This limits the plan preparation time to the technical concerns related to the unique erosion and sediment controls of each project.

5.2.2 The Notice of Intent (NOI)

The NOI is a three page form provided by SD DANR. Complete and file this form at least 15 days prior to the beginning of construction. It is recommended that a copy of the SWPPP documentation that is included in the plan set be submitted and attached by reference as a part of the NOI.
5.3 Preparing the Storm Water Pollution Prevention Plan (SWPPP)

5.3.1 Introduction

The SWPPP is only one part of meeting all the water quality mandates. Other requirements may exist for both water quantity and quality controls. Therefore, preparation of the SWPPP should begin during the early stages of the design process. For new construction, a preliminary review of water quality issues should be conducted just prior to selecting the final roadway alignment so that, to the extent possible, the alignment will minimize areas that will be difficult to stabilize or minimize alignments that may involve costly temporary and permanent measures to meet long term water quality issues. For reconstruction projects, planning for water quality should be part of the preliminary project design review. Many times, there may be a need to retrofit existing structures to provide more or better water quality and quantity controls, which may require additional right-of-way or consideration of underground structures. Likewise, the needs for temporary erosion and sediment controls should be evaluated to ensure that the appropriate field information is gathered and available as the detailed design process proceeds.

The issue of maintenance projects is sometimes problematic since any activities considered “maintenance” are excluded from the requirements of the General Permit. On the other hand, designers and maintenance engineers need to be alert to potentials for accelerated erosion and take appropriate steps to prevent potential discharges into water bodies adjacent to the state’s right-of-way.

5.3.2 Planning the Temporary Erosion and Sediment Controls for the Project

Temporary and permanent erosion and sediment controls are one part of the broader considerations of NPDES storm water quality issues. Therefore, it is important to consider the information in this section within the broader context of storm water quality. This includes the full package of structural and nonstructural controls utilized to achieve the storm water quality goals of a project. While the focus will be on temporary erosion and sediment controls related to the construction period, when relating this to the overall Road Design Process, reference will be made to other closely related storm water quantity and quality issues.

The SWPPP should begin in the early stages of project development. As the project progresses through the SDDOT Road Design Process, storm water quality issues and needs should be evaluated at each stage of development. There are specific points in the SDDOT process where, depending on the scope of the project, storm water quality and quantity review is recommended. The following section discusses considerations in the context of the SDDOT Preconstruction Engineering scheduling system referring to each step or activity of the process.
5.3.2.1 **Project Scope (3023)**

During this part of the process a preliminary review of all storm water quality issues is suggested. This would include, but not be limited to, both temporary and permanent erosion and sediment controls, as well as permanent storm water quality and quantity needs, particularly with respect to potential need for additional ROW and special site conditions such as the potential presence of historic properties or endangered species. These considerations may also impact final alignment selection.

5.3.2.2 **Field Survey (3137)**

The data needs for every project will be different in terms of the detail and extent. However, there are some basic storm quality data that should be collected for most projects of any significant scope. These data support the entire project development process but may include additional details to support water quality management.

- **Vicinity Map** This map should have topography and hydrology so that offsite runoff contributions and potential problem conditions (such as adjacent wetlands or other sensitive habitat) can be identified, and proper measures designed to avoid conflicts.

- **Drainage Information** Drainage information, such as channel cross sections, field drainages, potential off site discharges, or run-on potentials should be collected. Where significant flows may be encountered, information should be developed for flow depths and peak discharge rates.

- **Existing Erosion and Sediment Control Practices** Any existing erosion and sediment control measures should be identified. These might include diversion terraces on slopes, energy dissipaters at culvert outlets, stone riprap, or other channel protection measures.

- **Soils Data** Collect general engineering soils data and erosive properties of the soils on the project. This information is available from the South Dakota office of the National Resource Conservation Service (NRCS), formerly the Soil Conservation Service (SCS). Review of this information is important for selecting the most cost-effective erosion controls for the project.

- **Field Review** Conduct a field survey of the project corridor. Use a map to delineate special conditions and problem areas that will need special treatment. Be alert to the subtleties of the site such as potential neighbor problems, sites with possible historic connections, channels connected to pristine waters, or existing vegetation that will be very difficult to re-establish, etc.

5.3.2.3 **Preliminary Design Activities**

These sections of the preliminary design process need to be reviewed carefully to be sure that erosion and sediment controls, both temporary and permanent, are being considered. The amount of detail and the extent that any part of the project may be affected depends on the scope and the complexity of the project at hand. Not every project will require each action noted here.
- **Review/Update Scope (3053)** This should note any special provisions for storm water quality and/or erosion and sediment control in the Roadside Development section and the Environmental section of the scope summary. The Right-of-way (ROW) and Environmental Needs section should also be used if there are any special considerations.

- **Develop ROW Strip Map (3080)** This would note any special allocations of land for permanent sediment or storm water quality structures.

- **Develop Preliminary Gradeline (3055)** This would note any special allocations of land for permanent sediment or storm water quality structures.

- **Develop Preliminary Roadway Design (3056)** This contains specific provisions for review of drainage channels, erosion control, and other issues such as permanent storm water quality and quantity needs.

- **Revise Preliminary Roadway Design (3057)** This step includes an on-the-ground site inspection. This should be used to identify any problem areas for erosion and sediment control needs that may not yet have been identified in the design process. The information gathered here should be the basis for developing the .DGN level(s) that will carry the SWPPP erosion and sediment control requirements.

- **Develop Erosion Control Plans (3085)** This is the period when the detailed preparation of the SWPPP would take place.

### 5.3.2.4 Final Design Plans

These are the tasks involved in developing the finals plan sets that will go to letting. The new [SWPPP template](#) (formerly Section D Plan Notes), the standard erosion and sediment control plates, and the temporary sediment and erosion control plan sheets are incorporated into the project drawing set, and the Notice of Intent (NOI) is completed for submission to SD DANR.

- **Final Roadway Design 2 (3060)** This continues the review and preparation of the SWPPP and the NOI documents.

- **Develop Final Roadway Design and Conduct Inspection (3059)** This is the final opportunity to meet on-site with the design team and incorporate all revision made from meetings and reviews by the design squad. This review should integrate the guidance of the SWPPP preparation checklist with the Final Design Inspection checklist in Chapter 18 of the Roadway Design Manual.

- **Complete Erosion Control Plans (3086)** This is the final preparation for plans prior to review.

- **Revise Erosion Control Plans (3087)** This is to make revisions from review comments and to complete the plans for release to the Bid Letting Office.

### 5.4 Design Methods for Temporary Sediment and Erosion Controls

Field conditions during construction change constantly from day to day and weather events are unpredictable. For these reasons designing temporary erosion and sediment controls can be considered part art and part science. It is helpful if those charged with developing water quality plans, including temporary and permanent erosion and
sediment controls, have good professional judgment and an understanding of erosion processes, materials and methods of erosion control as well as working knowledge of soil mechanics, hydraulics, hydrology. The following section discusses the tools that are available to guide the design and selection of erosion and sediment controls. As appropriate, references will be made to existing SDDOT manuals and methods appropriate for design and selection of materials and methods.

This discussion of design methods will be divided into the two primary categories of erosion control and sediment control. Each of these categories will be further divided based on the design considerations and design methodologies.

**5.4.1 Modeling Erosion**

Often the decision about the appropriate types of controls requires some estimate of the potential sediment load a site may generate. The Revised Universal Soil Loss Equation (RUSLE) is a model used to estimate annual sheet and rill erosion rates caused by rainfall and the associated overland flow. RUSLE is the result of a tremendous amount of data collection and evaluation from the 1930s through the 1970s. It was originally developed in the 1930s as the Universal Soil Loss Equation (USLE) for farmers and the agriculture profession as a tool to manage their soil but its limited application led to the development of RUSLE. The need for this USLE revision, which took place in the 1980s, became apparent as users demanded more flexibility in modeling erosion which was not offered in the original equation. RUSLE is represented by the following equation:

\[ A = R \times K \times LS \times C \times P \]

Where:

- **A** = Average annual soil loss in tons per acre, per year across entire state
- **R** = Rainfall Runoff Erosivity Index is a statistic calculated from the annual summation of rainfall for a given area. It is calculated using the following equation:

\[ R = E \times \frac{I}{n} \]

Where:

  - **E** = Kinetic energy of raindrop
  - **I** = Maximum 30-minute storm intensity
  - **n** = Number of rainfall events

This equation indicates that the greater the intensity and duration of the storm, the higher the erosion potential. While total rainfall is important, intensity most affects the amount of erosion in that a slow, steady, gentle rain will not be as erosive as a short, intense torrential downpour. As expected, the R value varies geographically.
- **K** = Soil Erodibility Factor. This is a measure of the ease with which soil particles are detached by raindrop impact and tractive force of surface flow (runoff). The two most significant soil characteristics affecting soil erosion are infiltration capacity and structural stability. Tight clays do not allow infiltration as soils with high organic content. Structural stability, or the resistance of soil particles to breaking off, determines the amount of sediment displaced by the overland flow. This erodibility value is calculated by determining the amount of soil loss after placing a particular soil type in a plowed but unseeded condition in a test plot with a slope length of 72.6’ and slope steepness of 9%. K factors are available from South Dakota Department of Agriculture and Natural Resources, SSURGO Soil Reports.

- **LS** = Slope Length-Gradient Factor. The LS factor is based on the fact that the steeper slopes produce higher overland flow velocities. Longer slopes accumulate runoff from a larger area and also results in higher overland flow velocities. Thus, both result in increased erosion potential, but in a nonlinear manner. The LS factor represents a ratio of soil loss of a particular slope, possibly at a construction site, with the ‘standard’ slope length of 72’ and a steepness of 9%. For convenience L and S are grouped together into a single term.

- **C** = Crop Management Factor indicates the influence of cropping systems and other management variables on soil loss. It is the most computationally complicated of the RUSLE factors, yet it is the factor over which we have the most control. The C value for a specific location depends on a number of factors including the crop (vegetation) being grown, crop stage, tillage, and other management factors. Technically, the C value is the ratio of soil loss under the conditions found in the field in question to that which would occur under clean, tilled, yet unseeded conditions. The C value will be high (approaching 1.0) with bare soil. It will be low (<0.10) where large amounts of vegetation or crop residue are on the surface of the ground. These values are typically computed by experienced scientists with knowledge of the effects of vegetative cover and management practices in a given area. Actual values are available through the USDA Soil Conservation Service.

- **P** = Support Practice Factor (sometimes called Conservation Practice Factor) indicates the effects of practices that will reduce the amount and rate of the runoff thus reducing the amount of erosion. The P-factor is defined as the ratio of soil loss with a given surface condition to soil loss from up-and-downhill plowing. This factor accounts for the erosion control effectiveness of such land treatments as slope roughening, establishing sediment basins, and other control structures. Terracing, vegetated buffer strips, and contour plowing all reduce P values. If there are no support practices the P-factor is 1.0.

The biggest problem with RUSLE is that the C and P factors have not yet been calibrated for use in transportation construction applications. The Support Practice Factor, P, does not allow for evaluating combinations of practices in a way that will allow optimization of design. However, there are no better tools currently available that are as simple and rely on commonly available data.
The Modified Universal Soil Loss Equation (MUSLE) is a derivative of RUSLE. MUSLE follows the structure of the Universal Soil Loss Equation with the exception that the rainfall factor is replaced with a runoff energy factor. This form allows the estimate of the sediment yield for a single storm event rather than the annual loading. The estimates obtained with MUSLE are generally reliable within a watershed that does not exceed 5 square miles.

RUSLE has been derived empirically and has been used internationally because of its relative simplicity and because of the small amount of input required. However, one of the limitations of using the RUSLE model is that it predicts erosion across the entire site, but it does not account for deposition. In addition, it cannot account for complex topography even when integrated with complex GIS analysis. Though updated, the main focus of RUSLE is to predict long-term sheet and rill erosion on disturbed hill-slopes. As such, RUSLE does not provide estimates for gully erosion, streambank erosion, or sediment yield from watersheds or single rainfall events.

5.4.2 Public Domain Software for Modeling Erosion


RUSLE 2 is an advanced, user-friendly software program that predicts average annual erosion by water for construction, farming, mining, and forestry use. It is a public domain Microsoft Windows® based program and can be downloaded from:


**The Water Erosion Prediction Project (WEPP)**

The USDA Water Erosion Prediction Project (WEPP) erosion model is a continuous simulation erosion prediction model implemented as a set of computer programs for Windows® based personal computers. Continuous simulation means that the computer program simulates a number of years with each day having a different set of climatic conditions. On each simulation day, a rainstorm may occur, which may or may not cause a runoff event. If runoff is predicted to occur, the soil loss on the site (erosion), sediment deposition, and sediment loss off-site will be calculated. This value can then be divided by a time interval which allows erosion to be predicted on a daily basis.

WEPP represents a new generation of technology for estimating soil erosion and sediment delivery from slopes, channels and small watersheds based on the fundamentals of weather generation, infiltration theory, hydrology, soil physics, plant science, hydraulics, and erosion mechanics. It allows users to simulate runoff, erosion, and sediment delivery from entire watersheds (up to 2000 acres) or portions of the watershed. The program also allows the user to compare management practices under different scenarios. It offers a Landscape Profile application which provides a major advantage over existing erosion prediction technology. The advantages of this application include capabilities to estimate net soil loss for an entire hill-slope on a daily, monthly, or annual basis. Since the model is process-based it can be used to calculate a broad range of conditions that are not practical or economical to field test. In watershed applications, sediment yield from an entire watershed can be estimated.
The following erosion processes are simulated by the WEPP erosion model:

- Detachment and transport by raindrop impact
- Detachment, transport, and deposition by overland rill flow
- Detachment, transport, and deposition by concentrated channel flow
- Deposition by impoundments

Factors used to calculate these processes include rill erosion (caused by water flowing over the land) inter-rill erosion (caused by raindrop impact and splash), sediment transport and deposition, surface sealing, rill hydraulics, surface runoff, plant growth, evaporation, transpiration, snow melt, frozen soil effects, soil roughness, and others. WEPP considers both spatial and temporal variability in topography, surface roughness, soil properties, and land use conditions of hill-slopes. Almost all of these factors used for hill-slopes are duplicated for concentrated channel flow. Impoundments such as check dams, culverts, and filter fences can be simulated and evaluated to remove sediment from the flow. The model has been validated against approximately 1,000 plot years of natural rainfall from 15 different watersheds across the United States.

Included in the WEPP system is a climate database, a soil database, and user interface programs which allow end users to ‘customize’ and save information. The above mentioned factors and databases make the WEPP model a very powerful tool for users involved with natural resources or environmental issues.

The WEPP software and tutorial can be downloaded at: [http://www.ars.usda.gov/Research/docs.htm?docid=10621](http://www.ars.usda.gov/Research/docs.htm?docid=10621)

WEPP is an evolving tool and requires data at the watershed level. This data is seldom available for rural highways which may cross several watersheds within the limits of a single project. However, in time, the NRCS, cities, counties, and transportation agencies will continue to develop detailed geographic information systems. Therefore, the data required to effectively utilize WEPP, and other hydrology software will be increasingly available. Until that time, WEPP remains a tool of limited use in most transportation applications.

However, it is important that those in SDDOT charged with design of sediment and erosion controls for construction sites are familiar with these basic modeling tools. At this time RUSLE and WEPP are the most widely recognized and defensible tools available for estimating sediment loads. When projects involve particularly sensitive waters or habitat these programs are the best tools for addressing how decisions will be made regarding appropriate BMPs and how they will be maintained.
5.4.3 Designing Erosion Controls for Shoulders, Borrow Ditches, and Slopes

The design and selection of materials and methods for erosion control on shoulders, borrow ditches, and slopes focuses on minimizing the forces of wind, rain drop impact, and concentrated flows that can detach and transport soil particles. Some proprietary applications have been developed based on the RUSLE. These applications have been developed by manufacturers of erosion control products to guide the selection of their products. However, there is no similar public domain tool available other than RUSEL 2 and WEPP. Because of the wide range of materials and methods available for controlling general erosion, as well as sediment, designers need to consider several site related factors:

- Slope
- Soil type
- Material longevity

Slope: represents part of the energy component of driving the erosion process. The greater the slope the greater the shear stress will be on the soil surface. As water sheets over the surface of a slope it will accelerate down the slope, therefore the longer the slope the greater the velocity and the greater the stress.

Soil Type: The most significant property of a soil that affects erosivity is the soil texture. Soil texture refers to the particle size distribution of the soil horizons in terms of the percent of sand, silt, and clay. The relationships between the particle sizes are usually most often displayed in a three sided matrix called the “Soil Triangle” (see Figure1). Each side of the matrix represents the percent of sand silt or clay particles in a soil. The shaded part of the matrix represents soils that for erosion control purposes will behave as sands or non-cohesive soils. The soils in the un-shaded area will behave as clays or cohesive soils.

Material Longevity: The life of a material or method of erosion control affects selection in two ways. First, it is important that a material last for as long as needed. That is generally the period of time that it will take to establish enough permanent vegetation so that the temporary cover is no longer needed. The second consideration is cost. Materials that last longer are generally more expensive than shorter lived materials. The tendency to select a longer lived material as a measure of safety is not a particularly good choice. If a material persists after achieving a stand of vegetation it can interfere with maintenance activities and particularly mowing machinery. So, it is critical to select materials that will degrade at about the same rate as vegetation establishment. In cases where planting can be done in season (spring or fall planting), erosion controls that last for a single season are preferred. The only time longer lived materials are usually warranted are in high elevations or in drought prone areas where it may take two or three seasons for the vegetation to mature to a sufficient height and density to provide protection.
Because there are so many materials and methods from which to choose, a simple decision tree was developed that can be used to guide users through the selection process. The selection tool includes commercial products, mulches, blankets, turf reinforcement mats (TRM), bonded fiber matrices (BFM), as well as non-proprietary materials and methods, such as straw mulch and surface roughening. The tool is introduced in Section 3 of the Design Manual. The decision tree was developed based on over 15 years of research and field testing of erosion control products. It considers the primary considerations of soil type, slope steepness, and general function of erosion control or sediment control. It does not directly consider material longevity. Because of the variation in materials, the lack of any testing or ranking standards, and the impact of climate on breakdown, designers will have to exercise judgment in making decisions about longevity. As noted earlier, materials that will degrade over the period of a single season are usually sufficient except in very special cases where climatic extremes are encountered.

One word of caution about surface protection materials; in highly erosive soils it is important to select a material that is sufficiently flexible to maintain intimate contact with the soil, otherwise the material does little more than cover up the erosion below the blanket. Rigid materials, such as heavily tacked straw, stiff synthetic materials, and heavy coir fibers sometimes lack flexibility and will simply span rills which continue to grow with each succeeding rainfall event.

5.4.4 Temporary and Permanent Channel Liners

Channels require a more sophisticated design consideration. In general, the selection of the lining material should be based on the shear stress rating of the material and the design shear stress of the roadside channel. The design procedures for determining channel shear stress are in the Chapter 9 of the SDDOT Drainage Manual.

In Chapter 9 of the SDDOT Drainage Manual the use of the HEC-15 program to compute the shear stress on the channel bottom is recommended. However, the calculation is quite simple and for the selection of a channel liner the calculation can be done manually. Equation 1 is used to determine the shear stress on the bottom of a straight line channel. This is the most practical form of the equation since channels are usually parallel to straight line pavement sections so a value of one (1) is used for the bend coefficient.
As an example, the shear stress on the roadside channel that has a longitudinal slope of 0.043 and an estimated depth of flow of 18 inches.

\[
\tau = gDS_fK_b
\]

\(\tau\) = Shear in \#/\text{ft}^2

\(g\) = Unit weight of water (62.4#/\text{ft}^3)

\(D\) = The depth of flow in feet

\(S_f\) = Friction slope or bed slope of Channel

\(K_b\) = Bend Coefficient (\(K_b\) is 1 for straight channel)

**Equation 1: Shear Stress on Straight Line Channels**

\[
\tau = gDS_fK_b
\]

\[
\tau = \frac{62.4}{1.5} \cdot 0.043 \cdot 1 \text{ lb/ft}^2
\]

\[
\tau = 4.02 \text{ lb/ft}^2
\]

The channel will have a peak shear stress of 4 lb/sf. Working through the selection tool for channel protection, you determine that Type 1 Turf Reinforcement Mat (TRM) is the minimum product that will meet this need.

### 5.5 Design Checklist

This **SWPPP Checklist** was developed to guide the preparation of the SWPPP document. This tool ensures the requirements are met to secure approval of the Notice of Intent (NOI) and SWPPP under the SD DANR General Permit for Storm Water Discharges Associated with Construction Activities. The list can be used in either paper or electronic format. The first column of the checklist is a series of check boxes to indicate a task is complete. The second column of the checklist cites the section of the General Permit that task relates to. The third column is a description of the task or product to be produced, and the fourth column is used to provide quick references to the specific page in the SWPPP plan set that addresses the requirement of the permit. The check list follows the section organization of the SD DANR General Permit for Storm Water Discharges Associated with Construction Activities.
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6.7.21 Erosion Control Blanket

6.7.22 Shaping for Erosion Control Blanket

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6.8 Erosion and Sediment Control Design Computation Worksheets
6.1 Guidelines for Sediment Basin Design

6.1.1 Where are sediment basins needed?
A sediment basin is needed if there are 10 or more drainage acres going through a pipe, culvert, or other drainageway and 10 or more of those drainage acres are disturbed at once.

6.1.2 Eliminate the need for sediment basins.
The best way to eliminate the need for sediment basins is to limit the amount of disturbed area at one time. This can be achieved through construction sequencing and the quick stabilization of disturbed areas. Another way to avoid using sediment basins is by using a series of sediment traps and/or best management practices. Our ultimate goal is to keep sediment on-site and out of waters of the state.

6.1.3 If a sediment basin is necessary, how do I determine capacity?
Ask the project grading engineer to calculate the amount of runoff from the drainage area. You may want to have the engineer do this even if you think a sediment basin is not needed to make sure that the alternate best management practices you have chosen to use will be sufficient for the estimated runoff.

6.1.4 How much area is needed for the proposed sediment basins?
The shape of the basin plays an important role in determining the effectiveness for removing sediment. Length to width ratios should be a minimum of 4:1 to maximize flow path length within the basin. Length is the distance between the inlet and outlet structures. Instead of being a perfect rectangular shape, it is advisable to have the basin wedge-shaped with the inlet at the narrow end. When physical site constraints prevent construction of basins with a length/width ratio of 4:1, silt fence baffles should be used to increase the flow path length within the basin.

In regard to sediment removal, surface area is more important than depth. Additional depth only adds more storage volume. The basin depth should be a minimum of 2 feet and no willower than the length divided by 200. Basin dimensions can be determined using the following equations:

<table>
<thead>
<tr>
<th>Basins with volumes less than 80,000 cubic feet</th>
<th>Basins with volumes more than 80,000 cubic feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Width} = \sqrt{\text{Volume}/8} )</td>
<td>( \text{Width} = \sqrt[3]{12.5 \times \text{Volume}} )</td>
</tr>
<tr>
<td>( \text{Length} = 4 \times \text{Width} )</td>
<td>( \text{Length} = 4 \times \text{Width} )</td>
</tr>
<tr>
<td>( \text{Depth} = 2 \text{ feet (a constant)} )</td>
<td>( \text{Depth} = \text{Length}/200 )</td>
</tr>
</tbody>
</table>
6.1.5 Where should the sediment basin be located?

Refer to the ROW Section and Sections B and X to determine the best location. The sediment basin must:

- Be outside the clear zone (30’ from the edge of the driving lane) unless it is less than 2 feet deep
- Be within the ROW and proposed easements and above the water table
- Have side slopes 3:1 or less (preferably vegetated before water enters the basin)
- Be located a sufficient distance from property and waterbodies where a failure could cause catastrophic damage

6.2 Guidelines for Silt Fence Design as Perimeter Protection

Installation and removal of silt fence can increase disturbance—especially if installed incorrectly. Consider other BMP’s before choosing to use silt fence. Other options may include:

- Stabilized topsoil berms with rock weepers
- Erosion Control Wattles
- Quick stabilization to reduce sediment runoff and reduce the need for sediment controls such as: temporary/permanent seeding, temporary mulching, or soil stabilizer
- Temporary Sediment Barriers
- Floating Silt Curtain
- Temporary Water Barriers
- Triangular Silt Barriers

The guidelines for silt fence installation on slopes and as perimeter protection shown below have been adopted from the NRCS Colorado Fact Sheet.

<table>
<thead>
<tr>
<th>Slope Steepness</th>
<th>Maximum Slope Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:1</td>
<td>50 feet</td>
</tr>
<tr>
<td>3:1</td>
<td>75 feet</td>
</tr>
<tr>
<td>4:1</td>
<td>125 feet</td>
</tr>
<tr>
<td>5:1</td>
<td>175 feet</td>
</tr>
<tr>
<td>&lt;5:1</td>
<td>200 feet</td>
</tr>
</tbody>
</table>

- The area that contributes to runoff to be caught by the silt fence should not be greater than ½ an acre for 100 feet of fence.
- Silt Fence should be installed on the contour of a slope.
- Limit the length of silt fence to allow the passage of wildlife.
- Installing silt fence in a J-hook pattern on slopes and near work limits allows wildlife to pass and is effective at catching sediment when placed on contour in an overlapping pattern.
6.3 Guidelines for Erosion Control Blanket Design

Erosion Control Blankets are used where fiber or straw mulching is not sufficient to control erosion during vegetation establishment. Fiber Reinforced Matrices can provide protection similar to Erosion Control Blankets and may be easier to apply than blankets are to install. Fiber Reinforced Matrices should not be installed in ditch bottoms.

While determining which to use, consider the estimated time it will take to establish vegetation on the site. It typically takes longer to establish vegetation in the western portion of the state because of poorer soils and lower rainfall amounts (so Type 3 Erosion Control Blanket may be the best to use on that side of the state).

**Type 1 Erosion Control Blanket**
- Typical 3 to 6 month functional longevity
- Channels: Calculated Shear Stresses of 0 psf to 1.5 psf
- Slopes: Typically used on street boulevards to help establish vegetation
- This type of blanket is rarely utilized because most places where they would be applied are typically treated with Straw Mulch.

**Type 2 Erosion Control Blanket**
- Typical 6 to 12 month functional longevity
- Slopes: 4:1 (H:V) to 3:1 (H:V)
- Channels: Calculated Shear Stresses of 1.50 psf to 1.75 psf
- Ditch Grade: 2% to 4%

**Type 3 Erosion Control Blanket**
- Typical 12 to 24 month functional longevity
- Slopes: 3:1 (H:V) to 2:1 (H:V)
- Channels: Calculated Shear Stresses of 1.75 psf to 2.00 psf
- Ditch Grade: 4% to 6%
- One of the most used blankets, and typically the least expensive.

**Type 4 Erosion Control Blanket**
- Typical 24 to 36 month functional longevity
- Slopes: 2:1 (H:V) to 1:1 (H:V)
- Channels: Calculated Shear Stresses of 2.00 psf to 2.25 psf
- Ditch Grade: 6% to 8%
- At shear stresses this high, it could be more beneficial to use a Turf Reinforcement Mat because permanent erosion control is likely needed.
- Industry professionals have used this blanket sprinkled with powdered flocculants at sediment traps/basin inlets to increase sediment capture.
6.4 Guidelines for Turf Reinforcement Mat Design

Turf Reinforcement Mats are for permanent stabilization of erodible areas. They are not necessarily the next step up from Erosion Control Blankets because they are permanent and needed to prevent erosion even after vegetation has been fully established. Although the drainage manual states vegetation in ditches can withstand a shear stress of 2.10 psf when it is not mowed, it is best to use Turf Reinforcement Mats instead of Erosion Control Blankets in ditches with shear stresses near or above 2 psf. While Turf Reinforcement Mat is a more expensive option, it is a permanent BMP. Talk to the designer about placing Turf Reinforcement Mats under any rip rap adjacent to the planned TRM installation. It has been done in the Winner Area and this practice helps ensure that the mat is correctly anchored rather than trying to trench it in along the rip rap. It may also provide additional erosion control by allowing vegetation to grow through the rip rap.

**Type 1 Turf Reinforcement Mat**
- Channels: Calculated Shear Stresses of 2.00 psf to 4.00 psf

**Type 2 Turf Reinforcement Mat**
- Channels: Calculated Shear Stresses of 4.00 psf to 6.00 psf

**Type 3 Turf Reinforcement Mat**
- Channels: Calculated Shear Stresses of 6.00 psf to 8.00 psf
- Some Turf Reinforcement Mats can withstand Shear Stresses over 8 psf. To specify them, they will need to be called out in the plan notes.

6.5 Seeding vs Sodding Design

The following information can be used when the designer needs to choose between seeding and sodding on projects. Keep in mind that sodding can be used on some parts of the project and seeding can be used on other parts of the project depending on what the designer decides using the following information.

6.5.1 Design Information

When making design decisions, the following information should be accessed and taken into consideration:

- Aerial photos and site visits (Consider how well kept the existing lawn is).
- Slope of the existing lawn as determined in cross sections and in grading plans.
- Contact SDDOT field personnel for their input on whether to use seeding or to use sodding on a project.
- Consider requests from landowners for sodding on their property.
- Look at sodding and seeding Unit Prices in CES to access cost differences (Sodding is always more expensive than seeding).
6.5.1.1 Seeding Considerations

If seeding is used it must include the following:

- Seeding plus Fiber Mulch (commonly referred to as Hydro Turf).
- Seeding plus Soil Stabilizer.
- Seeding plus Fiber Reinforced Matrix.
- Seeding plus Erosion Control Blanket.

Advantages
- More grass types and varieties to choose from.
- Less expensive than sodding.
- Stronger root system development initially.

Disadvantages
- Initial establishment is longer than sodding.
- For best results, time of seeding is limited mainly to late Summer or early Fall.
- Watering must be available because moisture is critical for young seedlings.

6.5.1.2 Sodding Considerations

Some general considerations include:

- If there is an underground sprinkler system in place, sodding may be a better choice because of the ease of watering and less chance for erosion.
- Urban projects will be the primary application for sodding. Rural projects will seldom require sodding, unless specifically requested by landowners.
- Some sod farms offer more drought tolerant species in their sod than they had in the past.

Advantages
- Immediate protection from erosion thus helping to meet erosion and sediment control and storm water quality stabilization requirements sooner.
- Can be used as a buffer strip.
- Rapid establishment and relatively weed-free in the beginning.
- Good for slopes or areas prone to erosion.
- Can be laid at any time during the growing season as long as watering is available.

Disadvantages
- Somewhat expensive.
- Less selection as far as species and varieties of grasses.
- Availability depending on the time of year.
6.6 Erosion and Sediment Control Design Checklist

Date:__________
Project #:__________
County and PCN:__________

Plans, letters, and notes needed to design most projects:

- Scope Summary in HC65 C2C
- Section B Grading Plans and Profiles (Road Design Grading Squad)
- Section X Cross-sections (Road Design Grading Squad)
- Section Z Pipe Section Sheets (Road Design Grading Squad)
- Non-Section Plans (Road Design Grading Squad)
- Right-of-Way Photos (ROW Section of Road Design)
- Borrow Pit Agreements and Borrow Pit Layouts (Region Materials Engineer)
- Soils Letter (Geotechnical Office)
  - May have erosion control suggestions
  - Will likely note rocky areas or slopes
  - Will include topsoil depth and/or soil types for SWPPP checklist
- Landowner (LO) Meeting Notes (Road Design Grading Squad)
  - May have special requests for seeding or sodding
  - May request colored concrete/landscape rock replacement instead of grass
- Pavement Removal Plans (Road Design Grading Squad)
  - Will help with calculating topsoil, seed, fertilizer, and mulch quantities.
- Sequence of Operations (Section C from Area Office)
  - May help in deciding where more interim erosion and sediment controls are needed
- Drainage Memo (Hydraulics Office)
  - Will show drainage areas at culverts
  - Will identify "Waters of the US". More erosion and sediment controls may be needed.
- Section A Environmental Commitments (Environmental Office)
  - Tree and shrub replacement
  - Topeka Shiner
  - Fishery Waters
  - Wetlands

Other useful design information:

- Look at Average Unit Prices in CES when selecting Erosion and Sediment Control BMPs.
- USDA Plants Database: to determine plants native to each county for seed mix development
- Rocky or Rock Slopes
- Contours (use InRoads to import into gfile).
- Websoil Survey (USGS) for soils information on projects without Soils Letters
- ArcGIS: Pipe Surveys and other information
- Stream Relocation (A consultant may be hired to do the stream relocation plans.)
- Wetland Mitigation (Usually done in-house if right along a project)
- Google Maps (to get a better idea of what is shown in the topo and ROW photos)
- HR49 Roadway Inventory (similar to Google Maps)
- Environmental folders (if Section A isn’t complete before review)

Tasks for the Erosion and Sediment Control Designer:

- Keep electronic correspondence and other information in the project directory.
- Keep good documentation.
- Look through Electronic Project Files for pertinent information.
- Look through the entire “Grading Design Project File” in file drawer for pertinent information.
- Communicate with the Grading Designer throughout the project.
- Look at the completed set of grading plans before they go out for review to make sure nothing was missed in regard to Erosion and Sediment Control.
6.7 Erosion and Sediment Control Design Information

6.7.1 Placing Topsoil

Topsoil is salvaged from all areas where grading is to occur under the bid item “Unclassified Excavation” in Section B. It is replaced when grading is finished under the bid item “Placing Topsoil” in Section D. Refer to Section D Standard Notes.

<table>
<thead>
<tr>
<th>Example Placing Topsoil Calculation for Rural Projects*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area of Work Limits measured in Microstation</strong></td>
</tr>
<tr>
<td>-see U:\rd\Doc\CADD Procedures Manual, E-Erosion Control</td>
</tr>
<tr>
<td>-determine a quantity for each plan sheet</td>
</tr>
<tr>
<td><strong>Length of Roadway</strong></td>
</tr>
<tr>
<td>-calculated using the stationing on each plan sheet</td>
</tr>
<tr>
<td><strong>Area of Roadway</strong></td>
</tr>
<tr>
<td>-calculated by multiplying the length of the roadway by</td>
</tr>
<tr>
<td>the width found in Section B Typical Sections. Width</td>
</tr>
<tr>
<td>may vary along a measured section—use best judgment for</td>
</tr>
<tr>
<td>estimating area.</td>
</tr>
<tr>
<td><strong>Area of Work Limits minus area of Roadway</strong></td>
</tr>
<tr>
<td>284,548 SqFt – 156,000 SqFt = 128,548 SqFt</td>
</tr>
<tr>
<td><strong>+3% for slopes</strong></td>
</tr>
<tr>
<td>128,548 SqFt x 1.03 = 132,404 SqFt</td>
</tr>
<tr>
<td><strong>4 inches of topsoil inside Right-of-Way</strong></td>
</tr>
<tr>
<td>-if the Soils Recommendations Letter from the Geotechni</td>
</tr>
<tr>
<td>cal Office states that more is available, consider</td>
</tr>
<tr>
<td>using that quantity instead.</td>
</tr>
<tr>
<td>-if the Soils Letter states that less than 4 inches is</td>
</tr>
<tr>
<td>available, “Contractor Furnished Topsoil” may have to</td>
</tr>
<tr>
<td>be added.</td>
</tr>
<tr>
<td><strong>6 inches on Temporary Easements</strong>*</td>
</tr>
<tr>
<td>(outside Right-of-Way)</td>
</tr>
<tr>
<td>-multiply the sum of temporary easement areas shown on</td>
</tr>
<tr>
<td>each plan sheet by an additional 2&quot;</td>
</tr>
<tr>
<td><strong>Total CuFt</strong></td>
</tr>
<tr>
<td>43,693 CuFt + 7428 CuFt = 51,121 CuFt</td>
</tr>
<tr>
<td><strong>Convert to CuYd</strong></td>
</tr>
<tr>
<td>-place this number in the table after the appropriate</td>
</tr>
<tr>
<td>stationing</td>
</tr>
</tbody>
</table>

*It has been determined that projects in urban areas only need 4” on temporary easements. Also, urban grading jobs have many paved surfaces, so areas for topsoil placement, seeding, fertilizing, and mulching may need to be measured in Microstation using the curb and gutter file and topog rather than just subtracting the roadway.
6.7.2 Contractor Furnished Topsoil

If the Soil Recommendations Letter notes that less than 4” of topsoil is available on grading projects, subtract the quantity available from the 4” to get the amount for Contractor Furnished Topsoil. The quantity available will be listed under the “Placing Topsoil” bid item with the quantity needed listed under the “Contractor Furnished Topsoil” bid item. Contractor Furnished Topsoil may also be needed for landscaping projects in areas such as planting beds and medians with the thickness and quantity determined by the Landscape Architect.

6.7.3 Remove and Replace Topsoil

The topsoil is bladed down the inslopes prior to resurfacing, then bladed back up the inslope after resurfacing is complete. Refer to Standard Notes for more info.

<table>
<thead>
<tr>
<th>EXAMPLE REMOVE AND REPLACE TOPSOIL COMPUTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length of the Project</strong>&lt;br&gt;-typically shown on Section F title sheet</td>
</tr>
<tr>
<td><strong>One side of a 4-Lane Highway</strong>&lt;br&gt;-multiply length of the project by 28’ (11’ wide strip on inside lane inslope, 16’ wide strip on outside lane inslope)</td>
</tr>
<tr>
<td><strong>2-Lane Highway</strong>&lt;br&gt;-multiply length of the project by 32’ (16’ wide strip on each inslope)</td>
</tr>
<tr>
<td>+3% for slopes</td>
</tr>
<tr>
<td><strong>4 inches of topsoil inside Right-of-Way</strong></td>
</tr>
<tr>
<td><strong>Total CuFt</strong></td>
</tr>
<tr>
<td><strong>Convert to CuYd</strong>&lt;br&gt;-Create a &quot;Remove and Replace Topsoil” note in the plans by stating how many feet each inslope will be bladed back and how many total CuYd are estimated to be removed and replaced (in this case 1,893 CuYd).</td>
</tr>
</tbody>
</table>

6.7.4 Surface Roughening

Surface Roughening is a method of temporary stabilization that may be completed on slopes 3:1 or steeper, in ditch channels greater than 2%, or in areas deemed necessary by the engineer. Surface Roughening is measured to the nearest tenth of an acre.

6.7.5 Stabilized Construction Entrances

Add a Stabilized Construction Entrance on every grading project. During review, the Region and/or Area Engineer will advise to how many they think are actually necessary.
6.7.6 Option Borrow Pits and Borrow Pits

All borrow pit information comes from the Region Materials Offices. Borrow Pit Information Sheets will be available from the Project Engineer if borrow pits are utilized on the project. These sheets show the estimated volume of topsoil and the estimated area disturbed. Add the estimated volume of topsoil to the Option Borrow Pit section of the “Placing Topsoil” table. Use the estimated area disturbed to calculate seed and mulch quantities.

Borrow Pit Agreements indicate what type of seed the landowner requested. Landowner requests are usually honored. If the borrow pit area will be restored for use as cropland, permanent seed and mulch will not be needed. If Borrow Pit Agreements are not available, assume the pit will be seeded with the same seed mixture as the rest of the project and mulched unless otherwise informed.

If the project utilizes Contractor Furnished Borrow, quantities for Placing Topsoil, Permanent Seeding, and Mulching will not need to be included in the Section D Estimate of Quantities because these are taken care of by the Contractor.

6.7.7 Cover Crop Seeding

The area to be seeded with Cover Crop Seeding is typically computed as 25% of the total area to be Permanent Seeded. The application rate is 2 Bu/Acre. Cover Crop Seeding may not be necessary on projects that use Type F or G Permanent Seed Mixture as these already have a cover crop included.

6.7.8 Permanent Seeding

The area to be Permanent Seeded is the sum of the disturbed areas after adding 3% for slopes in the Topsoil Calculations (shown on page 52). Other areas that also need to be Permanent Seeded include the following:

- Temporary Easements
- Borrow Pits and Haul Roads
- Waste Disposal Sites (if Waste Disposal Sites are not furnished by the Contractor)
- Areas of Old Road Obliteration
- Other areas that vary by project

6.7.9 Hydroseeding

The Hydroseeding bid item may be used at the discretion of the Landscape Architect. The equipment used for hydroseeding will be a mechanical agitation hydroseeding machine. All costs for hydroseeding including equipment, labor, and materials will be incidental to the contract unit price per square yard for “Hydroseeding.” Although Permanent Seed and Fertilizer are part of Hydroseeding, they are separate bid items.
6.7.10 Sodding

Sod is measured to the nearest square yard. Water for Vegetation should also be included in the Estimate of Quantities (refer to Sodding in Spec. Book).

6.7.11 Fertilizing

Refer to the Section D Standard Notes for rates. Fertilizing is done on most projects using only organic slow-release fertilizers. Chemical fertilizers are discouraged because they benefit weeds and invasive species more than they benefit the native species. Chemical fertilizers are also more likely to leach into surface waters and create water quality issues.

6.7.12 Grass Hay or Straw Mulch

Grass Hay or Straw Mulch is applied at a rate of 2 Ton/Acre to areas to be permanent seeded on rural projects. An additional 25% is added for temporary stabilization. Steep slopes may require 3-4 Ton/Acre.

6.7.13 Fiber Mulching

Fiber Mulching is typically applied at a rate of 2000 Lbs/Acre to areas to be permanent seeded. Quantities may be added for temporary stabilization. Fiber Mulching is applied in a separate application after seeding. It is 50% effective during storm events lasting 60 minutes with 5" of total precipitation.

6.7.14 Soil Stabilizer

Soil Stabilizer is applied at various rates depending on the slope and product. Soil Stabilizer can be used interchangeably with Fiber Mulching. One benefit of Soil Stabilizer is that it can be broadcasted (applied as dry pellets) or hydraulically blown. Soil stabilizer can also be used to temporarily protect exposed soil and topsoil stockpiles and prevent them from eroding and creating dust (if applied in the liquid form).

6.7.15 Bonded Fiber Matrix

Use Bonded Fiber Matrix on permanently seeded areas on urban projects. Apply in a separate operation after seeding. Bonded Fiber Matrix is also used on steep slopes and bridge berms where conventional equipment such as a drill and straw crimper cannot be operated. The rate of application for Bonded Fiber Matrix will vary according to the Manufacturer’s recommendations. It is usually calculated at 3,900 Lbs/Acre. It is 95% effective during storm events lasting 60 minutes with 5” of total precipitation.

6.7.16 Fiber Reinforced Matrix

Use on critical slopes or near sensitive areas to provide immediate stabilization and faster revegetation. It requires no curing time and should not be placed in channels without being sprayed into the manufacturer recommended turf reinforcement mat. It is 99% effective during storm events lasting 60 minutes with 5” of total precipitation.
6.7.17 Rock Check Dams and Rip Rap

Use in ditches with shear stresses over 8 psf with Turf Reinforcement Mats.

6.7.18 Silt Fence

Do not use silt fence in streams or channels. Use sandbags/snake bags in places where soil is too rocky to be dug so that the silt fence material can be held to the ground for proper functioning.

6.7.18.1 High Flow Silt Fence

Use high flow silt fence where there is concentrated water such as at pipe inlets. 25% of total may be added for additional temporary sediment control. Refer to Standard Plate 734.05 for more information.

- APPROACH PIPES
  - Pipe 24" or less use 18 Ft in a U shape
  - Pipe larger than 24" use 30 Ft across ditch

- MAINLINE PIPES
  - Pipe 24" or less use 18 Ft in a U shape
  - Pipe larger than 24" use 30 Ft across ditch
  - Pipe with drainage area 50-100 acres use 60 Ft at each end of pipe
  - Pipe with drainage area 100+ acres use 100 Ft at each end of pipe

6.7.18.2 Low Flow Silt Fence

Use low flow silt fence to keep sediment from entering wetlands, streams, box culverts, and adjacent properties. 25% of total may be added for additional temporary sediment control. Refer to Standard Plate 734.04 for more information.

- BOX CULVERTS
  - End without Detour 200 Ft
  - End with Detour 400 Ft

- BRIDGES
  - Berms 300 Ft

6.7.18.3 Repair Silt Fence

Only 25% of the total length of high and low flow silt fence installed is used based on a review of past projects and the quantity actually repaired.

6.7.18.4 Remove Silt Fence

Only 25% of the total length of high and low flow silt fence installed is used based on a review of past projects and the quantity actually removed.
6.7.18.5  Mucking Silt Fence

Only 25% of the total length of high and low flow silt fence installed is used based on a review of past projects and the quantity actually mucked. See page 67 for more details.

6.7.19 Erosion Bales

Erosion Bales have been replaced by Erosion Control Wattles. Erosion Bales may be better suited as a substitute for Silt Fence as perimeter protection near sloughs and wetlands. Refer to Standard Plate 734.02 for more information.

6.7.20 Erosion Control Wattles

Use Erosion Control Wattles perpendicular to the highway in ditch channels to decrease the velocity of flowing water and to trap sediment. Erosion Control Wattles also work well on slopes, for perimeter protection, and with Erosion Control Blankets. Erosion Control Wattles can also be used for sediment control at pipe inlets on pipes up to 36”. Look at cross sections and ditch grades to determine placement. Wattles come in 6”, 9”, 12” and 20” diameters. Refer to Standard Plate 734.06 for more information. The following guidelines are for 12” diameter wattles:

<table>
<thead>
<tr>
<th>DITCH INSTALLATION SPACING</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>150 Ft</td>
</tr>
<tr>
<td>3%</td>
<td>100 Ft</td>
</tr>
<tr>
<td>4%</td>
<td>Use erosion control blanket.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SLOPE INSTALLATION SPACING</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>10 Ft</td>
</tr>
<tr>
<td>2:1</td>
<td>20 Ft</td>
</tr>
<tr>
<td>3:1</td>
<td>30 Ft</td>
</tr>
<tr>
<td>4:1</td>
<td>40 Ft</td>
</tr>
</tbody>
</table>

6.7.21 Erosion Control Blanket

Use in areas where Straw Mulch, Fiber Mulch, or Erosion Control Wattles are not sufficient for holding soil in place. Erosion Control Blanket is typically placed 16 or 20 Ft wide in highway ditch channels. See recommendations on page 49. Refer to Standard Plate 734.01 for more information.

6.7.22 Shaping for Erosion Control Blanket

Shaping for Erosion Control Blanket is calculated when Erosion Control Blankets are used in ditch channels. Shaping equals the length in feet of ditch channel that the blanket covers at 16 or 20 Ft wide.

6.7.23 Turf Reinforcement Mat

Use in areas where established vegetation alone will not hold soil in place - usually above 2 psf. Turf Reinforcement Mat is typically placed 16 or 20 Ft wide in highway ditch channels. See recommendations on page 50.
6.8 Erosion and Sediment Control Design Computation Worksheets

An Excel spreadsheet can be used as an alternative to the following sheet. Save the spreadsheet under the documents folder in the project folder of the project you are working on as “SectionD.xls”.

Placing Topsoil (calculation method for rural areas)

Date: __________
Project #: __________
County and PCN: __________

Area of Roadway

Using the typical sections, find the area of the roadway throughout the project.

Sta__________ to Sta__________ = _________Ft
__________Ft (Length) x _________Ft (Roadway Width) = _________SqFt
or_______ Acres

Sta__________ to Sta__________ = _________Ft
__________Ft (Length) x _________Ft (Roadway Width) = _________SqFt
or_______ Acres

Sta__________ to Sta__________ = _________Ft
__________Ft (Length) x _________Ft (Roadway Width) = _________SqFt
or_______ Acres

Sta__________ to Sta__________ = _________Ft
__________Ft (Length) x _________Ft (Roadway Width) = _________SqFt
or_______ Acres

Sta__________ to Sta__________ = _________Ft
__________Ft (Length) x _________Ft (Roadway Width) = _________SqFt
or_______ Acres

Sta__________ to Sta__________ = _________Ft
__________Ft (Length) x _________Ft (Roadway Width) = _________SqFt
or_______ Acres

Sta__________ to Sta__________ = _________Ft
__________Ft (Length) x _________Ft (Roadway Width) = _________SqFt
or_______ Acres

= _________ Acres  Total Area of Roadway
## PROJECT TOPSOIL COMPUTATION WORKSHEET

<table>
<thead>
<tr>
<th>to (Begin)</th>
<th>to</th>
</tr>
</thead>
<tbody>
<tr>
<td>SqFt</td>
<td>SqFt</td>
</tr>
<tr>
<td>Ft x Ft =</td>
<td>SqFt</td>
</tr>
<tr>
<td>SqFt - SqFt = SqFt</td>
<td>SqFt - SqFt = SqFt</td>
</tr>
<tr>
<td>SqFt x 1.03 = SqFt</td>
<td>SqFt x 1.03 = SqFt</td>
</tr>
<tr>
<td>SqFt x 0.33Ft (4&quot;) = CuFt</td>
<td>SqFt x 0.33Ft (4&quot;) = CuFt</td>
</tr>
<tr>
<td>SqFt x 0.17Ft (2&quot;) = CuFt</td>
<td>SqFt x 0.17Ft (2&quot;) = CuFt</td>
</tr>
<tr>
<td>CuFt + CuFt = CuFt</td>
<td>CuFt + CuFt = CuFt</td>
</tr>
<tr>
<td>CuYd</td>
<td>CuYd</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>to</th>
<th>to</th>
</tr>
</thead>
<tbody>
<tr>
<td>SqFt</td>
<td>SqFt</td>
</tr>
<tr>
<td>Ft x Ft =</td>
<td>SqFt</td>
</tr>
<tr>
<td>SqFt - SqFt = SqFt</td>
<td>SqFt - SqFt = SqFt</td>
</tr>
<tr>
<td>SqFt x 1.03 = SqFt</td>
<td>SqFt x 1.03 = SqFt</td>
</tr>
<tr>
<td>SqFt x 0.33Ft (4&quot;) = CuFt</td>
<td>SqFt x 0.33Ft (4&quot;) = CuFt</td>
</tr>
<tr>
<td>SqFt x 0.17Ft (2&quot;) = CuFt</td>
<td>SqFt x 0.17Ft (2&quot;) = CuFt</td>
</tr>
<tr>
<td>CuFt + CuFt = CuFt</td>
<td>CuFt + CuFt = CuFt</td>
</tr>
<tr>
<td>CuYd</td>
<td>CuYd</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>to</th>
<th>to</th>
</tr>
</thead>
<tbody>
<tr>
<td>SqFt</td>
<td>SqFt</td>
</tr>
<tr>
<td>Ft x Ft =</td>
<td>SqFt</td>
</tr>
<tr>
<td>SqFt - SqFt = SqFt</td>
<td>SqFt - SqFt = SqFt</td>
</tr>
<tr>
<td>SqFt x 1.03 = SqFt</td>
<td>SqFt x 1.03 = SqFt</td>
</tr>
<tr>
<td>SqFt x 0.33Ft (4&quot;) = CuFt</td>
<td>SqFt x 0.33Ft (4&quot;) = CuFt</td>
</tr>
<tr>
<td>SqFt x 0.17Ft (2&quot;) = CuFt</td>
<td>SqFt x 0.17Ft (2&quot;) = CuFt</td>
</tr>
<tr>
<td>CuFt + CuFt = CuFt</td>
<td>CuFt + CuFt = CuFt</td>
</tr>
<tr>
<td>CuYd</td>
<td>CuYd</td>
</tr>
</tbody>
</table>
Permanent Seeding

Permanent Seeding on Grading Projects

__________Acres (area within Work Limits minus area of Roadway) plus ___________Acres (other areas that need to be Permanent Seeded) =__________Acres (total acres that are to be Permanent Seeded)

__________Acres x __________ Lbs/Acre (Permanent Seeding Rate) =__________Lbs

Permanent Seeding on Surfacing Projects

_________Acres (area where topsoil is to be stripped) plus _________Acres (other areas that need to be Permanent Seeded)

=_______Acres (total acres that are to be Permanent Seeded)

_________Acres x ___________Lbs/Acre (Permanent Seeding Rate) =

__________Lbs

Other areas that need to be Permanently Seeded:

<table>
<thead>
<tr>
<th>(Acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of Option Borrow Pits and Haul Roads</td>
</tr>
<tr>
<td>Area of Temporary Easements (from Section B Plan Sheets)</td>
</tr>
<tr>
<td>Area of Waste Disposal Site (if Waste Disposal Site is not furnished by the Contractor)</td>
</tr>
<tr>
<td>Areas of Old Road Obliteration</td>
</tr>
<tr>
<td>Other areas that need to be permanent seeded that vary by project</td>
</tr>
<tr>
<td>Total Area to be Permanent Seeded:</td>
</tr>
</tbody>
</table>

Cover Crop Seeding

The area to be seeded with Cover Crop Seed is typically computed as 25% of the total area to be Permanent Seeded:

__________Acres x 0.25 (25%) = ________Acres

__________Acres x 2 Bu/Acre = ________Bu

Erosion Bales (rarely used since Erosion Control Wattles have been developed)

__________Locations x 12 Erosion Bales/Location = ________
Fertilizing

Rural Area Calculation (Refer to Section D Standard Notes for the rates)

\[ \text{_______Acres} \times \text{_______ Lbs/Acre} = \text{_______ Lbs or ________Ton} \]

Urban Area Calculation (Refer to Section D Standard Notes for the rates)

\[ \left( \frac{\text{_______SqFt}}{1,000\text{SqFt}} \right) \times \text{_______Lbs/1000 SqFt} = \text{_______Lbs or_______Ton} \]

**Grass Hay or Straw Mulch** (for rural areas and ditch sections in urban areas)

\[ \text{_______Acres (Acres that were Permanent Seeded)} \times 2 \text{ Ton/Acre} = \text{_______Ton} \]

\[ + \text{_______Ton (25% of the total acres that were Permanent Seeded)} \text{ for Temporary Erosion Control=} \text{_______Ton} \]

In addition, a quantity of Grass Hay or Straw Mulch is computed based on 25% of the total acres to be Permanent Seeded and added to the Estimate of Quantities for Temporary Erosion Control.

Note: Some areas of a project (such as steep slopes) may have 4 Ton/Acre of Grass Hay or Straw Mulch applied.

**Fiber Mulching** (≈50% effective during a 5 inch, 60 minute rain event)

\[ \text{_______Acres} \times 2000^* \text{ Lbs/Acre} = \text{_______Ton} \]

**Bonded Fiber Matrix** (≈95% effective during a 5 inch, 60 minute rain event)

\[ \text{_______Acres} \times 3900^* \text{ Lbs/Acre} = \text{_______Ton} \]

*The rate of application for Bonded Fiber Matrix will vary according to the Manufacturer’s recommendations.

**Rock Check Dams**

Use 4-8” Crushed Rock. Approximate Volume = 55 CuYd at each location.

**Repair Silt Fence**

Only 25% of the total is used based on a review of past projects and how much quantity was actually used.

\[ \text{_______Ft (Total Length of Silt Fence on the project including both Low Flow Silt Fence and High Flow Silt fence)} \times 0.25 \text{ (25%)} = \text{_______Ft} \]

**Removes Silt Fence**

Only 25% of the total is used based on a review of past projects and how much quantity was actually used.

\[ \text{_______Ft (Total Length of Silt Fence on the project including both Low Flow Silt Fence and High Flow Silt fence)} \times 0.25 \text{ (25%)} = \text{_______Ft} \]
Mucking Silt Fence

Note: Mucking Silt Fence is calculated as the volume in the shape of a triangular prism that accumulates behind the silt fence. Only 25% of the total is used based on a review of past projects and how much quantity was actually used.

__________Ft (Total length of Silt Fence on the project including both Low Flow Silt Fence and High Flow Silt Fence)x 1/2 x 1Ft x 15 Ft divided by 27 = _________CuYd x 0.25 (25%) = _________CuYd

Erosion Control Blanket

Sta___________to Sta___________

__________ Ft (Length) x _________ Ft (Width) (typically 16 Ft or 20 Ft Width in Highway Ditch Channel) = __________SqYd

Turf Reinforcement Mat

Sta___________to Sta___________

__________ Ft (Length) x _________ Ft (Width) (typically 16 Ft or 20 Ft Width in Highway Ditch Channel) = __________SqYd

Construction Entrance (information only, paid per construction entrance)

Pit Run Material

15 Ft x 50 Ft x 1 Ft = 750 CuFt or 28 CuYd
½(10 x10) = 50 SqFt, 50 SqFt x 1 Ft = 50 CuFt or 1.9 CuYd
1.9 CuYd x 2 = 3.8 CuYd
28 CuYd + 3.8 CuYd = 31.8 CuYd
31.8 CuYd x 1.89 Ton/CuYd (Conversion Factor) = 60 Ton

Granular Material for Construction Entrance

31.8 CuYd x 1.89 Ton/CuYd (Conversion Factor) = 60 Ton

MSE GeoTextile Fabric

Ft x 50 Ft =750 SqFt
½(10 x10) = 50 SqFt, 50 SqFt x 2 = 100 SqFt
750 SqFt + 100 SqFt = 850 SqFt or 94 SqYd use 95 SqYd for Estimate of Quantities
### Section 7: Erosion and Sediment Control Product Specifications

#### BONDED FIBER MATRIX

<table>
<thead>
<tr>
<th>PROPERTY AND TEST METHOD</th>
<th>SDDOT SPECIFICATIONS FOR APPROVED PRODUCTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material Composition and Properties</strong></td>
<td>100% biodegradable, 90% wood fiber, 9% natural water-resistant binder, and 1% organic and mineral activators (all by weight).</td>
</tr>
<tr>
<td>Tackifier</td>
<td>Tackifier will be non-toxic and should become insoluble and non-dispersing upon drying.</td>
</tr>
<tr>
<td>Minimum Organic Material <strong>ASTM D 2974</strong></td>
<td>90%</td>
</tr>
<tr>
<td>C-Factor <strong>ASTM D 6459</strong></td>
<td>≤0.05</td>
</tr>
<tr>
<td>Minimum Water Holding Capacity <strong>ASTM D 7367</strong></td>
<td>600%</td>
</tr>
<tr>
<td>Functional Longevity <strong>ASTM D 5338</strong></td>
<td>6-12 Months</td>
</tr>
<tr>
<td>Minimum Vegetation Establishment <strong>ASTM D 7322</strong></td>
<td>300%</td>
</tr>
</tbody>
</table>

#### FIBER REINFORCED MATRIX

<table>
<thead>
<tr>
<th>PROPERTY AND TEST METHOD</th>
<th>SDDOT SPECIFICATIONS FOR APPROVED PRODUCTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material Composition and Properties</strong></td>
<td>Sterilized, weed-free, defibrated fibers that are completely photo-degradable or biodegradable that when cured creates and intimate bond with the soil, and a continuous erosion resistant surface.</td>
</tr>
<tr>
<td>Tackifier</td>
<td>Tackifier will be non-toxic and should become insoluble and non-dispersing upon drying.</td>
</tr>
<tr>
<td>Minimum Organic Material <strong>ASTM D 2974</strong></td>
<td>90%</td>
</tr>
<tr>
<td>C-Factor <strong>ASTM D 6459</strong></td>
<td>≤0.02</td>
</tr>
<tr>
<td>Minimum Water Holding Capacity <strong>ASTM D 7367</strong></td>
<td>700%</td>
</tr>
<tr>
<td>Functional Longevity <strong>ASTM D 5338</strong></td>
<td>≥12 months</td>
</tr>
<tr>
<td>Minimum Vegetation Establishment <strong>ASTM D 7322</strong></td>
<td>400%</td>
</tr>
</tbody>
</table>

1 Cover Factor is calculated as soil loss ratio of treated surface versus an untreated control surface.

2 Functional Longevity is the estimated time period based upon ASTM D 5338 and field observations, that a material can be anticipated to provide erosion control and agronomic benefits as influenced by composition and site-specific conditions.

3 ASTM test methods developed for Rolled Erosion Control Products have been modified to accommodate Hydraulically Applied Erosion Control Products.
### FIBER MULCH

<table>
<thead>
<tr>
<th>PROPERTY AND TEST METHOD</th>
<th>SDDOT SPECIFICATIONS FOR APPROVED PRODUCTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiber Composition</td>
<td>100% wood fiber</td>
</tr>
<tr>
<td>Tackifier</td>
<td>3% by weight and 100% organic</td>
</tr>
</tbody>
</table>

### SILT FENCE FABRIC

<table>
<thead>
<tr>
<th>PROPERTY AND TEST METHOD</th>
<th>LOW FLOW</th>
<th>HIGH FLOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Flow Rate</td>
<td>20-70 g/min/ft²</td>
<td>71-145 g/min/ft²</td>
</tr>
<tr>
<td>Minimum Ultra-Violet Stability</td>
<td>70%</td>
<td>70%</td>
</tr>
</tbody>
</table>

1 strength retention at 500 hours

### EROSION CONTROL BLANKET

<table>
<thead>
<tr>
<th>PROPERTY AND TEST METHOD</th>
<th>SDDOT SPECIFICATIONS FOR APPROVED PRODUCTS LIST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Composition</td>
<td>Processed degradable 100% straw or 100% excelsior bound with regular to rapidly degrading, synthetic or natural fiber netting to form a continuous matrix.</td>
</tr>
<tr>
<td>Functional Longevity</td>
<td>Processed slow degrading 100% coconut fiber, excelsior, or a combo of coconut fiber and straw, bound between two slow degrading synthetic or natural fiber nettings.</td>
</tr>
<tr>
<td>Minimum Mass Per Unit Area</td>
<td>6 oz/yd²</td>
</tr>
<tr>
<td>Minimum Thickness</td>
<td>0.2 in</td>
</tr>
<tr>
<td>Minimum Tensile Strength</td>
<td>50 lbs/ft</td>
</tr>
<tr>
<td>Maximum Shear Stress</td>
<td>1.5 lbs/ft²</td>
</tr>
</tbody>
</table>

1 minimum average roll values, Machine Direction (MD)

2 (channel applications) blanket can sustain at least this shear stress without damage and without any more than 0.5” soil loss during a 30 minute flow event
**EROSION CONTROL WATTLES**

<table>
<thead>
<tr>
<th>Property and Test Method</th>
<th>SDDOT Specifications for Approved Products List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Composition and Properties</td>
<td>Erosion control wattles are tubes of 100% weed free straw, excelsior, or coconut husk encased in ultraviolet (UV) degradable or biodegradable netting.</td>
</tr>
</tbody>
</table>

**LANDSCAPE/WEED BARRIER FABRIC**

<table>
<thead>
<tr>
<th>Property and Test Method</th>
<th>SDDOT Specifications for Approved Products List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Composition and Properties</td>
<td>The geotextile fabric will be a woven, non-woven, or combination woven/non-woven material that allows water and air permeability, but prevents the growth of weeds and grasses. The geotextile fabric will have been designed and manufactured specifically for use as a landscape fabric/weed barrier fabric.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property and Test Method</th>
<th>SDDOT Specifications for Approved Products List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Mass Per Unit Area</td>
<td>3 oz/yd²</td>
</tr>
<tr>
<td>ASTM D 5261</td>
<td></td>
</tr>
<tr>
<td>Minimum Water Flow Rate</td>
<td>12 g/min/ft²</td>
</tr>
<tr>
<td>ASTM D 4491</td>
<td></td>
</tr>
<tr>
<td>Minimum Ultra-Violet Stability</td>
<td>70%</td>
</tr>
<tr>
<td>ASTM D 4355 (strength retention at 500 hours)</td>
<td></td>
</tr>
</tbody>
</table>

**TURF REINFORCEMENT MAT**

<table>
<thead>
<tr>
<th>Property and Test Method</th>
<th>SDDOT Specifications for Approved Products List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Composition</td>
<td>100% synthetic, non-degradable materials</td>
</tr>
<tr>
<td>manufacturer’s data</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property and Test Method</th>
<th>TYPE 1</th>
<th>TYPE 2</th>
<th>TYPE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Mass Per Unit Area</td>
<td>8 oz/yd²</td>
<td>10 oz/yd²</td>
<td>12 oz/yd²</td>
</tr>
<tr>
<td>ASTM D 6566</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Thickness</td>
<td>0.25 in</td>
<td>0.25 in</td>
<td>0.25 in</td>
</tr>
<tr>
<td>ASTM D 6525</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Tensile Strength</td>
<td>125 lbs/ft</td>
<td>150 lbs/ft</td>
<td>175 lbs/ft</td>
</tr>
<tr>
<td>ASTM D 6818</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Shear Stress</td>
<td>4 lbs/ft²</td>
<td>6 lbs/ft²</td>
<td>8 lbs/ft²</td>
</tr>
<tr>
<td>ASTM D 6460 (channel applications)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Ultra-Violet Stability</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>ASTM D 4355 (strength retention at 500 hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Light Penetration</td>
<td>20%</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>ASTM D 6567 (% passing)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section 8: Glossary of Erosion Control Terminology

A

Accretion. Outward growth of bank or shore by sedimentation. Increase or extension of boundaries of land by action of natural forces.

Active Construction Area. The area where the contractor intends to be actively involved in soil disturbing work during the ensuing 20 day period during the winter season. This may include areas where soils have been disturbed, as well as areas where soil disturbance has not yet occurred.

Aggradation. General and progressive rising of a stream bed by deposition of sediment. Modification of the earth's surface in the direction of uniformity of grade or slope by deposition as in a riverbed.

Aggressive. Refers to the corrosive properties of soil and water.

Alluvial. Referring to deposits of silts, sands, gravels, and similar detrital material which have been transported by running water.

Alluvium. Stream-borne materials deposited in and along a channel.

Apron. A lining of the bed of the channel upstream or downstream from a lined or restricted waterway. A floor or lining of concrete, rock, etc., to protect a surface from erosion, such as the pavement below chutes, spillways, at the toes of dams, or along the toe of bank protection.

Aqueduct. (1) A major conduit. (2) The entire transmission main for a municipal water supply that may consist of a succession of canals, pipes, tunnels, etc. (3) Any conduit for water; especially one for a large quantity of flowing water. (4) A structure for conveying a canal over a river or hollow.

Aquifer. Water-bearing geologic formations that permit the movement of ground water.

Arid Area. Area receiving less than 10 inches of rainfall per year.

Armor. Artificial surfacing of bed, banks, shore, or embankment to resist erosion or scour.

Arroyo. Waterway of an ephemeral stream deeply carved in rock or ancient alluvium.

Artesian Waters. Percolating waters confined below impermeable formations with sufficient pressure to spring or well up to the surface.

Articulated. Made flexible by hinging, particularly of small rigid slabs adapted to revetment.

B

Backfill. Earth used to fill a trench or excavation.

Backing Layer. A layer of graded rock between rock riprap and underlying engineering fabric or filter layer to prevent extrusion of the soil or filter layer material through the riprap.

Backwater. An unnaturally high stage in stream caused by obstruction or confinement of flow, as by a dam, a bridge, or a levee. Its measure is the excess of unnatural over natural stage, not the difference in stage upstream and downstream from its cause.

Baffle. A pier, vane, sill, fence, wall, or mound built on the bed of a stream to parry, deflect, check, or disturb the flow, or to float on the surface to deflect or dampen cross currents or waves.
**Bank.** The lateral boundary of a stream-confining water flow. The bank on the left side of a channel looking downstream is called the left bank, etc.

**Bank Protection.** Revetment or other armor protecting a stream bank from erosion, includes devices used to deflect the forces of erosion away from the bank.

**Bar.** An elongated deposit of alluvium within a channel or across its mouth.

**Barrier.** A low dam or rack built to control flow of debris.

**Base Flood.** The flood or tide having a 1 percent chance of being exceeded in any given year (100-year flood). The 'base flood' is commonly used as the 'standard flood' in Federal flood insurance studies (see Regulatory Flood).

**Base Floodplain.** The area subject to flooding by the base flood.

**Base Flow.** The groundwater flow contribution to a creek. During dry periods, base flow constitutes the majority of stream flow.

**Basin.** (1) The surface of the area tributary to a stream or lake. (2) Space above or below ground capable of retaining or detaining water and/or debris.

**Bay.** An indentation of bank or shore, including erosional cuts and slip outs, not necessarily large.

**Beach.** The zone of sedimentary material that extends landward from the low water line to the place where there is marked change in material or form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach, unless otherwise specified, is the mean low water line. A beach includes foreshore and backshore.

**Bed.** The earth below any body of water, limited laterally by bank or shore.

**Bed Load.** Sediment that moves by rolling, sliding, or skipping along the bed, and is essentially in contact with the stream bed.

**Bedding.** The foundation under a drainage structure.

**Beneficial Uses.** As referred to in the State Water Quality Standards, beneficial uses are activities that range from recreational to agricultural uses, depending on the source of the water.

**Berm.** (1) A bench or terrace between two slopes. (2) A nearly horizontal part of the beach or backshore formed at the high water line by waves depositing material. Some beaches have no berms, others have one or several.

**Best Management Practice (BMP).** (1) A measure that is implemented to protect water quality and reduce the potential for pollution associated with storm water runoff. (2) Any program, technology, process, siting criteria, operating method, measure, or device that controls, prevents, removes, or reduces pollution.

**Block.** Precast prismatic unit for riprap structure.

**Bluff.** A high, steep bank composed of erodible materials.

**Boom.** Floating log or similar element designed to dampen surface waves or control the movement of drift.
**Boulder.** Largest rock transported by a stream or rolled in the surf; arbitrarily heavier than 12 kg and larger than 200 mm.

**Braided Stream.** A stream in which flow is divided at normal stage by small islands. This type of stream has the aspect of a single, large channel with which there are subordinate channels.

**Breakwater.** A fixed or floating structure that protects a shore area, harbor, anchorage, or basin by intercepting waves.

**Bulkhead.** A steep or vertical structure placed on a bank, bluff, or embankment to retain or prevent sliding of the land and protect the inland area against damage.

**Buiking.** The increase in volume of flow due to air entrainment, debris, bedload, or sediment in suspension.

**Buoyancy.** Uplift force on a submerged body equal to the mass of water displaced, times the acceleration of gravity.

**C**

**Canal.** An artificial, open channel.

**Canyon.** A large, deep valley; also the sub-marine counterpart.

**Capacity.** The effective carrying ability of a drainage structure. Generally measured in cubic meters per second.

**Capillarity.** The attraction between water and soil particles, which cause water to move in any direction through the soil mass regardless of gravitational forces.

**Capillary Water.** Water which clings to soil particles by capillary action. It is normally associated with fine sand, silt, or clay, but not normally with coarse sand and gravel.

**Catch Basin.** A drainage structure which collects water. May be either a structure where water enters from the side or through a grating.

**Causeway.** A raised embankment or trestle over swamp or overflow areas.

**Cavitation.** Erosion by suction, especially in the partial vacuum of a diverging jet.

**Channel.** The space above the bed, and between banks, occupied by a stream.

**Channelization.** The process of making a channel or channels. A channel is the bed of a stream or river, or the hollow or course in which the stream flows.

**Check.** A sill or weir in a channel to control stage or velocity.

**Check Dam.** A small dam generally placed in steep ditches for the purpose of reducing the velocity in the ditch.

**Clean Water Act (CWA).** The Federal Water Pollution Control Act enacted in 1972 by Public Law 92-500 and amended by the Water Quality Act of 1987. The Clean Water Act prohibits the discharge of pollutants to Waters of the United States unless said discharge is in accordance with an NPDES permit. The 1987 amendments include guidelines for regulating municipal, industrial, and construction storm water discharges under the NPDES program.
**Cleanout.** An access opening to a roadway drainage system. Usually consists of a manhole shaft, a special chamber or an opening into a shallow culvert or drain.

**Cliff.** A high, steep face of rock; a precipice.

**Cloudburst.** Rainstorm of great intensity usually over a small area for a short duration.

**Coast.** (1) The strip of land, of indefinite width (up to several kilometers), that extends from the shoreline inland to the first major change in terrain features. (2) As a combining form, upcoast is northerly and downcoast is southerly.

**Cobble.** Rock, smaller than a boulder and larger than gravel; arbitrarily 0.5 to 12 kg, or 75 to 200 mm in diameter.

**Coefficient of Runoff.** Percentage of gross rainfall, which appears as runoff.

**Composite Hydrograph.** A plot of mean daily discharges for a number of years of record on a single year time base for the purpose of showing the occurrence of high and low flows.

**Concentrated Flow.** Flowing water that has been accumulated into a single, fairly narrow stream.

**Concentration.** In addition to its general sense, means the unnatural collection or convergence of waters so as to discharge in a narrower width, and at greater depth or velocity.

**Conduit.** Any pipe, arch, box or drain tile through which water is conveyed.

**Cone.** Physiographic form of sediment deposit washed from a gorge channel onto an open plain; a debris cone, also called an alluvial fan.

**Confluence.** A junction of streams.

**Constriction.** An obstruction narrowing a waterway.

**Construction Activity.** Includes clearing, grading, or excavation and contractor activities that result in soil disturbance.

**Construction Site.** The area involved in a construction project as a whole.

**Contraction.** The reduction in cross sectional area of flow.

**Control.** (1) A section or reach of an open conduit or stream channel which maintains a stable relationship between stage and discharge. (2) For flood, erosion, debris, etc., remedial means or procedure restricting damage to a tolerable level.

**Conveyance.** (1) A measure of the water carrying capacity of a stream or channel. (2) Any natural or man-made channel or pipe in which concentrated water flows.

**Core.** Central zone of dike, levee, rock groin, jetty, etc.

**Cradle.** A concrete base generally constructed to fit the shape of a structure that is to be forced through earthen material by a jacking operation. The cradle is constructed to line and grade. Then, the pipe rides on the cradle as it is worked through the given material by jacking and tunneling methods. Also serves as bedding for pipes in trenches in special conditions.

**Creek.** A small stream, usually active.
**Crest.** (1) Peak of a wave or a flood. (2) Top of a levee, dam, weir, spillway or other water barrier or control.

**Crib.** An open-frame structure loaded with earth or stone ballast to act as a baffle in bank protection.

**Critical Depth.** (Depth at which specific energy is a minimum) - The depth of water in a conduit at which under certain other conditions the maximum flow will occur. These other conditions are: 1) the conduit is on the critical slope with the water flowing at its critical velocity, and 2) there is an adequate supply of water. The depth of water flowing in an open channel, or a conduit partially filled, for which the velocity head equals one-half the hydraulic mean depth.

**Critical Flow.** That flow in open channels at which the energy content of the fluid is at a minimum. Also, that flow which has a Froude number of one.

**Critical Slope.** That slope at which the maximum flow will occur at the minimum velocity. The slope or grade that is exactly equal to the loss of head per meter resulting from flow at a depth that will give uniform flow at critical depth; the slope of a conduit which will produce critical flow.

**Critical Velocity.** Mean velocity of flow when flow is at critical depth.

**Culvert.** A closed conduit, other than a bridge, which allows water to pass under a highway. A culvert has a span of less than 6.1 m, or if multispans, the individual spans are 3.0 m or less.

**Current.** Flow of water, both as a phenomenon and as a vector. Usually qualified by adjectives like downward, littoral, tidal, etc. to show relation to a pattern of movement.

**Cutoff Wall.** A wall at the end of a drainage structure, the top of which is an integral part of the drainage structure. This wall is usually buried, and its function is to prevent undermining of the drainage structure if the natural material at the outlet of the structure is scoured by the water discharging from the end of the structure. Cutoff walls are sometimes used at the upstream end of a structure when there is a possibility of erosion.

**D**

**Debris.** Any material including floating woody materials and other trash, suspended sediment, or bed load moved by a flowing stream.

**Debris Barrier.** A deflector placed at the entrance of a culvert upstream, which tends to deflect heavy floating debris or boulders away from the culvert entrance during high-velocity flow.

**Debris Basin.** Any area upstream from a drainage structure utilized for the purpose of retaining debris, in order to prevent clogging of drainage structures downstream.

**Debris Rack.** A straight barrier that, when placed across the stream channel, tends to separate light and medium floating debris from stream flow and prevent the debris from reaching the culvert entrance.

**Degradation.** General and progressive lowering of the longitudinal profile of a channel by erosion.

**Denuded.** Land stripped of vegetation.

**Deposit.** An earth mass of particles settled or stranded from moving water or wind.

**Depth.** Vertical distance: (1) from surface to bed of a body of water, (2) from crest or crown to invert of a conduit.
**Design Discharge.** The quantity of flow that is expected at a certain point as a result of a design storm. Usually expressed as a rate of flow in cubic meters per second.

**Design Flood.** The peak discharge (when appropriate, the volume, stage, or wave crest elevation) of the flood associated with the probability of exceedance selected for the design of an encroachment in a FEMA flood plain.

**Design Frequency.** The recurrence interval for hydrologic events used for design purposes. As an example, a design frequency of 50 years means a storm of a magnitude that would be expected to recur on the average of every 50 years (See Probability of Exceedance).

**Design High Water.** The flood stage or tide crest elevation adopted for design of drainage and bank protection structures (See Design Flood and High Water).

**Design Storm.** That particular storm which contributes runoff which the drainage facilities were designed to handle. This storm is selected for design on the basis of its probability of exceedance or average recurrence interval (See Probability of Exceedance).

**Detention.** The process of temporarily collecting and holding back storm water for later release to receiving waters.

**Detention Storage.** Surface water moving over the land is in detention storage. Surface water allowed to temporarily accumulate in ponds, basins, reservoirs or other types of holding facility and which is ultimately returned to a watercourse or other drainage system as runoff, is in detention storage (See Retention Storage).

**Detritus.** Loose material such as rock, sand, silt, and organic particles.

**Dike.** (1) Usually an earthen bank alongside and parallel with a river or open channel to restrict overflow (See Levee). (2) An asphalt, concrete berm along the edge of a shoulder.

**Dike, Finger.** Relatively short embankments constructed normal to a larger embankment, such as an approach fill to a bridge. Their purpose is to impede flow and direct it away from the major embankment.

**Dike, Spur.** Relatively short embankments constructed at the upstream side of a bridge end for the purpose of aligning flow with the waterway opening and to move scour away from the bridge abutment.

**Dike, Toe.** Embankment constructed to prevent lateral flow from scouring the corner of the downstream side of an abutment embankment. Sometimes referred to as training dikes.

**Dike, Training.** Embankments constructed to provide a transition from the natural stream channel or floodplain, both to and from a constricting bridge crossing.

**Discharge.** A volume of water flowing out of a drainage structure or facility. Measured in cubic meters per second.

**Dissipate.** Expend or scatter harmlessly, as of energy of moving water.

**Disturbed Areas.** Areas that have been purposefully cleared, grubbed, excavated, or graded by the contractor; ground surface that has been disrupted by construction activities, including construction access/roads, staging, and storage sites producing significant areas of exposed soil and soil piles.

**Ditch.** Small artificial channel, usually unlined.
**Diversion.** (1) The change in character, location, direction, or quantity of flow of a natural drainage course (a deflection of flood water is not a diversion). (2) Draft of water from one channel to another. (3) Interception of runoff by works which discharge it through unnatural channels.

**Downdrain.** A prefabricated drainage facility assembled and installed in the field for the purpose of transporting water down steep slopes.

**Downdrift.** The direction of predominant movement of littoral materials.

**Drain.** Conduit intercepting and discharging surplus ground or surface water.

**Drainage.** (1) The process of removing surplus ground or surface water by artificial means. (2) The system by which the waters of an area are removed. (3) The area from which waters are drained; a drainage basin.

**Drainage Area (Drainage Basin) (Basin).** That portion of the earth's surface upon which falling precipitation flows to a given location.

**Drainage Course.** Any path along which water flows when acted upon by gravitational forces.

**Drainage Divide.** The rim of a drainage basin. A series of high points from which water flows in two directions, to the basin and away from the basin.

**Drainage Easement** (See Easement).

**Drainage System.** Usually a system of underground conduits and collector structures which flow to a single point of discharge.

**Drawdown.** The difference in elevation between the water surface elevation at a constriction in a stream or conduit and the elevation that would exist if the constriction were absent. Drawdown also occurs at changes from mild to steep channel slopes and weirs or vertical spillways.

**Drift.** (1) Floating or non-mineral burden of a stream. (2) Deviation from a normal course in a cross current, as in littoral drift.

**Drop.** Controlled fall in a stream to dissipate energy.

**Dry Weather Flows.** A small amount of water which flows almost continually due to lawn watering, irrigation or springs.

**Dune.** A sand wave of approximately triangular cross section (in a vertical plane in the direction of flow) formed by moving water or wind, with gentle upstream slope and steep downstream slope and deposition on the downstream slope.

**E**

**Easement.** Right to use the land of others.

**Ebb.** Falling stage or outward flow, especially of tides.

**Eddy Loss.** The energy lost (converted into heat) by swirls, eddies, and impact, as distinguished from friction loss.

**Eddy.** Rotational flow around a vertical axis.

**Embankment.** Earth structure above natural ground.
**Embayment.** Indentation of bank or shore, particularly by progressive erosion.

**Encroachment.** Extending beyond the original or customary limits, such as by occupancy of the river and/or flood plain by earth fill embankment.

**Endwall.** A wall placed at the end of a culvert. It may serve three purposes: 1) to hold the embankment away from the pipe and prevent sloughing into the pipe outlet channel, 2) to provide a wall which will prevent erosion of the roadway fill, and 3) to prevent flotation of the pipe.

**Energy.** Potential or kinetic, the latter being expressed in the same unit (meters) as the former.

**Energy Dissipater.** A structure for the purpose of slowing the flow of water and reducing the erosive forces present in any rapidly flowing body of water.

**Energy Grade Line.** The line which represents the total energy gradient along the channel. It is established by adding together the potential energy expressed as the water surface elevation referenced to a datum and the kinetic energy (usually expressed as velocity head) at points along the stream bed or channel floor.

**Energy Head.** The elevation of the hydraulic grade line at any section plus the velocity head of the mean velocity of the water in that section.

**Entrance.** The upstream approach transition to a constricted waterway.

**Entrance Head.** The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

**Entrance Loss.** The head lost in eddies and friction at the inlet to a conduit or structure.

**Environmental Protection Agency (EPA).** Government agency that issued the regulations to control pollutants in storm water runoff discharges (Clean Water Act and NPDES permit requirements).

**Ephemeral.** Of brief duration, as the flow of a stream in an arid region.

**Erosion.** The wearing away of natural (earth) and unnatural (embankment, slope protection, structure, etc.) surfaces by the action of external forces. In the case of drainage terminology, this term generally refers to the wearing away of the earth's surface by flowing water. It can also refer to the wear on a structural surface by flowing water and the material carried therein.

**Erosion Control.** Vegetation, such as grasses and wildflowers, and other materials, such as straw, fiber, stabilizing emulsion, protective blankets, etc., placed to stabilize areas disturbed by grading operations, reduce loss of soil due to the action of water or wind, and prevent water pollution.

**Estuary.** That portion of a river channel occupied at times or in part by both sea and river flow in appreciable quantities. The water usually has brackish characteristics.

**Evaporation.** A process whereby water as a liquid is changed into water vapor, typically through heat supplied from the sun.

**Excavation.** The process of removing earth, stone, or other materials.

**Existing Vegetation.** Any vegetated area that has not already been cleared and grubbed.
**F**

**Face.** The outer layer of slope revetment.

**Fan.** A portion of a cone, but sometimes used to emphasize definition of radial channels. Also reference to spreading out of water or soils associated with waters leaving a confined channel.

**Feasible.** Economically achievable or cost-effective measures which reflect a reasonable degree of pollutant reduction, achievable through the application of available nonpoint pollution control practices, technologies, processes, site criteria, operating methods, or other alternatives.

**Fetch.** The unobstructed distance over water in which waves are generated by wind of relatively constant direction and speed.

**Filter.** A porous article or mass (as of fabric or even-graded mineral aggregate) through which water will freely pass, but which will block the passage of soil particles.

**Filter Fabric** (RSP fabric). An engineering fabric (geotextile) placed between the backfill and supporting or underlying soil through which water will pass and soil particles are retained.

**Filter Layer.** A layer of even-graded rock between rock riprap and underlying soil to prevent extrusion of the soil through the riprap.

**Filter Sock.** A fabric tube filled with wood chips, compost or some other filter medium, used to filter sediment from storm water or to reduce velocity of flow in channels and slopes.

**Filter Strip.** A strip of vegetation left between exposed soil and a ditch or other receiving water for the express purpose of trapping sediment.

**Flocculants.** Substances (chemical additives) that cause solids suspended in storm water to aggregate into a mass and settle out of suspension.

**Flood Frequency.** Also referred to as exceedance interval, recurrence interval or return period. The average time interval between actual occurrences of a hydrological event of a given or greater magnitude; the percent chance of occurrence is the reciprocal of flood frequency, e.g., a 2 percent chance of occurrence is the reciprocal statement of a 50-year flood (See Probability of Exceedance).

**Flood Plane.** The position occupied by the water surface of a stream during a particular flood. Also, loosely, the elevation of the water surface at various points along the stream during a particular flood.

**Flood Stage.** The elevation at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

**Flood Waters.** Former stream waters which have escaped from a watercourse (and its overflow channel) and flow or stand over adjoining lands. They remain as such until they disappear from the surface by infiltration, evaporation, or return to a natural watercourse. They do not become surface waters by mingling with such waters or stream waters by eroding a temporary channel.

**Floodplain Encroachment.** An action within the limits of the base flood plain.

**Floodplain.** Normally dry land areas subject to periodic temporary inundation by stream flow or tidal overflow. Land formed by deposition of sediment by water; alluvial land.

**Flow.** A term used to define the movement of water, silt, sand, etc.; discharge; total quantity carried by a stream.
**Flow Line.** A term used to describe the line connecting the low points in a watercourse.

**Flow, Steady.** Flow at constant discharge.

**Flow, Unsteady.** Flow on rising or falling stages.

**Flow, Varied.** Flow in a channel with variable section.

**Free Outlet.** A condition under which water discharges with no interference such as a pipe discharging into open air.

**Free Water.** Water which can move through the soil by force of gravity.

**Freeboard.** (1) The vertical distance between the level of the water surface usually corresponding to the design flow and a point of interest such as a bridge beam, levee top or specific location on the roadway grade. (2) The distance between the normal operating level and the top of the sides of an open conduit; the crest of a dam, etc., designed to allow for wave action, floating debris, or any other condition or emergency, without overtopping the structure.

**French Drain.** A trench loosely backfilled with stones, the largest stones being placed in the bottom, with the size of stones decreasing towards the top. The interstices between the stones serve as a passageway for water.

**Friction.** Energy-dissipating conflict among turbulent water particles disturbed by irregularities of channel surface.

**Froude Number.** A dimensionless expression of the ratio of inertia forces to gravity forces, used as an index to characterize the type of flow in a hydraulic structure in which gravity is the force producing motion, and inertia is the resisting force. It is equal to a characteristic flow velocity (mean, surface, or maximum) of the system divided by the square root of the product of a characteristic dimension (as diameter of depth) and the gravity constant (acceleration due to gravity) all expressed in consistent units Fr = V/(gy)1/2.

**G**

**Gabion.** A wire basket or cage filled with stone and placed as, or as part of, a bank-protection structure.

**Gauging Station.** A location on a stream where measurements of stage or discharge are customarily made. The location includes a reach of channel through which the flow is uniform, a control downstream from this reach, and usually a small building to house the recording instruments.

**General Permit.** A general permit for storm water discharges associated with industrial or construction activity issued by EPA or a delegated state under the NPDES storm water regulations.

**Gorge.** A narrow, deep valley with steep or vertical banks.

**Grade.** Elevation of bed or invert of a channel.

**Grade to Drain.** A construction note often inserted on a plan for the purpose of directing the Contractor to slope a certain area in a specific direction, so that the surface waters will flow to a designated location.

**Gradient (Slope).** The rate of ascent or descent expressed as a percent or as a decimal as determined by the ratio of the change in elevation to the length.
Gradually Varied Flow. In this type of flow, changes in depth and velocity take place slowly over large distances, resistance to flow dominates and acceleration forces are neglected.

Gravel. Rock larger than sand and smaller than cobble, arbitrarily ranging in diameter from 5 to 50 mm.

Groin. A fingerlike barrier structure usually built perpendicular to the shoreline or oblique to primary motion of water, to trap littoral drift, retard erosion of the shore, or to control movement of bed material.

Ground Water. That water which is present under the earth's surface. Ground water is situated below the surface of the land, irrespective of its source and transient status. Subterranean streams are flows of ground waters parallel to and adjoining stream waters, and usually determined to be integral parts of the visible streams.

Grouted. Bonded together with an inlay or overlay of cement mortar.

Gulch. A relatively young, well-defined and sharply cut, erosional channel.

Gully. Diminutive of gulch. A well-defined and sharply cut, erosional channel with a cross sectional area greater than 16 sq.in.

H

Head. Represents an available force equivalent to a certain depth of water. This is the motivating force in effecting the movement of water. The height of water above any point or plane of reference. Used also in various compound expressions, such as energy head, entrance head, friction head, static head, pressure head, lost head, etc.

Headcutting. Progressive scouring and degrading of a streambed in the upstream direction, usually characterized by one or a series of vertical falls.

High Water. Maximum flood stage of a stream or lake; periodic crest stage of tide. Historic HW is stage recorded or otherwise known.

Hydraulic. Pertaining to water in motion and the mechanics of the motion.

Hydraulic Gradient. A line that represents the relative force available due to the potential energy available. This is a combination of energy due to the height of the water and the internal pressure. In any open channel, this line corresponds to the water surface. In a closed conduit, if piezometers are placed along the top of the pipe, a line connecting the water surface in each of these tubes would represent the hydraulic grade line.

Hydraulic Jump (or Jump). Transition of flow from the rapid to the tranquil state. A varied flow phenomenon producing a rise in elevation of water surface. A sudden transition from supercritical flow to the complementary subcritical flow, conserving momentum and dissipating energy.

Hydraulic Mean Depth. The area of the flow cross section divided by the water surface width.

Hydraulic Radius. The cross sectional area of a stream of water divided by the length of that part of its periphery in contact with water; the ratio of area to wetted perimeter.

Hydric. Characterized by, relating to or requiring an abundance of moisture. Also refers to soils that are formed in wet conditions.
**Hydrograph.** A graph showing stage, flow, velocity, or other property of water with respect to time.

**Hydrographic.** Pertaining to the measurement or study of bodies of water and associated terrain.

**Hydrography.** Water Surveys. Measuring, recording, and analyzing the flow of water; and of measuring and mapping watercourses, shore lines, and navigable waters.

**Hydrologic.** Pertaining to the cyclic phenomena of waters of the earth; successively as precipitation, runoff, storage and evaporation, and quantitatively as to distribution and concentration.

**Hydrology.** The science of the occurrence and movement of water upon and beneath the land areas of the earth. Overlaps and includes portions of other sciences such as meteorology and geology. The particular branch of Hydrology that a design engineer is generally interested in is surface runoff that is the result of excessive precipitation.

**Hydrophyte.** A perennial vascular aquatic plant having its over-wintering buds under water; a plant growing in water or in soil too waterlogged for most plants to survive. These are plants found in wetlands.

**Hydrostatic.** Pertaining to pressure by and within water due to gravitation acting through depth.

**Hyetograph.** Graphical representation of rainfall depth plotted in units of time, e.g. depth of precipitation in a five minute period.

I

**Impervious.** A surface that cannot be easily infiltrated; for instance, rain does not readily penetrate or infiltrate asphalt or concrete surfaces.

**Impinge.** To strike and attack directly, as in curvilinear flow where the current does not follow the curve but continues on tangent into the bank on the outside of bend in the channel.

**Incised Channel.** Those channels which have been cut relatively deep into underlying formations by natural processes. Characteristics include relatively straight alignment and high, steep banks such that overflow rarely occurs, if ever.

**Infiltration.** The passage of water through the soil surface into the ground.

**Inlet.** An entrance into a ditch, storm drain, or other water conveyance system.

**Inlet Time.** The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point where it enters a drain or culvert.

**Inlet Transition.** A specially shaped entrance to a box or pipe culvert. It is shaped in such a manner that in passing from one flow condition to another, the minimum turbulence or interference with flow is permitted.

**Inundate.** To cover with a flood.

**Invert.** The bottom of a drainage facility along which the lowest flows would pass.

**Isohyet/Isohyetal Line.** A line drawn on a map or chart joining points that receive the same amount of precipitation.
**Isohyetal Map.** A map containing isohyetal lines and showing rainfall intensities.

**J**

**Jacking Operations.** A means of constructing a pipeline under a highway without open excavation. A cutting edge is placed on the first section of pipe and the pipe is forced ahead by hydraulic jacks. As the leading edge pushes ahead, the material inside the pipe is dug out and transported outside the pipe for disposal.

**Jetty.** An elongated, artificial obstruction projecting into a stream or the sea from bank or shore to control shoaling and scour by deflection of strength of currents and waves.

**Jump.** Sudden transition from supercritical flow to the complementary subcritical flow, conserving momentum and dissipating energy; the hydraulic jump.

**L**

**Lag.** Variously defined as time from beginning (or center of mass) of rainfall to peak (or center of mass) of runoff.

**Lake.** A water filled basin with restricted or no outlet. Includes reservoirs, tidal ponds and playas.

**Laminar Flow.** That type of flow in which each particle moves in a direction parallel to every other particle and in which the head loss is approximately proportional to the velocity (as opposed to turbulent flow).

**Lateral.** In a drainage system, a drainage conduit transporting water from inlet points to the main drain trunk line.

**Level Spreader.** A device used to transform concentrated flows to uniform sheet flow

**Levee.** An embankment to prevent inundation, usually on or along the bank of a stream or lake to protect outer lowlands (See Dike).

**Lining.** Protective cover of the perimeter of a channel.

**Littoral.** Pertaining to or along the shore, particularly to describe currents, deposits, and drift.

**Littoral Drift.** The sedimentary material (sand) moved along the shoreline under the influence of waves and currents.

**Littoral Transport.** The movement of littoral drift along the shoreline by waves and currents. Includes movement parallel and perpendicular to the shore.

**Loading.** The total amount of material entering a system from all sources.

**Local Depression.** A low area in the pavement or in the gutter established for the special purpose of collecting surface waters on a street and directing these waters into a drainage inlet.

**M**

**Marginal.** Within a borderland area; more general and extensive than riparian.
**Marsh.** An area of soft, wet, or periodically submerged land, generally treeless and usually characterized by grasses and other low vegetation.

**Maximum Historical Flood.** The maximum flood that has been recorded or experienced at any particular highway location.

**Mean Annual Flood.** The flood discharge with a recurrence interval of 2.33 years.

**Mean Depth.** For a stream at any stage, the wetted normal section divided by the surface width. Hydraulic mean depth.

**Meander.** In connection with streams, a winding channel usually in an erodible, alluvial valley. A reverse or S-shaped curve or series of curves formed by erosion of the concave bank, especially at the downstream end, characterized by curved flow and alternating shoals and bank erosions. Meandering is a stage in the migratory movement of the channel, as a whole, down the valley.

**Mesh.** Woven wire or other filaments used alone as revetment, or as retainer or container of masses of gravel or cobble.

**Mulch.** A natural or artificial layer of plant residue or other material that covers the land surface and conserves moisture, holds soil in place, aids in establishing vegetation, and reduces temperature fluctuations.

**N**

"n" **Value.** The roughness coefficient in the Manning formula for determination of the discharge coefficient in the Chezy formula, \( V = C(RS)^{1/2} \), where \( C = (1/n)^{1/6} \)

**National Pollutant Discharge Elimination System (NPDES).** The EPA program to control the discharge of pollutants to waters of the United States. NPDES is a part of the Federal CWA, which requires point and nonpoint source dischargers to obtain permits. These permits are referred to as NPDES permits.

**Natural and Beneficial Floodplain Values.** Includes but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aqua-culture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

**Navigable Waters.** Those stream waters lawfully declared or actually used as such. Navigable Waters of the United States are those determined by the Corps of Engineers or the U.S. Coast Guard to be so used in interstate or international commerce. Other streams have been held as navigable by courts under the common law that navigability in fact is navigability in law.

**Nonactive Construction Area.** Any area not considered to be an active construction area. Typically, active construction areas become nonactive construction areas whenever construction activities are expected to be discontinued for a period of 20 or more days during the winter season.

**Nonpoint Sources (NPS).** Diffuse sources from which contaminants originate to accumulate in surface water or groundwater. These sources can add to a cumulative problem with serious health or environmental consequences.

**Nonuniform Flow** A flow in which the velocities vary from point to point along the stream or conduit, due to variations in cross section, slope, etc.
**Normal Depth.** The depth at which flow is steady and hydraulic characteristics are uniform.

**Normal Water Surface (Natural Water Surface).** The free surface associated with flow in natural streams.

**Notice of Intent (NOI).** A formal notice to the EPA or a state agency having delegated NPDES authority that a construction project seeking coverage under a General Permit is about to begin. The NOI provides information on the owner, location, and type of project, and certifies that the permittee will comply with conditions of the construction General Permit. The NOI is *not* a permit application, and no approval is required. Some local permits may require submittal of a Notice of New Construction (NONC) in lieu of filing a NOI with the state or EPA.

**Notice of Termination (NOT).** A formal notice to the EPA or delegated state agency for General Permit site terminating coverage under the permit.

**O**

**Off-Site Drainage.** Flow of water that originates outside the property.

**On-Site Drainage.** Flow of water that originates inside the property.

**Open Channel.** Any conveyance in which water flows with a free surface.

**Ordinary High Water Mark.** The line on the shore established by the fluctuation of water and physically indicated on the bank (1.5 + years return period).

**Outfall.** Discharge or point of discharge of a culvert or other closed conduit.

**Outwash.** Debris transported from a restricted channel to an unrestricted area where it is deposited to form an alluvial or debris cone or fan.

**Overflow.** Discharge of a stream outside its banks; the parallel channels carrying such discharge.

**P**

**Peak Flow.** Maximum momentary stage or discharge of a stream in flood; design discharge.

**Pebble.** Stone 10 to 75 mm in diameter, including coarse gravel and small cobble.

**Perched Water.** Ground water located above the level of the water table and separated from it by a zone of impermeable material.

**Percolating Waters.** Waters which have infiltrated the surface of the land and move slowly downward and outward through devious channels (aquifers) unrelated to stream waters, until they reach an underground lake or regain and spring from the land surface at a lower point.

**Permanent Erosion Control.** Permanent erosion control is most often associated with the reestablishment of vegetation. This can be either grasses as in the case of most transportation facilities or reforestation needed to reestablish woody vegetation after fires.

**Permeability.** The property of soils which permits the passage of any fluid. Permeability depends on grain size, void ratio, shape and arrangement of pores.
Permeable. Open to the passage of fluids, as for (1) pervious soils and (2) bank-protection structures.

Permit. An authorization, license, or equivalent control document issued by EPA or an approved state agency to implement the requirements of an environmental regulation.

Physiographic Region. A geographic area whose pattern of landforms differ significantly from that of adjacent regions.

Pier. Vertical support of a structure standing in a stream or other body of water. Used in a general sense to include bents and abutments.

Pile. A long, heavy timber or section of concrete or metal that is driven or jetted into the earth or bottom of a water body to serve as a structural support or protection.

Piping. The action of water passing through or under an embankment and carrying some of the finer material with it to the surface at the downstream face.

Point of Concentration. That point at which the water flowing from a given drainage area concentrates.

Point Sources. A source of pollutants from a single point of conveyance such as a pipe. For example, the discharge pipe from a sewage treatment plant or factory is a point source.

Practicable. Capable of being done within reasonable natural, social, and economic constraints.

Precipitation. Discharge of atmospheric moisture as rain, snow, or hail, measured in depth of fall or in terms of intensity of fall in unit time.

Preserve. To avoid modification to the functions of the natural floodplain environment or to maintain it, as closely as practicable, in its natural state.

Probability. The chance of occurrence or recurrence of a specified event within a unit of time, commonly expressed in three ways. Thus a 10-year flood has a chance of 0.1 per year and is also called a 10%-chance flood.

Probability of Exceedance. The statistical probability, expressed as a percentage, of a hydrologic event occurring or being exceeded in any given year. The probability (p) of a storm or flood is the reciprocal of the average recurrence interval (N).

Probable Maximum Flood. Flood discharge that may be expected from the most severe combination of critical meteorological and hydrological conditions reasonably possible in the region.

Q

Quality Assurance/Quality Control. A system of procedures, checks, audits, and corrective actions to ensure that all research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

R

Rainfall. Point precipitation: That which registers at a single gauge. Area precipitation: Adjusted point rainfall for area size.
Range. Difference between extremes, as for stream or tide stage.

Ravine. A valley larger than a gulch, smaller than a canyon, and less bold in relief than a gulch or arroyo.

Reach. The length of a channel uniform with respect to discharge, depth, area, and slope. More generally, any length of a river or drainage course.

Recession. Retreat of shore or bank by progressive erosion.

Reef. Generally, any solid projection from the bed of a stream or other body of water.

Regulatory Floodway. The open floodplain area that is reserved in by Federal, state, or local requirements, i.e., unconfined, or unobstructed either horizontally or vertically, to provide for the discharge of the base flood so that the cumulative increase in water surface elevation is no more than a designated amount (not to exceed 0.3048m as established by the Federal Emergency Management Agency (FEMA) for administering the National Flood Insurance Program (NFIP).

Regulatory Framework. A particular set of laws, rules, procedures, and agencies designed to govern a particular type of activity or solve a particular program.

Repose. The stable slope of a bank or embankment, expressed as an angle or the ratio of horizontal to vertical projection.

 Restore. To reestablish a setting or environment in which the functions of the natural and beneficial floodplain values adversely impacted by a development, can continue to operate.

Restriction. Artificial or natural control against widening of a channel, with or without construction.

Retard. Bank-protection structure designed to check the riparian velocity and induce silting or accretion.

Retarding Basin. Either a natural or manmade basin with the specific function of delaying the flow of water from one point to another. This tends to increase the time that it takes all the water falling on the extremities of the drainage basin to reach a common point, resulting in a reduced peak flow at that point.

Retention. The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass.

Retention Storage. Water that accumulates and ponds in natural or excavated depressions in the soil surface with no possibility for escape as runoff (See Detention Storage).

Revegetation. Planting of indigenous plants to replace natural vegetation that is damaged or removed as a result of construction projects or permit requirements.

Revetment. Bank protection to prevent erosion.

Rill. A streamlet or small surface channel caused by the erosion of the soil surface with a cross sectional area of up to 16sq.in.

Rill Erosion. The formation of numerous, closely spaced streamlets due to uneven detachment of surface soils by runoff on slopes.

Riparian. Pertaining to the banks of a stream.
**Ripple.** (1) The light fretting or ruffling of a water caused by a breeze. (2) Undulating ridges and furrows, or crests and troughs formed by action of the flow.

**Riprap.** A layer, facing, or protective mound of broken concrete, sacked concrete, rock, rubble, or stones randomly placed to prevent erosion, scour, or sloughing of a structure or embankment; also, the stone used for this purpose.

**River.** A large stream, usually active when any streams are flowing in the region.

**Rock.** (1) Cobble, boulder, or quarry stone as a construction material. (2) Hard natural mineral, in formation as in piles of talus.

**Rock Check.** A low dam made of coarse rock placed across a channel as a means of trapping sediment and reducing velocity.

**Rounded Inlet.** The edges of a culvert entrance that are rounded for smooth transition which reduces turbulence and increases capacity.

**Rubble.** Rough, irregular fragments of rock or concrete.

**Runoff.** (1) The surface waters that exceed the soil’s infiltration rate and depression storage. (2) The portion of precipitation that appears as flow in streams. Drainage or flood discharge which leaves an area as surface flow or a pipeline flow, having reached a channel or pipeline by either surface or subsurface routes.

**S**

**Sand.** Granular soil coarser than silt and finer than gravel, ranging in diameter from 0.05mm to 5mm.

**Scour.** The result of erosive action of running water, primarily in streams, excavating and carrying away material from the bed and banks. Wearing away by abrasive action.

**Sediment.** Fragmentary material that originates from weathering of rocks and is transported by, suspended in, or deposited by water.

**Sediment Bags.** Large bags made of filter fabrics used to trap and filter sediment from storm water. Storm water is usually collected in a basin and then pumped to the sediment bag.

**Sediment Control.** Actions take to trap sediments suspended in storm water by settling, filtration, or chemical deflocculation.

**Sedimentation.** Gravitational deposit of transported material in flowing or standing water.

**Sediment Trap.** A device used to trap and remove sediment from storm water by settling, or filtration.

**Seepage.** Percolation of underground water through the banks and into a stream or other body of water.

**Semi-Arid Area.** Area receiving between 10 and 20 inches of rainfall per year.

**Sheet Erosion.** Erosion of thin layers of soil by sheets of flowing water.

**Sheet Flow.** Any flow spread out and not confined, i.e., flow across a flat open field.
Sheet Pile. A pile with a generally slender, flat cross-section that is driven into ground or bottom of a water body and meshed or interlocked with like members to form a wall or bulkhead.

Shoal. A shallow region in flowing or standing water, especially if made shallow by deposition.

Shoaling. Deposition of alluvial material resulting in areas with relatively shallow depth.

Shore. The narrow strip of land in immediate contact with the water, including the zone between high and low water lines. See backshore, foreshore, onshore, offshore, longshore, and nearshore.

Silt. (1) Water-borne sediment. Detritus carried in suspension or deposited by flowing water, ranging in diameter from 0.005 to 0.05 mm. The term is generally confined to fine earth, sand, or mud, but is sometimes both suspended and bedload. (2) Deposits of water-borne material, as in a reservoir, on a delta, or on floodplains.

Silt Fence. Fabric materials used to filter suspended sediments from storm water.

Sinuosity. The ratio of the length of the river thalweg to the length of the valley proper.

Skew. When a drainage structure is not normal (perpendicular) to the longitudinal axis of the highway, it is said to be on a skew. The skew angle is the smallest angle between the perpendicular and the axis of the structure.

Slide. Gravitational movement of an unstable mass of earth from its natural position.


Slope. (1) Gradient of a stream. (2) Inclination of the face of an embankment, expressed as the ratio of horizontal to vertical projection. (3) The face of an inclined embankment or cut slope. In hydraulics it is expressed as percent or in decimal form.

Slough. (1) Pronounced SLU. A side or overflow channel in which water is continually present. It is stagnant or slack; also a waterway in a tidal marsh. (2) Pronounced SLUFF. Slide or slipout of a thin mantle of earth, especially in a series of small movements.

Source Control BMP. An effort to prevent or limit the exposure of significant materials to storm water at the source.

Specific Energy. The energy contained in a stream of water, expressed in terms of head, referring to the bed of a stream. It is equal to the mean depth of water, plus the velocity head of the mean velocity.

Spur Dike. A structure or embankment projecting a short distance into a stream from the bank and at an angle to deflect flowing water away from critical areas.

Stage. The elevation of a water surface above its minimum; also above or below an established 'low water' plane; above or below any datum of reference; gage height.

Steady Flow. A flow in which the flow rate or quantity of fluid passing a given point per unit of time remains constant.

Stone. Rock or rock-like material; a particle of such material, in any size from pebble to the largest quarried blocks.
**Storage.** Detention or retention of water for future flow which occurs naturally in channel and marginal soils, or artificially in reservoirs.

**Storage Basin.** Space for detention or retention of water for future flow, naturally in channel and marginal soils, or artificially in reservoirs.

**Storm.** A disturbance of the ordinary, average conditions of the atmosphere which, unless specifically qualified, may include any or all meteorological disturbances, such as wind, rain, snow, hail, or thunder.

**Storm Drain.** That portion of a drainage system expressly for collecting and conveying former surface water in an enclosed conduit. Often referred to as a ‘storm sewer’, storm drains include inlet structures, conduit, junctions, manholes, outfalls and other appurtenances.

**Storm Water.** Storm water runoff, snow melt runoff, and surface runoff and drainage.

**Storm Water Management.** The recognition of adverse drainage resulting from altered runoff and the solutions resulting from the cooperative efforts of public agencies and the private sector to mitigate, abate, or reverse those adverse results.

**Storm Water Pollution Prevention Plan (SWPPP).** A plan required by storm water regulations or permits that includes site map(s), an identification of construction/contractor activities that could cause pollutants in the storm water, and a description of measures or practices to control these pollutants.

**Stream Waters.** Former surface waters which have entered and now flow in a well defined natural watercourse, together with other waters reaching the stream by direct precipitation or rising from springs in bed or banks of the watercourse. They continue as stream waters as long as they flow in the watercourse, including overflow and multiple channels, as well as the ordinary or low-water channel.

**Subcritical Flow.** In this state, gravity forces are dominant, so that the flow has a low velocity and is often described as tranquil and streaming. Also defined as flow that has a Froude number less than one.

**Subdrain.** A conduit for collecting and disposing of underground water. It generally consists of a pipe, with perforations in the bottom through which water can enter.

**Subsidence.** A general lowering of the land surface by consolidation or removal of underlying soil.

**Substrate.** The layer of earth or rock that lies immediately below the surface soil.

**Sump.** In drainage, any low area that does not permit the escape of water by gravity flow.

**Supercritical Flow.** In this state, inertia forces are dominant, so that flow has a high velocity and is usually described as rapid, shooting, and torrential. Also defined as flow that has a Froude number greater than one.

**Support Base Floodplain Development.** To encourage, allow, serve, or otherwise facilitate additional base floodplain development. Direct support results from an encroachment, while indirect support results from an action out of the base floodplain.

**Surcharge.** A condition where the hydraulic capacity of the storm drain system is temporarily exceeded (e.g., during a storm event), and the amount of water that enters the system exceeds the conveyance capacity.
**Surface Runoff.** Water movement on earth’s surface, whether flow is over the surface of the ground, or in channels.

**Surface Waters.** Surface waters are those which have been precipitated on the land from the sky or forced to the surface in springs, and which have then spread over the surface of the ground without being collected into a definite body or channel. They appear as puddles, sheet or overland flow, and rills, and continue to be surface waters until they disappear from the surface by infiltration or evaporation, or until by overland or vagrant flow, they reach well-defined watercourses or standing bodies of water like lakes or seas.

** Suspended Load.** Sediment that is supported by the upward components of turbulent currents in a stream and that stay in suspension for an appreciable amount of time.

**Suspended Solids.** Organic or inorganic particles, which are suspended in and carried by the water. The term includes sand, mud, and clay particles, as well as solids in wastewater.

**T**

**Tapered Inlet.** A transition to direct the flow of water into a channel or culvert. A smooth transition to increase hydraulic efficiency of an inlet structure.

**Temporary Construction Site BMPs.** BMPs that are required, only temporarily, to address a short-term storm water contamination threat. For example, silt fences are located near the base of newly graded slopes that have a substantial area of exposed soil. Then, during rainfall, the silt fences filter and collect sediment from runoff flowing off the slope.

**Terrace.** Berm or bench-like earth embankment with a nearly level plain bounded by rising and falling slopes.

**Tetrahedron.** Bank protection element, basically composed of 6 steel or concrete struts joined together (like the edges of a triangular pyramid) with subdividing struts and tie wires or cables.

**Tetrapod.** Bank protection element, precast of concrete, consisting of 4 legs joined at a central block, each leg making an angle of 109.5 degrees with the other three, like rays from the center of a tetrahedron to the center of each face.

**Texture.** The arrangement and interconnection of surface and near-surface particles of terrain or channel perimeter.

**Time of Concentration.** The time required for storm runoff to flow from the most remote point of a drainage area to the point under consideration (in flow time). It is usually associated with the design storm.

**Total Maximum Daily Load (TMDL).** A process established by the Clean Water Act to guide the application of state water quality standards to individual water bodies and watersheds by defining the amount of a particular pollutant that a water body can absorb on a daily basis without violating applicable water quality standards. Once this load is determined, the regulatory agency allocates a portion to each source of that pollutant within a particular watershed.

**Total Suspended Solids (TSS).** The weight of particles that are suspended in water. Suspended solids in water reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles.
Training. Control of current direction.

Transition. A relatively short reach or conduit leading from one waterway section to another of different width, shape, or slope.

Transport. To carry solid material in a stream in solution, suspension, saltation, or entrainment.

Trash Rack. A grid or screen across a stream designed to catch floating debris.

Tributary. A river or stream which flows into a larger river or stream.

Trunk (or Trunk Line). In a drainage system, the main conduit for transporting the storm waters. This main line is generally quite deep in the ground so that laterals coming from fairly long distances can drain by gravity into the trunk line.

Turbidity. A measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity are harmful to aquatic life.

Turbulence. The state of flow wherein the water is agitated by cross-currents and eddies, as opposed to a condition of flow that is quiet and laminar.

Turbulent Flow. That type of flow in which any particle may move in any direction with respect to any other particle, and in which the head loss is approximately proportional to the square of the velocity.

U

Undercut. Erosion of the low part of a steep bank so as to compromise the stability of the upper part.

Underflow. The downstream flow of water through the permeable deposits that underlie a stream. (1) Movement of water through a pervious subsurface stratum, the flow of percolating water, or water under ice, or under a structure. (2) The rate of flow or discharge of subsurface water.

Urban Runoff. A substance, such as rain, that runs off of surfaces in a watershed in excess of the amount absorbed by the surfaces (usually the ground). Urban runoff can contain sediments and contaminants (nonpoint source pollution) that can add to water quality degradation in the watershed. Increases in impervious surface usually result in increased urban runoff.

V

Velocity. The rate of motion of objects or particles, or of a stream of particles.

Velocity Head. A term used in hydraulics to represent the kinetic energy of flowing water. This "head" is represented by a column of standing water equivalent in potential energy to the kinetic energy of the moving water, calculated as (V^2/2g), where the "V" represents the velocity in meters per second and "g" represents the potential acceleration due to gravity, in meters per second per second.

Vernal Pools. Vernal pools are seasonally flooded landscape depressions that support distinctive (and many times rare) plant and animal species adapted to periodic or continuous inundation during the wet season, and the absence of either ponded water or wet soil during the dry season.
Wash. Flood plain or active channel of an ephemeral stream, usually in recent alluvium.

Water Table. The surface of the groundwater below which the void spaces are completely saturated.

Watercourse. A definite channel with bed and banks within which water flows, either continuously or in season. A watercourse is continuous in the direction of flow and may extend laterally beyond the definite banks to include overflow channels contiguous to the ordinary channel. The term does not include artificial channels such as canals and drains, except natural channels trained or restrained by the works of man. The term also does not include depressions or swales through which surface or errant waters pass.

Waters of the United States. (a) All waters, which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; (b) All interstate waters, including interstate wetlands; (c) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters: (1) which are or could be used by interstate or foreign travelers for recreational or other purposes; (2) from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or (3) which are used or could be used for industrial purposes by industries in interstate commerce; (d) All impoundments of waters identified in paragraphs (a) through (d) of this definition; (f) The territorial sea; and (g) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition. Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.11 (m) which also meet the criteria of this definition) are not waters of the United States. This exclusion applies only to manmade bodies of water which neither were originally created in waters of the United States (such as disposal area in wetlands) nor resulted from the impoundment of waters of the United States.

Watershed. The area that contributes surface water runoff into a tributary system or water course.

Waterway. (1) That portion of a watercourse that is actually occupied by water. (2) A navigable inland body of water.

Wattles. Bundles or branches, or rolls made of materials such as excelsior, coir or straw. Generally placed perpendicular to the flow to act as a sediment trap, filter or as a velocity control measure.

Weephole. A hole in a wall, invert, apron, lining, or other solid structure to relieve the pressure of groundwater.

Weir. A low overflow dam or sill for measuring, diverting, or checking flow.

Wetland. Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Wet Weather Flow. Rainfall (storm water) runoff.

Windbreak. (1) A barrier fence or line of trees to break or deflect the velocity of wind. (2) Any device designed to block wind flow and intended for protection against any ill effects of wind, particularly wind erosion.