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STORMWATER POLLUTION, EROSION, AND SEDIMENT CONTROL PRODUCTS
DEMONSTRATION AND TRAINING CENTER

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16. Abstract

The University of Illinois at Urbana-Champaign (UIUC), the Illinois Department of Transportation (IDOT), and the Construction Engineering Research Laboratory (CERL) of the U.S. Army Corps of Engineers joined in a partnership to develop a training and demonstration facility for erosion and sediment control and stormwater management. With funding from IDOT and in-kind contribution from the Illinois Land Improvement Contractors Association (ILICA), a facility was built on 5 acres of land at the UIUC South Farm. The formal name of this training, demonstration, and research facility is the Erosion and Sediment Control Research and Training Center (ESCRTC). The aim of the center is to provide training and perform research and evaluation of stormwater management, soil erosion control, and sediment control best management practices (BMPs). The center has a field research and demonstration site, along with a field classroom for training. The field site includes a large earthen berm, a pump house, a detention pond, and three channels of varying configurations.

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EXECUTIVE SUMMARY

The University of Illinois at Urbana-Champaign (UIUC), the Illinois Department of Transportation (IDOT), and the Construction Engineering Research Laboratory (CERL) of the U.S. Army Corps of Engineers joined in a partnership to develop a training and demonstration facility for erosion and sediment control and stormwater management. With funding from IDOT and in-kind contribution from the Illinois Land Improvement Contractors Association (ILICA), a facility was built on 5 acres of land at the UIUC South Farm. The formal name of this training, demonstration, and research facility is the Erosion and Sediment Control Research and Training Center (ESCRTC). The aim of the center is to provide training and perform research and evaluation of stormwater management, soil erosion control, and sediment control best management practices (BMPs). The center has a field research and demonstration site, along with a field classroom for training. The field site includes a large earthen berm, a pump house, a detention pond, and three channels of varying configurations (Figures S.1 and S.2).

(a) (b)

Figure S.1. (a) Aerial view of site and (b) completed site layout with pump house.

(a) (b)

Figure S.2. (a) Lecture portion of training class and (b) field-demonstration component.

Four erosion plots, runoff collection structures, and a portable rainfall simulator were designed and calibrated to evaluate hill slope erosion control on the berm. A demonstration of three different check-dam series was performed in the channels, and various flow conditions were used to explore evaluation methodology. Five demonstration vegetation plots with different cover practices for a native-grass seed mixture were implemented and monitored to evaluate their performance. Preliminary results indicated that the compost and mulch covers led to greater vegetation establishment than either hydromulch treatment. The establishment of the research site has provided insights into appropriate strategies for the field evaluation of erosion control and sediment control BMPs, and will continue to allow any related products to be objectively and quantitatively evaluated under locally relevant conditions.

Three training classes have been developed related to stormwater management, soil erosion, and sediment control BMPs, design, inspection, and maintenance. The first class (referred to as Class 1 and fully completed) covers the fundamentals of hydrology and soil erosion, related laws and regulations, available BMPs and a short overview of inspection practices. This class is designed to assist those individuals working under IDOT's National Pollutant Discharge Elimination System (NPDES) permits to remain in compliance with the General Permits issued by the Illinois Environmental Protection Agency (IEPA). This class has been offered multiple times in 2011 and 2012 to several groups. Classes 2 and 3 have been developed but not fully tested and approved by IDOT yet. The target audiences for the second class are designers, and the class covers in greater detail the design aspect of these BMPs. The main objective of this class is to examine the erosion and sediment control design process to develop erosion and sediment control plan and stormwater pollution prevention plan (SWPPP) using classroom instruction and examples. The class activities includes design-process discussion, filling out the SWPPP using an example project with IDOT's *Bureau of Design and Environment (BDE) Manual* Form 2342, developing a basic design for the IL47 project, and discussing BMP practices. The third class provides a more detailed overview of the inspection and maintenance aspects of construction projects. The main objectives of this class are to provide regulatory requirements for the inspection and compliance of stormwater BMPs, to provide foundation knowledge for inspectors for identifying correct installation and maintenance of stormwater BMPs, and to familiarize the attendees with BMP maintenance requirements.

CONTENTS

CHAPTER 1 INTRODUCTION

There are many human activities that alter the composition of the land, such as agriculture, development, or construction. These activities can potentially change an environment's intrinsic hydrological characteristics, which may lead to a variety of adverse impacts. Such effects include higher peak-flow rates and runoff, increased downstream flooding, increased rates of sediment transport and deposition, increased shoreline erosion, widening of stream channels, contaminated water supplies, increased public health concerns, and loss of native species. As a result of greater public concern regarding these consequences and more stringent government regulation, many best management practices (BMPs) have been developed to address the problems caused by stormwater runoff.

Despite widespread adoption and implementation of stormwater BMPs to control runoff in a variety of settings, many prior studies have noted the lack of quantitative performance measurements, deficiencies in a critical understanding of the factors underlying BMP performance, inconsistent data reporting methods, and varying monitoring and evaluation protocols (Urbonas 1995). As an organization that continuously engages in high-impact construction throughout the state of Illinois, the Illinois Department of Transportation (IDOT) is greatly concerned with the selection, adoption, and implementation of BMPs for erosion and sediment control but currently lacks a robust approach for evaluating and selecting appropriate BMPs. To address this concern, IDOT has partnered with the University of Illinois at Urbana-Champaign (UIUC) to establish an Erosion and Sediment Control Research and Training Center (ESCRTC). The center provides a facility for training, research, and demonstration of stormwater management practices and erosion and sediment control within both laboratory and field settings.

There has been significant prior research and data collection for stormwater management technologies such as detention basins, retention ponds, and constructed wetlands; but smaller-scale practices—such as erosion control blankets (ECBs), check dams, inlet protectors, wattles, and grasses—have lagged somewhat behind (Strecker et al. 2001). All of these products are of particular interest to IDOT for their regular use in construction projects. To effectively evaluate BMPs in a manner that not only is applicable to the experimental site but also can be applied to BMP selection and installation in other locations, it is necessary to use more consistent monitoring techniques and data collection standards than have previously been employed (Strecker 1994). Apart from providing training on stormwater management, soil erosion, and sediment transport control, this center also aims at developing relevant criteria for the performance evaluation of stormwater management and erosion control BMPs, and recommended guidelines for further research of BMP practices, installation, and evaluation.

This report outlines the activities related to the development of this center. Section two provides the details of research-site establishment for demonstration and research purpose, and section three provides the details on three trainings provided by the center.

CHAPTER 2 DEVELOPMENT OF THE RESEARCH AND DEMONSTRATION FACILITY

The location for the ESCRTC site was selected based on proximity to the Agricultural and Biological Engineering South Farm, which is part of the UIUC research farm system. The total area was 1.6 hectares (ha) in size, with an average slope prior to construction of approximately 1.3%, as shown in Figure 2.1.

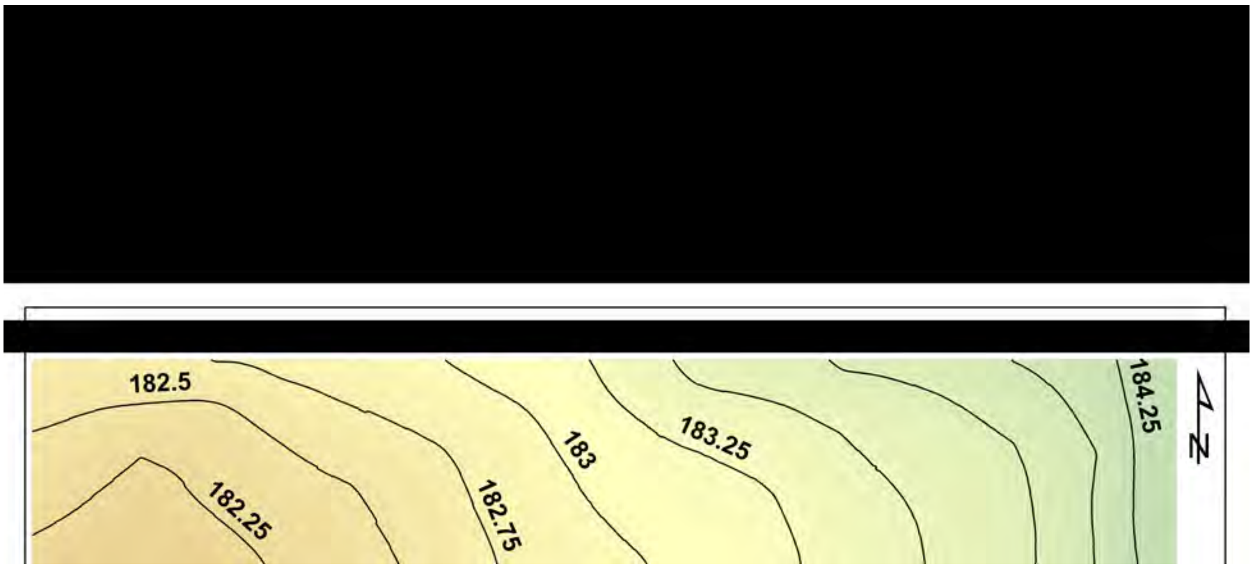

Figure 2.1. Site topography prior to construction, August 2009 (all units in meters).

The site exhibited a relatively equal mix of silt loam and silty clay loam soils (Figure 2.2). Specific soil types included the Brenton (38%), Drummer (47%), and Flanagan series (15%), as indicated by the Soil Survey Geographic (SSURGO) Database (Soil Survey Staff 2011). Both Brenton and Flanagan soils are very deep and somewhat poorly drained silt loams, with depths to carbonate layers of greater than 102 cm and from 114 to 165 cm, respectively. The surface layer of both soils typically has a clay percentage of 20 to 27; additionally, Brenton surface layers exhibit an organic matter content of 3% to 5%, while Flanagan ranges from 4% to 5%. Drummer soils are very deep and poorly drained silty clay loams, with depths to carbonate layers of greater than 102 cm. The Drummer surface layer typically has a clay percentage of 27 to 35, with organic matter ranging from 4% to 7%. The average saturated hydraulic conductivity at the surface for all three soils ranges from 1.5 to 5 cm/h (Endres 2003).

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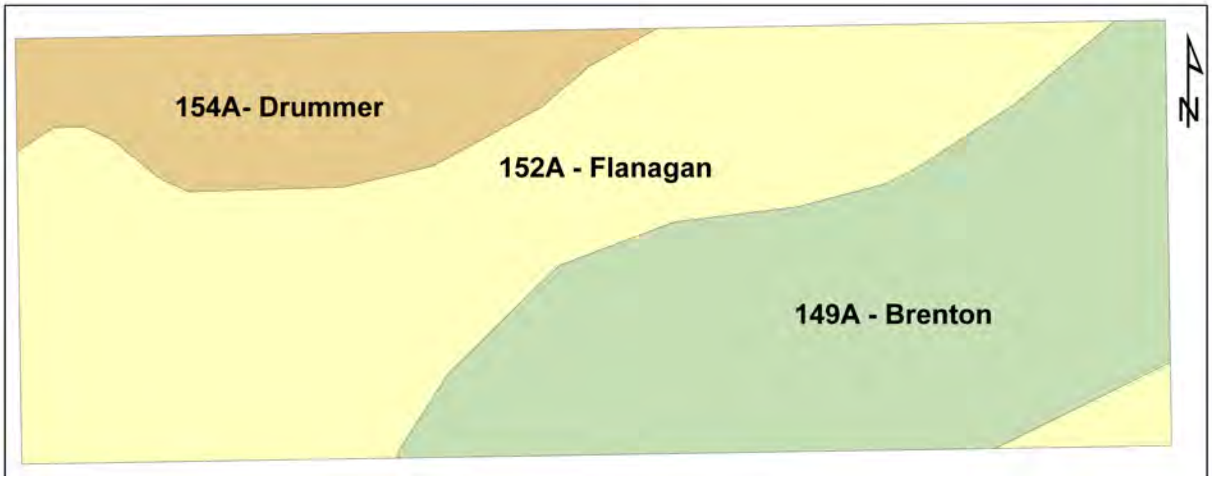

Figure 2.2. Site soil distribution prior to construction, August 2009.

2.1 SITE CONSTRUCTION AND MODIFICATION

During the initial site construction in August 2009, the western 0.8 ha of the area was used to prepare a berm, detention pond, and three channels. The berm was elbow-shaped, with a bend of 110° near the center, and measured approximately 91.4 m in length and 3.7 to 4.1 m in height. The intended slope for the southwestern face was 3:1, or 33%; and the intended slope for the northeastern face was 2:1, or 50%. After construction, the actual slope for the southwestern face ranged from 3.1:1 to 3.4:1, with an average value of approximately 3.25:1, or 31%; the northwestern face ranged from 2.5:1 to 2.6:1, with an average value of approximately 2.55:1, or 39%. The total volume of soil in the berm after settlement was approximately 3594 m^3.

The excavation of the detention pond provided some of the soil for the berm; and after completion, the pond had a surface area of approximately 1,271 m^2 and storage volume of 1,826 m^3. The three channels provided the remainder of the soil for the berm and were initially constructed with target lengths of 61 m and bed slopes of 4%, 4%, and 3%. Both channels with 4% slope had straight configurations, while the channel with 3% slope had an elbow configuration with a bend near the center of approximately 70°. This configuration for the western 0.8 ha of the site can be seen in Figure 2.3.

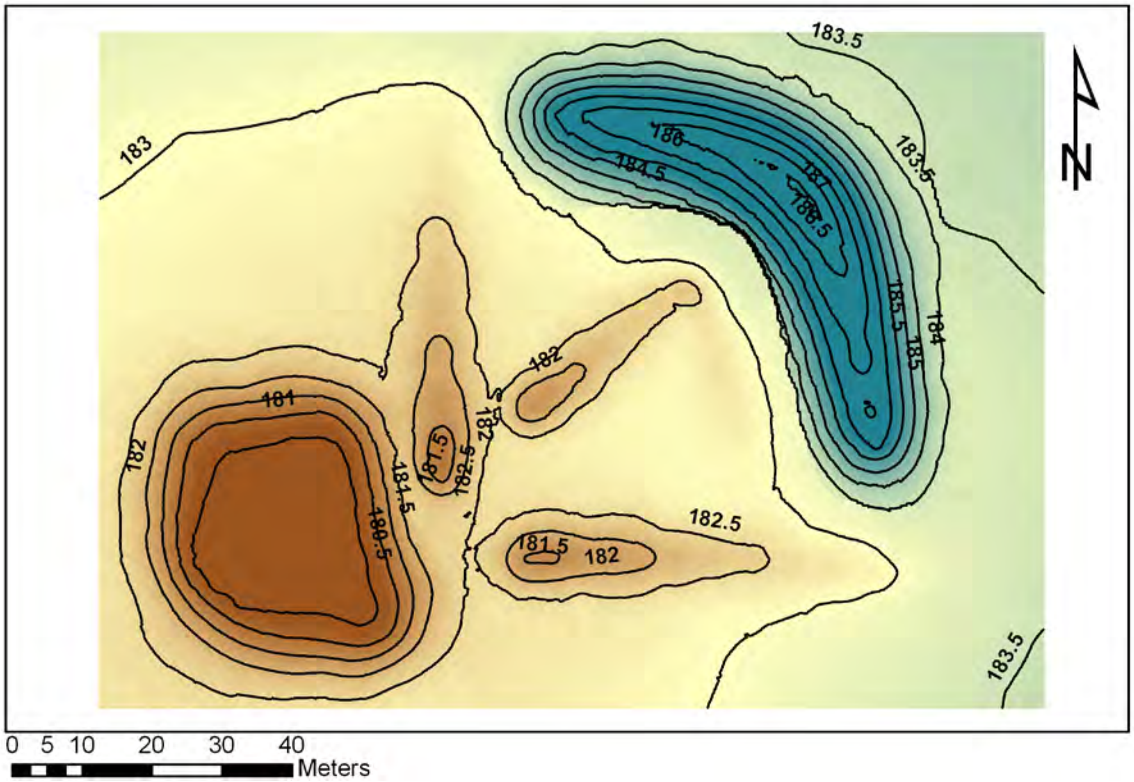

Figure 2.3. West site topography of following construction, August 2009 (all units in meters).

Following construction, a silt fence was installed along the downslope southern and western borders of the site, in order to serve as perimeter sediment control during future construction and stabilization. The geotextile fabric was trenched into the ground, secured to 2.5-cm-diameter wooden stakes, and remained in place for the following 22 months. A subsequent extension of the straight channel along the southern portion of the site occurred in October 2009, which added a 90° bend around the edge of the berm, increased its length to a target of 91 m, and decreased its slope to 2%. Following vegetation establishment and further settling over the course of 2010 and 2011, the usable portions of the channels measured 57 m for the straight channel, 58 m for the 70° angled channel, and 83 m for the 90° angled channel. The topography for the modified configuration can be seen in Figure 2.4, and an aerial image of this configuration is depicted in Figure 2.5.

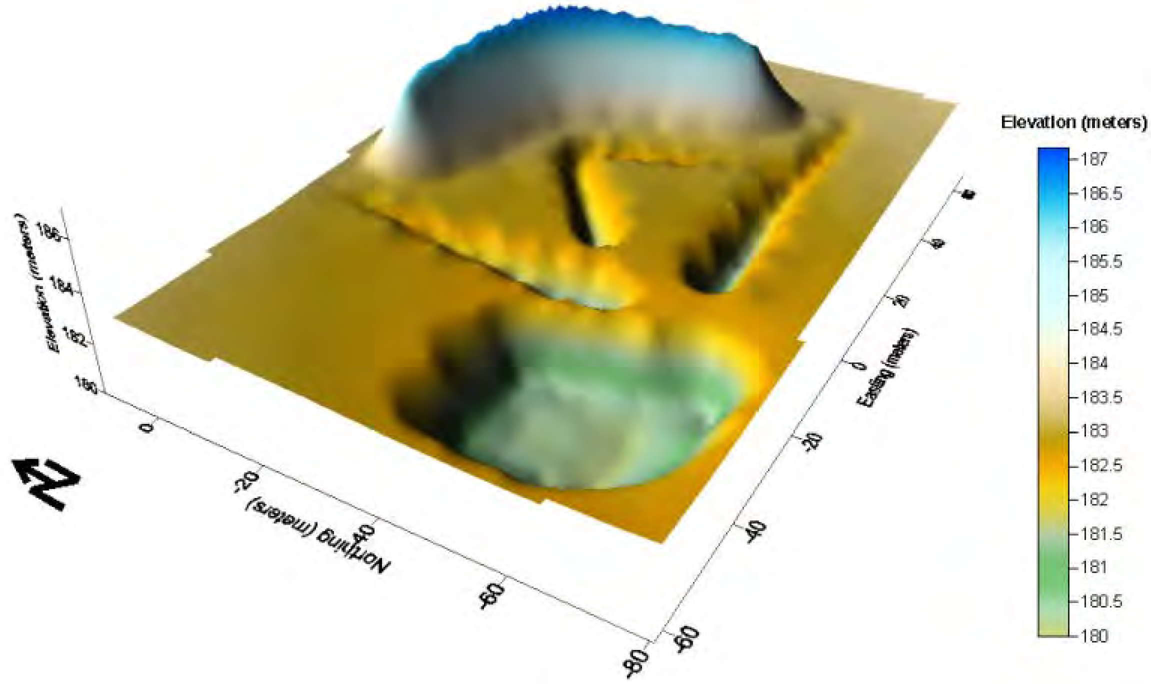

Figure 2.4. Topography of site with extended channel, April 2010.

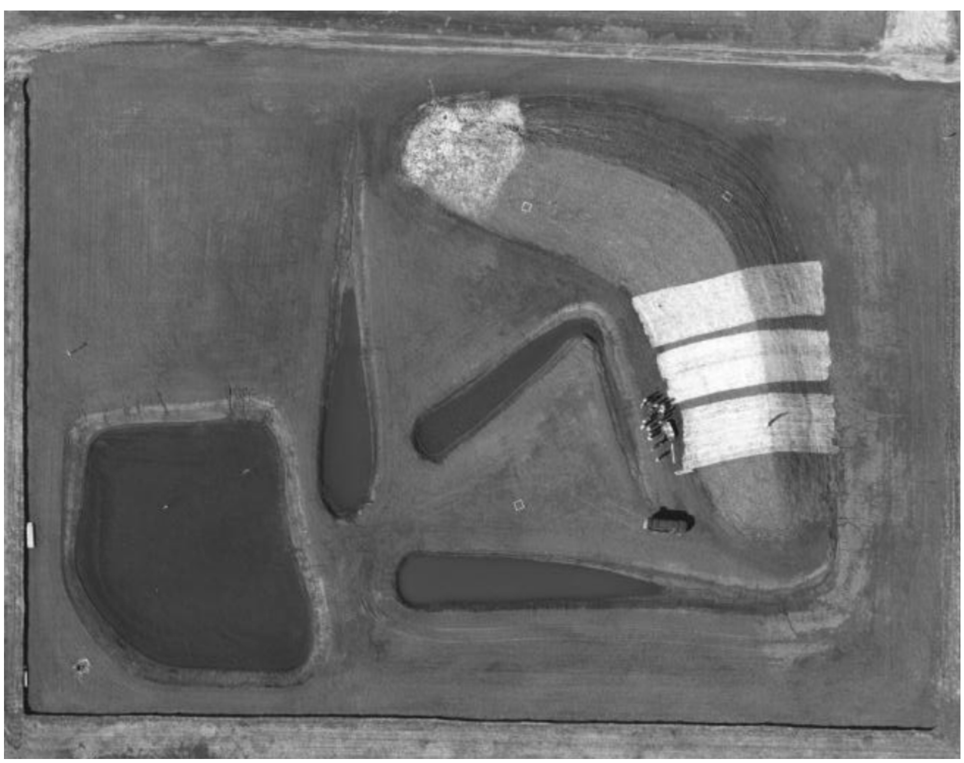

Figure 2.5. Aerial image of site with extended channel, March 2010.

2.2 SITE STABILIZATION

2.2.1 Vegetation Establishment

In September 2009, one month after the initial site construction was completed, the flat portions of the site were tilled for seeding. The flat areas, detention pond side slopes, and the berm were all broadcast seeded with fescue mix at a rate of 11 kg/ha and oats at a rate of 7 to 13 kg/ha. The oats were used only for temporary cover and stabilization, as they are killed by the lower winter temperatures (NRCS 2009). By October 2009, the berm had obtained a moderately fair cover relative to the flatter areas, as can be seen in Figure 2.6.

Figure 2.6. Vegetation establishment, October 2009.

Better performance in temporary vegetation cover for oats may have been achieved with drill seeding and/or a higher application rate, as the recommendation in Illinois is 112 to 146 kg/ha for broadcast and 72 to 112 kg/ha for drilling (NRCS 2009). Permanent fescue establishment also likely could have been improved with increased application, as 11 kg/ha exceeds the pasture recommendation for Illinois; but the recommended roadside or lawn rate is between 293 and 439 kg/ha (Graffis 1998; Reicher et al. 2006).

Over the following summer, a 2-4-D-amine broadleaf-herbicide treatment was applied to all flat areas at the site, and any bare patches of ground were tilled prior to reseeding. The portions not directly adjacent to the 3:1 base of the berm were drill seeded with a mixture of one part IDOT Class 1 Lawn mixture to one part Kentucky 31 tall fescue at an application rate of 45 to 56 kg/ha. The area at the base of 3:1 side of the berm would receive heavier traffic due to activity on the erosion plots and was broadcast seeded with four parts of the above mixture to one part *Poa supina* bluegrass, at the same rate. The seeds were raked into the tilled soil and covered with a 2- to 4-cm layer of premium shredded hardwood mulch obtained from the Urbana Landscape Recycling Center.

2.2.2 Winterization

Winter stabilization of the berm was performed in December 2009, and two types of erosion control practices were used. Three different types of ECBs were installed on the southern portion of the berm, and hydromulch was applied to the northwestern portion of the berm. The three types of blankets used and their relevant properties are summarized in Table 2.1.

Table 2.1. Erosion Control Blanket Properties

Blanket	**Manufacturer**	**Mat Fibers**	**Netting**	**Functional Longevity**	**Mass per Unit Area (kg/m^2)**
Curlex I CL	American Excelsior	Curled Great Lakes Aspen	Biodegradable polypropylene (top)	12–15 months	0.27
DS75	North American Green	Straw	Photodegradable polypropylene (top)	45 days	0.28
SC150	North American Green	70% Straw 30% Coconut	Photodegradable polypropylene (heavyweight top and lightweight bottom)	24 months	0.29

In total, seven overlapping sections of Curlex I CL, four overlapping sections of DS75, and four overlapping sections of SC150 were installed from the southern end of the berm to its center. The blankets were installed according to each manufacturer's specifications, using 15-cm staples and with adjacent sections overlapping. The blankets were unrolled from the base of one side of the berm to the base of the opposite side, with any excess length of blanket being removed. Each individual Curlex blanket had a width of 1.2 m, while the individual sections of DS75 and SC150 blankets had widths of 2.03 m. A buffer section of bare soil was also left in between the three different types of blankets. The installed blanket configuration can be seen in Figures 2.7 and 2.8, while the total installed widths for the blankets and buffer sections are summarized in Table 2.2.

Table 2.2. Total Installed Widths of Blanket and Buffer Sections

Berm position	SC150 (north)	Bare soil buffer	DS75 (center)	Bare soil buffer	Curlex I CL (south)
3:1 base	7.55 m	1.25 m	7.25 m	1.25 m	8.35 m
Top	7.35 m	1.45 m	7.35 m	1.45 m	8.25 m
2:1 base	7.55 m	2.3 m	6.9 m	1.83 m	8.4 m

Figure 2.7. Erosion control blankets on 2:1 side of berm (Curlex I CL, DS75, and SC150).

Figure 2.8. Erosion control blankets on 3:1 side of berm (SC150, DS75, and Curlex I CL).

The hydromulch applied to the northwestern section of the berm was Flexterra Flexible Growth Medium (FGM), which consisted of 74.5% wood fibers, 5% synthetic fibers, 10% tackifiers and additives, and 14.5% moisture content. The product had a functional longevity of up to 18 months, and the mass per unit area was 0.39 kg/m^2. The product was mixed and applied according to the manufacturer's recommendation for slopes between 3:1 and 2:1, as the same mixture was applied to both sides of the berm. The recommended application rate was 3,900 kg/ha of hydromulch, with a blending ratio of 23 kg hydromulch to 475 L water.

The mixture was applied with a mechanically agitated hydraulic mulching machine; but during the process, the mixture began clumping excessively and clogging the nozzle, as is shown in Figures 2.9 and 2.10. This caused uneven distribution, and the clogging eventually prevented the remainder of the hydromulch from being applied beyond the northwestern edge of the berm. These issues were likely caused by excessively cold temperatures on the day of application, which ranged from –0.6°C to 5°C.

Figure 2.9. Hydromulch application, December 2009.

Figure 2.10. Hydromulch clumping.

2.3 EROSION PLOT IMPLEMENTATION

Work on the design and implementation of erosion plots for product evaluation began in spring 2010. Initially, the test plots and runoff collection systems were placed along both sections of the 3:1 side of the berm and positioned based on prior installation of ECBs during winterization. The plots and runoff collection system were then modified to take a more permanent and maintainable form, in addition to better integrating with the rainfall simulator that subsequently had been designed.

2.3.1 Initial Plots and Runoff Collection System

Before the rainfall simulator design was completed, the runoff collection system focused on receiving natural events for the products already in place. The three blanket sections installed during winterization were divided into two adjacent plots; each plot measured 2.4 m in width and extended from the base of the 3:1 side to the top of the berm. Two additional pairs of adjacent plots were placed on the northwestern portion of the 3:1 side of the berm to serve as bare-plot controls. To restrict runoff within each plot, overlapping galvanized steel barriers 15 cm in height and 2 mm in thickness were placed on either side of the plots and inserted into the soil to a depth of 5 to 8 cm. The overlapping sections were then filled with a foam sealant.

Based on curve numbers provided by Beighley et al. (2010), runoff for each installed ECB was estimated for 2-year/12-hour events, 5-year/12-hour events, and 10-year/12-hour events. These runoff volumes ranged from 680 L to 1628 L, as shown in Appendix A. The 12-hour event was selected for the calculation, because any longer events would likely permit enough time for the tank to be emptied if it filled. Locally available galvanized steel stock tanks came in sizes up to 1,135 L and were purchased for use at the site. The tanks measured approximately 3 m in length, 0.6 m in height, and 0.9 m in width, although there was some variation in size between tanks.

A separate tank was installed at the base of each plot, with the top of each tank placed just above ground level. Using a backhoe, a hole large enough for two adjacent tanks was excavated at the base of each blanket section, and the hole was lined with a layer of semi-permeable geotextile. After the tanks were properly positioned and leveled, the holes were backfilled with the removed soil. The tank installation for two adjacent plots is shown in Figure 2.11.

Figure 2.11. Runoff tank installation.

To direct runoff from each plot to its collection tank, a triangular galvanized steel tray was placed at the base of each plot, with a spout that protruded over the edge of the tank. The trays measured 2.4 m in length by 0.9 m across at the widest portion, while the exterior walls along the tray sides and spouts were 10 cm in height. The open uphill edge of each tray had a 2- to 4-cm lip that was driven into the soil. On the bottom edge of the tray next to the tank, two wooden stakes 61 cm in length were inserted to further secure the tray in place. Photos of this initial plot, tray, and collection system are shown in Figures 2.12 and 2.13.

Figure 2.12. SC150 plots, trays, and collection tanks.

Figure 2.13. Bare plots, trays, and collection tanks.

2.3.2 Permanent Erosion Plots

The first modification to the erosion plots addressed issues with the initial runoff tank installation. The geotextile placed around the edge of the runoff tanks was inadequate for preventing sediment contamination of plot runoff from the ground surrounding the tank. The upper lip of the tank was close enough to ground level that sediment quickly accumulated during an event and was carried into the tank. A separate issue with the tanks was observed when the ground became overly saturated or the water table rose, in which case one or both sides of several tanks were lifted out of the ground.

To raise the tank elevation, the tanks were first completely removed from the ground and the hole backfilled with 7.6 cm of additional soil. Above this, a further 7.6-cm layer of gravel was added to improve infiltration and reduce saturation beneath the tank. This raised the upper lip of the tank to at least 15.2 cm above ground level, which was adequate for preventing sediment contamination from the surrounding area. Once the tanks were replaced, the holes were filled with gravel instead of soil, to further improve infiltration around the tanks, reduce ponding, and decrease the likelihood of the tanks' being periodically lifted out of the ground. To secure the tanks in the ground, a 15-cm U-bolt was welded to the top of a 1.5-m metal fence post, and the anchor was driven into the ground on opposite edges of each tank. The modified tank configuration is shown in Figure 2.14.

Figure 2.14. Runoff tank with gravel fill and fence post anchors.

The initial implementation of the erosion plots themselves also had several flaws that motivated a more permanent system. First, the metal borders were somewhat easily disturbed, which could have caused problems when tilling the plots between evaluations of different products. Second, the height of the berm was not constant along its length due to the curved configuration, and the center of the berm was up to 1 m higher than the elevation at its edges. Hence, when all plots terminated at the top of the berm, their length increased from those placed near the edge to those placed near the center. Additionally, the configuration of adjacent plot pairs was incompatible with the modular rainfall simulator that had been designed, which required sprinkler trees to be placed around the edge of each plot. Finally, a cover was needed for the plots to help prevent erosion, product degradation, and vegetation establishment when the plots were not in use.

Based on the size of the berm and the space needed for the rainfall simulator, four parallel permanent erosion plots were placed on the southern edge of the 3:1 side; this provided an adequate number for three treatment replications and one control. All four plots were located on the same section of the berm. This arrangement provided that they would experience similar wind conditions when collecting natural rainfall events and reserved the northwestern portion of the 3:1 side for vegetation evaluations. Because of the change in slope length from the edge to the center of the berm, there was not sufficient space to allow for the installation of four 12.2-m plots per ASTM D6459-07. Hence, two plots were initially designed to be 12.2 m in length and two plots were designed to be 10.7 m in length; the two longer plots were later shortened to 10.7 m so that all four would be equal in length. All plots measured 2.4 m in width, and a 2.4-m buffer was left between plots to allow for the placement of the rainfall simulator.

A wooden barrier was constructed between the base of each plot and runoff tank to stabilize the uphill plot slope, as well as to prevent erosion beneath the tray, leading to sediment accumulation around the tank. The barrier was constructed from six sections of 38-mm by 89-mm treated lumber placed on top of each other and screwed together, yielding a total height of 23 cm. The lengths of the boards decreased symmetrically from 3.0 m at the bottom to 2.6 m at the top in 8-cm increments, following the uphill slope along each side. Two 90-cm metal fence posts were driven into the ground on the downhill side of each barrier to secure it in place. In addition, a 15-cm plastic drainage tile was buried on the uphill side of the barrier to drain excess moisture from the soil and reduce pressure against the boards. The configuration of the barrier, drainage tile, and tank can be seen in Figure 2.15.

Figure 2.15. Wooden barrier and drainage tile at base of plot.

To prepare the selected portion of the berm for the installation of new plot borders, all vegetation was first killed with glyphosate; and the dead plants were cut with a combination of weed trimmers and serrated weed cutters. The area was then hoed and raked to remove most remaining plant roots and vegetation. The ground was tilled to a depth of 20 cm using a gas-powered tiller with forward-rotating rear tines, and any remaining detritus was raked to base of the berm. Finally, the selected plot locations were reworked to minimize any slope across the width of each plot that resulted from the elevation change along the length of the berm; extra soil was brought and deposited along the erosion plots, and the surface was raked to provide a more level cross section. Due to the shape of the berm, the slope along the 3:1 side gradually decreased from the southern edge to the center. This configuration precluded all four plots from having exactly the same slopes, and instead they were measured, from north to south, as 3.7:1, 3.4:1, 3.4:1, and 2.9:1.

To improve the stability of the plot borders, treated lumber with cross sections of 38 mm by 140 mm were attached end-to-end and placed in the ground to a depth of 9 cm along the sides and the top of each plot. The end of each border was positioned using a dumpy level to ensure equal elevation on both sides of the plot and minimize any slope across the plots' widths. To allow the plots to be covered between product evaluations, one edge of a 6-mil black polyethylene sheet measuring 15.2 m by 3.0 m was buried underneath one side of the plot border. The extra length along the bottom of the plot enabled both the tray and runoff tank to be covered as well. Along the opposite plot border, screw hooks were inserted into the outside edge of the boards every 1.5 m. Brass grommets were then attached to the free end of the black sheeting next to each screw hook to allow the cover to be easily removed and replaced. The wooden borders were further secured by screws attached to a series of 46-cm stakes into the ground along each side. Along the inside edge of each wooden border, the previous metal borders were again inserted to provide a non-permeable surface that would resist degradation longer than the wood and provide adequate containment of runoff.

After the plastic sheeting had been installed for 9 months, it began to show significant signs of wear. The extreme winds at the site had led to many tears forming along the top and bottom of the cover, and several of the sheeting's grommets had been torn out. To provide a more durable cover, four 12- to 14-mil-thick tarps were used instead. The tarps were made from low-density polyethylene (LDPE) laminated on both sides with high-density polyethylene (HDPE), had reinforced edges, contained preinstalled grommets every 46 cm, and measured 12.2 m by 3.0 m. The previous plastic sheeting was removed and new screw hooks were installed on each side of the border to secure the tarp.

To help secure the tarp during high winds and reduce strain on the grommets, a 14-m length of 9.4-mm chain was secured with a carabiner to an eyebolt through the center of the top border. At the bottom of the plot where the bottom of the tarp extended onto the tray, the extra chain length was laid twice along the edge of the tarp to protect against updrafts' entering beneath the tarp from the base of the berm.

At the bottom edge of each plot, another section of 38-mm by 140-mm treated lumber was buried completely to ground level and attached to the side borders, allowing the lip of the metal tray to fit over it. The bottom border was positioned to slope downward toward the runoff tank so that the tray would drain evenly. Because the plot positions had been changed after the runoff tanks were first installed, not all plots were evenly aligned with a tank; hence, some of the tray spouts were lengthened to extend over the edge of the closest tank. The extensions were attached with pop rivets, and any gaps or overlaps were filled with watertight sealant.

Prior to reattachment of the runoff tray, the soil between the plot base and the wooden barrier was seeded with IDOT Class 2 Roadside mix, raked, and covered with SC250 turf reinforcement mat (TRM). Once the tray was placed on the top, the lip was screwed into the wooden border to secure it in place. The modified tray configuration is shown in Figure 2.16, and the completed permanent plots can be seen in Figure 2.17.

Figure 2.16. Modified runoff tray at base of plot.

Figure 2.17. Completed permanent erosion plots.

2.4 RAINFALL SIMULATOR DESIGN AND IMPLEMENTATION

In order to evaluate various erosion control products under consistent and reproducible conditions, it was necessary to construct an outdoor rainfall simulator. The design for the rainfall simulator was based on the suggestions provided in ASTM D6459-07. This system is based on a modular system of sprinkler trees that can be easily and quickly moved between plots, as well as stored when not in use. The sprinkler trees are supplied with water from the detention pond through a gas-powered pump and a series of flexible hoses. To perform the test method contained in the ASTM standard, the system was required to deliver uniform rainfall intensities of 51 mm/hr, 102 mm/hr, and 152 mm/hr.

2.4.1 Sprinkler Trees

To produce uniform rainfall over the entire plot area, the rainfall simulator was designed to include a set of 11 sprinkler trees placed around the perimeter of the erosion plot, as shown in Figure 2.18. Nine of the trees were alternatingly spaced 3 m apart on each side of the plot, with five on one side and four on the opposite side. The remaining two trees were centered in the middle of the plot on the top and bottom. Each tree was placed a distance of 1.2 m from the plot border.

The trees were constructed from 25.4-mm-diameter galvanized steel pipe and fittings, with the vertical riser including a check valve at the base, a 5.1-cm-diameter polypropylene quick-connect fitting for the water supply line, a gate valve, and a pressure gauge. The horizontal crosspiece atop the riser contained four symmetrically spaced nozzles, each with its own gate valve. The ASTM standard recommended a nozzle height of 4.3 m; but for ease of movement, the initial configuration used a 3.4-m height. The trees were secured in the ground through a base support of 31.8-mm-diameter galvanized steel pipe 91.4 cm in length that was inserted into the ground to a depth of 81.3 cm. A 31.8-mm flexible coupler just below the check valve on each tree allowed the tree to fit snugly over the base support. An illustration of the basic tree and base support is depicted in Figure 2.18.

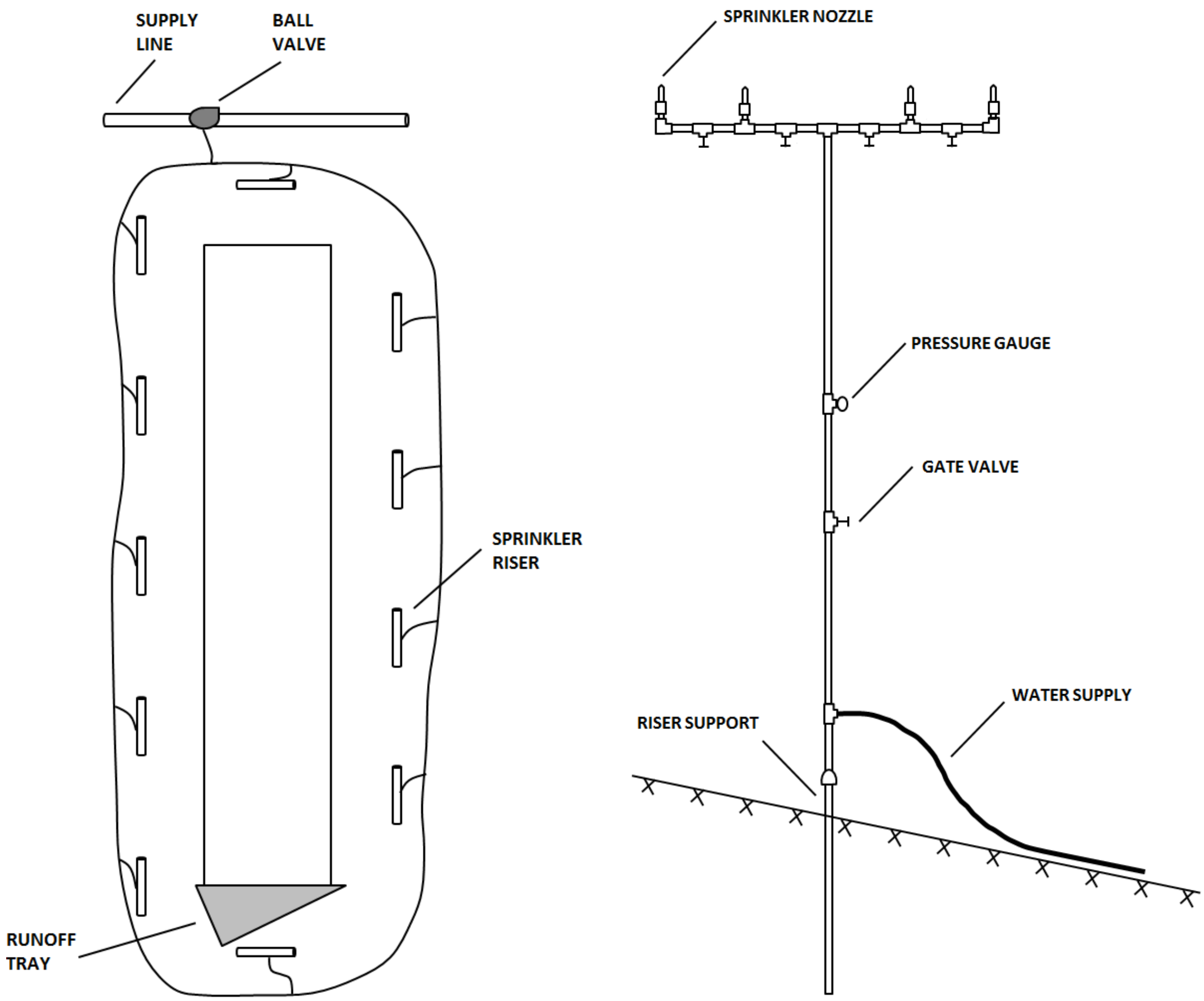

Figure 2.18. Sprinkler tree configuration and structure (ASTM 2007a).

After the trees had been assembled and tested, it was observed that even relatively gentle winds could cause large disruptions of the simulated rainfall intensity and distribution. This occurrence was partially due to the small nozzle droplet size but also was affected by the stronger winds experienced at greater elevations because the nozzle height varied from 3.4 m above ground level at the base of the berm to 7.1 m above ground level at the top of the berm. To address this issue, the tree height was later shortened to 1.9 m, as seen in Figure 2.19.

Figure 2.19. Shortened sprinkler tree.

2.4.2 Nozzles

To achieve uniform rainfall intensities of between 51 mm/hr and 152 mm/hr over the plot area of 29.7 m^2, the system needed to provide a total spray capacity of up to 4.5 m^3 per hour. Hence, each nozzle was required to discharge 1.7 L/min at an operating pressure of 138kPa to 241 kPa, a reasonable range for commonly available water pumps. To achieve this spray rate, 1/4KSS-5 stainless steel FloodJet wide-angle flat spray tips were initially selected for the side sprinkler trees, with a capacity of 3.3 L/min at 207 kPa. For the top and bottom trees, 460.603.17-BE stainless steel Lechler axial full-cone nozzles were initially selected, which have a capacity of 3.2 L/min at 207 kPa.

After the small droplet size proved to be an issue with wind, alternate nozzle options with larger droplet sizes were considered. The TTI11006 Turbo TeeJet induction flat spray tip was selected because it had the highest capacity of any of the largest-droplet-size TeeJet nozzles. The capacity was somewhat lower than the FloodJet nozzles, with a discharge of 2.0 L/min at 207 kPa, but was still adequate to produce the required intensities.

The new TeeJet nozzles were acquired during the winter, which precluded any outdoor testing on the erosion plots. Instead, the discharge capacity for both sets of nozzles was first measured in the laboratory at various pressures and compared to the manufacturer's specifications. Next, the distribution of a single sprinkler tree with the new nozzles was measured using a 4 by 9 grid of 36 rain-gauge buckets, positioned 1.2 m from the base of the tree. The rain gauges had openings of 285 cm^2 and were spaced at 61-cm intervals on top of the lab drainage grate (Figure 2.20). This allowed the distribution from a single tree to be measured over a subsection of the erosion plot that extended completely across the plot's width and 2.4 m in either direction parallel to the plot from the position of the tree.

The nozzles were evaluated under operating pressures of 138kPa, 207 kPa, and 241 kPa for 20 min, using both the full tree height of 3.4 m and reduced tree height of 1.9. After each test, the volume of water in the bucket gauges was measured using a 2-L graduated cylinder. The volume was converted to a depth measurement through dividing by the surface area of the gauge opening. Distributions for the entire 12.2-m plot area were then calculated by overlaying appropriately oriented single-tree distributions at each tree position along each side of the plot borders. Figure 2.20 shows the laboratory set up for testing the new nozzles.

The estimated distributions for the entire plot were used to calculate the average intensity and uniformity at each operating pressure and tree height. Each gauge collected rainfall for the same area; hence average intensity was calculated as the mean of all observations divided by the elapsed time of the test.

Figure 2.20. Laboratory testing of nozzle distribution.

2.4.3 Water Supply and Delivery

The site's detention pond served as the water supply for the rainfall simulator, with an estimated capacity of 651.3 m^3 when filled to half its maximum depth. An erosion control product evaluation consisting of three sequential 20-min simulated rainfall events of 51 mm/hr, 102 mm/hr, and 152 mm/hr required only 3.0 m^3 of water, so the available storage was more than adequate. The water was conveyed to the sprinkler trees using a 3.0-kW, gas-powered pump, with a maximum working pressure of up to 345 kPa and maximum flow up to 738 L/min.

The pump was positioned near the center of the pond's eastern edge, approximately 80 m from the southern end of the berm. The pump was supplied through a 3.8-cm suction hose connected to floating PVC filter. The filter was constructed of a 6.1-m horizontal piece of 3.8-cm-diameter pipe connected via a 90° elbow to a 30-cm vertical capped pipe 7.6 cm in diameter. A grid of 1-cm holes was drilled around the lower portion of the vertical piece, and then wrapped in aluminum wire screen to prevent algae and sediment particles from entering the filter. The filter was suspended in the water by a floating square of connected PVC pipe 15.2 cm in diameter, with a gap on one side and the exposed ends capped. A metal crosspiece was secured across the top of the square, and the end of the filter was positioned through the gap and hung from the crosspiece. A 5.1-cm-diameter collapsible discharge hose connected the pump to the sprinkler tree configuration.

All sprinkler trees were connected near their bases to the water supply line via polypropylene quick-connect fittings attached to a discharge hose with a quick-connect tee on the other end. Each tee was also connected to adjacent tees via discharge hoses, and the system was supplied at the top of the plot from the discharge hose connected to the pump. At the base of the plot, the system connected to a ball-valve discharge hose, which allowed it to be flushed before pressurizing the nozzles or serve as an emergency bypass. The hose and quick-connect configuration is illustrated in Figure 2.21, and the assembled system can be seen in Figure 2.22.

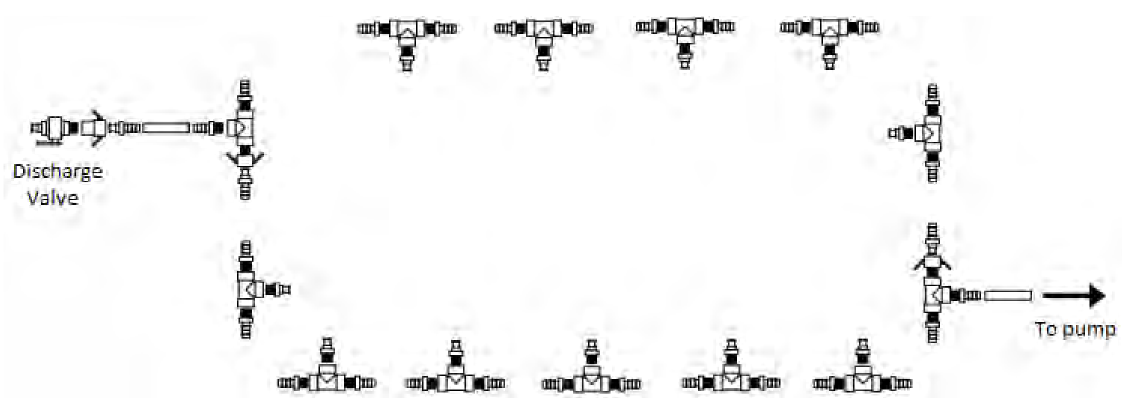

Figure 2.21. Quick-connect tee and hose system.

2.4.4 Calibration

To calibrate the rainfall simulator for achieving the desired distributions and intensities, a 3-by-13 grid of 39 plastic rain gauges was used to collect and measure depth of rainfall. To protect the plot soil, it was first covered with a clear plastic sheeting of 4-mil thickness and secured at the borders. Rain-gauge positions were marked on the sheeting at a distance of 0.4 m from the interior of the bottom and side borders, with 0.8-m spacing between adjacent gauges. Each gauge had an opening of 26 cm^2 with a rainfall depth capacity of 152 mm and was supported by a metal bracket attached to a thin vertical post.

As mentioned above, it was noted during field calibration that even minor winds greatly affected distribution and intensity. Hence, new nozzles with larger drop sizes were acquired and tested at the lower height of 1.9 m. The new nozzles were also tested, not just vertically but at various alternate orientations (0, 10, 15, 25, 30, 45, and 60 degrees from the horizontal), to determine which configuration yielded the best distribution. To determine whether the maximum average intensity was adequate for product evaluation of up to 152 mm/hr, the system was operated at the highest pressure, such that each tree was pressurized to the same extent (207 kPa). The calibrations were performed for 10- or 20-min durations, depending on whether winds arising during a test began to significantly impact performance.

The excess rainfall during calibration was collected in the runoff tank at the base of the plot. A second gas-powered utility pump was used to drain the tank before it reached capacity, and then convey the water back to the northeast corner of the detention pond. To protect the side slopes of the detention pond from the pump discharge, a layer of riprap was placed along the slope in that section. The plot configuration for calibration is depicted in Figure 2.22.

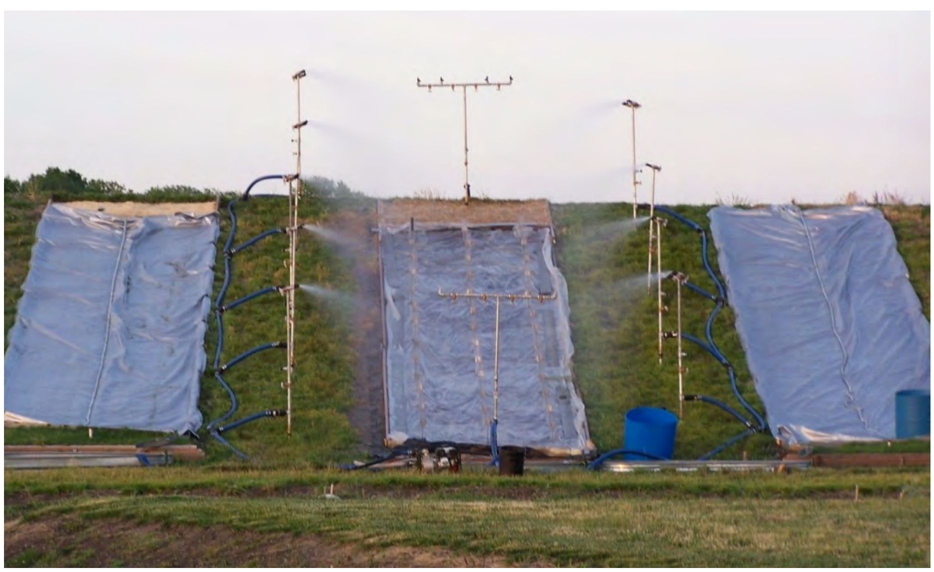

Figure 2.22. Rainfall simulator calibration.

2.5 DEVELOPMENT OF TESTING PROTOCOLS FOR EROSION CONTROL PRODUCTS

In order to evaluate soil erosion and sediment transport control products at the testing facility, two protocols were developed. The first protocol has been developed for erosion control product evaluation and is included in this report. The second protocol that was developed for ditch-check evaluation is still under testing, will be part of the IDOT R27-104 project, and will be submitted with final report of that project.

2.5.1 Testing Protocols for Erosion Control (Blanket) Products

An evaluation protocol based on ASTM D6459-07 has been developed for testing various erosion control products at the site. The four plots are used to test three replications of a single product and one control plot of bare soil. All plots are tilled to a depth of 10 cm, raked, and compacted with a tamper. The erosion control blankets (ECBs) to be tested are installed following the manufacturer's installation guidelines in three of the erosion control plots.

Once the erosion control blankets have been installed, the rainfall simulator is run until complete soil saturation has been reached, at least ten soil-moisture-content measurements are taken randomly throughout the plot to check if soil saturation is reached; if soil saturation has not been reached, the rain simulator is run until this condition is accomplished. The soil and the product installed are saturated to ensure that every product being tested has the same saturation conditions, due to the fact that some products are able to absorb water when they are not saturated, which significantly affects the runoff rate.

Prior to testing, a set of nine rain gauges are placed on the plot every 1.5 m from the bottom to the top, in an alternating sequence of one centered gauge and two gauges each 30 cm from the plot border. The rain gauges are installed to check if the target intensity and the rainfall distribution have been achieved during test operation.

2.5.1.1 Test Operation

During testing, a windscreen is raised to provide more consistent conditions between evaluations; and the rainfall simulator system is moved to the appropriate plot. The test is sequentially operated at pressures corresponding to the target intensity of 100 mm/h for 30 min each for every plot. After the test is finalized, the average rainfall depth is measured to verify correct calibration.

Visual observation, along with photographs, is documented. It is also recommended but not required to videotape the entire process. The time at start of rainfall, start of runoff, end of rainfall, and end of runoff will be recorded throughout the test.

It is assured that there is a minimum of a 30-min (or at a least 15-min) gap between replications to guarantee that runoff from previous test does not affect the new testing but ensuring that the soil is still saturated.

The runoff is collected from the plot using a series of 19-L plastic buckets. The time at start of rainfall, start of runoff, end of rainfall, and end of runoff is recorded throughout the test. The time is noted at which each bucket is filled, and the bucket is weighed using a digital hanging scale. The mass of the dry, empty bucket is subtracted to yield the net runoff mass and later to construct an appropriate runoff hydrograph.

Grab samples are taken at the outlet of the collection tray every 3 min in glass jars of 350 ml during test operation. The first grab sample is taken 3 min after starting the test, and the last sample is taken after 30 min.

2.5.1.2 Calculations

Total sediment concentration for each sample is measured, based on the procedures in ASTM D3977-97 *Standard Test Methods for Determining Sediment Concentration in Water Samples.* The samples are first placed in a drying oven set to just below 100°C until all visible moisture is removed. The temperature is then raised to 105°C and the samples dried for an additional 24 hours. The mass of each dried sample and jar is measured; and after the jars are thoroughly cleaned and dried, their empty masses are recorded as well. The concentration in ppm is calculated by dividing the net sediment mass by the net sample mass, and then converting to mg/L:

$$C_2 = \frac{C_1}{1 - C_1 * 6.22^{-7}}$$

where C_2 is the concentration in mg/L, C_1 is the concentration in ppm, and the bulk density of sediment is assumed to be 2.65 g/cm^3 (ASTM 2007b).

The total sediment yield for each test is calculated by multiplying the net mass of runoff collected in each bucket by the sediment concentration in ppm for the grab samples taken for the corresponding bucket. Finally, the sum of the net sediment mass from samples provides the total sediment yield.

The turbidity of each grab sample is measured using a turbidity meter (and the results are expressed in nephelometric turbidity units, NTU). To construct the runoff hydrograph, the volume of each sample is first calculated from the net mass of water from the sample and the net mass of sediment from the sample:

$$V = m_w + \frac{m_s}{2.65}$$

where V is the sample volume (mL), m_w is the net water mass (g), m_s is the net sediment mass (g), the density of water is assumed to be 1.00 g/cm^3, and the bulk density of sediment is assumed to be 2.65 g/cm^3. The runoff rate during each sample collection is calculated by dividing the sample volume by the elapsed collection time. The hydrograph is constructed by plotting the runoff rates against the times corresponding to the midpoint of the sample collection. The sediment concentration curve for each test is similarly constructed by plotting the concentration for each sample against the midpoint of the sample collection time as well.

2.5.1.3 Synthesis of Evaluation

All data and measurements (runoff, NTU, SSC) from an ECB test are compared with others under similar replicable test conditions. The results are shared and discussed in detail deliberation with the IDOT–TRP members. Based on the test results and the discussions, performance of an ECB is recommended.

CHAPTER 3 TRAINING CLASSES

As a part of this project, three training classes have been developed. The first course is a basic course that provides the fundamentals of stormwater pollution management for erosion and sediment control. The second course that has been developed is for designers and planners, and focuses on erosion and sediment control planning and design. The target group for third training is inspectors, as it focuses on inspection of erosion and sediment control best management practices (BMPs). The details of these classes are provided below.

3.1 TRAINING CLASS 1: FUNDAMENTALS OF STORMWATER MANAGEMENT FOR EROSION AND SEDIMENT CONTROL

The first course is designed for the Illinois Department of Transportation (IDOT) contractors, inspectors, designers, and others interested in erosion and sediment control and stormwater management BMPs for a sustainable environment. This 2-day course presents the following four topics: regulatory/permit requirements, fundamentals of hydrology and soil erosion, BMPs for erosion and sediment control, and inspection of erosion and sediment control measures. The following is the outline of this 2-day course.

Day 1	
9:30–10:00	Coffee/registration
10:00–10:10	Introductory remarks
10:10–11:10	Hydrology
11:10–11:20	Break
11:20–12:10	Soil erosion
12:10–1:00	Lunch
1:00–2:00	Federal and state regulations
2:00–2:10	Break
2:10–3:00	Federal and state regulations
3:00–5:00	Field visit

Day 2	
8:30–9:00	Coffee
9:00–10:15	Design BMPs
10:15–10:30	Break
10:30–12:00	Design BMPs
12:00–1:00	Lunch
1:00–2:00	Inspection
2:00–2:15	Break
2:15–3:00	Exam
3:00	Concluding remarks

The handout for this class is provided in Appendix B.

3.2 TRAINING CLASS 2: EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN

The second course is designed for planners and designers who are interested in planning and designing stormwater management, soil erosion and sediment control measures. This 1-day course contains erosion and sediment control plan (ESCP) design, the ESCP design process, stormwater pollution prevention plan (SWPPP), and an ESC design exercise. The outline of the class is as follows:

1. Objective
2. Goals
3. Overview
4. ESCP design and discussion
5. Design standards
6. ESCP design process
7. SWPPP
    a. IL SWPPP Form BDE 2342
    b. Overview of the IL47 project from Kreutzer to Reed Road
8. ESCP and the SWPPP
9. IDOT resources
    a. BDE
    b. Hydraulic report
    c. Field notes
    d. Soil reports
    e. Preliminary site-investigation reports
    f. Plan sheets
    g. Special concerns
10. Project reports and studies details
    a. Explanation of report types
    b. Topographic data
    c. Plan sheet data
11. ESCP planning
    a. Construction phases
    b. Staging
    c. Temporary ESCP planning
12. Preliminary plan review and final design
13. SWPPP introduction and case study introduction
14. SWPPP section 1
15. SWPPP section 1 class problem
16. SWPPP section 2
17. SWPPP section 2 class problem
18. SWPPP section 3
19. SWPPP section 3 class problem
20. ESC design exercise (Kreutzer to Kishwaukee)

3.3 TRAINING CLASS 3: INSPECTION OF EROSION AND SEDIMENT CONTROL BEST MANAGEMENT PRACTICES (BMPs)

The outline of the class is follows:

INTRODUCTION

- Purpose and scope
- Why soil conservation is important—how it relates to Clean Water Act (CWA)
- ILR40 and 10—how they relate to CWA and the Illinois Environmental Protection (IEP) Act
- SWPPP and ESC plan requirements and relation to ILR10
- BDE 2342—SWPPP breakdown (explanation of components)
- What to consider and look for; resources and considerations (wetlands, TES, 303; soil type; hydrology; vegetation, etc.)

CLASSROOM EXERCISE—HOW TO DEVELOP OR INTERPRET YOUR SWPPP

- BDE 2342 Section I—cite description
- BDE 2342 Section II—controls (ESC measures)
- BDE 2342 Section III—maintenance
- 11:30–12:00
- BDE 2342 Section IV—inspections
- BDE 2342 Section V—failure to comply
- BDE 2342 contractors certification statement

CLASSROOM EXERCISE

- Inspection requirements related to IDOT permits
- IDOT-approved construction BMPs
- Common implementation mistakes and maintenance issues of BMPs
- IDOT inspection checklist
- How to document for IDOT inspection reports

OUTDOOR CLASSROOM EXERCISE

- Conduct ditch-check/check-dam inspection.
- Students walk through with the IDOT inspection sheet and conduct inspection and fill it out to be gone over when they return to class.
  - Have demonstration using three or four products
    - Riprap/Enviro Berm/Rolled Excelsior/Triangular Silt Dike
    - Examples of poor installation (missing geotextile/wrong stake placement, improper spacing, or overlap)
    - Examples of required maintenance or repair
    - Examples of good installation
    - Examples of products not approved by IDOT
  - Installation of a ditch-check system
    - This will include questions on proper spacing, IDOT-approved installation specifications, etc.
  - Conduct inlet inspection.
    - IDOT-approved products
    - Demonstration with pumped water into channel
    - Ask students what they learned.

INSPECTION REPORT AND CLASSROOM EXERCISE

- Inspection report and exercise
  - Review regulatory requirements.
    - Bring up McHenry County overview.
    - Ask students where they might have issues with Incidence of Non-compliance IONs.
    - Impaired waters, threatened and endangered species TES habitat, dust, etc.
    - Ask students what they should look for during different phases of a project.
      - Check ESCP design against each phase.
      - Check for temporary and permanent phasing.
    - Inspection reports—the good and the bad
      - Show good and bad examples of inspection reports, and students provide written “corrections.”
    - Provide actions for documentation per IDOT requirements.
      - Pictures will illustrate
        - Deficiencies
        - Noncompliance
        - Violations

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APPENDIX A ESTIMATED EROSION PLOT RUNOFF

Table A.1. Adjusted curve numbers and runoff calculations for ECBs.

	Bare	Curlex I CL	DS75	SC150
Beighley (2010) CN	97.0	94.0	95.0	91.0
Adjusted CN for Hydrological Soil Group B	86.0	83.0	84.0	81.0
Correction Factor	1.00	1.00	1.00	1.00
S (mm)	41.4	50.8	47.6	60.8
P (mm), 2-yr,12-hr	62.3	62.3	62.3	62.3
Q (mm)	30.6	26.4	27.8	22.7
Q_{vol} (L)	918	793	833	680
P (mm), 5-yr, 12-hr	80.7	80.7	80.7	80.7
Q (mm)	46.1	41.0	42.7	36.3
Q_{vol} (L)	1383	1230	1280	1089
P (mm), 10-yr,12-hr	94.2	94.2	94.2	94.2
Q (mm)	58.0	52.4	54.2	47.1
Q_{vol} (L)	1741	1573	1628	1414

APPENDIX B SUPPLEMENTAL HANDOUT MATERIALS

University of Illinois at Urbana-Champaign
Department of Agricultural & Biological Engineering
1304 W Pennsylvania Avenue
Urbana, IL 61801
http://www.abe.illinois.edu

Supplemental handout materials

for

Class 1- Fundamentals of Storm Water Management for Erosion and Sediment Control

Section 1

Section 2

Section 3

Section 4

Appendix

Section 1

1.1 Introduction

This manual is to be used as a supplement to the presentation entitled “Module 1 - Fundamentals of Storm Water Pollution and Erosion Control and Sediment Control.” It is intended to be a training guide for designers, contractors, inspectors and others dealing with the Illinois Department of Transportation (IDOT) and other contractors. This training is provided at the University of Illinois - Agricultural and Biological Engineering South Farm at Urbana, Illinois.

1.2 Fundamentals of Hydrology

1.2.1 Hydrologic Cycle

The hydrologic cycle is the continuous movement of water on the earth’s surface, above the earth in the atmosphere, and below the earth’s surface. Since it is truly a cycle, there is really no precise beginning or end, but a common place to start is with the energy from the sun. The sun drives the water cycle by heating surface water on the earth, mainly in the ocean. This water then evaporates as water vapor into the atmosphere. Water also enters the atmosphere through a process known as evapotranspiration, which includes water transpired by plants along with all evaporation from surface waters and from the soil. Once water vapor has risen into the atmosphere, cooler temperatures cause it to condense and form clouds. Cloud particles then fall out of the sky and back to the earth’s surface as precipitation. Some precipitation may fall as snow and ice, whereas most precipitation is in the form of rain. Each type of precipitation can cause runoff weather it is from snowmelt or direct surface runoff from excess rainfall. A portion of the runoff enters streams and rivers as it makes it way back toward the ocean, but a lot of water also soaks into the ground as infiltration. This helps to restore groundwater storage deep under ground in aquifers. Some infiltrated water may also seep back into surface water bodies and ultimately make its way back to the ocean where the cycle initially began.

1.2.2 Precipitation

When designing erosion and sediment control, it is important to know what type of precipitation event for which to design. A common precipitation event to design for may be a 10 year design storm. This means that the likelihood or probability of an event with a specified intensity and duration has about a 10 year return period or frequency. However, it is important to keep in mind that as with all probabilities, it is possible to have multiple 10 year storms within the same year. The intensity can be predicted for any return period and storm duration from Intensity-Duration-Frequency (IDF) Curves that are based off of historic rainfall data for specific areas. This data can be obtained from NOAA’S National Weather Service website at **http://hdsc.nws.noaa.gov/hdsc/pfds/.**

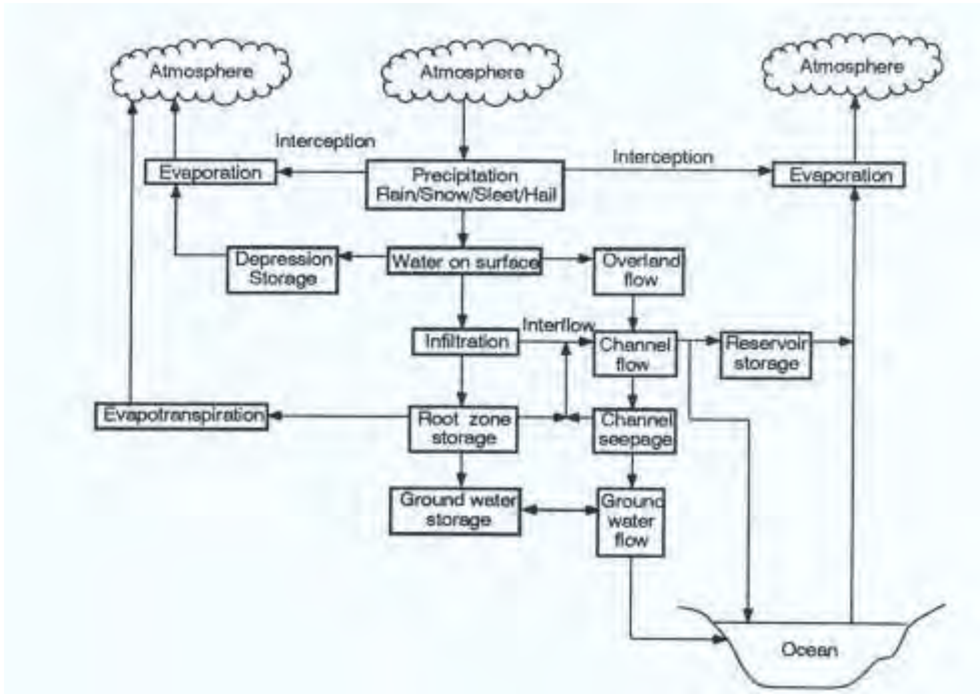

Figure 1.1: Hydrologic Cycle

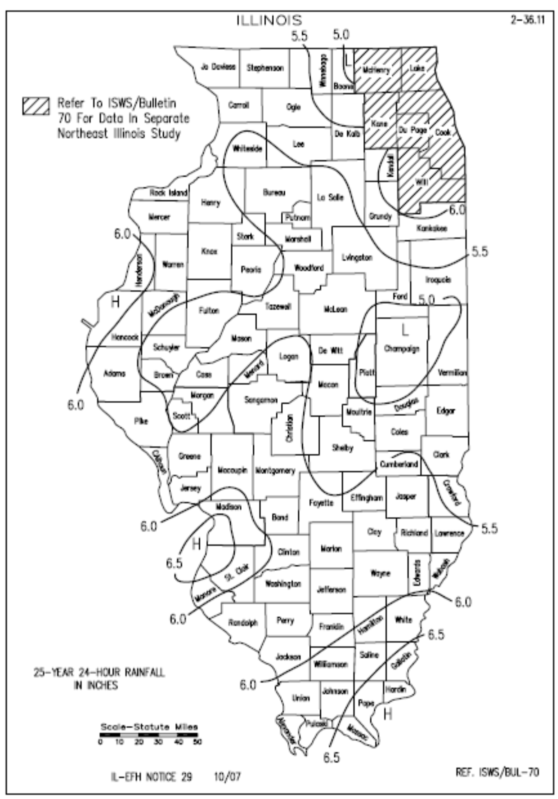

Figure 1.2: 25 year 24 hour rainfall for Illinois

1.2.3 Runoff and Infiltration

Surface runoff occurs when the rate of rainfall exceeds the rate at which water can infiltrate into the ground, and any depression storage on the surface has already been filled to capacity. This means that when rainfall is constant, the rate of infiltration will decrease as the soil becomes more saturated; therefore, increasing the rate of runoff. The following graph illustrates this relationship. Runoff can either be measured as a runoff rate typically expressed in cubic feet per second, or as a runoff volume expressed in a depth per area.

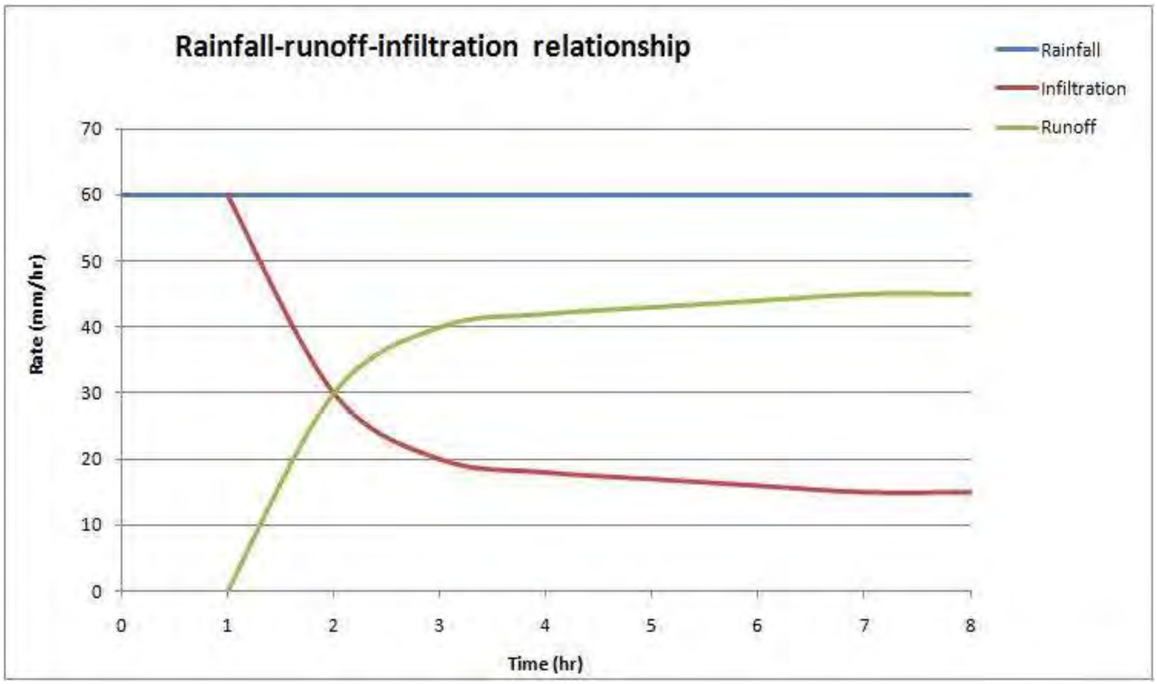

Figure 1.3: Rainfall-Runoff-Infiltration Relationship

1.2.4 Runoff Rate - Rational Method

The Rational Method is an equation used to calculate the peak surface runoff rate for a design storm with a specified return period. This method is suitable for small areas, typically less than 300 acres in size. The Rational Method equation is:

$$Q = C*I*A \qquad (1)$$

where Q is the peak surface runoff rate in cubic feet per second (cfs), from a watershed of area A in acres, and runoff coefficient C, due to a storm of intensity I in in/hr.

The drainage area (A) is often determined from a contour map by determining the boundaries of the drainage basin. The runoff coefficient (C) is an empirically determined constant ranging from 0 to 1 that is dependent upon the land surface, cover type, and even slope. Impervious areas, such as a pavement, have very high runoff coefficients of nearly 1. Very tightly packed clay soils will also have high C values, whereas sandy soils allow much more infiltration and will have a lower C value. Also, as the slope increases it is typical for the runoff coefficient to increase as well. The intensity (I) is the constant intensity of a design storm with a specified design return period and duration equal to the time of concentration of the drainage area. The intensity can be found using an Intensity-Duration-Frequency Curve.

The time of concentration is the time it takes for water to flow from the hydraulically most distant point in the watershed to the point of interest, often the outflow location. The time of concentration can be calculated using the simple equation:

$$T_c = \frac{L}{3600V} \qquad (2)$$

where T_c is the time of concentration in hr, L is the flow length in ft, and V is the flow velocity in ft/sec. Depending on surface conditions or slope, the area may be broken up into several sections for different flow lengths and flow velocities.

Table 1.1: Value of Runoff Coefficient (C) for the Rational method
(Source: ODOT Hydraulics manual)

	FLAT	ROLLING	HILLY
Pavement & Roofs	**0.90**	**0.90**	**0.90**
Earth Shoulders	0.50	0.50	0.50
Drives & Walks	0.75	0.80	**0.85**
Gravel Pavement	**0.85**	**0.85**	**0.85**
City Business Areas	0.80	**0.85**	**0.85**
Apartment Dwelling Areas	0.50	0.60	0.70
Light Residential: 1 to 3 units/acre	0.35	0.40	0.45
Normal Residential: 3 to 6 units/acre	0.50	0.55	0.60
Dense Residential: 6 to 15 units/acre	0.70	0.75	0.80
Lawns	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay & Loam	0.50	0.55	0.60
Cultivated Land, Sand & Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	**0.90**
Parks & Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland & Forests	0.10	0.15	0.20
Meadows & Pasture Land	0.25	0.30	0.35
Unimproved Areas	0.10	0.20	0.30

Note:

- ***Impervious surfaces in bold***
- *Rolling = ground slope between 2 percent to 10 percent*
- *Hilly = ground slope greater than 10 percent*

Examples of Rational Method:

(a) Two drainage channels will carry storm water runoff from two equally sized areas located either side of a County road. Which area contributes a greater runoff: (a) a forested area or (b) a city business area? What will be the channel capacity (CFS) of both channels if each area is 10 acres and the rainfall intensity is 2 inches/hr? (Consider rolling terrains)

Solution:

The channel carrying runoff from the city business area should have higher carrying capacity since city business area has higher runoff coefficient (C) than forested area.

Channel capacity carrying runoff from forested area = 0.15 * 2 * 10 = 3 cfs

Channel capacity carrying runoff from city business area = 0.85 * 2 * 10 = 17 cfs

(b) Calculate peak runoff from a 50 acres drainage area which contains 11 acres of asphalt roads (C = 0.85), 1 acre of playground (C = 0.25), 4 acres of parks (C = 0.15), and 34 acres of suburban residential areas (C = 0.35) with a design rainfall intensity of 1.78 inches per hour.

Solution:

It is first necessary to calculate a composite C for the entire area:

$$C = \frac{((0.85*11)+(0.25*1)+(0.15*4)+(0.35*34))}{50}$$

$$C = \frac{22.1}{50} = 0.442$$

Then apply the Rational Method Equation:

$$Q = C * I * A$$

$$Q = (0.442)*(1.78\tfrac{in}{hr})*(50 acres)$$

$$Q = 39.34 \; cfs$$

1.2.5 Runoff Volume - Soil Conservation Service (SCS) Method

The Soil Conservation Service (SCS) Method, also known as the curve number method, is used for predicting the amount of runoff volume. This particular method was primarily developed for agricultural watersheds, but it can also be used for urban areas with a few slight modifications. As previously mentioned, the runoff volume is typically expressed as a depth, similar to precipitation. A volume can be obtained from this information by simply multiplying the watershed area with the runoff depth.

The SCS basic runoff equation is:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \tag{3}$$

where Q is the direct surface runoff depth in inches, P is the storm rainfall depth in inches, and S is the maximum potential between rainfall and runoff, also known as storage in inches.

The storage variable includes both storage and infiltration potential of the watershed. The relationship between S and the curve number (CN) is:

$$S = \frac{1000}{CN} - 10 \tag{4}$$

The CN depends on soil type, land use, ground cover, and soil moisture conditions. The CN varies from 0 to 100 and a higher CN means smaller initial abstractions and higher runoff. Whereas a lower CN would give higher initial abstractions, such as a very dry soil, and therefore produce less runoff. CN values may be obtained from various tables that include most conditions that will be encountered while designing erosion and sediment control.

Table 1.2: Value of Curve Number (CN) for average rainfall condition

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

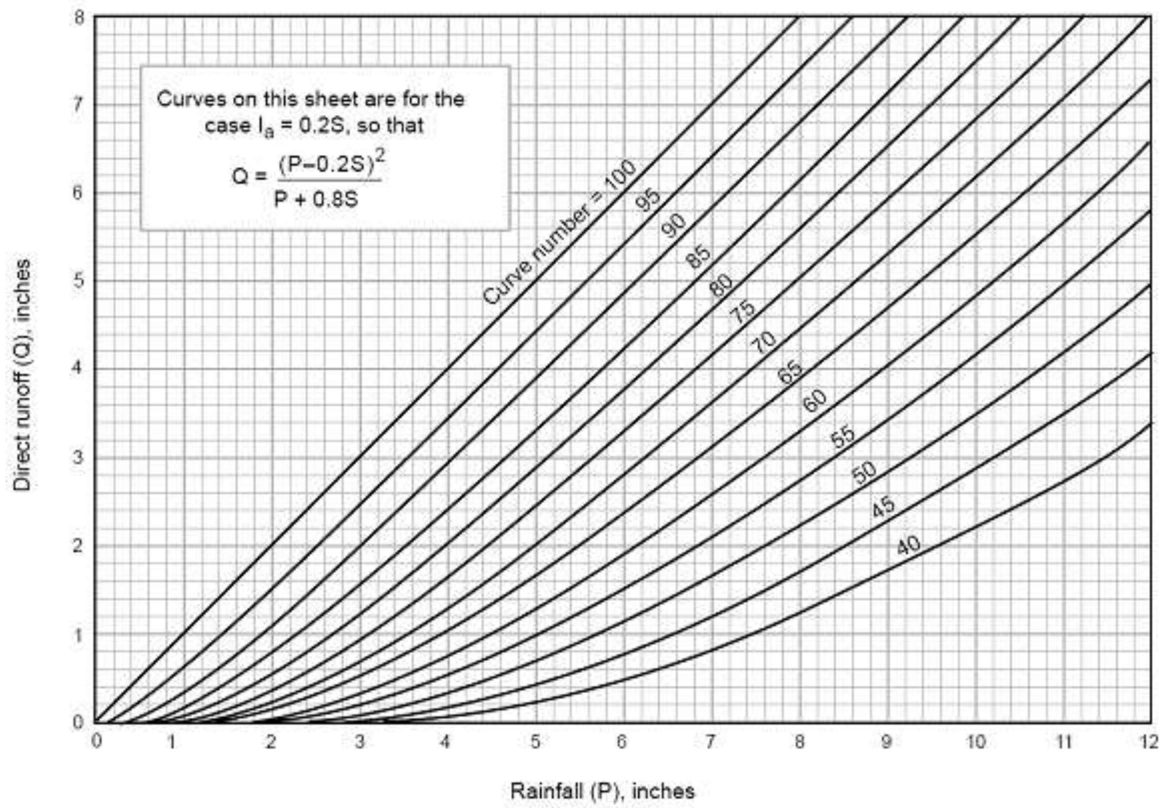

Figure 1.4: Rainfall and runoff relationship using Curve Number (CN)

Example of SCS Method:

If a detention pond receives runoff volume from a 10-acre parking lot, calculate the capacity of the pond (in cubic feet) for a 2-inch rainfall event.

Solution:

The Curve Number for pavement can be found in tables to be 98. Using this:

$$S = \frac{1000}{98} - 10$$

$$S = 0.20 \ \ inches$$

$$Q = \frac{(2-(0.2*0.2))^2}{2+(0.8*0.2)}$$

$$Q = 1.78 \ \ inches$$

Converting into feet and multiplying by the area:

$1.78 \ inches = 0.148\, ft$

$10 \ acres = 435600\, ft^2$

$435600\, ft^2 * 0.148\, ft = 64614\, ft^3$

1.3 Fundamentals of Soil Erosion

Soil erosion is the process of soil particles being displaced and transported by the actions of wind or water. Although soil erosion is a naturally occurring process, it has been dramatically increased by human activities and land use especially from industrial agriculture and construction practices. It takes over 100 years for an inch of top soil to form and with this increase more soil is eroding than can be replaced, which has many negative consequences.

Loss of soil health is one major consequence through the depletion of nutrients and organic matter. Severe soil degradation and erosion can also cause environmental degradation related to water and air quality. Water quality can be affected due to the runoff of potentially contaminated soil particles into water. Wind erosion can impact air quality in a similar manner. Erosion can also cause structural instability due to washouts or undercutting. This is often a problem around streams or river banks.

1.3.1 Water Erosion

Erosion by water can take place in many forms such as splash/raindrop erosion, sheet erosion, rill erosion, gully erosion, and shoreline erosion. Splash/raindrop erosion is caused by the direct impact of falling drops of rain on soil particles. The raindrops dislodge soil particles, which makes them more susceptible to movement by runoff. Sheet erosion is when rain forms a uniform layer of runoff over the land and detached soil particles are transported. The shear stress of the runoff also picks up additional soil particles along the way. Rill erosion takes place as sheet flows converge into more concentrated and faster flows. These flows produce small grooves with steep sides, known as rills, in the earth’s surface and carry sediment downstream. When rills converge, a large channel known as a gully is formed. These large channels carry large volumes of water at a high velocity, creating a high shear stress and easily displacing and transporting soil particles.

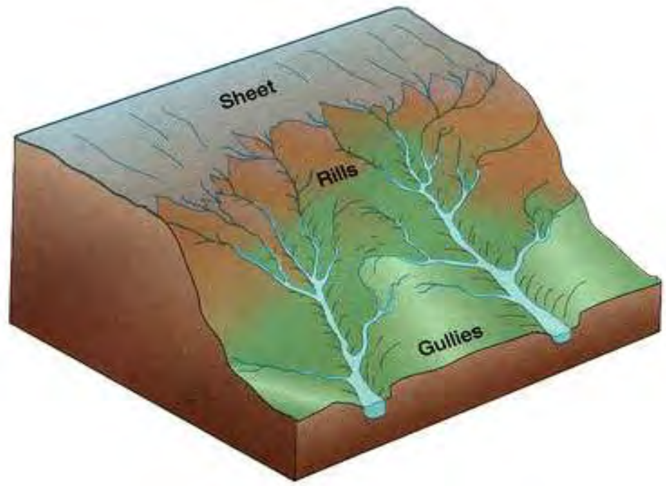

Figure 1.5: Progression of Water Erosion

Shoreline erosion may have many contributing factors. Widening or straightening a stream can cause significant erosion as the stream seeks to reestablish a stable size and pattern. Shoreline erosion may also be caused by degrading shoreline vegetation to the point where it no longer provides stability. Changes in land uses surrounding shorelines may also causes significant erosion if the changes create a large increase in the amount of runoff. Such changes could include clearing land for agriculture or urban development.

1.3.2 Predicting Soil Loss

Predicting soil loss is often essential for designing the appropriate types of erosion control practices to use on a particular site. There are many equations to use such as the Universal Soil Loss Equation (USLE), the Revised Universal Soil Loss Equation (RUSLE), and the Modified Universal Soil Loss Equation (MUSLE). USLE was originally developed in the 1930s as a way for farmers to estimate soil loss and help better manage their soils. Its limited application led to the development of RUSLE. It is used to estimate annual sheet and rill erosion rates generated by rainfall and the associated flow. RUSLE is made possible due to a large amount of data collection that took place between the 1930s and when it was put into place in the 1980s. RUSLE offers more flexibility in modeling erosion than was previously available with USLE. Currently there are no better tools or equations available that are as simple and produce such accurate results. MUSLE is a derivative of RUSLE that allows for the estimate of erosion from a single storm event as opposed to the annual amount.

1.3.3 Revised Universal Soil Loss Equation (RUSLE)

The Revised Universal Soil Loss Equation is:

$$A = R * K * (L * S) * C * P \tag{5}$$

where A is the average annual soil loss in (tons/acre), R is the rainfall and runoff erosivity index for the geographical location, K is the soil erodibility factor, L is slope length factor, S is slope steepness factor (LS is also known as the topographic factor), C is the cover management factor, and P is the conservation practice factor.

The rainfall erosivity index (R) is computed using long-term rainfall data for a location and is relatively unchangeable in the short term. R factor map for Illinois is provided below. (See Figure 1.6)

The soil erodibility Factor (K) is the measure of how easily soil particles are detached by such factors as raindrop impact and forces due to surface flow. It encompasses the potential for erosion in different types of soils including such parameters as size, organic matter content, structure, and permeability. An easy way to compute K value based on soil properties is illustrated in Figure 1.7. K-factors for numerous soils have been calculated and are accessible through many databases. (See Appendix for K value for typical Illinois soils).

The slope length factor (L) and the slope steepness factor (S) are usually put together and are known as the topographic factor. This factor is based on the fact that steeper and longer slopes produce higher overland flow velocities and accumulate more runoff. The (LS) factor represents a ratio of soil loss of a particular slope to that of a 'standard' slope length of 72' and a steepness of 9%. (See Figure 1.8)

The cover management factor (C) includes the influence of cropping system and other soil management variables. It takes into effect cover, crop sequence, productivity level, length of growing season, tillage practices, residue management, and the expected time distribution of the erosive events. C values are available through the USDA Soil Conservation Service. (See Table 1.3)

The conservation practice factor (P) indicates the effects of conservation measures taken that will help reduce the amount and rate of runoff, thus reducing 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. Agricultural practices such as no-till farming and terracing along with the implementation of control structures or vegetated buffer strips all reduce P-factor values. (See Table 1.4)

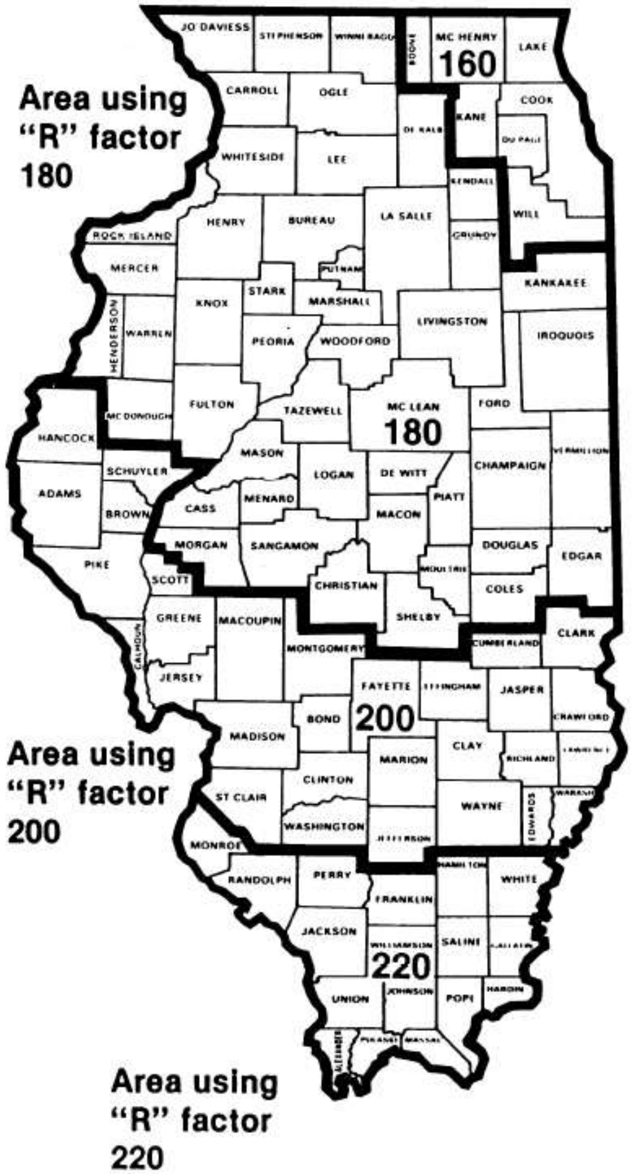

Figure 1.6: R factor map for Illinois

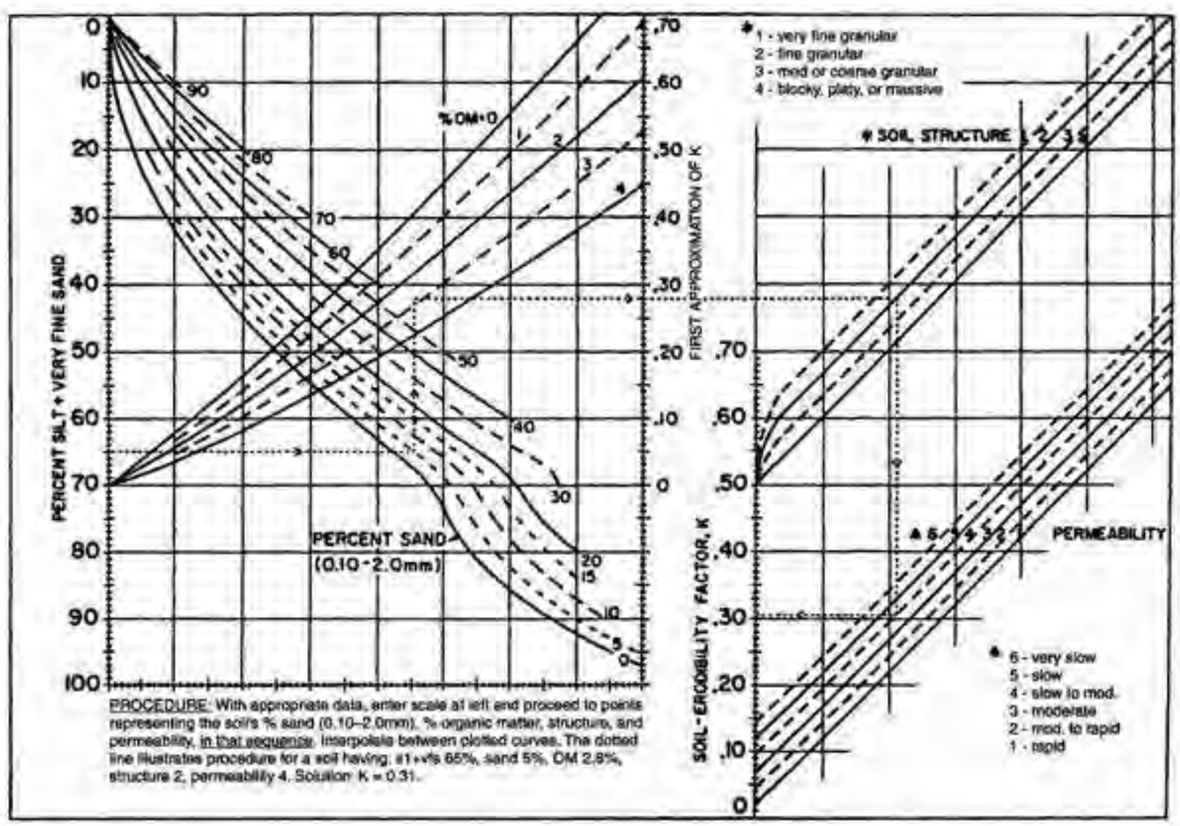

Figure 1.7: K factor computation based on soil properties

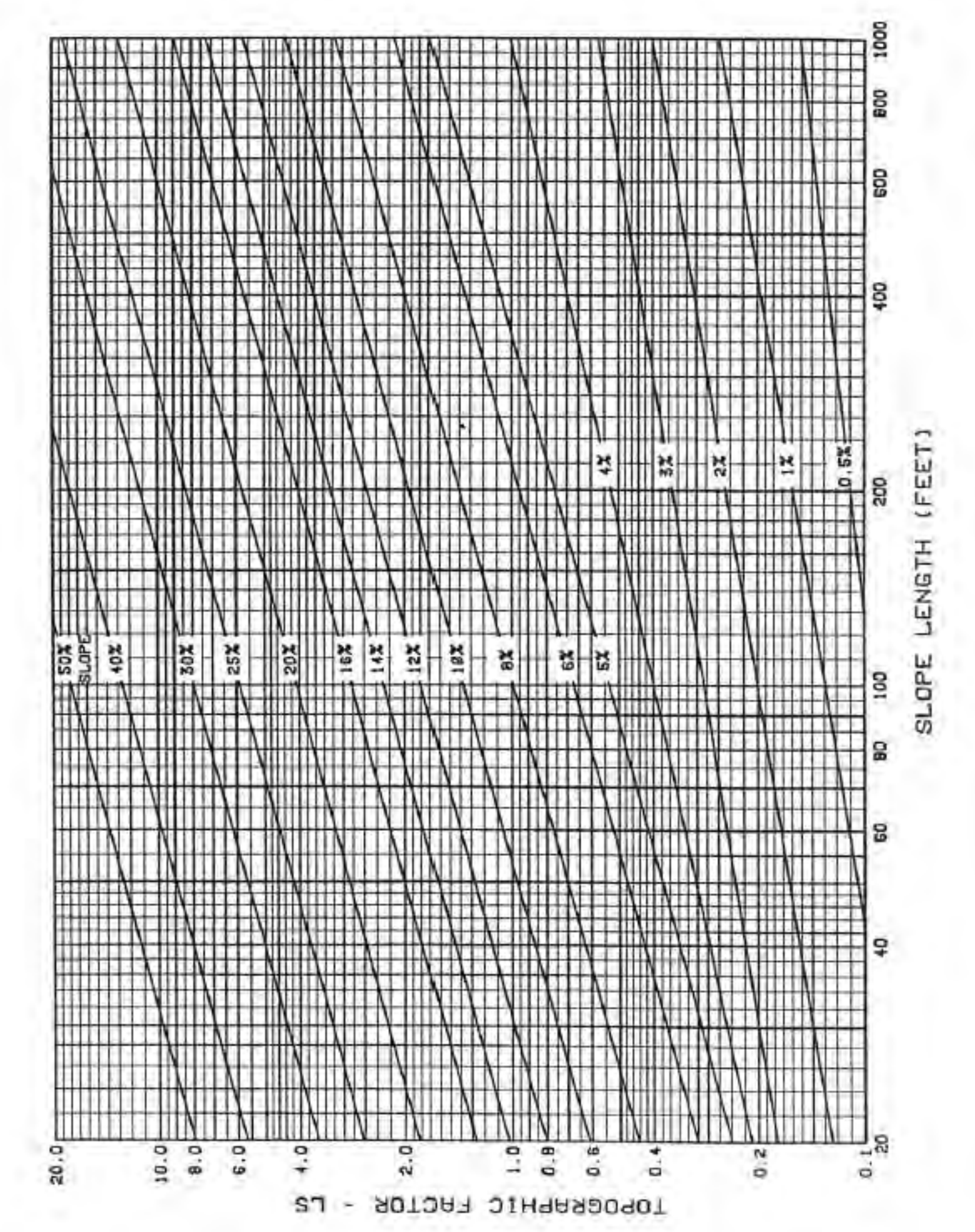

Figure 1.8: LS factor based on slope length and steepness

Table 1.3: Typical C-factors for different land cover conditions

Typical C-Factors for a Number of Land Cover Conditions

Vegetation		*Tillage Practice*		
Corn Belt	***Autumn Conventional***	***Spring Conventional***	***Spring Conservation***	***No-Till***
Continuous corn or soybeans	0.40	0.36	0.27	0.10
Corn and soybean rotation	0.40	0.35	0.24	0.10
Corn–corn–oats–meadow	0.14	0.12	0.11	0.07
Corn–oats–meadow–meadow	0.06	0.05	0.03	0.03
Permanent pasture (good)				0.01
Permanent pasture (poor)				0.04
Wheat Belt		***Conventional***	***Conservation***	***No-Till***
Winter wheat—fallow		0.20	0.17	0.04
Spring barley		0.06	0.02	
Wheat-barley-fallow rotation		0.21	0.13	0.02
Other Crops		***Conventional***	***Conservation***	
Winter wheat and pea rotation		0.11	0.02	
Cotton		0.40	0.30	
Peanuts—use soybeans				
Sorghum—use corn				
Nonagricultural		***Good***	***Poor***	
Rangeland		0.01	0.15	
Forest		0.001	0.002	
Forest after fire		0.01	0.15	
Unpaved road		0.35	0.45	
Construction site		0.50	1.00	

Note: These values are for example only. Contact local agencies for local C-factors.

Table 1.4: P-factor for different management practices

Support Practice	P Factor
Up & Down Slope	1.0
Cross Slope	0.75
Contour farming	0.50
Strip cropping, cross slope	0.37
Strip Cropping, contour	0.25
Terraces with graded channel sod outlets	0.2
Terraces with underground outlets	0.1

Example of RUSLE:

What is the average annual soil loss from a hill slope with drummer soil, located in Champaign County (IL), of length 600ft with 3% slope? The farming practice is corn and soybean rotation with no-till (C = 0.38) and the field has no conservation practices.

Solution:

For Champaign,	R factor = 180
For drummer soil,	K factor = 0.28
For hill slope length of 600 ft with 3% slope,	LS factor = 0.5
For corn and soybean rotation with no-till,	C factor = 0.38 (given)
For no conservation practices,	P factor = 1

Hence, average annual soil loss from the hill slope,
A = R.K.LS.C.P = 9.58 tons/acre

1.3.4 Sediment Delivery Ratio (DR)

The sediment delivery ratio (SDR) is commonly used in erosion and transport studies to describe the extent to which eroded soil (sediment) is stored within the hill slope or basin. The SDR is defined as:

DR = Y / A

where SDR = the sediment delivery ratio
Y = the sediment yield
A = the gross erosion per unit area above a measuring point.

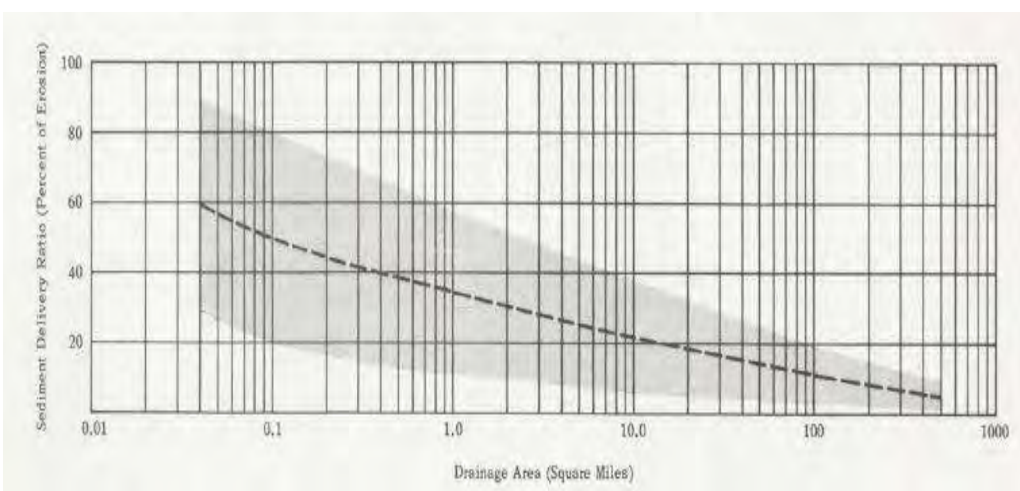

Figure 1.9: Relationship between sediment delivery ratio (DR) and drainage area

1.3.5 Wind Erosion

In arid and semiarid regions, larges areas can be affected by wind erosion. A major issue with wind erosion is its effect on air quality. Particulate matter in the air can be detrimental to human health which is why it is important to study and learn how to prevent wind erosion.

Wind erosion may be divided into three separate processes including initiation of movement, transportation, and deposition. Soil movement is initiated from air turbulence and velocity. Transportation of soils in influenced by the aggregate size, texture, wind velocity, and distance across the eroding area. Deposition of wind blown materials occurs when the gravitational force on the suspended particles is greater that the forces holding them in the air. This is often caused by a decrease in wind velocity due to physical barriers such as vegetation or ditches.

Types of soil movement due to wind erosion can also be classified into three types: saltation, suspension and surface creep. Saltation is the process where fine particles (0.1 to 0.5 mm in diameter) are dislodged from the surface and then return to the surface either to rebound or imbed and dislodge more particles. This creates an avalanching effect of additional soil movement. Saltation accounts for 55 to 72 percent of the soil movement during wind erosion. Suspended particles (0.02 to 0.1 mm in diameter) are removed by saltating soil particles and account for a very small amount of the eroding particles. These suspended particles can stay afloat for long distance and are the cause for air quality problems. Larger sized soil particles (0.5 to 2 mm in diameter) can also be set into motion and by saltating particles and then tend to roll or ‘creep’ atop top the surface. Creep can account for up to 25 percent of the wind erosion. The following figure outlines these 3 main processes of soil by wind.

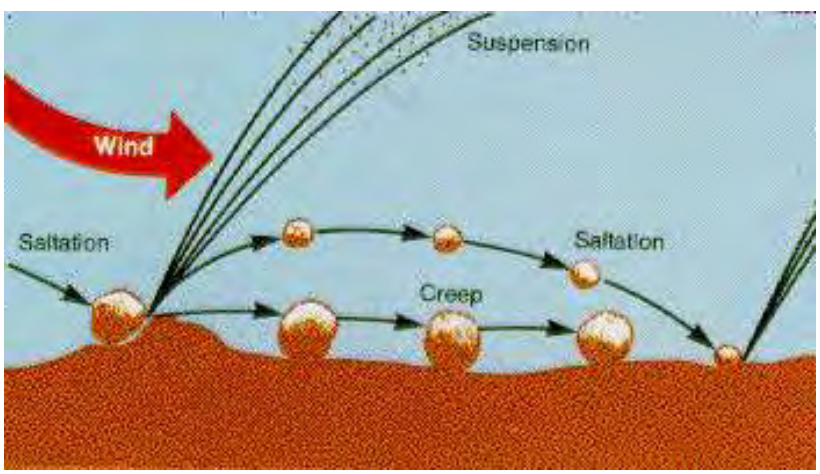

Figure 1.10: Processes of Soil Movement by Wind

1.3.6 Factors Affecting Wind Erosion

The soil erodibility index is a function of the soil aggregates greater than 0.84 mm in diameter. The sandy and drier a soil is, the more susceptible to wind erosion it will be where as silts and clays are more likely to stick to themselves because of there their relative size. The roughness factor is a measure of the effect of ridges made by tillage and planting implements on the erosion rate. Ridges absorb energy and deflect wind while also trapping moving soil particles. However, too much roughness can cause significant turbulence which can accelerate wind erosion rates.

The climate factor also greatly affects wind erosion. It is an index of the climate erosivity, which indicates the wind speed as well as the soil content on the surface. It is expressed as a fraction of the climate factor for Garden City, Kansas. Unsheltered distance along the prevailing wind erosion direction for the area eroding also affects the amount of wind erosion. Vegetative cover also has an effect. The more cover a soil has, the less likely it will be to erode due to wind.

Section 2

2.1 Regulations Related to Erosion and Sediment Control

The purpose of this section is to provide a brief overview of the federal and state laws for Illinois regulating erosion and sediment control. Understanding these laws is crucial to knowing permit requirements for construction activities that may adversely affect soil and water quality. Failure to gain permits due to a lack of knowledge can result in large fines for violations.

These state and federal laws aim to preserve and protect the environment and help secure the quality of life in Illinois. However, this is done in conjunction with maintaining the current transportation systems and conserving Illinois's natural regions as well as cultural, historic, and aesthetic resources.

2.2 Agencies

2.2.1 US Army Corps of Engineers

The Army Corps of Engineers purpose is to implement environmental operating principles through the integration of civil works and military environmental projects. The environmental operating procedures consist of seven separate parts as follows:

1. Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.
2. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.
3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
5. Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.
6. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.
7. Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems that also protect and enhance the environment.

With the implementation of these principles, the Corps continues its efforts to develop the scientific, economic, and sociological measures to determine the effects of various projects on the environment, thus helping to achieve environmentally sustainable practices. These practices can then be used by all to help protect the environment.

The U.S. Army Corps of Engineers (Corps), acting under Section 404 of the Clean Water Act, provides a vital function in protecting our valuable aquatic resources, including wetlands. The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Areas regulated under Section 404 are collectively referred to as "waters of the United States." Included are any parts of the surface water tributary system down to the smallest of streams, any lake, pond, or other water body on those streams, and adjacent wetlands. Isolated waters such as playa lakes, prairie potholes, old river scars, cutoff sloughs, and abandoned construction and mining pits may also be waters of the United States if they meet certain criteria. An important point is that waters of the United States include areas that are man-made, or man-induced, as well as natural.

2.2.2 Illinois Environmental Protection Agency (IEPA)

The Illinois Environmental Protection Agency (IEPA) of the state of Illinois is the primary body concerned with the protection of the environment for the state as designated by United States Environmental Protection Agency (USEPA). The purpose of the IEPA is to safeguard environmental quality, consistent with the social and economic needs of the State, so as to protect health, welfare, property and the quality of life. In support of this, the following program goals have been developed:

1. Provide leadership to chart a new course for clean air which is responsive to relevant needs in Illinois and complies with priority aspects of the Clean Air Act Amendments.
2. Address outstanding solid and hazardous waste management concerns and participate, as appropriate, in the national deliberations on reauthorization of the hazardous waste program.
3. Utilize creative means to address the priority needs for clean and safe water in Illinois and participate, as appropriate, in the national deliberations on reauthorization of the water programs.
4. Enhance capability to fund environmental cleanup, when necessary, and to provide better service for private party actions.
5. Promote pollution prevention and market-based approaches for continued environmental progress.
6. Develop an environmental planning capability which emphasizes risk-based analysis, good science and sound data, and open communication and informed participation.

The IEPA is split in to the Bureau of Air, Land, and Water. The Bureau of Air works to improve the air quality by identifying air pollution, proposing regulations, conducting inspections, and reviewing permit applications. The Bureau of Land's main concerns are to protect human health and the environment by ensuring that hazardous and solid waste are managed properly in order to reduce the spread of contaminated sites. The Bureau of Water aims to ensure that rivers, streams, and lakes are able to support all designated uses including the protection of wildlife. It also oversees the quality and consistency of the Illinois Public Water system along with protecting groundwater supplies used for drinking water purposes.

2.3 Laws and Regulations

2.3.1 Clean Water Act

Water pollution is regulated under the Federal Water Pollution Control Act of 1972 and by the Clean Water Act (CWA) which was established in 1977. The CWA established effluent discharge limitations and receiving water quality standards under United States Environmental Protection Agency regulation (US-EPA). Water quality standards are mainly regulated by the National Pollutant Discharge Elimination System (NPDES). The CWA also provided finding and developed controls for Publicly Owned Treatment Works (POTWs).

Until the mid-1980s, emphasis was on control of point source pollution, typically outfalls from industrial factories and municipal sewage treatment plants. The CWA was amended in 1987 to include non-point sources of pollution. These sources originate from diffuse and diverse activities in a watershed that enter a water body through non-discernible, unconfined and indistinct conveyances. Water pollution, especially storm water pollution, generally originates as non-point source pollution, but is typically collected, conveyed and discharged as a point source.

2.3.2 Clean Water Act: Section 401

Under the Clean Water Act (CWA), an applicant for a federal license or permit to conduct any activity that may result in a discharge to waters of the United States must provide the federal agency with a Section 401 certification. The 401 certification, made by the state in which the discharge originates, declares that the discharge will comply with water quality standards. A state's water quality standards specify the designated use of a stream or lake, pollutant limits necessary to protect the designated use, and policies to ensure that existing water uses will not be degraded by pollutant discharges.

Section 401 provides states with two distinct powers; first, the power indirectly to deny federal permits or licenses by withholding certification and secondly, the power to impose conditions upon federal permits by placing limitations on certification. Generally, Section401 certification is applied to hydropower projects seeking a license from the Federal Energy Regulatory Commission (FERC) and to dredge-and-fill activities in wetlands and other waters that require permits from the U.S. Army Corps of Engineers (CWA Section 404). In addition, it has the potential to be applied to a range of other activities that could affect water quality, a point that has increasingly become an issue.

2.3.3 Clean Water Act: Section 404

In 1972, Section 404 of the Clean Water Act established a program to regulate the discharge of dredged or fill material into waters of the United States. The Clean Water Act defines waters of the United States to include tributaries to navigable waters, interstate wetlands, wetlands which could affect interstate or foreign commerce, and wetlands adjacent to other waters of the United States.

Section 404 of the clean water act is jointly administered by the U.S. Army Corps of Engineers and the Environmental Protection Agency. The Corps is responsible for the day-to-day administration and permit review and the EPA provides oversight. The purpose of the section is that no discharge of dredged or fill material should be permitted if there is a practicable alternative that would be less damaging to aquatic resources or if significant degradation would occur to the nation's waters. Permit review and issuance follows a sequence process that encourages avoidance of impacts, followed by minimizing impacts and, finally, requiring mitigation for unavoidable impacts to the aquatic environment.

2.3.4 National Pollutant Discharge Elimination System (NPDES)

The National Pollutant Discharge Elimination System (NPDES) program, created in 1972 under the Clean Water Act, was created in order to control and regulate point sources of discharge pollutants to waters within states to maintain, protect, and restore the water quality of streams, lakes, and rivers.

The Illinois Environmental Protection Agency (IEPA) is responsible for administering the state's storm water programs. At the state level, storm water requirements are similar to the federal NPDES storm water requirements, requiring that storm water be treated to the maximum extent possible through the practices laid out in a Storm Water Pollution and Prevention Plan. This includes erosion and sediment control measures. Illinois's NPDES program requires all construction sites disturbing more than one acre, industrial sites, and all designated Municipal Separate Storm Sewer Systems (MS4s) to obtain permit coverage. Most sites are able to obtain coverage under the state general permit; however, sites that are of considerable risk to contaminate water may be required to obtain an individual permit.

In 1990, Phase I of the NPDES storm water program was established. It requires NPDES permit coverage for large Municipal Separate Storm Sewer Systems (MS4s) that contain populations of 100,000 or more. In 1999, Phase II of the NPDES storm water program was signed into law. This regulation builds upon the existing Phase I program by requiring smaller communities, also known as small municipal separate storm sewer systems (MS4s), to be permitted, and implement a comprehensive storm water management program that includes six minimum measures.

NPDES Permit No. ILR10

General NPDES Permit No. ILR10

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

General NPDES Permit
For
Storm Water Discharges From Construction Site Activities

Figure 2.1: Sample NPDES

2.3.5 Municipal Separate Storm Sewer System (MS4)

Phase II of the NPDES is an attempt by the U.S. EPA to preserve, protect, and improve the nation's water resources from polluted storm water runoff. Phase II is intended to further reduce adverse water quality and aquatic habitat conditions by instituting the use of controls on storm water discharges that have a high risk of causing harm to the environment.

This phase defines a small MS4 storm water management program as composed of six minimum control measures that, when administered, are expected to result in reduction of the discharge of pollutants into receiving waters. MS4 storm water programs are to be designed to reduce the discharge of pollutants to the "maximum extent practicable" (MEP), protect water quality, and satisfy the appropriate water quality requirements of the Clean Water Act. Implementation of the MEP standard will require the development and implementation of best management practices. Success in meeting these goals is measured by the following six minimum control measures:

1. ***Public Education and Outreach*:**
   Distributing educational materials and performing outreach to inform citizens about the impacts polluted storm water runoff discharges can have on water quality.

2. ***Public Participation/Involvement*:**
   Providing opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen representatives on a storm water management panel.

3. ***Illicit Discharge Detection and Elimination*:**
   Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system (includes developing a system map and informing the community about hazards associated with illegal discharges and improper disposal of waste).

4. ***Construction Site Runoff Control*:**
   Developing, implementing and enforcing an erosion and sediment control program for construction activities that disturb 1 or more acres of land.

5. ***Post-Construction Runoff Control*:**
   Developing, implementing and enforcing a program to address discharges of post-construction storm water runoff from new development and redevelopment areas. Applicable controls could include preventive actions such as protecting sensitive areas (e.g., wetlands) or the use of structural best management practices.

6. ***Pollution Prevention/Good Housekeeping*:**
   Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch-basin cleaning).

2.4 Storm Water Pollution Prevention Plan (SWPPP)

A Storm Water Pollution Prevention Plan (SWPPP) is a document that outlines the steps and techniques that will be put into place to reduce pollutants, mainly sediment, in storm water runoff from construction sites. Proper development and implementation of a SWPPP is crucial to ensure its effectiveness. In order to do so, it must be developed and implemented consistent with the applicable NPDES storm water construction permits. The goal of a SWPPP is to correctly identify all potential pollution sources that could come into contact with storm water leaving a site and to describe the BMPs that will be used to reduce these potential pollutants. It also includes written records of site inspections as well as follow-up maintenance.

2.4.1 Requirements/Recommendations

A Storm Water Pollution Prevention Plan (SWPPP) is to be developed following a list of required elements. The list includes:

1. Cover/Title Page
2. Project and SWPPP Contact Information
3. Site and activity description, including a site map and schedule
4. Identification of potential pollutant sources
5. Description of controls to reduce pollutants
6. Maintenance/Inspection Procedures
7. Records of inspections and follow-up maintenance of BMPs
8. SWPPP Amendments
9. SWPPP Certification

There are many objectives and recommendations to follow while developing and implementing a SWPPP that includes all of the above listed items. Keeping the following things in mind will help ensure that permit requirements are meet pertaining to water quality.

1. ***Stabilize the construction site as soon as possible***
   Quickly getting a site to final grade and permanently or temporarily stabilizing all bare soil will reduce runoff and erosion. Cover selections may include more than just grass, due to germination times. For this reason, such things as mulches or fiber roles may be used. However, establishing vegetated cover on as much of the site as possible in a timely manner is crucial. Even with permanent or temporary stabilization, all perimeter controls should remain in place until the project is complete.

2. ***Protect slopes and channels***
   Controls should be put in place such as earthen berms or pipe drains that will divert concentrated flows around exposed un-stabilized slopes. Also, extra care should be taken to avoid disturbing natural channels and vegetation surrounding them.

3. ***Reduce impervious surfaces and promote infiltration***
   Reducing impervious areas and diverting concentrated flows leaving impervious areas will help reduce serious soil erosion.

4. ***Control the perimeter of the construction site***
   Controlling the perimeter of the construction site does not only include preventing storm water from leaving, but also preventing it from entering the site where it may then become contaminated. Storm water runoff leaving the site should be caught and filtered before leaving the site through the use of silt fences or sediment basins.

5. ***Protect receiving waters adjacent to the site***
   Additional measures should be put into place along the perimeter of the site if it is located in close proximity to receiving waters or other environmentally sensitive areas.

6. ***Follow pollution prevention measures***
   Dispose of all waste and garbage properly from the site and store hazardous materials and chemicals to keep them from being exposed to storm water runoff.

7. ***Minimize the area and duration of exposed soils***
   Clearing/Grubbing only parts of the site that will be under construction in the near future, a practice know as construction staging, can greatly reduce sediment loads and pollution in storm water runoff.

While keeping all these objectives in mind, scheduling is also very important. Matching the BMPs to the right activities at the right time can have a large impact on the performance of the SWPPP. Also, the proper installation and maintenance of erosion control measures must be followed. Above all, the plan must be adhered to and any amendments must be reported along with records of inspections.

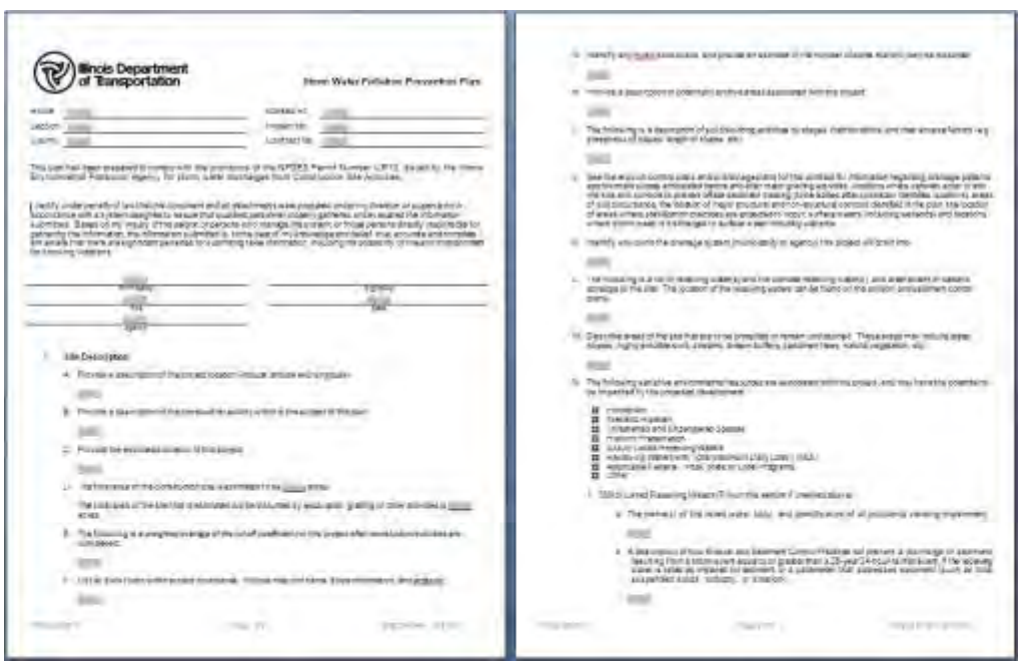
Illinois Department of Transportation

Figure 2.2: IDOT SWPPP form

2.5 State Permits

The state of Illinois requires permits for many activities that could have the potential for water pollution. Construction projects, state water supplies, and wastewater and storm water storage and treatment facilities all require permits under the Clean Water Act. The CAA requires a National Pollutant Discharge Elimination System (NPDES) permit for municipal effluent, industrial effluent, and storm water. The permits establish the conditions under which the discharge may occur and establish monitoring and reporting requirements. Construction projects related to these facilities also require special permits.

State permits are also required for public water supply installation, maintenance, and operation. No construction of any new public water supply is to be completed without a construction permit issued by the IEPA's, Bureau of Water, Division of Public Water Supplies, Permit Section. Daily operations may also require state permits due to the threat of water contamination. An algaecide permit shall be obtained from the IEPA before algaecides, such as copper sulfate, can be applied to any stream, reservoir, lake, pond, or other body of water used as a public water supply surface water source. Aquatic Pesticide Permits may also be required in situations where pesticide applications may have an effect on public or food processing waters.

2.6 Clean Air Act

The clean Air Act (CAA) is a federal law that regulates air emissions from a variety of sources. It allows the EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and welfare by regulating emission of hazardous air pollutants. The Clean Air Act was originally passed in 1970 with the main goal of setting and achieving NAAQS in every state by 1975. With the development of these, states were to create state implementation plans (SIPs) accordingly. The Act was then amended in 1977 and 1990 to set new goals and dates for achieving attainment of NAAQS due to many failures across the country.

Prior to 1990, the CAA established a risk-based program to regulate hazardous air pollutants for which few standards were ever developed. The 1990 amendments required issuance of technology-based standards for major sources and certain area sources. Major sources are defined as a stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of hazardous air pollutants or 25 tons per year or more of a combination of hazardous air pollutants. An area source is any stationary source that is not a major source.

For major sources, the CAA requires the EPA to establish emission standards that require the maximum degree of reduction in emissions of hazardous air pollutants. These are often referred to as maximum achievable control technology (MACT) standards. Eight years after the development of such standards, the EPA is required to review the standards and make any additional changes to ensure there is no residual risk for any on site or source category.

2.6.1 Fugitive Dust Control

Fugitive dust control strategies are composed of a balance of available dust mitigation techniques applied on an as needed basis for construction site or even pertaining to agricultural practices. This implies the use of adequate measures put into place at the right time throughout the evolution of a project. Such measures may include wind breaks, frequent water applications, applications of soil additives, control of vehicle access, vehicle speed regulations, covering of materials, or even work stoppages. Time of year, length of project, and acres per day being disturbed should also be taken into consideration when implementing dust control measures.

Section 3

3.1 BMPs for Erosion and Sediment Control

The purpose of this section is to provide some knowledge and understanding of a variety of possible ways to implement soil and water conservation practices. Effectively controlling soil erosion requires the ability to assess needs on a day by day basis and recognize which conservation practices will have the best results for various situations and circumstances.

3.2 Design Considerations/Scheduling

There are many different erosion control practices that can be implemented to help reduce soil erosion on both agricultural ground and construction sites. Many of these will be discussed in more detail in the following sections, but first it is important to take into account some of the design that goes into these practices. It is also important to try to schedule erosion control measures to be installed and implemented at the right times in order to achieve the best results.

Many things need to be accounted for when designing erosion and sediment control. Hydrologic conditions must be factored in such as the design rainfall and the runoff rate and volume. Soil factors are very important as well. The exact composition of the soil on a particular site must be known in order to design and implement the best practices possible. This has to do with certain soils being more erodible than others. Vegetation plays a large role in erosion as well, which has previously been discussed in great detail. For this reason, it is also taken into account. Also, topography must be considered to ensure certain control measures or structures will be successful.

When building permanent or semi-permanent structures, there are additional things to keep track of in the design. This may include the cost or availability of materials depending on the type of structure being built. Certain erosion control structures can become very expensive and add a lot of unexpected cost to a project if it is not properly designed from the start.

The scheduling of a project is crucial to erosion and sediment control. It is important to schedule the project for the right time of year and also to schedule erosion control measures to be implemented at the right time during construction. Planning certain construction activities around predicted storms may also be beneficial. Scheduling and performing routine maintenance must also be done in order for all controls to perform effectively. The inspection of all controls is the responsibility of everyone working on the construction site.

3.3 Best Management Practices (BMPs)

This section covers the Best Management Practices (BMPs) that can be implemented to prevent or reduce soil erosion and sediment transport. It will concentrate on the physical BMPs. Physical BMPs can be organized into two parts; erosion control (preventing soil detachment) and sediment control (trapping detached soil), both of which will be covered. Sediment control is required since no erosion control measures are exactly 100% effective; however, they are very effective in reducing erosion rates. The more effective erosion control BMPs used, the more effective the sediment control BMPs.

3.3.1 Silt Fencing

Silt fence is a temporary sediment barrier consisting of a geotextile fabric. The barrier is attached to supporting posts and stood up all along the perimeter of a construction site in order to reduce the amount of sediment leaving the site. Silt fence can also be constructed within the borders of a site to contain sediment and other contaminants from spreading, such as around the borders of material stock piles. IDOT requires the use of site fence on every site and it is to be constructed according to their specifications and built out of approved materials.

The purpose of silt fence is to reduce the transport of sediment from a construction site by providing a temporary permeable barrier designed to intercept and slow the flow of sediment laden sheet flow runoff. Silt fence creates temporary ponding which allows time for large sized sediment to filter out of the runoff collected.

There are many rules and guidelines to be followed to properly construct and use silt fencing. Most importantly, silt fence is not to be used to retard concentrated flow. This means that it should not be installed in streams or ditches, but may be used along the sides of them to prevent sediment from entering. Silt fence is only to be used in areas of sheet flow. It is also important to install silt fence along level contours. Installing it across contours will divert flow and cause it to concentrate and possibly cause more erosion due to the formation of rills and gullies. Continuous stretches of fencing should never exceed more than 500 feet and the ends of a stretch must overlap as opposed to being connected together end to end.

It is also very important to inspect the condition of silt fence on a regular basis to ensure that it is working properly. Inspection is especially needed after heavy rainstorms that tend to cause a lot of excess runoff. Fencing can be knocked over as a result of high runoff rates or sediment can become built up in front of the fence. In this case, it should be fixed and cleaned out. Any washouts underneath the silt fence must also be fixed in order to prevent water from flowing around or underneath it. Silt fence must remain in place and in good working condition throughout the construction project and possibly even longer until permanent erosion control is established, such as vegetative cover.
The following figure depicts the proper way to install silt fence:

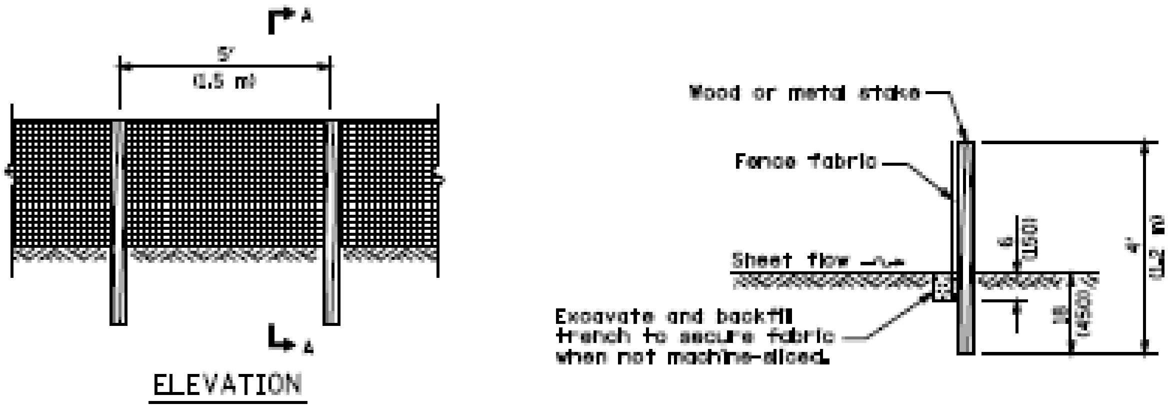

Figure 3.1: Proper Installation of Silt Fence

3.3.2 Slope Grading and Terraces

Slope grading is important to both the final design and during the construction process. During construction it is important to take precautions to reduce runoff and erosion from slopes. Slopes should always be stabilized as soon as possible after disturbance by some sort of erosion control such as temporary seeding or mulching. It is never good to leave bare soil exposed for any longer than it has to be. Slope grading is also very important along roads within the construction site, whether they are to be temporary or permanent. Proper slope grading and drainage design along roads is important in reducing erosion due to the high amount of concentrated runoff that is diverted around roads.

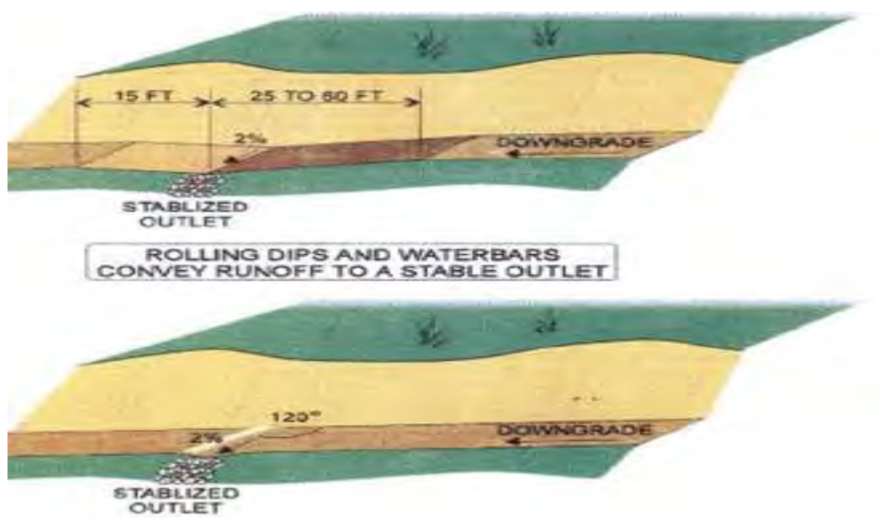

Figure 3.2: Road Drainage

Some of the other BMPs depicted in the figure above will be explained in more detail in the following sections.

Roughened soil as opposed to an entirely smooth surface can greatly reduced erosion rates. Terraces can also be implemented to help control erosion, but these are more of a permanent measure and must be incorporated into the final design. However, roughening of the soil is simple and often done just by running heavy machinery over the exposed slopes. Heavy machinery with tracks is very effective in making tracks in the soil that help slow runoff and give more surface depression storage.

Tracking the surface of a slope must be done in the right way or it has the potential to cause more harm than good. It is crucial to track perpendicular to the slope in order for the tracks to retard surface flow. This requires driving up and down the slope so that the tracks will be oriented correctly. Driving across the slope makes the tracks go up and down the hill providing small areas for water to concentrate and cause severe erosion.

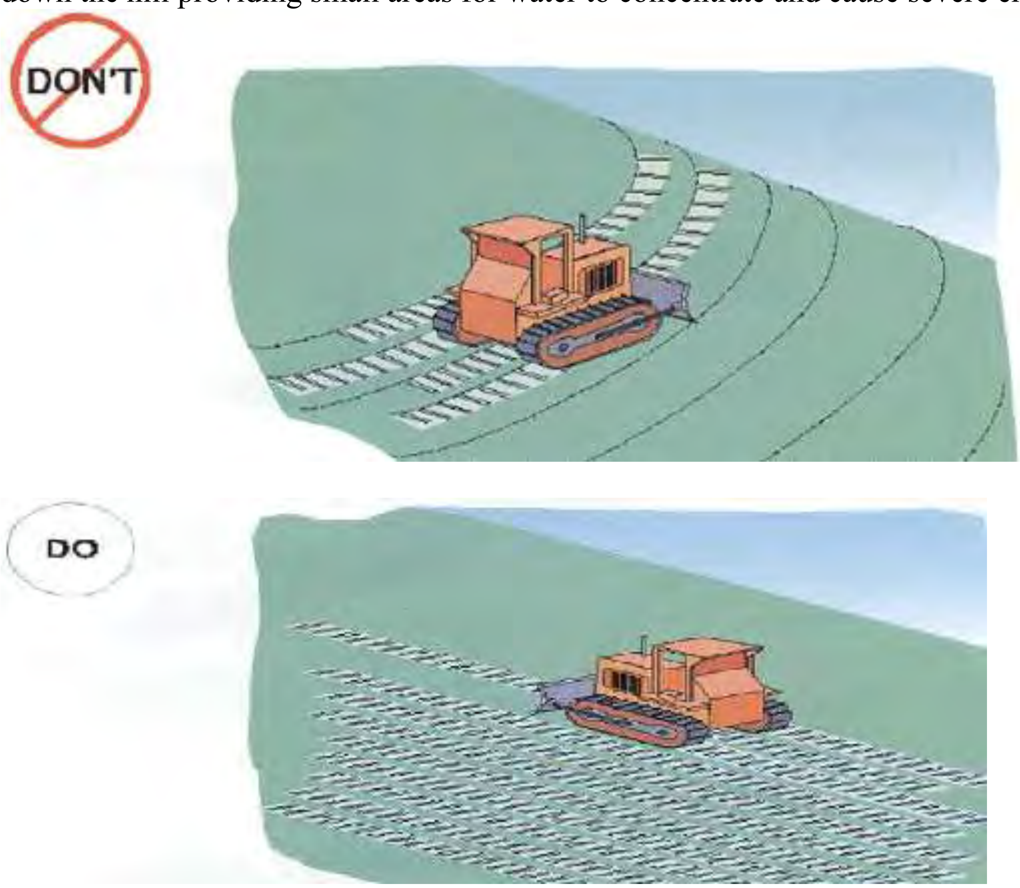

Figure 3.3: Soil Roughening

As previously mentioned, terracing can also be implemented in a final design to reduce runoff and erosion. Terraces help to reduce the slope of the ground as well as shorten the slope length. This allows for lower runoff velocities which increases infiltration. Although there are many techniques and guidelines that can be followed for constructing terraces, the following diagram is a common way.

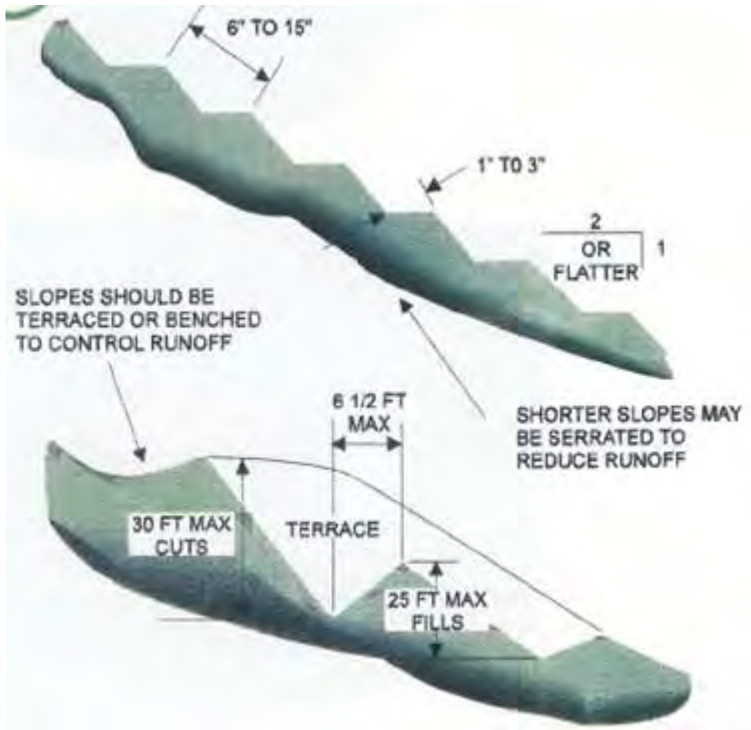

Figure 3.4: Slope Terraces

3.3.3 Seeding and Mulching

The establishment on vegetative cover on disturbed areas by seeding is one of the most effective methods of reducing erosion by protecting bare soil from raindrop impact and binding the soil with roots. Mulching, which is the application of organic material to protect bare soil, is often coupled with seeding to enhance seed germination. Mulch does so by conserving moisture, holding fertilizer, seed, and top soil in place, and it moderates soil temperatures. Mulches may consist of many things such as straw, wood chips, or compost. These will all be discussed in the following sections.

Seeding may consist of temporary seeding or permanent seeding. Temporary seeding is not very common on construction sites unless the site will be dormant for long periods of time where it will be highly susceptible to soil erosion. However, permanent seeding and mulching has to be done on every construction site prior to completion. Careful design considerations must be made to plant the right type of vegetation for soil types within the construction area.

Hydro-seeding, also known as hyrdo-mulching, is a common way to plant and establish vegetative cover on construction sites as opposed to the traditional process of sowing or broadcasting seed. Hydro-seeding is a process that utilizes a wet slurry of seed, mulch, fertilizer, and water. The slurry is hauled to the site and applied to prepared ground in a uniform layer. It promotes a quick germination and inhibits soil erosion. Hydro-seeding does not require any additional mulching since it is already built in, but if vegetation is planted the traditional way it is required. Straw is commonly used as mulch over freshly seeded ground. The straw helps absorb energy from raindrops and hold the seed in place. Straw mulch works best if it is crimped into the ground. This doesn't allow for it to wash away as easily and adds stability. Crimping is simple and can be done just by using heavy tracked machinery similar to the previously described method of soil roughening.

Hydraulic matrices, also known as bonded fiber matrices, are another form of mulch commonly used. It is similar to the slurry used in hydro-seeding but it has added synthetic fibers to reinforce the matrix once cured. This results in greater stability. However, there is a cure time of zero rain ranging from 24 to 48 hours. Once cured the matrix crusts up and bonds to the soil, preventing soil erosion.

3.3.4 Erosion Control Blankets and Fiber Rolls

Erosion control blankets are woven from a chosen material and are meant to slow down the velocity of runoff and therefore reduce erosion. The material chosen is usually something with lots of ridges to help obstruct the flow of water. There are many different types of erosion control blankets, some that are synthetic and some that are natural. There are even a few that are both synthetic and natural. These blankets can be made out of straw, coconut fiber, aspen fiber, jute, and polypropylene (plastic).

Erosion control blankets are most commonly used in places of high soil erosion because they typically do the best to reduce erosion rates. These areas may be on particularly steep slope or maybe next to stream banks. The installation is easy but the material is generally more expensive than other measures.

Figure 3.5: Erosion Control Blanket Installation

The erosion control blankets are relatively easy to install. The largest concern is making sure the water flows over the top of the blankets as opposed to under them. To do this, the blanket needs to be 'keyed' into the slope by digging a small trench on the top of the slope. Lay the top end of the material into the trench to line it. To line it, the edge is folded underneath itself and then it is secured using staples. The trench is then backfilled to the previous soil level.

Figure 3.6: A slope covered with erosion control blanket

Fiber rolls are a type of sediment control measure. These are usually made of the same materials used in erosion control blankets but are rolled into large diameter logs. These logs can be made to just about any diameter and are incased in photodegradable open weave netting. The purpose of these logs is to slow down water long enough for any sediment that is in the water to settle out. The three major materials used in fiber rolls are coconut fiber, rice wattle and wheat wattle. The concept behind the fiber roll is the same regardless of the material.

The installation of the fiber logs does not change based on the material used. The basic concept of a fiber log is to lock it into place so that soil and water cannot remove it. A trench is dug at a depth equal to half of the diameter of the log. This is so that the fiber log can become part of the slope. Wooden stakes are used to hold them in place. Fiber rolls can also be live staked into the ground by using small trees such as willows. It is sometimes a good idea to use a live stake to hold the log in place in order to start establishing vegetation.

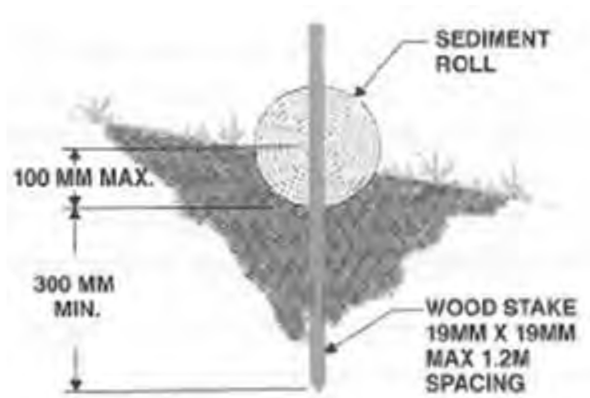

Figure 3.7: Fiber Roll Installation

3.3.5 Check Dams (ditch checks)

Check dams are the correct erosion control measure to be used in areas of concentrated flow. They are small dams constructed across and swale, drainage ditch, or channel. The dams help to reduce the velocity of concentrated flows, reduce erosion, and allow for deposition of sediment in ponded areas above check dams. Check dams are subject to failure during large storms and should always be inspected after significant rainfall events.

Check dams should form a triangle when viewed from the side. This prevents undercutting as water flows over the dam rather than falling directly on the ditch bottom on the back side. The material used should not contribute to the sediment load in runoff, which is why clean gravel should always be used. The dam should also be constructed in a way to keep the water within the natural limits of the ditch to avoid flooding. The following figure helps illustrate these points.

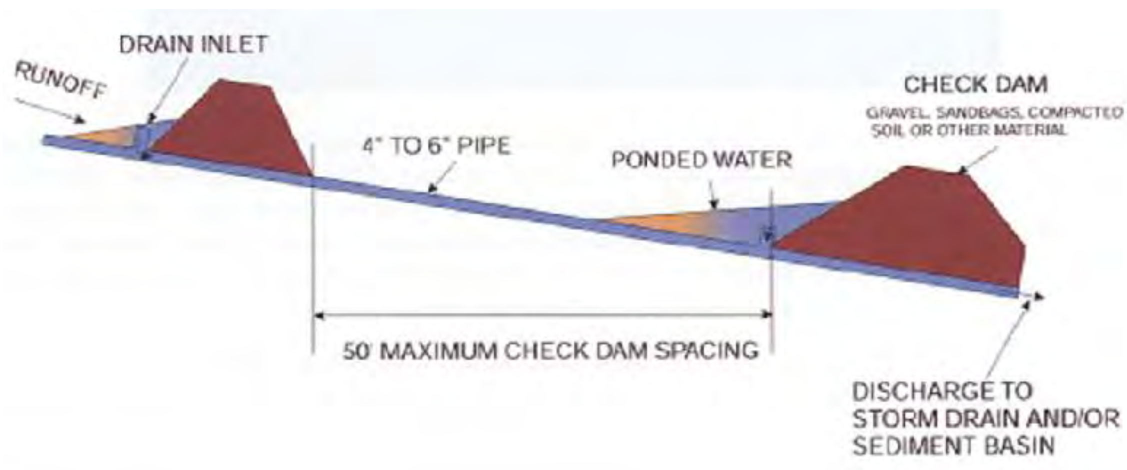

Figure 3.8: Check Dam Installation

3.3.6 Inlet Protection

Inlet protection is the last opportunity to minimize sediment impact to receiving waters. Storm drain inlets are often blocked off during construction to prevent excessive amounts of sediment from entering. These inlets may be blocked by straw bales, fiber rolls, or sandbags to help filter the water that does enter. Inlet protection does a good job at removing relatively large sized particles in runoff storm water, but most fine silt or clay particles will pass through. Inlet protection should only be used in situations where temporary ponding will not create a safety hazard or cause property damage.

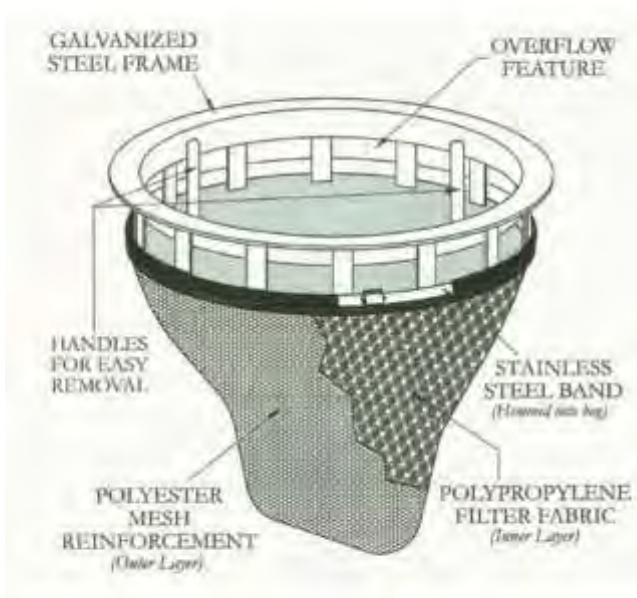

Figure 3.9: An inlet protection device

3.3.7 Outlet Protection/Energy Dissipation

Pipe outlet protection is a protective armor for the immediate area around the outlet of a pipe or culvert. It is used to protect it and the receiving channel from scour and deterioration. This practice is applicable to the outlets of underground conduits, culverts, and the principle spillways in detention and sediment ponds.

All outlets must be adequately protected from scour caused by the exit velocity, turbulence, and suction of water leaving the outlet. Outlets are points of critical erosion potential. To prevent scour, a flow transition structure is needed to absorb the initial impact of the flow. The most commonly used device for outlet protection is a structurally lined apron. The apron is generally lined with riprap or concrete.

Section 4

4.1 Inspection of Erosion and Sediment Control Measures (ESCM)

As it has been mentioned many times previously, inspection and maintenance to erosion and sediment control measures is extremely important to ensure that they function properly. Inspections are typically conducted prior to construction, during construction, and when construction is completed and all final grading has been done. Inspections during construction are usually on a weekly basis and are also done after any significant rainfall event. Inspections may also be conducted if any complaint has been received about a particular construction site.

In order for inspections to go well, it is very important for the inspector, the contractor, and the field engineer to know exactly how every part of the Storm Water Pollution Prevention Plan is going to work. The inspector needs to be familiar with the site and know what the contractor is going to due to ensure major any areas of concern are dealt with properly.

4.1.1 Initial Inspection

Initial inspections take place after all erosion control measures have been installed but prior to any major grubbing or clearing taking place. This is done to make sure everything is properly installed before the site is exposed to increased risks of soil erosion. The initial inspection checklist is as follows:

- Perimeter control measures in place
- Access drive(s) installed
- Catch basin/storm sewer inlet protection in place
- Ditch checks in place
- Retention/detention basins stabilized
- Areas of the property not under construction stabilized
- Approved erosion control plan conditions being adhered to

The perimeter control measures typically consist of silt fence. It is important to check the locations where silt fence is proposed on the plan sheets and verify the installation is within the design criteria. It is crucial that the silt fence is installed correctly as well.

Access drives, also known as temporary construction entrances, must be installed correctly. Geo-textile fabric must be installed before any rock is placed on the road to prevent the rock from sinking into the soil. The roads and entrances must be of adequate length as well.

Inlet protection must be installed along with ditch checks. These measures must be within the regulations in the approved plans. Retention/detention basins must be in place as well and stabilized to ensure that they will not erode. The most important thing is to make sure that all the conditions in the erosion control plan are being adhered to.

4.1.2 Inspection during Construction

During construction is when the erosion control inspections are perhaps the most important. They are intended to make sure that all erosion control measures are being maintained properly so that they perform as planned. The during construction checklist is as follows:

- Check contractor log of daily maintenance and repair
- Perimeter control measures maintained
- Perimeter control measures adjusted with vegetation line
- Access drive(s) maintained
- Containment of approved soil storage piles maintained
- Dumpster or other approved method of debris control on site
- Mud tracking on street cleaned at end of each workday
- Storm water inlet and catch basin controls maintained

The contractor is required to keep a record off all inspection and maintenance of erosion control measures throughout the duration of the project. These need to be available upon request at all times. Perimeter erosion control requires a lot of maintenance and as a general rule must be cleared of sediment if it has collected to be half the initial height of the silt fence. Along with this, inlet protection and catch basins must be cleared if too much sediment is deposited. Access drives must be in proper condition to prevent the tracking of mud onto public road ways as vehicles enter and leave the construction site. Also, all waste must be disposed of or stored properly to keep it from contaminating runoff from the site. Materials must be stored properly as well for the same reason.

4.1.3 Final Inspection

After construction is complete an inspection must be conducted as well. This is basically to ensure the site meets all the design criteria laid out in the approved plans. The checklist is as follows:

- All excess soil and soil piles removed from site
- All construction debris, materials, dumpsters and equipment removed from site
- All temporary erosion and sediment control measures removed from site
- Final landscaping installed
- Finished grade at property lines is in conformance with approved drainage plan

All construction materials and waste must be removed from the site. This includes all of the temporary erosion control measures that were used during construction. The site must be to the proper final grade and all permanent erosion control measures must be in place.

4.1.4 Construction inspector's checklist for Erosion Control (IDOT)

While its use is not required, this checklist has been prepared to provide the field inspector a summary of easy-to-read, step-by-step requirements relative to the proper construction of project items related to Erosion Control. The following questions are based on information found in the Standard and Supplemental Specifications, Highway Standards, and appropriate sections of the Construction Manual.

Have you reviewed the contract Special Provisions, Supplemental Specifications and Plans? ___

PROGRESS PROJECT EROSION CONTROL

A. National Pollutant Discharge Elimination System (NPDES) Storm Water Permit

1. Is your contract subject to the NPDES Permit requirements discussed in Construction Memorandum No. 60?
2. If yes, is a copy of the Storm Water Pollution Prevention Plan(SWPPP) on file at the project site?
3. Has a Notice of Intent been submitted to the IEPA 48 hours before any disturbance was undertaken?
4. Is the Contractor placing the proposed controls in a timely manner, in accordance with SWPPP?
5. Are inspections being conducted every seven calendar days or within 24 hours after a 13 mm (0.5 inch) rainfall or equivalent snowfall and the results reported on Form BC 2259, NPDES/Erosion Control Inspection Report?
6. If an inspection disclosed a violation of the SWPPP, was an Incidence of Noncompliance submitted to the IEPA within five days?
7. Has the violation been corrected?
8. Has this violation been noted on the following weekly BC 2259, NPDES/Erosion Control Inspection Report?
9. Has a Notice of Termination been submitted to the IEPA when all permanent erosion control measures are in place and 70% viable vegetative cover, or equivalent, is achieved?

B. Erosion Control Plan

1. Does your contract contain temporary erosion control measures and/or special provisions or does the nature of the contract require an erosion control plan? (Art. 280.01)
2. If yes, do you have a copy of the required approved Erosion Control Plan?
3. The Erosion Control Plan provides for both temporary and permanent erosion controls to protect adjacent property, water courses, and completed construction. Are you familiar with your Plan?
4. Are those items needing special attention being protected prior to soil disturbances?

5. If so, have you analyzed your erosion control needs and determined which of the permanent erosion control items you need to supplement with temporary items and when they need to be installed?

SEEDING

A. Temporary Seeding

Temporary seeding will be expected to be placed upon disturbed ground, at regular intervals shortly after the ground has been worked but before the surface has dried and hardened. Two elements are necessary to establish seeding, first seed/soil contact and adequate moisture.

Traditional methods can be used to temporary seed, including spreading by hand, but without rain, your best means of providing moisture is seed incorporation with compaction. With temporary seeding we are trying to prevent soil particles from moving and to slow down the movement of water. Seed placed on top of the ground without incorporation or compaction will sprout only if it stays in place and has moisture available for several days.

1. Is temporary seeding growing?
2. Is compaction or incorporation method being used?

B. Prior to Seed Bed Preparation (Permanent)

1. Read Sections 211, 212, 250, 251 and 252 in the Standard Specifications. Do you understand the requirements? If not, ask your Resident, Field Supervisor or Landscape Architect.
2. Prior to commencing any permanent seeding operation, has the right-of-way been shaped, trimmed, cleaned up and finished in accordance with Section 212 of the Standard Specifications?
3. Prior to any seeding, is the seed Illinois certified seed, or has the Contractor had the seed tested and do you have the test results?
4. Is an inspector at the scales to initial tickets and witness the weighing of straw, emulsified asphalt, bulk fertilizer and agricultural ground limestone; items paid for on a weight basis?
5. Has the seeding equipment been properly adjusted and calibrated for the specified rate of application?
6. Are fertilizer nutrients being uniformly applied at the kilogram/hectare (pounds/acre) rate specified in the contract?
7. When fertilizer is delivered in bags, is each bag or part of each bag that cannot be duplicated, collected each day to determine the weight of fertilizer to be paid for? (Afterentering the pay quantity in the Quantity Book, burn or otherwise destroy the bags so they cannot be used again for determining pay weight.)
8. Do the fertilizer bags show the percent analysis, manufacturer, brand weight, and guarantee as required in Article 1081.08 of the Standard Specifications?

9. Is payment for fertilizer nutrients being determined on the basis of analysis and not on the total weight? (A mixed fertilizer with a 10-6-4 analysis contains only 7 kg of nutrients per 35 kg sack) (16 pounds of nutrients per 80-pound sack).
10. When their use is specified, is the agricultural ground limestone and fertilizer uniformly distributed over the areas to be seeded prior to the disking operation?
11. Is the Agricultural Ground Limestone, when specified, applied at the rate (multiplied by the producers Source Correction Factor) set by the Engineer or specified on the plans? Normally, 4.5 metric tons/ha (2 tons per acre)

C. Seed Bed Preparation (Art. 250.05)

1. Has the seed bed been worked to a depth of not less than 75 mm (3 inches) with a disc or other type of approved equipment reducing all soil particles to a size not larger than 50 mm (2 inches) in the largest dimension?
2. Is the disked seed bed free from debris, washes, gullies, clods and stones?

D. Sowing the Seed

1. Your plans will specify which Seeding Class is to be used and beginning and termination dates for seeding. (Table 1, Art. 250.07)?
2. Are the delivered seed lots tested and certified in accordance with Article 1081.04 of the Standard Specifications?
3. Are the seed bag weight tickets collected to ensure that the minimum number of pounds of each type of seed as shown in Table 1 of Article 250.07 is being sown?
4. Is the sowing of seed prohibited outside your designated season, during periods of high winds, or when the ground is frozen or crusted?
5. Are all legumes (clovers, vetches, lespedezas, alfalfas) being inoculated with an approved inoculant within 24 hours prior to sowing?
6. If a hydro-seeder is used, is 3 times the normal amount of inoculant being used and is the seeder hopper being agitated during use to prevent segregation of the seed mixture?
7. 7. Are the seeded areas being compacted with an agricultural roller or cultipacker at right angles to run-off within 12 hours after seeding and before mulching? (Not required on slopes steeper than 1:3 (V:H) on areas seeded with a hydraulic seeder or rangeland type grass drill, or if Method 3 Mulch is specified.)
8. Are all authorized surfaces of permanent seeded area being measured and paid for in acres? (Exception: Form BC 981, Agreement on Accuracy of Plan Quantities can be mutually signed and the plan quantity paid.)

E. Mulch (Section 251 of the Standard Specifications)

1. Has the mulch material been inspected and accepted as reasonably dry and free of noxious weed seeds?
2. Has a mulch storage location (when needed) been selected on the jobsite that is away from structures, buildings, or other property to eliminate or minimize the possibility of fire damage?
3. When mulching is specified, has the method (1, 2 or 3) as designated on the plans been determined and is the application made within 24 hours after seeding? If Method 2 mulch is specified, has the stabilizing procedure to be used been approved in advance?
4. Is Emulsified Asphalt, Method 2, Procedure 1, being applied at a rate of not less than 300 L/metric ton (75 gallons/ton) of mulch, the exact rate specified by the Engineer?
5. Are measures being taken to protect roadside hardware from emulsified asphalt damage?

SODDING

A. Material Inspection

1. Has the Contractor informed the Engineer where his/her source of sod will be prior to beginning his/her sodding operation? Peat or muck sod is unacceptable. (Art.252.11)
2. The sod must be inspected at the source by:
   • Illinois Department of Agriculture (Division of Plant Industries) Rev. 12/14/07 Erosion Control Sheet 6 of 8
   • A representative of the Department of Transportation
3. Is each load of sod accompanied by an Illinois Department of Agriculture Certificate of Inspection? Collect and retain.
4. Has the load of sod been inspected at the jobsite for improper handling, drying out, and poor physical condition?
5. Is all sod which has not yet been placed within 48 hours of its cutting, being placed only with your approval?
6. If sod is specified as salt tolerant, has a material certification been furnished from the grower attesting to its composition? (Art. 252.11 and Art. 1081.03)

B. Soil Preparation for Sod

1. Are the contract-specified rates of application for fertilizer nutrients (Art. 1081.08) and agricultural ground limestone (Art. 1081.07) being met?
2. When specified, is agricultural ground limestone or fertilizer applied as required prior to completion of ground preparation operations so that it is completely incorporated in the area to be sodded?
3. Has the soil surface been worked to a depth of not less than 75 mm (3 inches), and is it free from debris, washes, gullies, clods and stones not earlier than 24 hours before the sodding operations? (Art. 252.03)

4. Is the soil surface moist at the time of sod placement? If not the Contractor shall apply water at the minimum rate of 5 L per square meter (1 gallon/square yard) immediately prior to placing the sod. (Art. 252.03)

C. Placing the Sod

1. Is the sod not allowed to be placed when the sod or ground is frozen, or during extremely hot weather with temperature of 26°C (80°F) and above? (Art. 252.04)
2. Is the sod placed with tightly butted unexposed edges and staggered joints on moist, workable soil? (Art. 252.06)
3. Is the ditch sod being placed with the longer dimension perpendicular to the flow of the ditch water? (Art. 252.06)
4. When sod slopes are specified, is the operation started at the toe of the slope and is the sod placed with the larger dimension parallel with the ground contour? (Art. 252.06)
5. If the ground slope is 1:2 (V: H) or steeper, are stakes being used? (Art. 252.07)
   - Shall be pointed lath or similar material.
   - Drive with flat side against slope.
   - Drive 150 mm (6 inches) into ground.
   - Leave 13 mm (1/2 inch) above ground.
   - Use not less than 4 stakes per square meter (yard) of sod.
   - Use at least one stake per piece of sod.

D. Watering Sod

1. Is the sod being watered at a rate of 25 L per square meter (5 gallons per square yard) within 2 hours after it is placed (initial watering)?
   a) Thereafter, are the following additional watering requirements being met? (Art. 252.08) Number of additional watering applications, not to exceed 7.
   b) Apply at a rate of 15 L per square meter (3 gallons per square yard) to each application.
2. After the eight required waterings, are any additional waterings being paid for per unit (1000L) (1000 gal) as Supplemental Watering? (Art. 252.09)

E. Measurement & Payment of Sod (Art. 252.13)

1. Is the sod knitted to the soil prior to acceptance and in a healthy growing condition before measuring?
2. Is the sod being measured in place and paid for in square meters (square yards)?

EROSION CONTROL BLANKET

A. Material Inspection

Does the erosion control blanket meet the requirements of Article 1081.10(a)(b) of the Standard Specifications and is each shipment accompanied by the manufacturers certification?

B. Placement Requirements (Art. 251.04)

1. Is the blanket, being placed within 24 hours after seeding operations have been completed?
2. Is the area to be covered relatively free of all rocks or clods over 40 mm (1 ½ inches) in diameter and all sticks and other foreign material?
3. Is the matting or blanket spread evenly and smoothly without stretching?
   a) Lay the blanket either parallel or perpendicular to slopes, when used on cuts and fills.
   b) Lay the blanket parallel to the flow of water when used in ditches, with no longitudinal seams within 600 mm (24 inches) of the ditch centerline.
   c) Are the blankets butted snugly end to end?
4. If Excelsior Blanket is used:
   a) Are the edges overlapped at least 50 mm (2 inches)?
   b) Are four staples used at each end of a roll and on 1.2 m (4 feet) centers for ditches, or 1.8 m (6 feet) for slopes, along each side, with a common row of staples used for adjacent pieces?
5. If Straw Mat is used:
   a) Are staples in a diamond pattern with a long dimension of 1.8 m (6 feet) in the direction of the slope, and the short dimension of 900 mm (3 feet) across the slope?
   b) Is a common row of staples used on adjoining rolls? On slopes, does the mat extend a minimum of 900 mm (3 feet) over the crest of the slope, and are six staples anchoring the uphill and downhill ends of the roll?

C. Payment

Is the Erosion Control Blanket being paid for at the contract unit price per square meter (square yard) of surface area protected? (Not by the number of rolls used multiplied by the number of meters (yards) per roll.)

4.1.5 Terminology

Deficiency – Refers to unmaintained or failing BMPs. It may also apply to repeated failures of a particular BMP that has not been resolved. Deficiencies are not serious and can usually be solved or simply avoided with weekly inspections as well as inspections after storm events. Deficiency deductions are the first way to make contractors comply with the storm water pollution prevention plan.

Non-compliance – Refers to events or conditions that lead to the discharge of sediment beyond the limits of construction. This is mainly due to gross disregard for the installation, inspection, or maintenance of erosion and sediment control measures. In the case of non-compliance, an incident of non-compliance (ION) will be filed with the Illinois Environmental Protection Agency.

Violation – A violation can refer to many things. If an ION occurs and is not filed, a site is considered to be in violation of its permit or erosion control plan. Also, IONs repeatedly occurring due to negligence can be considered a violation. Violations can result in large fines.

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US Army Corps of Engineers. <http://www.usace.army.mil>

US Environmental Protection Agency. "Developing your Stormwater Pollution Prevention Plan: A Guide for Construction Sites."

US Environmental Protection Agency. "Introduction to the Clean Water Act." <http://www.epa.gov/watertrain/cwa/>

US Fish & Wildlife Service. "Clean Water Act Section 404." <http://www.fws.gov/habitatconservation/cwa.htm>

Washington State Department of Transportation. "Construction Site Erosion and Sediment Control Certification Course."

Appendix

The following information is provided to all the trainees on site

A. Soil erodibility (K) values for specific Illinois soils
B. General NPDES permit number ILR40
C. General NPDES permit number ILR10
D. Notice of Intent (NOI)
E. Incidence of Non-Compliance (ION)
F. Notice of Termination (NOT)
G. SWPPP Template
H. IDOT SWPP Erosion Control Inspection Report
I. BDE Manual Chapter 41