STATE OF FLORIDA

EROSION AND SEDIMENT CONTROL

DESIGNER AND REVIEWER MANUAL

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Table of Contents

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SECTION I

GENERAL INFORMATION

TABLE OF CONTENTS

INTRODUCTION

With the adoption of the statewide stormwater rule in 1982, Florida was the first state in the country to require the treatment of stormwater from all new development. The stormwater rule is a technology-based rule relying upon a performance standard (environmental goal) and Best Management Practices (BMPs) design criteria that are presumed to meet the goal. The performance standards are set forth in the Water Resource Implementation Rule (Chapter 62-40, F.A.C.).

Performance standards for erosion and sediment control during grading is to retain sediment on-site, with a backstop that no discharge shall violate the State of Florida's water quality standard for turbidity. Thus, goals of Florida's stormwater regulatory program and the Florida Department of Environmental Protection (FDEP) are to protect water quality and to minimize erosion and sedimentation by requiring the use of effective BMPs during and after grading.

Additionally, as mandated by the Clean Water Act (CWA), permits must be obtained for stormwater discharges from construction sites that meet or exceed the Environmental Protection Agency (EPA)'s criteria (see http://www.epa.gov/region5/water/cwa.htm). The EPA has the responsibility of administering CWA requirements by requiring National Pollutant Discharge Elimination System (NPDES) discharge permits. FDEP implements the NPDES program in Florida and to issue Florida NPDES discharge permits. By reviewing http://www.dep.state.fl.us/water/stormwater/npdes/index.htm, readers of this manual can obtain more detailed information on Florida statutory requirements and FDEP programs and requirements.

Purpose of the Manual

This manual will assist designers and reviewers in providing meaningful and practical Erosion and Sediment Control (E&SC) drawings as part of the Stormwater Pollution Prevention Plan (SWPPP) for the contractor to implement. Preparation and review of SWPPP and E&SC drawings need to be done by, or under the supervision of, professionals having demonstrative erosion and sediment control experience and skills necessary for development and review of effective and practical documents. These individuals are identified throughout this manual as Designers. It is important to note that additional qualifications may be required by governmental agencies, such as having construction field experience, supplementary training and education, passing an examination, and so forth.

This manual has been developed to strive toward a consistent level of technical expertise and professional conduct for designers and reviewers developing and reviewing E&SC drawings and SWPPP. These are required not only to meet NPDES stormwater requirements but are also an integral part of the stormwater management plan that must be approved by FDEP or the Water Management Districts (WMDs) to obtain a Florida stormwater or Environmental Resource Permit (ERP). Ultimately, the guidance in this manual strives to ensure the desired benefits of stormwater management systems are being achieved.

Three Basic Definitions

Natural erosion occurs at a relatively slow rate; however, accelerated erosion is primarily caused by the removal of natural vegetation or alteration of the ground contour by land disturbing and construction activities. The nature of construction activities will result in increased erosion rates, transportation of sediment by runoff, and create problems associated with sedimentation. The purpose of this manual is to present methods that Designers can use and reviewers will recognize to reduce sediment in runoff waters and minimize the erosion process on sites where construction activity is occurring. It is important that Designers and reviewers understand the following three basic definitions:

- Erosion: The process by which rainfall, wind and water dislodges soil particles.
    - *Splash erosion* is the dislodging of soil particles by raindrop impacts, resulting in the dispersal and mobilization of the soil particles.
    - *Sheet flow erosion* is the uniform removal of saturated soil particles conveyed in runoff waters.
    - *Rill erosion* is a long, narrow depression or soil incision caused by increased topographic relief and higher runoff velocities. They are the result of concentrated flows that result in vertical (meaning, incising into the ground) and sheet flow erosion.
    - *Gully erosion* is the deep and wide depression caused by concentrated flows.
    - *Stream bank erosion* is the removal of soil by a natural drainage pattern, such as toe cutting and bank sloughing.
    - *Shoreline erosion* is the removal of soil by high-energy wave action, resulting in sloughing and mass wasting.
- Sediment: Soil particles suspended in, or moved by, stormwater runoff.
- Sedimentation: The deposition of sediment.

Some of the factors influencing erosion include soil characteristics, existing vegetative cover, topography and climate. Soil properties which influence erosion by rainfall and stormwater runoff are those which affect the infiltration capacity of a soil and those which affect the resistance of the soil to detachment and transport by flowing or falling water. Vegetative cover plays an extremely important role in reducing erosion and can be controlled during land disturbing activities.

Sequentially scheduling and limiting the removal of vegetation and decreasing the area and duration of exposure can significantly reduce soil erosion and sedimentation. Topographic characteristics of the watershed can influence the amount and rate of stormwater runoff since slope length and gradient directly influence the volume and velocity of runoff and erosion risks. Climate, especially rainfall frequency, intensity and duration are fundamental factors in determining the amount of runoff. As volume and velocity increase, the capacity of runoff to detach and transport soil particles also increases.

This manual will provide guidelines for developing and reviewing effective E&SC drawings that incorporate methods for removing sediment from runoff waters and minimize erosion in a cost effective and practical manner that protects the environment while construction activities occur.

Designers must confer with the appropriate Water Management District (WMD), as well as the Florida Department of Transportation (FDOT) office when completing projects within their jurisdiction to ensure that they address all necessary environmental concerns.

Sediment Loading

Impact to Water Bodies

When Total Suspended Solids (TSS) occur in large quantities, degraded water quality can be harmful to plants and animals and interfere with such life functions as photosynthesis, respiration, growth, and reproduction. Since construction projects can be one source of soil particles that fill Florida's streams, lakes, canals, and shorelines, it is important to understand how to control sediment both during and following land disturbance activities.

As construction activities disturb land, erosion occurs during rainfall or wind events. Once suspended in water, soil particles may become a major water pollutant. For example, sediment loading causes the following:

- Construction areas can produce 10 to 20 times more than soil particles lost from lands where vegetation exists.
- Reservoirs, harbors, and canals to clog with silt.
- Loss of recreational areas and wildlife habitat.
- Reduces the beneficial uses of water for humans and can harm plants, animals, and aquatic life.

Nutrients, Pesticides, and Heavy Metals

Sediment loading from construction areas may also increase the amount of nutrients in water. Nutrients (especially phosphorus and nitrates) may come from fertilizers used at construction sites to aid in the establishment of vegetation. When runoff waters carry sediment downstream into water, plants that live in water use the nutrients to increase the biomass, which robs the water of oxygen, which kills aquatic organisms, including fish.

In addition to nutrients, herbicides and pesticides may also exist in construction site soils. When runoff events occur, these harmful chemicals are also carried with the sediments. In addition, improper application of pesticides can also result in the direct contamination of water.

It is estimated that over half of the trace metals carried in runoff waters are attached to sediments (Caltrans, 1996). Sources of these metals found at construction sites include galvanized metal, paint, and preserved wood. Nearly all metals can be toxic to plants, animals, and fish. In addition, metals can accumulate in the tissues of plants, animals, and fish and have the potential to contaminate drinking water.

Hydrocarbons and Other Wastes Found in Runoff Waters

Other pollutants found in runoff from construction sites include hydrocarbon compounds caused by leaks from heavy equipment, hydraulic line failures, hydrocarbon spills during refueling, inappropriate disposal of drained fluids, and so forth. When runoff occurs, these hydrocarbons can wash into the water, harming plant and animal life.

Other wastes from construction sites that can lead to unsightly and polluted water include:

- Wash water from concrete mixers

- Paints and painting equipment
- Wastes from cleaning of vehicles and equipment
- Wastes from trees and shrubs removed during land clearing
- Wood and paper from building product packaging
- Food containers, such as paper, aluminum, and metal cans
- Sanitary wastes

The Importance of Vegetation

The best method for minimizing the discharge of sediment from a construction site is to keep a good vegetative cover on the soil. When sufficient plant cover exists, raindrops or runoff waters can only cause minimal erosion of the soil. An extensive root system will also bind soil together to resist erosion by flowing water.

Identifying the Sources

Construction activities will result in the disturbance of existing plants, soil, and rocks. Problems often occur when soil is stockpiled, used to fill holes or low areas, or removed from the area. Other problems might occur from careless handling of construction materials or fuels on-site, since nutrients, trace metals, and hydrocarbons can seep into the ground from these sources. In addition, when storm events occur runoff may carry contaminated soils away from the construction site to become a source of downstream pollution. Less erosion means less sediment in runoff waters. Therefore, good erosion control means good sediment control. Reducing the amount of sediment in runoff water means there will be fewer pollutants carried downstream from their source.

Wetlands and fish habitats might require considerable time to recover following construction projects. To allow for recovery, activities should include establishing vegetation on disturbed areas to reduce the sediment entering downstream waters during and after grading activities occur. Care should also be taken to avoid excessive application of chemicals that could find their way into runoff from the site. Once the flow of sediment and pollutants is reduced, spawning beds can recover and the danger of fish suffocation is reduced.

REGULATIONS AND STATUTORY REQUIREMENTS

On average, Florida receives 40- to 60-inches of rain each year, often in the form of torrential downpours that cause runoff carrying sediment, fertilizers, pesticides, oil, heavy metals, bacteria, and other contaminants which enter our surface waters. To minimize these adverse impacts, a Florida Stormwater or Environmental Resource Permit (ERP) must be obtained from the applicable WMD or FDEP office before construction begins. ERPs integrate stormwater quantity and quality, as well as wetland protection requirements into a single permit. They regulate activities such as dredging and filling-in wetlands, construction of stormwater facilities, stormwater treatment systems, construction of dams or reservoirs, and other activities affecting state waters. Each WMD has an operating agreement with FDEP about which agency will process ERPs for particular projects, based on the type of land use.

Specific requirements for stormwater management, including erosion and sediment control during grading, flood control, and stormwater treatment can be found in the specific ERP regulations applicable within the appropriate WMD. These requirements include specific design criteria for various types of stormwater treatment practices. For additional details about these regulations, refer to http://www.dep.state.fl.us/water/wetlands/erp/index.htm or http://flwaterpermits.com.

In December 2000, the EPA authorized FDEP to implement the National Pollutant Discharge Elimination System (NPDES) Stormwater Program within the State of Florida, with the exception of Indian Nation lands. Mandated by the United States Congress under the Clean Water Act, the NPDES Stormwater Program is a national program for addressing many urban stormwater discharges, which may adversely impact water quality.

The NPDES Stormwater Program is completely separate from the State's stormwater/environmental resource permitting programs found under Part IV, Chapter 373 of the Florida Statutes. The NPDES Stormwater Program does not establish additional regulations for the construction/design features for retention areas, detention ponds, swales and other stormwater management systems. Additionally, the permit required under FDEPs NPDES Stormwater permitting program is also separate from any local government's stormwater discharge permit for construction activity.

The sources of stormwater discharges regulated under the NPDES Stormwater Program include the following three categories:

- Construction Activities
- Industrial Activities
- Municipal Separate Storm Sewer Systems

This section will only address construction activities. Florida's WMDs may have more stringent criteria than what is being presented in this manual and should be consulted for their requirements.

Construction Activities

Stormwater runoff from construction activities can have a significant impact on water quality by contributing sediment and other pollutants to water bodies. The NPDES Stormwater Program regulates construction activities that disturb one or more acres of land and discharge stormwater to surface waters of the State or into a municipal separate storm sewer system (MS4).

> ***The regulatory definition of a MS4 is "a conveyance or system of conveyances like roads with stormwater systems, municipal streets, catch basins, curbs, gutters, ditches, constructed channels, or storm drains."***

If a project is less than one acre, but part of a larger common plan of development or sale that will ultimately disturb one or more acres, permit coverage is also required. A larger common plan or development or sale is a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules. An example of this condition is the development of a housing subdivision.

When a developer buys a 20-acre parcel and builds roads, installs water/sewer with the intention of constructing homes or other structures in the future, this would be considered a larger common plan or development or sale. If the land is parceled off or sold, and construction occurs on plots that are less than one acre by separate, independent builders, this activity still would be subject to NPDES stormwater permitting requirements regardless of the size of any of the individually owned lots.

Identification of Operators

The Generic Permit for Stormwater Discharge from Large and Small Construction Activities *(CGP), (FDEP Document 62-621.300(4)(a), effective May 2003)* defines "operator" as:

> ***"The person, firm, contractor, public organization, or other legal entity that owns or operates the construction activity and that has authority to control those activities at the project to ensure compliance with the terms and conditions of this permit."***

The operator is ultimately responsible for obtaining permit coverage and implementing appropriate pollution prevention techniques to minimize erosion and sedimentation from stormwater discharges during grading.

For construction projects where the operator changes, the new operator should obtain permit coverage at least two (2) days before assuming control of the project. The previous operator should file a NPDES Stormwater Notice of Termination (FDEP Form 62-621.300(6)) to terminate coverage under the CGP. The previous operator must meet the conditions to terminate coverage in accordance with Part VIII of the CGP.

CGP Requirements

The following is a brief summary of major CGP requirements. For a complete summary of the regulatory requirements always refer to the CGP.

- A copy of the NOI or the acknowledgement letter from the Notices Center confirming coverage under the CGP must be posted at the construction site in a prominent place for public viewing (such as alongside the building permit).
- Inspections
- Termination of Coverage
- Retention of Records

To obtain NPDES stormwater permit coverage, a regulated construction operator must complete the following steps:

<u>Understand the CGP and Develop a SWPPP</u>

1) Obtain and carefully read the CGP (The CGP is available online at: http://www.dep.state.fl.us/water/stormwater/npdes/construction3.htm)
2) Develop a site specific Stormwater Pollution Prevention Plan (SWPPP). See Section II of this manual for additional information on how to develop a SWPPP.

<u>Complete an NOI Application</u>

1) Complete in its entirety the application or Notice of Intent (NOI) form (FDEP Form 62-621.300(4)(b)).

2) Submit the NOI with the appropriate processing fee to the NPDES Stormwater Notices Center.

   a. Rule 62-4.050(4) (d), Florida Administrative Code, requires the processing fee*. **The fee is subject to change so check the Rule to determine the appropriate fee when applying. Chapter 62-4 is available online at*: http://www.dep.state.fl.us/legal/Rules/mainrulelist.htm or http://fac.dos.state.fl.us/

   b. **Do not** send plans or a copy of your SWPPP when applying for permit coverage. Only the NOI and appropriate fee is required. If the project site is inspected, the regulatory agency or designated representative will review the contents of the SWPPP at the time of the inspection. (*The regulatory agency may also at any time request that the SWPPP be submitted for review.)*

   c. For projects that discharge stormwater to a MS4, a copy of the NOI must also be submitted to the operator of the MS4.

Operators seeking coverage under the CGP must apply for permit coverage at least two (2) days prior to the commencement of construction. Permit coverage under the CGP is effective two (2) days after the date of submittal of a complete NOI and appropriate fee. Submittal is interpreted as "postmarked." All NOIs should be mailed to:

Florida Department of Environmental Protection
NPDES Stormwater Notices Center, MS#2510
Tallahassee, FL 32399

The NPDES Stormwater Notices Center will send an acknowledgement letter to the operator after reviewing and processing your complete NOI and fee. The acknowledgment or confirmation letter identifies the permit or project number for your activity and indicates the issuance and expiration date for the CGP. Permit coverage under the CGP is limited to a term of five (5) years. If construction activity extends beyond a period of five (5) years, the operator will be required to reapply for permit coverage.

Inspections

One of the key components of the CGP is the requirement for a qualified inspector to inspect all discharge points, disturbed areas, material storage areas, structural controls and construction entrances/exits at least once every seven (7) days and after every 0.50-inch or greater storm event. Major observations and incidents of non-compliance should be recorded in the inspection report, as well as corrective actions and maintenance.

Unless advised otherwise, maintenance must occur within seven (7) calendar days of the inspection. These inspections must be documented and signed by a qualified inspector as defined by the CGP. The report shall contain a certification that the facility is in compliance with the SWPPP and the CGP when the reports do not identify any incidents of non-compliance.

Notice of Termination (NOT)

Upon completion of the project and final stabilization, the permittee needs to submit a signed NOT application to the NPDES Stormwater Notices Center and the MS4. Final stabilization is defined within the CGP as:

"All soil disturbing activities at the site have been completed, and that a uniform perennial vegetative cover with a density of at least 70% for all unpaved areas

and areas not covered by permanent structures has been established or equivalent permanent stabilization measures have been employed."

When the operator changes to relinquish control of a project to a new operator, A NOT also shall be filed at:

NPDES Stormwater Section
Florida Department of Environmental Protection
NPDES - stormwater@dep.state.fl.us
www.dep.state.fl.us/water/stormwater/npdes/

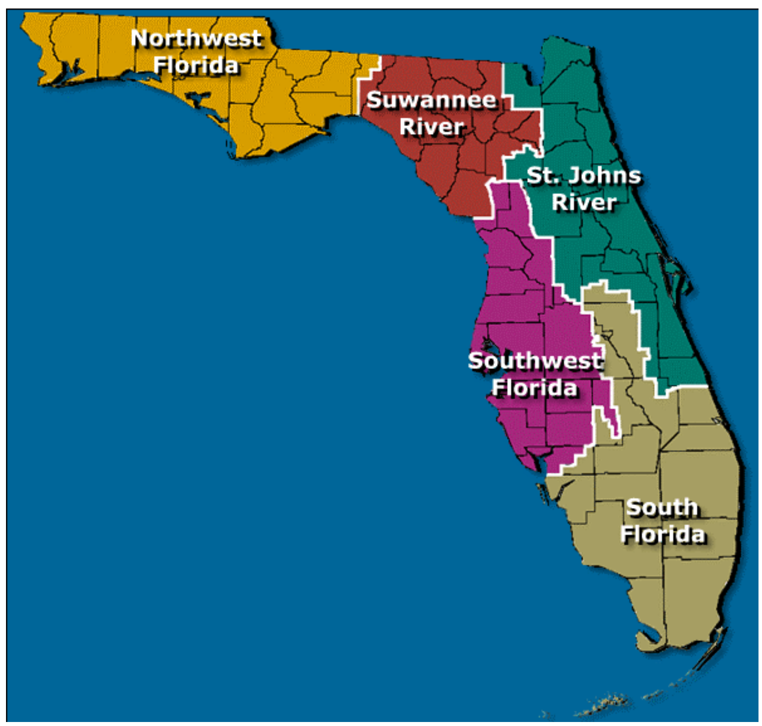
Retention of Records

The permittee needs to retain copies of the NOI, SWPPP, inspection reports, NOT, and any other supporting documentation for at least three (3) years from the date the site is finally stabilized.

General Comments

It is important to note that the permit required under FDEP's NPDES Stormwater permitting program is separate from the Environmental Resource Permit (ERP) required under Part IV, Chapter 373, F.S., a stormwater discharge permit required under Chapter 62-25, FAC, or any local government's stormwater discharge permit for construction activity.

The FDEP/WMD Environmental Resource Permitting Program benefits Florida by requiring the implementation of effective mitigation measures that will minimize stormwater pollution to Florida's lakes and streams and protect wetlands (see http://www.flwaterpermits.com).



Designers need to identify within which of the five WMDs (seen at right) that their project is located to ensure all permits and environmental issues are properly addressed within their SWPPP. Also, it will be necessary to contact the appropriate WMD office for specific ERP and dewatering permit requirements.

SECTION II

DEVELOPING EFFECTIVE SWPPP'S AND E&SC DRAWINGS

Table of Contents

CONTENTS OF A SWPPP

The Stormwater Pollution Prevention Plan and accompanying E&SC plans shall identify potential sources of pollution that may reasonably be expected to affect the quality of stormwater discharge associated with construction activity. In addition, the plan shall describe and ensure the implementation of BMPs, which will be used to reduce the pollutants in stormwater discharge associated with construction activity and to assure compliance with the terms and conditions of the permit. A thorough understanding of the plan is essential for proper implementation and maintenance.

The SWPPP must be developed before an NOI is filed to receive the Generic Permit for Stormwater Discharge from Large and Small Construction Activities (CGP) coverage and meet or exceed FDEP requirements. Also, beginning on the first day of construction activities, the SWPPP and E&SC drawings must be available at the location identified in the NOI (see http://www.dep.state.fl.us)

A copy of the NOI or Notice of Coverage from FDEP shall be posted at the construction site in a prominent place for viewing. The location of the SWPPP is identified in the NOI and may or may not necessarily be at the construction site.

A SWPPP will consist of a narrative (including any calculations), E&SC drawings, and record requirements. In addition, the CGP requires a certification statement to be signed by the operator. It is strongly recommended that the Designer also sign a certification to ensure accountability exists. The SWPPP shall be developed and implemented for each construction site covered by this permit and be prepared in accordance with good engineering and scientific practices.

Narrative Report

The narrative report provides general information on what is to be completed to ensure minimal environmental damage as a construction project is developed. It should briefly describe the overall strategy for erosion and sediment control, as well as summarize the aspects of the project that are important for erosion control on-site for the plan reviewer and project superintendent.

A site description shall be included in the narrative report and include at a minimum the following information about the site:

- Description of the construction activity
- Total area of the site and total disturbance area
- Intended sequence of land disturbing activities
- Description of the soils and an identification of those that are highly erodible
- Drainage area for each major discharge point
- Latitude and longitude of each major discharge point
- Names of receiving water(s)
- Description of proposed pollution control measures (i.e. BMPs) to be used
- General sequence during the construction process in which the measures will be installed
- Estimated start date, completion date and stabilization schedule

- If possible, an identification of the contractor or subcontractor responsible for the BMP implementation, inspection, and maintenance

Operator (Permittee) Certification Requirement

Designers must sign, stamp (if appropriate), and date the following certification statement as part of their SWPPP:

> *"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."*

Contractor Certification Requirement

All contractors and subcontractors identified in the SWPPP, or those selected at a later date, must sign and date the following certification statement before conducting land-disturbing activities on the site:

> *"I certify under penalty of law that I understand, and shall comply with, the terms and conditions of the State of Florida Generic Permit for Stormwater Discharge from Large and Small Construction Activities and this Stormwater Pollution Prevention Plan prepared there under."*

Inspection and maintenance of structural (e.g. sediment control) and non-structural (e.g. erosion control) BMPs are important aspects of the CGP and must be addressed in the SWPPP. The narrative report should briefly describe procedures that will be followed to ensure the timely installation, inspection, and maintenance of existing vegetation, erosion and sediment controls, stormwater management practices, and other protective measures so they will remain in effective operating condition.

All points of discharge into any surface waters (including wetlands), disturbed areas, material storage areas, structural controls, and vehicle ingress/egress areas must be inspected and documented at least once a week and after each storm event of 0.50-inches or greater. Unless advised otherwise, deficiencies will be corrected within seven (7) calendar days after being noted in the inspection report.

The CGP also requires that other potential pollutants be addressed in the SWPPP. Some of the items to consider may include paints, herbicides, pesticides, fertilizers, fuel, construction debris, chemicals, litter, and sanitary waste. The SWPPP will need to identify the storage areas, means of minimizing exposure to stormwater, proper disposal, as well as spill prevention and response measures.

The permit does not authorize the discharge of solid materials to surface waters of the State or an MS4; however, some non-stormwater discharges are allowable under the CGP if they meet conditions outlined in the CGP.

Calculations

This section of the SWPPP (usually an appendix) will contain information and calculations used in completing the design and illustration of BMPs found in the E&SC drawing. Examples include (but are not limited to) the following:

- Sizing of sediment containment systems (SCSs)
- Sizing of slope drains
- Shear stress and velocity values for drainage channel Rolled Erosion Control Products (RECPs)
- Seed mixture and application rates
- Application rates of soil amendments, herbicides, pesticides and fertilizers
- Flood flow evaluations at critical design points

Erosion and Sediment Control Drawings

The site plan or E&SC drawing is a key component of the SWPPP and must be developed for the contractor in a manner that meets federal, state and local environmental concerns. It has been found that contractors implement components of E&SC drawings more effectively when definitive legend symbols, informative leader notes, and meaningful shading appear throughout the drawings. While use of standard symbols denoting erosion and sediment control BMP measures are acceptable, they can be confusing to contractors if not used prudently and conservatively.

At a minimum, E&SC drawings will depict the following:

- Pre- and post-development drainage patterns
- Critical areas (e.g. highly erodible soils, wetlands, major discharge points, etc.)
- Structural and nonstructural controls
- Locations where offsite flows enter the site
- Discharge locations
- Existing vegetation and limits of clearing
- Erosion and sediment control measures (include proposed sediment basins) and proposed locations
- Proposed post-construction stormwater management measures
- Off-site soil tracking prevention devices

Land disturbance contractors have the task of "molding" existing terrain into a final product for their client. At the same time, they have to complete their construction activities in a manner that meets FDEP, EPA, and other regulatory agency requirements for protecting waters of the United States. Therefore, it is recommended that Designers include the following when developing E&SC drawings:

- A Title Sheet that provides general information about the site including a general location map with sufficient detail to identify the construction site location and waters of the United States within one mile of the site. Also included should be a preliminary schedule for implementation of sediment and erosion control BMPs.

- Pre Grading drawings that illustrate existing site conditions and identify major discharge points, names of the receiving water(s) for each point, and show where to install structural (i.e. sediment control) measures before construction activities begin.
- During Grading drawings that illustrate what happens while land modifications activities occur. These sets of drawings evolve from project grading plans and must demonstrate the implementation of structural (i.e. sediment control) methods while major grading activities occur. In addition, references to non-structural (i.e. erosion control) BMPs found on After Grading drawings are to occur.
- After Grading drawings that illustrate the implementation of sediment and erosion control measures after grading activities are completed. It is on this set of plans where non-structural measures are depicted that are to be implemented while construction activities occur.
- Typical Detail and Specification drawings that provide the contractor with visual concepts of what is to be installed to reduce sediment from leaving a construction site as well as the type of erosion control methods that are to be used.

Designers may find that combining Pre- and During Grading drawings is feasible and may be acceptable to regulatory agencies. *However, except perhaps for very small projects, combining all three construction plans into a single drawing is discouraged because of legibility.*

Construction details, often in large-scale drawings, provide key dimensions and spatial information that will not fit on the E&SC drawing or site map. Other important information also should be provided such as specifications for planting seed, mulching, sediment barriers, erosion control materials, installation procedures, inspection requirements, and maintenance instructions. Detailed information and explanation about construction site BMPs can also be found in FDEP's manual at http://www.dep.state.fl.us/water/nonpoint/ero_man.htm.

In addition to the above, designers will include within the E&SC drawings, guidelines for development of concrete washout areas and how storage of hazardous waste materials will occur. Criteria for concrete washout areas may include (but is not limited to) the following items:

- Shallow excavations lined with a material to prevent infiltration of washout material
- A soil tracking prevention device (see Section V) at the access point
- Signs throughout the construction site identifying the location
- Development of a containment structure
- Maintenance and termination plan

Designers should be innovative and consider other alternatives such as portable containment units, using washout material as part of driveways, and so forth.

Criteria for storage of hazardous waste material (e.g. petroleum products, pesticides, or paints, etc.) are more stringent and may include (but not be limited to) the following items:

- Development of temporary containment facilities that are away from water bodies and include sufficient spill containment areas and impervious surfaces
- Maintenance of temporary containment facilities against rainfall and spills
- Proper drum storage
- Location of where cleaning of paint related equipment is to occur

- Refueling stations
- Labeling waste containers
- Disposal procedures
- Procedures for reporting spills

For those having expertise on sediment and erosion control methods, this Designer manual provides summary information and illustrations of BMPs commonly found on land development, linear, and vertical/big box construction sites. As a summary, the remaining sections of this manual include the following:

- Section III provides information and drawings about erosion control methods and includes the following topics:
  - √ Runoff control structures such as diversion dikes, slope drains, and channel check structures
  - √ Vegetation topics such as staging, filter strips, and seeding requirements
  - √ Importance of mulches, soil binders
  - √ Selecting and installing RECPs on hillsides and in drainage channels
- Section IV discusses what is needed for the design of SCSs (a.k.a. sediment ponds, basins, and traps) and includes:
  - √ Criteria for containment of design size suspended particles
  - √ How to increase the efficiency of SCSs
  - √ Criteria for development of pre-sedimentation (a.k.a. forebay) basins
- Section V presents information on, and limitations of, commonly found sediment control BMPs that remove limited amounts of sediment from runoff waters. Specific topics include:
  - √ Uses of silt fence barriers
  - √ Information on using check structures and wattles
  - √ Methods for reducing sediment discharging into area (a.k.a. catch basin) drains
  - √ Methods for reducing sediment discharging into curb inlet drains

Designers need to remember that they are developing E&SC drawings for contractors to implement. In addition, reviewers, inspectors, and contractors must remember that E&SC drawings are only a "first appraisal" as to what is needed for reducing sediment in runoff waters and minimizing erosion. Consequently, Designers need to clearly indicate throughout the SWPPP and E&SC drawings, that these documents will require updating and modification while construction activities occur.

Record Requirements

The last part of a SWPPP involves keeping good inspection records. Record keeping is one of the most critical components of SWPPP requirements. Consequently, FDEP (and EPA) expects the contractor to complete the necessary record keeping tasks in a regular and expedient manner *while construction activities are occurring.*

1. Contractors must record the following dates:
   a) When major grading activities occur
   b) When construction activities temporarily or permanently cease on a portion of the site
   c) When stabilization (i.e. erosion control) measures begin

2. Contractors are to provide qualified inspectors who have knowledge and experience in the principles and practice of sediment and erosion control and can complete project site inspections:
   a) At least once every seven (7) days
   b) Within 24 hours after the end of a storm event of 0.50-inches or more
3. Contractors are encouraged to provide a Designer responsible for evaluating and inspecting the construction site at least once every 30 days while activities are occurring. This individual will be responsible for developing and signing their inspection report upon completion of site visits.

Reports for each inspection are to be part of the SWPPP records while construction activities occur and are to include certification about compliance and non-compliance issues found. In addition, those that have signed the NOI application are to retain reports for at least three (3) years from the date permit coverage expires or terminates. Appendix IV contains suggested inspection forms.

SWPPP and E&SC Drawing Update Requirements

The SWPPP is a dynamic document containing a set of sediment and erosion control drawings that provide a first appraisal of where to install BMPs on construction sites. Consequently, Designers need to clearly indicate in the SWPPP and accompanying E&SC drawings that they must be revised within seven calendar days following an inspection when additions and/or modifications to BMPs are necessary to correct observed problems. Revisions should occur:

- Whenever a change in the design, construction, operation, or maintenance at the construction site has a significant effect on the discharge of pollutants to the waters of the United States not previously addressed in the document.
- Whenever discharges are causing water quality "exceedance" (an EPA term) or the BMPs are ineffective (to an extent practical) in minimizing pollutants in stormwater discharging from the construction site.

It is expected that the operator's inspectors and Designers will work together to ensure updates occur in a timely manner.

DEVELOPING EFFECTIVE E&SC DRAWINGS

There are many ways to develop E&SC drawings, all of which require Designers to address the following questions:

1. For **WHOM** is the plan being written?

   Drawings must be readable, practical, and easily understood for use by contractors.

2. **WHO** is going to develop the plans?

   Designers must have the skills and qualifications to understand what is required for effective sediment and erosion control.

3. **HOW** will the plan be implemented?

   Sufficient guidelines and illustrations must appear on the plans to ensure contractors doing land disturbance activities understand what BMPs to install, inspect, and maintain for Pre-, During, and After Grading conditions.

4. **WHEN** will the plan be implemented and inspected?

   Plans must contain sufficient information to demonstrate when installation of BMPs should occur and provide guidelines for their inspection and maintenance.

5. **WHERE** will BMPs be installed?

   All E&SC drawings must identify to contractors those approximate locations where installation of BMPs is to occur while land disturbance activities are occurring.

6. **WHY** are plans being developed?

   Designers must understand that they are developing plans so that contractors will be able to protect the environment while construction activities occur. In addition, the E&SC drawings need to demonstrate competency to regulatory personnel reviewing the plans.

7. **WHAT** has been developed?

   Designers, contractors, and regulatory personnel must understand that E&SC drawings only provide a conceptual illustration as to how to reduce sediment in runoff waters and minimize erosion. Changes to the E&SC drawings must occur during the construction process.

The Importance of Pertinent Data

Locating and reviewing data are essential for understanding what is required for effective control of sediment and erosion and developing an effective E&SC drawing. Consequently, Designers are expected to collect, interpret, and evaluate data about the construction site.

Collecting Data

Regulatory agencies expect that E&SC drawings reflect a Designer's expertise and professional skills by demonstrating that data collected includes at least the following items:

- Climate and rainfall data
- Soils data
- Existing and new vegetation requirements
- Location of critical areas
- Potential water quality problems and how they will be addressed
- Existing drainage channels
- Hydrologic characteristics of the site
- Topographical mapping

Interpreting and Evaluating Data

Development of effective E&SC drawings requires Designers to understand runoff flow patterns, soil erodibility, vegetation establishment requirements, and potential impacts to downstream properties. Thus, it is important that identification of the following hydrologic characteristics for contributing drainage basins occur:

1. Drainage divides within the construction site boundaries
2. Historic and developed flow patterns
3. Identification of offsite drainage conditions that may impact the project site
4. Major basin discharge points

5. Existing natural drainage ways

In addition to the above, it is suggested that volume and peak flood flows for 2-year, 24-hour storm events also be provided so that proper design of SCSs can occur.

Another essential part of an effective E&SC drawing is identifying "critical" areas, including (but not limited to):

1. Highly erodible lands within the project area
2. Wetlands and riparian areas
3. Threatened or endangered wildlife and plants
4. Known contaminated sites (e.g. fuel storage facilities, waste stations, etc.)
5. Historic sites
6. Fishery and spawning streams
7. Waters impaired by pollutants

Evaluating soils and existing vegetation must occur to develop historic data for comparison with final reclamation of the site. When possible, Designers need to assess the following parameters before construction activities begin:

- Topsoil and subsoil materials nutrient levels
- Location of highly erodible soils
- Existing vegetative species identification (e.g. grasses, forbs, shrubs, and trees)
- Vegetative re-establishment criteria

Developing Effective E&SC Drawings

Once construction site data and information is interpreted and evaluated, results must become part of practical and realistic plans. Readers of this manual are encouraged to review examples of E&SC drawings found in Appendix V for linear and vertical/box projects.

<u>Title Sheet</u>

As part of the sediment and erosion control drawings, a title sheet shall be prepared that illustrates at least the following general information about the construction site:

1. Project Name,
2. One quarter Section, Township, Range
3. Project location illustrated on a USGS quadrangle map (scale of 1" = 2,000' or smaller)
4. Contractor commitments along with accompanying signature
5. Preliminary schedule of activities
6. Index to the sheets
7. Signed and stamped (if appropriate) by a designer who is acceptable to the reviewing agency

Located within Appendix IV is a template for developing a preliminary schedule of activities that Designers may find to be helpful. Contractors need to adhere to the intent of a preliminary schedule since it provides guidelines for regulatory agencies to complete their inspections.

Pre Grading Drawings

Perhaps the most important set of drawings are those that clearly identify to contractors what to install *before* major construction activities begin. These "Pre Grading" drawings must illustrate what and where to initially install sediment control measures that ensure minimal runoff impacts to adjacent properties or water bodies when land disturbance activities begin. More than one drawing may be needed.

Pre Grading drawings shall contain detailed drawings using an adequate scale that clearly illustrate the project site as well as include a north arrow, legend, date, elevation datum, and so forth. In addition, each Pre Grading drawing shall include at least the following information:

1. Project boundaries.
2. Existing (do not include proposed) contours throughout, *and at least 50 feet outside the perimeter of*, the project site. Suggested contour intervals are 0.5- to 2-feet apart, but others may be necessary to ensure clarity of the plan.
3. Existing topographic features (streams, ponds, wetlands, roads, existing drainage channels, existing buildings, where offsite flows enter the property, and so forth) throughout, *and at least 50 feet outside the perimeter of*, the project site.
4. Existing types of vegetation throughout, *and at least 50 feet outside the perimeter of*, the project site.
5. Existing drainage basins and flow arrows illustrating runoff patterns within the project site.
6. Identifying different disturbance phases of the project site.
7. Location of sensitive areas and (if appropriate) existing problems within the project site.
8. Identifying approximate locations of where to install structural (i.e. sediment control) BMPs *before* construction activities begin. For some agencies, it may be necessary to illustrate "Owners Pay Item Structure" for the BMPs (see Appendix V).
9. Minimum requirements for inspection and maintenance of BMPs.

One of the important tasks to complete with pre grading drawings is for designers to identify where water flows through the project and where critical discharge points exist. It is at these locations that significant flows can enter a water body and carry sediment onto downstream locations. As indicated earlier, latitude and longitude values are necessary for critical discharge points. The next (i.e. during grading) drawings must illustrate how discharges at the critical discharge points are addressed.

Notice that the Pre grading drawings illustrate only existing land contours. By not combining existing and future contours, the contractor can properly assess the site for selecting and implementing sediment control BMPs. Final land contours will be illustrated on After Grading drawings, and may be required for During Grading drawings.

The E&SC drawings need numerous notes and "leaders" to inform contractors as to what is expected for minimizing impacts to the environment while construction activities occur (see example in Appendix V). Also, it is important to identify when part of a site is not to be immediately disturbed, illustration of sediment control measures to install are still shown. However, the contractor needs only to install and maintain those BMPs illustrated for lands where immediate disturbance activities occur.

Lastly, Designers, contractors, and regulatory agency personnel must understand that items identified on Pre Grading drawings are <u>only a preliminary assessment</u> of what may be required. Modifications to the drawings will be necessary while construction activities occur. Finally, Designers are encouraged to explore relevant updates with the contractor and regulatory agencies.

<u>During Grading Drawings</u>

The primary goal of any E&SC drawing while construction activities are occurring is to have clear illustrations for the contractor to install and maintain BMPs that ensure optimal treatment of concentrated runoff waters as land disturbance activities happen. This means that the Designers must clearly illustrate on their drawings what methods to install at critical discharge points to treat runoff while major land disturbance activities occur.

Grading of the land requires many different tasks to be completed simultaneously. In addition to major land disturbance, installation of storm sewer systems, development and paving of roads, grading land for building pads, and numerous other construction activities occur. It is for this reason that designers need to develop easy-to-read and effective During Grading drawings for the contractor of sediment and erosion control measures to implement, inspect, and maintain. Like Pre Grading plans, more than one drawing may be required.

During Grading plans shall contain detailed drawings using the same scale as pre grading plans to clearly illustrate the project site as well as include a north arrow, legend, date, elevation datum, and so forth. In addition, During Grading drawings shall include at least the following information:

1. Project boundaries and limits of soil disturbance.
2. Existing (<u>try not to include proposed, if feasible</u>) contours throughout, *and at least 50 feet outside the perimeter of*, the project site. Suggested contour intervals are 0.5- to 2-feet apart, but others may be necessary to ensure clarity of the plan.
3. Boundaries for undisturbed riparian buffer strips.
4. Extent of construction lines within which major land disturbance activities are to occur along with historic flow arrows.
5. Outline of the project footprint that illustrates boundaries, roads, layout, and so forth.
6. Identifying approximate locations of where to install structural (i.e., sediment control) BMPs *while* construction activities occur. For some agencies, it may be necessary to illustrate “Owners Pay Item Structure” for the BMPs (see Appendix V).
7. Identifying approximate locations of where to install nonstructural (i.e., erosion control) BMPs while construction activities are occurring (reference to After Grading drawings may be necessary). For some agencies, it may be necessary to illustrate “Owners Pay Item Structure” for the BMPs (see Appendix V).
8. Notes that indicate the contractor’s responsibility for locating and reporting where (as well as where not) topsoil stockpiles, staging areas, equipment storage, refueling/maintenance areas, and disposal areas are to exist.
9. Minimum requirements for inspection and maintenance of BMPs.

During Grading drawings illustrate to the contractor critical “containment” contours to ensure that optimal treatment of runoff from the disturbed lands will occur. Essential to this process is to illustrate on During Grading drawings what BMPs to install at critical discharge points. This means Designers must develop their drawings so that contractors can clearly envision the BMPs to install for major grading activities (see example in Appendix V).

As with Pre Grading drawings, Designers, contractors, and regulatory agency personnel must understand that During Grading drawings are <u>only a preliminary assessment</u> of what BMPs may be required. Modifications to the drawings may be necessary while construction activities occur and Designers are encouraged to explore relevant updates with the contractor and regulatory agencies.

<u>After Grading Drawings</u>

Contractors also need a set of drawings that clearly illustrate how the site will appear After Grading activities are completed. Special consideration may be needed for each of the four (i.e., large land, linear, vertical, and big box) different types of projects. These drawings will also need instructions on removing unnecessary sediment control measures (see example in Appendix V).

One of the main purposes of After Grading drawings is to illustrate where to install erosion control practices for final stabilization of the disturbed lands. Included on these plans are such items as installing sod, planting seed, applying mulch, swale protection, hillside BMPs, and so forth. Another important aspect of After Grading drawings is to clearly illustrate what must occur while building activities happen. As with the previous drawings discussed, more than one drawing may be required.

After Grading plans shall contain detailed drawings using the same scale as Pre Grading plans. In addition, all plans must clearly illustrate the project site as well as include a north arrow, legend, date, elevation datum, and so forth. Finally, After Grading drawings shall include at least the following information:

1. Project boundaries and adjacent lands.
2. Proposed (<u>do not include existing unless topography does not change</u>) contours throughout, *and those existing at least 50 feet outside the perimeter of*, the project site. Suggested contour intervals are 0.5- to 2-feet apart, but others may be necessary to ensure clarity of the plan.
3. Developed basin drainage boundaries and accompanying flow arrows.
4. Boundaries for undisturbed riparian buffer strips.
5. Outline of the project footprint that illustrates lot boundaries, roads, layout, and so forth.
6. Illustrations of where re-establishment of permanent vegetation on disturbed lands are to occur. For some agencies, it may be necessary to illustrate “Owners Pay Item Structure” for the BMPs (see Appendix V).
7. Illustrations where installations of other erosion control measures (e.g., riprap, RECPs, etc.) are to occur. For some agencies, it may be necessary to illustrate “Owners Pay Item Structure” for the BMPs (see Appendix V).
8. Instructions on removing unnecessary sediment control (e.g., silt fence barriers) BMPs once 70% vegetative cover and/or other stabilization measures exist.
9. Minimum requirements for inspection and maintenance of erosion control BMPs.

When final contours of a site are not available, regulatory agencies may waive what is required in Item No. 2. When such a waiver is granted, spot elevations will be necessary to clearly illustrate high points, flow directions and so forth.

Lastly, Designers, contractors, and regulatory agency personnel must understand that items identified on After Grading drawings are <u>only a preliminary assessment</u> of what may be required. Modifications to the drawings may be necessary while construction activities occur and Designers are encouraged to explore relevant updates with the contractor and regulatory agencies.

<u>Typical Detail and Specification Sheets</u>

Contractors need to install, inspect, and maintain BMPs in a manner that will be effective in removing sediment from runoff waters and minimize erosion. Designers need to provide adequate information about the details so that the contractor can visualize what needs to be installed. This means keeping wording about BMPs on a specification sheet to a minimum. Instead, let the details provide basic information for the contractor about BMPs.

Appendix V illustrates an example of how details and specifications may appear. Do not clutter these sheets with meaningless information and material. Illustrate only those BMPs that are pertinent to the project and recommended to be installed on construction sites as shown on the E&SC drawings. However, do not limit the contractor from installing other BMPs when regulatory agencies and/or the designer give approval for their use and implementation.

<u>Miscellaneous Comments</u>

Perhaps the greatest fallacy that Designers and contractors have with designing and implementing a SWPPP and E&SC plan, respectively, lies with their over-reliance on sediment control BMPs. The only <u>structural</u> practice to effectively reduce sediment in runoff from construction sites is a properly designed SCS (a.k.a., sediment basin, pond, or trap) that treats a majority of site stormwater. Failure to minimize sediment leaving a construction site will be the norm when relying solely upon sediment barriers, such as silt fences or rock barriers, in front of inlets.

While ineffective sediment barriers may be the only alternative BMP to consider, they must be viewed as being only a temporary mitigation measure. Designers need to strategically place notes on their E&SC drawings that alert contractors to their obligation of implementing cost effective and practical erosion control practices <u>*while grading and construction activities occur*</u>. Examples of such practices might include (but not be limited to) applying sod, planting temporary or perennial grass seed, applying mulch and/or soil binder, installing inexpensive erosion control blankets, and so forth.

Finally, Designers need to impart the message that E&SC drawings are (at best) only an estimate of what needs to be done on the construction site. It is for this reason that contractors need to be aware that E&SC drawings are subject to additional, new and alternative BMPs when requested or approved by the Designer and/or regulatory agency.

<u>E&SC Drawing Summary</u>

Some of the more important items Designers need to consider when developing their E&SC drawings include:

- Remember that development of E&SC drawings are for the contractor.

- Research existing conditions of the site, including drainage patterns, inflow and outflow locations for runoff, soils, sensitive areas, and so forth.
- Use only existing contours on Pre- and (if feasible) During Grading drawings.
- Use only proposed contours and/or spot elevations on After Grading drawings.
- After grading, drawings may need to include sufficient information about the use of BMPs while building activities occur.
- Include sufficient notes and leaders about the BMPs.
- Provide accurate and complete detail drawings and simple specifications.
- Identify inspection and maintenance requirements.

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SECTION III

EROSION CONTROL METHODS

Table of Contents

Summary Sheets for Erosion Control BMPs

Table of Figures and Tables

Introduction

Sediment control practices remove some, but rarely all, particles suspended in runoff waters. It is for this reason that erosion control practices are an essential part of any E&SC plans to minimize the forces of raindrops, concentrated flows, and wind from detaching and transporting soil particles. Examples of erosion control include:

- Maintaining, establishing, and using vegetation
- Applying and maintaining mulches
- Applying soil tackifiers
- Diverting and controlling runoff waters

Good erosion control practices result in good sediment control, yet the opposite is not true. Thus, sediment control practices should always be considered as *secondary* (yet sometimes the only) treatments for construction sites. More importantly, as the effectiveness of erosion control practices increases, the need for sediment control will diminish. Hence, it is important for Designers to clearly identify to contractors through their E&SC drawings that stabilization of disturbed lands must occur as construction activities happen.

USE OF VEGETATION

The optimal erosion control practice is to maintain existing vegetation or when lands are disturbed, establish new vegetation. As with check dams, vegetation can serve two purposes, namely, capture sediment and minimize erosion. Additional information on coastal vegetation appears in Appendix I.

Maintaining Established Vegetation

One of the most effective methods for minimizing erosion is to only disturb areas immediately needed for construction. By "staging" land-disturbance activities, existing vegetation reduces the potential for sediment generation due to erosion of bare ground. Existing vegetation also provides “buffer strips” to remove suspended particles from sheet flows. This is important when construction activities occur near watercourses.

When possible, existing vegetated drainage channels should not be disturbed during initial land clearing stages of a project. Leave these drainage channels stabilized until the new drainage system is in place or until the earthwork phase of the project precludes their continued use and a temporary drainage system is established.

Vegetative Filter Strips

Vegetative Filter Strips (VFS) are examples of what can be done for sediment and erosion control. When flows pass over and through these strips, large suspended particles (e.g. sands and silts) settle within a short distance. Finer particles (e.g. clays) are carried the furthest before settling and may stay suspended if runoff velocity remains high.

The following provides a summary of VFS ability to reduce sediment in runoff waters:

- They can effectively remove sediment in runoff water when *shallow or sheet flow* conditions exist or ponding can occur. Some reduction of sediment may occur for concentrated flows.

- As sediment accumulates on the strips, they become less effective; however, with slow accumulations, grass re-growth may restore the filtering capacity.
- Larger diameter particles (sands and silts) are removed first. Small particles (e.g. clays) settle more slowly and may experience limited removal due to strip width and flow rates.

It is recommended that VFS have a minimum width of 25 feet. However, widths may be dependent upon site conditions and local regulatory requirements. Also, when Designers recommend this form of sediment control, they must clearly identify the need for continual maintenance of the strips.

Establishing Vegetation

The most efficient and economical method for controlling erosion and minimizing sediment yields is to establish a vegetative cover. Two common methods used in Florida are to place and establish sod on disturbed lands or plant seed.

<u>Sod</u>

Sod provides a quick and relatively inexpensive method for establishing vegetation, but can be very labor intensive. While sod planted on a disturbed slope provides nearly instantaneous vegetation establishment, it cannot be classified as a success within drainage channels until root establishment.

<u>Permanent Vegetation</u>

Designers may find that it is more economical and practical to establish vegetation by planting seed rather than using sod. Permanent vegetation usually requires a perennial grass or legume to be used. Whenever possible, Designers should specify plant species that are native to the local area. Permanent vegetation is recommended for:

1. Final graded or cleared areas where permanent vegetative cover is needed to stabilize the soil.
2. Slopes designated to be treated with erosion control blankets.
3. Drainage channels or waterways designed to be protected with channel liners.

<u>Temporary Vegetation</u>

Rapidly growing annuals and legumes are examples of temporary vegetation recommended for disturbed lands that:

1. Will not be brought to final grade within seven (7) days or are likely to be re-disturbed.
2. Require seeding of cut and fill slopes under construction.
3. Require stabilization of soil storage areas and stockpiles.
4. Require stabilization of temporary dikes, dams, and sediment containment systems (SCSs).
5. Require development of cover or nursery crops to assist with establishment of perennial grasses.

Examples of temporary vegetation include wheat, oats, barley, millet, and Sudan grass.

Planting Seed

Advantages of planting seed to establish vegetation include:

- Low initial costs
- Reduction of expenses associated with sediment control
- Low labor requirements
- Ease of establishing vegetation in difficult areas

Some disadvantages of planting seed are:

- The potential for erosion exists during the establishment stage
- The potential exists for the need to re-seed areas that fail
- Sufficient moisture conditions might not exist in a timely manner for germination of the seed

Seed selection may involve warm season, cool season, or a combination of both types of grasses. Usually, Florida will use warm season grasses that prefer warmer climatic and soil conditions to germinate. Cool season grasses germinate under cooler climatic and soil conditions.

Pure Live Seed Rates vs. Bulk Rates

Not all seeds applied on bare ground will germinate. Likewise, seed-harvesting techniques do not result in the capture of a single grass species. Thus, Designers should express seed specifications as pure live seed (*PLS*) rather than in only bulk rates. The following equation illustrates how to calculate the percentage of *PLS* in a seed mixture:

$$\boldsymbol{PLS\ (\%) = [\text{purity}\ (\%) \times \text{germination}\ (\%)]} \qquad \textbf{Equation 1}$$

For example, if a specific seed is tagged as being 95% pure with an 81% germination rate, then the *PLS* = 95% × 81% = 77.0%.

Another way to specify seed mixture application rates is to use "bulk rates." However, bulk rates do not provide information on seed purity and germination rates. When bulk-rate application rates are specified, they are calculated by the following equation:

$$\textbf{Bulk Rate} = \boldsymbol{PLS}\ \textbf{Rate} \div \boldsymbol{PLS}\ \textbf{Percentage} \qquad \textbf{Equation 2}$$

Thus, if the PLS application rate of the above seed is 25.4 *lbs./ac*., then the bulk rate is 25.4 *lbs./ac*. ÷ 77.0% = 33.0 *lbs./ac*.

Additional information of selection of species and their application rates can be found from local Natural Resource Conservation Service (NRCS), regulatory agencies, and through seeding and mulching companies.

Methods of Planting Seed

One or more of the following methods can be used to plant seed:

1. Drill
   a) Seed is in direct contact with the soil
2. Broadcast
   a) Seed is on top of the ground.

b) Raking is required to ensure seed is covered with soil.
c) Application rate of seed is 2x to 4x times the drilled rate.

3. Hydraulic
    a) Seed is part of the slurry mixture applied on the soil.
    b) Application rate of seed is 5x to 6x the drilled rate.

Polymer Enhanced Soil Stabilization

If there is a requirement for increased erosion protection of disturbed slopes, Designers can consider adding polymers to the soil before applying soil binders, mulch, or erosion control blankets (see below).

Polymer additions can assist in the temporary or permanent establishment of grass by binding the seed, fertilizer, mulch, and soil together until germination happens. However, it is important that dosage rates be determined based upon site conditions (see Appendix III for more information).

Polymer dosage rates will vary with site-specific applications along with water and soil requirements. Using information found in Appendix III, the following rates might be applicable once site-specific conditions have been evaluated:

SOIL TYPE	**SLOPE IS LESS THAN 1V:3H**	**SLOPE IS 1V:3H TO 1V:1H**
HIGH CLAY CONTENT	10 TO 20 LBS/ACRE	20 TO 35 LBS/ACRE
HIGH SAND CONTENT	15 TO 20 LBS/ACRE	25 TO 50 LBS/ACRE

It is important that Designers work with professionals that are experienced in using polymers on construction sites. In this manner, potential environmental problems can be professionally addressed and problems avoided.

Mulches

Mulches are applied over the soil surface to reduce erosion from rainfall and wind. They are also used to aid the establishment of vegetation. Some typical uses for mulches include:

- Reduce soil erosion by wind and raindrop impact through temporary soil stabilization
- Providing cover until vegetation can be established
- Adding soil amendments such as organic matter and fertilizers
- Improving soil structures
- Decrease the velocity of runoff over exposed soil areas, which increase the infiltration of water

Mulches can be used alone (usually temporarily) as a protective blanket on the soil. However, it is best to plant seed prior to any application of mulch. In this manner, vegetation will become available for erosion protection. Additional information on using mulches within coastal areas appears in Appendix I.

All mulches have limitations. For example, they are not suitable for areas with high tidal fluctuations, heavy wave action or where concentrated flows exist. In addition, some materials are susceptible to removal or disturbance by wind in exposed areas.

Successful use of dry or hydraulic mulches is dependent upon a rapid establishment of vegetation. Once vegetation becomes well established, and minimal amounts of weeds are present, erosion protection is provided by the vegetation root system and canopy cover.

Dry Mulches

Mulches can be classified as "dry" or "wet" products. Dry mulches usually consist of organic or inorganic materials, whereas wet mulches are applied with hydraulic equipment and also consist of organic materials.

Dry mulches can consist of:

- Certified noxious weed free straw or hay
- Compost materials, including wood or bark chips
- Rolled Erosion Control Products (RECPs)
- Rock

The standard application rate of straw/hay mulch is about 2.0 tons/acre with 80% to 100% ground coverage of material having minimum fiber lengths of 6.0- to 8.0-inches. Dry mulches must be held in place, usually by crimping, which forces, or punches, fibers into the ground by use of a weighted disk.

When straw/hay mulch fibers are short, anchoring material by crimping usually will not occur and removal by wind happens. A tackifier can overcome some wind removal problems by "gluing" the fibers together. However, strong winds could still remove sections of tackified dry mulches.

Compost Materials

A cost-effective method of developing dry mulch is to shred existing vegetation during clearing activities. This type of mulch, also known as compost material, can include:

- Dry straw/hay
- Wood chips, bark, cellulose fiber, or excelsior
- Other vegetative trimmings such as grass, shredded shrubs, and trees

An advantage of compost material is that vegetation removed during grading activities can be quickly ground or shredded and immediately applied onto disturbed lands. Thus, mulch is available during and after grading activities and may contain seeds of local grasses, bushes, and trees.

Unless there are some undesirable species in the compost material, it can often be applied adjacent to the soil/water interface. However, one possible limitation about compost is that it may contribute to water quality degradation. For example, it is possible that the introduction of organic (tannic) acids and dissolved organic carbon from decaying plant material to nearby coastal water bodies can occur.

Hydraulic Mulches

Hydraulic mulches have an advantage in that they can cover the ground but do not have to be crimped as with dry mulches. They are a mixture of shredded wood, paper, or corn stalk fiber and often include a stabilizing emulsion, tackifier, or polymer that can be applied with specialized equipment. However, without a "tackifier" to help bind the material, hydraulic mulches are susceptible to removal by precipitation and runoff.

The standard application rate of hydraulic mulches is 1.5 tons/acre. As with straw or hay, it is important that 80% to 100% ground coverage by material occurs.

Soil Binders

When dry mulch cannot be crimped, other methods to control erosion or hold fibers in place must be used. Soil binders and tackifiers have been developed to accomplish this task with examples including:

- Tackifying straw or hay mulches
- A component of hydraulic mulches and matrices
- Dust-control products

An excellent use of soil binders is to temporarily stabilize cut and fill areas. These low-cost erosion control products provide an effective, temporary method to reduce sediment leaving construction sites. However, soil binders should not be depended upon for more than three to six months as an erosion control practice. Also, they do not replace the need for permanent vegetation establishment by planting seed and mulching.

Rolled Erosion Control Products

Rolled Erosion Control Products (RECPs) are manufactured mulch materials used to protect disturbed soils from erosion. They are also known as erosion control blankets or mats. All RECPs reduce the erosion process and create conditions to assist in establishing vegetation. They also allow for increased infiltration, conserve soil moisture, and help keep seed in place.

RECPs are composed of organic and/or inorganic materials. Organic materials are subject to both biological- and photo-degradation processes. Thus, they may degrade within three to 12 months. The inorganic materials may or may not be photodegradable and are less susceptible to the degradation processes. Examples of RECP materials include the following:

- Straw
- Coconut and related fibers
- Wood excelsior
- Jute
- Polypropylene
- Nylon

In addition to the above materials, combinations of different material can be used (e.g. straw and coconut).

All RECPs require a method to keep the material in place. Usually, this consists of a polypropylene netting place on one or both sides of the material. Designers should evaluate the use of “net less” blankets or those RECPs using degradable netting that break down within specific project requirements.

RECPs for Disturbed Slopes

Significant reduction of erosion and good establishment of vegetation on disturbed slopes will occur by using properly installed RECPs. When establishing vegetation on disturbed slopes, organic RECPs are usually used. However, there may be situations where inorganic materials will be required.

Figure III-1 provides guidelines for selecting RECPs for disturbed slopes based upon criteria developed by the Erosion Control Technology Council (ECTC). Detailed information about the different types of products appears after Figure III-1.

While additional information is presented about the different types of RECP products, Designers are encouraged to obtain and review more detailed material found on the ECTC web site by accessing www.ectc.org.

Disturbed Slope (V:H)

	1:5	1:4	1:3	1:2	1:1.5	1:1	1:0.5
< 3	TYPE 1a	TYPE 1b	TYPE 1c	TYPE 1d			
3 - 12	TYPE 2a	TYPE 2b	TYPE 2c	TYPE 2d			
12 – 24	TYPE 3a	TYPE 3b	TYPE 3c	TYPE 3d	TYPE 3d		
24 – 36	TYPE 4a	TYPE 4b	TYPE 4c	TYPE 4d	TYPE 4d	TYPE 4d	
>36	TYPE 5 a,b,c						

Figure III-1: Disturbed Slope RECP Selection Guide (ECTC, 2004 and latest edition).

- Type 1 products are lightweight and typically are composed of single/double net straw or excelsior material, as well as jute.
- Type 2 products are more durable than Type 1 products and typically may be composed of single/double net straw or excelsior material, as well as jute.
- Type 3 products are more durable than either Type 1 or Type 2 products and typically may be composed of double net straw, straw-coconut, coconut, and excelsior, as well as jute.
- Type 4 products are expected to remain a viable erosion control material for long durations. .
- Type 5 products are expected to have long-term functional longevity and are typically composed of polyolefin fibers, polypropylene, and nylon. Some products may be excelsior or a combination of polypropylene and straw-coconut/coconut material.

Some typical examples of the letter designation are:

1a, 2a, 3a – "netting only" used over Mulch (synthetic or natural) with 3, 12, or 24 month life.

1b. 2b – “net less” Erosion Control Blanket – usually 3or 12 month life.
1c, 2c - Single Net Erosion Control Blanket or Open Weave Textile – 3 or 12 month life.
1d, 2d - Double Net Erosion Control Blanket - 3 or 12 month life.
3b - Double Net Erosion Control Blanket or Open Weave - 24 month life.
4 - Double Net Erosion Control Blanket or Open Weave - 36 month life.
5a, 5b, 5c - Permanent Erosion Control Blanket - 6, 8, or 10 lb/sf shear stress limits.

These designations may change with time and are subject to labeling practices, thus the users should consult the latest manufacturer and industrial standard publications when specifying a RECP. Additional information on installing disturbed slope RECPs appears in Figure III-2.

Rolled Erosion Control Product for a Disturbed Slope

WHAT IS ITS PURPOSE?

To protect disturbed slope surfaces against erosion due to rainfall or flowing water.

WHERE AND HOW IS IT COMMONLY USED?

- Installed on slopes or embankments.
- Where steep slopes exist.
- Used as mulch after seeding has occurred.
- Where vegetation is difficult to establish.

WHEN SHOULD IT BE INSTALLED?

- While construction activities are occurring.
- After Grading activities are finished.

WHEN SHOULD IT NOT BE INSTALLED?

- Over very rough ground having extensive amounts of rock, rills, or gullies.
- On slopes where weeds are established.

WHAT NEEDS TO BE INSPECTED?

- Does the RECP have any tears or other damage to it?
- Is water flowing under the blanket and causing erosion?
- Was it installed correctly?
- Did planting of seed occur before installing the RECP?
- Is the material secured to the slope with a sufficient number of staples?
- Was the top of material secured in a trench or by some other method?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of material.
- Repair of eroded ground.

NOTES

- RECPs are composed of natural material including straw, straw-coconut, coconut (or coir), wood excelsior, and so forth. They must be held in place with netting sewn on both sides of the material.
- Material must be placed in an uphill trench or adequately stapled.
- Additional information on RECPs can be found at www.ectc.org.

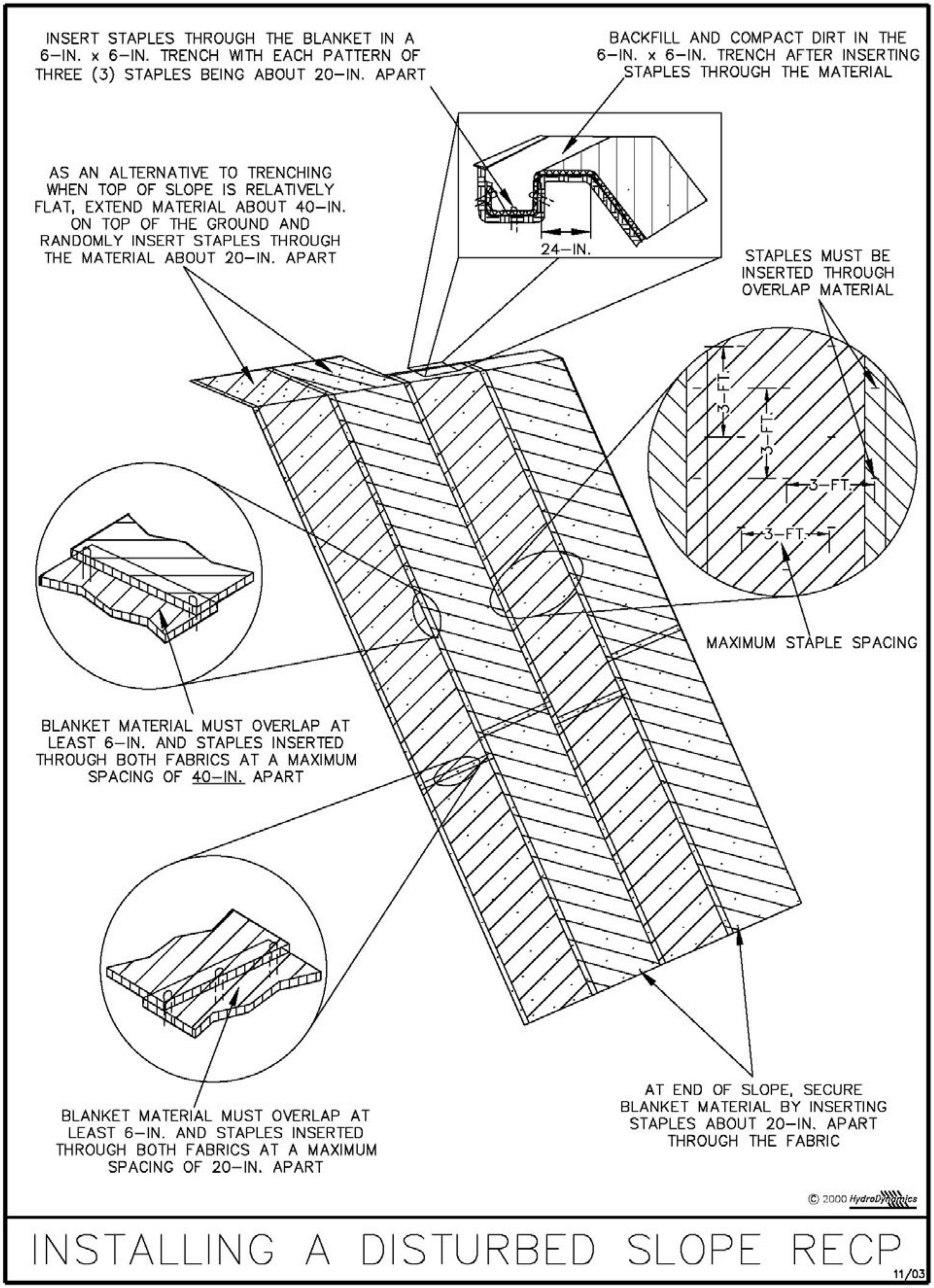

Figure III-2: Illustration of Installing a RECP on a Disturbed Slope

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Soft Armoring RECPs for Concentrated Flows

When water flows within roadside drainage ditches or into/out of culverts, intense hydraulic conditions exist that will cause erosion of stream embankments or channel beds. Similar hydraulic problems can occur with wave action on reservoir shorelines.

A common method used by Designers for protecting exposed soils against erosion is to install riprap, concrete structures, gabions or some other hard armoring. These methods have proven to be successful in controlling erosion of drainage channels and stream banks. However, "soft armoring" RECPs can provide an alternative to the traditional hard armors.

<u>Small Drainage Channel RECPs</u>

Vegetation usually provides the best method for reducing erosion in drainage channels. However, establishing vegetation in bare ground drainage channels is difficult when flows occur. Not only will the water remove seed and mulch, the kinetic energy of runoff causes erosion. Use of RECPs in channels may alleviate this problem.

Two types of RECPs can be used in drainage channels: Erosion Control Blankets (ECBs) and Turf Reinforcement Mats (TRMs). An ECB is the same organic material described previously for protecting hillsides against erosion. As with disturbed slope products, planting of seed must occur prior to installing the mat. The main purpose of an ECB is to provide temporary protection for grass seed to germinate and become established within the drainage channel. However, erosion problems may occur when the ECB deteriorates or is destroyed by high flows. It is for this reason that consideration needs to be given to using TRMs.

The EPA (1999) describes TRMs as being composed of interwoven layers of non-degradable geosynthetic materials such as polypropylene, nylon, and polyvinyl chloride netting, stitched together to form a three-dimensional matrix. A TRM can also consist of organic materials (e.g. coconut or straw) combined with geosynthetic products.

TRMs are thick and porous enough to allow for planting seed and filling with soil. In this manner, conditions will exist to allow for development of a root structure within the matrix. However, until the establishment of vegetation occurs, seed and soil may wash away due to runoff events. Planting seed directly onto the channel overcomes this problem.

Figure III-4 illustrates installation procedures for ECBs and TRMs in drainage channels.

<u>Selecting a RECP for Small Drainage Channels</u>

The most important item Designers need to consider in selecting an ECB or TRM is whether the product will be able to withstand anticipated shear stress forces and flow velocities. The following provides information on how this is determined.

Selecting a RECP for a small drainage channel (e.g. roadside ditch) requires proper evaluation of shear stress and flow velocity so that either an ECB or TRM is selected. Velocity of flows in channels can be calculated by use of Manning’s Equation.

$$\boldsymbol{V = (1.486 \div n) \times R^{2/3} \times S^{1/2}} \qquad \textbf{Equation 3}$$

where V = Mean velocity of flow (*ft./sec.*)

R = Hydraulic radius = A/WP (*ft.*)

WP = Wetted perimeter (*ft.*)

S = Slope of the energy gradient (*ft./ft.*)

n = Roughness coefficient

Table III-1 provides roughness coefficients for different types of channel materials and Figure III-3 can be used to calculate channel parameters having different geometric shapes.

Flow velocity is not the only parameter to calculate when selecting an ECB or TRM for stabilizing small drainage channels. Shear stress must also be evaluated since it represents the frictional forces of water. Maximum shear stress occurs on the bottom material of a channel and is represented by:

$$\boldsymbol{\tau_{max} = 62.4 \times Y \times S} \qquad \textbf{Equation 4}$$

where τ_{max} = Maximum shear stress (*lbs./ft.*^{2})

Y = Depth of water (*ft.*)

S = Slope of the energy gradient (*ft./ft.*)

Table III-2 provides permissible shear stress and flow velocities for different products and natural conditions.

Finally, Designers must remember that organic materials will biodegrade. Thus, selection of organic products must be based upon the maximum permitted shear stress values for *final vegetative conditions* rather than for the RECP material. However, it is important that any RECP selected be able to withstand anticipated shear stress and velocity until vegetation is established.

Additional information on selecting ECBs and TRMs in drainage channels can be found by accessing www.ectc.org or reviewing Fifield, 2004. An example of how to select a TRM or ECB appears in the example part of this section.

Table III-1: Manning's Roughness Coefficients for Various Materials (Fifield, 2004)

Material	Depth of 0 to 6 in.	Depth of 6 in. to 24 in.	Depth >24 in.
Bare soil[a]	0.023	0.020	0.020
Rock cut[a]	0.045	0.035	0.025
Gravel riprap[a]			
D50 = 1.0 inches	0.044	0.033	0.030
D50 = 2.0 inches	0.066	0.041	0.034
Rock riprap[a]			
D50 = 6.0 inches	0.104	0.069	0.035
D50 = 12 inches	----	0.078	0.040
Concrete[a]	0.015	0.013	0.013
Grouted riprap[a]	0.040	0.030	0.028
Stone masonry[a]	0.042	0.032	0.030
Soil cement[a]	0.025	0.022	0.020
Asphalt[a]	0.018	0.016	0.016
Fiberglass roving[a]	0.028	0.021	0.019
Straw (loose) covered with net[a]	0.065	0.033	0.025
EROSION CONTROL BLANKET			
Jute net[a]	0.028	0.022	0.019
Wood excelsior mat[a]	0.066	0.035	0.028
TURF REINFORCEMENT MAT			
Bare ground conditions[b]	0.036	0.026	0.020
Vegetation conditions[b]	0.023	0.020	0.020

a Chen and Cotton (1988)
b IECA (1995)

HYDRAULICS: ELEMENTS OF CHANNEL SECTIONS

Section	Area a	Wetted Perimeter p	Hydraulic Radius r	Top Width T
Trapezoid	$bd+zd^2$	$b+2d\sqrt{z^2+1}$	$\frac{bd+zd^2}{b+2d\sqrt{z^2+1}}$	$b+2zd$
Rectangle	bd	$b+2d$	$\frac{bd}{b+2d}$	b
Triangle	zd^2	$2d\sqrt{z^2+1}$	$\frac{zd}{2\sqrt{z^2+1}}$	$2zd$
Parabola	$\frac{2}{3}dT$	$T+\frac{8d^2}{3T}$ [1]	$\frac{2dT^2}{3T^2+8d^2}$ [1]	$\frac{3a}{2d}$
Circle - < ½ full [2]	$\frac{D^2}{8}\left(\frac{\pi\theta}{180}-\sin\theta\right)$	$\frac{\pi D\theta}{360}$	$\frac{45D}{\pi\theta}\left(\frac{\pi\theta}{180}-\sin\theta\right)$	$D\sin\frac{\theta}{2}$ or $2\sqrt{d(D-d)}$
Circle - > ½ full [3]	$\frac{D^2}{8}\left(2\pi-\frac{\pi\theta}{180}+\sin\theta\right)$	$\frac{\pi D(360-\theta)}{360}$	$\frac{45D}{\pi(360-\theta)}\left(2\pi-\frac{\pi\theta}{180}+\sin\theta\right)$	$D\sin\frac{\theta}{2}$ or $2\sqrt{d(D-d)}$

[1] Satisfactory approximation for the interval $0<\frac{d}{T}\leq 0.25$
When $d/T>0.25$, use $p=\frac{1}{2}\sqrt{16d^2+T^2}+\frac{T^2}{8d}\sinh^{-1}\frac{4d}{T}$

[2] $\theta=4\sin^{-1}\sqrt{d/D}$
[3] $\theta=4\cos^{-1}\sqrt{d/D}$
Insert θ in degrees in above equations

REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE H. H. Bennett, Chief ENGINEERING STANDARDS UNIT	STANDARD DWG. NO. ES-33 SHEET 1 OF 1 DATE 6-6-50

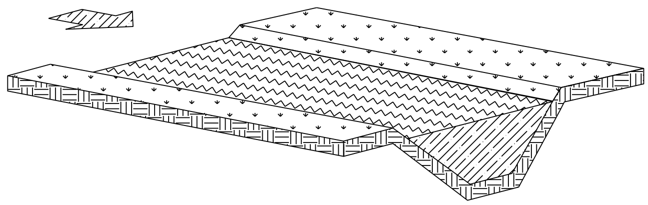
Figure III-3: Channel Cross-Section Equations (NRCS, 1950)

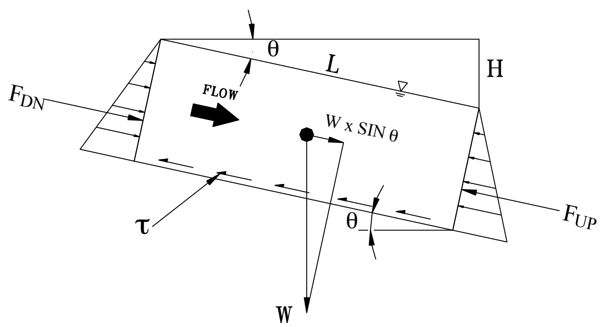
Table III-2: Permissible Shear-Stress Values and Velocities for Various Materials Note: there is a shear value for each product. (Fifield, 2004)

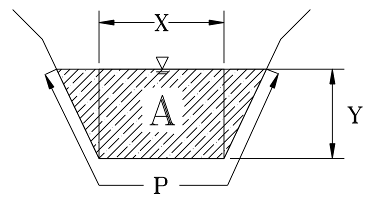
Material	Test Time (hr.)	Maximum Shear Stress (lbs./ft.^{2})	Maximum Velocity (ft./sec.)
Bare soil[a]			
Non-cohesive (Diameter = 0.004 to 4.0 in.)	NDG	0.004 to 1.67	NDG
Cohesive Loose (Plasticity Index = 3.0 to 50)	NDG	0.01 to 0.090	NDG
Cohesive Medium Compact (Plasticity Index = 3.0 to 50)	NDG	0.015 to 0.27	NDG
Cohesive Compact (Plasticity Index = 3.0 to 50)	NDG	0.022 to 0.79	NDG
Gravel riprap[a]			
D_{50} = 1.0 inches	NDG	0.31	NDG
D_{50} = 2.0 inches	NDG	0.67	NDG
Rock riprap[a]			
D_{50} = 6.0 inches	NDG	1.99	NDG
D_{50} = 12 inches	NDG	3.99	NDG
Grass (established)[a] Height Classification Examples			
A (30 in.) Weeping lovegrass and Yellow bluestem	NDG	3.76	NDG
B (12 to 24 in.) bermuda grass, Little bluestem, Bluestem, Blue gamma, and other long and short Midwest grasses	NDG	2.09	NDG
C (6 to 12 in.) Crabgrass, bermuda grass, orchard grass, redtop, Italian ryegrass, Kentucky bluegrass, common lespedeza	NDG	1.05	NDG
D (2 to 6 in.) bermuda grass, buffalo grass, orchard grass, redtop, Italian ryegrass, common lespedeza	NDG	0.63	NDG
E (1.6 in.) bermuda grass	NDG	0.31	NDG
Fiberglass Roving[a]			
Single	NDG	0.61	NDG
Double	NDG	0.86	NDG
Straw (loose) covered with net[a]	NDG	1.44	NDG
EROSION CONTROL BLANKET			
Coconut material	0.5	2.26	9.8
Wood excelsior material[a,b,c]	NDG	0.50 to 2.00	4.9 to 7.9
Jute net[a]	NDG	0.45	NDG
Straw blanket with sewn net[b,c]	0.50	1.50 to 1.75	4.9 to 5.9
Straw/coconut blanket with sewn net[b,c]	0.5	2.00 to 2.10	7.9
TURF REINFORCEMENT MAT			
Bare Ground Conditions[a,b,c]	0.50	3.00 to 8.00	8.9 to 20.0
	50	2.00 to 3.00	7.9 to 14.1
Vegetation Established[b,c]	0.50	6.00 to 14.0	14.8 to 25.0
	50	6.00 to 12.0	9.8 to 14.1

a Chen and Cotton (1988)
b IECA (1991, 1992, 1995)
c As reported by the manufacturer
NDG = No data given

Shear Diagram Information







τ = SHEAR (FRICTIONAL) STRESS
F_{DN} = DOWNWARD STATIC PRESSURE
F_{UP} = UPWARD STATIC PRESSURE
W = WEIGHT OF WATER
A = CROSS-SECTIONAL AREA

$F_{DN} = F_{UP}$
$W = \gamma \times A \times L$
$\sin\theta = \tan\theta = H / L$ FOR SMALL ANGLES
SLOPE = $S = \tan\theta = H / L$
γ = SPECIFIC WEIGHT OF WATER

Σ FORCES DOWN = Σ FORCES UP

$F_{DN} + W \times \sin\theta = F_{UP} + P \times L \times \tau$

$F_{DN} + W \times H / L = F_{UP} + P \times L \times \tau$

$A \times L \times \gamma \times H / L = P \times L \times \tau$

$\underline{\underline{\tau = (\gamma \times A \times S) / P}}$ MEAN SHEAR STRESS

MAXIMUM SHEAR STRESS IS ON THE BOTTOM. THUS, P = X

$\tau_{MAX} = (\gamma \times A \times S) / X$

$\tau_{MAX} = (\gamma \times Y \times X \times S) / X$

$\underline{\underline{\tau_{MAX} = \gamma \times Y \times S}}$ MAXIMUM SHEAR STRESS

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Rolled Erosion Control Product for a Drainage Channel

WHAT IS ITS PURPOSE?

To protect a drainage channel against erosion due to flowing water.

WHERE AND HOW IS IT COMMONLY USED?

- In drainage channels where vegetation needs to be established and significant flows occur.

WHEN SHOULD IT BE INSTALLED?

- While construction activities are occurring.
- After Grading activities are finished.

WHEN SHOULD IT NOT BE INSTALLED?

- Over impervious surfaces.
- On very rough ground.

WHAT NEEDS TO BE INSPECTED?

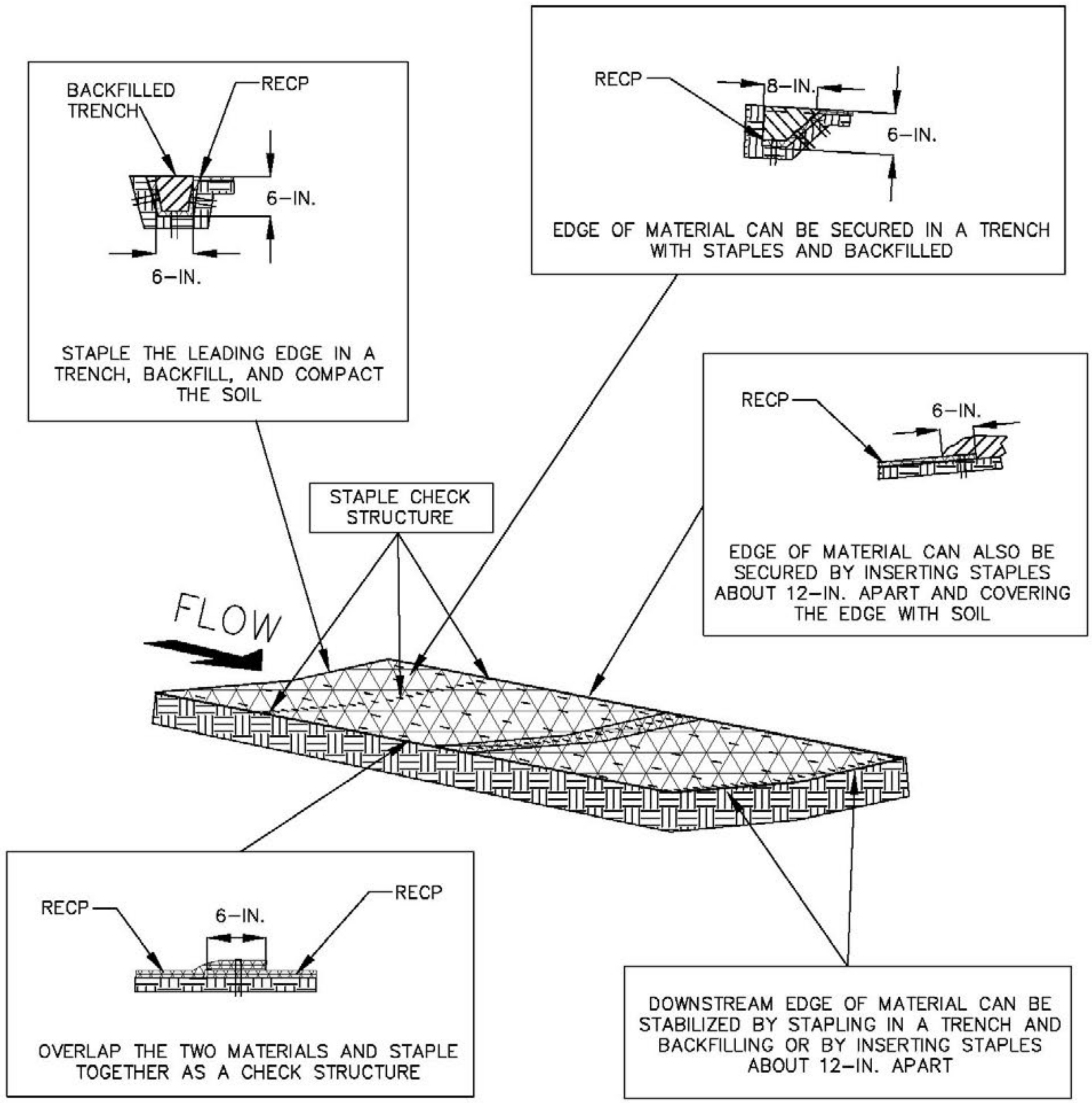
- Does the RECP display any damage?
- Have check structures (staple or trench) been installed?
- Are sufficient numbers of staples used?
- Was seed planted before installing the RECP?
- Was the channel bed smooth when the RECP was installed?
- Is water flowing under the blanket and causing erosion?
- Is the correct material used?
- Should straw mulch be used?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of material.
- Repair of eroded ground.

NOTES

- Erosion Control Blankets (ECBs) are composed of natural material including straw, straw-coconut, coconut (or coir), wood excelsior, and so forth. They must be held in place with netting sewn on both sides of the material.
- One type of Turf Reinforcement Mats (TRMs) is composed of 100% polypropylene or nylon and held in place with netting sewn on both sides of the material.
- Another type of TRM is composed of straw-coconut or coconut matter reinforced with strands of polypropylene threads and all held in place with netting sewn on both sides of the material.
- Designers must complete shear stress and velocity calculations in selecting an ECB or TRM for drainage channels.
- Additional information about ECBs and TRMs can be found at www.ectc.org.



1. PLACE STAPLES ABOUT 24–IN. APART ALONG THE FLOW LINE.
2. CREATE A CHECK STRUCTURE BY PLACING A ROW OF STAPLES ABOUT 2–IN. APART ALONG THE MATERIAL WIDTH. CHECKS ARE TO BE INSTALLED ABOUT 25 FT. TO 33 FT. APART ALONG THE MATERIAL LENGTH. A RIPRAP CHECK STRUCTURE CAN BE USED IN PLACE OF STAPLES.
3. SUFFICIENT NUMBER OF STAPLES MUST BE USED TO SECURE MATERIAL TO THE SOIL.
4. WHEN MORE THAN ONE BLANKET IS REQUIRED, OVERLAP MATERIAL BY AT LEAST 6.0 INCHES.

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INSTALLING A DRAINAGE CHANNEL RECP

11/03

Figure III-4: Illustration of Installing a RECP in a Drainage Channel

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RUNOFF CONTROL STRUCTURES

Construction activities usually result in the removal of vegetative cover and increases in impermeable surfaces, both of which lead to an increase in the peak flood flows, velocity, and volume of runoff. Increases in runoff volume and velocity lead to increased erosion (i.e. rills and gullies), sediment transport, and offsite delivery (sedimentation). These increases must be addressed when implementing sediment and erosion control measures.

Runoff-control measures are practices that mitigate the erosive and sediment transport forces of stormwater during and after grading activities. Some examples of runoff control measures include:

- Outlet protection
- Temporary slope drains
- Vegetative buffer strips
- Grass-lined channels
- Diversion dikes and conveyance channels
- Rock-lined channels
- Check dams
- Wattles located along contours of a hillside

Diversion Dikes and Conveyance Channels

Diversion dikes will intercept and divert runoff waters in properly designed drainage conveyance channels. Essentially, diversion dikes can prevent runoff from flowing down a disturbed slope. Once these flows are reduced, rill and gully erosion will also be reduced.

Transporting runoff in drainage channels must be completed in a manner that minimizes erosion. Appropriate uses of diversion structures include the following:

- Diverting runoff from drainage areas away from disturbed areas and toward a stabilized outlet.
- Diverting sediment-laden runoff from a disturbed area into a sediment containment structure.
- Using a dike to divert runoff waters to a conveyance channel in a manner that improves working conditions at the construction site and minimizes erosion.
- Using a dike to ensure that sediment-laden stormwater will not leave the site without treatment.
- Using methods that are sometimes preferable over barriers because they are more durable, less expensive, and require less maintenance when properly constructed.

Any channel created by a dike must have a sufficient grade that forces flows to a stabilized outlet. When the channel slope is less than or equal to 1.0%, stabilization might be required for soils that generate turbidity in runoff waters. Channel slopes greater than 1.0% must be stabilized to prevent degradation.

Sediment-laden waters must be diverted into a properly designed sediment containment system (SCS). In addition, runoff from undisturbed lands must discharge onto an outlet protection system.

As with all methods to control sediment and erosion, frequent inspections and maintenance must occur with diversion dikes and conveyance channels. The following guidelines should be followed when conducting inspections and maintenance:

- Inspect temporary facilities before and after significant runoff events and at least once per week during the rainy season.
- Channel linings, embankments, and channel beds must be continually inspected for erosion.
- Removal of debris and prompt repairs should always occur.

Slope Drains for Basins

Slope drains consist of flexible tubing, pipe, or other conduit extending from the top to the bottom of a cut or fill slope. Their purpose is to convey runoff waters across (and usually down) erodible lands in a manner that prevents erosion.

It is important that slope drains be sized, installed, and properly maintained since their failure could result in severe slope erosion. Entrance to the pipe must be well entrenched and stable. Increased inflows can be realized by installing flared end sections on the pipe. Finally, the pipe should extend beyond the toe of the slope or into an appropriately stabilized outlet. Figure III-5 illustrates the placement of these conveyance structures.

When selecting the diameter of a pipe for slope drains, Designers must be cognizant of contributing basin areas and the accompanying hydrologic conditions. For example, runoff from contributing bare ground basins of sandy soils will be different from what occurs with flows from bare ground clay soils.

When a containment berm has a height that is at least twice the pipe diameter of a slope drain (see Figure III-5), the pipe diameter can be calculated from:

$$\boldsymbol{D = 4.29 \times Q^{0.50} = 4.29 \times (CiA)^{0.50}} \qquad \textbf{Equation 5}$$

Where D = Pipe diameter (inches)

Q = Peak flood flow for the design storm event (*cfs*)

C = Runoff coefficient

i = Rainfall intensity (inches/hour)

A = Contributing area (acres)

Located within the example part of this section is a table of runoff coefficients and Intensity Duration Frequency (IDF) curves for 11 FDOT regions throughout Florida.

Selections of the rainfall intensity should be based upon an average return period and the time of concentration for the site location, unless otherwise dictated by local regulations. The example at the end of this section illustrates the selection of a pipe diameter using the intensity of a 10-year return period.

Slope drain for Small Basins

WHAT IS ITS PURPOSE?

To protect hillside surfaces against erosion due to concentrated flows of runoff waters.

WHERE AND HOW IS IT COMMONLY USED?

- On fill slopes.
- On cut slopes.

WHEN SHOULD IT BE INSTALLED?

- While construction activities are occurring.
- After Grading activities are finished.

WHEN SHOULD IT NOT BE INSTALLED?

- When contributory basins are large (usually greater than five acres).

WHAT NEEDS TO BE INSPECTED?

- Are there areas where the earthen berm has been breached?
- Is water discharging onto an embankment?
- Is there protection (i.e. riprap) at the end of the slope drain?
- Is water flowing around the slope drainpipe?
- Is the pipe secured to the hillside?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair or replacement of slope drain.
- Repair breached sections of earthen berm.
- Replacement of riprap.

EQUATION USED TO CALCULATE PIPE DIAMETER:

$$\boldsymbol{D = 4.29 \times Q^{0.50} = 4.29 \times (CiA)^{0.50}}$$

Where D = Pipe diameter (inches)

Q = Peak flood flow for the design storm event (*cfs*)

C = Runoff coefficient

i = Rainfall intensity (inches/hour)

A = Contributing area (acres)

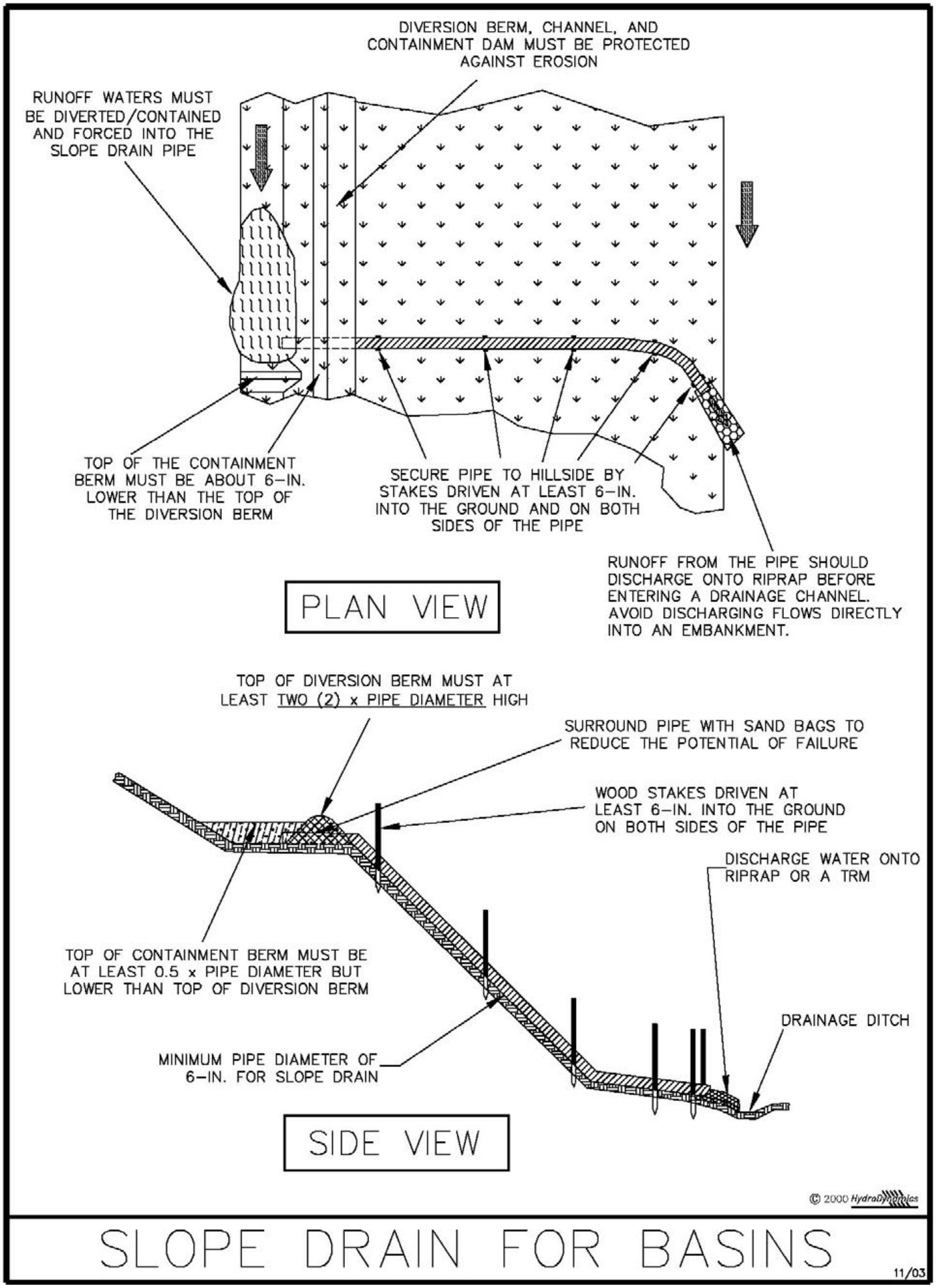

Figure III-5: Installing a Slope Drain on a Disturbed Slope

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Slope Drains for Roads

Protecting fill slopes from developing rills and gullies due to runoff waters off a road is similar to what is required for basins. Use of high flow diversion dikes is not always possible or advisable since erosion control of a channel is not always feasible in a practical manner. However, placement of temporary slope drains along the top of a road embankment is feasible.

Spacing of temporary slope drains for roads are usually based upon pre-determined pipe diameters. What designers need to identify is the amount of runoff entering the pipe, which is dependent upon the width of the roadway. Figure III-6 and Figure III-7 illustrate placement of temporary roadway slope drains.

Assuming that a road has a rectangular shape and a containment berm along the side of the road has a height that is at least twice the pipe diameter of a slope drain, the spacing between each pipe can be calculated by:

$$L = (245.8 \times D^{2.5}) \div (i \times W) \qquad \textbf{Equation 6}$$

Where L = Spacing between slope drains (feet)

D = Slope drain pipe diameter (inches)

i = rainfall intensity when the time of concentration is eight minutes (inches/hour)

W = Average width of the road that contribute runoff to the slope drain (feet)

Located at the end of the section are examples of how spacing of pipes is calculated for different pipe diameters, contributing road widths, and different frequency storm events.

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Slope Drain for Road Embankments

WHAT IS ITS PURPOSE?

Protection of road embankments from erosion where concentrated flows discharge off a road onto a fill slope.

WHERE AND HOW IS IT COMMONLY USED?

- Along roads being constructed.
- To remove excess runoff waters.

WHEN SHOULD IT BE INSTALLED?

- While construction activities are occurring.
- After Grading activities are finished.

WHEN SHOULD IT NOT BE INSTALLED?

- Where no containment or diversion berm exists.

WHAT NEEDS TO BE INSPECTED?

- Are there areas where the earthen berm has been breached?
- Do the sandbags need to be repaired or replaced?
- Has the discharge pipe been secured to the slope?
- Is water flowing around the sandbag diversion berm?
- Is the spacing between pipes correct for the diameter pipe used?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of sandbags.
- Repair breached sections of earthen berm.
- Removal of slope drain.

EQUATION USED TO CALCULATE THE SPACING OF SLOPE DRAINS

$$\boldsymbol{L = 245.8 \times D^{2.5} \div (i \times W)}$$

Where L = Spacing between slope drains (feet)

D = Slope drain pipe diameter (inches)

i = rainfall intensity when the time of concentration is eight minutes (inches/hour)

W = Average width of the road that contributes runoff to the slope drain (feet)

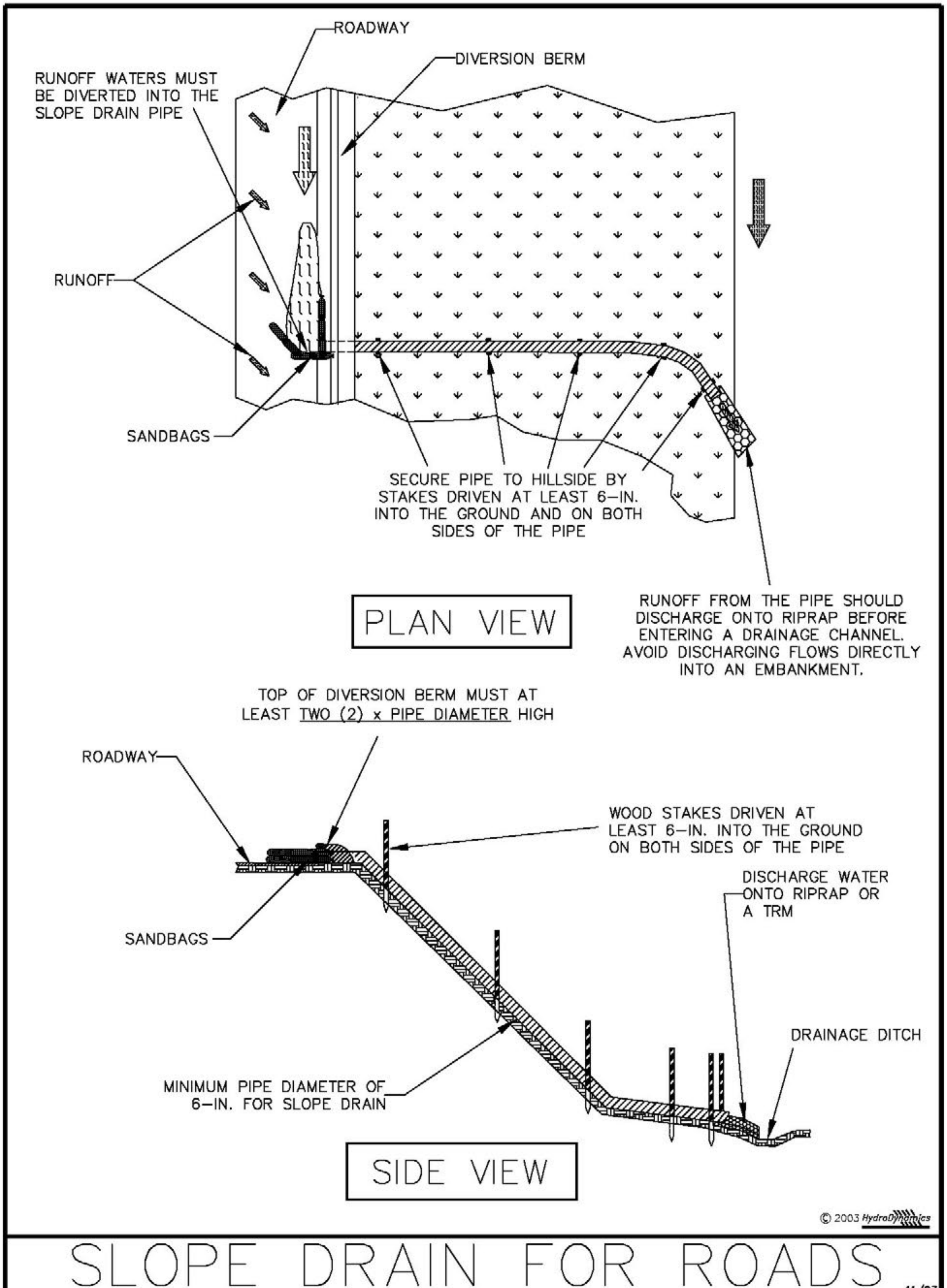

Figure III-6: Installing a Slope Drain for Road Embankments

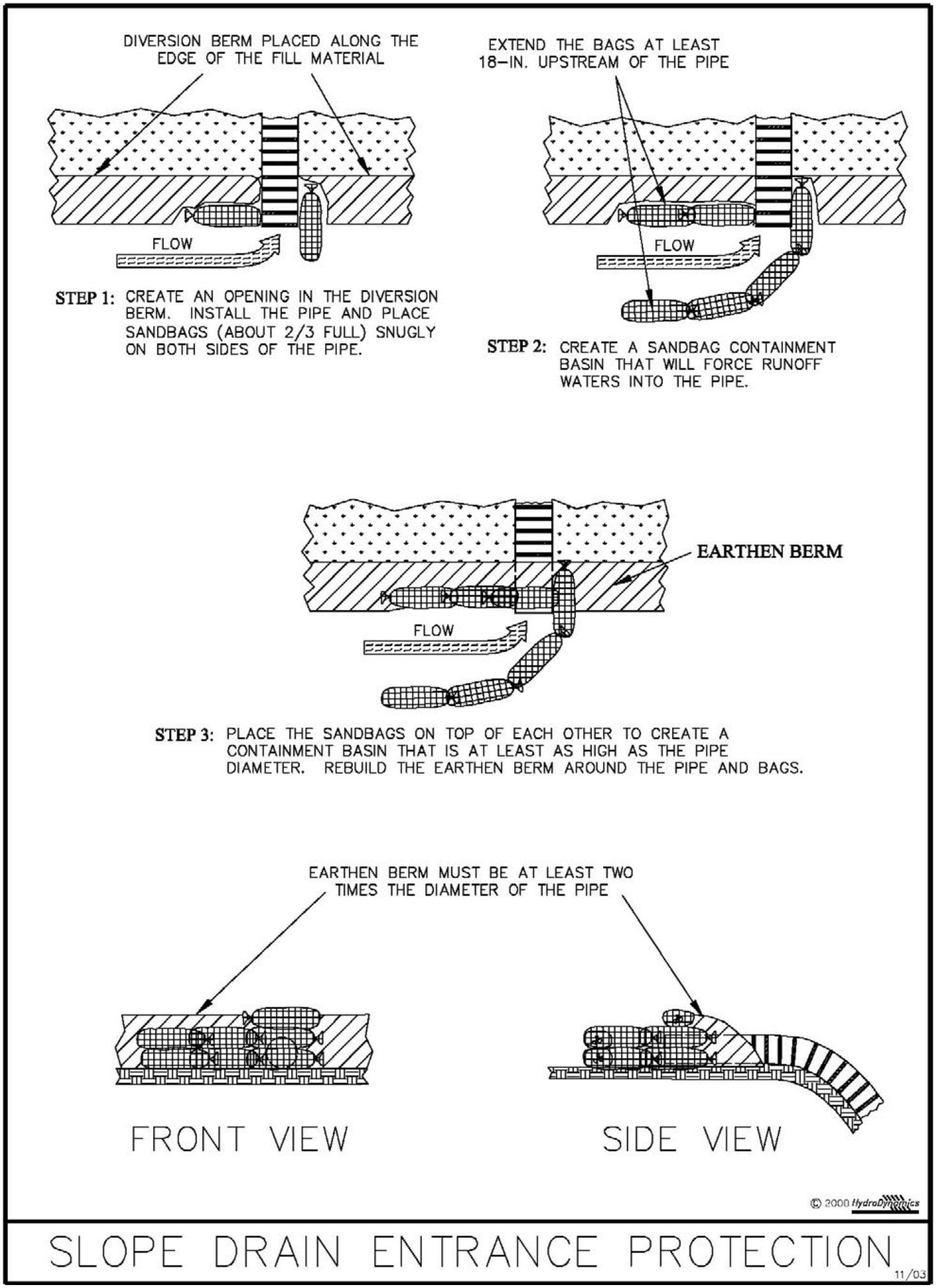

Figure III-7: Containment Chamber for a Road Embankment Slope Drain

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Channel Check Structures

Check structures in drainage channels are one of the more common methods found on construction projects. Many Designers associate the use of these structures as a way to control sediment. In reality, check structures in a drainage channel are examples of sediment containment systems *and* erosion control devices.

Only when *properly installed* will check structures in drainage channels create small SCSs behind the barriers and create erosion protection conditions. As flow velocity becomes sufficiently reduced (usually at the end of a significant runoff event), deposition of suspended particles will occur. Once sedimentation occurs, small "terraces" of deposit material are created behind the barrier (see Figure III-8) and a new channel slope is created that approaches 0.0%. Thus, properly installed check structures in drainage channels for controlling sediment in drainage channels "evolve" into an erosion control method.

<u>Spacing of Check Structures</u>

If check structures are to reduce channel erosion until stabilization occurs, it is important that they be installed in a manner that allows for energy dispersion of the runoff. This is achieved by creating small stilling ponds behind the structures in a manner that prevents erosion of the channel bed (see Figure III-8).

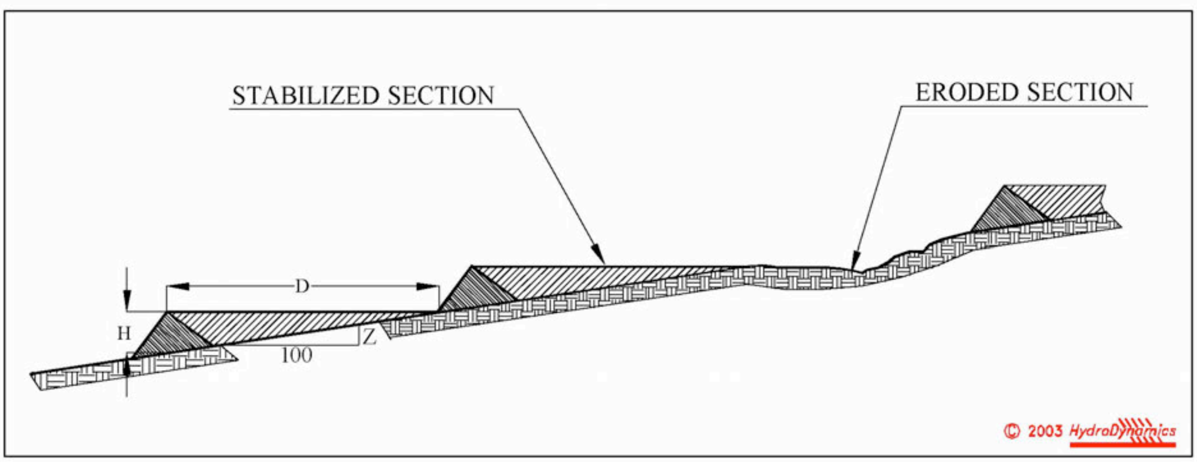

Figure III-8: Placement of Check Structures for Channel Stability

As illustrated in Figure III-8, water can pond behind a properly installed barrier check structure. Thus, it is important that the containment structures be able to withstand the large hydraulic force stored water places on the material. It is for this reason, silt fence barriers are *not recommended* as drainage channel check structures unless they are properly installed and supported. Otherwise, these barriers will fail.

Figure III-8 illustrates that placement of barriers along a drainage channel is very important if erosion is to be minimized. Spacing of barriers having different heights is illustrated in Figure III-9.

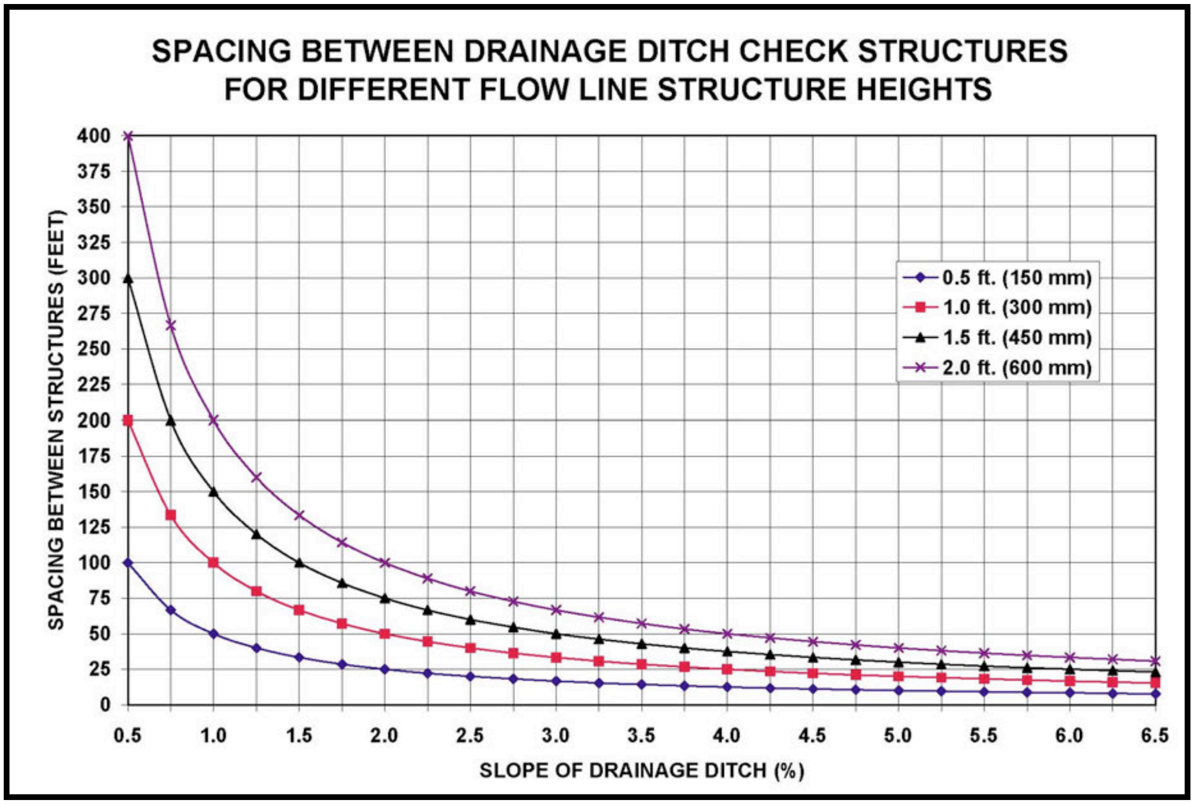

Figure III-9: Recommended Spacing of Barriers in Drainage Channels When Installed as Erosion Control Measures

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Geosynthetic Barrier Check Structure

WHAT IS ITS PURPOSE?

Temporary containment structures to capture sediment and reduce runoff velocities in drainage channels while grading or construction activities occur.

WHERE AND HOW IS IT COMMONLY USED?

- Within roadside drainage ditches.
- As small sediment traps.

WHEN SHOULD IT BE INSTALLED?

- While grading or construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading or construction activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Is the structure properly installed?
- Is there a depression for runoff to flow over?
- Does runoff flow over the structure?
- Does runoff flow around the structure?
- Is channel erosion occurring between structures?
- Is the spacing correct?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of the barrier.
- Removal of sediment.
- Repair of eroded channel.
- Removal of the barrier.

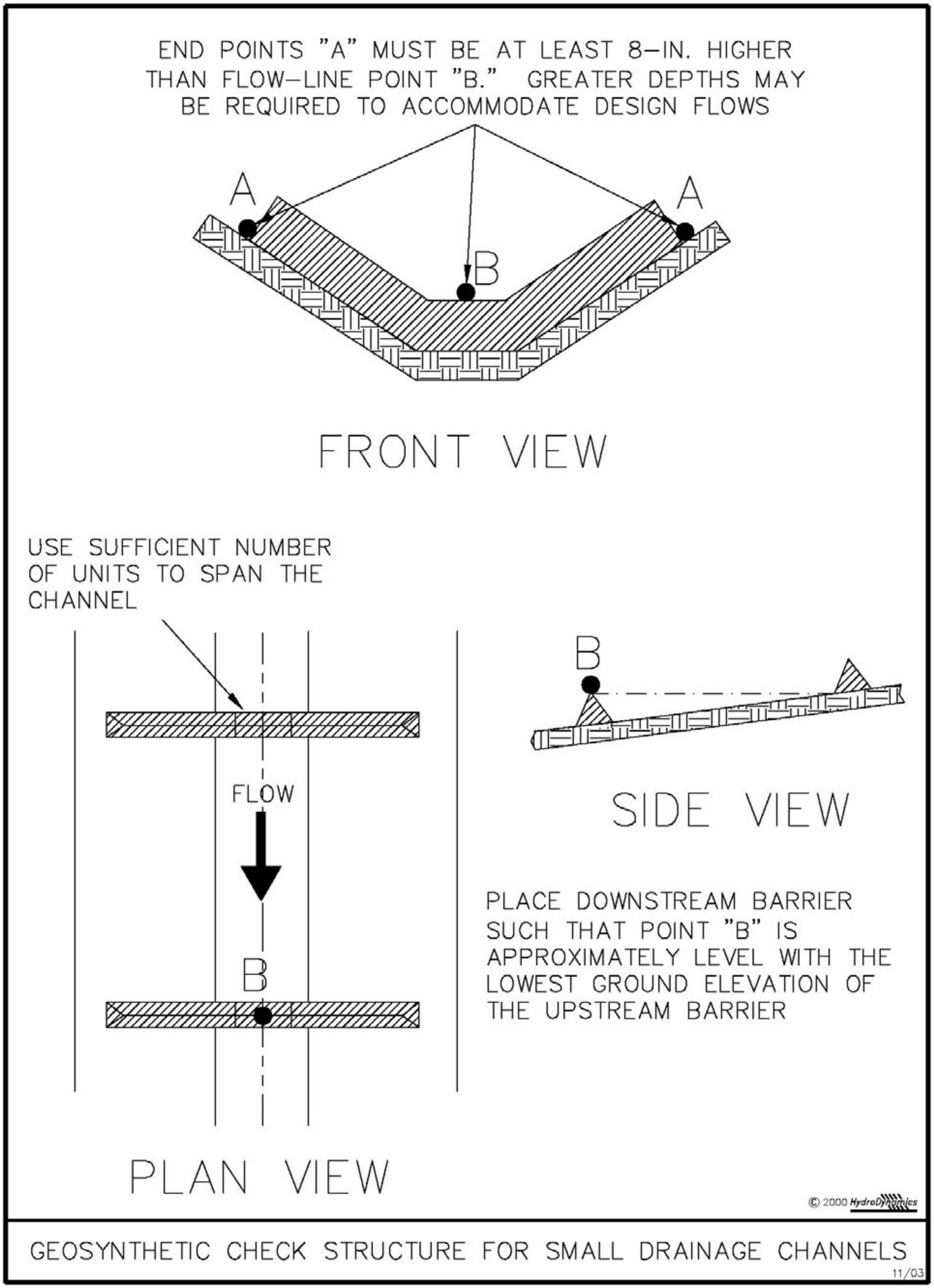

Figure III-10: Geosynthetic Barrier Check Structure for Small Drainage Ditches

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Rock Barrier Check Structure

WHAT IS ITS PURPOSE?

Temporary containment structures to capture sediment and reduce runoff velocities in drainage channels while grading or construction activities occur.

WHERE AND HOW IS IT COMMONLY USED?

- Within roadside drainage ditches.
- As small sediment traps.

WHEN SHOULD IT BE INSTALLED?

- While grading or construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading or construction activities are completed and if they are to be the only method used for stabilizing drainage ditches.

WHAT NEEDS TO BE INSPECTED?

- Are the correct rock diameters used?
- Will water flow over the rocks?
- Is channel erosion occurring between structures?
- Is there a depression for runoff to flow over?
- Will water flow around the rocks?
- Is the spacing correct?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of rock.
- Repair of eroded ground.
- Removal of sediment.
- Removal of rock.

D_{50} OF ROCK (IN)	DOWNSTREAM FACE OF STRUCTURE 35%	30%	25%	20%	15%	10%
	MAXIMUM FLOW DEPTH ON ROCK (IN)					
3	6	7	8	10	13	20
6	12	14	16	20	26	40

SUGGESTED ROCK DIAMETER & FLOW DEPTHS

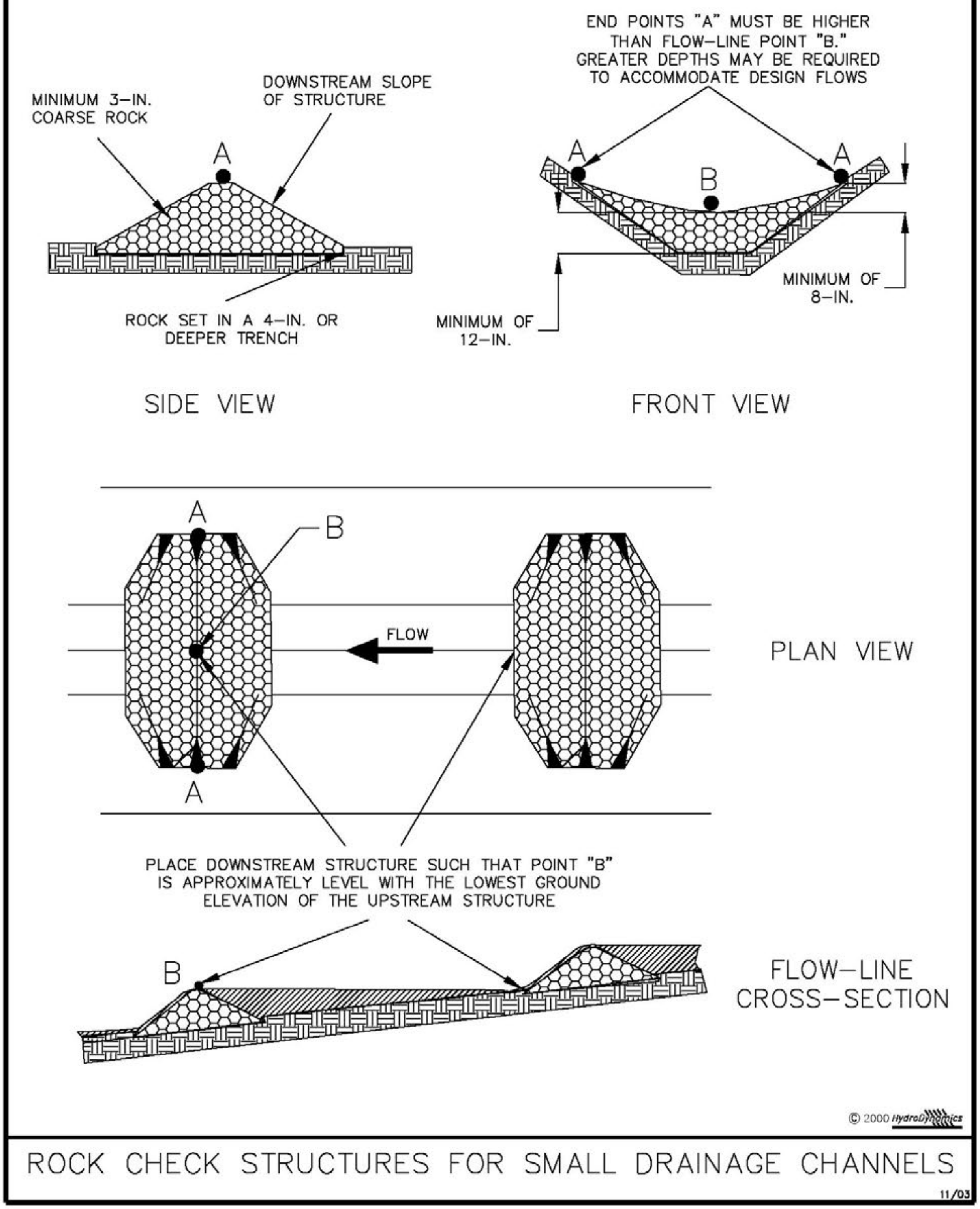

Figure III-11: Rock Check Structures in Small Drainage Channels

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EXAMPLES

Channel RECP for a Specific Flow

What type of RECP is recommended for a triangular channel with 1V:5H side slopes and a channel grade of 1.25% to provide adequate erosion protection against a flow of 24 cfs and to assist with establishment of Type B vegetation?

This type of problem requires using the following equations:

$$\mathbf{V = (1.486 \div \boldsymbol{n}) \times \boldsymbol{R}^{2/3} \times \boldsymbol{S}^{1/2}} \qquad \boldsymbol{\tau}_{\mathbf{max}} \mathbf{= 62.4 \times \boldsymbol{Y} \times \boldsymbol{S}} \qquad \boldsymbol{Q = A \times V}$$

It is not possible to use any of the above equations to solve for a specific variable that ensures a correct solution. Instead, an iterative approach on specific variables has to occur.

The one parameter that Designers should know about for drainage channels is flow. In order to calculate flow in a drainage channel, it is necessary to determine cross-sectional area and flow velocity. This can only be accomplished by knowing the depth of flow in the channel when design flows (in this case, Q = 24.0 cfs) occurs.

<u>Iteration No. 1</u>

Assume an initial flow depth of 12 inches:

√ Decide upon a product to use. For this example, assume installation of an excelsior ECB is to occur, which (from Table III-1) has a roughness coefficient n = 0.035.

√ Calculate the cross-sectional area, wetted perimeter, and hydraulic radius of the trapezoidal channel for a flow depth d = 12 inches = 1.0 feet.

- From Figure III-3, the cross-sectional area of a triangular channel is calculated by:

$$A = Z \cdot d^2 = 5 \times (1.0)^2 = 5.0\ ft.^2$$

- From Figure III-3, the wetted perimeter (WP) of a trapezoidal channel is calculated by:

$$WP = 2d \times (Z^2 + 1)^{1/2} = 2 \times 1.0 \times (5^2 + 1)^{1/2} = 10.2\ ft.$$

The hydraulic radius is calculated by:

$$R = A \div WP = 5.0 \div 10.2 = 0.49\ ft.$$

√ Calculate the flow velocity using:

$$V = (1.486 \div n) \times R^{2/3} \times S^{1/2} = (1.486 \div 0.035) \times (0.49)^{2/3} \times (0.0125)^{1/2} = 2.97\ ft./sec.$$

√ Calculate the flow rate using:

$$Q = A \times V = 5.0 \times 2.97 = 14.9\ cfs$$

STOP: The first iteration for flow did not result in calculating Q = 24.0 *cfs*. Therefore, a second iteration is required.

Iteration No. 2

Now, assume a flow depth of 1.2 feet and continue using an excelsior ECB having a roughness coefficient $n = 0.035$.

Calculate the cross-sectional area, wetted perimeter, and hydraulic radius of the trapezoidal channel for a flow depth $d = 1.2$ feet.

$$A = Z \cdot d^2 = 5 \times (1.2)^2 = 7.20\ ft.^2$$

$$WP = 2d \times (Z^2 + 1)^{1/2} = 2 \times 1.2 \times (5^2 + 1)^{1/2} = 12.2\ ft.$$

$$R = A \div WP = 7.20 \div 12.2 = 0.59\ ft.$$

√ Calculate the flow velocity using:

$$V = (1 \div n) \times R^{2/3} \times S^{1/2} = (1.486 \div 0.035) \times (0.59)^{2/3} \times (0.0125)^{1/2} = 3.36\ ft./sec.$$

√ Calculate the flow rate using:

$$Q = A \times V = 7.20 \times 3.36 = 24.2\ cfs \approx 24.0\ cfs \quad [within\ acceptable\ measurement\ error]$$

√ Calculate the maximum shear stress using:

$$\tau_{max} = 62.4 \times Y \times S = 62.4 \times 1.2 \times 0.0125 = 0.94\ lbs./ft.^2$$

√ Compare the calculated shear stress and velocity values to those found in Table III-2.

- An excelsior product has a maximum permissible shear stress of 1.44 to 2.00 *lbs./ft.*^{2}, which is greater than 0.94 *lbs./ft.*^{2}
- An excelsior product has a maximum permissible velocity of 4.9 to 7.9 *ft./sec*., which is greater than 3.36 *ft./sec*.

Therefore, it is possible to use a properly installed excelsior product.

√ Use Table III-2 to determine if anticipated shear stress values will impact vegetation when flows of 3.36 *ft./sec*. occur having a depth of 1.2 feet and no ECB material exists.

- Class B vegetation cannot have shear stress values that exceed 2.09 *lbs./ft.*^{2} > 0.94 *lbs./ft.*^{2}

Therefore, when flows of 24.0 *cfs* occur, properly installed excelsior ECB should provide protection against channel erosion until Class B vegetation is established.

Designers are encouraged to evaluate shear stress and velocity for different scenarios. For example, if in the above example the channel slope were increased to 5.0%, then the shear stress would be about 2.6 *lbs./ft.*^{2} with a flow velocity of 7.0 *cfs* and a water depth of 10 inches. Only a TRM can be installed in the channel to ensure adequate protection exists.

Finally, values reported in Table III-1 and Table III-2 provides only an estimate of how RECPs will perform. When developing specifications for a TRM or ECB, Designers must always obtain up-to-date shear stress and velocity information from manufacturers for their projects to ensure proper product selection.

Basin Slope Drain

A roadway project is to be constructed within a wooded area and on sandy soils. It has been determined that approximately 8.4 acres will discharge offsite flows onto the construction site. What diameter pipe for a slope drain is needed to route offsite flows caused by a 10-year storm event? Assume the offsite basin has an average slope of 2.3% and Time of Concentration of 12 minutes in Zone 3.

Step 1. Determine the C from Table III-3 following this page:

$$C = 0.15 \text{ to } 0.20$$

Step 2. Determine the rainfall intensity in Zone 3 from Figure III-15:

$$i = 6.8 \text{ inches/hour}$$

Step 3. Calculate a theoretical pipe diameter from the equation:

$$D = 4.29 \times Q^{0.50} = 4.29 \times (CiA)^{0.50}$$

$$\text{When } C = 0.15,\ D = 4.29 \times (0.15 \times 6.8 \times 8.4)^{0.50} = 12.6 \text{ inches}$$

$$\text{When } C = 0.20,\ D = 4.29 \times (0.20 \times 6.8 \times 8.4)^{0.50} = 14.5 \text{ inches}$$

Step 4: Determine the diameter pipe to use.

Unless the Designer is confident that the minimum runoff coefficient is applicable, use the worst case scenario to select a pipe having a readily available diameter. In this situation, it is possible to use a 15-inch diameter pipe---if one can be found. More than likely, an 18-inch diameter pipe will have to be installed.

Roadway Slope Drain

The above roadway project will have a section where approximately 160 feet of fill material will exist. The Designer observes from the plan and profile drawings that runoff from about 30 feet of upstream road construction will discharge onto where road fill material exists. In order to minimize damage to the two-lane road fill material, it is decided to install a series of 6-inch diameter slope drains. The first pipe will be installed to capture runoff from the upstream contributing 30 feet of roadway.

If each lane of the road is approximately 16 feet wide, how far apart should the slope drains be placed and what is the height of the containment berm along the edge of the roadway fill material for a 10-year storm event?

Step 1. Determine the intensity of rainfall occurring in Zone 3 when the time of concentration is 8 minutes:

$$i = 7.5 \text{ inches/hour}$$

Step 2. Calculate the distance between each slope drain:

$$L = (245.8 \times D^{2.5}) \div (i \times W) = (245.8 \times 6^{2.5}) \div (7.5 \times 16 \times 2) = 90 \text{ feet}$$

Step 3: Calculate the height of the containment berm:

$$H = 2 \times \text{pipe diameter} = 2 \times 6 \text{ inches} = 12 \text{ inches} = 1.0 \text{ feet}$$

Note: Since there are 160 linear feet of fill material, placing the slope drains about 90 feet apart will be adequate to convey road runoff via 6-inch diameter pipes.

Table III-3. Runoff Coefficients for the Rational Method (from FDOT, 1987)

SLOPE	LAND USE	SANDY SOILS MIN	SANDY SOILS MAX	CLAYEY SOILS MIN	CLAYEY SOILS MAX
Flat (0-2%)	Woodlands	0.10	0.15	0.15	0.20
	Pasture, grass, and farmland[b]	0.15	0.20	0.20	0.25
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements[c]	0.75	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.30	0.35	0.35	0.45
	Smaller lots	0.35	0.45	0.40	0.50
	Duplexes	0.35	0.45	0.40	0.50
	MFR: Apartments, townhouses, etc.	0.45	0.60	0.50	0.70
	Commercial and Industrial	0.50	0.95	0.50	0.95
Rolling (2-7%)	Woodlands	0.15	0.20	0.20	0.25
	Pasture, grass, and farmland[b]	0.20	0.25	0.25	0.30
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements[c]	0.80	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.35	0.50	0.40	0.55
	Smaller lots	0.40	0.55	0.45	0.60
	Duplexes	0.40	0.55	0.45	0.60
	MFR: Apartments, townhouses, etc.	0.50	0.70	0.60	0.80
	Commercial and Industrial	0.50	0.95	0.60	0.95
Steep (7%+)	Woodlands	0.20	0.25	0.25	0.30
	Pasture, grass, and farmland[b]	0.25	0.35	0.30	0.40
	Rooftops and pavement	0.95	0.95	0.95	0.95
	Pervious pavements[c]	0.85	0.95	0.90	0.95
	SFR: 1/2-acre lots and larger	0.40	0.55	0.50	0.65
	Smaller lots	0.45	0.60	0.55	0.70
	Duplexes	0.45	0.60	0.55	0.70
	MFR: Apartments, townhouses, etc.	0.60	0.75	0.65	0.85
	Commercial and Industrial	0.60	0.95	0.65	0.95

Source: FDOT (1987)

[a]Weighted coefficient based on percentage of impervious surfaces and green areas must be selected for each site.
[b]Coefficients assume good ground cover and conservation treatment.
[c]Depends on depth and degree of permeability of underlying strata.

NOTE: SFR = Single Family Residential; MFR = Multi-Family Residential

For recurrence intervals longer than ten years, the indicated runoff coefficients should be increased, assuming that nearly all of the rainfall in excess of that expected from the ten year recurrence interval rainfall will become runoff and should be accommodated by an increased runoff coefficient.

The runoff coefficients indicated for different soil conditions reflect runoff behavior shortly after initial construction. With the passage of time, the runoff behavior shortly after initial construction. With the passage of time, the runoff behavior in sandy areas will tend to approach that in heavy soil areas. If the designer's interest is long term, the reduced response indicated for sandy soils should be disregarded.

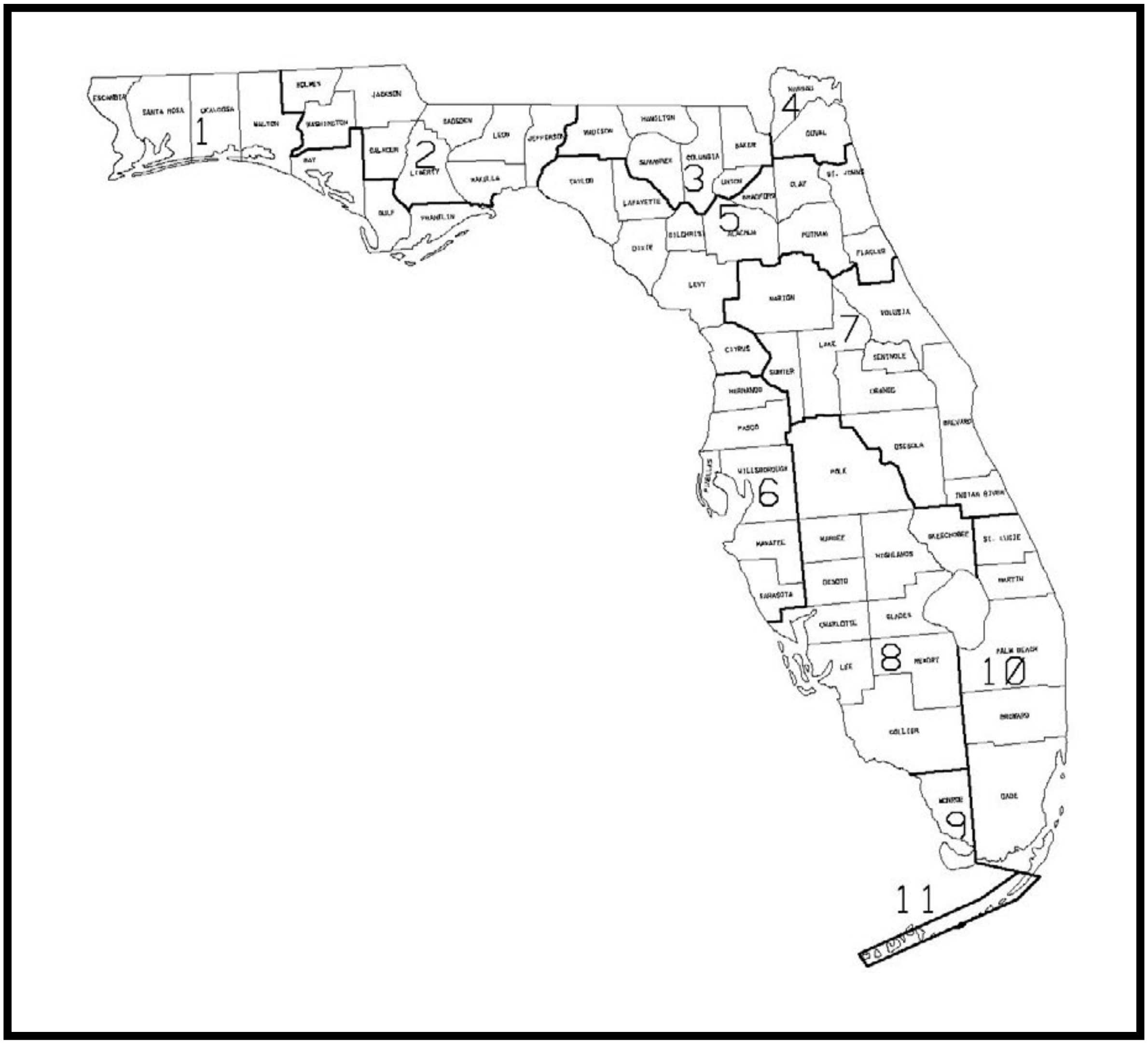

Figure III-12. **Zones for Precipitation Intensity Duration Frequency Curves as Developed by the FDOT (2001)**

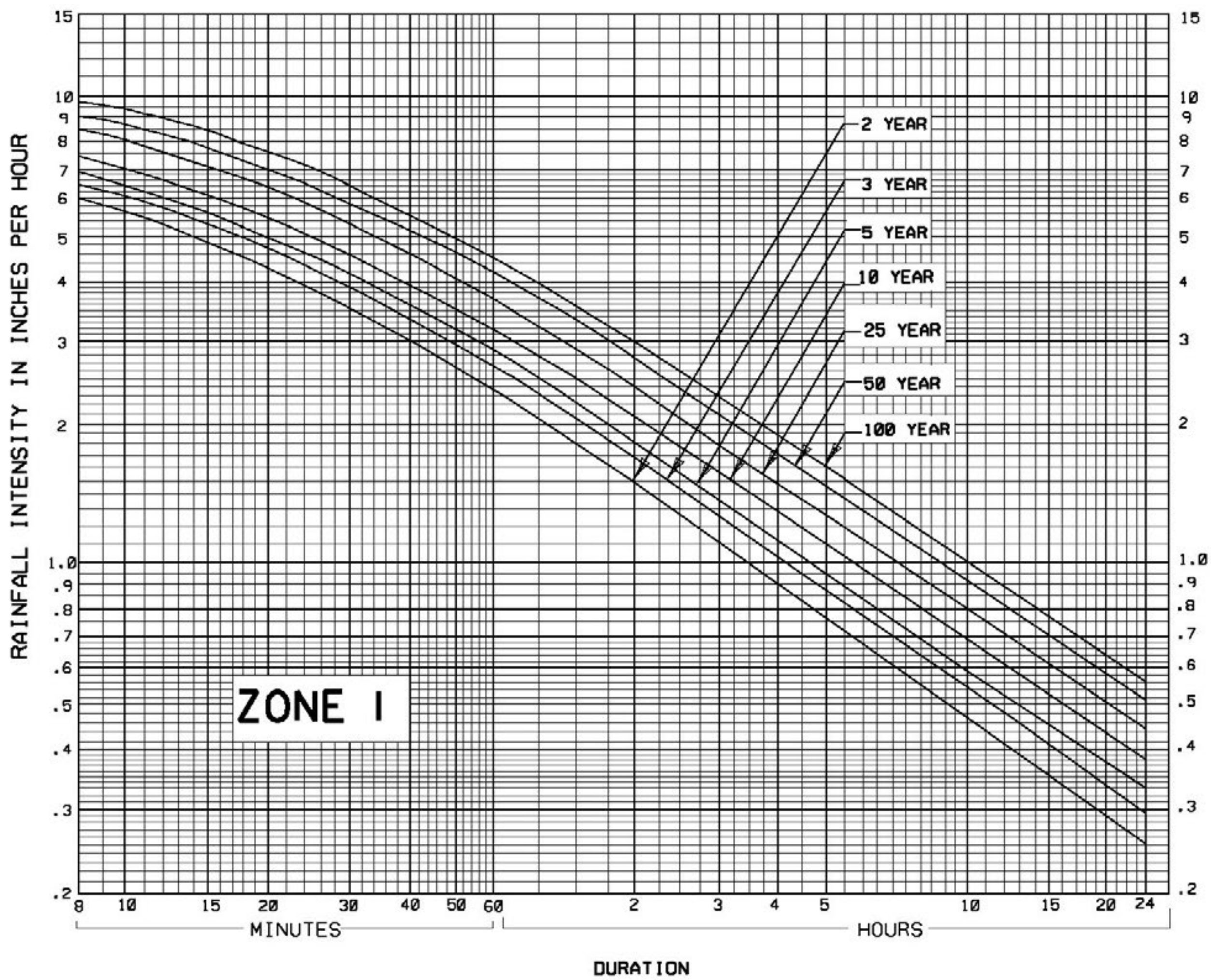

Figure III-13. Rainfall Intensity Duration Frequency Curve for Zone 1 (FDOT, 2001)

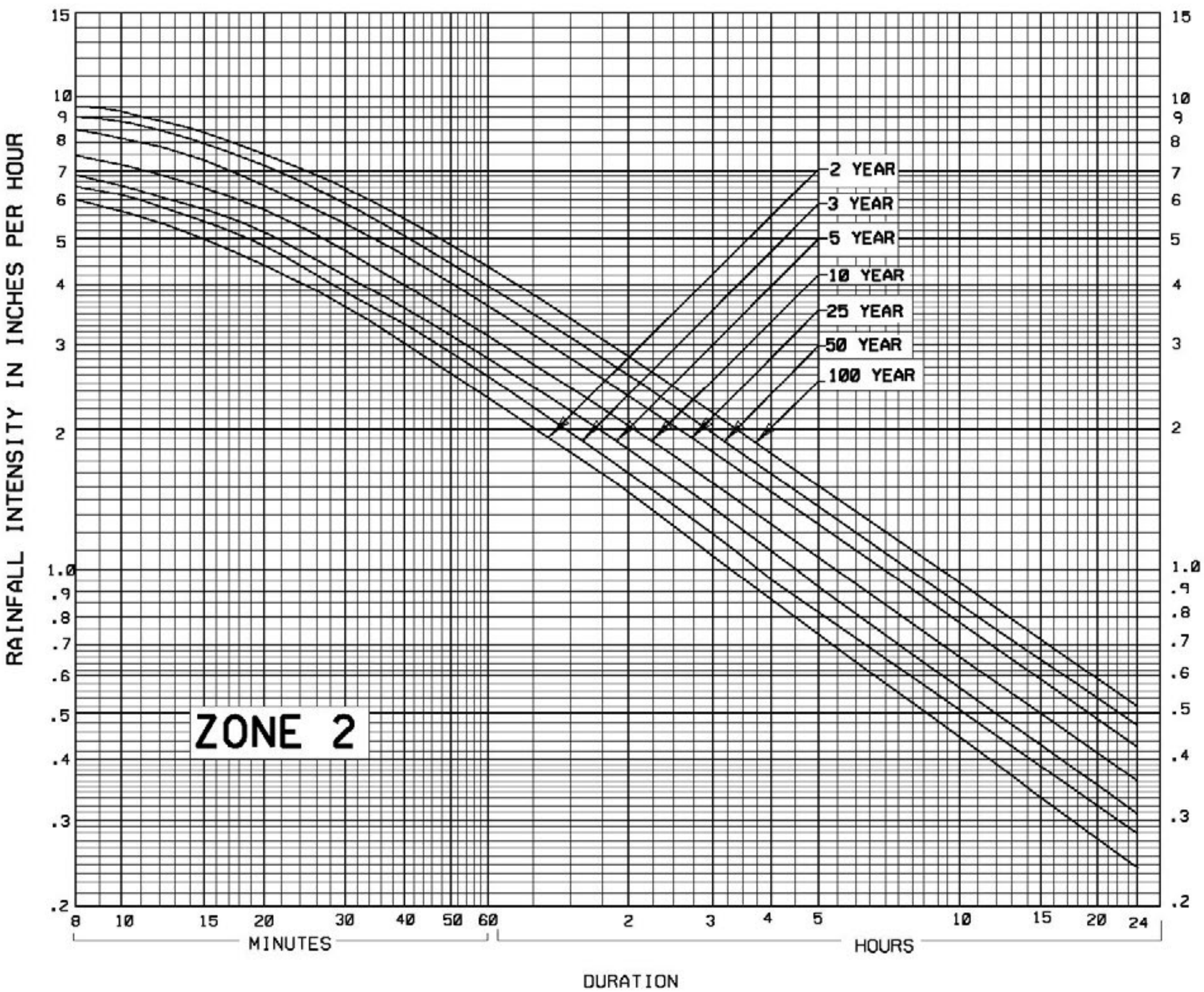

Figure III-14. Rainfall Intensity Duration Frequency Curve for Zone 2 (FDOT, 2001)

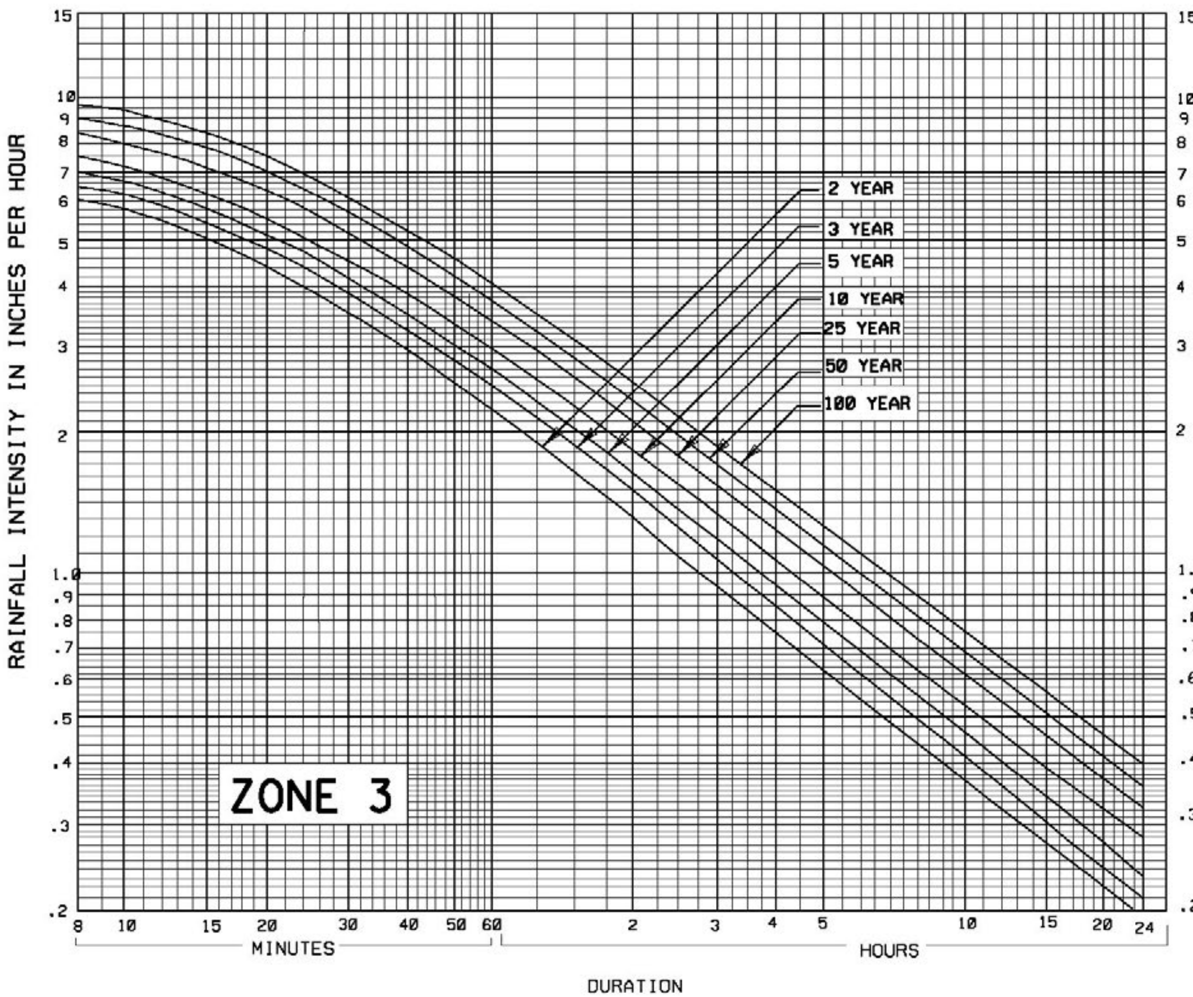

Figure III-15. Rainfall Intensity Duration Frequency Curve for Zone 3 (FDOT, 2001)

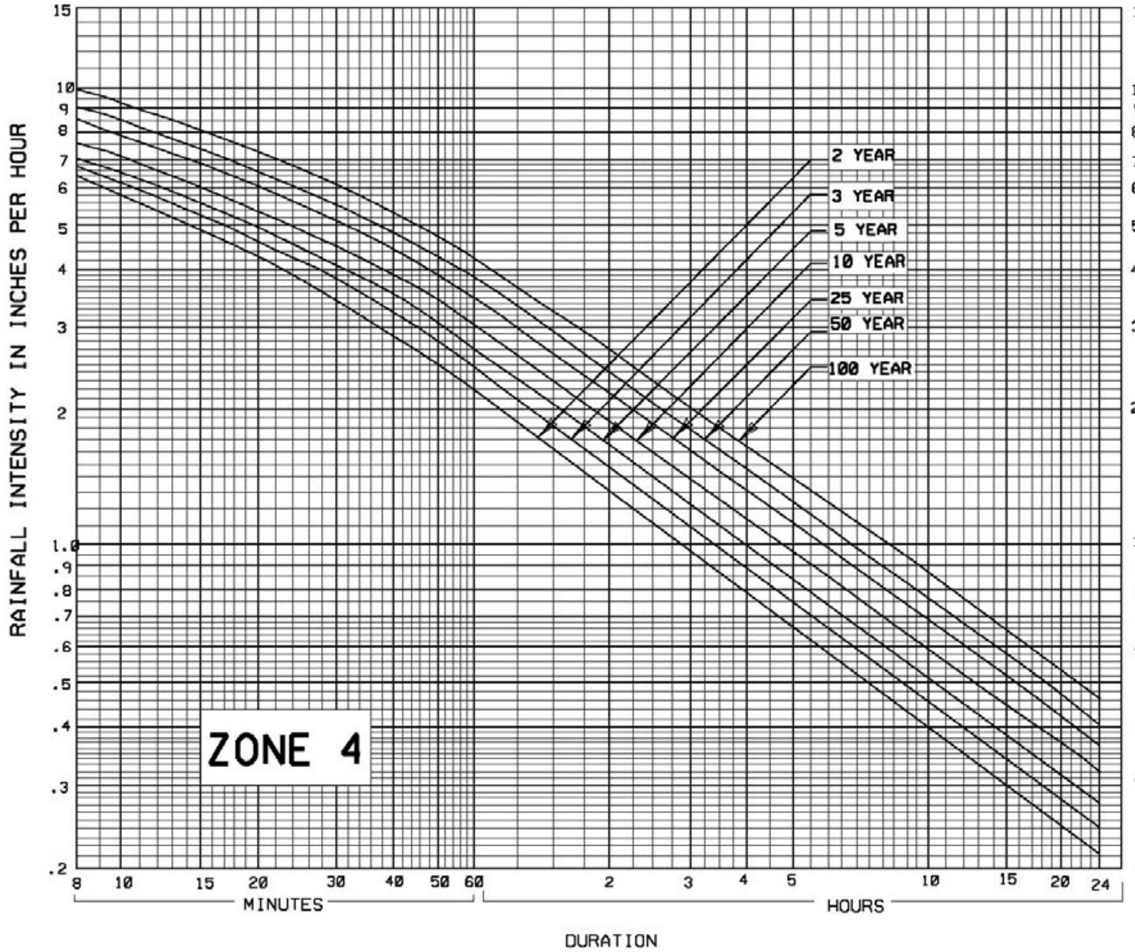

Figure III-16. Rainfall Intensity Duration Frequency Curve for Zone 4 (FDOT, 2001)

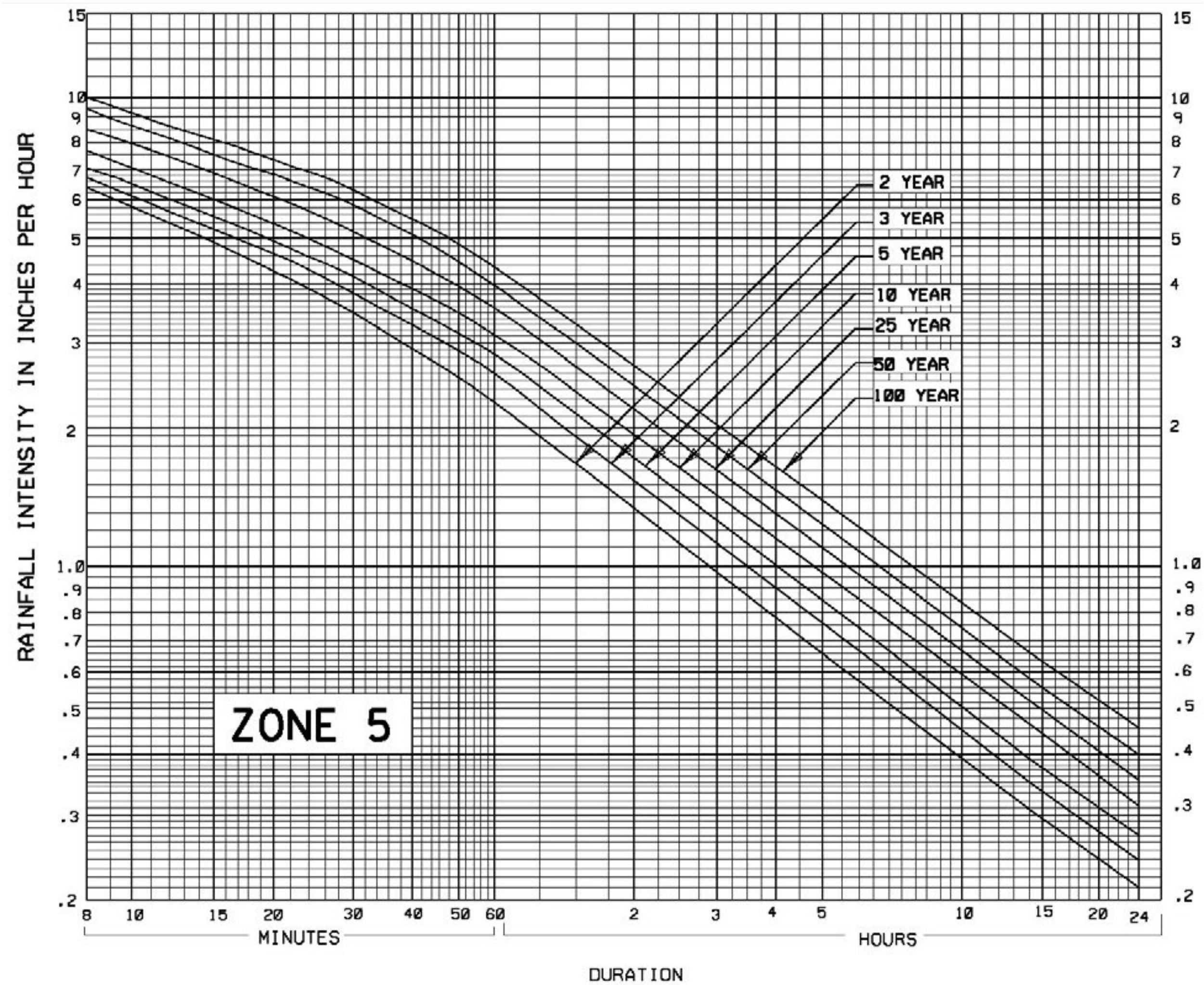

Figure III-17. Rainfall Intensity Duration Frequency Curve for Zone 5 (FDOT, 2001)

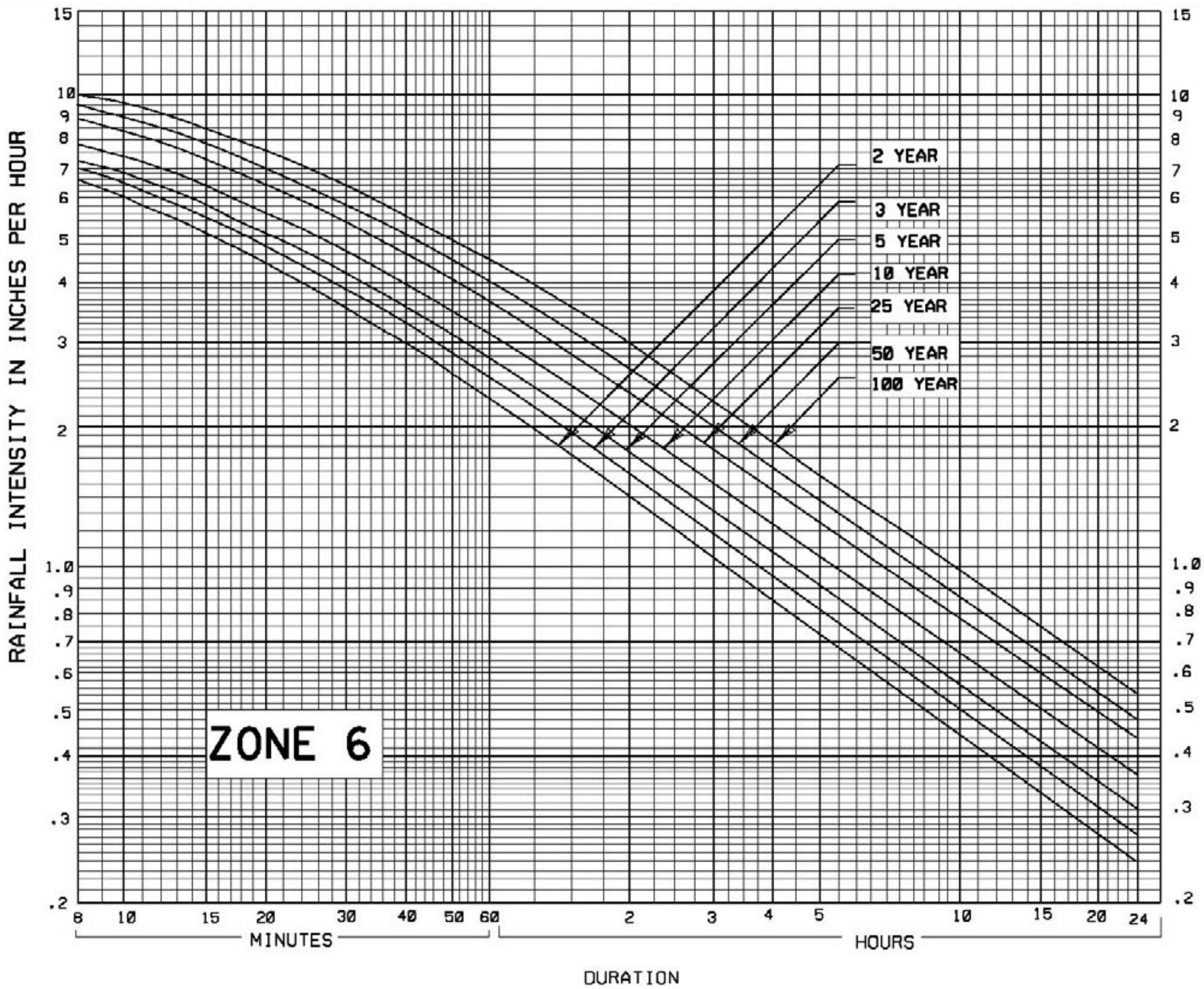

Figure III-18. Rainfall Intensity Duration Frequency Curve for Zone 6 (FDOT, 2001)

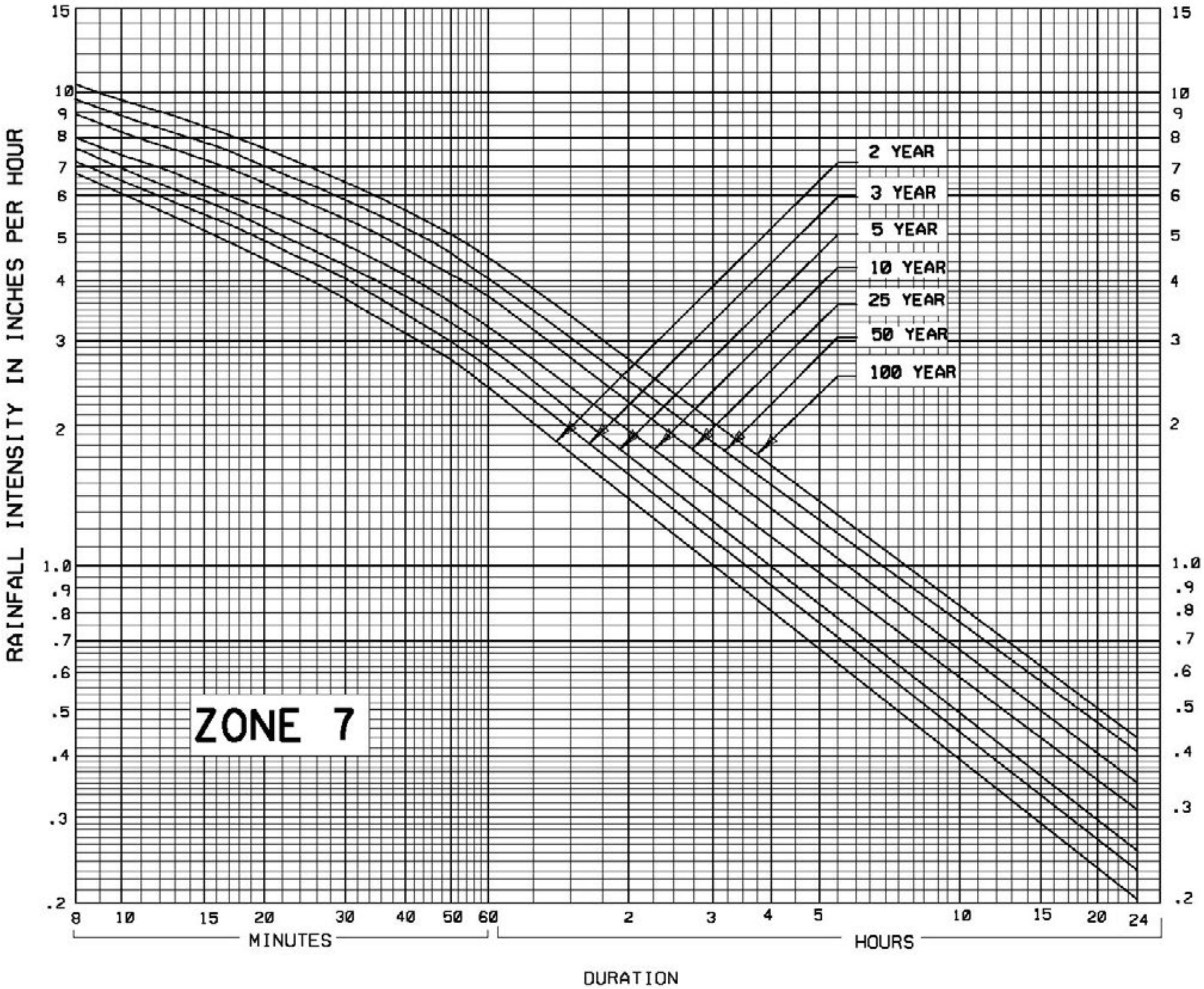

Figure III-19. Rainfall Intensity Duration Frequency Curve for Zone 7 (FDOT, 2001)

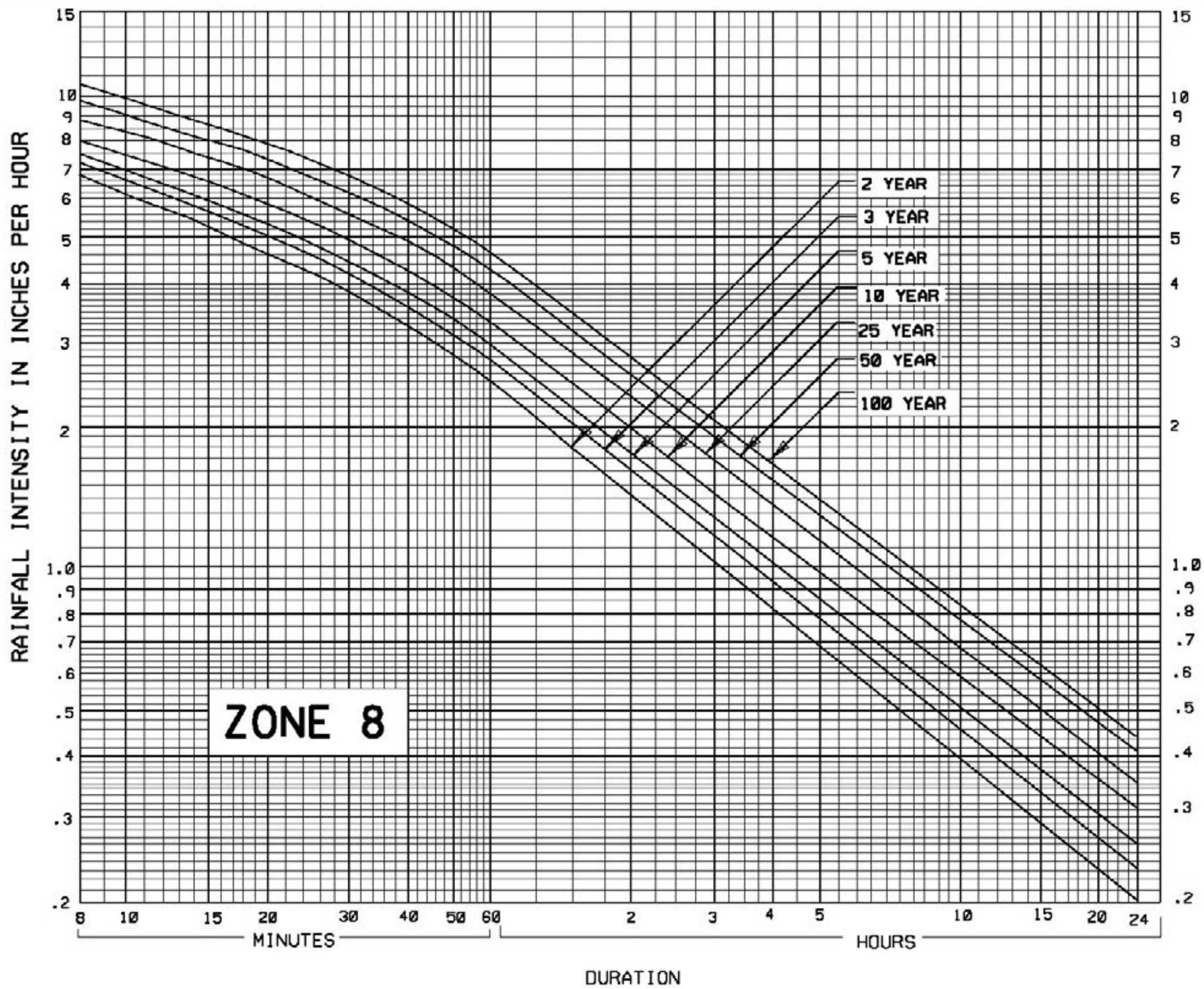

Figure III-20. Rainfall Intensity Duration Frequency Curve for Zone 8 (FDOT, 2001)

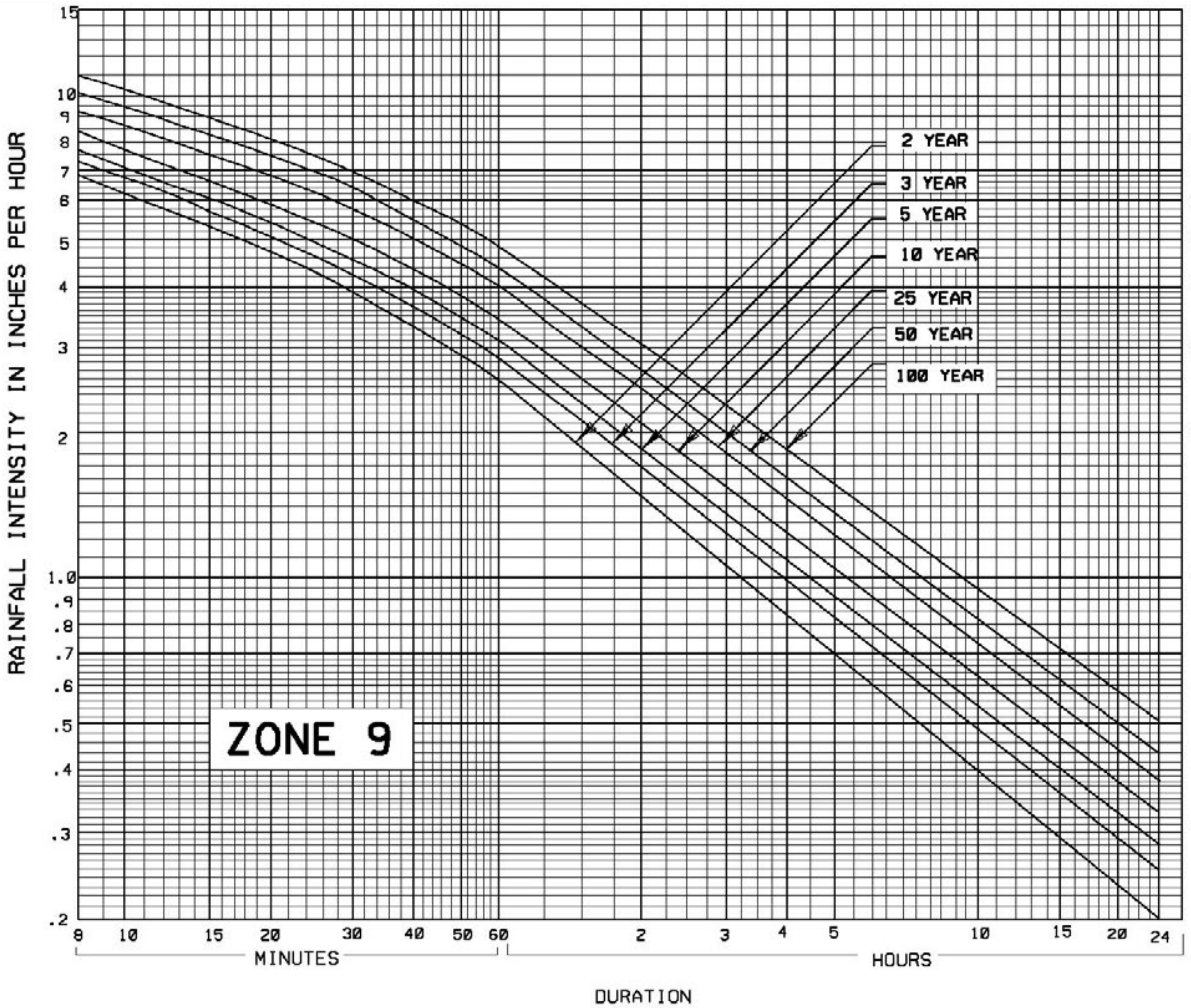

Figure III-21. Rainfall Intensity Duration Frequency Curve for Zone 9 (FDOT, 2001)

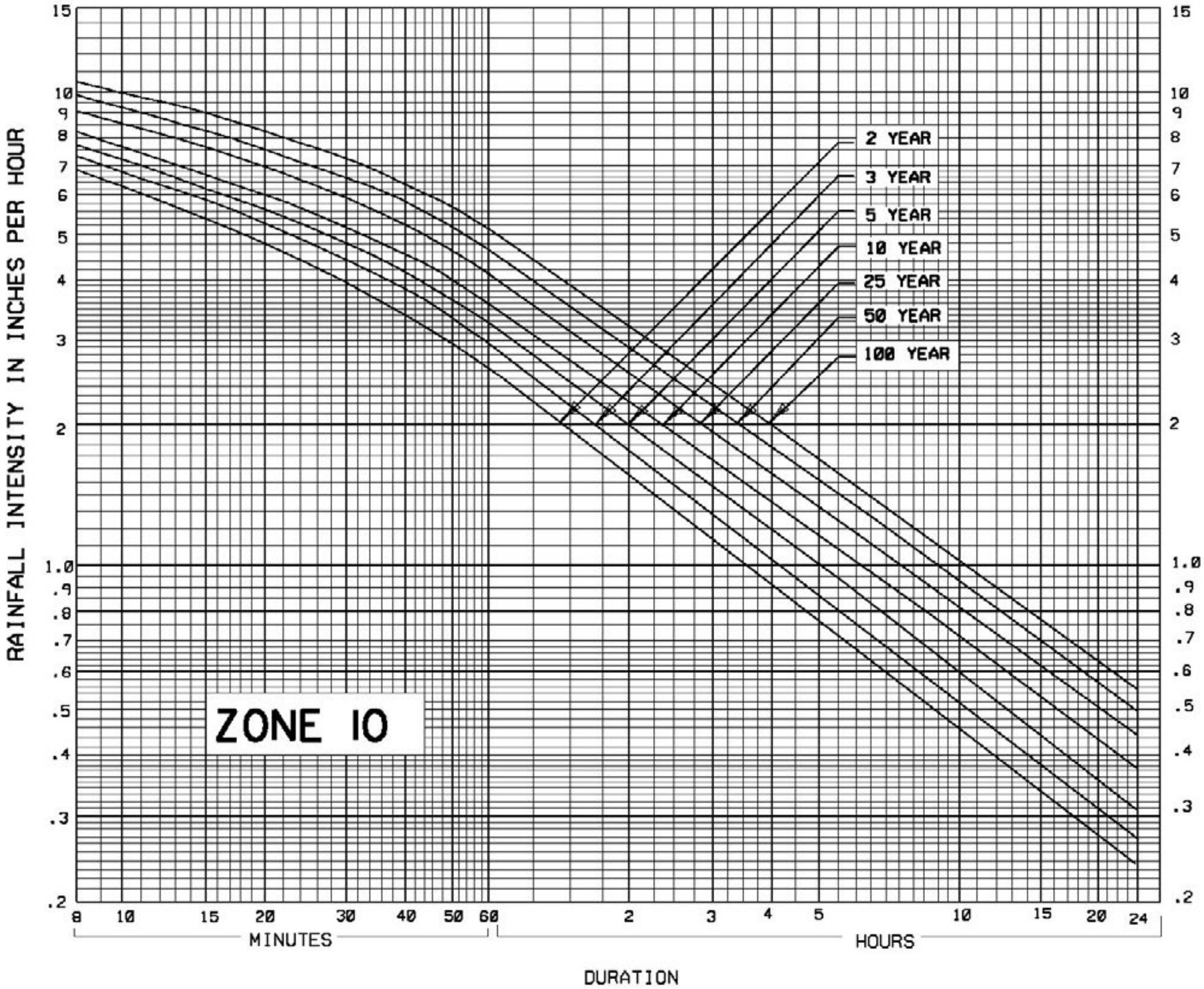

Figure III-22. Rainfall Intensity Duration Frequency Curve for Zone 10 (FDOT, 2001)

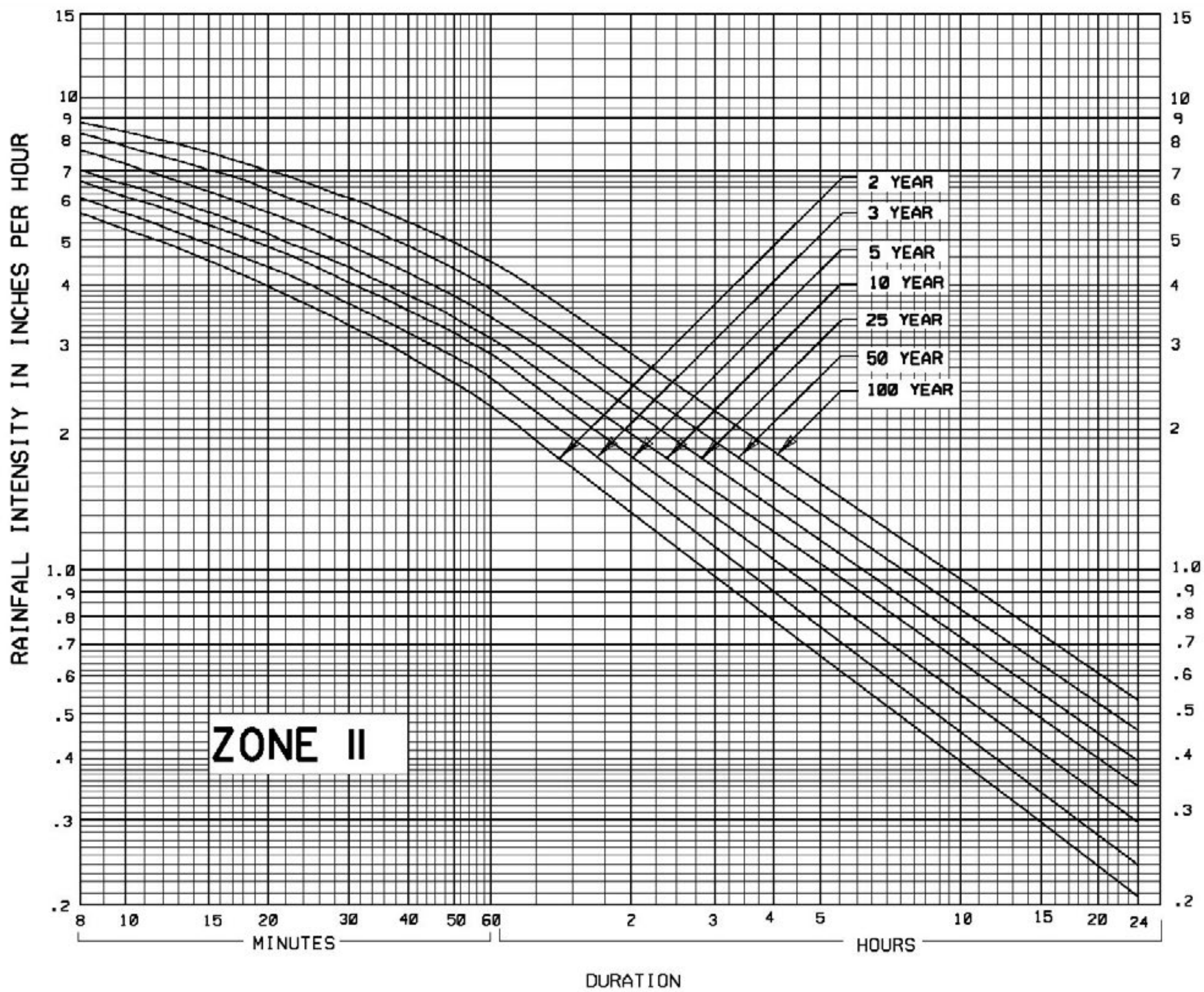

Figure III-23. Rainfall Intensity Duration Frequency Curve for Zone 11 (FDOT, 2001)

SECTION IV

SEDIMENT CONTAINMENT SYSTEMS

Table of Contents

Table of Figures

INTRODUCTION

Sediment containment systems (SCSs) are barriers having hydraulic controls that function by modifying the storm-runoff hydrograph and slowing water velocities. This allows for the deposition of larger suspended particles by gravity. Some of the more common names for these structures are *sediment basins*, *sediment ponds*, and *sediment traps*.

The only structural BMPs that can effectively remove sediment when large storm water discharges occur from active construction sites are strategically placed SCSs. Since erosion control methods cannot always be implemented in a timely manner during the construction process, Designers must include properly designed SCSs as an integral part of their E&SC plan. More importantly, the development of effective SCSs must be based upon capturing design size particles.

The role of any SCS is to create conditions for sedimentation; that is, to allow for the settlement of suspended soil particles found in runoff waters. When soil-particle transport mechanisms, such as water or wind, move at a slow rate, particles can settle out of suspension due to gravity. Deposition of sediment in an SCS is dependent upon many different parameters, including:

- Mass of the suspended particles falling through contained waters
- Surface area and containment storage volume for incoming runoff waters
- Sufficient flow path lengths within the containment system
- Uniform flow zones within the storage volume
- Discharge rates of water out of the containment system

Designing SCSs into an E&SC Drawing

While construction sites present dynamic conditions, Designers can prepare for worse case scenarios by assuming the following on construction activities for lands that discharge into a SCS:

1. Land development activities result in 100% bare ground conditions.
   a) During the initial phase of over lot grading, temporary retention structures may be able to capture all contributing runoff waters. The EPA requires these containment volumes capture runoff resulting from a 2-year, 24-hour storm event when 10 acres or more of land is disturbed. *The FDEP requires a minimum of 3,600 cubic feet of containment volume when 10 acres or more of land is disturbed.*
      i. Detention/retention design volumes usually exceed what is needed to capture runoff resulting from a 2-year, 24-hour storm event.
   b) The amount of bare ground will begin to decrease as installation of erosion control measures and pavement occurs.
   c) Once an outlet structure is installed, treatment of inflows and discharges may need to occur.
   d) Once a storm sewer system is installed and runoff discharges into a SCS, then treatment of inflows needs to occur.

2. Constructing vertical/big box structures results in less than 100% bare ground conditions tributary to an SCS as the building process occurs.
   a) Install and maintain effective SCSs for vertical/big box construction activities until at least 80% full build out conditions exist.
   b) When the developer's disturbed lands are totally re-vegetated, then only minimal treatment of runoff waters into the SCS may be required. However:
      i. Vertical/big box construction activities will destroy nearly all pre-existing vegetation.
      ii. The amount of vertical/big box disturbed lands will vary depending upon the buildings under construction, installation of landscaping material, installation of walkways and driveways, pavement of parking lots, and so forth.
      iii. Often, development of strategically placed pre-sedimentation (a.k.a. forebay) basins will minimize vertical/big box construction impacts to downstream water bodies (i.e. ponds, canals, etc.).
      iv. If the developer's land is not re-vegetated, then detention/retention ponds will intercept all sediment-laden runoff waters.
         (1) Sealing of pond bottoms may occur for untreated inflow waters.
         (2) Sediment-laden waters may discharge from the pond.
         (3) Large pre-sedimentation basins may be required.
3. Linear projects will result in 100% bare ground conditions that can be tributary to a SCS.
   a) During the initial phase of over lot grading, temporary SCSs can be developed and strategically placed to capture contributing runoff waters.
      i. If installation of outlet structures occurs, treatment of discharge waters (e.g. adding a polymer, ensuring slow release rates, etc.) may need to occur.
      ii. Development of strategically placed pre-sedimentation basins can minimize linear construction impacts to downstream water bodies (i.e. ponds, canals, etc.).
   b) The amount of bare ground conditions will decrease as installation of erosion control measures and pavement occurs.
   c) Once a storm sewer system is installed:
      i. Treatment of inflows into a containment system is advisable, if waters are released from the SCS.
      ii. Treatment of outflows is advisable when there is direct discharge into a water body or sensitive area.

Defining Sediment Containment Systems

When capturing all runoff waters, efficiency of the containment system is 100%. However, the feasibility of *retaining* all runoff waters throughout the life of a construction site (i.e. retention) may be difficult for most sites. Instead of trying to retain all runoff waters, a containment system should detain an adequate volume of runoff long enough to capture suspended "design size" particles. These systems are best represented by detention facilities.

Theoretically, design size particles can have any diameter. However, limitations will exist for design size particles depending upon whether the sediment consists of sandy or clayey materials.

Designers need to select a design size particle that represents the largest percentage of the inflow sediments.

If detention of runoff from construction sites is to be effective in removing suspended particles, contained waters must remain long enough for deposition of suspended particles within the system to occur. This is not a simple task to achieve since suspended particles fall at different rates depending upon their mass. Since outflow from the system will occur, 100% reduction of all incoming suspended particles will not be possible without the addition of polymers.

It is suggested that SCSs be developed based upon design size particles to be removed from inflow waters. Such classifications can be found in Table IV-1.

Table IV-1: Sediment Containment System Classifications

Type-1 Sediment Containment System	Design-Size Particle ≤ 0.075 mm (very fine sand and clays)
Type-2 Sediment Containment System	0.075 mm < Design-Size Particle ≤ 0.41 mm (between very fine sand and medium sands)
Type-3 Sediment Containment System	Design-Size Particle > 0.41 mm (larger than medium sands)

Type-1 Sediment Containment System

A Type-1 SCS will require development of a structure to capture the maximum possible number of coarse silt and smaller suspended particles. Since particles of this size settle very slowly without flocculation, large storage volume Type-1 SCSs require long flow-path lengths, large containment volumes, and controlled discharges.

> ***Usually, development of Type-1 SCSs requires the expertise of a professional having skills in proper design of embankments, outlet structures, and spillways.***

Type-2 Sediment Containment System

The Type-2 SCS will capture suspended particles that settle faster than particles requiring Type-1 structures. Consequently, use of smaller storage volumes and shorter flow-path lengths is feasible. As with a Type-1 structure, these sediment control systems will also have controlled discharges. The traditional sediment trap best represents Type-2 systems.

> ***Depending upon the complexity of the structure, development of Type-2 SCSs may or may not require the expertise of a professional having skills in proper design of embankments, outlet structures, and spillways.***

Type-3 Sediment Containment System

The least effective methods to control suspended particles in runoff waters are Type-3 SCSs. These are not necessarily design structures, as found with Type-1 and Type-2 systems, but are often temporary BMPs commonly found on construction sites such as silt-fence barriers, inlet control structures, and ditch check structures.

Whenever significant runoff occurs, all Type-3 systems have very low effectiveness to control suspended particles without some additional treatment (e.g. adding a polymer). However, when runoff is small and adequate maintenance exists, the Type-3 sediment control systems may be effective in removing larger diameter suspended particles. Extensive information on Type-3 systems appears in Section V.

Effectiveness of Sediment Containment Systems

Field studies conducted by EPA (1976) to characterize containment systems and to evaluate their effectiveness for trapping sediment produced the following observations:

- Poor construction and inadequate maintenance of the sites were the major factors contributing to pond ineffectiveness.
- Predicted efficiency was higher than observed efficiency. Containment systems were effective in trapping sediment during baseline flows, but not during rainfall events.
- Outlet riser pipes and emergency spillways were not properly sized. Trash quickly clogged the pipes. The rising waters rushed over the unprotected spillways and scoured out large holes in the embankment.
- Containment systems that appeared to need cleaning transferred additional inflow directly to the outlet.

It was concluded from these studies that efficiencies of sediment containment systems could be increased by:

- Using techniques that reduce inflow energy
- Allowing sufficient travel time for design-size particles to fall through the water
- Preventing re-suspension of particles

Documentation on the effectiveness of containment systems for trapping suspended solids is limited and there are conflicting opinions on their actual effectiveness. However, the general concept is that if properly designed, constructed, and maintained, SCSs will always be effective in trapping some sediment.

Fifield (2004) developed equations found in Table IV-2, which can assist Designers with identifying *minimum parameters* for ensuring the development of effective containment structures. The equations assume removal of design size particles will occur when terminal (a.k.a. particle settling) velocity conditions exist.

One method (albeit not entirely accurate since sediments are not spherical in shape) for determining terminal velocities in water is to calculate the rate of fall based upon Stokes' Law. Table IV-3 illustrates particle-settling velocities for some design size particles at different temperatures as calculated by Stokes' Law.

Finally, equations found in Table IV-2 make reference to different graphs. Figure IV-1 provides an Apparent Effectiveness chart, which is a measure of a SCS to remove design size particles. Figure IV-2 provides a graph to determine the percent of Particles Equal to or Greater (PEG) than a design size particle that can become suspended in water when runoff events occur.

Use of the equations and accompanying graphs are illustrated in the example found at the end of this section. Additional information on sizing a SCS exists in the publication by Fifield (2004).

Table IV-2: Minimum Parameters for Sediment Containment Systems (Fifield, 2004)

MINIMUM PARAMETERS	ENGLISH UNITS
Surface Area	$SA_m = (1.2 \times Q_{out}) \div V_s$
Flow-Path Length	$L = [(L \div W_e) \times SA_m]^{0.5}$
Effective Width	$W_e = SA_m \div L$
Type-1 System Volume *(Select the larger value)*	$VOL_m \geq 2.2 \times SA_m$ or $VOL_m \geq$ runoff from a 2-year, 24-hour storm event for a minimum 3,600 $ft.^3$ of disturbed upstream land and for 10 acres.
Type-2 System Volume	$VOL_m \geq 2.2 \times SA_m$
Net Effectiveness	$NEff = AEff \times PEG$
Average Depth	$D_{avg} \geq 2.2\ ft.$
Outlet Depth	2.0 *ft.*

LEGEND

$AEff$ = Apparent effectiveness (%) of the SCS to remove design size (and larger) particles suspended in runoff waters = $20(L \div W_e) - (L \div W_e)^2$

D_{avg} = (Actual volume) ÷ (actual surface area)

V_s = Particle settling velocity (*ft./sec.*)

L = Particle flow distance (*ft.*)

VOL_m = Minimum water volume ($ft.^3$)

$NEff$ = Net effectiveness (%) of the SCS to remove all particles suspended in runoff waters

W_e = Effective pond width (*ft.*)

PEG = Percent of particles that are equal to or greater than the design-size particle (%)

SA_m = Minimum water-surface area of system ($ft.^2$)

Q_{out} = Outflow ($ft.^3/sec.$)

Table IV-3: Estimated Settling Velocities for Suspended Particles (Specific Gravity = 2.65) in Water at Different Temperatures as Calculated by Stokes' Law

DIAMETER	SETTLING VELOCITY IN FEET PER SECOND						
(mm)	40°F	50°F	60°F	70°F	80°F	90°F	PARTICLE
0.01	0.00019	0.00023	0.00026	0.00030	0.00034	0.00039	FINE SILT
0.02	0.00076	0.00090	0.00105	0.00121	0.00137	0.00154	MEDIUM SILT
0.03	0.00172	0.00203	0.00236	0.00271	0.00308	0.00347	
0.04	0.00305	0.00361	0.00420	0.00483	0.00548	0.00617	COARSE SILT
0.05	0.00477	0.00564	0.00656	0.00754	0.00856	0.00963	
0.06	0.00687	0.00811	0.00945	0.01086	0.01233	0.01387	
0.07	0.00935	0.01105	0.01286	0.01478	0.01678	0.01888	VERY FINE SAND
0.08	0.01221	0.01443	0.01680	0.01930	0.02192	0.02466	
0.09	0.01545	0.01826	0.02126	0.02443	0.02774	0.03121	
0.10	0.01908	0.02254	0.02625	0.03016	0.03425	0.03854	
	4.4°C	10.0°C	15.6°C	21.1°C	26.7°C	32.2°C	

COMMONLY USED CONVERSION FACTORS

1.0 *cm/sec.* = 0.03281 *ft. /sec.* = 0.3937 *in./sec.*

1.0 *m* = 3.281 *ft.* = 39.37 *in.*

1.0 *in.* = 2.54 *cm* = 25.4 *mm*

1.0 *ha.* = 2.471 *ac.* = 107,637 $ft.^2$

1.0 m^3 = 35.3 $ft.^3$

$°C = 5/9\ (°F - 32°)$

NOTE: Design size particles larger than 0.10 *mm* are assumed to accelerate downward through water based upon Newtonian principles.

A conservative approach to sizing SCSs is to use a settling velocity when a water temperature is at its lowest value.

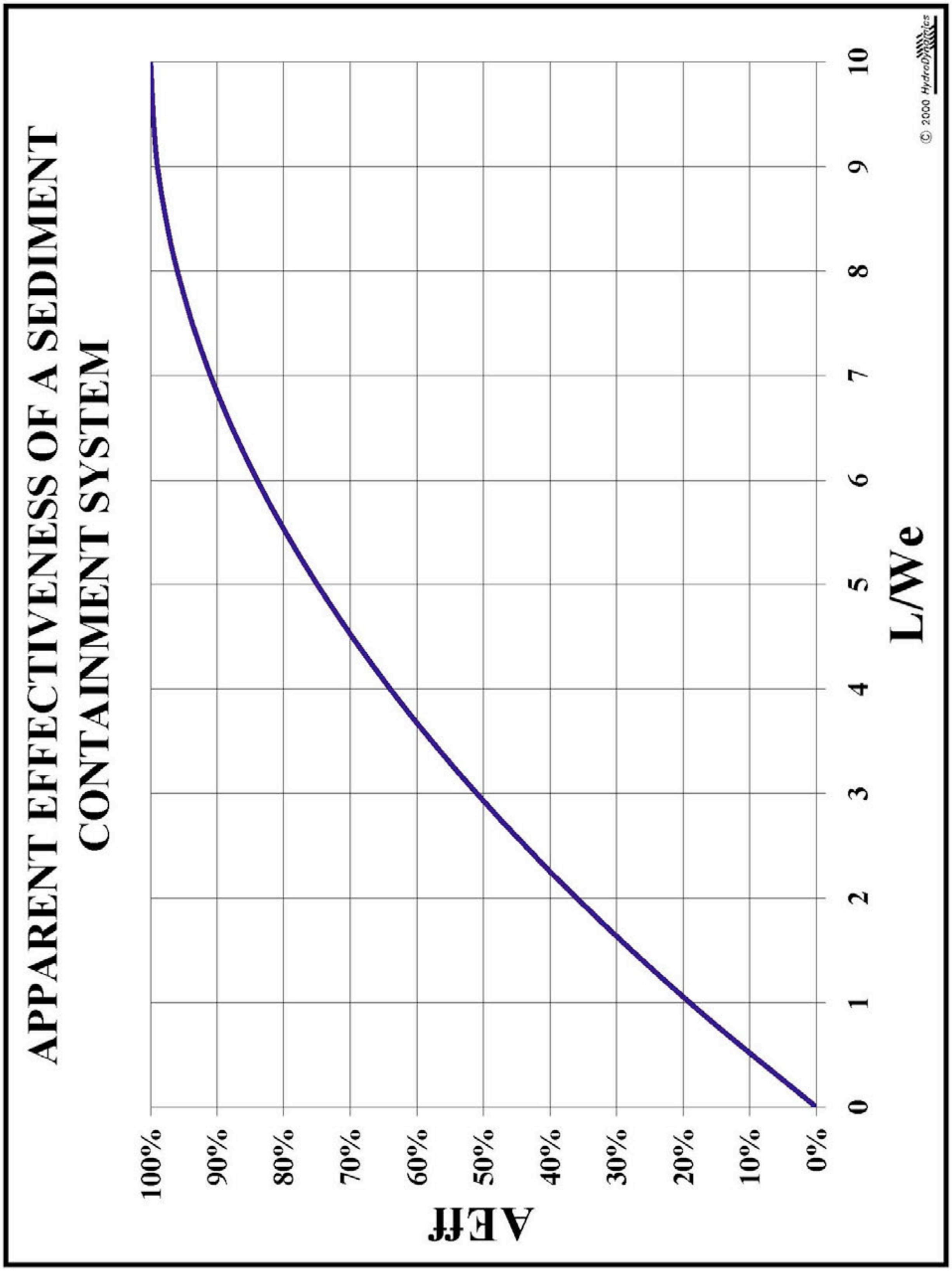

Figure IV-1: Apparent Effectiveness Graph (Fifield, 2004)

Project Name: **Date:** **By:**
Project Number: **Sample Location:**
Soil Type/Name (if known):

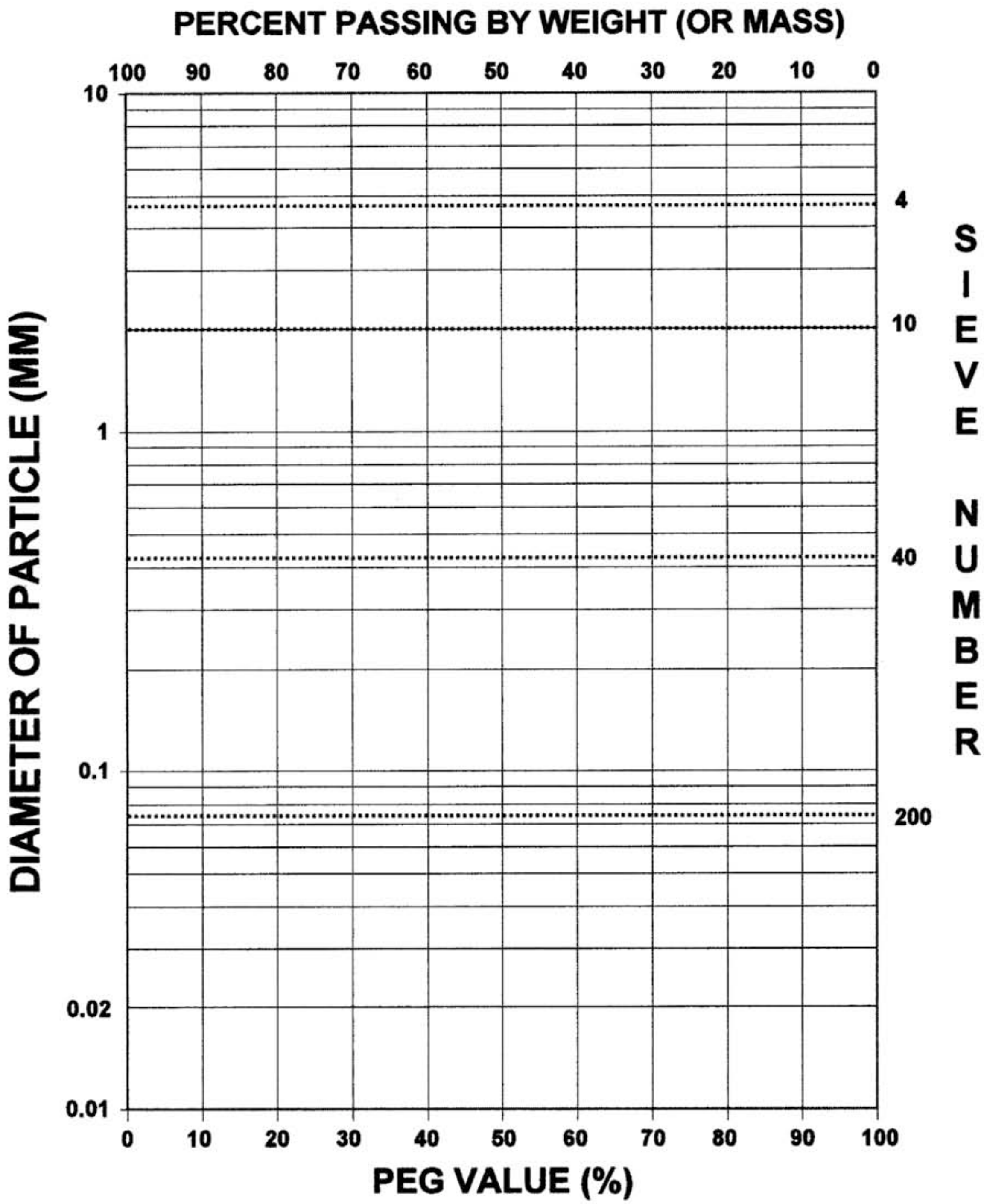

Figure IV-2: PEG Chart for Sediment Containment Systems (Fifield, 2004)

Sediment Containment System Outlet Structures

An important element of effective sediment containment systems is the outlet structure. These are required when containing runoff waters by any structure and can include the following systems.

Surface Skimmers

Skimmers remove water from the upper pond layers of a Type-1 SCS. Since the upper layer of water will have the least amount of suspended particles, discharges may be relatively free of sediment. This method is one of the more effective outlet structures to use for large containment systems (see Figure IV-4). Unfortunately, without additional treatment, discharges through a skimmer will usually not meet water quality turbidity standards. However, when a polymer or alum is introduced into the system that results in clear water within the upper (i.e. 3- to 6-inches) pond depths, then discharges through a skimmer may meet water quality turbidity standards.

Selection of a skimmer is dependent upon how long water is to be detained within the SCS. In absence of regulatory requirements, it is recommended that contained waters take about 48 hours to drain from an SCS.

Perforated Riser Pipes

Commonly used outlet structures for a Type-1 SCS are PVC or corrugated metal riser pipes. They release water through the top of the pipe and through side perforations. Since removal of contained waters occurs at different elevations, their effectiveness is less than skimmers (see Figure IV-5). In absence of regulatory guidelines, it is recommended that contained waters take about 48 hours to drain from an SCS.

Increased trapping efficiency of a riser pipe will occur by placing a rock barrier around the perforated section. However, when rock is not available, then placement of fabric material around a perforated riser pipe might have to occur. Unfortunately, use of the wrong fabric will result in clogging of the material resulting in the lack of drainage, which causes difficulties in maintenance of the structure. Therefore, it is critical that Designers specify the proper selection of fabric to ensure pore clogging does not happen.

DEWATERING ACTIVITIES

Dewatering operations are an important component in the construction process and receive special attention from the local water management agencies. Regulators are especially concerned with the protection of wetlands from drawdown effects and protecting the receiving water body from sedimentation and capacity limitations.

Types of Dewatering Methods

Rim Ditching

Rim ditching is one of the more commonly used dewater methods where a ditch is excavated along the inside perimeter of the excavation area and a pump is used to keep the level of the ground water below the bottom surface of the excavation. This is the least expensive of the methods, requiring only a trash pump and backhoe. However, it produces the dirtiest water that must be treated prior to offsite discharge. While rim ditching may be the cheapest method of construction dewatering, potential costs of treating water prior to discharge may result in much higher costs.

Sock Pipe/Horizontal Wells

The second common method of dewatering used in Florida includes the installation of perforated plastic pipes, usually wrapped in geosynthetic fabric, in a horizontal fashion on the inside of the excavation pit. While this method is more expensive to install then the traditional rim ditching, it does produce significantly cleaner discharge water. Initial installation of the sock pipe is limited to 15-20 feet. However deeper dewatering depth can be achieved in phases. The use of sock pipe is limited in clay soils.

Well Point Systems

The last of Florida's common method of dewatering includes the installation of multiple shallow wells that are attached to a main collection pipe attached to a central pump. Well point systems are typically used in linear projects such as installation of pipelines and culverts in roadways and shallow, linear ponds. The cost of this method is the most expensive of the three methods; however, it produces the cleanest water.

Turbidity Monitoring for Off-site Discharge

When dewatering operations consist of off-site discharge, the contractor must ensure the effluent meets state water quality standards. The standards for discharging water into a receiving body cannot exceed 29 nephelometric turbidity units (NTU's) above background. Samples of the effluent should be taken at the discharge point into the receiving body. For best results, samples should be taken 2 times a day, at least 4 hours apart.

Using SCSs for Dewatering

All of the dewatering activities described above usually will involve pumping water into a temporary containment system to ensure proper settlement of suspended particles. The equations found in Table IV-2 can assist Designers in development of a small SCS needed for these dewatering activities. Unfortunately, it is not known what the diameter of suspended particles will occur during pumping activities. However, Designers can provide preliminary assessments and recommendations using the following assumptions:

- The design size particle will be 0.02 *mm*
- The discharge rate of water out of the SCS will equal the pumping rate
- The minimum volume of contained water will be that found for a Type-2 system

Once actual field conditions exist, changes to Designer's preliminary recommendations may occur due to finding larger design size particles, greater outflows, use of polymers, and so forth. An example of sizing an SCS for dewatering activities is illustrated at the end of this section.

Increasing the Efficiency of a SCS

How can more particles be captured by a SCS? One method is to capture all runoff waters. However, this is neither practical nor feasible. Another technique is to increase the flow path that runoff waters have to travel within the structure before discharging. Unfortunately, physical limitations of the pond, re-suspension problems, lack of uniform sizing (a Stokes Law assumption for development of Table IV-3), and so forth will prevent this theoretical solution.

Sediment Containment System Internal Barrier and Weir

WHAT IS ITS PURPOSE?

To extend the flow path length of suspended particles within a sediment containment system.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-3 FOR AN EXAMPLE)?

- In ponds with small surface areas and small volumes.
- To increase the efficiency of a sediment containment system.
- In ponds with short flow path lengths.

WHEN SHOULD IT BE INSTALLED?

- Immediately after the sediment containment system is constructed.
- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- Where high inflow runoff waters exist.
- As a “stand alone” method that is not part of a properly designed SCS.
- Where high internal pond flow velocities exists due to improper outlet structures.
- After grading activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Does the fence need repair?
- Are metal stakes used and are they properly spaced?
- Is water flowing under the fence material?
- Does water flow over the weir?
- Does accumulated sediment need to be removed?
- Is the outlet structure causing ponding?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of fence material.
- Repair of eroded ground.
- Removal of accumulated sediment.

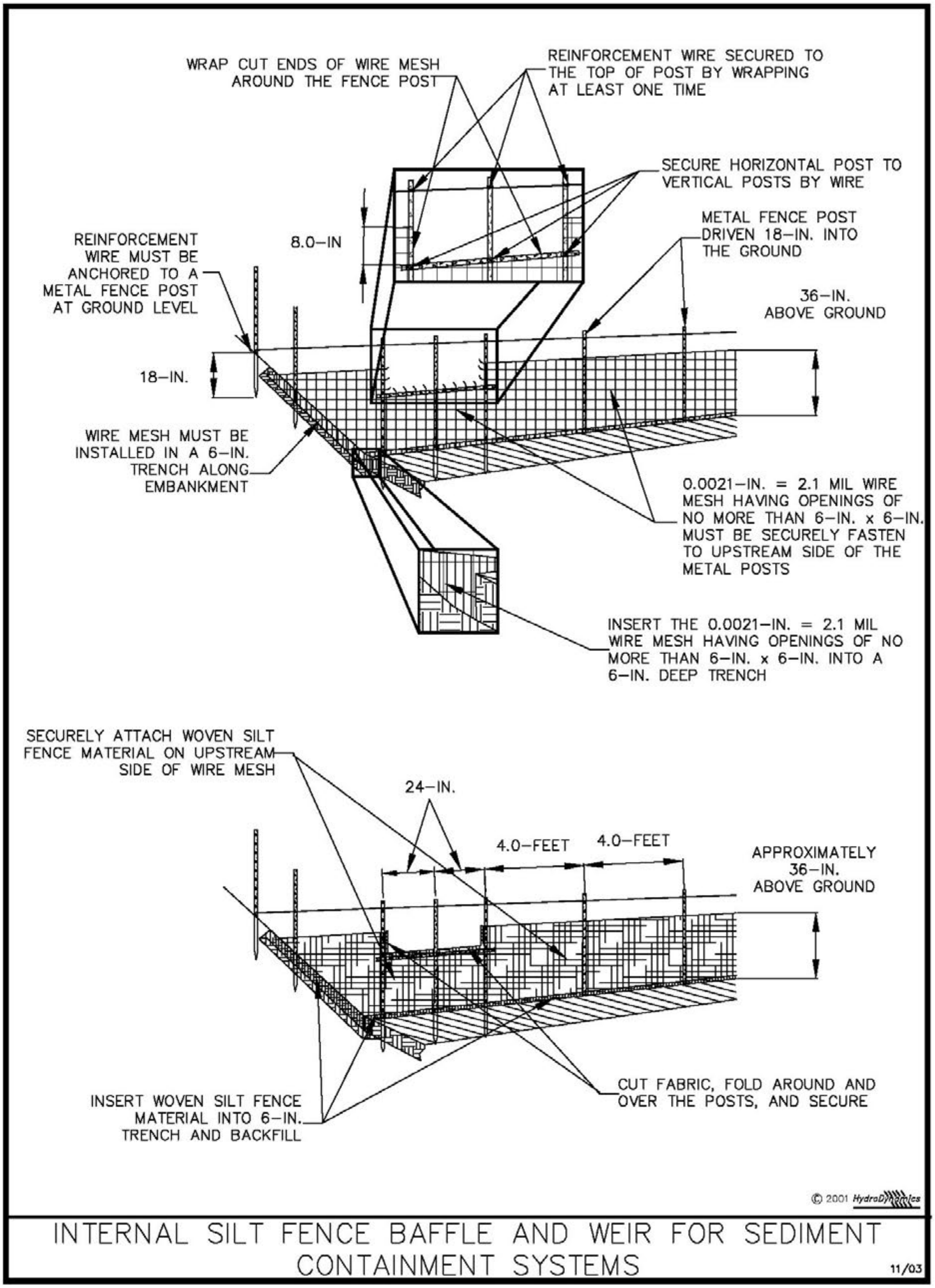

Figure IV-3: Illustration of a SCS Internal Silt Fence Barrier and Weir

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Sediment Containment System: Faircloth® Surface Skimmer

WHAT IS ITS PURPOSE?

To drain a sediment containment system by removing water from the top layer where the least amount of suspended particles exist.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-4)?

- In Type-1 sediment containment systems
- At sites with large amounts of fines are suspended in runoff waters.
- Where low discharge of pond water is desired.

WHEN SHOULD IT BE INSTALLED?

- Immediately after a Type-1 sediment containment system is constructed.
- Before construction activities begin.
- To increase the effectiveness of capturing suspended particles that has been treated with a polymer or alum.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- In small basins better suited for Type-2 Sediment Containment Systems.

WHAT NEEDS TO BE INSPECTED?

- Overall appearance of the skimmer?
- Are there any cracks or broken pieces?
- Is the trash screen clogged?
- Is the skimmer draining properly?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Removal of trash from orifice.
- Repair of unit due to vandalism.

Notes

- Unless advised otherwise, resident time of contained waters within an SCS is at least 48 hours.
- See Table IV-2 for equations to size an SCS as well as examples at the end of this section.

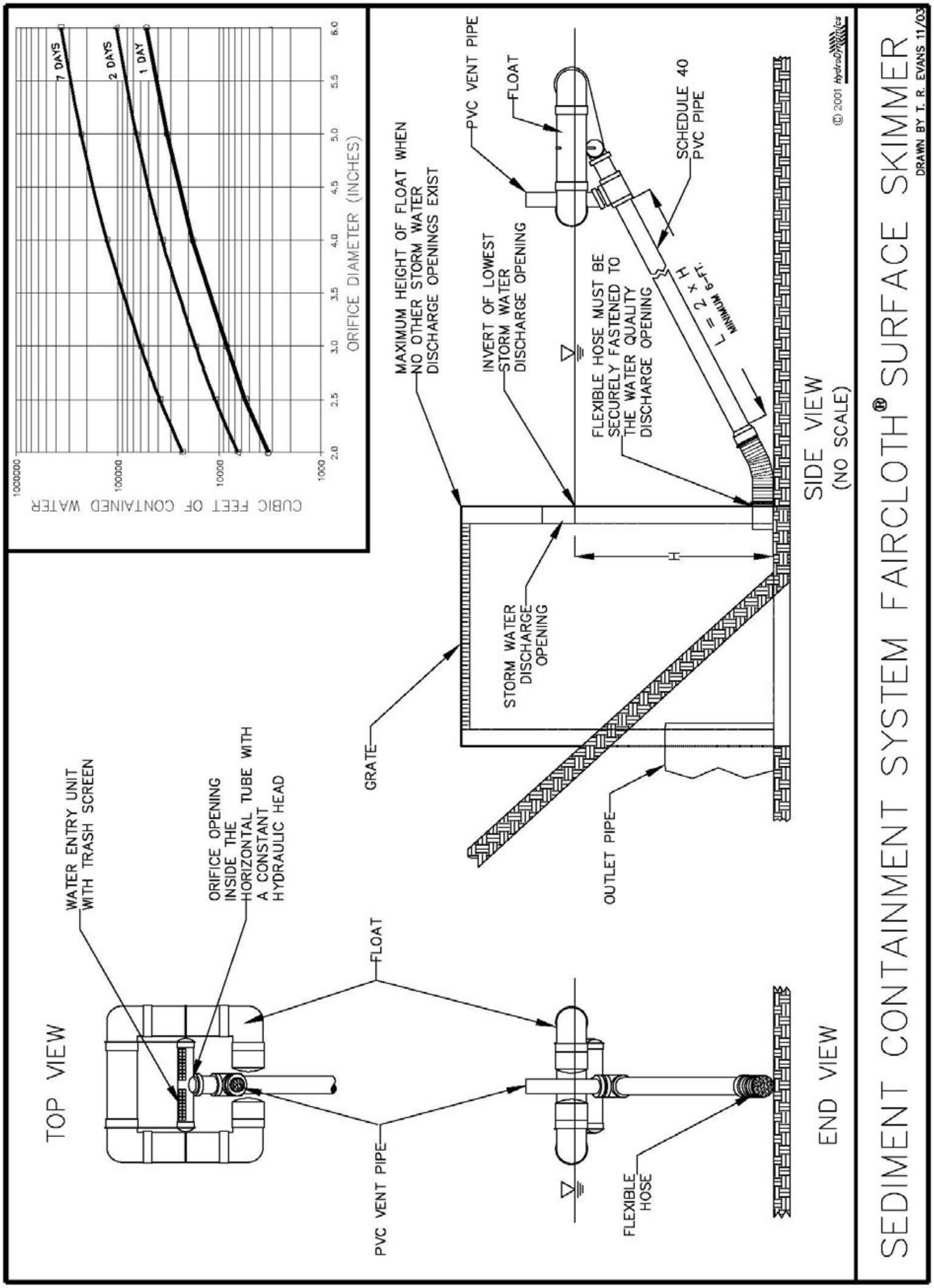

Figure IV-4: Illustration of a SCS Faircloth® Surface Skimmer

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Sediment Containment System: IAS® Water Quality Skimmer

WHAT IS ITS PURPOSE?

To increase the TSS removal efficiencies of sediment basins, sediment traps, and water quality ponds.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-5)?

The skimmer is used as a replacement for the riser/barrel in sediment traps. It serves as the dewatering device in sediment basins. The skimmer removes the cleaner surface water from the BMP, which reduces the TSS and improves the turbidity.

WHEN SHOULD IT BE INSTALLED?

The skimmer is installed in conjunction with the construction of sediment traps, sediment basins and water quality ponds.

WHEN SHOULD IT NOT BE INSTALLED?

The skimmer should not be installed in any other erosion control measure other than sediment traps, sediment basins or water quality ponds.

WHAT NEEDS TO BE INSPECTED?

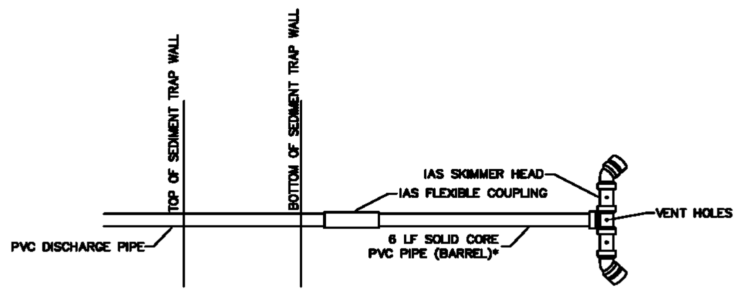
The skimmer has color banding to allow for easy identification of the skimmer size. The skimmer has this side up and this side down stickers to indicate orientation. The skimmer's general condition should be checked (cracking, ect.)

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

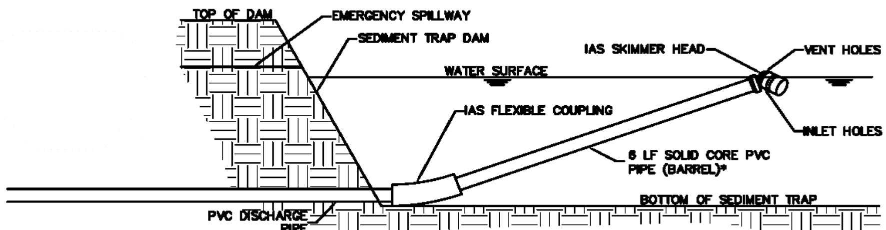
None anticipated.

Notes

Skimmers will need some onsite assembly. Assembly instructions are included in the kit as shipped from the manufacturer. Additional information can be found at www.iasllcusa.com



INSTALLATION PLAN VIEW
NTS



INSTALLATION PROFILE VIEW
NTS

QUANTITY	SKIMMER SIZE (IN)	BARREL SIZE (IN)	DISCHARGE PIPE SIZE (IN)	24 HOUR FLOW (CF)	2 DAY FLOW (CF)	3 DAY FLOW (CF)	4 DAY FLOW (CF)	5 DAY FLOW (CF)	6 DAY FLOW (CF)	7 DAY FLOW (CF)
	1.5	2	2	1,804	3,608	5,412	7,216	9,020	10,824	12,628
	1.75	2	2	2,405	4,810	7,216	9,621	12,027	14,432	16,837
	2	3	3	3,928	7,856	11,784	15,712	19,640	23,568	27,496
	2.5	3	3	6,137	12,275	18,412	24,550	30,687	36,825	42,962
	3	4	4	10,205	20,410	30,616	40,812	51,026	61,232	71,437
	4	6	6	22,220	44,440	66,661	88,881	111,101	133,322	155,542
	5	6	6	34,719	69,438	104,157	138,877	173,596	208,315	243,034
	6	6	6	49,995	99,991	149,987	199,983	249,978	299,974	349,970
	8	8	8	102,631	205,262	307,894	410,525	513,156	615,788	718,419

Figure IV-5: Illustration of a SCS IAS® Water Quality Skimmer

Sediment Containment System Riser Pipe Outlet Structure

WHAT IS ITS PURPOSE?

Provide controlled release of contained water.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-6)?

- Provide a method to allow for the slow discharge of contained runoff waters.
- Commonly used in Type-1 sediment containment systems.

WHEN SHOULD IT BE INSTALLED?

- Immediately after the sediment containment system is constructed.
- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Is the rock filled with sediment?
- Does water drain through rock?
- Is the right sized rock used?
- Is top of riser pipe below the spillway and open?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Replacement of rock.
- Removal of sediment.

Notes

- It is important that wrapping a riser pipe of an SCS with a fabric material not occur since clogging with clay and silt particles will occur, which will prevent proper drainage.
- Sizing is dependent upon the amount of inflow and required outflow from the containment system.
- Unless advised otherwise, resident time of contained waters within an SCS is at least 48 hours.
- See Table IV-2 for equations to size an SCS as well as examples at the end of this section.

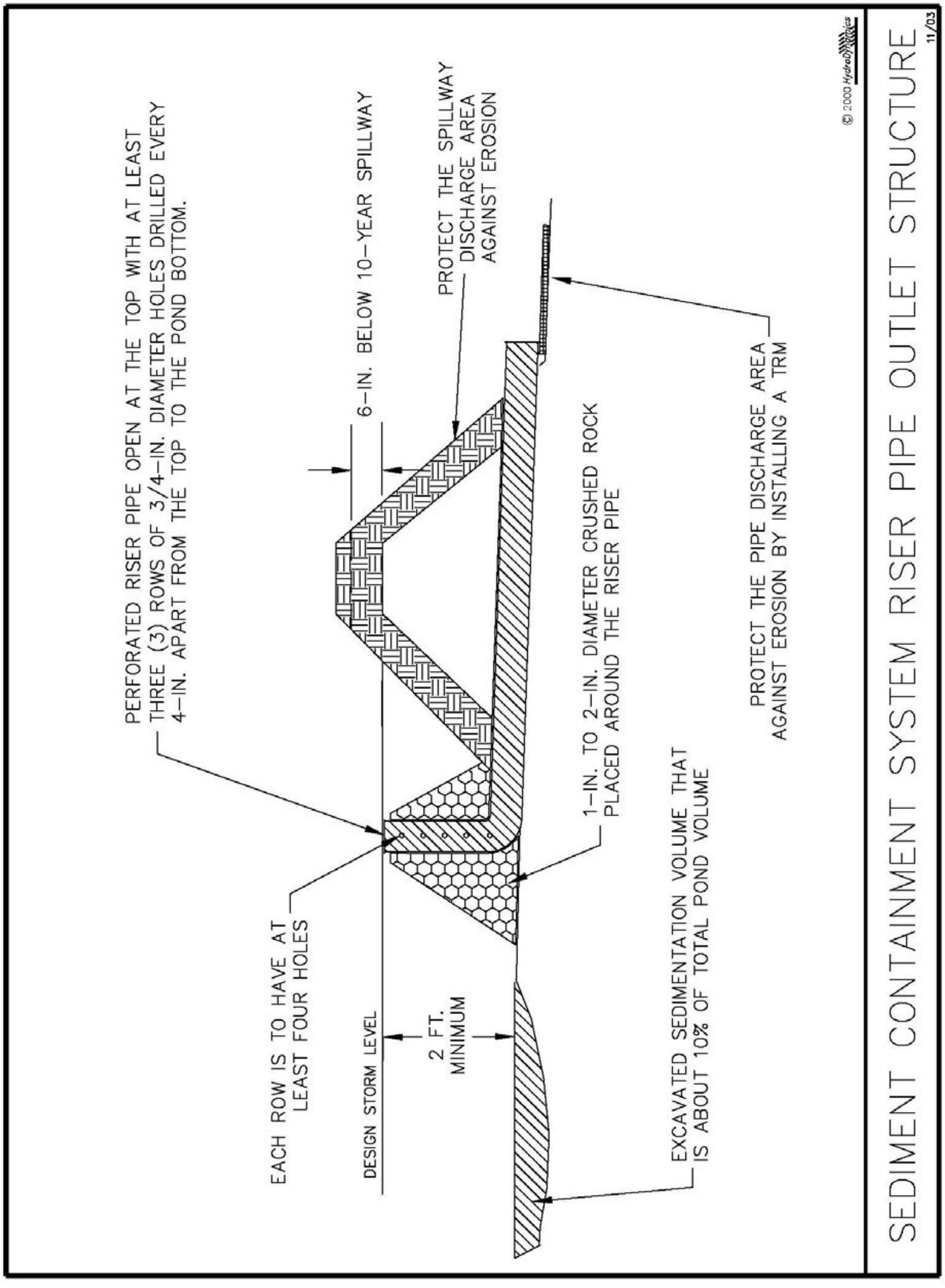


Figure IV-6: Illustration of a SCS Riser Pipe Outlet Structure

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During the construction phase of a project, significant amounts of sediment can potentially flow into (and often out of) a SCS. Increased efficiency can occur by trapping larger diameter particles with a pre-sedimentation (a.k.a. forebay) and/or introducing a polymer (when suspended clay colloidal materials exist) or possibly alum (for other types of colloidal materials).

Pre-Sedimentation Basins

Essentially, a pre-sedimentation basin is a small SCS specifically designed to capture anticipated sediment loading from disturbed lands. However, it is important that sufficient volume exist to capture larger diameter sediments while inflows equal outflows. Figure IV-7 illustrates some conceptual pre-sedimentation basins in which deposition of larger suspended particles occur.

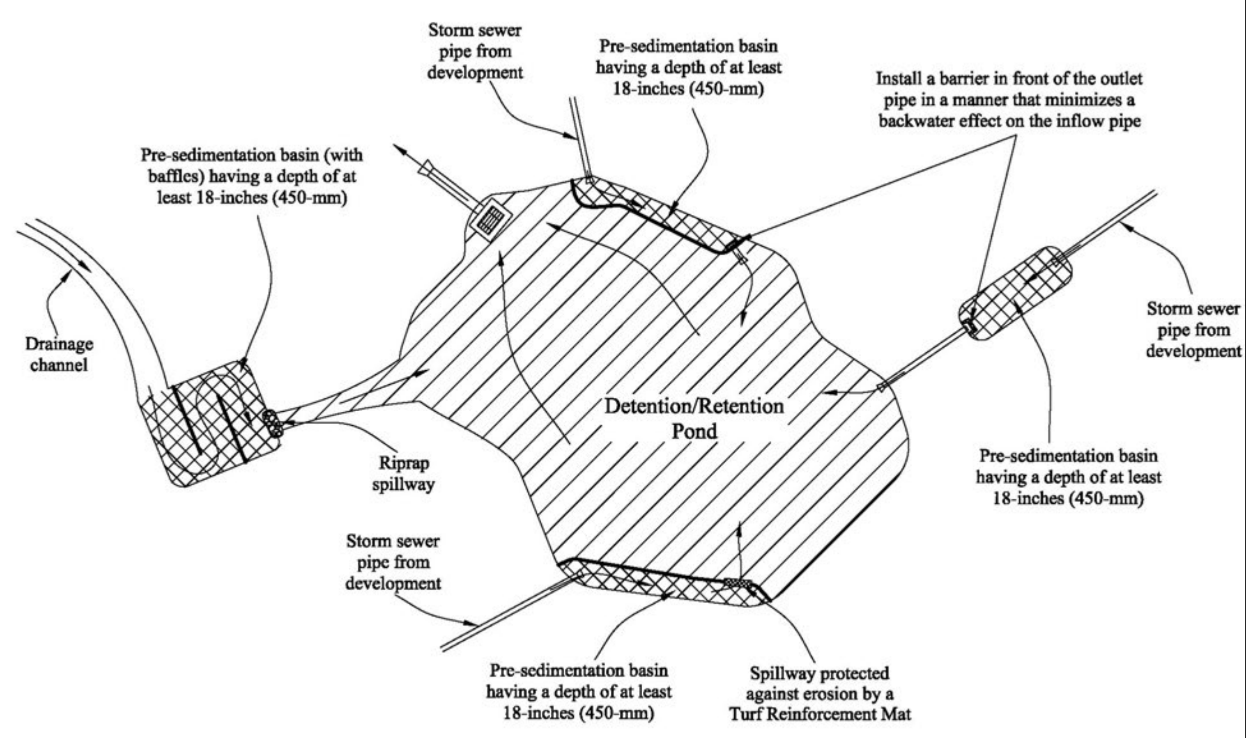


Figure IV-7: Conceptual Pre-Sedimentation (a.k.a. Forebay) Basins (No Scale)

The concept of a pre-sedimentation basin is simple; instead of allowing inflow waters to discharge directly into a large detention/retention pond, they first enter a smaller containment system to allow for the deposition of larger suspended particles. These pre-sedimentation basins can be periodically cleaned to remove accumulated sediments.

During the land development or linear phase of a project, Designers must use data on upstream erodibility of soils, hydrologic characteristics of contributing basins, and a design storm event to determine the size of a pre-sedimentation basin. By applying and modifying information found in Fifield (2004), use the following equations to calculate the size of a pre-sedimentation basin (see examples at the end of this section):

Sediment Yield = $(K_{\text{site}} \div K_{\text{chart}}) \times LR \times A^{1.12}$ (cubic feet) **Equation IV-7**

Surface Area = 0.67 × Sediment Yield (square feet) **Equation IV-8**

Length = 3.79 × (Surface Area)$^{0.50}$ (feet) **Equation IV-9**

Width = 0.10 × Length (feet) **Equation IV-10**

Where K_{site} = Anticipated Soil Erodibility Factor of the site

K_{chart} = Soil Erodibility Factor found on Figure IV-8 through Figure IV-11

LR = Loading Ratio value found from Figure IV-8 through Figure IV-11

A = Contributing area in acres

It is important that all pre-sedimentation basins have a minimum depth of 18 inches.

An added benefit for full build out conditions may exist when installing and maintaining a pre-sedimentation basin that becomes part of a detention/retention facility. Such a facility can be part of the water quality features needed to ensure that the project remains compliant for post-construction conditions.

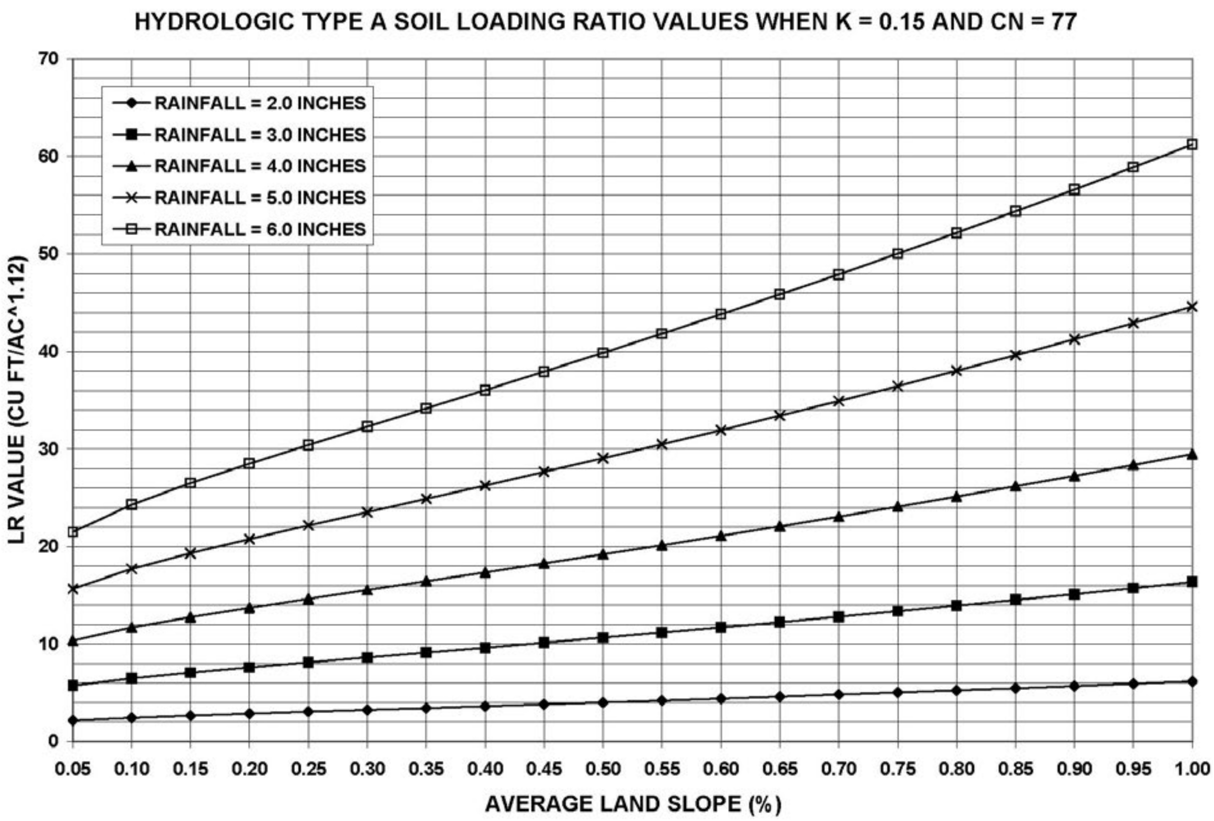
Barriers for Pre-Sedimentation Basins

A riprap barrier at the discharge end of a pre-sedimentation basin provides a simple method to detain runoff waters and still allow for the deposition of larger sized suspended particles while ensuring inflow values equal outflow values. Figure IV-12 through Figure IV-15 illustrates these types of containment structures.

Use of these barriers is more commonly for "in-line" basins placed within drainage channels. It is important that sufficient spillway width be available to ensure flood flow conditions can occur without damaging the structure.

Another type of barrier consists of material placed in front of a culvert in a manner that allows for pond development and conveyance of inflow waters from drainage swales or upstream storm sewer systems. It is important that proper design and installation occur to ensure outflow values are not less than inflow values (see Figure IV-15).

Occasionally there is a need for small containment systems such as when pumping water from behind cofferdams or small dewatering projects. The filter bag (see Figure IV-16) may provide a temporary method for removing larger diameter particles suspended in runoff waters.



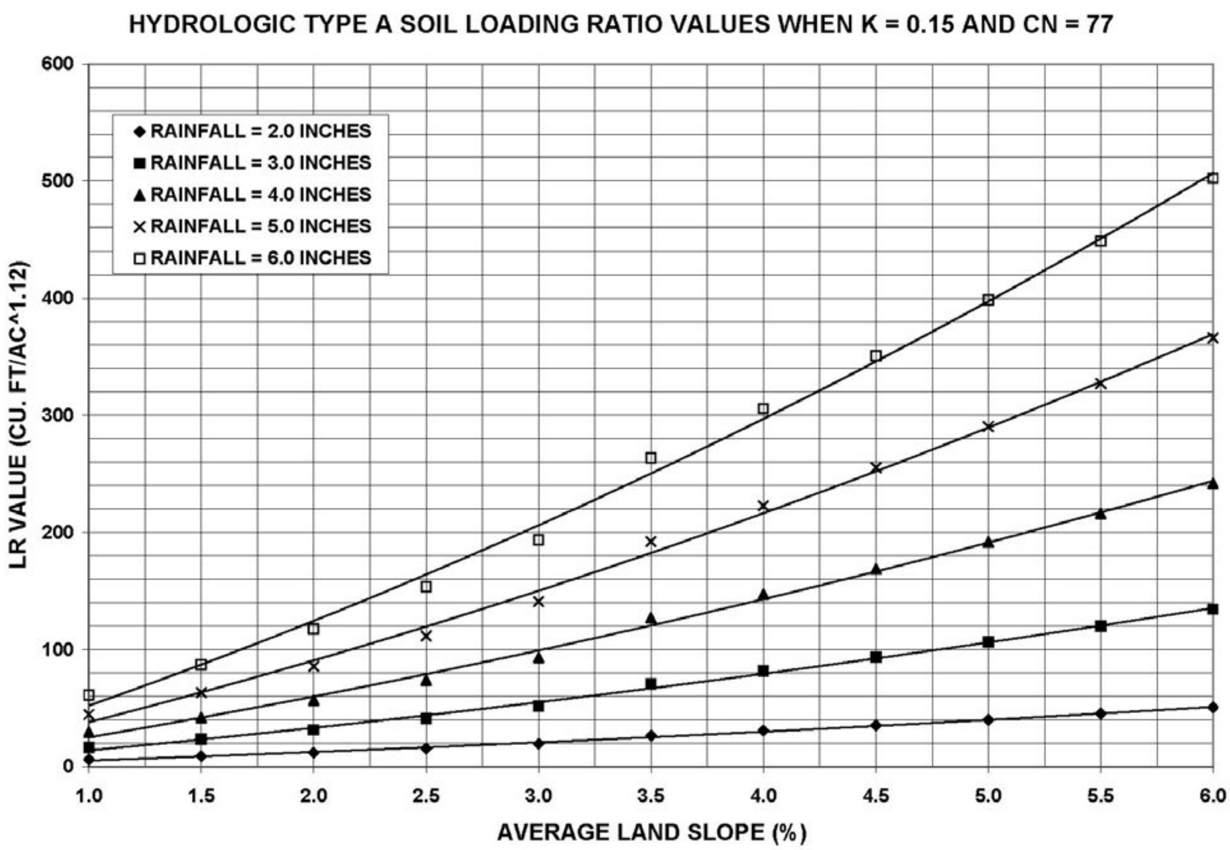
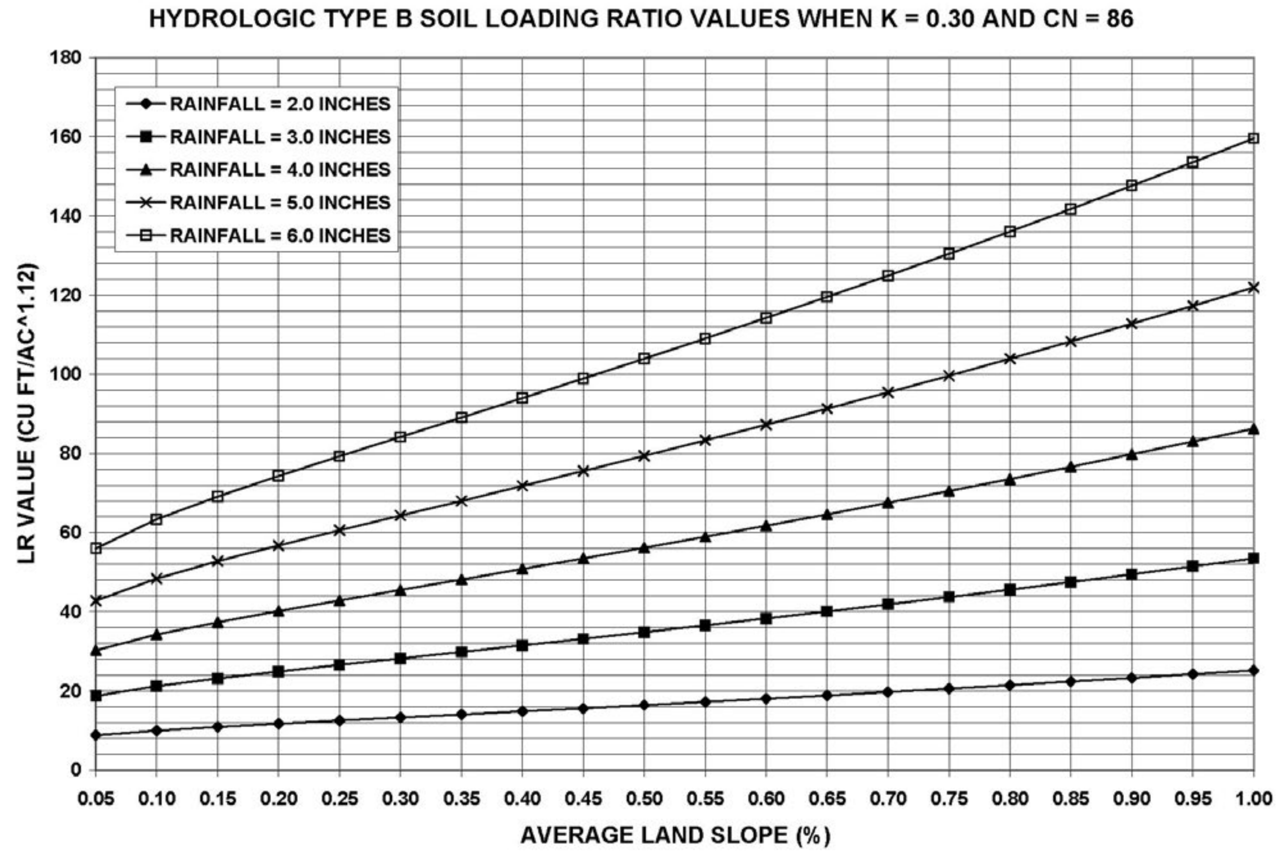


Figure IV-8: Hydrologic Type A Soils Loading Ratio Graph



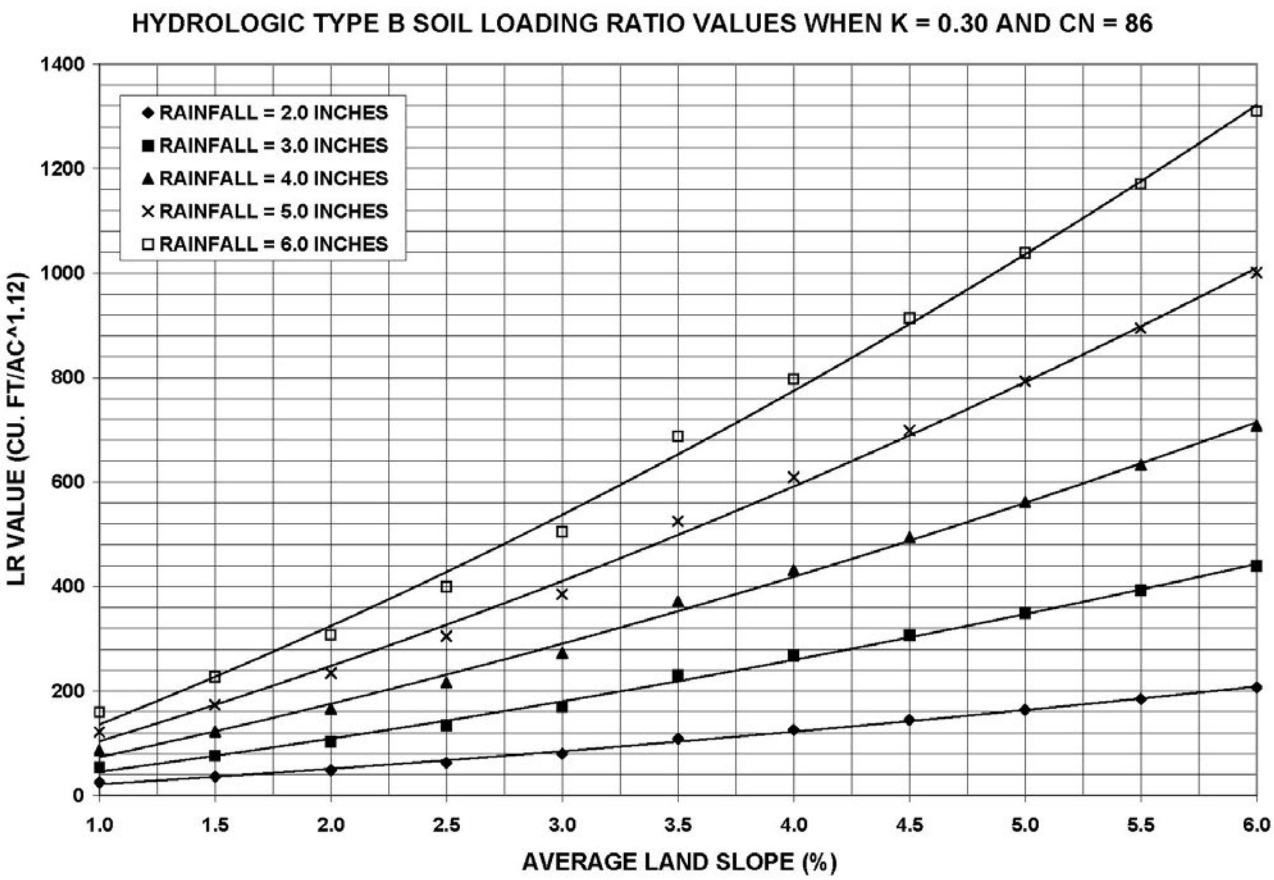
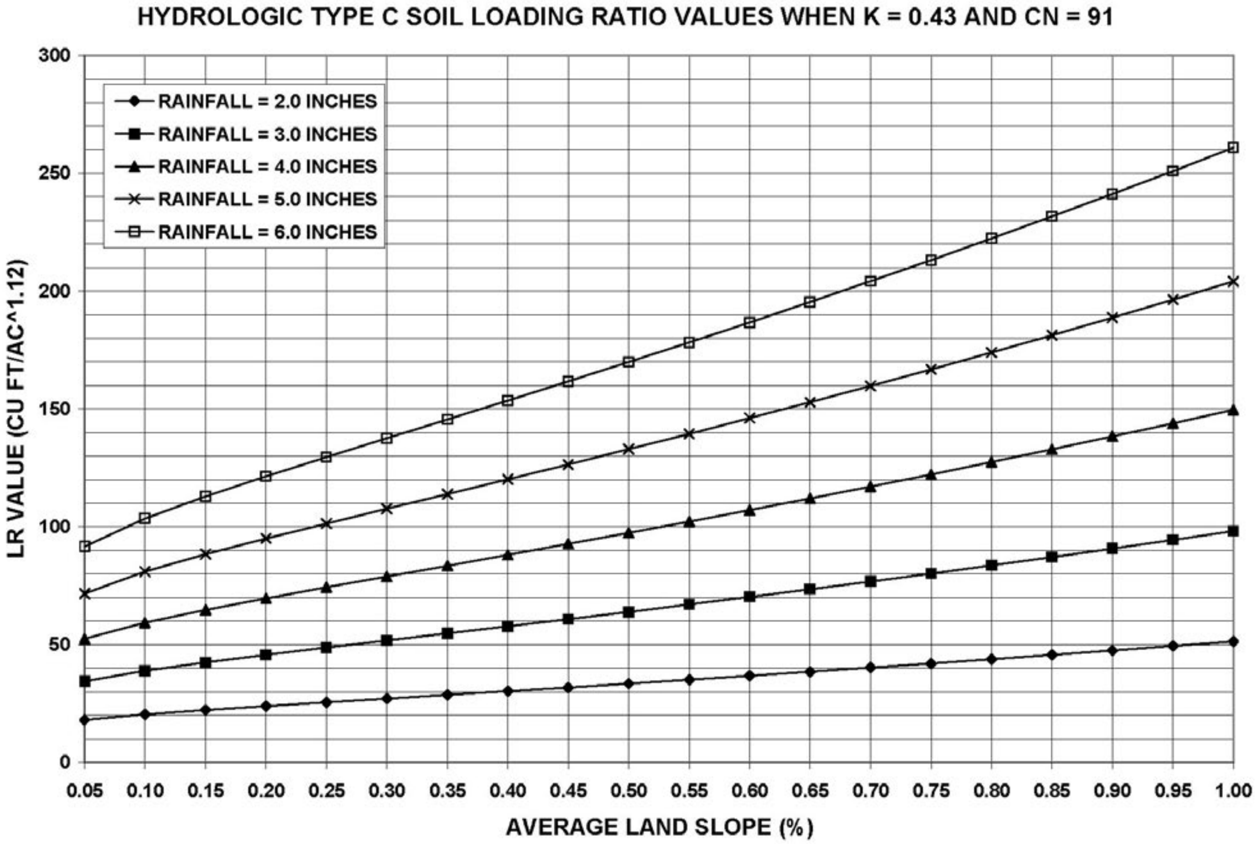


Figure IV-9: Hydrologic Type B Soils Loading Ratio Graph



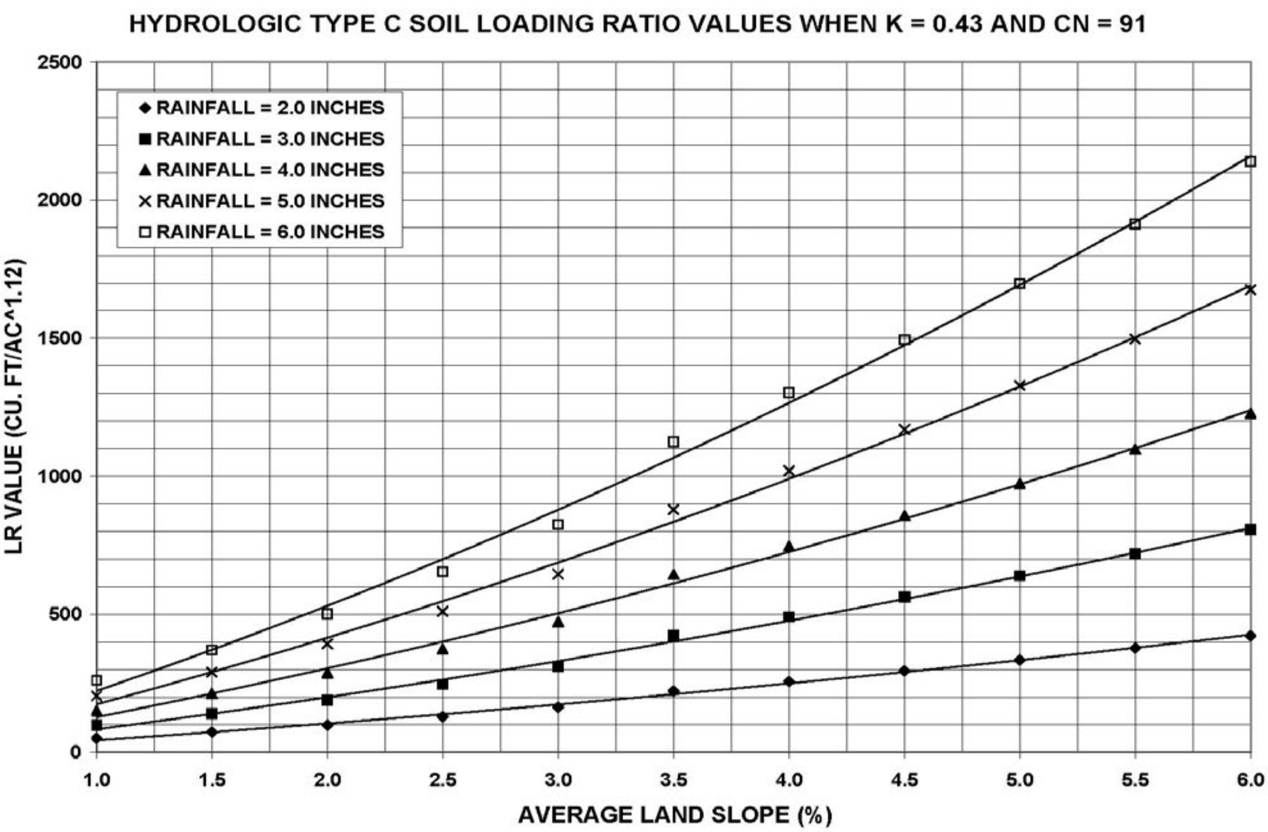
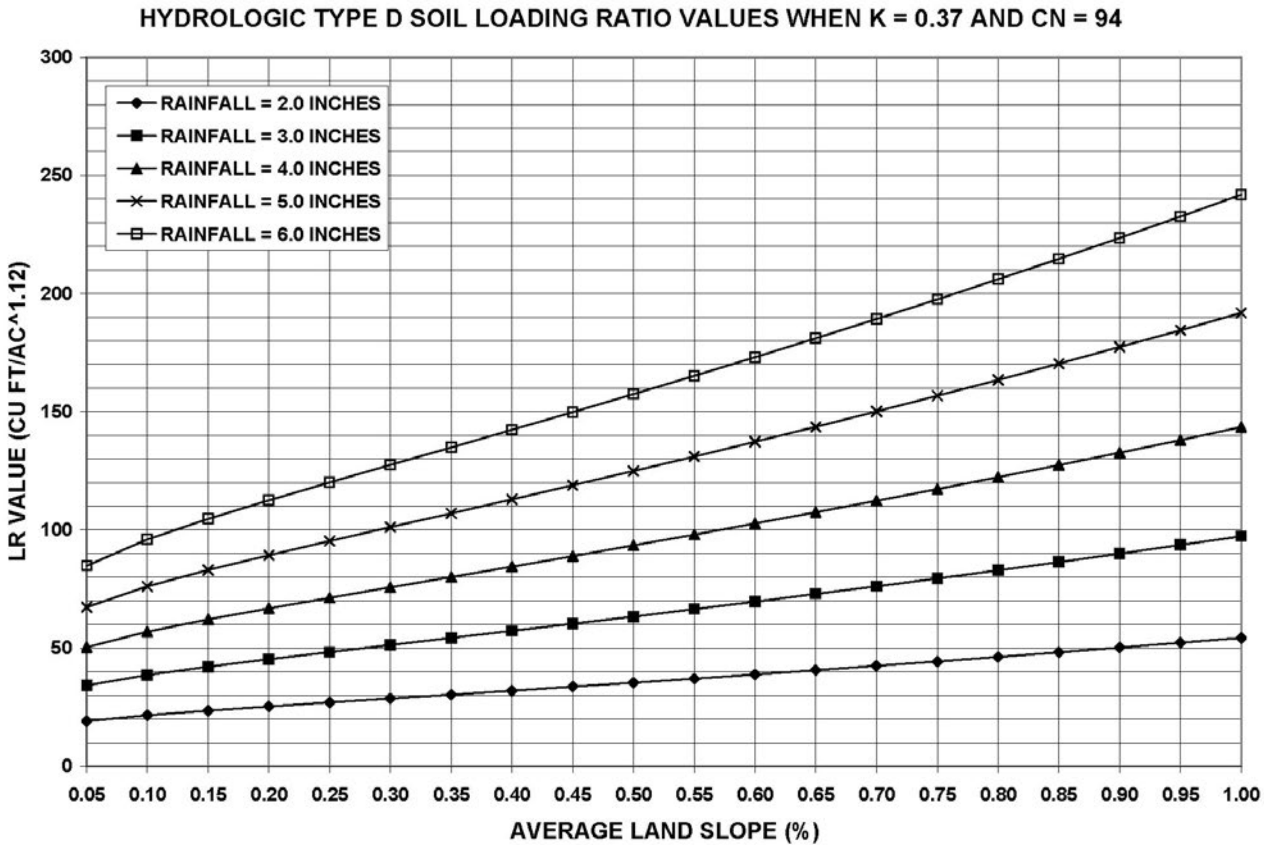


Figure IV-10: Hydrologic Type C Soils Loading Ratio Graph



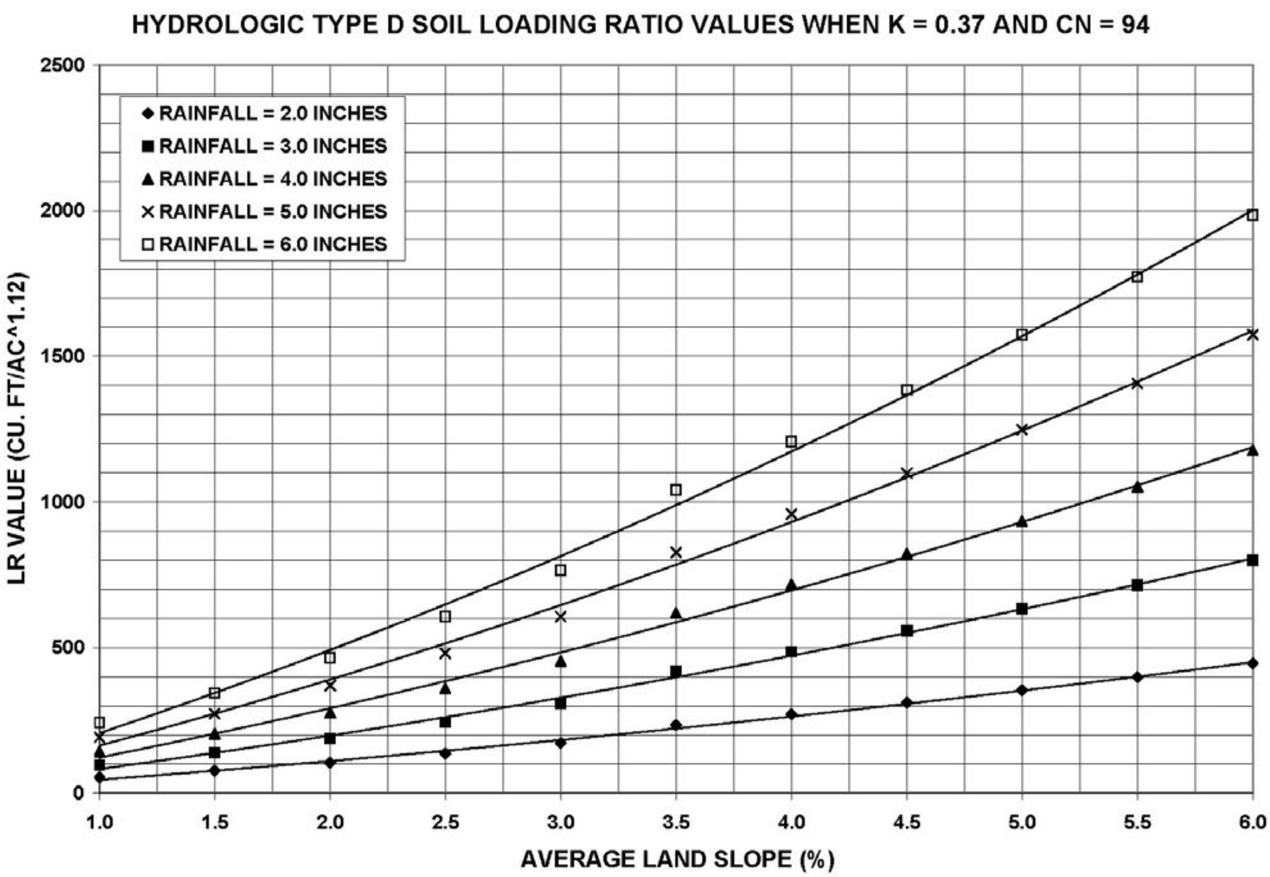


Figure IV-11: Hydrologic Type D Soils Loading Ratio Graph

Sediment Containment System Rock Berm Outlet Structure

WHAT IS ITS PURPOSE?

Provide a relatively maintenance free method for releasing contained waters when outflow values are equal to inflow values.

WHERE AND HOW IS IT COMMONLY USED(SEE FIGURE IV-11)?

- Method of a structure to capture larger diameter suspended particles.
- Provides development of small wetlands after grading is done.
- Allows the discharge of contained waters.
- Relatively maintenance free outlet structure.

WHEN SHOULD IT BE INSTALLED?

- Immediately after the sediment containment system is constructed.
- Before major construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading activities are completed unless wetlands are to be developed.

WHAT NEEDS TO BE INSPECTED?

- Are the containment berms vegetated?
- Have any of the containment berms been destroyed?
- Does a low point in the rock exist?
- Does water drain through the rock?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair destroyed sections.
- Removal of sediment.
- Removal of the rock berm.

Notes

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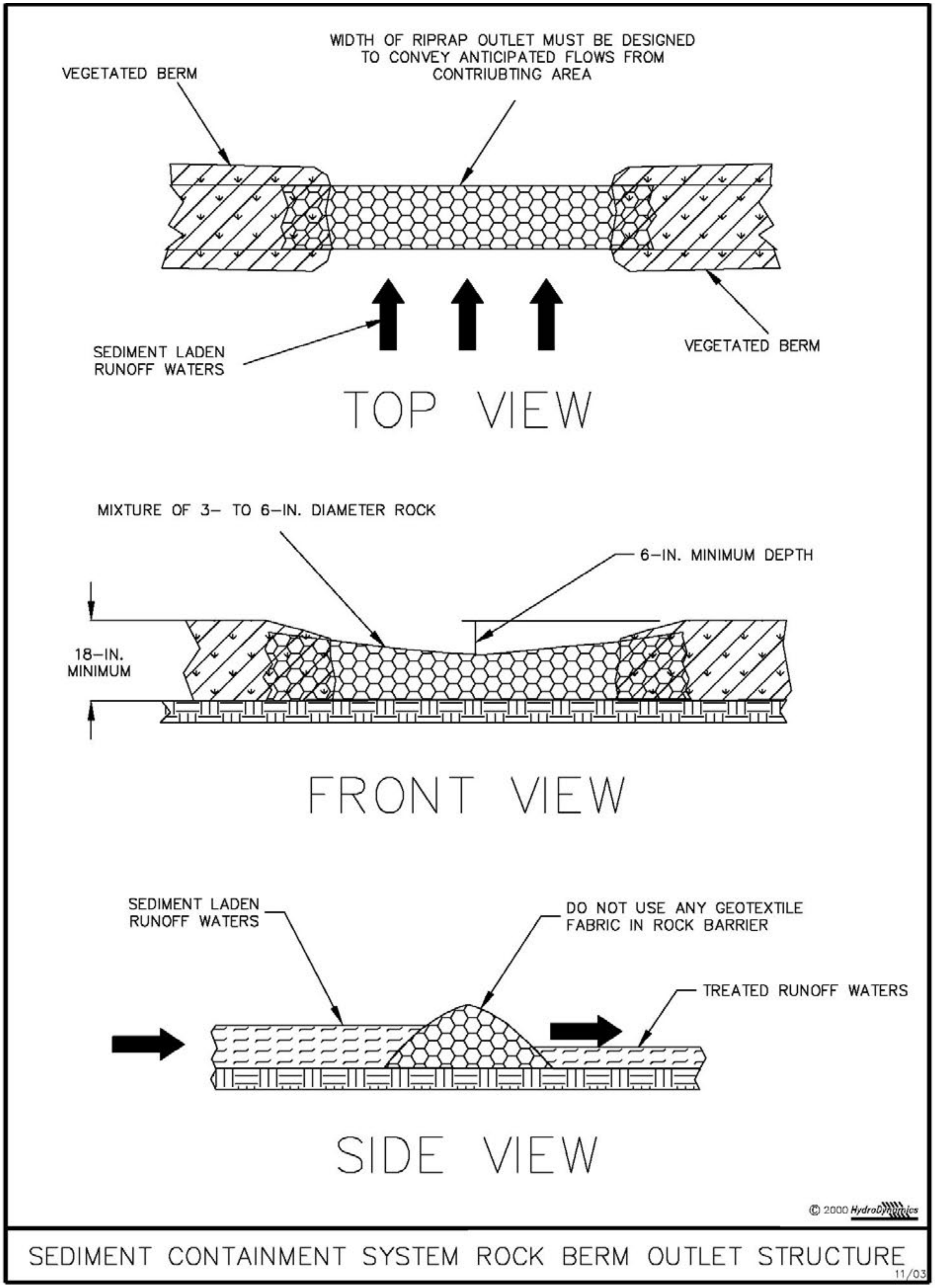

Figure IV-12: Illustration of a SCS Rock Berm Outlet Structure

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Sediment Containment System Single Chamber

WHAT IS ITS PURPOSE?

To cause the deposition of large diameter suspended particles in runoff waters from small contributory basins.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-12)?

- On construction sites.
- Areas where limited space exists for a sediment containment system.
- Low point of small drainage basins.
- Where capture of larger size particles found in runoff waters is required.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.
- To treat waters being pumped from behind coffer dams and for dewatering activities.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading activities are finished.
- As the only method to capture suspended particles without some type of chemical treatment.

WHAT NEEDS TO BE INSPECTED?

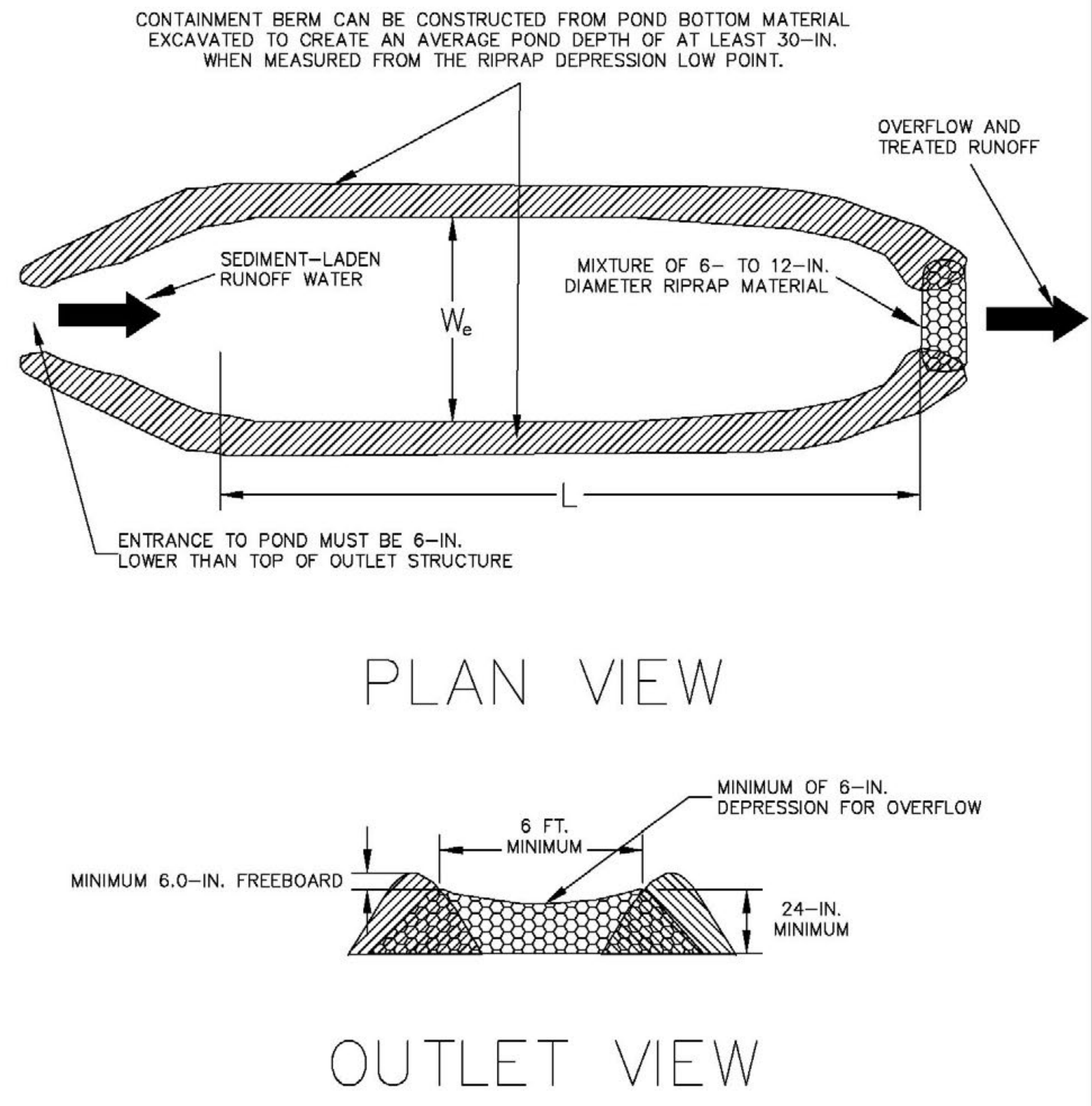
- How much sediment is in the chamber?
- Will the structure capture runoff?
- Should the riprap outlet structure be wider?
- Will runoff flow over the riprap outlet structure?
- Are the lengths and widths correct as calculated by the Designer?
- Is the inflow higher than the outflow?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Removal of sediment.
- Repair of destroyed embankments
- Repair of destroyed riprap.
- Ensure establishment of vegetation occurs on all embankments.

Notes

- Basin parameters L = Length and W_e = Width as calculated by the Designer from equations found in the pre-sedimentation basin section.
- Develop the outlet structure so that it is able to safely convey flood flows for design storm events.



1. CONTRIBUTING AREA MUST NOT BE LARGER THAN 5.0 ACRES.
2. NOT EFFECTIVE FOR REMOVING FINE LOAM/CLAY PARTICLES SUSPENDED IN RUNOFF WATERS.
3. ONCE THE POND IS FULL, INFLOW RATES WILL EQUAL OUTFLOW RATES.

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SINGLE CHAMBER SEDIMENT CONTAINMENT SYSTEM

11/03

Figure IV-13: Illustration of a Single Chamber SCS

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Sediment Containment System Double Chamber

WHAT IS ITS PURPOSE?

To cause the deposition of large diameter suspended particles in runoff waters from small contributory basins.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-13)?

- On construction sites.
- Areas where limited space exists for a sediment containment system.
- Low point of small drainage basins.
- Where capture of larger size particles found in runoff waters is required.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.
- To treat waters being pumped from behind cofferdams and for dewatering activities.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading activities are finished.
- As the only method to capture suspended particles without some type of chemical treatment.

WHAT NEEDS TO BE INSPECTED?

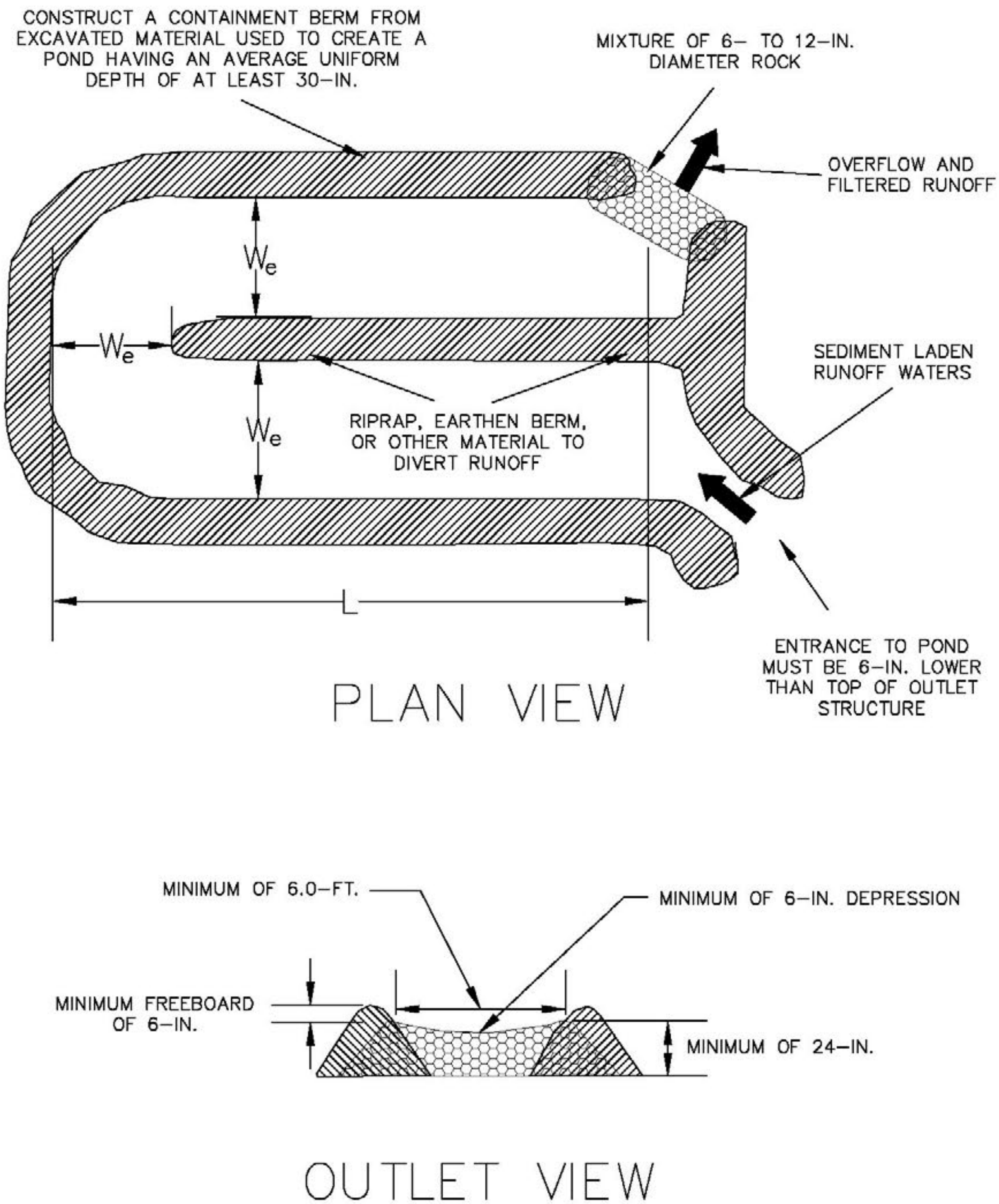
- How much sediment is in the chamber?
- Will the structure capture runoff?
- Should the riprap outlet structure be wider?
- Will runoff flow over the riprap outlet structure?
- Are the lengths and widths correct as calculated by the Designer?
- Is the inflow higher than the outflow?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Removal of sediment.
- Repair of destroyed embankments.
- Repair of destroyed riprap.
- Ensure establishment of vegetation occurs on all embankments.

Notes

- The length parameter is to be reduced by 50% (i.e., $\boldsymbol{L_{final} = \frac{1}{2} \times \text{Length}}$) as calculated by the Designer from equations found in the pre-sedimentation basin section.
- Develop the outlet structure so that it is able to safely convey flood flows for design storm events.



1. CONTRIBUTING AREA MUST NOT BE LARGER THAN 5.0 ACRES.
2. NOT EFFECTIVE FOR REMOVING FINE LOAM/CLAY PARTICLES SUSPENDED IN RUNOFF WATERS.
3. ONCE THE POND IS FULL, INFLOW WILL EQUAL OUTFLOW.

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DOUBLE CHAMBER SEDIMENT CONTAINMENT SYSTEM

11/03

Figure IV-14: Illustration of a Double Chamber SCS

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Sediment Containment System Barrier for Culvert

WHAT IS ITS PURPOSE?

To reduce inflow velocity so that deposition of suspended particles found in runoff can occur upstream of the barrier.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-14)?

- On the upstream side of culverts.
- As part of a sediment containment system.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading activities are completed.
- If it appears they will interfere with the discharge of major runoff.

WHAT NEEDS TO BE INSPECTED?

- Does water flow through the rock?
- Is the right sized rock used?
- Is the rock full of sediment?
- Is the barrier placed far enough away from the pipe opening?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Replacement of rock.
- Removal of sediment.

Notes

- Installation of a fabric that does not become clogged with clay and silt particles that impact the material's permeability might be adequate for use in place of a rock barrier.

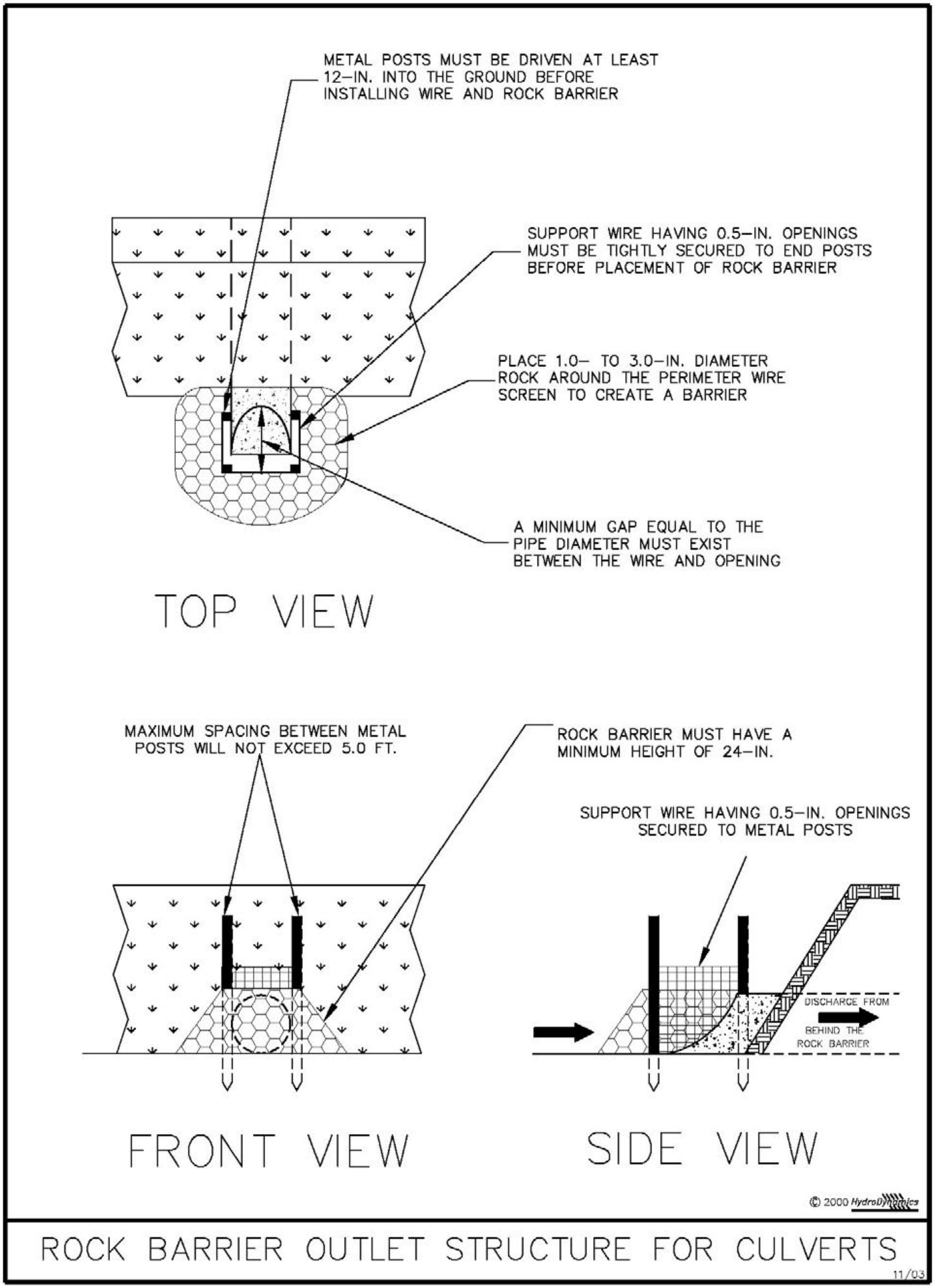

Figure IV-15: Illustration of a Rock Barrier Structure for Culverts

Sediment Containment System Filter Bag

WHAT IS ITS PURPOSE?

To remove larger diameter size particles from sediment-laden waters by filtration.

WHERE AND HOW IS IT COMMONLY USED (SEE FIGURE IV-15)?

- Removing water collected behind cofferdams.
- Small ponds on construction sites.
- Removing water collected behind water barriers.
- Use in dewatering operations.

WHEN SHOULD IT BE INSTALLED?

- Prior to pumping contained water captured behind a barrier.
- Prior to pumping operations associated with dewatering activities.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After grading activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Overall appearance of the filter bag?
- Are there any tears or damage to the filter bag?
- Is the filter bag filled with sediment?
- Is the filter bag draining properly?
- Does water discharging from the bag flow away from water bodies?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Removal of accumulated sediment.
- Removal of the bag.
- Repair to damaged parts of bag.

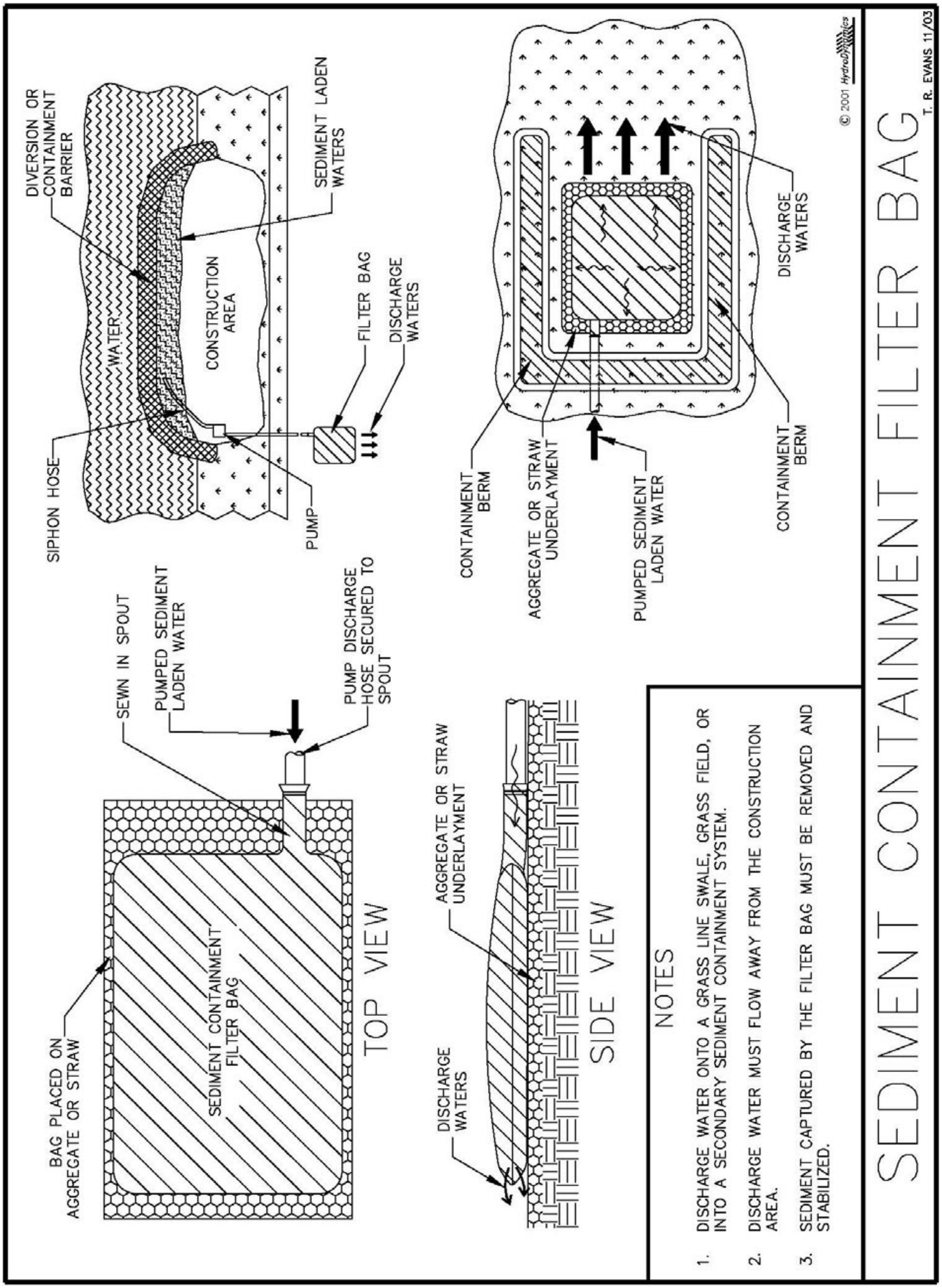

Figure IV-16: Illustration of a Sediment Containment System Filter Bag

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Use of Polymers or Alum

When polymers or alum are added in correct amounts to sediment-laden waters, suspended colloidal particles combine resulting in an increased mass that is subject to acceleration by gravity through the water column. However, designers need to be aware that polymers or alum may be detrimental to aquatic life if introduced in inappropriate quantities or not properly selected for site conditions. For example, only cationic charged polymers can adhere to the gills of fish and may cause suffocation if not properly evaluated and introduced into contained waters. Anionic polymers do not adhere to fish gills. More detailed information about the use of polyacrylamides, dual-polymers and alum appears in Appendix III.

If the erosion of contributing soils results in runoff having suspended clay colloidal particles, properly introducing the use of polymers into these waters may dramatically reduce the size of a SCS, perhaps down to a pre-sedimentation basin. More importantly, proper use of polymers may assist in ensuring discharge waters from construction sites do not exceed Florida's water quality standard of 29 (or less) NTUs above background conditions. If suspended particles are not clay colloidal particles, then the Designer may require more detailed analyses if other chemicals (e.g., alum) may have to be introduced into runoff waters to achieve deposition (see Appendix III).

<u>Steps for Introducing Polymers into Runoff Waters</u>

If polymers are to be used to increase the efficiency of an SCS, it is important that Designers complete the following steps:

Step 1: Select Polymers Using Performance Based Standards

Obtain representative soil and water samples from the active construction site and have them tested for a polymer that demonstrates superior removal capacity of suspended particles found in runoff waters. Tests need to demonstrate that within 60 seconds; at least 95% of all sediment and suspended colloidal particles found in 29-inch (735 *mm*) high vertical water column are captured and accelerating downward. More than likely, performance-based tests will have to be completed while construction activities continue to ensure optimal capturing capabilities of the polymer remains viable.

Step 2: Determine Design Inflow Values and Accompanying Polymer Concentration

Sediment yields will vary depending upon the amount of land not protected against erosion as well as the magnitude of rainfall. Thus, it is important that Designers fully evaluate anticipated flows in drainage ditches and storm sewer systems that discharge into a SCS.

Specific frequency storm events are a norm for designing a detention pond or selecting the size of an inlet opening. The EPA emulated this requirement by specifying that when 10-acres or more of land is disturbed, a sediment containment system is to capture runoff resulting from a 2-year, 24-hour storm event. As a minimum, FDEP requires that once 10-acres or more of land are disturbed, at least 1-inch of runoff per unit area is to be contained (i.e. 3,600 cubic feet per disturbed upstream acre).

At each major inflow location (e.g. pipe, drainage swale, etc.) to a SCS, it is important that Designers determine flow rates resulting from at least a 2-year, 24-hour frequency storm event. More stringent requirements may be imposed by different regulatory agencies. It is at these inflow locations where the introduction of polymers is to occur in a manner (using manufacturer's specifications) that ensures optimal mixing.

Step 3: Determine Anticipated Sediment Yields

Figure IV-8 through Figure IV-11 provide charts to calculate anticipated sediment yields for 100% bare ground conditions assuming Hydrologic Type A through Hydrologic Type D soils, respectively. These values were calculated using the Modified Universal Soil Loss Equation (MUSLE) (Williams, 1976) as customized by Fifield (2004) and can be adjusted for different erodibility (i.e. *K*–Factor) values to reflect site conditions.

Step 4: Complete Sizing of the Pre-Sedimentation (a.k.a. forebay) Basin

When proper selection of a polymer is done, it is possible for nearly 100% of the suspended and colloidal particles to settle out of the runoff waters when design storm events occur. However, when these particles settle to the bottom of a detention/retention pond or lake, the possibility exists that infiltration properties will be compromised. Fortunately, development of a properly sized pre-sedimentation (a.k.a. forebay) basin to capture deposited material can overcome this potential problem.

<u>Sediment Retention Barriers Using Polymers</u>

Appendix III illustrates a different SCS from above, namely Sediment Retention Barriers (SRB). These structures are placed around area (a.k.a. catch basin) drains to treat sediment-laden runoff waters.

As discussed in Appendix III, SRBs can consist of a double row of silt fence barriers placed about 4- to 6-feet apart. Loose mulch, straw, woodchips, or other organic matter is mixed or blended with the site-specific polymer and placed between the silt fence barriers. The polymer within the mulch reacts with the suspended sediments, binding them into large particles that are trapped within the material.

Failure of these SRBs will occur if they are not installed correctly. Some specific items Designers need to address in their SWPPP include the following:

1. Selection of silt fence fabric material must be made to ensure passage of runoff waters will allow <u>inflows to equal outflows</u>. This implies that the standard woven or needle punched silt fence materials often found on construction sites <u>will not</u> be adequate. A minimum suggested permeability value of silt fence material is 75 gpm/ft^2.
2. Silt fence barriers will require diagonal bracing and wire backing to prevent collapsing of the structure.
3. Site selection of an SRB must be made to ensure sufficient containment volume exists around the structure to allow for temporary storage of inflow waters for a proposed design storm event.
4. Inspection and maintenance of SRBs is critical to ensure free passage of contained runoff waters.

It is important that Designers work with professionals that are experienced in using polymers on construction sites. In this manner, potential environmental problems can be professionally addressed and problems avoided.

Using Alum to Remove Sediment from Runoff Waters

Some sediment found in runoff waters will not react with polymers (e.g. coral), but may react with alum. The use of alum within an erosion and sediment control plan will require the use of a properly designed sediment containment system.

Once alum has been identified as an option in a stormwater retrofit project, extensive laboratory testing must be performed to verify the feasibility of alum treatment and to establish process design parameters. The feasibility of alum treatment for a particular construction activity related stormwater stream is typically evaluated in a series of laboratory jar tests conducted on representative runoff samples collected from the project watershed area.

Alum treatment requires close monitoring of dosages since overdosing may be harmful. In addition, alum may result in lowered pH and elevated levels of Al^{+3} if improperly applied. As with using polymers, it is important that Designers work with professionals that are experienced in using alum on construction sites. In this manner, potential environmental problems can be professionally addressed and problems avoided. Additional information on the use of alum appears in Appendix III.

EXAMPLES

SCS Effectiveness of an Existing Pond

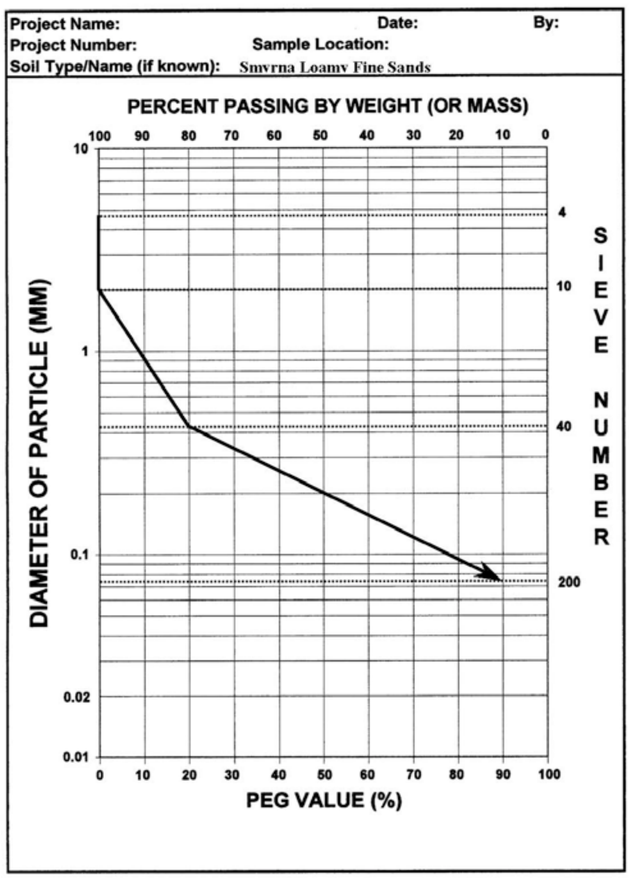
When a detention/retention pond is to be part of the development, it should be one of the first items constructed and converted into an effective SCS. As an example, consider a site having the following parameters for a land development project in Orange County, Florida where predominate soil types are Smyrna loamy fine sands.

- Contributing Basin = 18.5 Acres
- Maximum Surface Area of Pond = 12,800 Square Feet
- Flow Path within Pond =200 Feet
- Average Pond Width = 64 Feet

If a SCS is to be effective it must meet criteria that ensure an efficient system exists. The following steps illustrate how this is accomplished:

Step 1: Complete a PEG Soils Analyses

Usually, when development occurs, soil analyses of contributing lands are routine; however, in the event that such data are not available, cursory values can be obtained from the Natural Resource Conservation Service (NRCS) by consulting their soil surveys. Assume for this example that data obtained from the NRCS survey resulted in development of the graph shown at the right.



The PEG graph of Smyrna loamy fine sands demonstrates that about 90% of particles have diameters that are about 0.075 *mm* (0.003-*in*.) and larger. This indicates that at least 10% of the suspended particles entering the pond will be smaller than 0.075 *mm* (0.003-*in*.). More than likely, turbidity values associated with runoff waters can be related to particles having diameters smaller than 0.075 *mm* (0.003-in.).

For this example, we will consider our design size particle to have a diameter of 0.075 *mm* (0.003-*in*.).

Step 2: Evaluate how Surface Area Varies with Discharges

For this exercise, our design size particle for the SCS calculations will remain at 0.075 *mm* (0.003-*in*.). Using equations found in Table IV-2, we see that a minimum surface area (square feet) of a pond is calculated by:

$$SA_m = (1.2 \times Q_{out}) \div V_S$$

From Table IV-3, a 0.075 *mm* (0.003-*in.*) diameter particle will have a settling velocity of about 0.01107 *ft. /sec.* at a water temperature of 50 degrees Fahrenheit. Notice that settling velocities of suspended particles become less in colder water due to greater fluid viscosity. Conversely, settling velocities increase for warmer waters. *Designers should always select a representative cold-water temperature when designing a SCS to ensure greater capture of suspended particles when warmer inflow water conditions exist.*

From Table IV-2, we see that:

$$SA_m = (1.2 \times Q_{out}) \div V_S = (1.2 \times Q_{out}) \div 0.011 = 109 \times Q_{out} \quad \text{(square feet)}$$

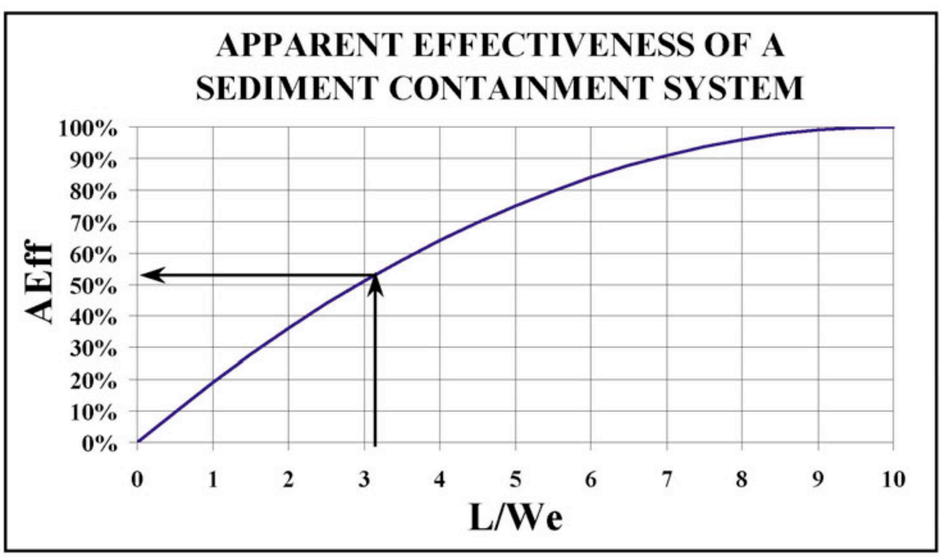
Since minimum surface area of the pond is dependent upon the discharge from the system, the above equation allows for development of the following table to evaluate what pond surface areas must exist if capturing 0.075 *mm* (0.003-*in.*) diameter particles is feasible for different outflows:

Discharge ($ft.^3/sec.$)	*Surface Area* ($ft.^2$)
10	1,090
20	2,180
30	3,270
40	4,360
50	5,450

The above table demonstrates for large discharge values that the existing pond surface area of 12,800 square feet is more than adequate for capturing suspended 0.075 *mm* (0.003-*in.*) diameter particles. Now the only question lies with determining a pond effectiveness to capture design size and larger, particles by gravitational means.

Step 3: Calculate the Apparent Effectiveness of the System to Capture Design Size Particles

Using the above information, it is found that L/W_e ratio is 200 feet ÷ 64 feet = 3.1. By using Figure IV-1, the following graph illustrates the apparent effectiveness of this pond to capture 0.075 *mm* (0.003-*in.*) and a larger diameter particle is about 52%.



Step 4: Calculate the Net Effectiveness of the System

The *AEff* value of 52% gives an indicator of effectiveness for the existing pond to capture *design size* and larger particles associated with inflows of runoff from contributing lands, assuming terminal velocity conditions exist. However, this value does not represent the net effectiveness of a SCS to remove all suspended particles.

Earlier, we found that about 90% of the contributing land particles (i.e. *PEG* = 90%) are 0.075 *mm* (0.003-*in*.) and larger. Therefore, the net effectiveness (see Table IV-2) of this pond to capture suspended design size particles of 0.075 *mm* (0.003-*in*.) and larger is:

$$NEff = AEff \times PEG = 52\% \times 90\% = 46.8\%$$

While this pond may capture about 47% of the particles that are 0.075 *mm* (0.003-*in*.) and larger, it still will release nearly 100% - 47% = 53% of all incoming sediments when discharge occurs.

Sizing a Dewatering SCS

Dewatering activities need to occur to reduce the ground water level for construction activities. It has been decided that pumping rates will vary from 125 to 300 gallons per minute (*gpm*). In order to maximize the treatment of waters, the Designer has decided a SCS structure should have a length to width ratio of at least 7.0 with the pumped water being discharged into a double chamber system (see Figure IV-14):

Step 1: Decide Upon a Design Size Particle to Treat.

Since no information about the size of suspended particles exist, assume treatment will be for a 0.02 *mm* (0.0008-*in*.) diameter particle when ground water has a temperature of 60°*F*.

Step 2: Determine the Settling Velocity and Range of Discharge Values.

From Table IV-3, a 0.02 *mm* (0.0008-*in*.) particle will fall through 60°*F* water at about 0.00105 *ft. /sec*.

125 gallons per minute = 125 *gpm* × 0.00228 *cfs/gpm* = 0.29 *cfs*

and 300 *gpm* = 0.68 *cfs*.

Step 3: Calculate and Decide Upon the Minimum SCS Pond Surface Area.

$$SA_m = (1.2 \times Q_{out}) \div V_S = (1.2 \times 0.29) \div 0.00105 = 331\ ft.^2$$

and

$$SA_m = (1.2 \times Q_{out}) \div V_S = (1.2 \times 0.68) \div 0.00105 = 777\ ft.^2$$

The Designer decides to be conservative and uses 800 $ft.^2$

Step 4: Calculate the Remaining Parameters.

$$L = [(L \div W_e) \times SAm]^{0.5} = [7.0 \times 800]^{0.50} = 75\ feet$$

$$W_e = SAm \div L = 800 \div 75 = 11\ feet$$

$$D_{avg} \geq 2.2\ ft.$$

$$VOL_m \geq 2.2 \times SA_m \geq 2.2\ x\ 800 \geq 1{,}760\ ft.^3$$

Step 5: Since a Double Chamber is to be used, Convert the Length and Width Values.

From Page IV-26, $L_{\text{final}} = \frac{1}{2} \times L = 37.5$ feet long. Thus, each chamber in the temporary SCS should be about 37.5 feet long, 11 feet wide, and have an average depth of around 2.2 feet.

Additional information on dewatering methods appears in Appendix II.

Builder Pre-Sedimentation Basin

A builder purchases 15 acres of re-vegetated land from a developer on which 50 condominiums will be built. The land has an average slope (V: H) of 0.50% with approximately 10% held in a natural condition.

The development is located within Hydrologic Type B soils having an erodibility factor of 0.24. Assuming a polymer is introduced into the storm drain system, determine the size of a pre-sedimentation basin constructed at the outfall of the storm sewer system to treat runoff due to a 2-year, 24-hour storm event of 3.50 inches.

Step 1: Determine the Amount of Land that will be Under Construction.

Different land disturbing scenarios can exist depending upon how the builder wants to construct the condominiums. However, a worse case scenario exists when all the possible land is being disturbed.

$$A = 15 \text{ acres} - (10\% \text{ of } 15 \text{ acres}) = 13.5 \text{ acres}$$

Step 2: Determine the Sediment Yield.

From Figure IV-8, $LR = 46$ cubic feet/acres$^{1.12}$ when a 2-year, 24-hour storm event occurs on a watershed with a 0.50% (V: H). Notice that the chart erodibility value is $K = 0.30$, but the site erodibility value is 0.24. Thus, it is necessary to adjust the LR value.

$$\text{Sediment Yield} = (0.24 \div 0.30) \times 46 \times 13.5^{1.12} = 679 \text{ cubic feet}$$

Step 3: Determine the Pre-Sedimentation Basin Parameters.

$$\text{Surface Area} = 0.67 \times 679 = 455 \text{ square feet}$$
$$\text{Length} = 3.79 \times (455)^{0.5} = 81 \text{ feet}$$
$$\text{Width} = 0.10 \times 81 = 8 \text{ feet}$$
$$\text{Depth} = 18 \text{ in.} = 1.5 \text{ ft. (recommended minimum depth)}$$

Thus, creating a structure at the storm sewer discharge pipe that is at least 81 feet long, about 8 feet wide, and 18 inches deep will serve as a pre-sedimentation basin.

Linear Road Pre-Sedimentation Basin

A highway project contractor has to ensure runoff waters from about 5.0 acres of disturbed lands that flows through a drainage ditch before discharging into a river will meet 29 NTUs above background conditions when a storm event of 2.75 inches occur.

The Designers completed an analysis of the area and concluded the following:

- The average slope of contributing lands is about 2.50% (2.5 feet V: 100 feet H).
- Contributing lands are Hydrologic Type C soils with K = 0.40

Assume tests indicate that the addition of a polymer within the drainage channel will provide conditions to remove nearly 100% of the suspended colloidal particles, determine the parameters of an "in-line" temporary sedimentation basin.

Step 1: Determine the Sediment Yield.

When 2.75 inches of rain falls on a bare ground slope of 2.50%, then $LR = 210\ cu.\,ft/ac^{1.12}$ and

$$\text{Sediment Yield} = (0.40 \div 0.43) \times 210 \times 5.0^{1.12} = 1{,}185 \text{ cubic feet}$$

Step 2: Calculate the Temporary Sedimentation Basin Parameters.

$$\textit{Surface Area} = 0.67 \times 1{,}185 = 794 \textit{ square feet}$$

$$\textit{Length} = 3.79 \times (794)^{0.5} = 106 \textit{ feet}$$

$$\textit{Width} = 0.10 \times 106 = 11 \textit{ feet}$$

$$\textit{Depth} = 1.5 \textit{ feet}$$

Thus, when sufficient polymer is continually introduced into runoff waters discharging from 5.0 acres of disturbed lands, a pre-sedimentation basin about 106 feet long, 11 feet wide, and 18 inches deep is required. It may be adequate to place the SCS in line with the drainage swale to capture anticipated sediment loads caused by a 2.75-inch (and smaller) storm event.

SECTION V

TEMPORARY CONSTRUCTION SITE BMPS

Table of Contents

Table of Figures

INTRODUCTION

Examples of sediment control methods commonly found on construction sites are barriers. These structures are usually inexpensive and easy to install. Also, since their effectiveness is minimal for large runoff events, they do not require the detailed design needed for sediment containment systems. However, they are expensive Best Management Practices (BMPs) to use when considering the need for frequent maintenance.

USING BARRIERS TO REMOVE SEDIMENT FROM RUNOFF WATERS

A barrier is any structure that obstructs or prevents the passage of water. If runoff cannot pass through a barrier, then water will either be contained or flow over the structure. Consequently, small sediment barriers may function as a small SCS or as a method to reduce flow velocity.

Some examples of commonly used sediment barriers are:

- Silt fences
- Belted Strand Reinforced Silt Fences
- Inlet barriers
- Staked turbidity barriers
- Diversion barriers

Appropriate places for sediment barriers are:

- Along sections of a site perimeter
- Below disturbed areas subject to sheet and rill erosion
- Below the toe of exposed and erodible slopes
- Along the toe of stream and channel banks
- Around area drains or inlets located in a “sump” when properly supported
- Downstream edge of areas undergoing vertical and/or big box construction activities

Inappropriate places for sediment barriers include:

- Parallel to a hillside contour
- In channels where concentrated flows occur, unless properly reinforced
- Upstream or downstream of culverts where concentrated flows occur
- In front of or around inlets on a grade where concentrated flows occur
- In flowing streams

Illustrations of different barriers commonly used on construction sites appear in Summary Sheets and associated Figures within this section.

Limitation of Bale Barriers

Use of straw or hay bales has traditionally been one of the more popular methods used in trying to reduce sediment from construction sites. Unfortunately, their widespread use does not justify the fact that they are relatively ineffective. It is for this and other reasons that the FDOT does not allow use of straw or hay bale barriers on construction sites.

Silt-Fence Barriers

Silt (also known as sediment) fence barriers consist of geosynthetic material placed in a manner that controls ***sheet flow*** from disturbed lands (see Figures V-2 through V-4). Except for very large diameter (e.g. sand) particles, silt fences do not "filter" sediment out of runoff waters. Instead, the effectiveness of a silt fence is dependent upon its ability to create a small "containment system" to allow for deposition of suspended particles.

If a silt fence is to be successful in removing sediment from runoff waters, installation must occur in a manner that allows for the deposition of suspended particles. Consequently, proper installation and continued maintenance is essential.

Fiber Logs

Fiber logs (a.k.a. fiber rolls or wattles) are beginning to be used more extensively on construction sites. These tightly bound “logs” of material (see Figure V-5) must be viewed as a barrier that is simulating bales. As such, they must be installed correctly, will require extensive maintenance, and have limited use.

Installing fiber logs along hillsides will provide a temporary erosion control BMP. However, proper seeding and mulching will be more effective in stabilizing disturbed slopes. Usually, fiber logs should not be used in drainage channels since they will be impacted by large flows. However, their use on vertical and/or big box construction sites might be appropriate where small runoff events occur.

Temporary Compost Berms

Temporary compost berms are commonly found where runoff sheet flows from a site. Examples include at the base of hills and along the downstream edges of lots where homes are being built.

Typical berm materials include shredded wood (wood chips, wood bark, wood cellulose fiber, and wood excelsior) and “green” material (vegetative trimmings such as grass, shredded shrubs, and trees).

Tests in Texas have shown compost berms do not have much resistance to failure unless a root structure is found within the material. Thus, it is important that when these containment systems are installed, vegetation be established as soon as possible.

Area-Drain (a.k.a. Drop, Catch Basin, or Ditch Bottom) Inlet Barriers

Placing barriers around an area drain or drop inlet must be avoided unless it is located in a low area that receives runoff from surrounding lands (i.e. in a "sump"). When the drain is located on a grade, runoff diverted by the barrier might cause significant downstream flooding problems as depicted in Figure V-1.

When not in a sump condition, placing barriers upstream of the structure and across a drainage channel perpendicular to the flow should be considered. The barriers will create a SCS and the drainage system will continue to remove runoff waters to reduce the potential of downstream flooding. Attention should be given to the surrounding topography and placement of the upstream barrier so that runoff waters flow over, and not around, the structure.

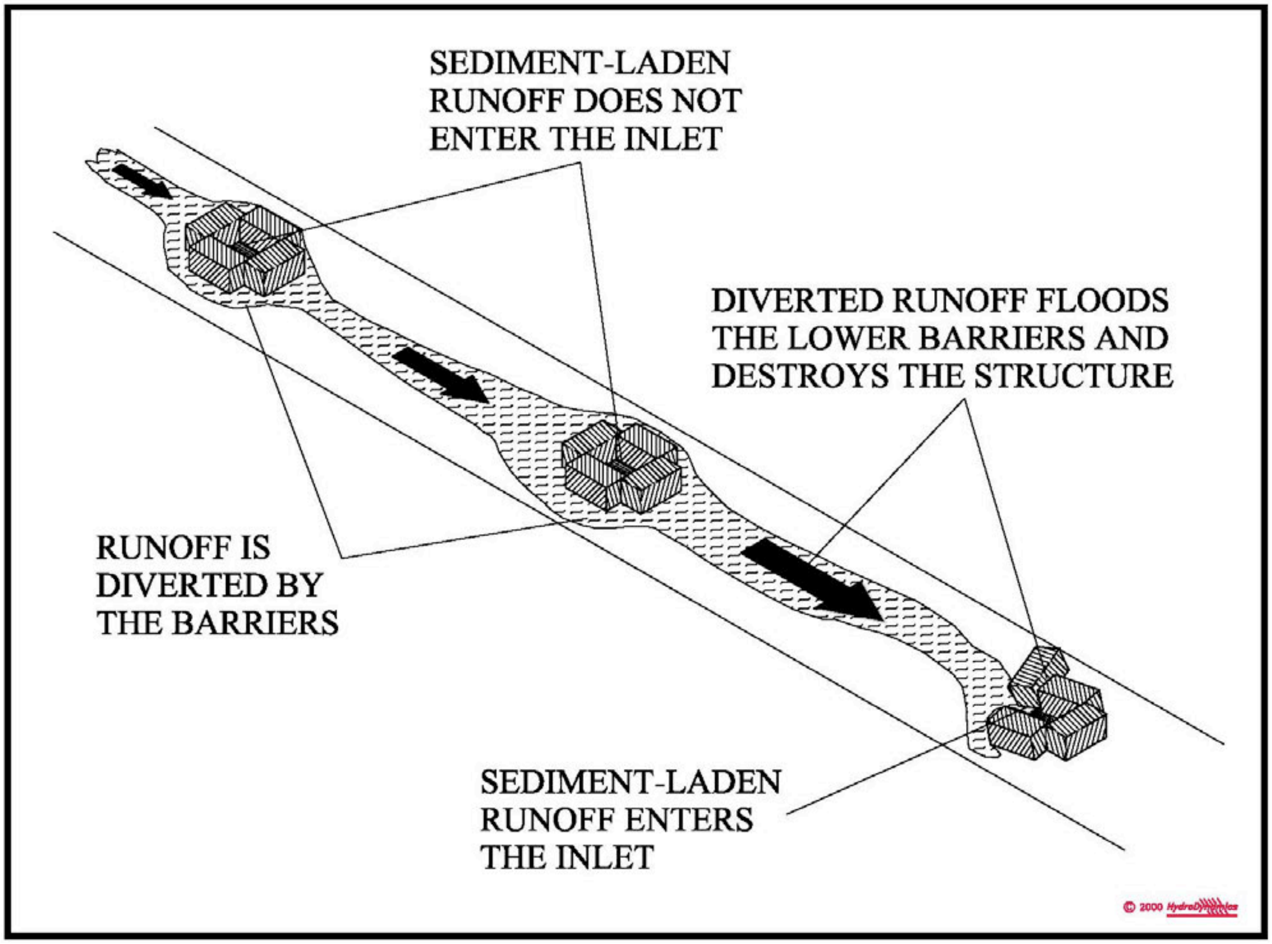


Figure V-1: How Barriers Around Area Drains on a Grade Fail During Runoff Events

When sump conditions exist, various methods exist to allow for ponding of runoff. For example, installing rock or fabric filter (having adequate support) barriers or placing a fiber log having a height of at least 12-inches might be alternatives. However, use of silt fence barriers is *not recommended* unless properly installed and supported.

Barriers for Storm Sewer Curb Inlet Openings

Placing rock barriers in front of inlets where street grades exist prevents the capturing of flows in gutters. Once runoff waters are prevented from entering inlets, downstream flooding becomes a major problem.

Only when a curb inlet is at a sump location should placement of a rock or coral barrier in front of a curb inlet occur. Otherwise, the possibility of diverting runoff waters away from the inlet and causing downstream flooding exists. In addition, at no time should rock or coral completely cover the opening of an inlet. Finally, install warning signs to alert drivers about potential damage to vehicles.

The advantage of using rock or coral barriers at curb inlets is that they will drain and reduce ponding around the inlet when sump conditions exist. However, maximum efficiency will be realized only by collecting runoff behind the barrier. Once runoff waters flow over the top and into the inlet, little sediment will be captured (Fifield, 1997).

A reported (by contractors) disadvantage of allowing runoff to pond in front of an inlet is the damage that often occurs to the pavement. As water seeps between the concrete and asphalt junction, structural integrity may become compromised and could cause damage to the road.

Curb and Gutter Sediment Containment System

Figure V-17 illustrates how placing rock or sand bags in a gutter flow line will create small SCS on streets having a grade. When properly installed, deposition of sediment will occur without compromising the role of an inlet to capture runoff waters in gutters.

One would think that rock bags are recommended over sand bags to allow for drainage. However, rock bags tend to be rigid whereas partially filled sand bags conform to the gutter system. In addition, rock bags tend to become clogged with sediment and function similar to sand bags, which is as barriers.

When installed in the gutter, bag tops must be lower than the curb height. As with all barriers, these systems will capture only a small amount of the total suspended particles found in runoff waters. Hence, they are more effective for small runoff events.

Inlet Inserts

During the grading phase of a project, it is advisable to install fabric under a grate or within a storm sewer opening to prevent soil from entering the system. However, these fabrics will become clogged and prevent the passage of water into a storm sewer system. As a result, once pavement is placed or developed conditions exist for vertical construction, localized flooding occurs.

Designers must clearly indicate on the E&SC plans that placing fabric material in a manner that totally blocks (e.g. under grates) runoff waters entering a storm sewer system will result in localized flooding. Inlet inserts overcome this problem by catching sediment but not preventing runoff from entering the storm sewer system. They are placed inside the inlet structure to treat incoming flows. Refer to Figure V-18 for more information on inlet inserts.

Inflow waters continually stir the captured soil before discharging into existing drainage pipes. Thus, only a small amount of the total suspended particles found in runoff waters are actually captured. However, the ability of an inlet to control drainage is not compromised. As with all SCSs, continual maintenance of the inserts must occur.

Cellular Confinement Systems

When conditions result in high flow values, it may be necessary to install cellular confinement systems. These rigid units can be installed on hillsides, in drainage ditches, as a soil tracking prevention device, or serve as temporary stream crossings. Each system has cells in which rock, soil, or cement can be placed. Once this occurs, increased stabilization exists creating a system that can withstand large loads while preventing erosion. Refer to Figure V-20 for additional information on cellular confinement systems.

Using Polymers to Increase Sediment Removal from Runoff Waters

Temporary sediment control measures by themselves are not very effective in removing sediment from runoff waters. However, their efficiency can increase by properly applying polymers. Some of these techniques include the following (see Appendix III):

1. Apply soil-specific polymer surrounding an area drain and cover the soil with a layer of jute fabric.
2. Install polymer logs inside and/or upstream of water conveyance devices to treat runoff after it has moved through a rock barrier.
3. Place the polymer logs so that runoff within a drainage channel having check structures will flow over and around them. The number of logs is determined by the flow rate of the water. Longer mixing times will have the best reduction of turbidity.
4. Cover rock check structures with jute fabric that has been applied with a site-specific polymer powder.

It is important that Designers work with professionals that are experienced in using polymers on construction sites. In this manner, potential environmental problems can be professionally addressed and problems avoided.

Silt Fence Barrier

WHAT IS ITS PURPOSE?

Temporary sediment containment structures while construction activities occur.

WHERE AND HOW IS IT COMMONLY USED?

- At the toe of cut and fill slopes.
- As small containment systems.
- On downstream sides of lots.
- Protecting water bodies.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- Where concentrated flows are expected such as in drainage ditches, around inlets, and above/below where culverts discharge.
- After construction activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Are stakes on the downstream side?
- Does water flow under the fabric?
- Has water "flattened" the structure?
- Is the fabric torn?
- Is the fabric secured in the ground?
- Is the fabric attached to posts?
- Will water flow around the fence?
- Has wind destroyed the fence?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of material.
- Removal of fence material.
- Removal of sediment.

NOTES

- Silt fence barriers are not to be used where concentrated flows of water are anticipated such as in drainage ditches, around inlets, or above/below where culverts discharge.
- When installed properly, silt fence barriers can create Type-2 sediment containment systems to allow for deposition of suspended particles, especially on vertical/big box construction sites.
- Silt fence barriers do not filter small-suspended particles in runoff waters.
- Using wire backing for support is discouraged due to disposal problems.
- Compacting trench fill material is very critical.

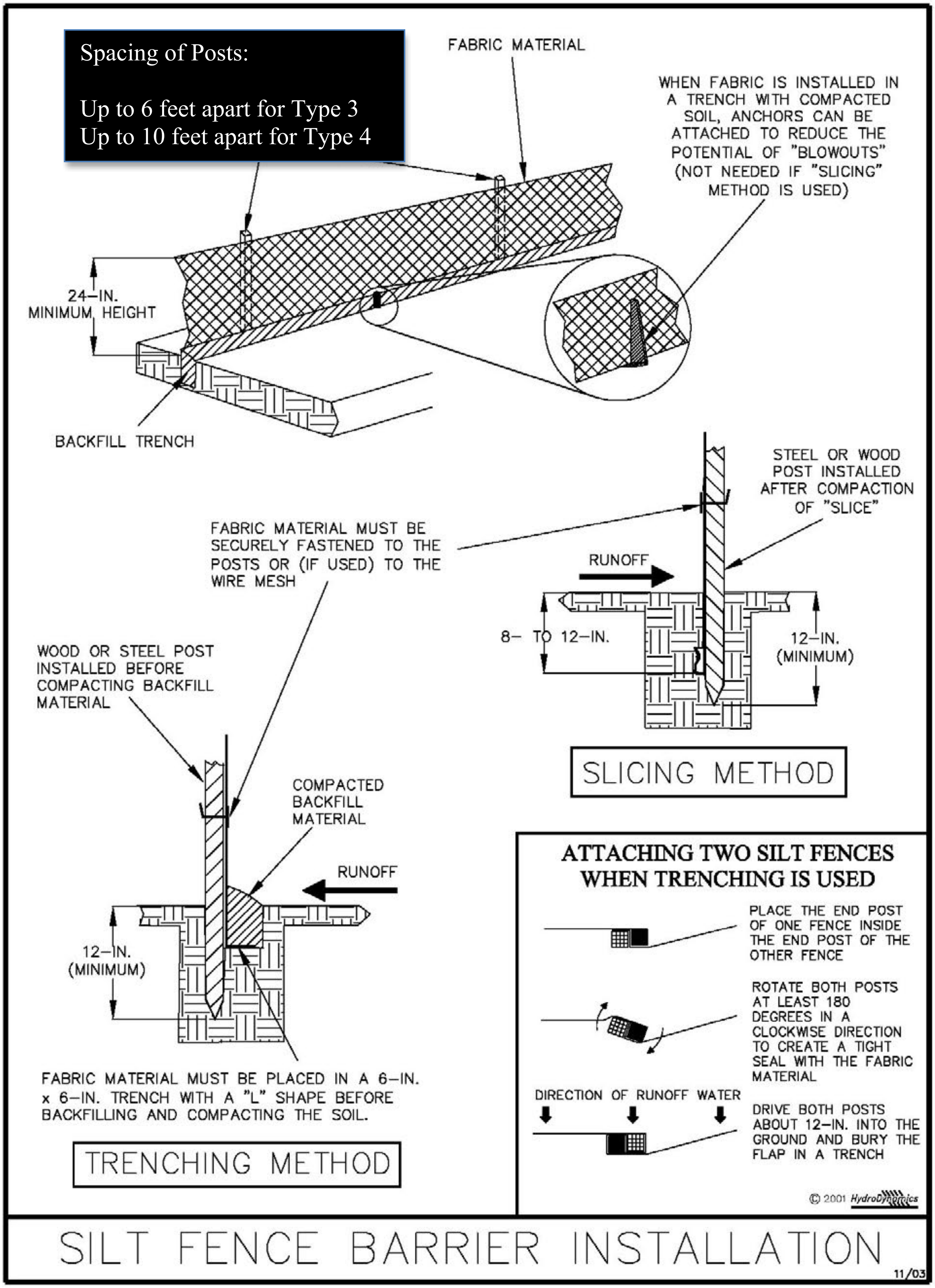


Figure V-2: Illustration of a Silt Fence Barrier

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Silt Fence Priority 2 (Black Band)

WHAT IS ITS PURPOSE?

The Priority 2 Silt Fence shall be used as a vertical interceptor of sediment transported by overland *sheet flow* on construction sites. This silt fence is a 36-inch wide, non-woven, spun-bond polyester fabric. The system encompasses wood stakes and a specific method of attachment (see Installation Specifications in Notes below).

WHERE AND HOW IS IT COMMONLY USED?

- At the toe of cut and fills slopes
- To protect water bodies.
- As a small sediment containment system
- To provide filtering capabilities in slurry conditions

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- It is designed for control of sheet flow.

WHEN SHOULD IT NOT BE INSTALLED?

- Shall not be installed across streams, ditches, waterways, or anywhere there is concentrated flow.
- Shall not be placed around storm water inlets, which receive concentrate flow.

WHAT NEEDS TO BE INSPECTED?

- Are stakes on the downstream side?
- Does water flow under the fabric?
- Has water flattened the structure?
- Is the fabric torn?
- Is the fabric secured correctly in the ground?
- Is the fabric attached to the posts?
- Will water flow around the fence?
- Has wind destroyed the fence?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Regular inspection at the end of each workday and after each rainfall event.
- Remove the fence and accumulated sediment and stabilize the exposed area at completion of the project.
- Accumulated sediment should be removed when it reaches half the height of the fence to prevent failures.

NOTES

- The life of the product is determined at the point in which it is no longer effective or needed to do the job for which it is designed (Approximately one year).
- Installation Specifications: The method of installation for the Priority 2 Silt Fence is an integral part of the system and is unlike other installation practices. The specifically designed process includes wood (oak) stakes and wood bonding strips placed at six (6') foot intervals. The silt fence shall be installed in a trench 4" wide and 8" deep. Installation of trenches over 4" wide are not recommended. Stakes are driven to a depth, which allows 24" of fabric to be above ground. The bonding strips (typically 1" x 3/8" x 24") are attached to the stake with 1" x 1 ¼" staples. Four staples are used to secure the fabric in place against the 1 1/8" x 1 1/8" oak posts. This installation bonds the fabric to the vertical support post. The remaining fabric is now tucked into the trench forming a "J" and when filled with dirt creates a "ground bite". With its firm attachment to each post, the load is now spread to the total linear strength of all the posts within the system.
- *Any variance from the material specifications installation requirements may alter the performance of this product.* The product is available pre-staked to these specifications.

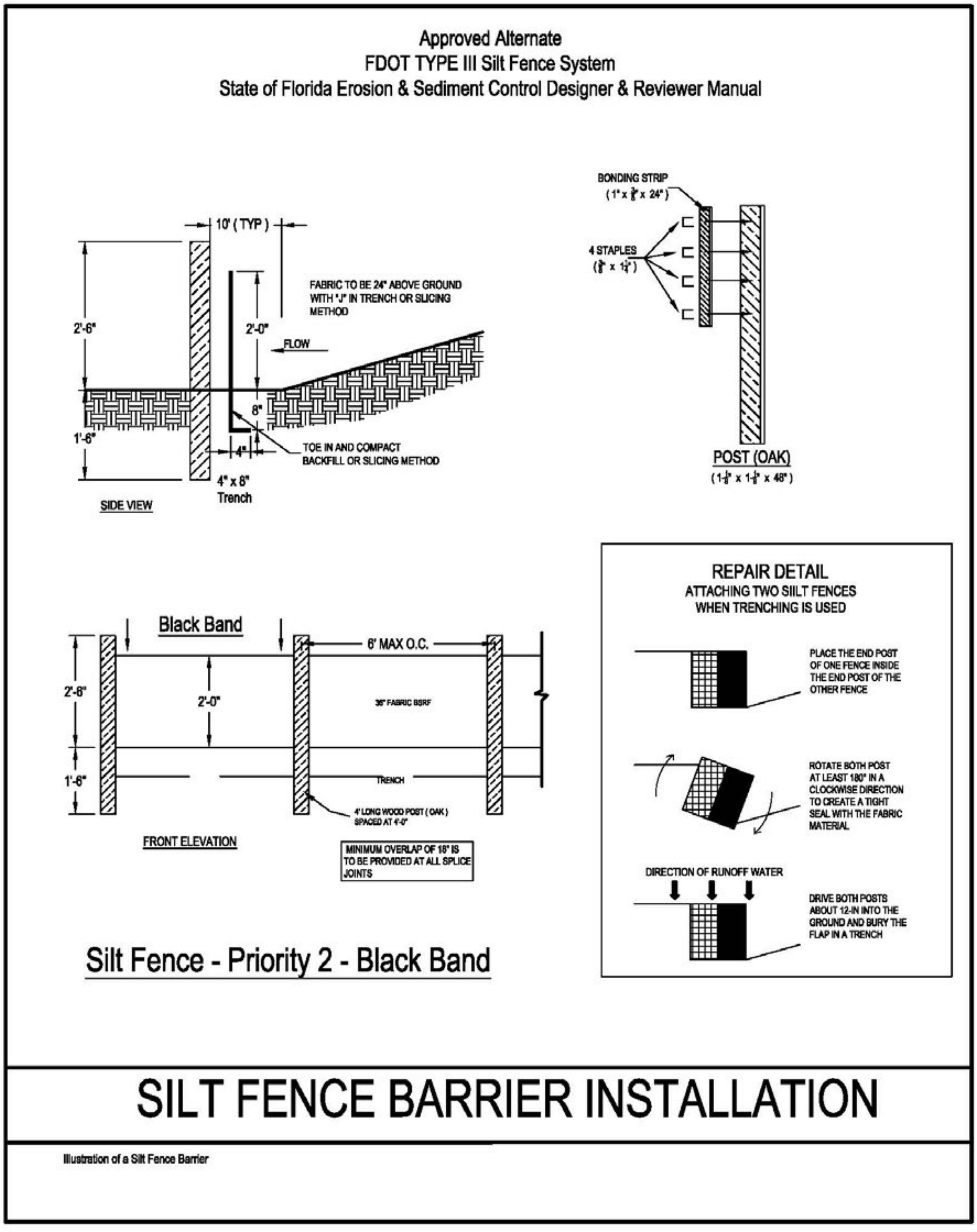

Figure V-3: Illustration of Silt Fence Priority 2 – Black Band

Belted Silt Retention Fence – Type IV Priority 1

WHAT IS ITS PURPOSE?

The BSRF shall be used as a vertical interceptor of sediment transported by overland *sheet flow* on construction sites. The Belted Silt Retention Fence (BSRF) has been designed and tested as a silt fence *system* with steel posts and wire supports. The BSRF is a 36-inch wide, spun-bond polyester fabric with an internal scrim. The system encompasses wood stakes and a specific method of attachment (see Installation Specifications in Notes below).

WHERE AND HOW IS IT COMMONLY USED?

- At the toe of cut and fills slopes
- To protect water bodies.
- As a small sediment containment system
- To provide filtering capabilities in slurry conditions

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- It is designed for control of sheet flow.

WHEN SHOULD IT NOT BE INSTALLED?

- Shall not be installed across streams, ditches, waterways, or anywhere there is concentrated flow.
- Shall not be placed around storm water inlets, which receive concentrate flow.

WHAT NEEDS TO BE INSPECTED?

- Are stakes on the downstream side?
- Does water flow under the fabric?
- Has water flattened the structure?
- Is the fabric torn?
- Is the fabric secured correctly in the ground?
- Is the fabric attached to the posts?
- Will water flow around the fence?
- Has wind destroyed the fence?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Regular inspection at the end of each workday and after each rainfall event.
- Remove the fence and accumulated sediment and stabilize the exposed area at completion of the project.
- Accumulated sediment should be removed when it reaches half the height of the fence to prevent failures.

NOTES

- As evidenced by a recent study, the BSRF meets the 75% filtration efficiency requirements of the Federal Highway Administration.

- Installation Specifications: The method of installation for the BSRF is an integral part of the system and is unlike any other installation practices. The specifically designed process includes wood (oak) stakes and wood bonding strips at four (4') foot intervals. Stakes that 4 feet high are driven to a depth, which allows 24" of fabric to be above ground. The fabric is then stretched along the inside perimeter of the stakes, pulled tightly and held in place with bonding strips. The bonding strips (typically 1" x 3/8" x 24") are attached to the stake with 1" x 1 ¼" staples. Four staples are used to secure the fabric in place against the 1 ¼" x 1 ¾" wood posts. This installation bonds the fabric and support system (scrim) to the vertical support post. The remaining fabric is now tucked into the trench forming a "J" and when filled with dirt creates a "ground bite". With its firm attachment to each post, the load is now spread to the total linear strength of all the posts within the system.

- *Any variance from the material specifications installation requirements may alter the performance of this product.* The product is available pre-staked to these specifications.

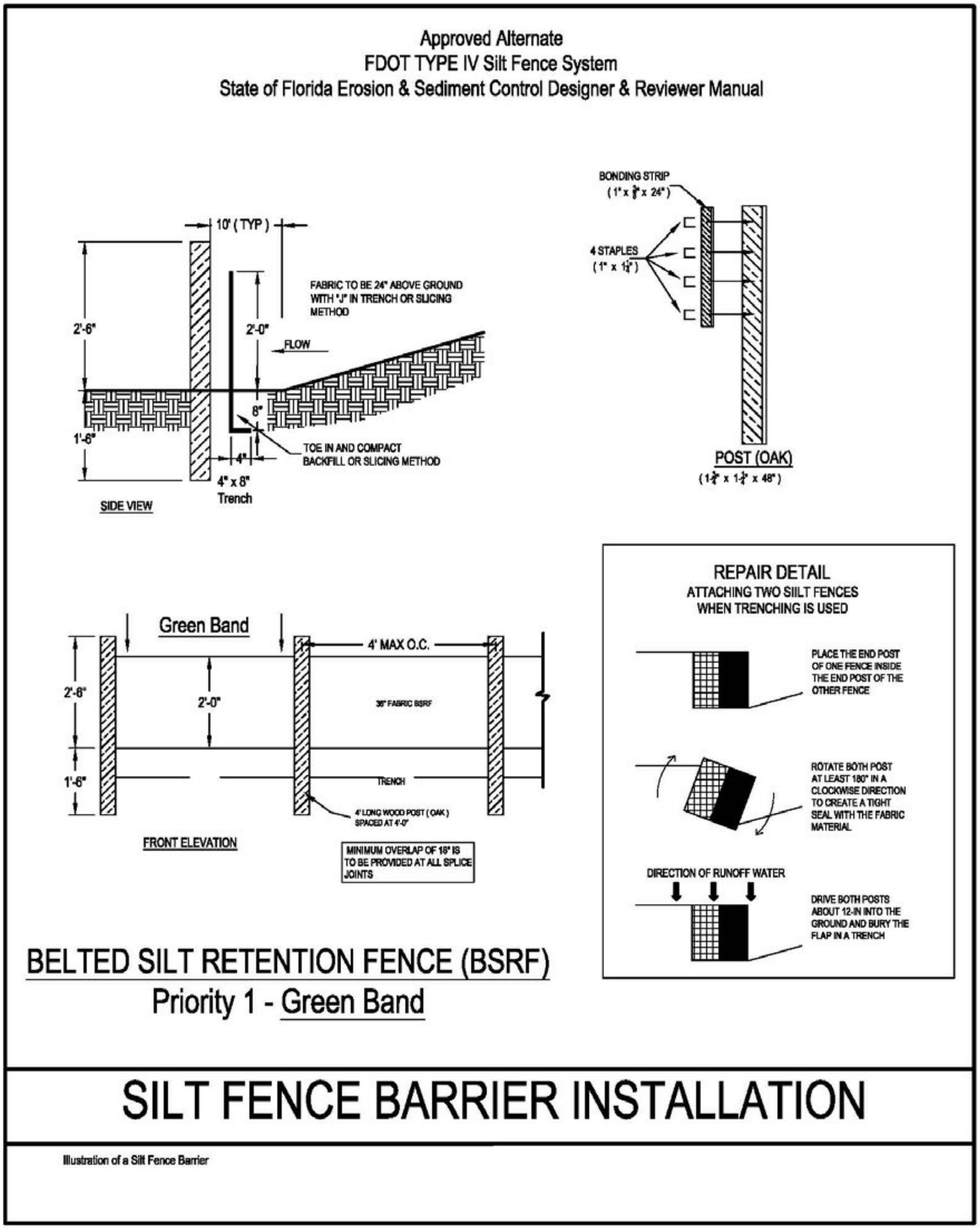

Figure V-4: Illustration of Belted Silt Retention Fence – Type IV Priority 1

Fiber Log Barriers for Individual Lots

WHAT IS ITS PURPOSE?

Temporary sediment containment structures while construction activities occur.

WHERE AND HOW IS IT COMMONLY USED?

- As a temporary barrier to contain sediment on vertical construction lots.
- As a barrier in front of an area drain.
- As diversion structures.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- Where concentrated flows are expected such as in drainage ditches, around inlets, and above/below where culverts discharge.
- After construction activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Is the material staked properly?
- Does water flow under the fiber log?
- Has traffic "flattened" the structure?
- Is the fiber log placed within a depression?
- Is the fiber log “pinned” on the upstream side?
- Will water flow around the fiber log?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of the wattle.
- Removal of fiber log materials.
- Removal of sediment.

NOTES

- Fiber logs are not to be used where concentrated flows of water are anticipated (e.g. in drainage ditches, around inlets, or above/below where culverts discharge) unless properly installed.
- Fiber logs can create a very small Type-2 sediment containment system to allow for deposition of suspended particles on vertical/big box construction sites.
- Fiber logs do not filter small (e.g. clay) suspended particles in runoff waters.

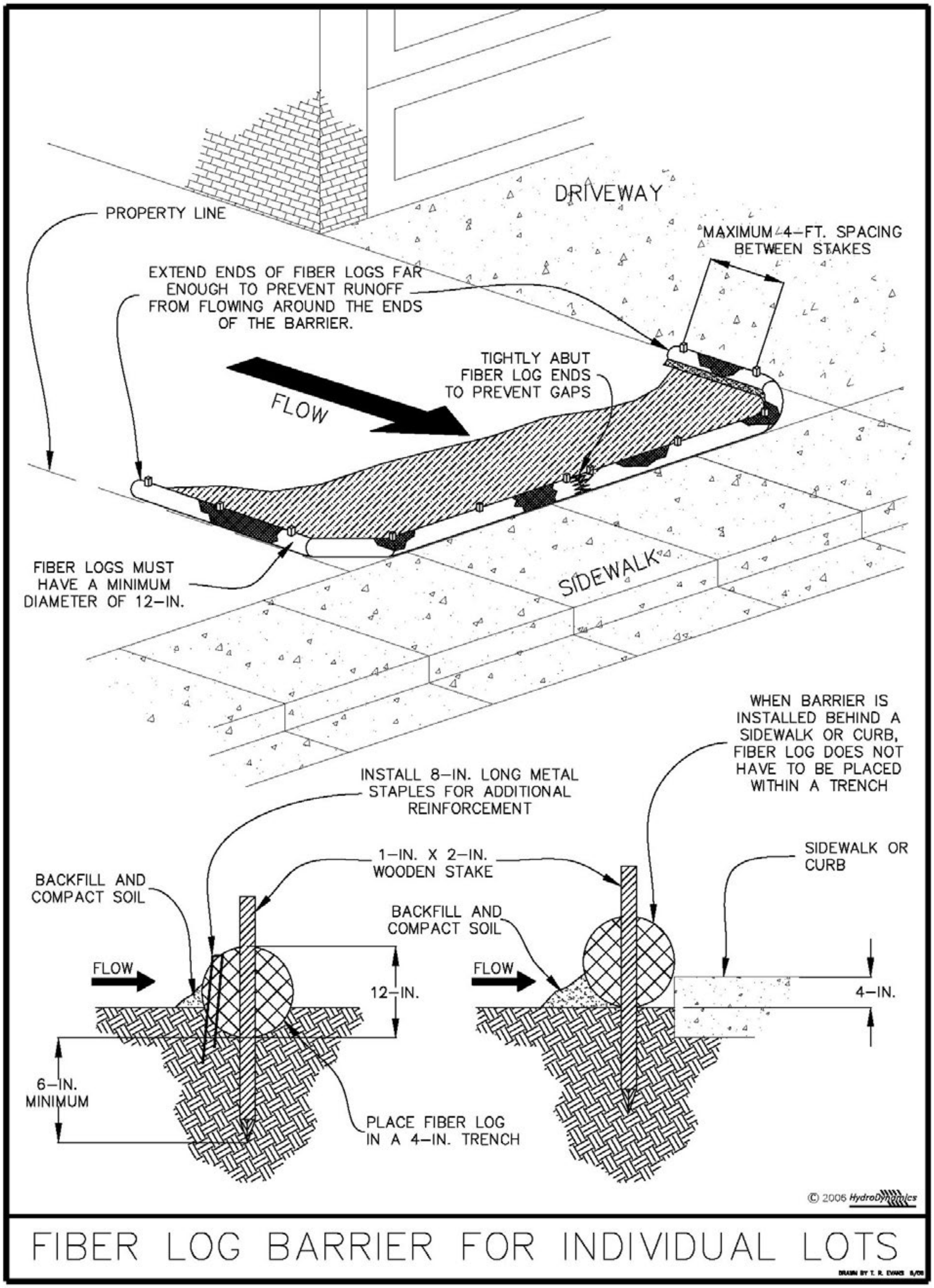

Figure V-5. Illustration of Fiber Log Barriers for Individual Lots

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Compost Filter Socks for Sediment Control

WHAT IS ITS PURPOSE?

Temporary sediment containment structures while construction activities occur.

WHERE AND HOW IS IT COMMONLY USED?

- As a temporary barrier to contain sediment on vertical construction lots.
- As a barrier in front of an area drain.
- As diversion structures.
- As a check dam.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- In streams or ephemeral waterways.
- On extremely rocky, bumpy, or unprepared ground surfaces.

WHAT NEEDS TO BE INSPECTED?

- Is the material staked properly?
- Does the water flow under the compost filter sock?
- Has traffic "flattened" the structure?
- Will water flow around the compost filter sock?
- Is the correct compost media used inside the sock (Particle sizes = 99% < 3 in, 50% > 3/8 in)?
- Is the mesh netting material made of photodegradable (polypropylene, HDPE) or biodegradable (cotton) knitted fabric with 1/8 to 3/8 in openings?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of sock (if needed).
- Removal of netting (compost may be incorporated into landscape).
- Removal of sediment.

NOTES

- Compost filter socks have been shown to remove suspended solids, heavy metals, petroleum hydrocarbons, harmful bacteria, and nutrients from stormwater runoff.
- Compost filter media may be left on site and incorporated into the landscape once stabilization is complete. Netting should be removed.
- Compost filter socks are available in a variety of diameters, including 8 in, 12 in, 18 in, and 24 in.
- Compost filter socks can be used as a Type-2 sediment containment system to allow for deposition of suspended particles on vertical/big box construction sites.

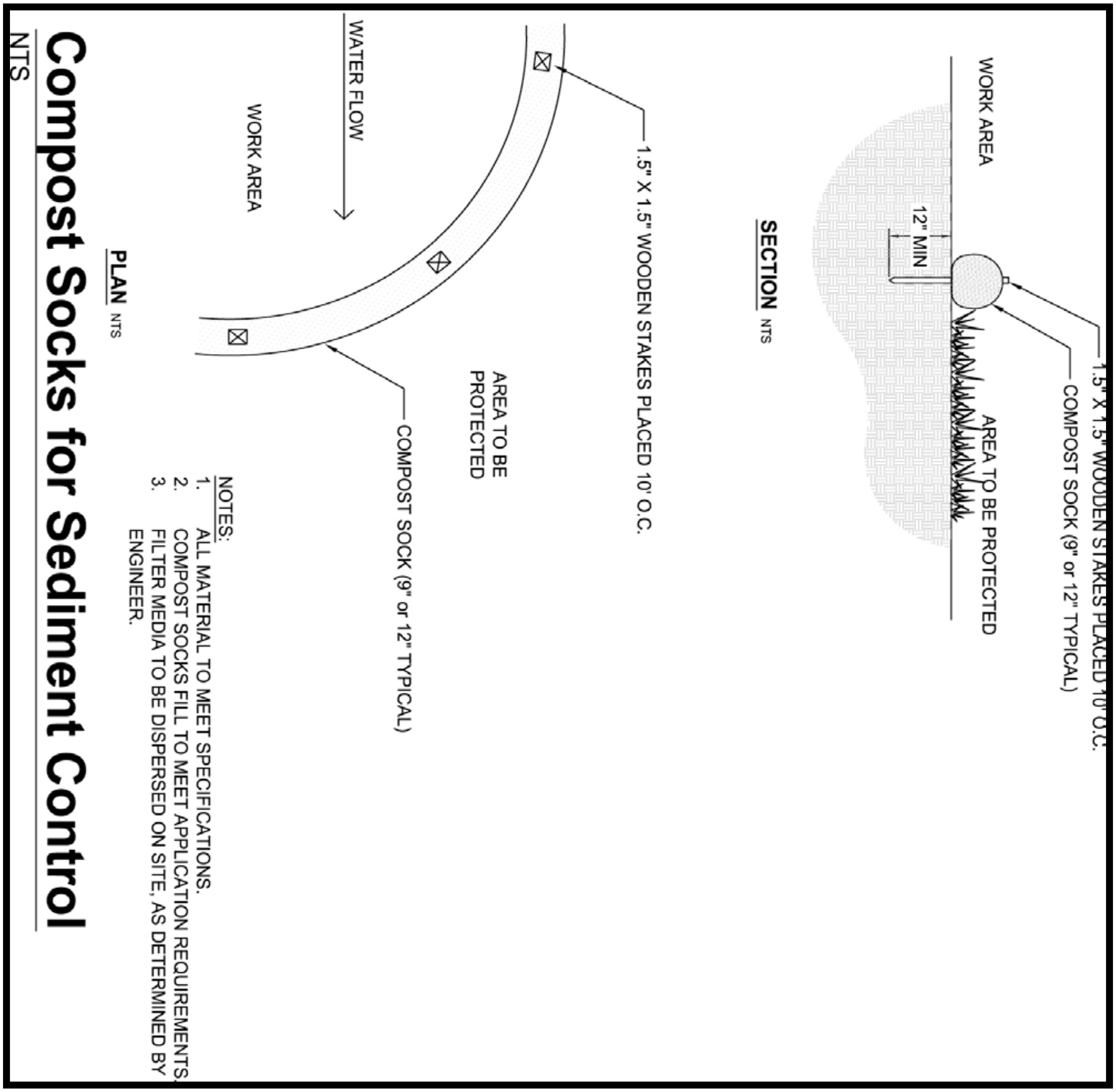

Figure V-6. Illustration of Compost Filter Sock for Sediment Control

Continuous Berm Barrier

WHAT IS ITS PURPOSE?

Temporary sediment containment structures while construction activities occur.

WHERE AND HOW IS IT COMMONLY USED?

- At the toe of cut and fill slopes.
- As small sediment containment structures.
- As diversion structures.
- Protecting water bodies.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After construction activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Is the fabric material torn?

Are the top fasteners in place?

- Has the berm been destroyed?

Does water drain through the rock?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair destroyed sections.
- Removal of the berm.
- Removal of sediment.

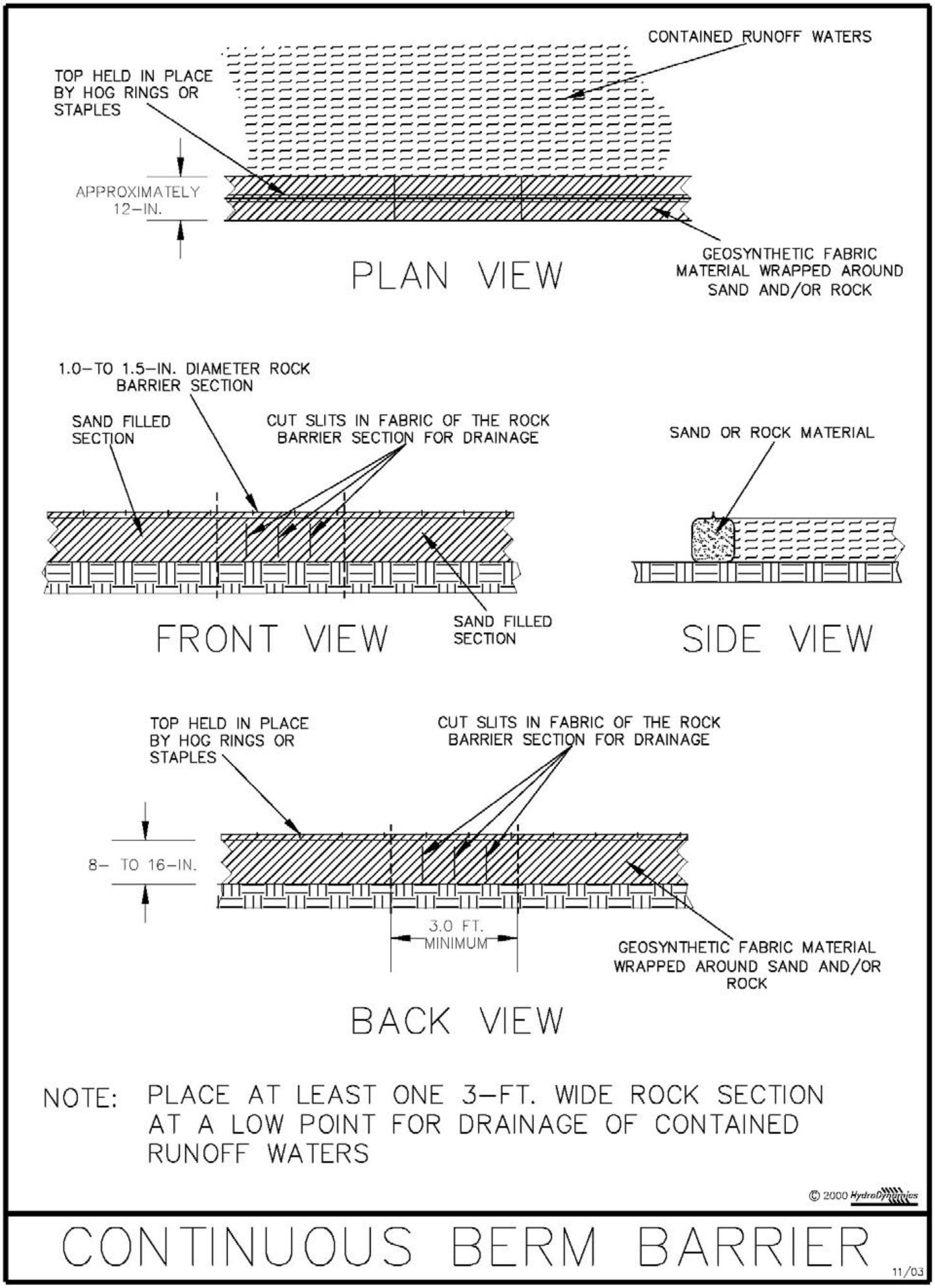

Figure V-7: Illustration of a Continuous Berm Barrier

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Geosynthetic Barrier

WHAT IS ITS PURPOSE?

Temporary sediment containment structures while construction activities occur.

WHERE AND HOW IS IT COMMONLY USED?

- At the toe of cut and fill slopes.
- As small check structures.

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- After construction activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Is the structure installed per manufacturer specifications?
- Is it properly stapled?
- Will water flow over the structure?
- Will water flow around the structure?
- Does water flow between the structures?
- Does water flow under the structure?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Repair and replacement of structures.
- Removal of sediment.
- Repair of eroded ground.
- Removal of structures.

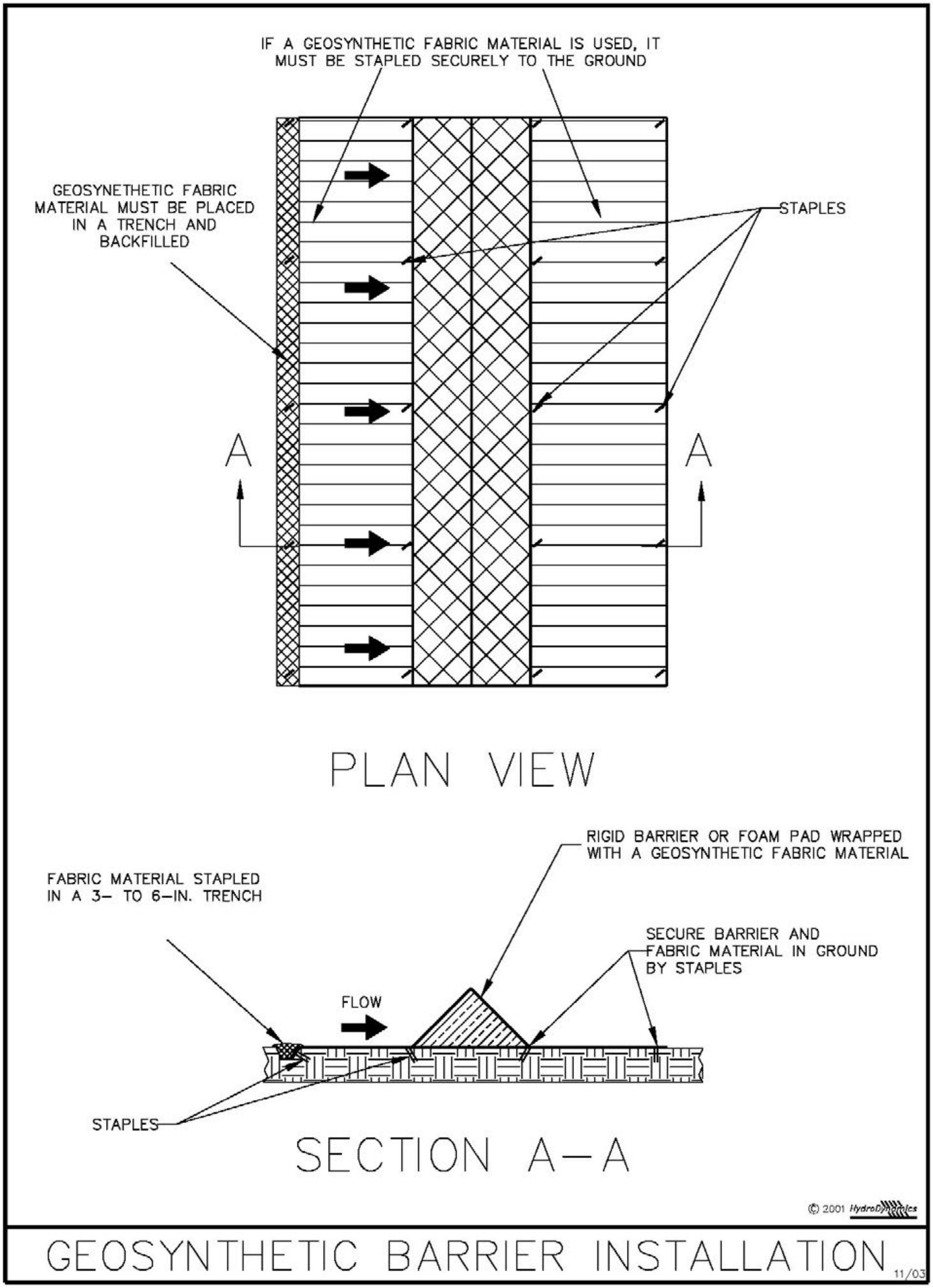

Figure V-8: Illustration of a Geosynthetic Barrier

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Floating Turbidity Barrier

WHAT IS ITS PURPOSE?

A temporary sediment containment structure suspended vertically in water bodies for the purpose of preventing sediment-laden water from escaping the immediate work area and entering the main body of water during construction activities

WHERE AND HOW IS IT COMMONLY USED?

- In bays, lakes, rivers, and streams.
- To protect wetlands.
- As a sediment containment system

WHEN SHOULD IT BE INSTALLED?

- Before construction activities begin.
- While construction activities are occurring.

WHEN SHOULD IT NOT BE INSTALLED?

- Where water currents perpendicular to the barrier exceed 3 knots, or wind/weather conditions are too great to be effective.
- After construction activities are completed.

WHAT NEEDS TO BE INSPECTED?

- Is the curtain anchored properly for the site conditions?
- Does the curtain contain turbidity?
- Does the barrier float with at least 4-inch freeboard?
- Does the curtain move excessively?

WHAT MAINTENANCE ACTIVITIES CAN BE EXPECTED?

- Regular inspection of installed barrier and anchor systems.
- Removal of curtain material at completion of job.
- Repair and replacement of damaged barrier material.

NOTES

- Do not install turbidity barriers where the flow of water is greater than 3 knots perpendicular to the barrier.
- When winds/tides change regularly, anchor systems must be placed on opposite sides of the barrier to prevent it from overriding an anchor.
- When used in a live stream, turbidity barriers must be installed parallel, not perpendicular, to the water flow.

- Barrier should never be anchored from the bottom hem.
- Barrier should not be installed so close to construction activity as to risk damaging the barrier or otherwise reducing its efficiency.
- A minimum distance of 12 inch must be maintained between the barrier skirt hem and the bottom at the mean low water level.
- When barrier is installed in a navigable waterway, lighted buoy(s) must conform to regulatory standards.
- Installation should follow manufacturer's guidelines.