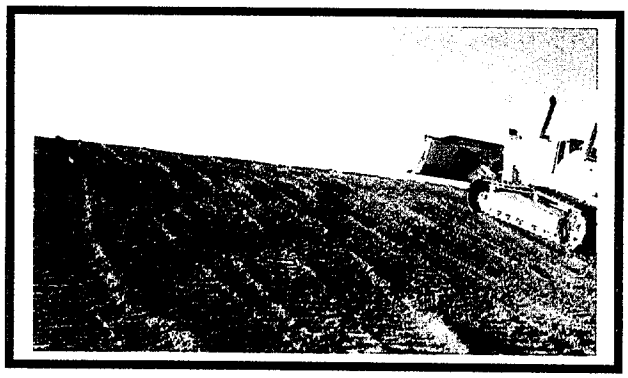
ALABAMA HANDBOOK

FOR

EROSION CONTROL, SEDIMENT CONTROL, AND STORMWATER MANAGEMENT

ON CONSTRUCTION SITES AND URBAN AREAS



ALABAMA SOIL AND WATER CONSERVATION COMMITTEE
MONTGOMERY, ALABAMA

JULY 2002

STATE OF ALABAMA

SOIL AND WATER CONSERVATION COMMITTEE

RSA Union Building
100 North Union Street
Suite 334
P.O. Box 304800
Montgomery, Alabama 36130-4800
Telephone (334) 242-2620
Fax (334) 242-0551

A Message From Stephen M. Cauthen, Executive Director

The Alabama Soil and Water Conservation Committee is pleased to provide this revision to the **Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas**. Because of the need for making additional practices available before we can complete revising the entire handbook, we decided to provide Chapter 9 - Additional Practices as the first revision to the original Alabama Handbook. We plan to provide a complete revision of the Alabama Handbook within a few months.

Citizens of our State are seeing many changes on the landscape, particularly as nonagricultural uses replace fields and forests. The Alabama Soil and Water Conservation Committee recognizes that erosion and sediment control over all of the landscapes is essential for clean water and protection of related land and water resources. It is the hope of the Committee that the technology embedded in the Alabama Handbook will be used to protect our natural resources as landscape changes occur.

The enclosed first revision material should be placed in appropriate sections of the Alabama Handbook and the outdated material should be removed (insert Preface to The First Revision behind the Introduction divider and insert the Chapter 9 material behind Chapter 8; replace the cover sheet with the new cover sheet and replace the Table of Contents).

July 2002

PREFACE TO THE FIRST REVISION

The Alabama Soil and Water Conservation Committee is pleased to provide the first revision to the Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas as one of its effort to support the protection of land and water resources in Alabama

The first revision to the Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas adds Chapter 9 - Additional Practices. The guidelines included in these additional practices are needed to support erosion and sediment control activities at construction sites in Alabama.

The Alabama Soil and Water Conservation Committee is aware of the many changes occurring on the landscapes of Alabama, particularly as nonagricultural uses replace fields and forests. The Committee recognizes that erosion and sediment control over all of the landscapes is essential for clean water and protection of related land and water resources.

It is the hope of the Committee that the technology embedded in the Alabama Handbook will be used to protect our natural resources as landscape changes occur.

Because the practices in Chapter 9 were needed before the Alabama Handbook could be completely updated, the Committee chose to provide Chapter 9 at this time rather than waiting until the entire Alabama Handbook is updated. A complete revision of the Alabama Handbook is underway and should be available in the near future.

The Committee appreciates the support of its partners in preparing the first revision. Partners include the Natural Resources Conservation Service, the Home Builders Association of Alabama, the Alabama Department of Environmental Management, the Alabama Association of Conservation Districts, the Alabama Chapter of the Soil and Water Conservation Society, the Alabama Department of Transportation, and the Biosystems Engineering Department of Auburn University.

TABLE OF CONTENTS

ALABAMA HANDBOOK FOR EROSION CONTROL, SEDIMENT CONTROL, AND STORMWATER MANAGEMENT ON CONSTRUCTION SITES AND URBAN AREAS

Table of Contents

Introduction and Erosion and Sedimentation Processes

Acknowledgements

Chapter 1 - Developing Plans For Erosion and Sediment Control and Storm Water Management

Chapter 2 - Soil Considerations

Chapter 3 - Structural measures for Erosion and Sediment Control

Chapter 4 - Vegetation for Erosion and Sediment Control

Chapter 5 - Measures for Stabilizing Coastal Dunes

Chapter 6 - Managing Stormwater

Chapter 7 - Landscape Architecture's Role in Erosion and Sediment Control

Chapter 8 - Applicability of Manual to Regulations

Chapter 9 - Additional Practices for Erosion and Sediment Control

Glossary - Terms and Definitions

References

Appendix A1 - Erosion and Sediment Control Plans

Appendix A2 - Characteristics of Soils in Alabama

Appendix A3 - Standard Drawings of Structural Measures

Appendix A4 - Information on Installing Vegetative Measures

Appendix A5 - Standard Drawings for Measures Used in Stabilizing Coastal Dunes

Appendix A6 - Information for Designing Stormwater Management Measures

Introduction and Erosion And Sedimentation Processes

Introduction

July 1, 1993

INTRODUCTION

The ALABAMA HANDBOOK FOR EROSION CONTROL, SEDIMENT CONTROL, AND STORMWATER MANAGEMENT ON CONSTRUCTION SITES AND URBAN AREAS was developed to address several land and water management concerns that are important on non-rural land throughout Alabama. Erosion, sedimentation, and uncontrolled stormwater runoff from urban areas and construction sites degrade land and water resources and cause considerable damage to individuals and society from onsite and offsite impacts.

The Alabama Soil and Water Conservation State Committee (State Committee) acting under authorities set forth in Section 9-8-22 of the Code of Alabama 1975 initiated an effort in 1991 to prepare a handbook to aid land developers and land users (including contractors, homeowners, city, county and state planners and planning boards, other governmental officials, and consultants) in adequately addressing the soil erosion, sediment, and stormwater problems associated with urban land and other land disturbing activities associated with development.

Development of the handbook was a team effort. The State Committee enlisted the assistance of the USDA Soil Conservation Service for technical expertise in developing the handbook. Several other agencies, members of soil and water conservation district boards, and several individuals with a keen interest in the environment assisted in developing the handbook. The State Committee's role was that of an oversite committee offering general direction to the intent of the manual and providing necessary guidance and review.

The handbook recognizes that erosion and runoff are influenced primarily by climate, topography, soils, vegetative cover and land-disturbing activities of man. It provides guidelines for developing plans and implementing measures that prevent or minimize the related problems of sediment and storm water. The guidelines and measures can address a broad range of soil-disturbing activities statewide. It should be noted that because the climate, topography, and soils vary throughout the state, the application of the guidelines should be tailored to local site-specific conditions.

This handbook is a guide which can be easily referenced to provide information relating to the use of soil, water, and plants to improve environmental quality. The measures

included in this manual have been proven effective in controlling erosion, sedimentation and managing stormwater. Although this document is developed as a voluntary guide, it should be noted that where regulations currently exist, it can provide accurate and reliable information that meet the requirements of the regulation in place. The handbook will be updated as new and improved technology becomes available and as State Committee resources permit.

Erosion and Sedimentation Processes

Erosion is the process by which the land surface is worn away by the action of water, wind, ice or gravity. Water-generated erosion is unquestionably the most damaging in Alabama and is the problem that this handbook addresses.

The Appalachian Plateau, the Limestone Valleys and Uplands and Piedmont Plateau of Northern Alabama are all the products of uplift and extended erosion caused by natural forces. The Coastal Plain and Blackland Prairie of Alabama represents the sedimentation and deposition product from millions of years of geologic erosion from the upland sources. With the exception of shorelines and stream channels where erosion may be rapid and catastrophic, geologic erosion occurs at very slow and uniform rates and remains a vital factor in maintaining environmental balance. This natural erosion process which has taken place over millions of years, has probably occurred at rates comparable to erosion from present day well covered forested areas, while man, through agriculture and development has generated several inches of erosion over a comparatively short period, the last 100 to 150 years.

Human alternation of the earth's surface can lead to "accelerated erosion". This occurs in Alabama where developing sites are either poorly planned or the plans that appear adequate are not implemented properly.

Water-generated erosion is unquestionably the most damaging problem in developing areas. It is helpful to think of the erosive action of water as the effects of the energy, developed by rain as it falls, or as the energy derived from water's motion as it runs off the land surface. The force of falling rain is applied vertically. The force of flowing water is applied horizontally. They both perform work in detaching and moving soil particles, but their actions are different.

The energy of raindrops falling on denuded or exposed soils detaches soil particles. Water flowing over exposed soil picks up detached soil particles. As the velocity of flowing water increases, additional soil particles are detached and transported. Water flows have a tendency to concentrate. This first creates small channels or rills and eventually gullies of varying widths and depths are formed. As the volume and velocity of runoff increases in unprotected streams and channels, additional erosion occurs on stream banks and floodplains.

Sedimentation is the process where soil particles settle out of suspension as the velocity of water decreases. The larger and heavier particles, gravel and sand, settle out more rapidly than fine silt and clay particles. The silt and clay particles are easily transported and settle out very slowly. It is difficult and perhaps impossible to totally eliminate the transportation of these fine particles even with the most effective erosion control programs.

Factors Influencing Erosion

The erosion process is influenced primarily by climate, topography, soils, and vegetative cover.

Climate. The frequency, intensity and duration of rainfall are principal factors influencing the volume of runoff from a given area. As the volume and intensity of rainfall increase, the ability of water to detach and transport soil particles increases. When storms are frequent, intense, and of long duration, the potential for erosion of bare soils is high. Temperature has a major influence on soil erosion. Frozen soils are relatively erosion resistant. However, bare soils with high moisture content are subject to "spew", or uplift by freezing action, and are usually very easily eroded upon thawing.

Topography. The size, shape and slope characteristics of a watershed influence the amount and duration of runoff. The greater the slope length and gradient, the greater the potential for both runoff and erosion. Velocities of water will increase as the distance from the top of the slope or the grade of the slope increases.

Soils. Texture, structure, organic matter content and permeability determine the erodibility of soil. Soils containing high percentages of fine sands and silt are the most susceptible to sheet and rill erosion. As the clay and organic matter content of soils increase, the erodibility

decreases. Clays act as a binder to soil particles thus reducing erodibility. But, while clays have a tendency to resist erosion, they are easily transported by water once eroded. Soils high in organic matter resist rain drop impact and the organic matter also increases the binding characteristics of the soil. Clearly, well-graded and well-drained sands are usually the least erodible soils. The high infiltration rates and permeabilities of sands either prevent or delay runoff except where overland flow is concentrated. Sandy soils are highly susceptible to gully erosion where flows concentrate.

Vegetative Cover. Vegetative cover is an extremely important factor in reducing erosion at a site. It will:

a. Absorb energy of rain drops.
b. Bind soil particles.
c. Slow velocity of runoff water.
d. Increase the ability of a soil to absorb water.
e. Remove subsurface water between rainfalls through the process of evapotranspiration.

By limiting the amount of vegetation disturbed and the exposure of soils to erosive elements, soil erosion can be greatly reduced.

Erosion and Sediment Hazards Associated With land Development

The principal effect land development activities have on the erosion process consists of exposing disturbed soils to raindrops and to storm runoff. Shaping of land for construction or development purposes alters the soil cover in many ways, often detrimentally affecting onsite drainage and storm runoff patterns and, eventually, offsite stream and streamflow characteristics. Ways that development may be detrimental from an erosion and sedimentation standpoint include: Protective vegetation is reduced or removed, excavations are made, topography is altered, the removed soil material is stockpiled--often without protective cover--and the physical properties of the soil itself are changed.

The development process is such that many people may be adversely affected, even by development of small areas. Adverse effects of erosion and sedimentation include impacts on soil, water quantity, and water quality.

Hazards associated with development included:

1. An increase in areas exposed to storm runoff and soil erosion.

2. Increased volumes of storm runoff, accelerated soil erosion and sediment yield and higher peak flows caused by:

   a. Removal of existing protective vegetative cover.
   b. Exposure of underlying soil or geologic formations potentially more erodible than original soil surface.
   c. Reduced capacity of exposed soils to absorb rainfall due to compaction caused by heavy equipment.
   d. Enlarged drainage areas caused by grading operations, diversions and street construction.
   e. Prolonged exposure of unprotected disturbed areas due to scheduling problems and/or delayed construction.
   f. Shortened times of concentration of surface runoff caused by altering steepness, distance and surface roughness and through installation of "improved" storm drainage facilities.
   g. Increased impervious surfaces associated with the construction of streets, buildings, sidewalks and paved driveways and parking lot.

3. Creation of exposures facing south and west that may hinder plant growth due to adverse temperature and moisture conditions.

4. Exposure of subsurface materials that are rocky, acid, droughty or otherwise unfavorable to the establishment of vegetation.

Acknowledgements

Acknowledgements

Acknowledgements

July 1, 1993

ACKNOWLEDGEMENTS

Handbook Task Force

Stephen M. Cauthen, Soil and Water Conservation Specialist, Alabama Soil and Water Conservation Committee, Montgomery, Alabama

Alton Hall, District Supervisor, Calhoun County Soil and Water Conservation District, Anniston, Alabama

Gary Kobylski, Director of Marketing, USDA-Soil Conservation Service, Lexington, Kentucky (formerly District Conservationist, USDA-Soil Conservation Service, Vestavia Hills, Alabama)

Bobby Moore, State Conservation Engineer, USDA-Soil Conservation Service, Auburn, Alabama

John Morris, District Supervisor, Jefferson County Soil and Water Conservation District, Vestavia Hills, Alabama

Earl Norton, State Resource Conservationist, USDA-Soil Conservation Service, Auburn, Alabama

Don Presley, Area Conservationist, USDA-Soil Conservation Service, Tuscaloosa, Alabama

James Ray, District Supervisor, Pike County Soil and Water Conservation District, Troy, Alabama

Dorothy Reynolds, District Supervisor, Macon County Soil and Water Conservation District, Tuskegee, Alabama

Linda Shrader, District Supervisor, Jackson County Soil and Water Conservation District, Scottsboro, Alabama

Roland Stewart, District Supervisor, Jefferson County Soil and Water Conservation District, Vestavia Hills, Alabama

Cecil Tanner, District Supervisor, Mobile County Soil and Water Conservation District, Mobile, Alabama

Ricky McWhorter, Pollution Control Specialist, Department of Environmental Management, Montgomery, Alabama

The Task Force expresses appreciation to the many individuals that made the handbook possible. Each person that was involved contributed significantly to the activity. The handbook provides a tool that should enable future development in Alabama to proceed without the adverse impacts of erosion and sedimentation. The ultimate measure of the effort will be the benefit to Alabama's environment in the future.

Handbook Authors

Dr. Larry Curtis, Extension Agricultural Engineer, Soil and Water, Alabama Cooperative Extension Service, Auburn University, Auburn, Alabama

Bob Fulmer, Geologist, USDA-Soil Conservation Service, Athens, Georgia

Jerry Johnson, State Staff Forester, USDA-Soil Conservation Service, Auburn, Alabama

Gary Kobylski, Director of Marketing, USDA-Soil Conservation Service, Lexington, Kentucky (formerly District Conservationist, USDA-Soil Conservation Service, Vestavia Hills, Alabama)

John Meetze, State Soil Scientist, USDA-Soil Conservation Service, Auburn, Alabama

Bobby Moore, State Conservation Engineer, USDA-Soil Conservation Service, Auburn, Alabama

Earl L. Norton, State Resource Conservationist, USDA-Soil Conservation Service, Auburn, Alabama

Perry Oakes, Assistant State Conservation Engineer, USDA-Soil Conservation Service, Auburn, Alabama

Don Presley, Area Conservationist, USDA-Soil Conservation Service, Tuscaloosa, Alabama

Philip Richardson, Landscape Architect, American Society of Landscape Architects, Birmingham, Alabama (SCS Earth Team Volunteer, Vestavia Hill, Alabama)

Ken Rogers, Conservation Agronomist, USDA-Soil Conservation Service, Auburn, Alabama

Staff, Alabama Department of Environmental Management, Montgomery, Alabama

Don Surrency, Plant Materials Specialist, USDA-Soil Conservation Service, Athens, Georgia

Dr. Ken Tilt, Associate Professor and Extension Horticulturist, Nursery Production and Landscape Management, Alabama Cooperative Extension Service, Auburn University, Auburn, Alabama

Dr. J. David Williams, Assistant Professor and Extension Horticulturist, Home Horticulture, Alabama Cooperative Extension Service, Auburn University, Auburn, Alabama

Handbook Reviewers

Sue Daniel, Secretary, USDA-Soil Conservation Service, Auburn, Alabama

Randall East, Area Engineer, USDA-Soil Conservation Service, Ozark, Alabama

Rod Goode, District Conservationist, USDA-Soil Conservation Service, Vestavia Hill, Alabama

Lee Y. Greene, Area Engineer, USDA-Soil Conservation Service, Decatur, Alabama

Deloris Jones, Secretary (Office Automation), USDA-Soil Conservation Service, Auburn, Alabama

Randy Martin, Area Engineer, USDA-Soil Conservation Service, Grove Hill, Alabama

Larry J. McCray, Area Engineer, USDA-Soil Conservation Service, Tuscaloosa, Alabama

Dr. Robert Pitt, Assistant Professor of Civil Engineering, University of Alabama at Birmingham, Birmingham, Alabama (SCS Earth Team Volunteer, Vestavia Hills, Alabama)

William Prince, Area Engineer, USDA-Soil Conservation Service, Oxford, Alabama

Ed Wegener, SCS Earth Team Volunteer, Auburn, Alabama

Others

The authors received materials and suggestions from experts in several other states including Georgia, North Carolina, New York and Virginia.

Walter Schoel Engineering Company Inc., Consulting Engineers of Birmingham, Alabama provided valuable assistance in drafting maps. (SCS Earth Team Volunteer, Vestavia Hills, Alabama)

Deloris Jones and Sue Daniel of the Alabama SCS State Office were instrumental in providing word processing support, in developing format, and providing drafts for review.

CHPT. 1- Developing Plans for Erosion and Sediment Control and Storm Water Management

Chapter 1

DEVELOPING PLANS FOR EROSION AND SEDIMENT CONTROL AND STORM WATER MANAGEMENT

CONTENTS

	Page
Purpose Of The Plan	I-1
General Considerations	I-1
Components Of The Plan	I-3
Step By Step Procedures For Plan Development	I-4
Checklist For Erosion and Sediment Control Plans	I-11

July 1, 1993

DEVELOPING PLANS FOR EROSION AND SEDIMENT CONTROL AND STORM WATER MANAGEMENT

What is an Erosion and Sediment Control Plan?

An erosion and sediment control plan is a working document which explains and stipulates the measures and actions which are to be taken to control potential erosion and sedimentation problems. The plan has a written narrative and a graphic portion known as a treatment map or site map. It contains specifications that describe how the measures are to be installed to meet the appropriate criteria. Also, it contains enough information to ensure that the party responsible for development of a site can install the measures in the correct sequence at the appropriate season of the year. The plan may contain a description of the potential erosion and sedimentation problems.

Purpose Of The Plan

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

General Considerations

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

The planner should have a sound understanding of the requirement of any state and/or local erosion and sediment control laws, erosion and sedimentation control principles, and vegetative, structural, and management type measures and their role in erosion and sediment control before preparing an erosion and sedimentation control plan on a selected site. This section describes the plan format/content and provides ideas for improving plan effectiveness.

The erosion and sediment control plan should be a separate document. The plan should include at a minimum the erosion and sediment control layout, measure details and specifications. The approved plan should be included in the general construction contract.

What Is an "Adequate" Plan?

An erosion and sediment control plan must contain sufficient information to describe the site development and the system intended to control erosion and off-site sedimentation. If regulations exist the plan must satisfy the approving authority that the potential problems of erosion and sedimentation will be adequately addressed. The length and complexity of the plan should be commensurate with the size and importance of the project, severity of site conditions, and the potential for off-site damage.

Obviously, a plan for constructing a house on a single subdivision lot may not need to be as complex as a plan for a shopping center development. Plans for projects undertaken on flat terrain will generally be less complicated than plans for projects constructed on steep slopes with higher erosion potential. The greatest level of planning and detail should be evident on plans for projects which are adjacent to flowing streams, dense population centers, high value properties, etc., where damage may be particularly costly or detrimental to the environment.

The Step-by-Step Procedures for Plan Development outlined later in this chapter are recommended for the development of all plans. The checklists following the procedures can be used by planners and reviewers as a checklist for plan content and format.

Who is Responsible for Preparing the Plan?

The owner or lessee of the land being developed has the responsibility for plan preparation and submission. The owner or lessee may designate someone (i.e, an engineer, architect, contractor, etc.) to prepare and implement the plan, but the owner or lessee retains the ultimate responsibility.

Components Of The Plan

As a minimum, include the following components in the plan:

- a location or vicinity map,

- a narrative written in a clear, concise manner that describes the type of proposed development, existing conditions at the site and adjacent areas, proposed erosion and sediment control measures, and rationale or justification for those decisions. Adequate information provided by the narrative is important for the plan reviewer who may not be familiar with the site and to the construction superintendent and inspector who are responsible for plan installation. Details of the narrative can save time and insure that erosion and sediment control measures are properly installed.

- specifications for planned erosion and sediment control measures. These should include standards and specifications for both vegetative and structural measures. Chapters 3 and 4 of this manual contain minimum standards and specifications for the various measures. The specific name and number of planned measures should be identified in the narrative and marked on the site plan or treatment map. By properly referencing the State Handbook, the planner could reduce the need for detailed drawings and lengthy conservation practice descriptions.

  New innovative conservation measures or modifications to State standard measures may be used, but only after being thoroughly described, detailed designs developed, and concurred in by the Approving Authority.

- site plan or treatment map. This map may include a site development drawing and a site erosion and sediment control drawing depicting type and to the extent possible locations of planned conservation practices. Map scales and drawings should be appropriate for clear interpretation. An example of an erosion sediment control plan is located in Appendix No. A1.

  Site planners are urged to use the standard coding system for conservation practices contained in this manual. Appendix A1 contains a large fold-out chart listing each measure with its designated code. This chart can be placed on the wall for fast and easy reference. Use of the coding system will result in increased uniformity of plans and better readability

for plan reviewers, job superintendents, and inspectors statewide.

The following components should be separate or included as applicable in the written narrative or site plan:

- supporting material such as sketches and calculations for design of conservation practices
- construction schedule
- other maps; e.g., soils maps, charts, or other materials as applicable

Step-By-Step Procedures For Plan Development

Step 1 - Data Collection

Inventory the existing site conditions to gather information which will help the planner develop the most effective erosion and sediment control plan. The information obtained should be shown on a map and verbally explained in the narrative portion of the plan.

A. Topography - A small-scale topographic map of the site should be prepared to show the existing contour elevations. The suggested interval is usually 1 to 5 feet depending upon the slope of the terrain. However, the contour interval may be increased on steep slopes.

B. Drainage Patterns - All existing drainage swales and patterns on the site should be located and clearly marked on the topographic map.

C. Soils - Major soil type(s) on the site should be determined and shown on the topographic map. Soils information can be obtained from a soil survey if one has been published for the county. If a soil survey is not available, a request can be made to the local Soil Conservation District Office. Commercial soils evaluations are also available from consultants. For ease of interpretation, soils information should be plotted directly onto the map or an overlay of the same scale.

D. Ground Cover - The existing vegetation on the site should be shown. Such features as trees and other woody vegetation, grassy areas, and unique vegetation should be shown on the map. In addition, existing bare or exposed soil areas should be indicated.

E. Adjacent Areas - Areas adjacent to the site should be delineated on the topographic map. Applicable features such as streams, roads, houses, and utilities or other buildings and wooded areas should be shown.

Step 2 - Data Analysis

When all of the data in Step 1 are considered together, a picture of the site potentials and limitations should begin to emerge. The site planner should be able to determine those areas which have potentially critical erosion hazards. The following are some important points to consider in site analysis:

A. Topography - The primary topographic considerations are slope steepness and slope length. The longer and steeper the slope, the greater the erosion potential from surface runoff. When the percent of slope has been determined, areas of similar steepness should be outlined. Slope gradients can be grouped into three general ranges of soil erodibility:

0-2% - Low erosion hazard
2-5% - Moderate erosion hazard
over 5% - High erosion hazard

Within these slope gradient ranges, longer slope lengths further increase the erosion hazard. Therefore, in determining potential critical areas the site planner should be aware of excessively long slopes. As a general rule, the erosion hazard will become critical if slope lengths exceed these combined values:

0-2% - 300 feet
2-5% - 150 feet
over 5% - 75 feet

B. Drainage Patterns - Natural drainage patterns exist on the land. These patterns, known as swales, depressions, and natural watercourses, should be identified in order to plan around critical areas where water will concentrate. Where it is possible, natural drainageways should be used to convey runoff over and off the site to avoid the expense and problems of constructing an artificial drainage system. Man-made ditches and waterways will become part of the erosion problem if they are not properly stabilized. Care should also be taken to be sure that increased runoff from the site will not erode or flood the existing natural drainage

system; this includes locating possible sites for stormwater detention.

C. Soils - Such soils properties as natural drainage, depth to bedrock, depth to seasonal water table, permeability, shrink-swell potential, texture, and erodibility should exert a strong influence on land development decisions. Also, the flood hazard related to the soils can be determined based on the relationship between soils and flooding. Chapter 2 contains basic guidelines for using soils information in site planning. A list of common Alabama soils along with interpretations for developmental uses is included in Appendix No. A2.

D. Ground Cover - Ground cover is the most important factor in terms of preventing erosion. Any existing vegetation which can be saved will help prevent erosion. Trees and other vegetation protect the soil as well as beautify the site after construction. If the existing vegetation cannot be saved, the planner should consider staging construction, temporary mulching and/or vegetation. Staging of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once, minimizing the time ground is left bare. Temporary mulching and/or vegetation involves seeding or mulching areas which would otherwise be left bare for long periods of time; therefore, time of exposure is limited and the erosion hazard is reduced.

E. Adjacent Areas - Generally, the analysis of adjacent properties should focus on areas downslope or downstream from the construction project. Watercourses which will receive direct runoff from the site should be of major concern; these streams should be analyzed to determine their carrying capacity. The potential for sediment pollution of these watercourses should be considered as well as the potential for downstream channel erosion due to increased velocity and peak flow rate of storm water runoff from the site. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be analyzed so that appropriate sediment retention measures can be planned.

Step 3 - Facility Plan Development

This step does not apply to established developments. On the other hand, this step is relevant to those situations where

facilities are being planned and there is flexibility in their extent and location. After analyzing the data about the site and determining any site limitations, the planner can then develop a site plan that is in harmony with the landscape. An attempt should be made to locate the buildings, roads, and parking lots and develop landscaping plans to exploit the strengths and overcome the limitations of the site. The following are some points to consider in making these decisions:

A. Fit development to terrain. The development of an area should be tailored, as much as possible, to existing site conditions. This will avoid unnecessary land disturbance while minimizing the erosion hazards and development costs.

B. Confine construction activities to the least critical areas. Any land disturbance in the critically erodible areas will necessitate the installation of more costly erosion and sediment control measures.

C. Cluster buildings together. This minimizes the amount of disturbed area, concentrates utility lines and connections in one area while leaving more open natural space. The cluster concept not only lessens the erodible area, but it generally reduces runoff and development costs.

D. Minimize impervious areas. Keep paved areas such as parking lots and roads to a minimum. This goes hand in hand with cluster developments in eliminating the need for duplicating parking areas, access roads, etc. The more land that is kept in vegetative cover, the more water will infiltrate thus minimizing runoff and erosion. Consider the use of special pavements which will allow water to infiltrate or cellular blocks which have soil and vegetation components.

E. Utilize the natural drainage system. If the natural drainage system of a site can be preserved instead of being replaced with storm sewers or concrete channels, the potential for downstream damages due to increased runoff can be minimized, making compliance with stormwater management criteria as noted in Chapter 6 much easier.

Step 4 - Planning for Erosion and Sediment Control

When the site facility plan layout has been developed, a plan to control erosion and sedimentation from the disturbed areas is then formulated.

The following general procedure is recommended for erosion and sediment control planning:

A. Divide the site into drainage areas. Determine how runoff will travel over the site. Consider how erosion and sedimentation can be controlled in each small drainage area before looking at the entire site. Remember, it is easier to control erosion than to contend with sediment after it has been carried downstream.

B. Determine limits of clearing and grading. Decide exactly which areas must be disturbed in order to accommodate the proposed construction. Pay special attention to critical areas which must be disturbed. The important point in this activity is to minimize the areas to be disturbed.

C. Select erosion and sediment control measures. Erosion and sediment control practices can be divided into 3 broad categories: vegetative measures, structural measures, and management measures. This handbook should be used for the selection and design of vegetative and structural measures. Management measures include items such as construction management techniques which, if properly utilized, can minimize the need for more costly vegetative/structural erosion and sediment control measures.

1. Vegetative Controls - Vegetative controls should generally be considered first, because of economics. Usually, vegetation should be established on a temporary basis to minimize offsite impacts at the beginning of land disturbances.

   Vegetation protects the soil surface from raindrop impact and overland flow of runoff water. Vegetative measures should be maximized to provide as much erosion and sediment control as possible with a minimum of structural measures. One of the simplest ways to protect the soil surface is by preserving existing ground cover where protective cover already exists. Where existing ground cover must be removed and land disturbance is necessary, temporary seeding or mulching can be used on areas that are to be exposed for long periods.

Erosion and sediment control plans must contain provisions for permanent stabilization of disturbed areas. Selection of permanent vegetation should include the following considerations:

a. adaptability to site conditions
b. establishment requirements
c. aesthetics
d. maintenance requirements

2. Structural Controls - Structural measures are generally more costly than vegetative controls. However, they are necessary on areas where vegetation alone will not control erosion. In addition, structural measures are often needed in combination with vegetative measures as a second or third line of defense to capture sediment before it leaves the site.

   It is very important that structural measures be selected, designed, constructed, and maintained according to the standards and specifications in Chapter 3 of this handbook. Poorly planned or constructed structural measures can increase development costs and create maintenance problems. Structural measures that fail may increase erosion and sedimentation. Therefore, it is very important that structural measures be designed and installed properly.

3. Management Measures - Good construction management is as important as physical measures for erosion and sediment control and there is generally little or no cost involved. Following are some management considerations which should be included in the erosion and sediment control plan:

   a. Sequence construction so that no area remains exposed for unnecessarily long periods of time.
   b. When possible, avoid grading activities during months such as July and November through February because these months are unsuitable for seeding and the potential for erosion and sedimentation is high.
   c. Temporary seedings should be done immediately after grading.

d. On large projects, stage the construction if possible, so that one area can be stabilized before another is disturbed.
e. Develop and carry out a regular maintenance schedule for erosion and sediment control measures.
f. Physically mark off limits of land disturbance on the site with tape, signs or other methods, so the workers can see areas to be protected.
g. Make sure that all workers understand the major provisions of the erosion and sediment control plan.
h. Responsibility for implementing the erosion and sediment control plan should be designated to one individual (preferably the job superintendent or foreman).

D. Plan for stormwater management. Where increased runoff will cause the carrying capacity of a receiving channel to be exceeded (for a 2-year storm), the site planner must select appropriate stormwater management measures. Chapter Six describes the planning considerations for stormwater management that must be satisfied.

Step 5 - Plan Assembly

The necessary planning work was done in steps 1-4; therefore, this final step consists of consolidating the pertinent information and developing it into a specific erosion and sediment control plan for the project.

The two major plan components are a narrative and a site plan. The narrative verbally explains the problems and their solutions with all necessary documentation. The site plan is one or a series of maps or drawings pictorially explaining information contained in the narrative.

The following checklists may be used in completing the narrative and site plan. These checklists can be used as a guide by the site planner as a ready reference to be sure all major items are included in the erosion and sediment control plan.

Checklist For Erosion and Sediment Control Plans

Narrative

- project description-Briefly describe the nature and purpose of the land disturbing activity and the amount of grading involved.

- existing site conditions-A description of the existing topography, vegetation, and drainage.

- adjacent areas-A description of neighboring areas such as streams, lakes, residential areas, roads, etc., which might be affected by the land disturbance.

- soils-A brief description of the soils on the site giving such information as soil names, mapping unit, erodibility, permeability, depth, texture, soil structure, and any other limitations.

- critical areas-A description of areas on the site which have potential serious erosion problems.

- erosion and sediment control measures-A description of the methods which will be used to control erosion and sedimentation on the site.

- permanent stabilization-A brief description, including specifications, of how the site will be stabilized after construction is completed.

- stormwater management considerations-Will the development of the site result in increased peak rates of runoff? Will this result in flooding or channel degradation downstream? If so, considerations should be given to stormwater control structures on the site. Local ordinances must be considered and met.

- maintenance-A schedule of regular inspections and repair of erosion and sediment control measures should be set forth.

Checklist For Erosion and Sediment Control Plans

Site Plan

- vicinity map-A small map locating the site in relation to the surrounding area.
- existing contours-The existing contours of the site should be shown on a map.
- existing vegetation-The existing tree lines, grassy areas, or unique vegetation should be shown on a map.
- soils-The boundaries of the different soil types should be shown on a map.
- indicate north-The direction of north in relation to the site should be shown. The top of all maps should be north, if possible and practical.
- critical erosion areas-Areas with potentially serious erosion problems should be shown on a map.
- existing drainage patterns-The dividing lines and the direction of flow for the different drainage areas should be shown on a map.
- final contours-Changes to the existing contour should be shown on a map.
- development features-The outline of buildings, roads, drainage appurtenances, utilities, landscaping features, parking areas, improvements, impervious areas, topographic features, and similar man-made installations should be shown to scale and relative location.
- limits of clearing and grading-Areas which are to be cleared and graded should be outlined on a map.
- location of measures-The locations of the erosion and sediment control and stormwater management practices used on the site should be shown on a map.
- detail drawings-Any structural measures used that are not referenced to the manual or other local manuals should be explained and illustrated with detail drawings.

CHPT. 2- Soil Considerations

Chapter 2

SOIL CONSIDERATIONS

CONTENTS

	Page
Major Soil Areas	II-1
Characteristics Affecting Disturbed Sites	II-3

July 1, 1993

SOIL CONSIDERATIONS

Soil formation in Alabama has been influenced primarily by parent materials and relief. The Appalachian Plateau, Limestone Valleys and Uplands, and Piedmont Plateau of Northern Alabama are all products of uplift and extended geologic erosion. The Coastal Plain and Blackland Prairie sections of the state represent the sedimentation and deposition product from millions of years of geologic erosion. As a result, soils differ among the major soil areas throughout the state (See Figure II-1). The following is a very general description of the soils in these areas and some of the characteristics to consider in the stabilization of disturbed sites.

Major Soil Areas

Limestone Valleys and Uplands

Soils in this area were formed mainly in residuum weathered from limestone. Soils in the Tennessee and Coosa river valleys are weathered from pure limestones and are mainly red clayey soils with a loamy surface texture. Most of the land is open and cropped to cotton or soybeans.

Most of the soils of the uplands are derived from cherty limestone. They typically have a cherty loamy or cherty clayey subsoil and a cherty loamy surface layer. Much of the area is used for pasture or forest. Cotton and soybeans are the major row crops.

Appalachian Plateau

The Appalachian Plateau consist of Cumberland, Sand, Lookout, Gunter, Brindlee, Chandler and smaller mountains. Most of the soils are derived from sandstone or shale.

The more level areas with slopes of less than 10 percent generally have a loamy subsoil and a sandy loam surface layer. Corn, soybeans, potatoes, and tomatoes are major crops.

The more rugged portions of the Appalachian Plateau are dominated by soils which formed in residuum from shale. These soils have either a very channery loamy, or a clayey subsoil and a loamy surface layer. Most of these areas are too steeply sloping for agriculture.

Piedmont Plateau

Most of the soils in this area are derived from granite, hornblende, and mica schists. They commonly have a red clayey subsoil and a sandy loam surface layer. Topography is rolling to steep. Most rolling areas were once cultivated but are now in pasture or forest.

Coastal Plain

Most of the soils in this area are derived from marine and fluvial sediments. The area consists of the Upper and Lower Coastal Plains.

Soils of the Upper Coastal Plain generally have a loamy or clayey subsoil and a sandy loam surface layer. The topography is nearly level to very steep. Narrow ridgetops and broad terraces are cultivated, but most of the area is in forest.

Soils of the Lower Coastal Plain generally have a loamy subsoil and a sandy loam surface layer. Most slopes are less than 10 percent. Major crops are corn, peanuts, and soybeans.

Blackland Prairie

This area of central and western Alabama is known locally as the "Black Belt" because of the dark surface color of many of the soils. These soils were derived from alkaline, chalk or acid marine clays. Acid and alkaline soils are intermingled throughout the area. The alkaline soils ordinarily are clayey throughout and have a dark surface layer and a yellowish subsoil. The acid soils ordinarily are clayey throughout and have a red subsoil and a light-colored surface layer. These clayey soils contain a large percentage of montmorillonitic clays and shrink and crack when dry and swell when wet. The area is level to undulating. Most of these soils are used for timber production and pasture.

Major Flood Plains and Terraces

These soils are not extensive but are important where they occur along streams and river terraces. They are derived from alluvium deposited by the streams. A typical area consists of cultivated crops on the nearly level terraces and bottomland hardwood forests on the flood plain of streams.

Coastal Marshes and Beaches

These soils are not extensive and occur only on nearly level and level bottomlands and tidal flats along the Mobile River, Mobile Bay and Gulf of Mexico. Most of the soils are deep and very poorly drained.

Characteristics Affecting Disturbed Sites

Nature of Disturbed Soils

Many characteristics of soils--including texture, organic matter, fertility, acidity, moisture retention, drainage, and slope--have an influence on the soils' vulnerability to erosion. Except for the majority of the Prairie area, after grading, most disturbed sites end up, with a surface layer of acid infertile subsoil materials. The soils of these sites can be toxic to many plants and may not be capable of supporting growth sufficient to prevent erosion. Construction activities further decrease soil productivity by increasing compaction, and altering the slopes and drainage patterns. To offset these problems, the topsoil should be removed, stockpiled, and reapplied to the disturbed area. Then soil amendments should be applied based on a soil test of the area. In some areas special seedbed preparation will be necessary.

Soil Sampling

A sediment control plan should include a thorough sampling of the different soils of the area. Each different soil should be sampled separately. Containers and instructions for proper sampling may be obtained from the local Agricultural Extension Service office. Test results include lime and fertilizer recommendations. Fertilizing according to soil test recommendations ensures the most efficient use of fertilizer and allows for a minimum of excess fertilizer to pollute streams of groundwater. Soil sampling should begin well in advance of planting because it takes from 1 to 6 weeks to obtain soil text results.

Soil Limitations

Certain soil characteristics are difficult to modify and can impose severe limitation for plant growth. These include the effective depth roots can penetrate, stoniness, texture,

and properties related to texture such as water and nutrient holding capacity. Sandy soils result in droughtiness and nutrient deficiencies. Clayey soils on the other hand, impede the movement of water into and through the soil, thereby increasing the volume of runoff. Some soils have toxic levels of elements such as aluminum, iron, and manganese which limit the growth of plants. However, these can usually be overcome by liming.

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

U.S.D.A.–SOIL CONSERVATION SERVICE

ALABAMA COOP. EXTENSION SERVICE

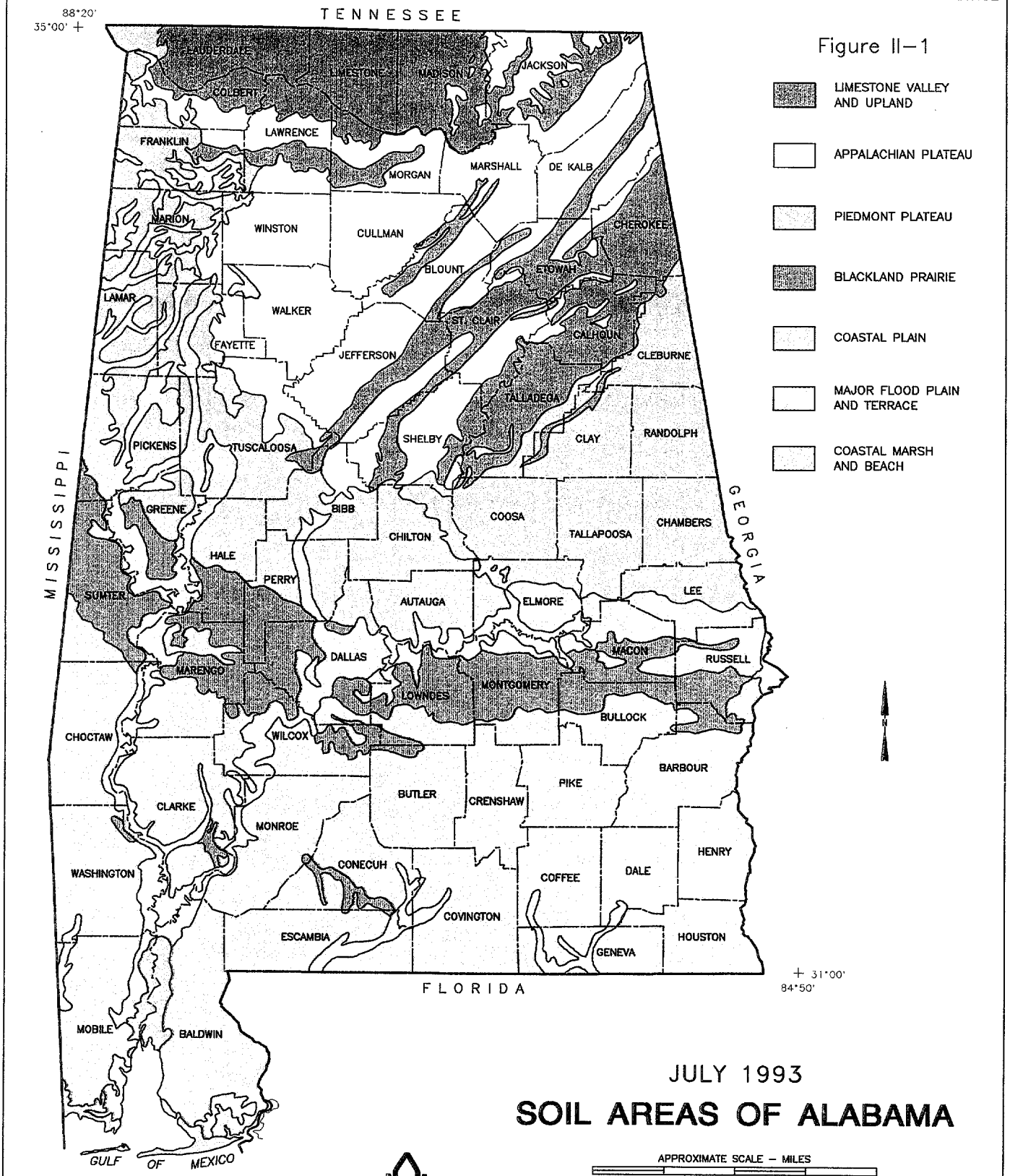


Figure II–1

- LIMESTONE VALLEY AND UPLAND
- APPALACHIAN PLATEAU
- PIEDMONT PLATEAU
- BLACKLAND PRAIRIE
- COASTAL PLAIN
- MAJOR FLOOD PLAIN AND TERRACE
- COASTAL MARSH AND BEACH

JULY 1993

SOIL AREAS OF ALABAMA

APPROXIMATE SCALE – MILES

0 20 40 60 80

SOURCE:
INFORMATION FROM SCS FIELD PERSONNEL.
MAP PREPARED USING AUTOMATED MAP CONSTRUCTION.
LATITUDE AND LONGITUDE GEOGRAPHIC COORDINATE SYSTEM
CALCULATED BY THE APPLICATIONS SOFTWARE,
NATIONAL CARTOGRAPHY AND GEOGRAPHIC INFORMATION
SYSTEMS CENTER, FORT WORTH, TEXAS, 1993.

General soil map of
Alabama No. 4–R–33619
published January 1984

CIR. ANR–340
JULY 1993 1003452–02

USDA, SCS, NATIONAL CARTOGRAPHY & GIS CENTER, FORT WORTH, TX, 1993

CHPT. 3- Structural Measures for Erosion and Sediment Control

Chapter 3

STRUCTURAL MEASURES FOR EROSION AND SEDIMENT CONTROL

CONTENTS

	Page
Introduction	III-1
Checkdam (CD)	III-CD-1
Channel Stabilization (CS)	III-CS-1
Construction Exit (CE)	III-CE-1
Diversion (DV)	III-DV-1
Downdrain Structure (DN)	III-DN-1
Drop Structure (DS)	III-DS-1
Gabion (GB)	III-GB-1
Inlet Protection (NP)	III-NP-1
Outlet Protection (OP)	III-OP-1
Paved Flume (PF)	III-PF-1
Retaining Wall (RW)	III-RW-1
Retrofitting (RT)	III-RT-1
Riprap (RR)	III-RR-1
Sediment Barrier/Fence (SF)	III-SF-1
Sediment Basin (SB)	III-SB-1
Storm Water Retention Structure (RS)	III-RS-1
Stream Crossing (SX)	III-SX-1
Surface Roughening (SR)	III-SR-1
Topsoil (TS)	III-TS-1
Waterway or Storm Water Conveyance Channel (WW)	III-WW-1

CHECK DAM (CD)

Definition

Small barriers or dams constructed across a swale, drainage ditch or areas of concentrated flow.

Purpose

To prevent or reduce erosion by lessening the gradient of the flow channel which reduces the velocity of storm water flows. Some sediment will be trapped upstream from the check dams, but its volume will be insignificant and should not be considered in off-site sediment reduction.

Conditions Where Practice Applies

This measure is limited to use in small open channels and drainageways which drain 10 acres or less. It should not be used in a live stream. Specific applications include:

1. Temporary ditches or water courses which, because of their short length of service, cannot establish a non-erodible lining but still need some protection against erosion.

2. Permanent ditches or water courses which for some reason cannot establish an enduring non-erodible lining.

3. Either temporary or permanent ditches or water courses which need protection during the establishment of protective linings.

Planning Considerations

Check dams may be constructed of rock, logs, hay bales or other suitable material. Most check dams would be constructed of rock. Rock may not be acceptable in some installations because of aesthetics and hay bales or logs may need to be considered.

Rock check dams (Figures CD-1 and CD-2) are easier to install with backhoes or other suitable equipment. The rock is usually purchased and would create cost. Some locations in the state may not have rock readily available. Rock should be handled carefully in areas to be mowed. Some rock

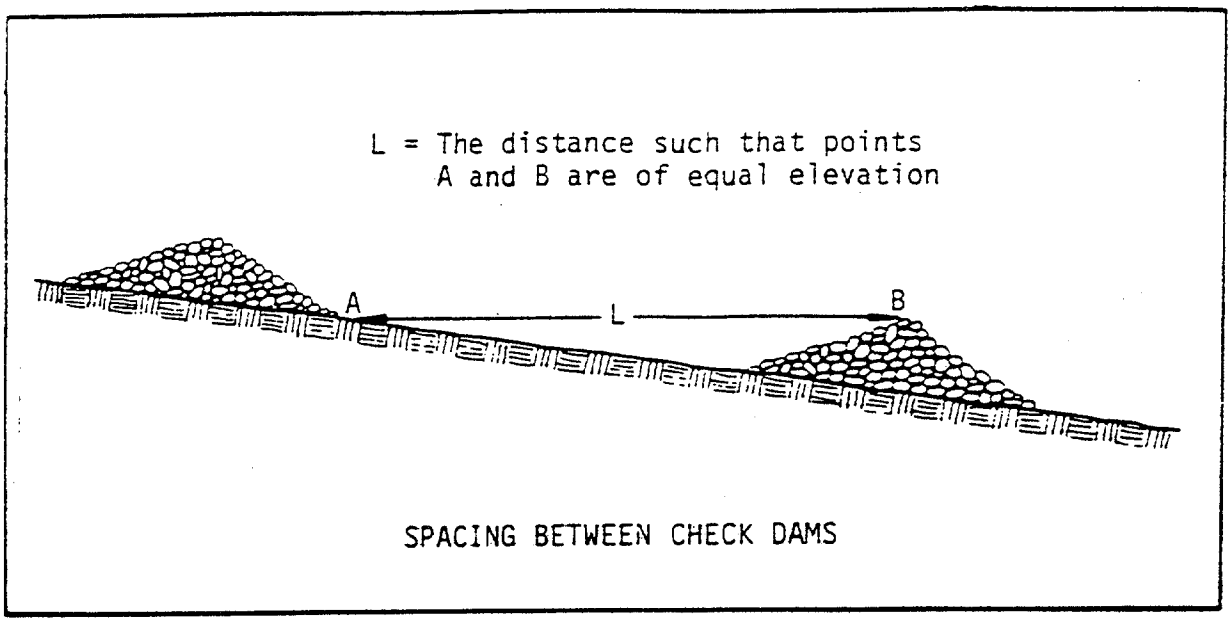


Figure CD-1. Profile of Typical Rock Check Dams.

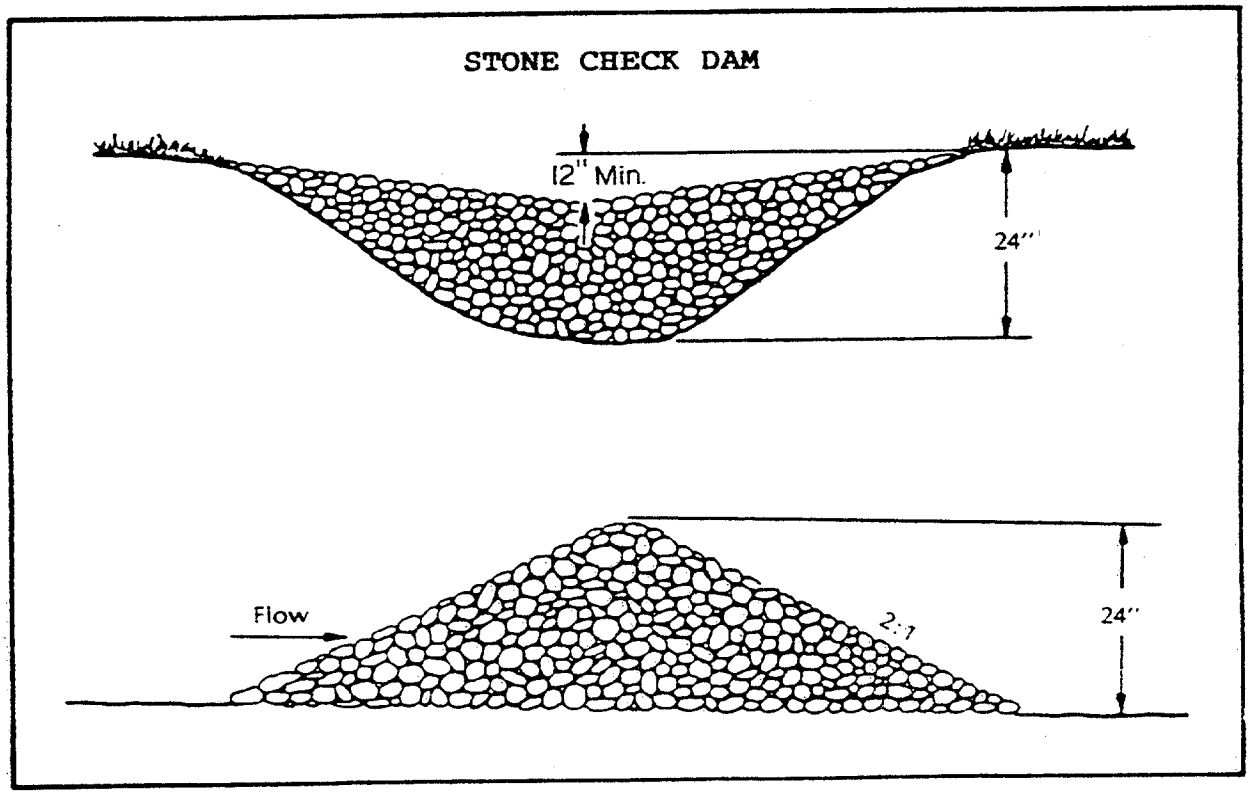


Figure CD-2. Cross Section of Typical Rock Check Dam.

may be washed downstream and should be removed before each mowing operation.

Log check dams (Figure CD-3) are more economical from a material cost standpoint since logs can usually be salvaged from clearing operations. The time and labor required would be greater for log check dams. Increased labor costs would offset the reduced material costs. Log check dams would not be permanent but would last long enough to get grass linings established.

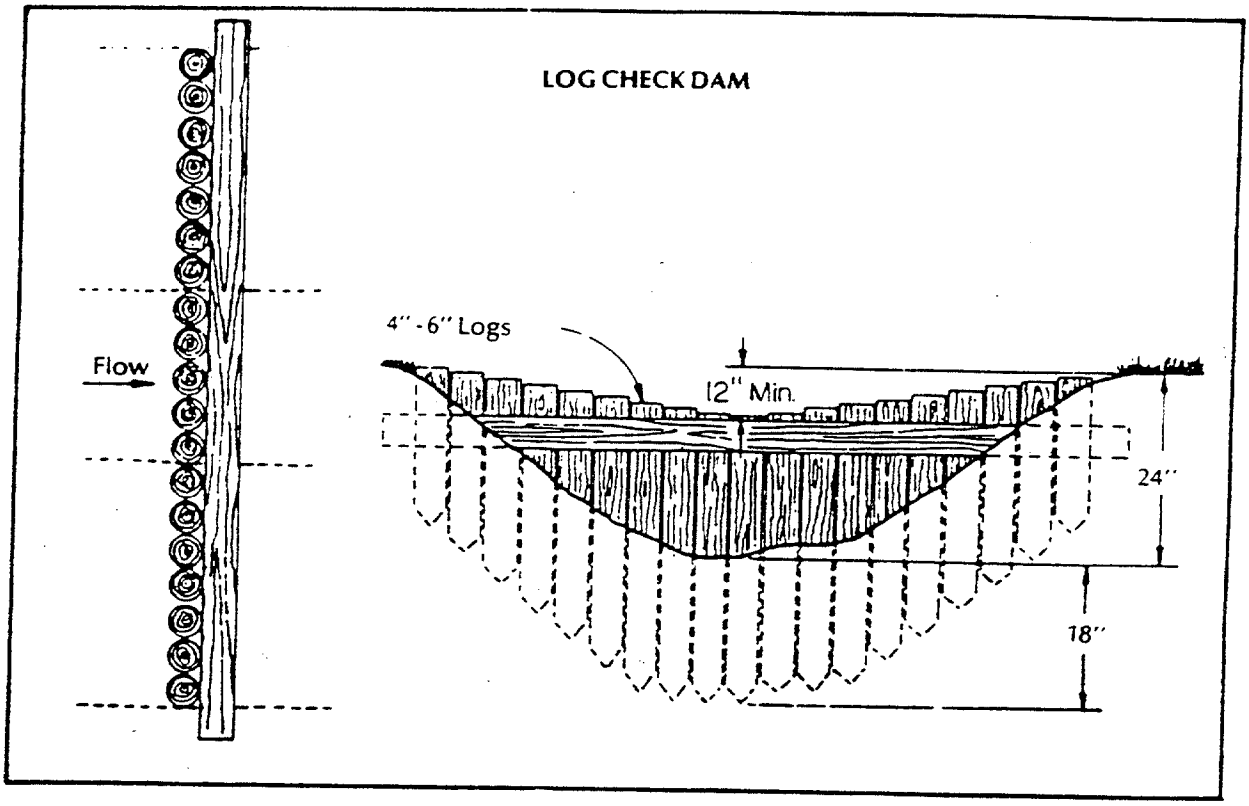
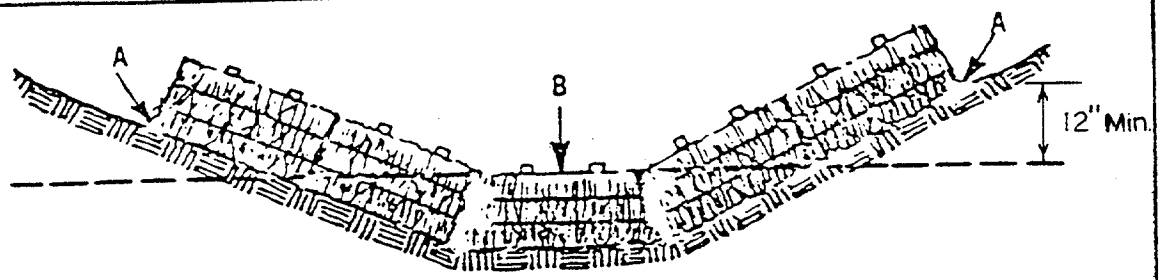


Figure CD-3. Typical Log Check Dam.

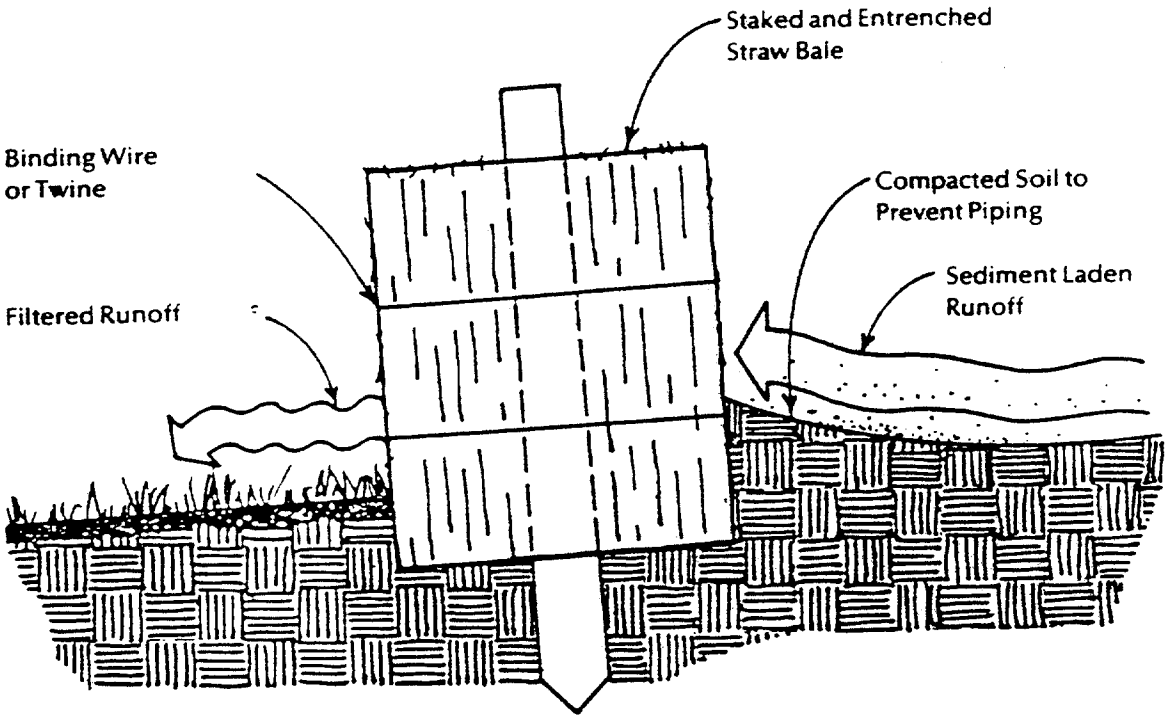
Check dams should be planned to be compatible with the other features such as streets, walks, trails, sediment basins and rights-of-way or property lines. Check dams may be constructed in series and the dams should be located at a normal interval from other grade controls such as culverts or sediment basins.

Check dams constructed of hay bales (Figure CD-4) have the shortest life of the materials discussed. Hay bale check dams should not be used where permanent water course protection is needed. They should not be used where the drainage areas exceeds 5 acres.



Points A should be higher than point B

PROPER PLACEMENT OF STRAW BALE BARRIER IN DRAINAGE WAY



CROSS-SECTION OF A PROPERLY INSTALLED STRAW BALE

Figure CD-4. Typical Hay Bale Check Dam.

Design Criteria

Formal design is not required. The following limiting factors shall be adhered to when designing check dams.

Drainage Area:	10 acres or less (Rock or logs) 5 acres or less (Hay bale Check Dam)
Maximum Height:	2 feet when drainage area is less than 5 acres 3 feet when drainage area is 5 to 10 acres
Depth of Flow:	6 inches when drainage area is less than 5 acres 12 inches when drainage area is 5 to 10 acres
Side Slopes:	2:1 or flatter
Max. Spacing between dams:	Elevation of toe of upstream dam is at or below elevation of crest of downstream dam.

Top of dam, perpendicular to flow, should be parabolic. The center of the dam must be lower than the ends. The dam shall be constructed well into the abutment so that water cannot run around the dam.

Rock check dams should be constructed of durable rock riprap. Riprap gradation shall conform to the requirements of Class I Riprap, Alabama Highway Department, Standard Specification for Highway Construction.

Maintenance

Check dams may be removed when their useful life has been completed. Whenever check dams are removed, care shall be taken to minimize disturbance to the remainder of the watercourse.

The area where check dams are removed shall be shaped and smoothed to water course dimensions and seeded and mulched immediately. On rock check dams, care shall be taken to remove all rock if the area is to be mowed.

Periodic inspection is necessary on check dams. Repair should be done as soon as need is noted to minimize damage and expense of repair.

Construction Specifications
for
Check Dams

Check dams shall be constructed to be stable throughout their planned life. A key way should be constructed under rock check dams. The keyway should be 12 inches deep and at least 12 inches wide at the bottom. The keyway should be located under the center of the dam or upstream of the center. The keyway shall be backfilled with the same rock that is used to construct the dam. Equipment placed rock with hand placement of individual rocks to conform to the lines, grades and shape of the drawing is acceptable. Check dams should be constructed at the locations as shown on the plans. Non-woven geotextile should be placed under the rock in sandy or silty soils and in locations where velocities may be excessive.

Log check dams should be constructed of sound 4 to 6 inch logs salvaged from the site clearing operations, if possible. The logs shall be embedded into the soil at least 18 inches. Embedded logs shall be thoroughly compacted when backfilling.

CHANNEL STABILIZATION (CS)

Definition

Improving, constructing or stabilizing a channel, either natural or artificial, in which water flows with a free surface.

Purpose

Open channels are constructed or stabilized to be non-erosive and provide adequate capacity for flood water, drainage, other water management practices, or any combination thereof.

Conditions Where Practice Applies

This standard applies to the improvement, construction or stabilization of open channels and existing streams or ditches with drainage areas less than one square mile. Channels with drainage greater than one square mile will be designed with appropriate criteria. In all cases, channel stabilization design should be done by a professsional engineer experienced in hydrology and hydraulics.

An adequate outlet for the modified channel length must be available for discharge by gravity flow. Construction or other improvements of the channel should not adversely affect the environmental integrity of the area and must not cause significant erosion upstream or flooding and/or sediment deposition downstream.

Design Criteria

Planning

The alignment and design of channels shall give careful consideration to the preservation of valuable fish and wildlife habitat and trees of significant value for wildlife food or shelter or for aesthetic purposes.

Where channel construction will adversely affect significant fish or wildlife habitat, mitigation measures should be included in the plan. Mitigation measures may include pools, riffles, flats, cascades or other similar provisions.

As many trees as possible are to be left inside channel rights-of-way considering the requirements of construction, operation, and maintenance. Unusually large or beautiful trees shall be saved.

Realignment

The realignment of channels shall be kept to an absolute minimum and should be permitted only to correct an adverse environmental condition.

Channel Capacity

The capacity for open channels shall be determined by procedures applicable to the purposes to be served.

Hydraulic Requirements

Manning's formula shall be used to determine velocities in channels. The "n" values for use in this formula shall be estimated using currently accepted guides along with knowledge and experience regarding the conditions. Acceptable guides can be found in hydrology textbooks.

Channel Cross-Section

The required channel cross section and grade are determined by the design capacity, the materials in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains and tributary channels.

Channel Stability (General)

All channel construction, improvement and modification shall be in accord with a design expected to result in a stable channel which can be maintained.

Characteristics of a stable channel are:

1. It neither agrades nor degrades beyond tolerable limits.

2. The channel banks do not erode to the extent that the channel cross section is changed appreciably.

3. Excessive sediment bars do not develop.

4. Excessive erosion does not occur around culverts, bridges or elsewhere.

5. Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel. The determination of channel stability considers "bankfull" flow. Bankfull flow is defined as the flow in the channel which creates a water surface that is at or near normal ground elevation for a significant length of a channel reach. Excessive channel depth created by cutting through high ground, such as might result from realignment of the channel, should not be considered in determinations of bankfull flow.

Channel Stability
(Drainage area of one square mile or less)

Channels in this category shall be considered stable if the check velocity is less than the allowable velocities shown in Table CS-1. The check velocity is defined as the lesser of the bankfull velocity or 10-year frequency peak discharge velocity.

Table CS-1. Allowable Velocities For Various Soil Textures.

Soil Texture	Allowable Velocity (ft/sec.)
Sand and sandy loam (noncolloidal)	2.5
Silt loam (also high lime clay)	3.0
Sandy clay loam	3.5
Clay loam	4.0
Stiff clay, fine gravel, graded loam to gravel	5.0
Graded silt to cobbles (colloidal)	5.5
Shale, hardpan and coarse gravel	6.0

This standard does not apply to channels containing drainage areas greater than one square mile. Channels in this category will be designed based on stability requirements contained in suitable references.

Channel Linings and Structural Measures:

Where channel velocities exceed safe velocities for vegetated lining due to increased grade or a change in channel cross section, or where durability of vegetative lining is adversely affected by seasonal changes, channel

linings of rock, concrete or other durable material may be needed. Grade stabilization structures may also be needed.

Channels may be stabilized by using one or more of the following methods:

Rock Riprap Lining: Rock riprap shall be designed to resist displacement when the channel is flowing at the bankfull discharge or the 25-year/24-hour frequency discharge whichever is the lesser.

Dumped and machine placed riprap should be installed on slopes flatter than 2 horizontal to 1 vertical. Where riprap is placed by hand the slopes may be steeper. A filter blanket of sand and/or gravel or geotextile material should be placed between the riprap and base material. The sand and/or gravel filter blanket material shall be at least 6 inches thick with a gradation that is consistent for use with the base material and the riprap. Design procedures for filters can be found in the Filter Blankets section of the Riprap standard.

Rock shall be dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended.

Concrete Lining: Concrete linings shall be designed according to currently accepted guides for structural and hydraulic adequacy. They must be designed to carry the required discharge and to withstand the loading imposed by site conditions.

Grade Stabilization Structures: Grade stabilization structures are used to reduce or prevent excessive erosion by reduction of velocities in the watercourse or by providing structures that can withstand and reduce the higher velocities. They may be constructed of concrete, rock, masonry, steel, aluminum or treated wood.

These structures are constructed where the capability of earth and vegetative measures is exceeded in the safe handling of water at permissible velocities, where excessive grades or overall conditions are encountered or where water is to be lowered structurally from one elevation to another. These structures should generally be planned and installed along with or as a part of other erosion control practices. The structures must be designed hydraulically to adequately carry the channel discharge and structurally to withstand loadings imposed by the site conditions.

Maintenance

All structures should be maintained in an "as built" condition. Structural damage caused by storm events should be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank. Unwanted brush or excessive sediment that will impede flow should be removed in order to maintain design conditions.

Construction Specifications
for
Channel Stabilization

1. Where needed, all trees, brush, stumps and other objectionable materials shall be removed so they will not interfere with the construction or proper functioning of the channel.

2. Where possible, trees will be left standing, and stumps will not be removed. Channels will be excavated from one side leaving vegetation on the opposite side.

3. Excavation shall be at the locations and grades shown on the drawings.

4. Construction plans will specifically detail the location and handling of spoils. Spoil material resulting from clearing, grubbing and channel excavation shall be disposed of in a manner which will:

   a. not cause an increase in flood stage,
   b. minimize overbank wash,
   c. not cause an adverse effect on the environmental integrity of the area,
   d. provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed,
   e. leave the right-of-way in the best condition feasible, and
   f. improve the aesthetic appearance of the site to the extent feasible.

5. Channel linings shall be established or installed immediately after construction or as soon as weather conditions permit.

6. Structures shall be installed according to lines and grades shown on the plan. Some hand placement of riprap may be required to obtain the designed surface. The foundation for structures shall be cleared of all undesirable materials prior to the installation of the structures.

7. Materials used in construction shall be of permanency commensurate with the design frequency and life expectancy of the facility.

STRUCTURAL MEASURES FOR EROSION AND SEDIMENT CONTROL

Chapter 3 contains standards and specifications for structural erosion and sediment control measures. Specifications given in this section are conservative and are intended to minimize the time required to design measures for use under typical site conditions. Unusual conditions may dictate that specifications be modified and practices specially designed. The construction specifications contained herein are not intended to be complete; therefore, detailed construction specifications should be prepared for each land disturbing activity. Additional guidelines on the design and use of practices as well as standard drawings are contained in the appendices.

The structural measures described in this chapter are not intended to stand alone. They should be employed as a system with vegetative measures, sequenced and sited to control erosion and sedimentation during development and to stabilize disturbed land as development is completed. By combining vegetative and structural measures into a comprehensive plan, successful erosion and sedimentation control can be achieved. Planners should consider the changing requirements of their site when determining the sequence in which measures are to be implemented.

The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source. As much of the site as possible should be left undisturbed in the total site plan and land disturbance should be in small increments, if possible.

8. Earthfill, when used as a part of the structures, shall be placed according to the installation requirements for sediment basin embankments.

9. Seeding, fertilizing and mulching shall conform to the standard for permanent vegetative cover.

10. Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized. State and local laws concerning pollution abatement shall be complied with.

11. Vegetation shall be established on all disturbed areas immediately after construction. If weather conditions cause a delay in establishing vegetation, the area shall be mulched in accordance with the standard for mulching.

12. All temporary access roads or travelways shall be appropriately closed to exclude traffic.

13. Trees and other fallen natural vegetation not causing a deterrent to stream flow should be left for the purpose of fish habitat.

14. Construction work in the stream should be done after consultation with the State Game and Fish Division.

CONSTRUCTION EXIT (CE)

Definition

A stone or rock stabilized pad located at points of vehicular ingress or egress to a construction site.

Purpose

To reduce or eliminate the transport of mud from the construction area onto public right-of-ways by motor vehicles or by runoff.

Conditions Where Practice Applies

This practice is applied where vehicular traffic will be leaving a construction site and move directly onto a public road or street.

Planning Considerations

Roads and streets adjacent to construction sites should be kept clean for the general safety and welfare of the public. A construction exit (Figure CE-1) should be provided where mud can be removed from construction vehicle tires before they enter a public road. If travelling over the rock stabilized pad does not remove the mud from construction vehicles, a wash area (Figure CE-2) should be provided for that purpose. Whenever washing is used, the wash water shall be collected in a sediment basin and allowed to settle before leaving the site.

Construction of stabilized roads throughout the development site should be considered to lessen the amount of mud transported by vehicular traffic. The rock pad should be located to provide for maximum use by all construction vehicles. Consideration should be given to limiting construction vehicles to only one ingress and egress point. Measures may be necessary to make existing traffic use the construction exit.

Design Criteria

Aggregate Size: Aggregate should be Alabama Highway Department coarse aggregate gradation No. 1.

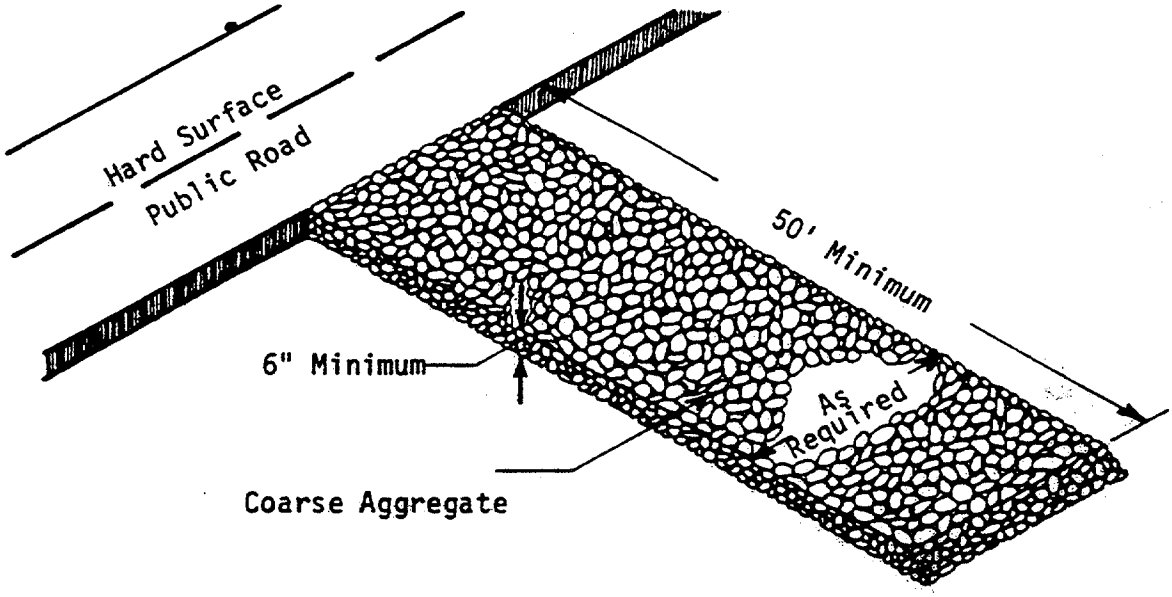
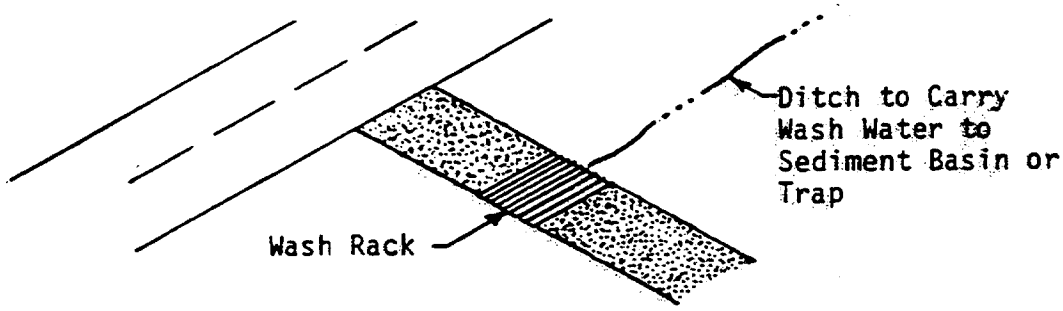
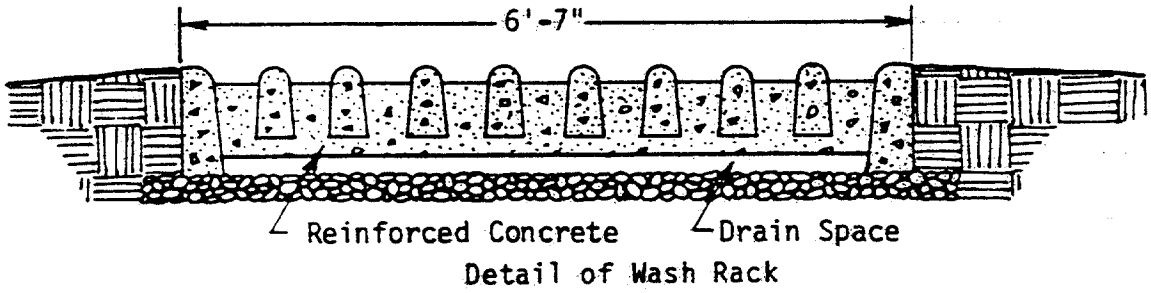


Figure CE-1. Gravel Construction Exit.





Source: Smith Cattleguard Company

Figure CE-2. Construction Exit with Wash Rack.

Entrance Dimensions: The rock pad shall be a minimum of six inches thick. It shall be at least 50 feet long or the length required to enter and park the longest anticipated construction vehicles. The width shall be at least 20 feet.

Geotextiles: A non-woven geotextile meeting the requirements of Soil Conservation Service Material Specification 592, Class IV should be used under the rock when the subgrade is soft or the blow count is less than 10.

Washing: A wash rack shall be provided as necessary to prevent mud from being transported to public streets and highways. It shall be constructed of concrete and/or other durable materials. Provisions shall be provided for the mud and other material to be carried away from the wash rack to a sediment basin to remove the mud from the water before release from the site.

Maintenance

The construction exit shall be maintained in such a way to prevent the movement of mud into public travel ways. Aggregate should be added to the pad whenever it will not serve as an all weather travel way for the construction vehicles. Sediment basins shall be cleaned out whenever one-half of the design storage volume is depleted.

Construction Specifications
for
Construction Exit

1. Remove all vegetation, roots and other objectionable material from the stone pad area.

2. Smooth the area to an even grade and fill in and recompact material in holes low places or overexcavated areas. Recompacted material shall be as dense as the surrounding material.

3. Place any required geotextile over the area to be protected. Take care not to pull the geotextile tight, but leave sufficient slack for the fabric to conform to the ground after rock is placed and loaded with vehicles. The fabric shall be unrolled parallel to the roadway centerline. The recommended geotextile overlap is 24 inches when the blow count is 10, 36 inches when the blow count is four to nine and 48 inches when the blow count is three or less. Geotextile meeting the full width of the roadway is recommended.

4. The stone pad should be dumped and spread in a full uniform thickness before vehicular traffic is permitted to travel on it.

5. Wash racks shall be installed in accordance with the design drawings and or manufacturers recommendations as specified.

6. Sediment basins or other related facilities constructed in conjunction with the wash rack shall be constructed in accordance with the plans and specifications. Sediment basins for wash racks shall be constructed before the wash rack is put into service.

DIVERSION (DV)

Definition

A channel constructed on grade across a slope with a supporting ridge on the lower side.

Purpose

Primarily to intercept stormwater runoff and safely divert it to stabilized outlets at non-erosive velocities.

Conditions Where Practice Applies

1. Where runoff from higher areas may damage property, cause erosion, or interfere with the establishment of vegetation on lower areas.

2. Where surface and/or shallow subsurface flow is damaging sloping upland, manmade improvements or unstabilized areas.

3. Where the slope length needs to be reduced to minimize soil loss.

4. Where there is a need to decrease or increase the drainage area into a water management structure.

5. Where a need exists to protect flat land from upland runoff and overland flow from adjacent areas.

Planning Considerations

Diversions can be useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion.

Diversions may be placed at the top of cut or fill slopes to keep runoff from upland drainage areas off the slope. Diversions are also typically built at the base of steeper slopes to protect flatter developed areas which cannot withstand runoff water from outside areas. They can also be used to protect structures, parking lots, adjacent properties, and other special areas from flooding.

Diversions are preferable to other types of man-made stormwater conveyance systems because they more closely simulate natural flow patterns and characteristics. Flow velocities are generally kept to a minimum. When properly coordinated into the landscape design of a site, diversions can he visually pleasing as well as functional.

As with any earthen structure, it is very important to establish adequate vegetation as soon as possible after installation. It is usually important to stabilize the drainage area above the diversion so that sediment will not enter and accumulate in the diversion channel.

Design Criteria

Location

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seepage (where seepage is a problem) and the development layout. Outlets must be stable after the diversion empties stormwater flow into it, therefore, care shall be exercised in the location selection of the diversion and its outlet.

Capacity

1. The diversion channel must have a minimum capacity to carry the runoff expected from a storm frequency meeting the requirements of Table DV-1 with a freeboard of at least 0.3 foot. (Figure DV-1).

2. Peak rates of runoff values used in determining the capacity requirements shall be as outlined in the Soil Conservation Service Engineering Field Manual for Conservation Practices, Chapter 2, Estimating Runoff, Soil Conservation Service Technical Release No. 55, Urban Hydrology for Small Watersheds, Alabama Engineering Field (Design) Manual, Chapter 2, Estimating Runoff or other equivalent methods.

3. Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high-risk areas, and those designed to function in connection with other structures, shall have sufficient capacity to carry peak runoff expected from a storm frequency consistent with the hazard involved.

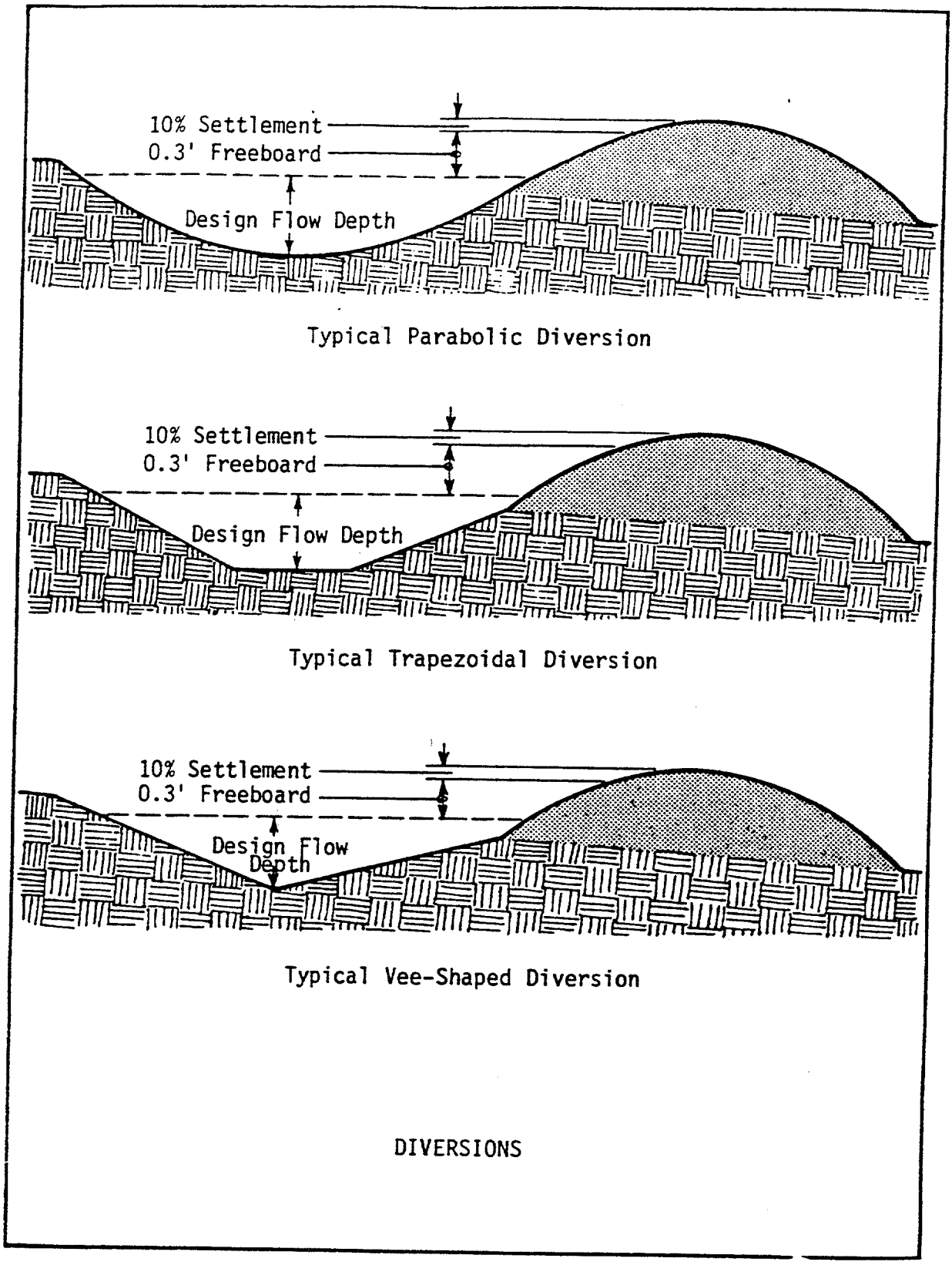


Figure DV-1. Typical Diversions Details

Table DV-1. Design frequency

Diversion Type	Typical area of protection	Twenty-four hour design storm frequency
Temporary	Construction areas	2 year
	Building sites	5 year
Permanent	Agricultural land	10 year
	Mined reclamation area	10 year
	Recreation areas	10 year
	Isolated Buildings	25 year
	Urban areas, residential, school, industrial areas, etc.	50 year

Velocities

Diversions should be designed so that the design velocities are as high as will be safe for the planned type of protective vegetation and the expected maintenance. Maximum permissible velocities are dependent upon the erosion resistance of the soil (Table DV-2) and the quality of the vegetation maintained.

Table DV-2. Permissible Velocities.

Soil Texture	Velocity in Ft./Sec.		
	Condition of Vegetation		
	Poor	Fair	Good
Sand, silt, sandy loam, silt loam	1.5	2.0	3.0
Silty clay loam, sandy clay loam	2.5	3.0	4.0
Clay	3.0	4.0	5.0

Channel Design

The diversion channel may be parabolic, trapezoidal or vee-shaped as shown in Figure DV-1 and shall be designed in accordance with the procedure shown in Chapter A6 of this manual. Diversions shall be constructed in accordance with the Construction Specifications section of this standard.

Ridge Design

The supporting ridge cross-section shall meet the configuration and requirements of (Figure DV - 1).

1. The side slopes shall be no steeper than 2:1. Side slopes should be flatter, 5:1 to 10:1, when the diversion is to be permanent with mowing and other maintenance activities performed on or around it.

2. The width of the ridge at the design water elevation shall be a minimum of 4 feet.

3. The minimum freeboard shall be 0.3 foot.

4. The design shall include a 10 percent settlement factor.

Outlet

Diversions shall have adequate outlets which will convey concentrated runoff without erosion. Acceptable outlets include Waterways, Drop Structures, Riprap Channels, Sediment Basins and other stabilized areas.

Stabilization

1. Unless otherwise stabilized, the ridge and channel shall be seeded within 15 days of installation in accordance with the Standard for Disturbed Area Stabilization (With Permanent Vegetation).

2. Disturbed areas draining into the diversion shall be seeded and mulched prior to or at the time the diversion is constructed.

Maintenance

Before final stabilization, the diversion should be inspected after every rainfall. Sediment shall be removed from the ditch line and repairs made as necessary. Seeded areas which fail to establish a vegetative cover shall be reseeded as necessary.

After stabilization, the diversion should be inspected for erosion following each significant flow. Damaged areas should be patched with compacted soil and re-vegetated to prevent further erosion. The vegetation should be fertilized on an annual basis to keep the grass vigorous and protective. The vegetation should be re-established whenever it does not cover the ground and does not provided protection against erosion damage.

Construction Specifications
for
Diversions

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion.

2. The diversion shall be excavated or shaped to line, grade, and cross-section as required to meet the dimensions, shape and size as shown on the plans. Irregularities which would impede flow shall be removed and smoothed out.

3. Ridges, fills or embankments shall be compacted as needed to prevent unequal settlement that would cause damage in the completed diversion.

4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the diversion.

5. Permanent stabilization of disturbed areas shall be done in accordance with the applicable standard and specifications contained in this manual. Permanent stabilization techniques shall be in accordance with the attached specifications or the standard for Permanent Vegetation.

DOWNDRAIN STRUCTURE (DN)

Definition

A flexible conduit of plastic tubing or heavy duty fabric or other material extending from the top to the bottom of a cut or fill slope.

Purpose

To temporarily conduct concentrated stormwater runoff safely down the face of a cut or fill slope without causing erosion problems on or below the slope.

Conditions Where Practice Applies

This applies to locations on construction sites where runoff water above an excavated or filled slope will cause erosion if allowed to flow over the slope. These structures are usually temporary and will be removed whenever the permanent structures are functional.

Planning Considerations

There is often a significant lag between the time a cut or fill slope is completed and the time a permanent drainage system can be installed. During this period, the slope is usually not stabilized and is particularly vulnerable to erosion. This situation also occurs on slope construction which is temporarily delayed before final grade is reached. Temporary down drains (Figure DN-1) can provide valuable protection of exposed slopes until permanent drainage structures can be installed.

When used in conjunction with diversion dikes, temporary down drains can be used to convey stormwater from the entire drainage area above a slope to the base of the slope without erosion. It is very important that these temporary structures be installed properly since their failure will often result in severe gully erosion. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be securely staked.

Prior approval may be required from local regulatory agencies if the downdrain outlet is tied into an existing storm sewer or in areas where municipal stormwater is regulated (Huntsville, Birmingham, Montgomery, and Mobile).

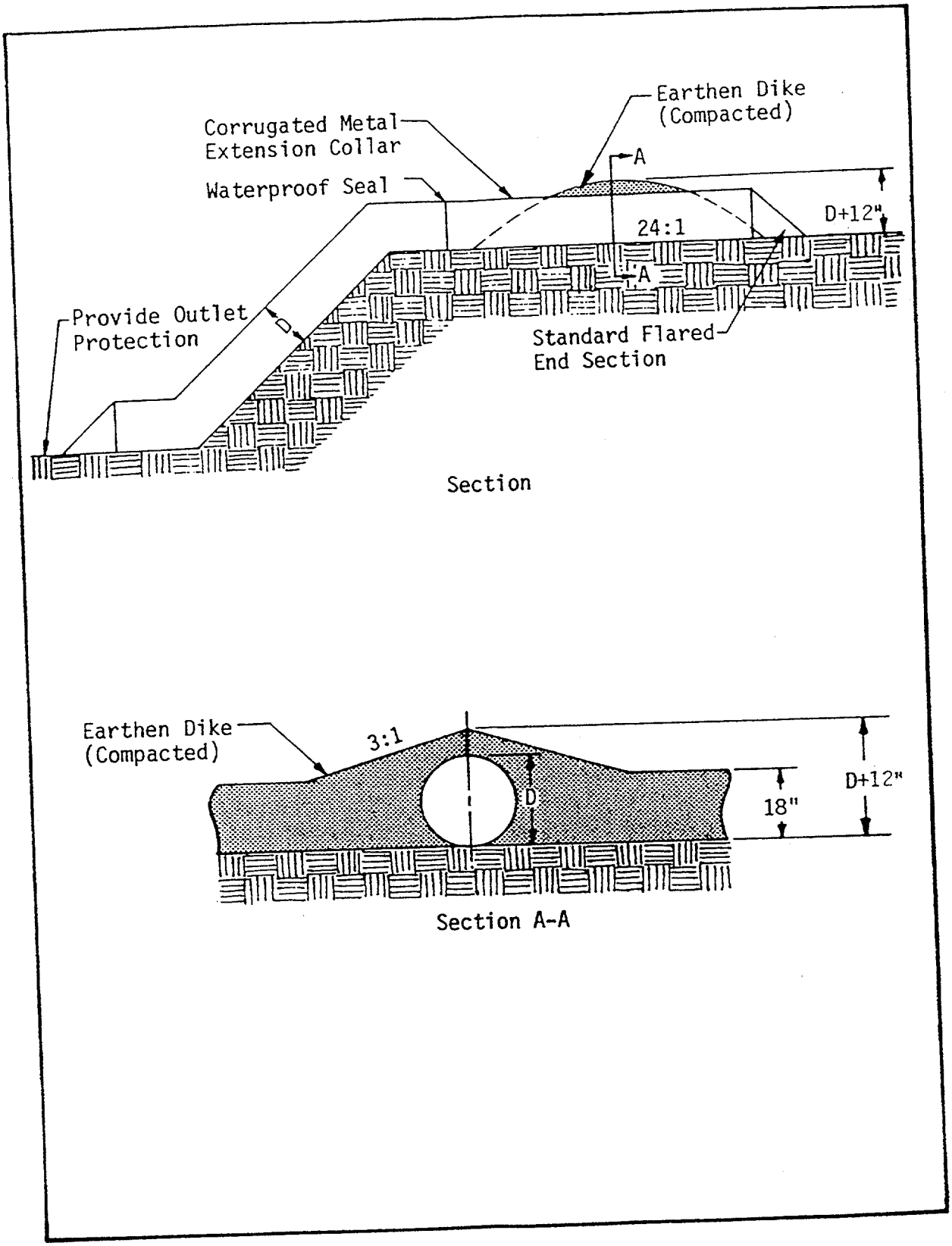


Figure DN-1. Typical Down Drain Details.

Design Criteria

Drainage Area

The maximum allowable drainage area per drain is 5 acres.

Flexible Conduit

1. The down drain shall consist of heavy duty flexible material designed for this purpose. The diameter of the down drain shall be equal over its entire length. Reinforced hold-down grommets shall be spaced at 10-foot (or less) intervals. The conduit should extend beyond the toe of the slope.

2. Down drains may be sized according to the following table:

Table DN-1. Size of Down Drain

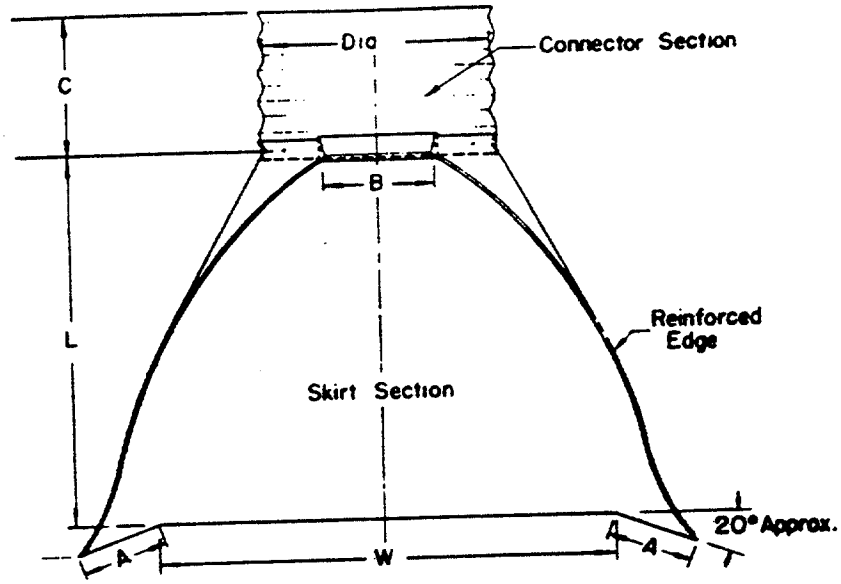
Maximum Drainage Area (Acres)	Pipe Diameter(D) (Inches)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

Drains shall be designed to convey the peak rate of runoff from a 10-year/24-hour rainfall whenever it is desired to individually design each installation.

Entrance Sections

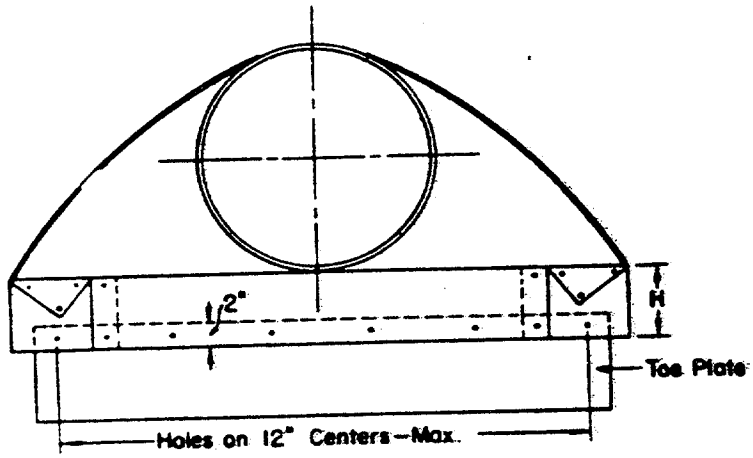
The entrance to the down drain (Figures DN-2 and DN-3) shall consist of a Standard Flared End-Section for Metal Pipe Culverts. All fittings shall be watertight. The toe plate shall be a minimum of 8 inches deep.

Extension collars shall consist of 12 inch long corrugated metal pipe. Avoid use of helical pipe. Securing straps shall be fabric, metal or other material well suited to providing a watertight connection. The strap shall secure at least one corrugation of the extension collar.



Plan

Where Flared End-Sections are to be used with bituminous coated and paved metal pipe, they are to be galvanized only.

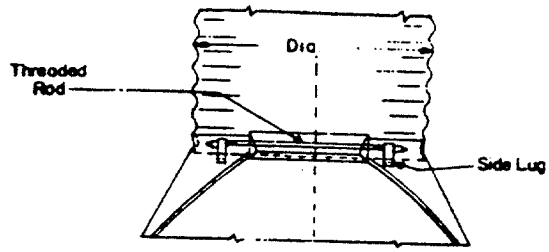


Elevation

FLARED END-SECTION

Figure DN-2. Flared End Section Details.

Alternate Connection



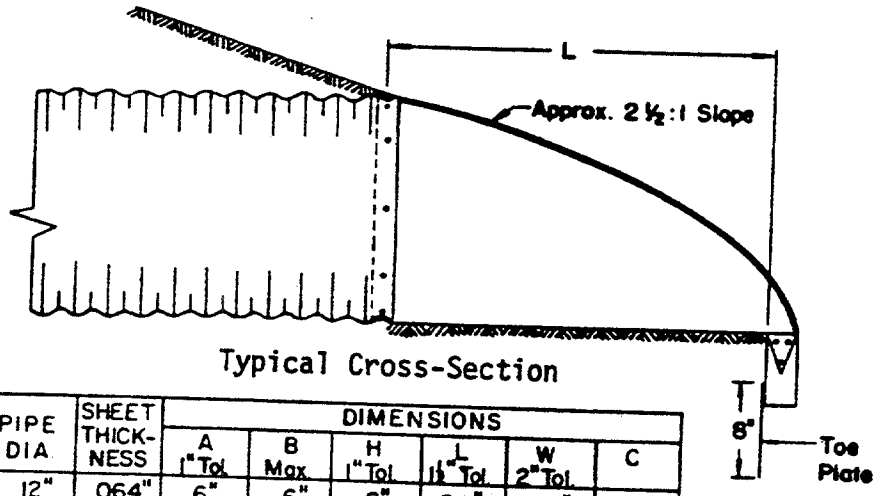
Toe plate, where needed, to be punched to match holes in skirt lip. 3/8" galv. bolts to be furnished. Length of toe plate is W+ 10" for 12" to 30" dia. pipe and W+22" for 36" to 60" dia. pipe.

Skirt Section for 12" to 30" dia. pipe to be made in one piece.

Skirt Section for 36" to 54" dia. pipe may be made from two sheets joined by riveting or bolting on center line, 60" may be constructed in 3 pieces.

Connector Section, Corner Plate and Toe Plate to be same sheet thickness as skirt.

End-sections and fittings are to be galvanized steel or aluminum alloy for use with like pipe.



Typical Cross-Section

PIPE DIA	SHEET THICK-NESS	DIMENSIONS					
		A 1" Tol.	B Max.	H 1" Tol.	L 1½" Tol.	W 2" Tol.	C
12"	.064"	6"	6"	6"	21"	24"	24"
15"	.064"	7"	8"	6"	26"	30"	24"
18"	.064"	8"	10"	6"	31"	36"	24"
24"	.064"	10"	13"	6"	41"	48"	24"
30"	.079"	12"	16"	8"	51"	60"	24"
36"	.079"	14"	19"	9"	60"	72"	36"
42"	.109"	16"	22"	11"	69"	84"	36"
48"	.109"	18"	27"	12"	78"	90"	24"
54"	.109"	18"	30"	12"	84"	102"	36"
60"	~~.109~~ .138	18"	33"	12"	87"	114"	36"

FLARED END-SECTION
(Continued)

Figure DN-2. Flared End Section Details (Continued).

Diversion Design

1. An earthen diversion shall be used to direct stormwater runoff into the down drain and shall be constructed according to the measure entitled DIVERSION.

2. The height of the diversion at the centerline of the inlet shall be equal to the diameter of the pipe (D) plus 12 inches. Where the dike height is greater than 18 inches at the inlet, it shall be level for 3 feet each side of the pipe and be sloped at the rate of 3:1 or flatter to transition with the remainder of the dike.

Outlet Protection

The outlet of the down drain shall be protected from erosion according to the standard entitled OUTLET PROTECTION.

Maintenance

The down drain structure shall be inspected weekly and after every storm and repairs made if necessary. The contractor should avoid the placement of any material on and prevent construction traffic across the down drain. The diversion directing stormwater runoff to the down drain structure and around the structure shall be maintained to design height at all times. Any silt that collects around the structure shall be removed and spread at an acceptable location. The anchors securing the drain shall be inspected after each storm and retightened or replaced when found loose.

Construction Specifications
for
Downdrain Structure

1. The measure shall be placed on undisturbed soil or well-compacted fill.

2. The entrance section shall slope toward the down drain at the minimum rate of 1/2-inch per foot.

3. The soil around and under the entrance section shall be hand-tamped in 6 inches or less lifts to the top of the diversion to prevent piping failure around the inlet. It should be overfilled 10% for settlement.

4. The down drain shall be securely staked to the slope at the grommets provided, but no more than 10 feet apart.

5. The down drain sections shall be securely fastened together and have watertight fittings.

DROP STRUCTURE (DS)

Definition

A structure installed to safely conduct runoff water from the top to the bottom of a slope or to lower water from a waterway into an open channel.

Purpose

To prevent erosion of slopes and channel banks by preventing high velocity flows.

Conditions Where Practice Applies

This practice applies to sites where earth and vegetation cannot safely handle water at permissible velocities, where excessive grades or over fall conditions are encountered, or where water is to be structurally lowered from one elevation to another. These structures should be planned and installed along with or as a part of other conservation practices in an overall surface water disposal system.

This standard does not apply to storm sewers, concrete overfall structures, in channel grade control structures, or road culverts.

Design Criteria

Design and specifications shall be prepared for each structure on an individual job basis depending on its purpose and site conditions.

Capacity

The minimum design capacity for pipe structures shall be as required to pass the peak runoff expected from a 2-year frequency, 24-hour duration storm. Runoff will be computed by the SCS method or by other equivalent methods. Runoff computation will be based upon the most severe soil and cover conditions that will exist in the area draining into the pipe structures during the planned life of the structure.

All pipe structures should be designed as island type with an emergency spillway to safely pass storms larger than the structure design storm. The minimum total capacity of the

principal and emergency spillways shall be that required to handle the 25-year frequency, 24-hour duration storm, or the peak rate of flow from the contributing structure, whichever is greater.

General

The planning and design of antivortex devices, trash racks, anti-seep collars and outlet protection should be in accordance with the requirements of SEDIMENT BASIN, pipe spillway design.

Straight pipe structures should be built in accordance with Figure DS-1.

Pipe drop structures should be built in accordance with Figure DS-2.

The crest elevation for the emergency spillway shall be set at the minimum level necessary to ensure full pipe flow of the principal spillway. The top of the settled embankment shall be based on one foot of freeboard above the design flow depth in the emergency spillway.

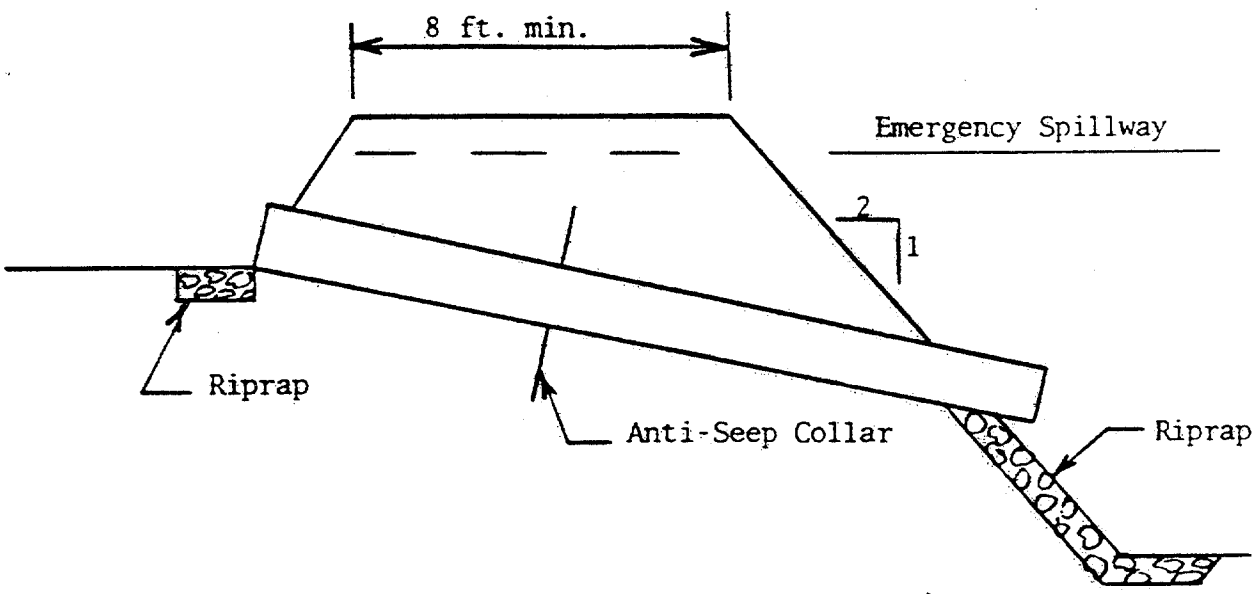


Figure DS-1. Straight Pipe Structure.

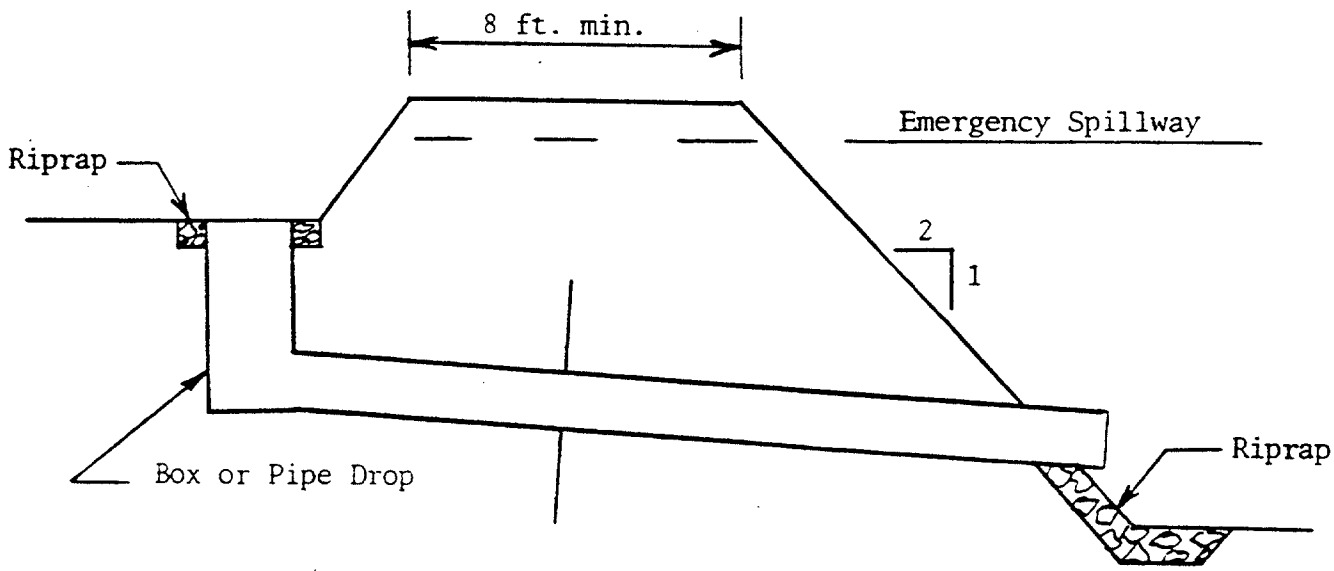


Figure DS-2. Pipe Drop Structure.

Maintenance

The drop structure should be inspected after each major storm event. The emergency spillway should be inspected for scour damage if flow has occurred. The pipe structure should be inspected for any scour damage at the inlet or outlet of the pipe and for piping around the structure. Any damage to the structure should be immediately repaired.

Construction Specifications
for
Drop Structure

The pipe structure shall be placed in undisturbed soil or well compacted fill. Backfill around the pipe shall be placed in 4-inch layers and hand compacted to ensure adequate compaction.

The embankment shall be constructed according to the specifications for sediment basin embankments.

Protective measures of concrete or riprap shall be installed at the inlet and outlet as needed to protect against erosion.

The embankment and all disturbed areas shall be seeded, fertilized, and mulched according to the specifications for Critical Area Planting.

GABION (GB)

Definition

Gabions are large, multicelled rectangular wire baskets filled with rock used in channel stabilization, retaining walls, slope protection, check dams and similar applications.

Purpose

Rock-filled baskets, properly wired together, form flexible monolithic building blocks used for construction of erosion control structures. Gabions are used to stabilize steep or highly erosive slopes.

Conditions Where Practice Applies

This is applicable to stream sections which are subject to excessive erosion. Gabions usually are used on streambanks (Figure GB-1), but can be used on channel bottoms as well. Gabions may also be used for retaining walls or on slopes needing protection (Figure GB-2).

Gabions may also be installed to be a drop structure or other similar structures such as culvert headwalls, outlet aprons, bridge abutments and wings, weirs and training walls.

Planning Considerations

Gabions may be considered to be expensive structures compared to loose rock riprap. Gabions compare favorably to concrete, cellular block and other similar materials. Gabions require considerable manual labor to install. Gabions should not be considered when temporary protection is desired.

The wire mesh used in gabions is heavily galvanized. It may be safely used in contact with water. In areas where the pH of the water in contact with it is acidic or where the water is abrasive in nature, a PVC (polyvinyl chloride) coating should be used over the galvanizing. PVC coated wire should also be used on shore line protection structures and all locations in a corrosive environment.

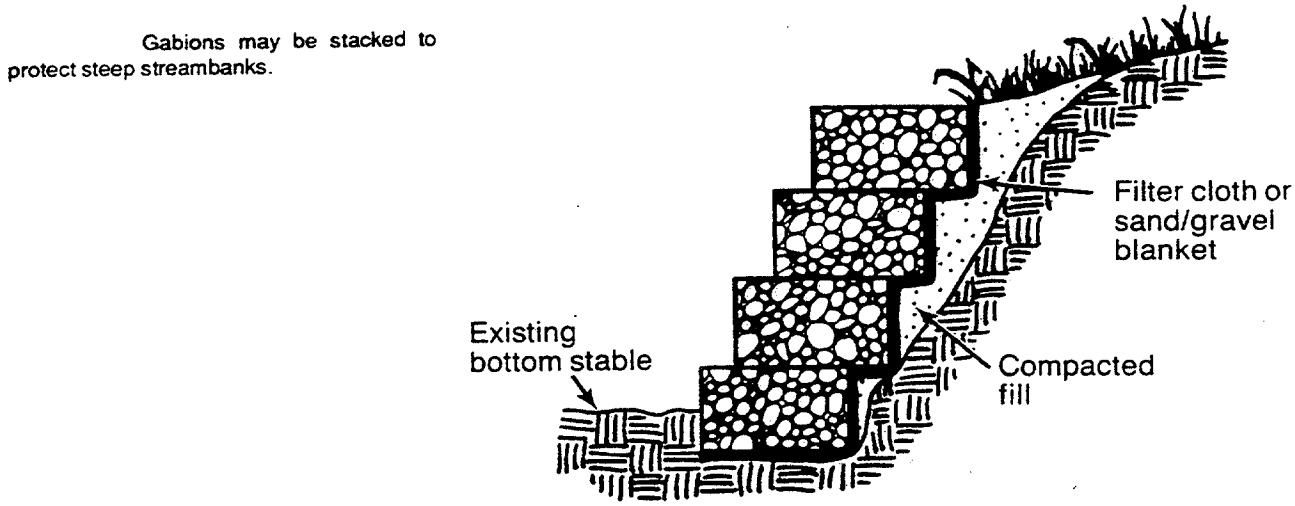


Figure GB-1. Gabions Used for Streambank Protection.

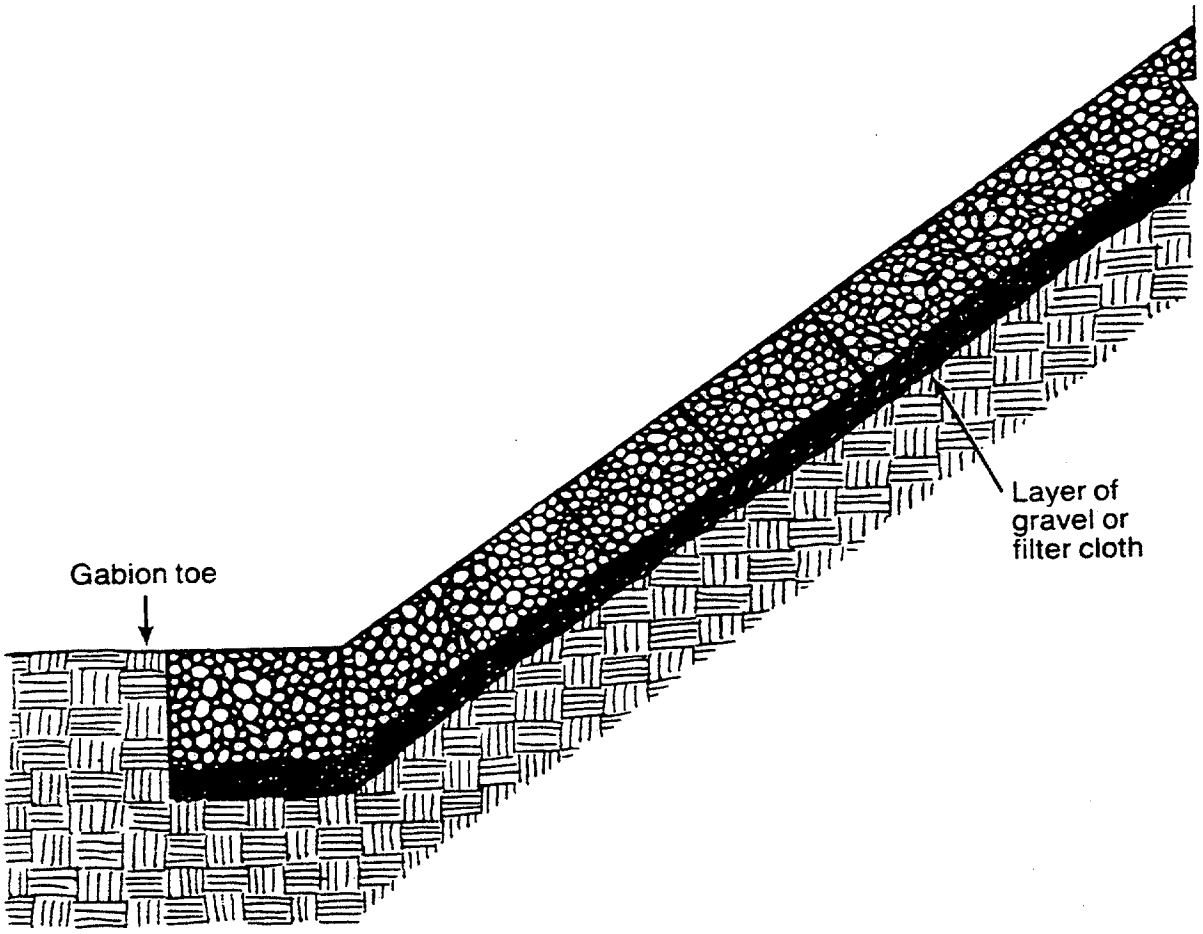


Figure GB-2. Gabions Used for Slope Protection.

Hydrostatic heads do not develop behind a gabion wall. The wall is pervious to water and stabilizes a slope by the combined action of draining and retaining. Drainage is accomplished by gravity and by evaporation as the porous structure permits an active air circulation through it. Moreover, as plant growth invades the structure, transpiration further assists in removing moisture from the backfill. This system is much more efficient than weep holes in standard masonry walls. Geotextiles should be used between the gabion structure and the backfill material.

Design Criteria

Gabions involve the use of manufactured products and should be installed in accordance with manufacturer's recommendations. Gabions may be available from only one supplier in some locations. Most gabion manufacturers have design aids for use in designing gabion structures.

Construction plans and drawings should be prepared by professionals familiar with the use of gabions. Erosion and sediment control construction design should ensure that foundations are properly prepared to receive gabions, that the gabion structure is securely "keyed" into the foundations and abutment surfaces, and that rock used is durable and adequately sized to be retained in the baskets.

Maintenance

Periodic inspection should be performed. Inspection should be done following each major flow event and each spring. Note any signs of undercutting or excessive erosion at transitional areas. Immediate repairs should be made to protect the overall function of the structure and prolong its life.

Construction Specifications
for
Gabions

The subgrade shall be prepared to line, grade and elevation as shown on the drawings. Subgrade shall be carefully prepared because any deformation of lines will be transferred through the structure and will give an unworkmanlike appearance. The subgrade should be firm and any mud or unstable material should be removed and backfilled with rock or concrete to create a stable base.

Geotextile shall be laid in the correct position before the baskets are placed. Geotextiles shall be left with sufficient slack so that it will not be in tension after the baskets and rock are in place. Geotextiles should be non-woven needle punched as specified in the specifications.

The wire baskets shall be securely wired together in accordance with the manufacturer's recommendations. Baskets shall be put into position before backfilling. The first basket shall be carefully filled in position so as not to move it out of line. Any succeeding baskets shall be securely tied to the prior baskets.

At least two empty baskets shall be put together and tied to the basket being filled. The empty baskets should be placed in proper position and pulled in tension with a come-along or other instrument.

The tensional baskets shall be kept in position at all times throughout the filling of the basket.

The gabion is normally filled with hand-sized, 4"-8" pieces of stone, usually dumped into it mechanically. The filled gabion then becomes a large flexible, and permeable building block from which a broad range of structures may be built. This is done by setting and wiring individual units together in courses and filling them in place.

Each basket shall be filled to capacity with care so that it will not be moved out of position. The filled basket shall have the top securely wired in position. The construction of baskets on a lower row shall stay at least two full baskets ahead of baskets in an upper row.

INLET PROTECTION (NP)

Definition

A sediment filter installed around a storm drain drop inlet or curb inlet to reduce sediment discharge.

Purpose

To prevent sediment from entering storm drainage systems during construction and prior to permanent stabilization of the disturbed area.

Conditions Where Practice Applies

Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different situations.

Planning Considerations

Storm sewers which are made operational before their drainage area is stabilized can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the storm sewer itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

This practice contains several types of inlet filters and traps which have different applications dependent upon site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after careful study of their effectiveness should they be installed.

Note that these various inlet protection devices are for drainage areas of less than one acre. Runoff from large disturbed areas should be routed through a SEDIMENT BASIN.

The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

Sediment is best treated by preventing erosion. Leave as much of the site undisturbed as possible in the total site plan. Clear and disturb the site in small increments, if possible.

Design Criteria

1. The drainage area shall be no greater than 1 acre.

2. The inlet protection device shall be constructed in a manner that will facilitate cleanout and disposal of trapped sediment and minimize interference with construction activities.

3. The inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.

4. Design criteria more specific to each particular inlet protection device will be found with that construction specification.

5. Ponding of water or deposition of sediment on roadways that will create traffic hazards will be prevented.

Maintenance

1. The structure shall be inspected after each rain and repairs made as needed.

2. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to 1/2 the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode. Stabilize all sediment disposal areas with appropriate vegetation.

3. Structures shall be removed and the area stabilized when the contributing drainage area has been properly stabilized.

Construction Specifications
for
Inlet Protection

1. STRAW BALE DROP INLET STRUCTURE. (Figure NP-1)

   a. Bales shall be either wire-bound or string-tied with the bale oriented so that the bindings are around the sides rather than over and under the bales. Bales will be laid on edge.

   b. Bales shall be placed lengthwise in a single row surrounding the inlet, with the ends of adjacent bales pressed together.

   c. The filter barrier shall be entrenched and backfilled. A trench shall be excavated around the inlet the width of a bale to a minimum depth of 4 inches. After the bales are staked, the excavated soil shall be backfilled and compacted against the filter barrier.

   d. Each bale shall be securely anchored and held in place by at least two stakes or rebars driven through the bale.

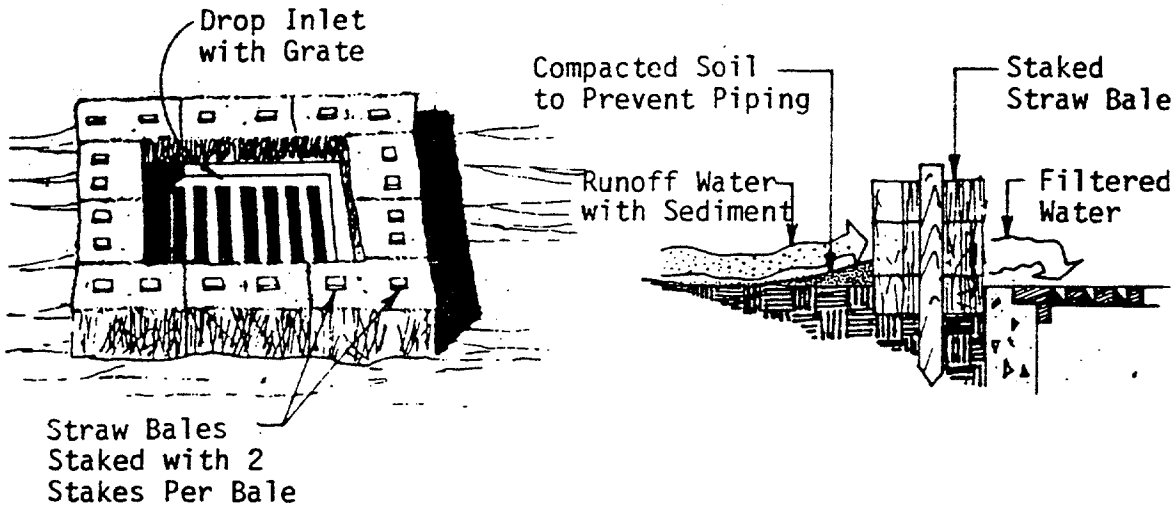
   e. Loose straw shall be wedged between bales to prevent water from entering between bales.

   f. Stakes for anchorage shall be nominal 1" X 2" durable wood or equivalent. The wood shall be sound with a minimum actual dimension of 1/2". The minimum embedment into the ground shall be 12".

2. GRAVEL AND WIRE MESH DROP INLET SEDIMENT FILTER. (Figure NP-2)

   a. Wire mesh shall be laid over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Hardware cloth or comparable wire mesh with 1/2-inch openings shall be used. If more than one strip of mesh is necessary, the strips shall be overlapped and securely tied or wired together.

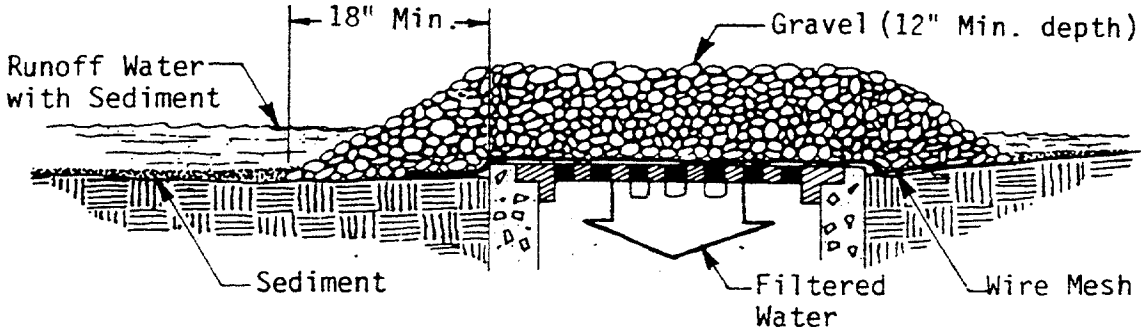
   b. Alabama Highway Department No. 1 Coarse Aggregate shall be placed over the wire mesh as indicated on Figure NP - 2. The depth of stone shall be at least 12 inches over the entire inlet opening. The stone shall extend beyond the inlet opening at least 18 inches in all directions.



Specific Application

This method of inlet protection is applicable where the inlet drains a relatively flat area (slopes no greater than 5 percent) where sheet or overland flows (not exceeding 0.5 cfs) are typical. The method shall not apply to inlets receiving concentrated flows, such as in street or highway medians.

Figure NP-1. Straw Bale Drop Inlet Sediment Filter.



Specific Application

This method of inlet protection is applicable where heavy concentrated flows are expected, but not where ponding around the structure might cause excessive inconvenience or damage to adjacent structures and unprotected areas.

Figure NP-2. Gravel and Wire Mesh Drop Inlet Filter.

c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stones must be pulled away from the inlet, cleaned and replaced.

Warning: This filtering device has no overflow mechanism, therefore, ponding is likely, especially if sediment is not removed regularly. This type of device must never be used where overflow may endanger an exposed embankment slope. Consideration should also be given to the possible effects of ponding on traffic routes, nearby structures, working areas, adjacent property, etc.

3. SOD DROP INLET SEDIMENT FILTER. (Figure NP-3)

a. Soil shall be prepared and sod installed according to the standard and specification in Vegetative Measures - Sodding.

b. Sod shall be placed to form a turf mat covering the soil for a distance of 4 feet from each side of the inlet structure.

4. GRAVEL CURB INLET SEDIMENT FILTER. (Figure NP-4)

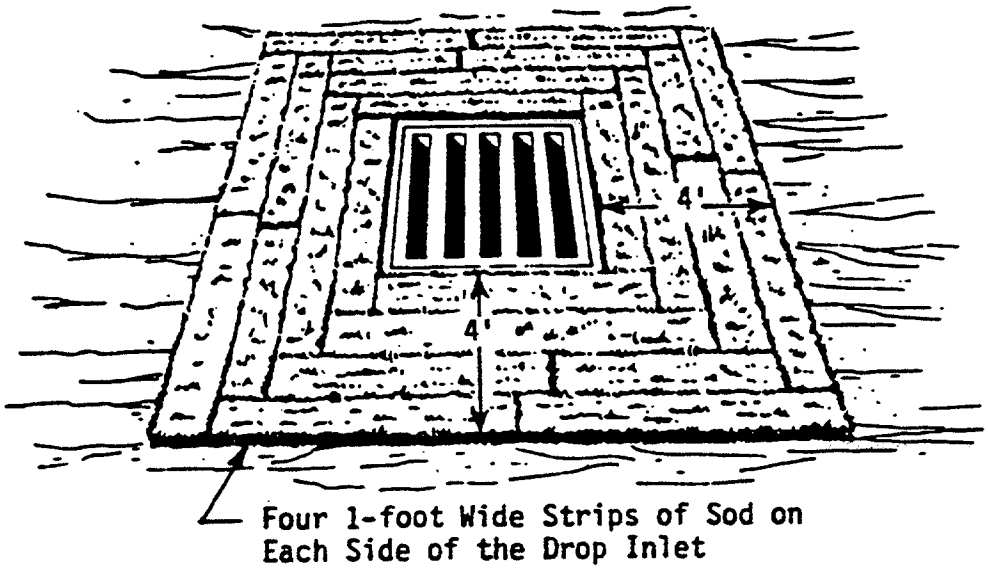
a. Hardware cloth or comparable wire mesh with 1/2-inch openings shall be placed over the curb inlet opening so that at least 12 inches of wire extends across the inlet cover and at least 12 inches of wire extends across the concrete gutter from the inlet opening.

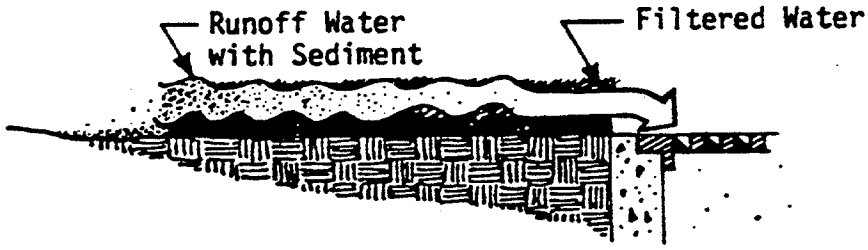
b. Stone shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely. Alabama Highway Department No. 1 Coarse Aggregate shall be used.

c. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the block, cleaned and replaced.

5. BLOCK AND GRAVEL CURB INLET SEDIMENT FILTER. (Figure NP-5)

a. Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening.





Specific Application

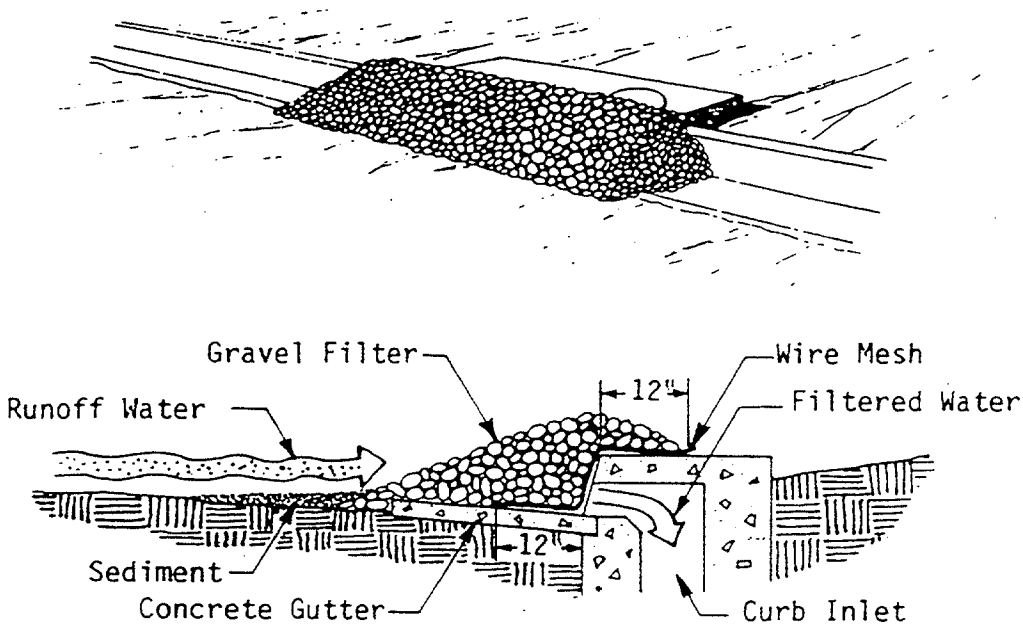
This method of inlet protection is applicable only at the time of permanent seeding, to protect the inlet from sediment and mulch materials until permanent vegetation has become established.

Figure NP-3. Sod Drop Inlet Sediment Filter.

b. A 2-inch by 4-inch stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.

c. Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks as illustrated in Figure NP-5.

d. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to



Specific Application

This method of inlet protection is applicable at curb inlets where ponding in front of the structure is not likely to cause inconvenience or damage to adjacent structures and unprotected areas.

Figure NP-4. Gravel Curb Inlet Sediment Filter.

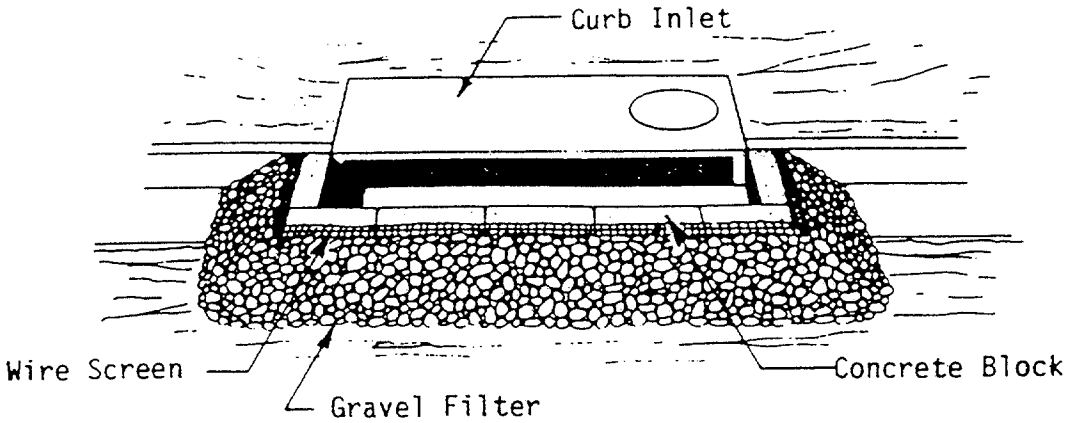
prevent stone from being washed through the holes in the blocks. Chicken wire or hardware cloth with 1/2-inch openings shall be used.

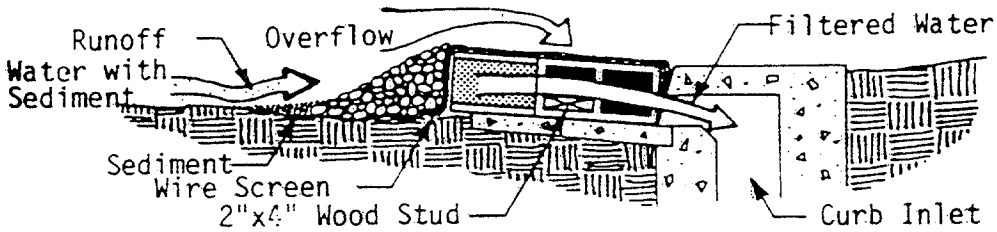
e. Alabama Highway Department No. 1 Coarse Aggregate shall be piled against the wire to the top of the barrier as shown in Figure NP-5.

f. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and replaced.

6. BLOCK AND GRAVEL DROP INLET SEDIMENT FILTER. (Figure NP-6)

a. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, with the ends of adjacent blocks abutting. The





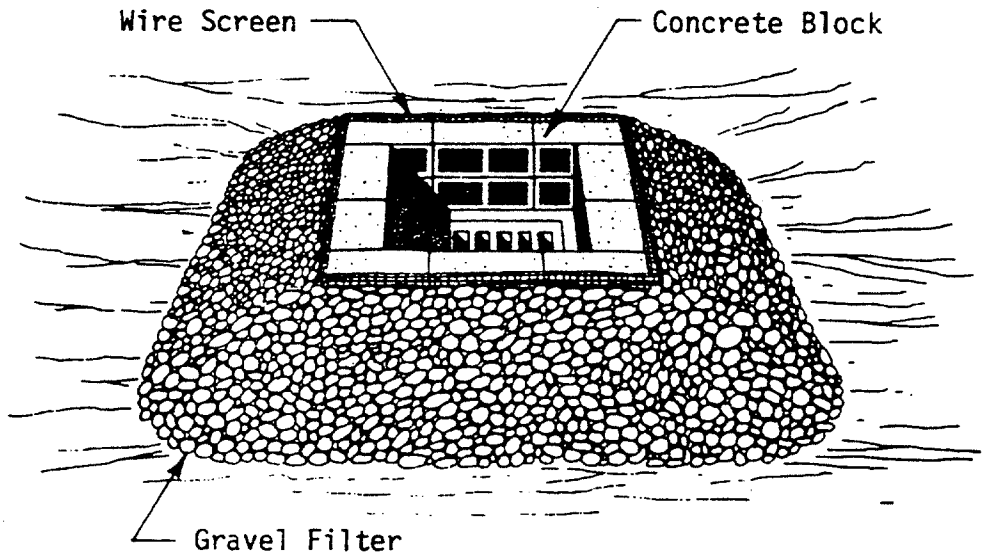
Specific Application

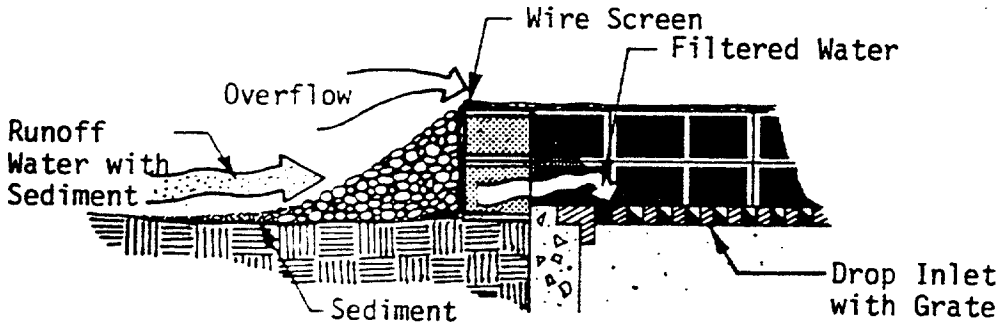
This method of inlet protection is applicable at curb inlets where an overflow capability is necessary to prevent excessive ponding in front of the structure.

Figure NP-5. Block and Gravel Curb Inlet Sediment Filter.

height of the barrier can be varied, depending on design needs, by stacking combinations of 4-inch, 8-inch and 12-inch wide blocks. The barrier of blocks shall be at least 12 inches high and no greater than 24 inches high.

b. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Hardware cloth or comparable wire mesh with 1/2-inch openings shall be used.





Specific Application

This method of inlet protection is applicable where heavy flows are expected and where an overflow capacity is necessary to prevent excessive ponding around the structure.

Figure NP-6. Block and Gravel Drop Inlet Sediment Filter.

c. Stone shall be piled against the wire to the top of the block barrier, as shown in Figure NP-6. Alabama Highway Department No. 1 Coarse Aggregate shall be used.

d. If the stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned and replaced.

OUTLET PROTECTION (OP)

Definition

Structurally lined aprons of riprap, concrete or other acceptable energy dissipating devices placed at the outlets of pipes or paved channel sections.

Purpose

To prevent scour at stormwater outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions Where Practice Applies

Applicable to the outlets of all pipes and paved channel sections where the velocity of flow at design capacity of the outlet will exceed the permissible velocity of the receiving channel or area. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

Planning Considerations

The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the ability of the receiving channel or area to resist erosion. To prevent scour at stormwater outlets, a flow transition structure is required which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

The most common used structure for outlet protection is an erosion resistant lined apron. These aprons are generally lined with loose rock riprap, grouted riprap or concrete. They are constructed at zero grade for a distance which is related to the outlet flow rate and the tailwater level. Criteria for designing these structures are contained in this standard. Sample problems of outlet protection design are contained in the appendix of this manual, Chapter A6.

Where the flow is excessive for the economical use of an apron, excavated stilling basins may be used. Acceptable designs for stilling basins may be found in the following documents available from the U. S. Government Printing Office.

1. Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulics Engineering Circular No. 14, U. S. Department of Transportation, Federal Highway Administration.

2. Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering monograph No. 25 U. S. Department of Interior - Bureau of Reclamation.

Design Criteria

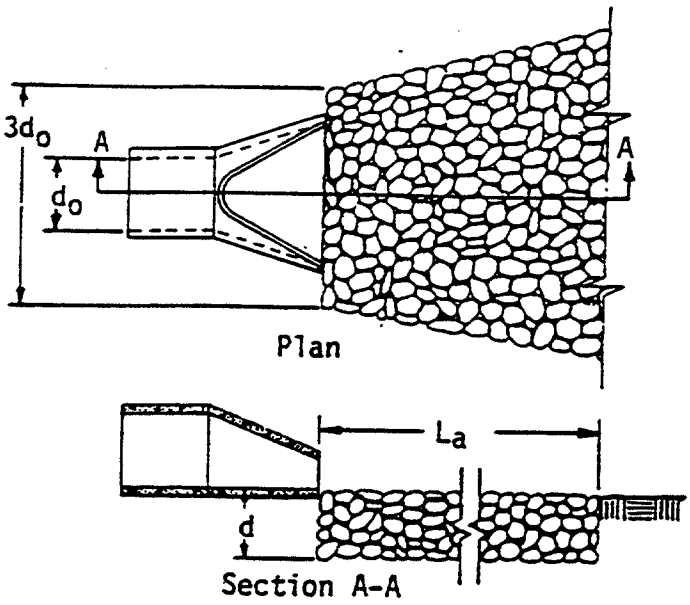
Structurally lined aprons at the outlets of pipes and paved channel sections shall be designed according to the following criteria:

PIPE OUTLETS (Figure OP-1)

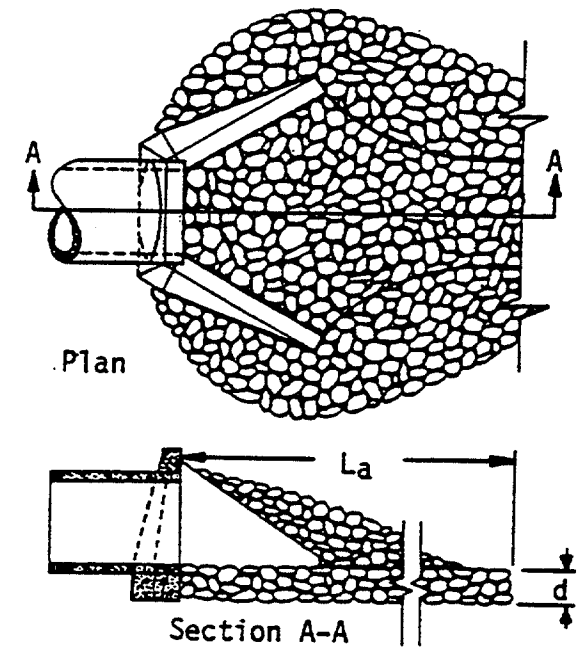
Tailwater - The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth. Manning's Equation may be found in the standard for Waterways in this manual. If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet to flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

Apron Length - The apron length shall be determined from Figure OP-1 or OP-2 according to the tailwater condition.

Apron Width - If the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank (whichever is less).



Pipe Outlet To Flat Area
With No Defined Channel



Pipe Outlet To Well-Defined Channel

Notes

1. Apron lining may be riprap, grouted riprap, or concrete.
2. La is the length of the riprap apron as calculated using Figure OP-2 and OP-3.
3. d = 1.5 times the maximum stone diameter but not less than 6 inches.

Figure OP-1. Pipe Outlet Conditions.

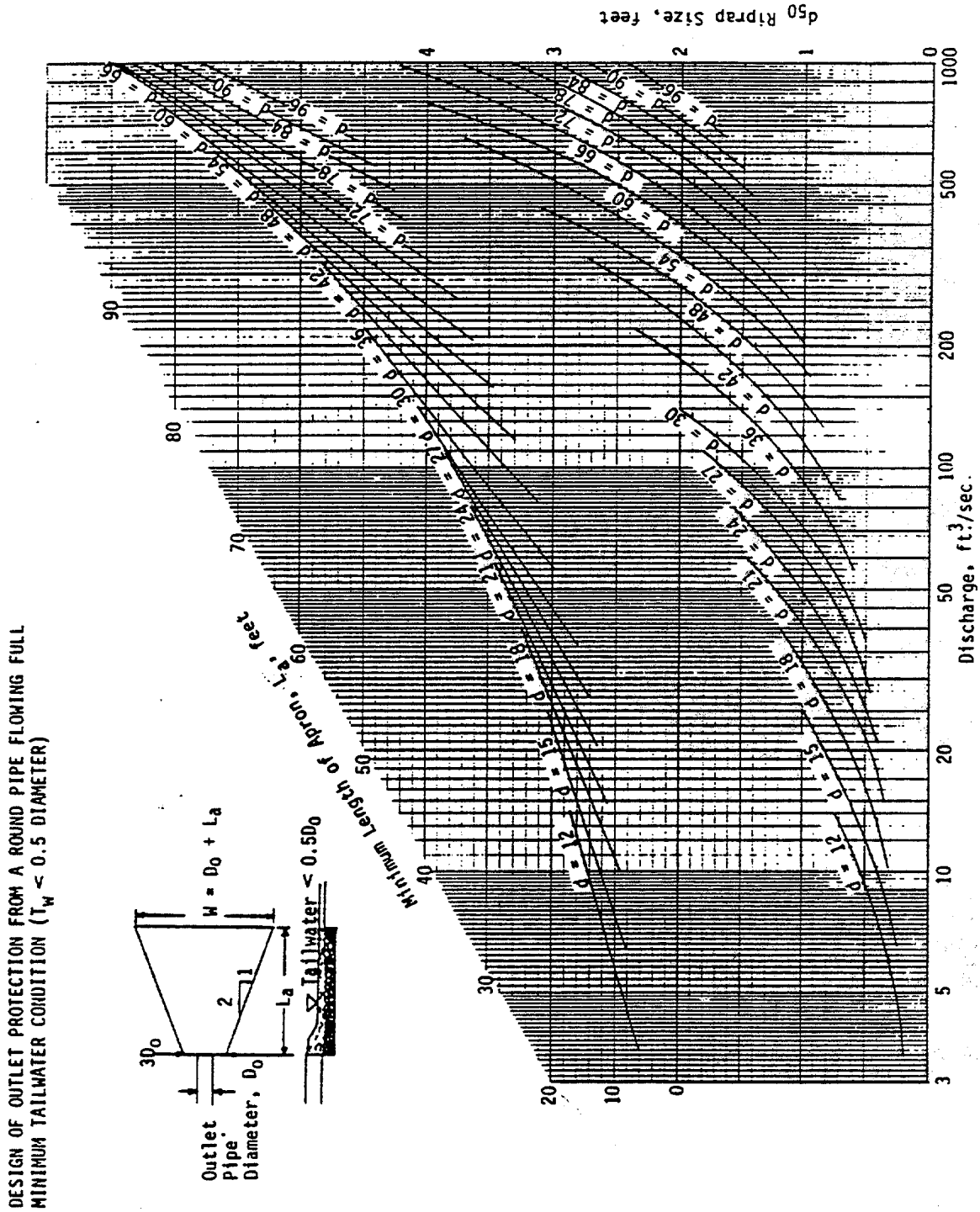


Figure OP-2. Outlet Protection Design for Tailwater < 0.5 Diameter.

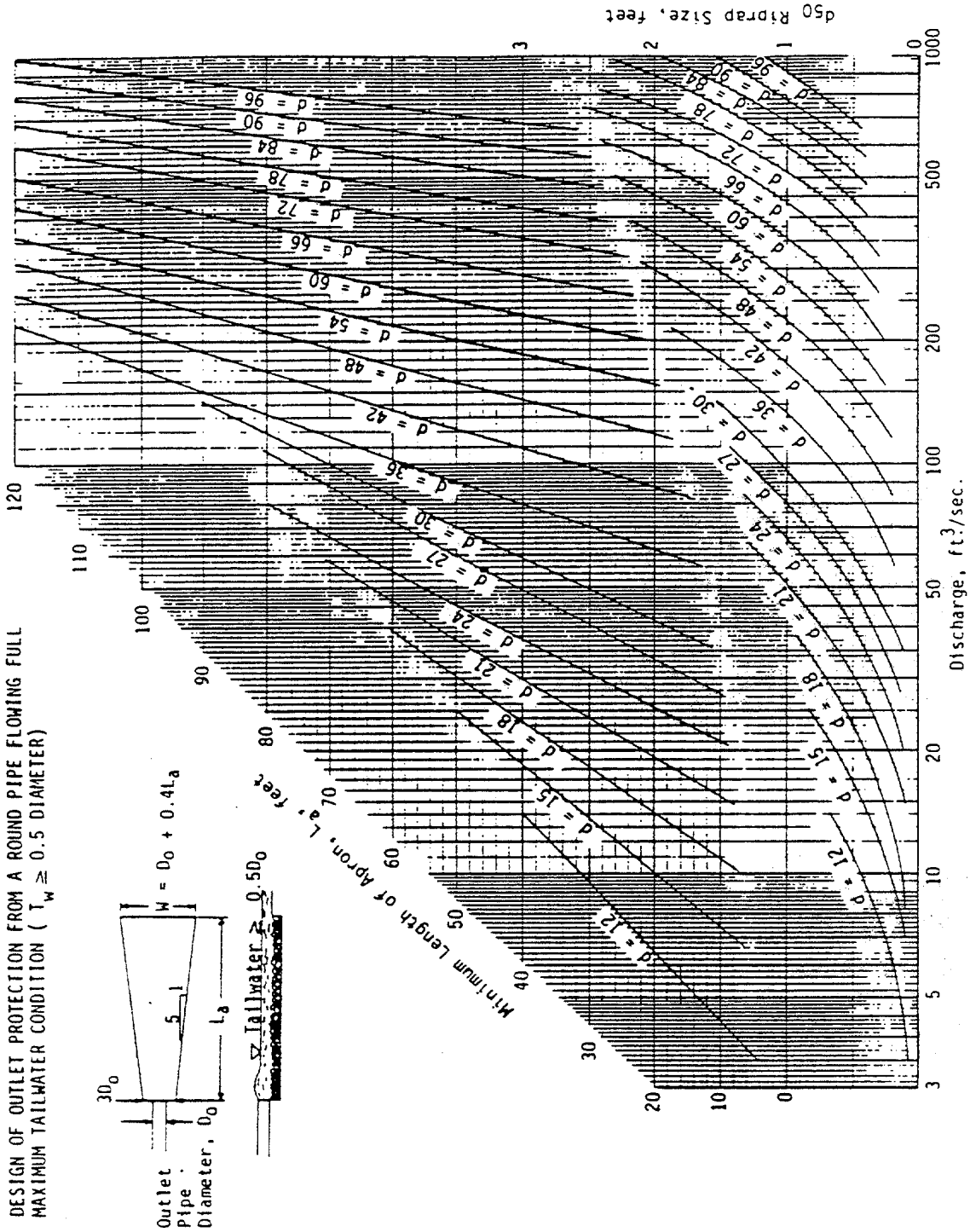


Figure OP-3. Outlet Protection Design for Tailwater ≥ 0.5 Diameter.

If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

a. The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.

b. For a Minimum Tailwater Condition, the downstream end of the apron shall have a width equal to the pipe diameter plus the length of the apron obtained from the figures.

c. For a Maximum Tailwater Condition, the downstream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron from Figures OP-2 or OP-3.

Bottom Grade - The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

Side Slope - If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (Horizontal : Vertical).

Alignment - The apron shall be located so that there are no bends in the horizontal alignment.

Materials - The apron may be lined with loose rock riprap, grouted riprap, or concrete. The median sized stone for riprap shall be determined from the curves on Figure OP-2 and OP-3 according to the tailwater condition. The gradation, quality, and placement of riprap shall conform to Standard and Specification for Riprap in this manual.

PAVED CHANNEL OUTLETS (Figure OP-4)

1. The flow velocity at the outlet of paved channels flowing at design capacity must not exceed the permissible velocity of the receiving channel.

2. The end of the paved channel shall merge smoothly with the receiving channel section. There shall be no overfall at the end of the paved section. Where the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a

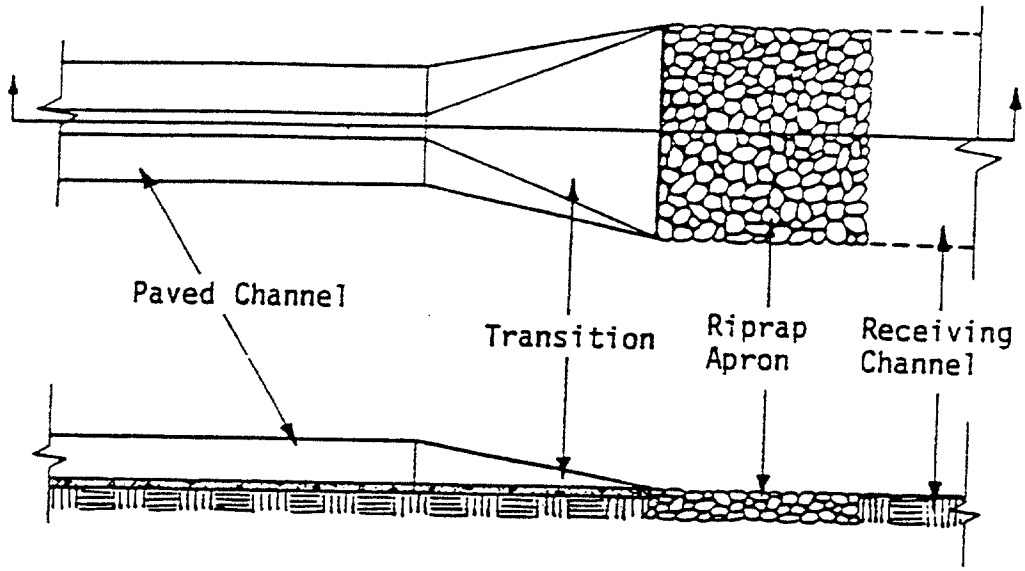


Figure OP-4. Paved Channel Outlet.

transition section shall be provided. The maximum side divergence of the transition shall be 1 in 3F where;

$F = \frac{V}{gd}$, and

F = Froude number
V = Velocity at beginning of transition (ft./sec.)
d = depth of flow at beginning of transition (ft.)
g = 32.2 ft./sec.^{2}

3. Bends or curves in the horizontal alignment of the transition are not allowed unless the Froude number (F) is 0.8 or less, or the section is specifically designed for turbulent flow.

Maintenance

Inspect riprap outlet after heavy rains to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Immediately make all needed repairs to prevent further damage.

Construction Specification
for
Outlet Protection

Subgrade Preparation

Brush, trees, stumps, and other objectionable material shall be removed. The subgrade for the riprap or filter shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximating that of the surrounding undisturbed material.

Bedding or Filter Cloth

Filter bedding shall be placed to the depth, line and grade and in the manner specified. Geotextile shall be installed where specified and laid on the subgrade with sufficient slack so that it will not suffer extreme tension during placement of riprap or other linings.

Stone Placement

Placement of riprap should follow immediately after subgrade preparation. The riprap should be placed so that it produces a dense well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry, controlled dumping of successive loads during final placing, or by a combination of these methods.

The riprap should be placed to its full thickness in one operation, not in layers. The riprap should not be placed by dumping into chutes or similar methods which are likely to cause segregation of the various stone sizes. Care should be taken not to dislodge the underlying material when placing the stones. Some hand placing may be necessary to achieve the required grades and a good distribution of stone sizes.

PAVED FLUME (PF)

Definition

A permanent concrete-lined channel constructed on a slope.

Purpose

To conduct stormwater runoff safely down a slope without causing erosion problems on or below the slope.

Conditions Where Practice Applies

Wherever concentrated stormwater runoff must be conveyed down a slope on a permanent basis. The slope is generally too steep to control erosion from occurring in the concentrated flow area with conventional vegetation. Also where shallow road ditches outlet into deeper open ditches or catch basins.

Planning Considerations

Paved flumes or gutters are used routinely on highway cuts and fills to convey concentrated stormwater runoff from the top to bottom of a slope without erosion. These structures have equal applicability to construction projects other than highways.

Design Criteria

Capacity

Paved flumes shall be capable of passing the peak flow expected from a 10-year frequency, 24-hour duration storm. Peak flows which exceed 50 cfs should be designed by a professional engineer.

Slope

This measure only applies to paved flumes that are installed on slopes of 25% or less. Slopes steeper than this should be designed by a professional engineer.

Cross Section

With peak flow (capacity) and slope known, the paved flume cross-section can be determined by using Figure PF-1.

Concrete

Flumes should be constructed of concrete with a minimum strength of 3,000 psi. Flumes shall have a minimum concrete thickness of four (4) inches.

Cutoff Walls

Cutoff walls shall be constructed at the beginning and end of every flume except where the flume connects with a catch basin or inlet.

Alignment

Keep paved flumes as straight as possible because they often carry supercritical flow velocities.

Inlet Section

The inlet section to the paved flume should be at least 6 ft. long and have a bottom width equal to twice the bottom width of the flume itself. The bottom width should transition over the 6 ft. length.

Outlet

Outlets of paved flumes shall be protected from erosion. The standard for Outlet Protection can be used to provide this protection. A method to dissipate the energy of low flows is to bury the last section of the flume in the ground. This will usually force the development of a "scour hole" which will stabilize and serve as a plunge basin. For the design of large capacity flumes it may be necessary to design a larger energy dissipator at the outlet.

Maintenance

Before permanent stabilization of the slope, the structure should be inspected after each rainfall and damages to the slope or paved flume repaired immediately. After the slope is stabilized, little maintenance should be required.

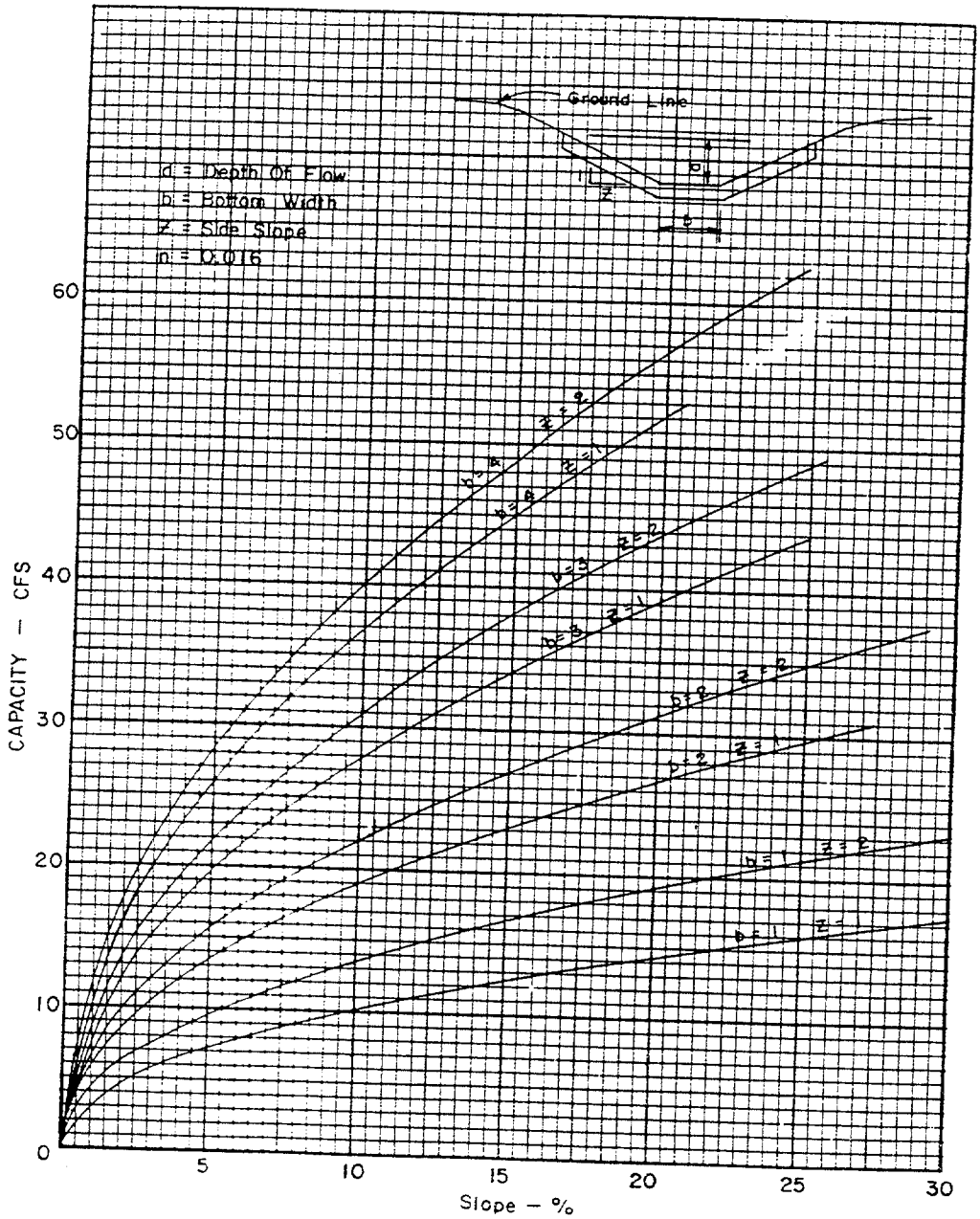


Figure PF-1. Capacity chart for concrete flume. Depth of flow = 0.5 ft.

(Sheet 1 of 3)

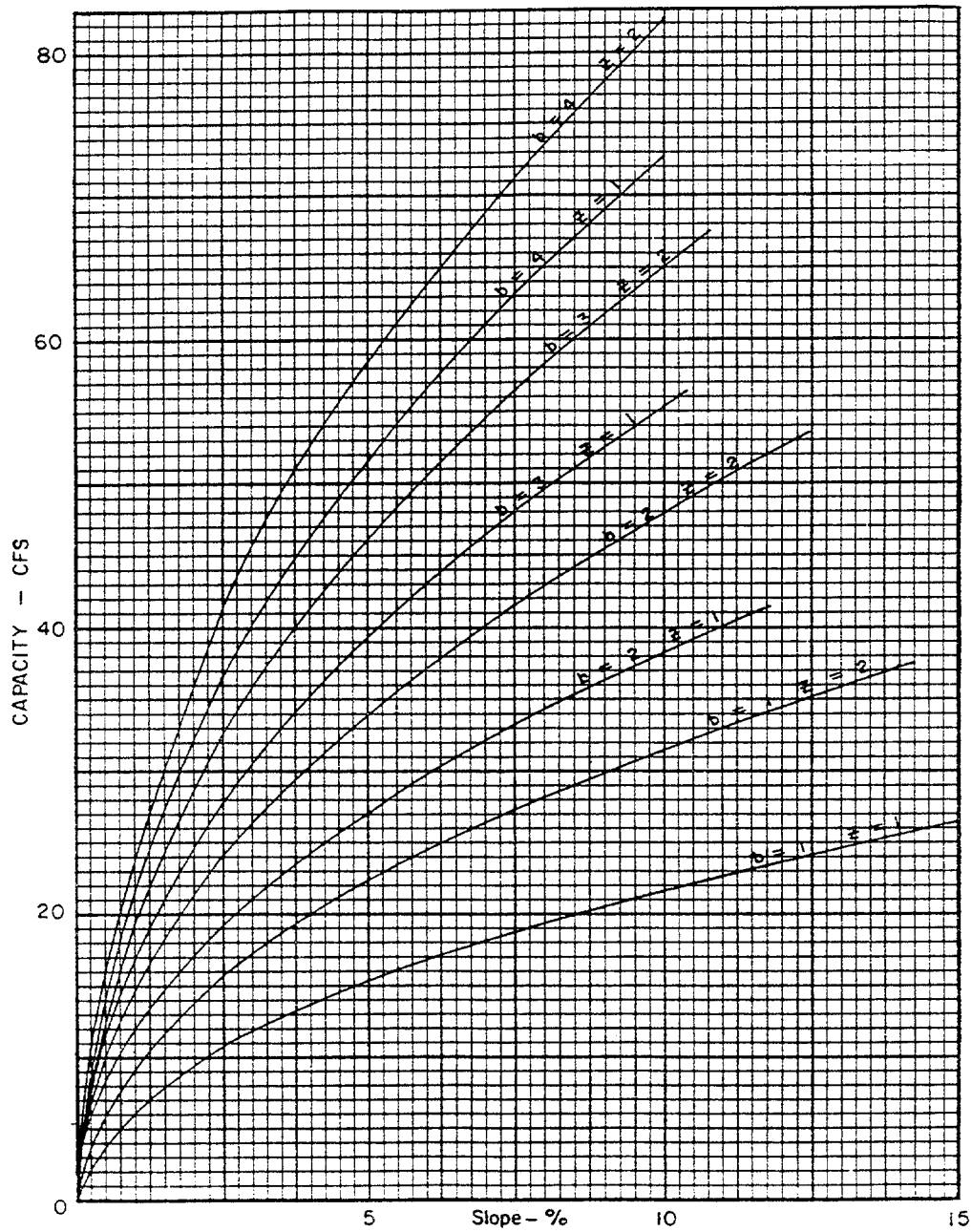


Figure PF-1. Capacity chart for concrete flume. Depth of flow = 0.75 ft.

(Sheet 2 of 3)

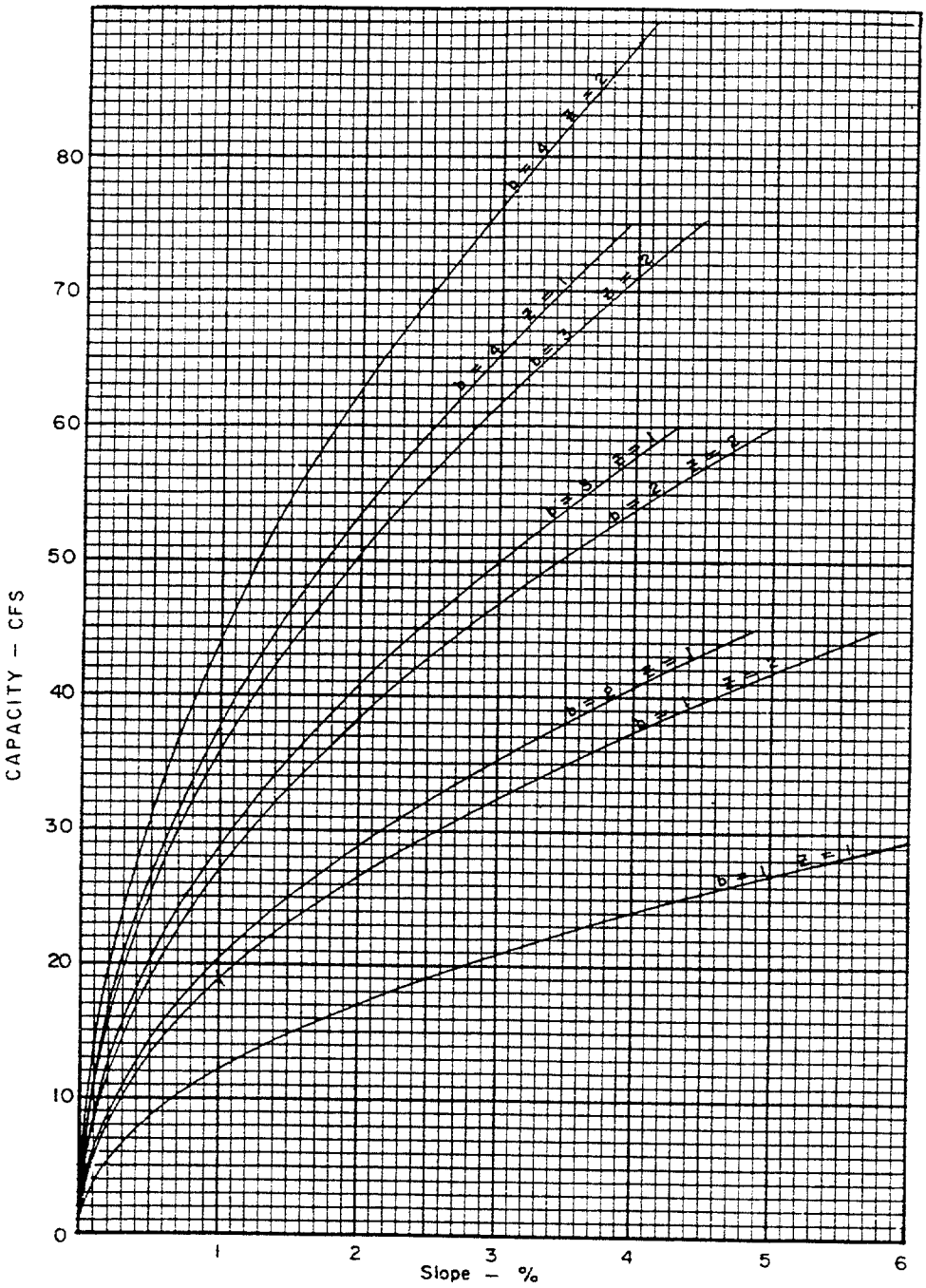


Figure PF-1. Capacity chart for concrete flume. Depth of flow = 1.0 ft.

(Sheet 3 of 3)

Construction Specifications
for
Paved Flume

1. The subgrade shall be constructed to the required elevations. All soft sections and unsuitable material shall be removed and replaced with suitable material. The subgrade shall be thoroughly compacted and shaped to a smooth, uniform surface. The subgrade shall be moist at the time the concrete is placed.

2. Construction and expansion joints shall be used on long concrete flumes. Construction joints shall be spaced at 10 feet intervals and expansion joints at intervals not to exceed 20 ft.

3. Standard concrete practice shall be followed to install the paved flume. Appropriate portions of the American Concrete Institute, Alabama Highway Department or Soil Conservation Service concrete specifications shall be incorporated into these specifications to insure that quality concrete is installed.

4. Place concrete for the flume to the thickness shown on the plans and finish it in a workmanlike manner. Take adequate precautions to protect the freshly poured concrete from extreme temperatures to ensure proper curing. The concrete should be coated with an approved curing compound as soon as finish work is complete, and the free water has disappeared from the surface.

5. Properly stabilize all disturbed areas immediately after construction. One row of sod should be placed at the edges of the paved flume according to the appropriate vegetation measure.

RETAINING WALL (RW)

Definition

A wall constructed of one or more of the following materials: reinforced concrete, masonry concrete, treated timbers, concrete blocks, used cross-ties, gabions, steel piling, rock riprap, etc.

Purpose

To stabilize steep slopes where there is not enough horizontal distance to construct the steepest permissible slope.

Conditions Where Practice Applies

Retaining walls should be used in conjunction with steep cut or fill slopes, which may be unstable due to steepness or space limitations or poor soil conditions, to stabilize the site. Retaining walls may be used to relieve the need to construct cuts into steep hillsides or on small lots where fill toe-outs or slope cut-outs would go off of the property being developed. Retaining walls may be required to get the best or intended use of the property.

Design Criteria

The design of a retaining wall is or can be a complicated engineering procedure. There are many factors to consider. Each case is different and requires a different set of considerations and a different design.

The designer should consider the stresses and forces outside and within the wall as well as allowable height and minimum thickness. Other considerations are foundation design with respect to loadings, bearing values of soils and footing dimensions. Additional design factors include safety hazards, drainage aspects and appearance.

Each retaining wall requires specific engineering design which requires the capabilities of a competent design engineer. A professional consulting engineer should be retained to make the design if a qualified design engineer is not available on the staff. Retaining walls are engineering structures which affect public property, life and welfare of citizens. Alabama law which regulates the

practice of professional engineering in the State of Alabama must be followed on structures such as retaining walls. The State Board of Registration for Professional Engineers and Land Surveyors in Montgomery is responsible for administering the provisions of the law.

Construction Specifications
for
Retaining Wall

The designer should develop appropriate construction specifications. Standard construction procedures for concrete, steel, excavation, backfill and other associated procedures should be followed.

RETROFITTING (RT)

Definition

A device or structure placed in front of a permanent stormwater retention outlet structure to serve as a temporary sediment filter.

Purpose

This structure allows permanent stormwater retention structures to function as temporary sediment basins for land-disturbing projects.

Conditions Where Practice Applies

This standard applies under the following conditions:

1. Cannot be used in retention basins on live streams or in basins with a total contributing drainage area of 100 acres or more.

2. Can only be used in retention basins large enough to store 67 cu. yds. sediment per acre of drainage area in the project and large enough to also store the stormwater runoff of a 2-year frequency, 24-hour duration storm event from the contributing drainage area. Basins that are smaller than this, because they are designed to store only the increase in runoff from a project, must be enlarged to store the total runoff from a 2 year storm frequency.

3. Shall be considered a temporary structure and will be removed as soon as the project is completed. All accumulated sediment will be removed from the retention pond basin.

Design Criteria

The height of the retrofit must be at least as high as the expected 10-year frequency, 24-hour duration stormwater level from the total contributing drainage area in the retention basin and no less than two feet high.

Maintenance

All types of retrofit structures must be kept clear of trash and debris. This will require continuous monitoring and maintenance. Structures are temporary and should be removed when the land-disturbing project has been re-stabilized.

Construction Specifications for Retrofitting

The following types of structures are acceptable under the designated conditions:

1. Perforated half-round pipe with stone filter (See Figure RF-1).

   a) Diameter of half-round pipe should be 1.5 times the diameter of the principal pipe outlet or wider than the greatest width of the concrete weir.

   b) Perforations should be constructed as shown in the figure and be smaller than the filter stone used around the half-round.

   c) Shall be fixed by specified means (bolts, etc) to concrete outlet structure, but never used on exposed pipe end or winged headwall.

   d) Should be used only in retention ponds with less than 30 acres total drainage area.

2. Slotted board dam with stone (See Figure RF-2).

   a) Can be used with open end pipe outlets, winged headwalls, or concrete weir outlets.

   b) Should be installed with minimum size 4x4" posts.

   c) Boards should have 0.5-1.0 inch spaces between them.

   d) Minimum size 3-5 inch stone filter shall be installed around the upstream side of the board dam.

   e) Can be used in retention ponds with drainage areas up to 100 acres.

3. Stone filter rings (See Figure RF-3)

   a) Can be used in conjunction with half-rounds or board dams, as additional sediment filtering device.

   b) Stone size should be a minimum 10-15 inch stone, faced with smaller filter stone on the upstream side.

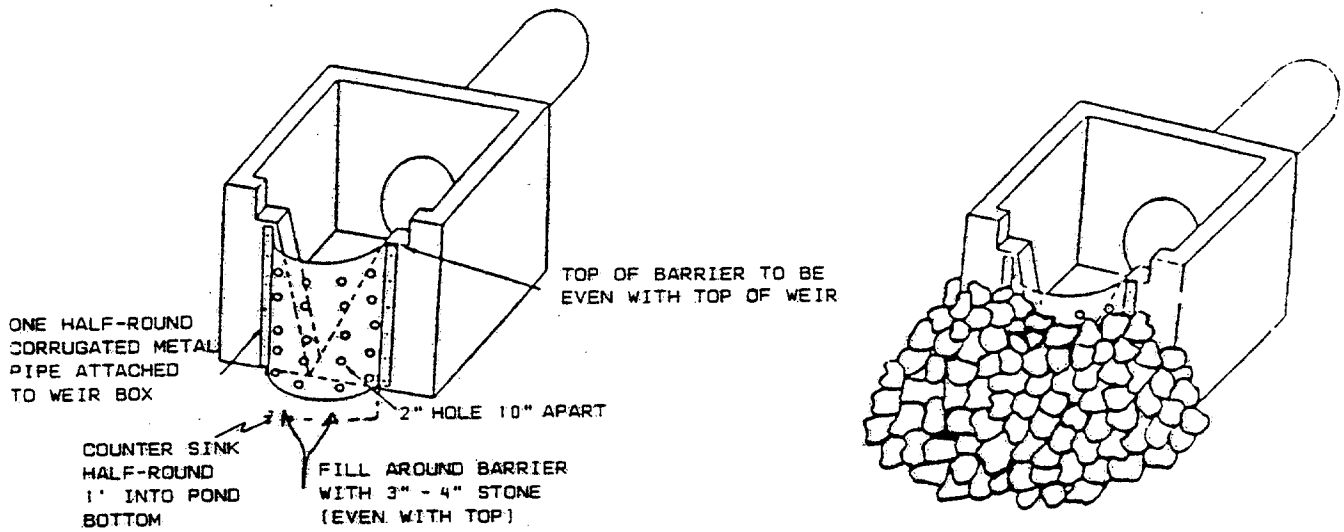


Figure RF-1. Perforated Half-Round Pipe with Stone Filter.

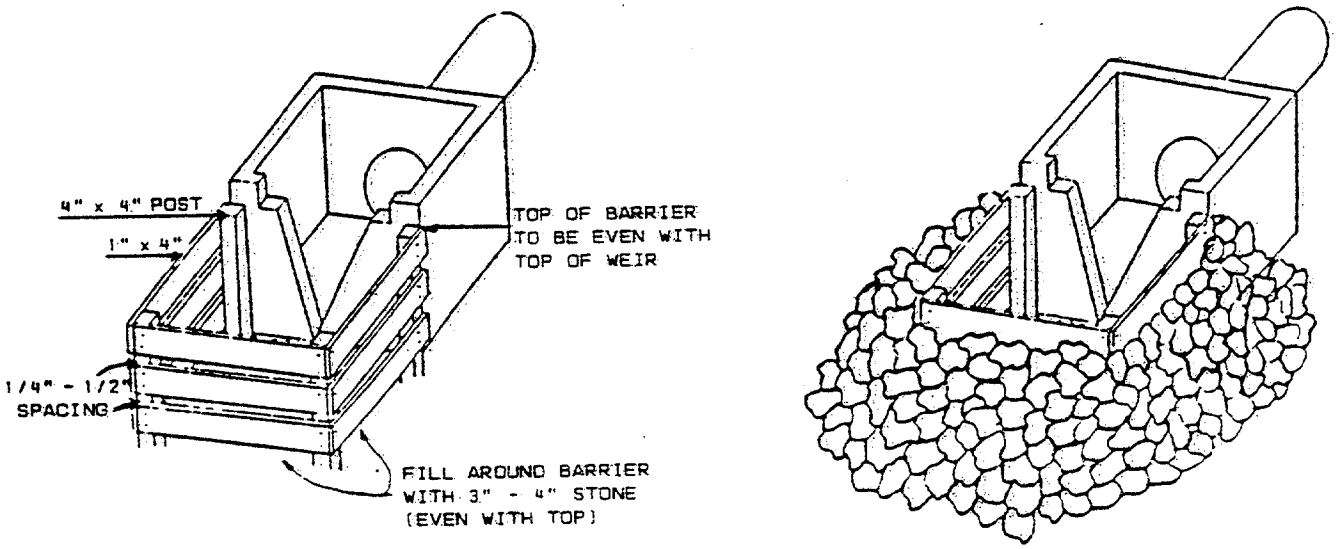


Figure RF-2. Slotted Board Dam with Stone Filter.

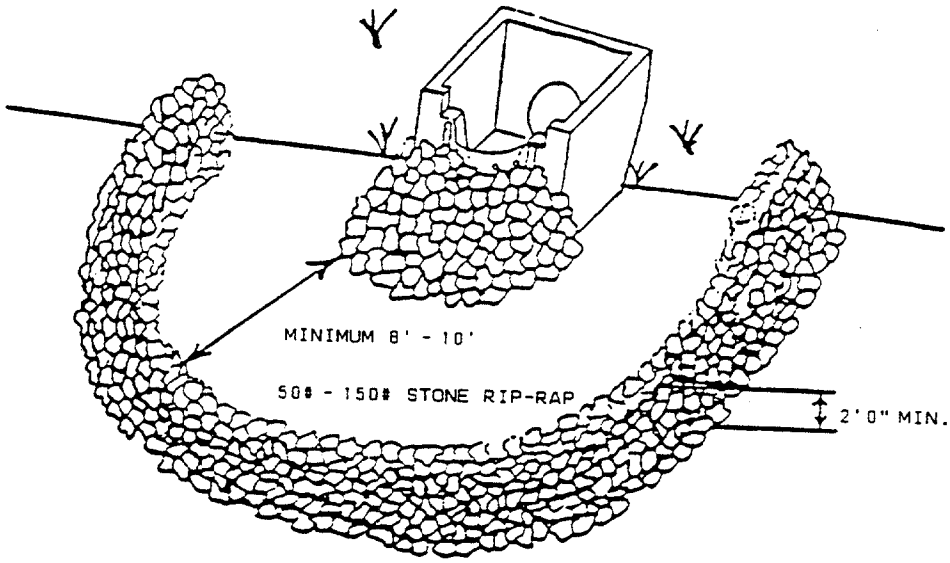


Figure RF-3. Stone Filter Ring.

RIPRAP (RR)

Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone.

Purposes

1. To protect the soil surface from the erosive forces of concentrated runoff.

2. To slow the velocity of concentrated runoff while enhancing the potential for infiltration.

3. To stabilize slopes with seepage problems and/or non-cohesive soils.

Conditions Where Practice Applies

Soil-water interfaces where the soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at storm drain outlets, on channel banks and/or bottoms, roadside ditches, drop structures, at the toe of slopes, etc.

Planning Considerations

Graded vs. Uniform Riprap

Riprap is classified as either graded or uniform. A sample of graded riprap would contain a mixture of stones which vary in size from small to large. A sample of uniform riprap would contain stones which are all fairly close in size.

For most applications, graded riprap is preferred to uniform riprap. Graded riprap forms a flexible self-healing cover, while uniform riprap is more rigid and cannot withstand movement of the stones. Graded riprap is cheaper to install, requiring only that the stones be dumped so that they remain in a well-graded mass. Hand or mechanical placement of individual stones is limited to that necessary to achieve the proper thickness and line. Uniform riprap requires placement in a more or less uniform pattern, requiring more hand labor or mechanical effort.

Riprap sizes can be designated by either the diameter or the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be rectangular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Table RR-1 lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed specific weight of 165 lbs./ft^3.

Table RR-1. Size of Riprap Stones.

Weight (lbs)	Mean Spherical Diameter (ft)	Rectangular Shape	
		Length (ft)	Width, Height (ft)
50	0.8	1.4	0.5
100	1.1	1.75	0.6
150	1.3	2.0	0.67
300	1.6	2.6	0.9
500	1.9	3.0	1.0
1000	2.2	3.7	1.25
1500	2.6	4.7	1.5
2000	2.75	5.4	1.8
4000	3.6	6.0	2.0
6000	4.0	6.9	2.3
8000	4.5	7.6	2.5
20000	6.1	10.0	3.3

Since graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in the mixture for which some percentage, by weight, will be smaller. For example, d_{85} refers to a mixture of stones in which 85% of the stone by weight would be smaller than the diameter specified. Most designs are based on d_{50}. In other words, the design is based on the average size of stone in the mixture. The State of Alabama Highway Department classifies riprap according to Table RR-2.

Sequence of Construction

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when

Table RR-2. Graded Riprap.

Class	Weight (lbs.)					
	d_{10}	d_{15}	d_{25}	d_{50}	d_{75}	d_{90}
1	10	-	-	50	-	100
2	10	-	-	80	-	200
3	-	25	-	200	-	500
4	-	-	50	500	1000	-
5	-	-	200	1000	-	2000

final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

Design Criteria

Gradation

The riprap shall be composed of a well-graded mixture down to the one inch size particle such that 50% of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size.

The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of damage by children shall be considered in selecting a riprap size, especially if there is nearby water to toss the stones into.

Thickness

The minimum thickness of the riprap layer shall exceed the maximum stone diameter by 6 inches and the total thickness cannot be less than 18 inches.

Quality of Stone

Stone for riprap shall consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all other respects for the purpose intended. The specific gravity of the individual stones shall be at least 2.5.

Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirements of this Standard and Specification.

Riprap at Outlets

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structures are contained in OUTLET PROTECTION.

Riprap for Channel Stabilization

Riprap for channel stabilization shall be designed to be stable for the condition of full bank flow in the reach of channel being stabilized. The design procedure in Appendix VI which was taken from the Federal Highway Administration's Design of Stable Channels with Flexible Linings can be used for this design.

Riprap shall extend up the banks of the channel to a height equal to the maximum depth of flow or to a point where vegetation can be established to adequately protect the channel.

The riprap size to be used in a channel bend shall extend upstream from the point of curvature and downstream from the point of tangency a distance of at least 5 times the channel bottom width.

Where riprap is used only for bank protection and does not extend across the bottom of the channel, riprap shall be keyed into the bottom of the channel to a minimum depth equal to the thickness of the blanket and shall extend across the bottom of the channel the same distance. (See Figure RR-1).

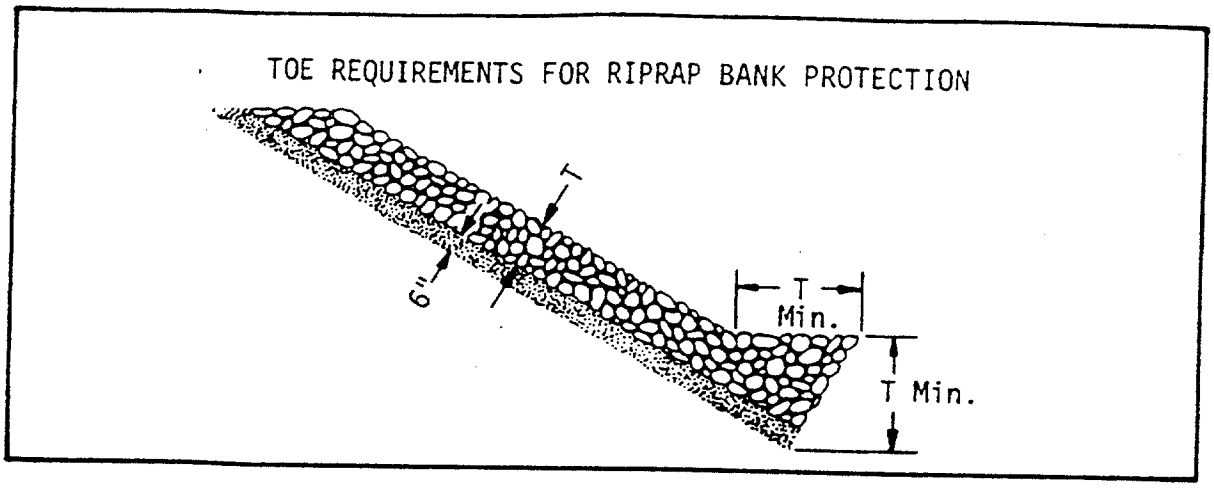


Figure RR-1. Riprap Channel Bank Protection.

Riprap for Slope Stabilization

Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is greater than the gradient of the slope being stabilized (see Appendix VI design procedures).

Filter Blankets

A filter blanket is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap.

A filter blanket can be of two general forms: a gravel layer or a geotextile filter cloth. A determination of the need for a filter blanket is made by comparing particle sizes of the overlying material and the base material in accordance with the criteria below.

Gravel filter blanket: The following relationships must exist:

$$\frac{d_{15}\text{filter}}{d_{85}\text{ base}} < 5 < \frac{d_{15}\text{ filter}}{d_{15}\text{ base}} < 40$$

and,

$$\frac{d_{50}\text{ filter}}{d_{50}\text{ base}} < 40$$

In these relationships, filter refers to the overlying material and base refers to the underlying material. The relationships must hold between the filter material and the base material and between the riprap and the filter material. In some cases, more than one layer of filter material may be needed. Each layer of filter material should be approximately 6 inches thick.

Geotextile filter cloth: Geotextile filter cloth may be used in place of or in conjunction with gravel filters. The following particle size relationships must exist:

1. For filter cloth adjacent to granular materials containing 50 percent or less (by weight), of fine particles (less than 0.074mm):

   a) $$\frac{d_{85} \text{ base (mm)}}{\text{EOS}^* \text{ filter cloth (mm)}} > 1$$

   b) Total open area of filter is less than 36 percent

2. For filter cloth adjacent to all other soils:

   a) EOS* less than U. S. Standard Sieve No. 70.

   b) Total open area of filter is less than 10 percent.

No filter cloth should be used with less than 4 percent open area or an EOS* less than U. S. Standard Sieve No. 100.

*EOS - Equivalent Opening Size to a U. S. Standard Sieve Size.

Filter blankets should always be provided where seepage from underground sources threatens the stability of the riprap.

Maintenance

Once a riprap installation has been completed, it should require very little maintenance. However, it should be inspected periodically to determine if high flows have caused scour beneath the riprap or dislodged any of the stone. If repairs are needed, they should be accomplished immediately.

Construction Specifications
for
Riprap

Subgrade Preparation: The subgrade for the riprap or filter shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximating that of the surrounding undisturbed material. Brush, trees, stumps and other objectionable material shall be removed.

Filter Blanket: Placement of the filter blanket should be done immediately after slope preparation. For gravel filters the stone should be spread in a uniform layer to the specified depth. Where more than one layer of filter material is used, the layers should be spread so that there is minimal mixing of the layers.

For geotextile filter cloths, the cloth should be placed directly on the prepared slope. The edges of the sheets should overlap by at least 12 inches. Anchor pins, supplied by the manufacturer, should be spaced every 3 feet along the overlap. The geotextile material should not be stretched tight but should be loosely placed on the prepared surface. The upper and lower ends of the cloth should be buried a minimum of 12 inches deep. Care should be taken not to damage the cloth when placing the riprap. If damage occurs, that sheet should be removed and replaced. For large stone (12 inches or greater), a 4-inch layer of gravel may be necessary to prevent damage to the cloth.

Stone Placement: Placement of riprap should follow immediately after placement of the filter. The riprap should be placed so that it produces a dense well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry, controlled dumping of successive loads during final placing, or by a combination of these methods. The riprap should be placed to its full thickness in one operation. The riprap should not be placed in layers. The riprap should not be placed by dumping into chutes or similar methods which are likely to cause segregation of the various stone sizes. Care should be taken not to dislodge the underlying material when placing the stones.

The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve the required grades and a good distribution of stone sizes. Final thickness of the riprap blanket should be within plus or minus 1/4 of the specified thickness.

SEDIMENT BARRIER/FENCE (SF)

Definition

A sediment barrier is a temporary structure constructed of a silt fence or hay bales along a contour, property line or development line. Other barrier materials may include sand bags, brush piles or other filtering mediums.

Purpose

To retard sheet and rill erosion and to intercept and detain small amounts of sediment from disturbed areas during site development in order to prevent sediment from leaving the site.

Conditions Where Practice Applies

1. On or along the down slope side of disturbed areas where sheet and rill erosion would occur.

2. At storm drain inlets, along right-of-way lines, property lines or along the edge of developing areas.

3. Where the size of the drainage area is no more than one-fourth acre per 100 feet of sediment barrier length; where the maximum length of slope behind the barrier does not exceed 100 feet; and where the maximum gradient behind the barrier is 25% (4:1). The length of slope behind the barrier should not exceed 50 feet where the slope is steeper than 50% (2:1).

4. In small waterways, minor swales or ditch lines where the maximum contributing drainage area is less than two acres and where maximum flow is less than one cubic feet per second.

5. Sediment barriers should not be used on high sediment producing areas.

Planning Considerations

Silt fences are usually preferable to hay bales because silt fences can trap a much higher percentage of suspended solids. The success of silt fences depends on a proper installation so as to develop maximum efficiency of

trapping. Silt fences as well as hay bales should be carefully installed to meet the intended purpose.

Sediment barriers may be used on developing sites. They should be installed on the contour so that flow will not concentrate and cause bypassing, overtopping and/or failure. Barriers may be placed on a slight grade (less than 0.5%) when the flow can be safely released at the end of the barrier and the length does not exceed 500 feet.

The primary sediment barrier is a silt fence. A silt fence is specifically designed to allow water to pass through while retaining sediment on the site. Silt fences shall be installed to be stable under the flows expected from the site. Silt fences are composed of woven geotextile supported between steel or wooden posts. Silt fences are commercially available with geotextile attached to the post and can be rolled out and installed by driving the post into the ground. This type of silt fence is simple to install, but more expensive than some other installations. Silt fences must be trenched in at the bottom to prevent rills from developing under the fence.

Hay bale barriers are the next most common sediment barrier. Hay bales are laid end to end along the contour and anchored in place by driving wooden stakes through the bales into the soil. Some embedment is needed to prevent water from going under the barrier. The bales should be embedded three or four inches on the upslope side of the bales on steep sites. Sediment barriers shall be of sufficient length to eliminate end flow whenever it is constructed across a swale or ditch line. The plan configuration shall resemble an arc or horseshoe with ends oriented upstream.

Design Criteria

1. No formal design is required.

2. Silt fences are normally limited to situations in which only sheet or overland flow is expected. They normally cannot filter the volumes of water generated by channel flow. Silt fences are normally constructed of synthetic fabric (woven geotextile) and the life is expected to be the duration of most construction projects.

3. Hay bales have an expected life of six to twelve months and replacement should be anticipated on projects lasting a longer time. They are applicable to ditch

lines, around drop inlets and at other temporary locations.

4. Silt fences shall be a minimum of 30" high above ground and shall not exceed 36".

5. Posts shall extend at least 18" below ground.

Maintenance

The contractor shall maintain sediment barriers until the upslope area is satisfactorily vegetated or the job is accepted.

Sediment barriers are a high maintenance measure. They shall be inspected immediately after each rainfall and at least weekly during normal construction activities, and daily during prolonged rainfall. Any needed repairs shall be made immediately.

Sediment deposits shall be removed when the deposits reach one-half the height of the barrier. Any sediment deposits remaining after the sediment barrier is no longer required shall be smoothed to conform to the natural topography, and seeded and mulched in accordance with permanent vegetation specifications of Chapter 4 of this manual.

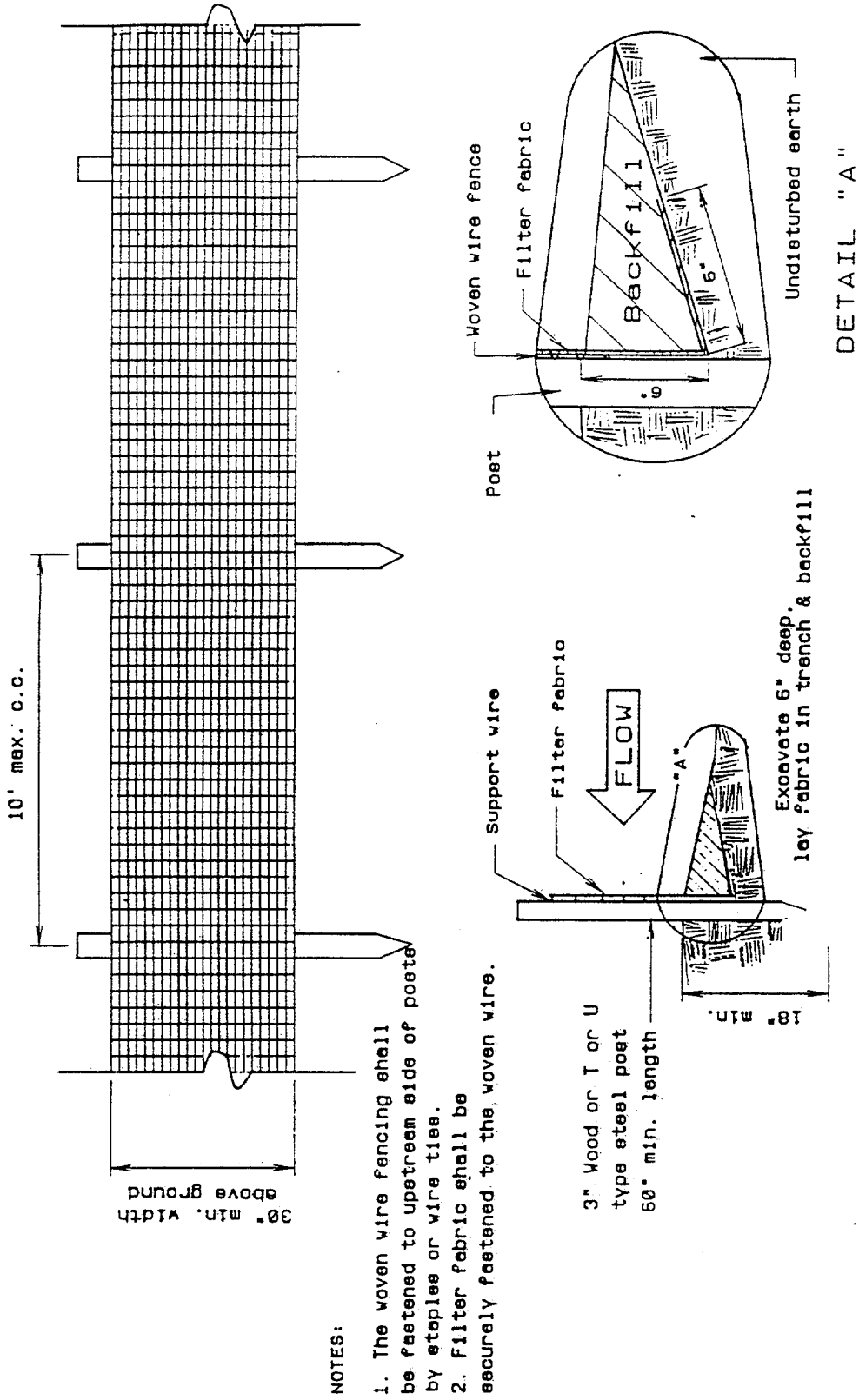


Figure SF-1. Silt Fence Detail

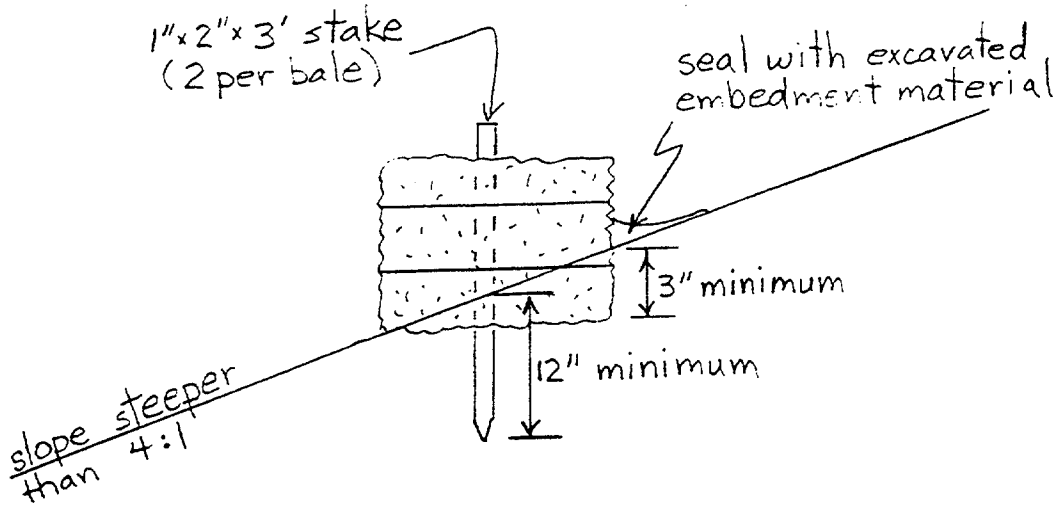


Figure SF-2. Hay Bale Barriers on Steep Slope

- ANCHOR AND EMBED INTO SOIL TO PREVENT WASHOUT OR WATER WORKING UNDER BARRIER
- REPAIR OR REPLACEMENT MUST BE MADE PROMPTLY AS NEEDED

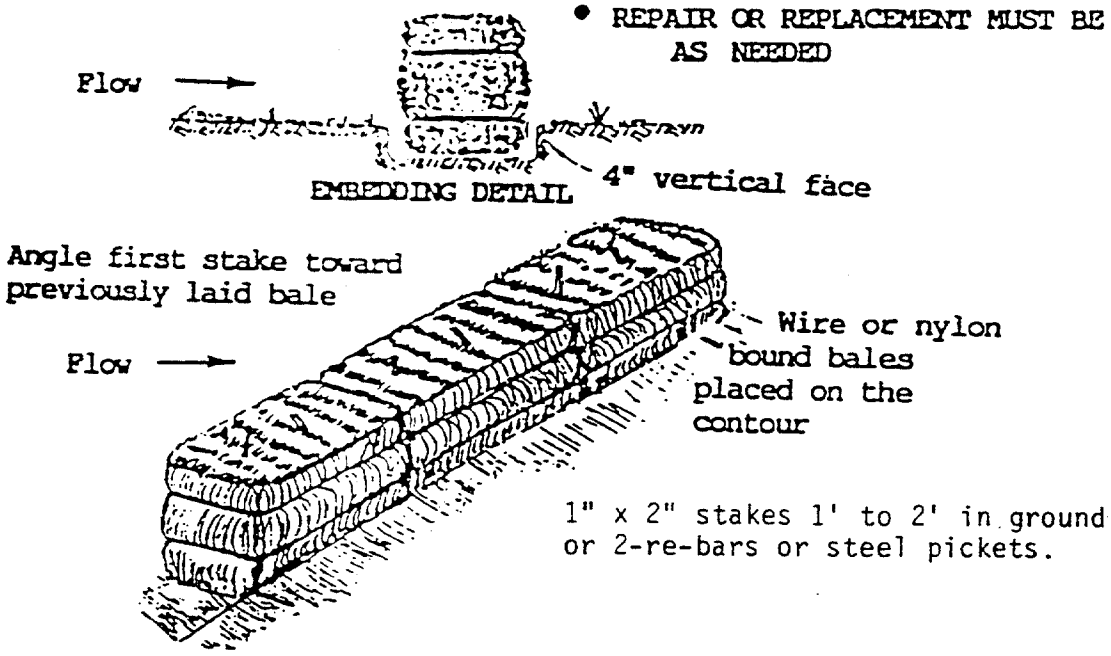


Figure SF-3. Staked Haybale Barriers in Swales.

Construction Specifications
for
Sediment Barriers/Fences

1. Silt fence may be premanufactured equivalent to Mirofi Envirofence or Armco Propex Silt Stop. Silt fence may also be built on the site with post, wire and fabric of approved materials.

2. When silt fence is built on the site, the fabric shall be Filter X, Poly-filter X, Mirafi 100X, Laurel Erosion Control Cloth, Bidim or other similar fabrics which have been developed for sediment control applications. Wooden posts shall be sound and have a minimum actual diameter of 3 inches. Steel posts of Standard T or U section weighing not less than 1.33 pounds per linear feet may be used; woven wire fencing shall have a minimum 14 gauge with a maximum 6 inches mesh opening.

3. The silt fence shall be installed at locations shown on the drawings or as staked by the engineer.

4. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are necessary, the fabric shall be spliced together only at a support post with a minimum 36 inch overlap, and securely sealed. The overlap shall be pointed downstream if the barrier has any grade along its length.

5. A trench shall be constructed along the bottom of the silt fence as shown in Figure SF-1.

6. The posts for the silt fence shall be spaced a maximum of 10 feet apart. The posts shall extend into the ground at least 18 inches and more depth is recommended when the ground is soft or concentrated flow is expected to cross the sediment barrier.

7. The woven wire fencing shall extend into the trench a minimum of 4 inches and securely fastened to the uphill side of the post with 1 inch staples or other appropriate fasteners.

8. The filter fabric shall be securely fastened to the fencing with staples or hog rings or other fasteners made for this purpose. The filter fabric shall be installed in the trench as shown in Figure SF-1. The trench shall be backfilled and the soil compacted over the filter fabric.

9. Premanufactured silt fence shall be installed in accordance with manufacturers directions and details, but must be embedded in the soil.

10. Hay bales shall be tame hay, or straw from wheat, oats, barley or rye. Bales containing noxious weeds or seeds will not be acceptable. The bales shall be dense and securely tied with string.

11. Stakes for hay bale barriers shall be nominal 1 inch by 2 inch wood. The wood shall be sound with a minimum cross section of 1.25 square inches. The minimum actual dimension shall be not less than one-half inch. The minimum length shall be 3 feet. The stakes shall be driven into the ground at least 12 inches. Equivalent metal rods or steel bars may be used, but wood is preferred.

12. Hay bale barriers shall be placed at locations shown on the drawings and as selected by the engineer.

13. Hay bales shall be placed end to end with two stakes in each bale to anchor it in place. Bales shall be placed in full contact with the ground, not spanning rills or depressions which would allow water to flow under the bales.

14. When hay bale barriers are installed on steep sites (steeper than 25% or 4:1), the upstream side of the hay bale shall be embedded 3 inches. See Figure SF-2. Embedment soil should be placed on upslope site of the bale and used to seal the barrier.

15. When hay bale barriers are installed across swales or concentrated flow areas, the entire hay bale should be embedded 4 inches in accordance with Figure SF-3.

SEDIMENT BASIN (SB)

Definition

A basin created by the construction of a barrier or dam across a natural drainage path or by excavating a basin or by a combination of both. Basins usually consist of a dam, a pipe outlet (principal spillway), and an emergency spillway. The size of the structure will depend upon the location, size of drainage area, soil type, rainfall pattern, available storage and selected outflow releases.

Purpose

To detain rainfall runoff water, reduce and/or maintain peak discharges, and trap sediment from highly erodible areas in order to protect properties and drainage ways located downstream from damage by sedimentation and debris. The water is temporarily stored and a portion of the sediment carried by the water drops out and is retained in the basin while the water is automatically released. The basin is for temporary use and may be removed after the disturbed area in the drainage area has been stabilized.

Conditions Where Practice Applies

This practice applies to critical areas where physical site conditions, construction schedules, or other restrictions preclude the installation or establishment of erosion control practices to satisfactorily reduce runoff volumes, erosion, and sedimentation. The structure may be used in combination with other practices and should remain in place until the sediment-producing area is permanently stabilized.

This standard applies to the installation of temporary sediment basins on sites where: (1) failure of the structure would not result in loss of life or interruption of use or service of public utilities, (2) the peak rate of runoff from the drainage area into the basin, produced by the 10-year/24-hour storm, does not exceed 200 cfs, (3) the peak flowrate through the principal spillway does not exceed 50 cfs, (4) the maximum height of the embankment measured from the low point of the original centerline cross-section does not exceed 15 feet, and (5) the total storage below the emergency spillway crest does not exceed 50 ac-ft.

Design Criteria

Compliance With Laws and Regulations

Design and construction shall comply with State and local laws, ordinances, rules and regulations. The design criteria as stated in this standard may be exceeded by a professional engineer with experience in hydrology and hydraulics.

Location

The sediment basin should be located to obtain the maximum storage benefit from the terrain and for ease of cleanout of the trapped sediment. It should be located to minimize interference with construction activities and construction of utilities. Whenever possible, sediment basins should be located so that storm drains may outfall or be diverted into the basin.

Volume of the Basin

The volume of the sediment basin, as measured from the bottom of the basin to the elevation of the principal spillway crest shall be at least 67 cubic yards per acre of the total drainage area of the basin. This storage is equivalent to 1/2 inch of runoff per acre of total drainage area and provides for sediment control and stormwater management of the site.

Sediment basins shall be cleaned out when 50% of the basin volume has filled with sediment. Cleanout shall be performed to restore the original design volume in the sediment basin. The elevation corresponding to the sediment cleanout level shall be determined and shall be stated in the design data as a distance below the top of the riser. In no case shall the sediment cleanout level be higher than 1 foot below the top of the riser and this cleanout elevation should be clearly marked on the riser.

As a minimum, provisions should be made to dewater the basin down to the sediment cleanout elevation. Dewatering of the basin may be accomplished by using perforations in the riser, or by providing a maximum 4 inch diameter hole at the sediment cleanout elevation or other acceptable methods.

Shape of the Basin

To improve trapping efficiency of the basin, the effective flow length must be twice the effective flow width. This

basin shape may be accomplished by properly selecting the site of the basin, by excavation or by using baffles.

The dimensions necessary to obtain the required basin volume and shape shall be clearly shown on the plans to facilitate plan review, construction and inspection.

Basin Design

Runoff shall be computed by the SCS method or other acceptable methods. Runoff computations for the principal spillway and emergency spillway design storms shall be based upon the worse soil-cover conditions expected to prevail in the contributing drainage area during the anticipated effective life of the structure.

The combined capacities of the principal and emergency spillway shall be sufficient to pass the peak rate of runoff from a 25-year/24-hour storm.

1. Principal spillway - A spillway consisting of a vertical pipe or box type inlet (riser) joined (watertight connection) to a pipe (barrel) which shall extend through the embankment and outlet beyond the downstream toe of the fill. The maximum capacity of the principal spillway shall not exceed the peak runoff rate produced by the 10-year/24-hour pre-development peak discharge assuming a meadow type of land use. The barrel and riser size shall be determined through routing procedures of a 10-year/24-hour storm (land use conditions during construction) taking into account the storage characteristics of the basin between the top of the riser and the crest of the emergency spillway. If during the design process the routed peak discharge through the principal spillway exceeds the pre-development discharge, the pipe sizes will need to be reduced, the storage increased and then redesigned. The minimum size of the barrel shall be 8 inches in inside diameter. The principal spillway should be adequately sized to remove 50% of the runoff volume of the 10-year/24-hour storm within a 3 day period.

   a. Crest elevation - The crest elevation of the riser shall be a minimum of one foot below the elevation of the control section of the emergency spillway.

   b. Watertight riser and barrel assembly - The riser and all pipe connections shall be completely watertight except for the inlet opening at the top and dewatering openings, and shall not have any other holes, leaks, rips or perforations.

c. Dewatering the basin - As previously mentioned, the basin shall be dewatered to the sediment cleanout elevation. A dewatering device shall be included in the sediment basin plans submitted for approval and shall be installed during construction of the basin. Dewatering shall be done in such a manner as to remove the relatively clean water without removing any of the sediment that has settled out and without removing any appreciable quantities of floating debris. Dewatering may be accomplished using perforations in the riser, or by a maximum 4 inch hole at the sediment cleanout elevation or other acceptable methods.

d. Anti-vortex device and trash rack - An antivortex and trash rack shall be securely installed on top of the riser and shall be the concentric type as shown in the design material in Appendix VI (page A-VI-SB-14).

e. Base - The riser shall have a base attached to the bottom of the pipe with a watertight connection and shall have sufficient counter weight to prevent flotation of the riser. Two approved bases for risers ten feet or less in height are (1) a concrete base 18" thick with the riser embedded 9" in the base, and (2) a 1/4" minimum thickness steel plate attached at the base of the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have at least 2.5 feet of stone, gravel or compacted earth placed on top of it to prevent flotation. For both cases, each side of the square base shall have dimensions twice the riser diameter. For risers greater than ten (10) feet high, computations shall be made to design a base which will prevent flotation. The minimum factor of safety shall be 1.20 (downward forces = 1.20 x upward forces).

f. Anti-Seep Collars - anti-seep collars shall be installed around all conduits through earth fills of impoundment structures according to the following criteria:

1. Collars shall be placed to increase the seepage length along the pipe (barrel) by a minimum of 15 percent of the pipe length located within the normal saturation zone.

2. Collar spacing shall be between 5 and 14 times the vertical projection of each collar.

3. All collars shall be placed within the normal saturation zone.

4. The assumed normal saturation zone (phreatic line) shall be determined by projecting a line at a slope of 4 horizontal to 1 vertical from the point where the normal water (riser crest) elevation touches the upstream slope of the fill to a point where this line intersects the invert of the pipe (barrel) outlet. All fill located within this line may be assumed as saturated.

g. Outlet - An outlet shall be provided, including a means of conveying the discharge in an erosion-free manner to an existing stable channel. Where discharge occurs at the property line, drainage easements will be obtained in accordance with local ordinances. Adequate notes and references will be shown on the erosion and sediment control plan.

Protection against scour at the discharge end of the principal spillway shall be provided. Measures may include an impact basin, riprap, revetment, excavated plunge pools, or other acceptable methods. See the Standard and Specifications for Outlet Protection.

2. Emergency Spillways - The entire flow area of the emergency spillway shall be constructed in undisturbed soil material (not fill). The emergency spillway cross-section shall be trapezoidal with a minimum bottom width of eight feet. This spillway channel shall have a straight control section of at least 20 feet in length and a straight outlet section for a minimum distance equal to 25 feet or 1/2 the base width of the embankment fill.

a. Elevation - The elevation of the emergency spillway control section will be determined through routing procedures of the 10-year/24-hour storm taking into account the principal spillway and the storage characteristics above the top of the riser.

b. Capacity - The minimum capacity of the emergency spillway shall be that required to pass the difference between the peak rate of runoff from the 25-year/24-hour storm and the 10-year/24-hour storm. Emergency spillway dimensions may be determined by using the method described in this standard.

c. Velocities - The velocity of flow in the exit channel shall not exceed 6 feet per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be within the non-erosive range for the type of protection used.

d. Erosion Protection - Vegetation, riprap, asphalt or concrete shall be provided to prevent erosion.

e. Freeboard - Freeboard is the difference in elevation between the design high water elevation in the emergency spillway and the top of the settled embankment. The freeboard shall be a minimum of one foot. The minimum elevation between the control section of the emergency spillway and the top of the dam shall be 2 feet.

Entrance of Runoff into Basin

Points of entrance of surface runoff into excavated sediment basins shall be protected to prevent erosion and sediment generation. Dikes, swales or other water control devices shall be installed as necessary to direct runoff into the basin. Points of runoff entry should be located as far away from the riser as possible, to maximize travel time.

Maintenance

Repair all damages caused by soil erosion or construction operations at or before the end of each working day. Sediment shall be removed from the basin when it reaches the specified distance below the top of the riser. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment, adjacent to a stream or in a floodplain.

Final Disposal

When temporary structures have served their intended purpose and the contributing drainage area has been property

stabilized, the embankment and resulting sediment deposits shall be removed and the site stabilized in accordance with the approved sediment control plan.

Construction Specifications
for
Sediment Basin

Site Preparation

Areas under the embankment and under structural works shall be cleared, grubbed, and stripped of topsoil. All trees, vegetation, roots and other objectionable material shall be removed and disposed of by acceptable methods. In order to facilitate cleanout or restoration, the pool area (measured at the top of the riser pipe) will be cleared of all brush and trees.

Keyway Trench

A keyway trench will be excavated along the center-line of earth fill embankments. The minimum depth shall be 2 feet and the actual depth determined by the engineer during excavation. The keyway trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 8 feet, but wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be drained during the backfilling and compacting operations.

Embankment

The embankment shall have a minimum 8 ft. top width and 3:1 side slopes. Flatter side slopes may be needed for stability purposes on certain types of soils. The fill material shall be taken from approved areas shown on the plans. It shall be clean mineral soil free of roots, woody vegetation, oversized stones, rocks or other objectionable material. Relatively pervious materials such as sand or gravel (Unified Soil Classes GW, GP, SW & SP) shall not be placed in the embankment. Areas on which fills are to be placed shall be scarified prior to placement of fill. Fill material shall be placed in six inch to eight inch thick continuous layers over the entire length of the fill. Compaction shall be achieved by traversing the entire surface of each lift with two tracks of earth hauling equipment or with the use of a roller type compactor. Earth fill shall be considered too wet for placement if free moisture can be seen on the surface of a hand molded sample and too dry for placement if the material can not be easily molded by hand into a firm ball. The core of the embankment should be at least 8 feet wide and consist of the most impermeable material available at the site. The core should extend from the bottom of the

keyway trench to the crest of the emergency spillway. The embankment shall be constructed to an elevation 10 percent higher than the design height to allow for settlement.

Principal Spillway

The riser shall be securely attached to the barrel or barrel stub making a watertight structural connection. The barrel stub must be attached to the riser at the same angle or grade as the outlet conduit to ensure the riser is vertical. The connection between the riser and the riser base shall be watertight. All connections between barrel sections must be achieved by approved watertight band assemblies or other approved methods. The barrel and riser shall be placed on a firm, smooth foundation of impervious soil as the embankment is constructed. Breaching the embankment to install the barrel is unacceptable. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the pipe or anti-seep collars. The fill material within 2 feet of the pipe spillway shall be placed in four inch layers and compacted by hand equipment under and around the pipe to at least the same density as the adjacent embankment. A minimum depth of two feet of hand compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment. Steel base plates used to prevent flotation of risers shall have at least 2-1/2 feet of compacted earth, stone or gravel placed over it.

Emergency Spillway

The emergency spillway shall be installed in undisturbed ground. The achievement of planned elevations, grades, design width, entrance and exit channel slopes are critical to the successful operation of the emergency spillway and must be constructed within a tolerance of ± 0.2 feet. Side slopes of the emergency spillway should be a minimum of 3:1.

Vegetative Treatment

The embankment, borrow areas, emergency spillway and other disturbed areas shall be stabilized in accordance with the appropriate vegetative standards immediately following construction of the basin. Vegetative treatment shall be applied to these areas within 7 days after the site has been completed.

Erosion and Pollution Control

Construction operations will be carried out in such a manner that erosion and water pollution will be minimized. State

and local laws concerning pollution abatement shall be complied with.

Safety

State and local requirements shall be met concerning fencing and signs warning the public of hazards of soft sediment and floodwater.

STORM WATER RETENTION STRUCTURE (RS)

Definition

A permanent basin created by the construction of a barrier or dam across a drainageway or excavated basin (or combination of both) in order to control storm water runoff and trap sediments.

Scope

This standard applies only to permanent basins on sites where:

1. Failure of the dam will not result in loss of life; in damage to homes, commercial, or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.

2. The storage capacity below the crest of the principal spillway shall be sufficient to store the runoff from a 2-year frequency, 24-hour duration storm event and the accumulation of 1/2-inch of sediment from the potential disturbed portion of the drainage area.

3. The peak release rate of stormwater from the basin shall not exceed the peak storm water runoff rate from the drainage area in its natural undeveloped state for all intensities up to and including the design storm frequency for the type structure (see Classification) or as required by local ordinances.

4. The drainage area does not exceed 150 acres. When the peak flow through the principle spillway exceeds 50 cfs the structure should be designed by a Professional Engineer with expertise in hydrology and hydraulics. Structures shall be designed as water impoundment structures in accordance with SCS Pond Standard 378 or other approved methods. Design criteria shall be commensurate with the complexity of site conditions, including consideration of damages that would be caused by breaching of the embankment by overtopping.

Purpose

The purpose of a Storm Water Retention Structure is to intercept stormwater runoff and to protect drainageways, properties, and right-of-ways downstream of the structure.

Conditions Where Practice Applies

A Storm Water Retention Structure is appropriate where physical site conditions or land ownership restrictions preclude the installation of other erosion control measures to adequately control runoff, erosion, and sedimentation. It may be used below construction operations which expose areas to soil erosion. The basin shall be maintained throughout the life of the development which produced the need for the basin.

Design Criteria

Classification

Type 4/	Max. W/S Size(ac.)	Max. Dam 1/ Ht.(ft.)	Design Storm Frequency 2/	Freeboard 3/ (ft.)
1	20	7	10-yr/24-hr	0.5
2	20	10	10-yr/24-hr	0.5
3	150	15	25-yr/24-hr	1.0

1/ Height is measured from the top of the dam to the low point on the original centerline survey of the dam.

2/ Runoff shall be determined by SCS methods or other methods accepted by local ordinances. Soil and cover conditions used should be based on those expected during the construction period.

3/ Vertical distance between basin water surface at maximum design stage and top of dam.

4/ Type 1 basins are to be used only where site conditions prevent the construction of an emergency spillway on residual earth.

Location

The stormwater retention structure should be located to obtain the maximum storage benefit from the terrain and for ease of cleanout of trapped sediment. It should be located to minimize interference with construction activities and construction of utilities. Whenever possible, retention basins should be located out of flood plain areas and shall not be located on flowing streams. Retention basins can be an excavated basin type as well as an earthfill dam type or a combination of the two.

Entrance of Runoff Into Basin

The entrance points of surface runoff into the basins shall be protected to prevent erosion. Considerable care should be given to the major points of inflow into basins to prevent gullying and sediment generation within the basin. Riprap check dams, grade stabilization structures, or other water control devices shall be installed at main points of inflow to ensure direction of runoff and protect the points of entry into the basin. Points of entry should be located so as to ensure maximum travel distance of runoff water through the basin to the point of exit from the basin.

Erosion and Sedimentation Control

Construction operations shall be carried out in such a manner that erosion and sedimentation will be minimized. State and local laws shall be complied with concerning pollution abatement.

Safety

Stormwater retention structures are attractive to children and can be very dangerous. Local ordinances and regulations must be adhered to regarding health and safety. The developer or owner shall check with local building officials on applicable safety requirements. If fencing of sediment basins is required, the location of and type of fence shall be shown on the plans.

Storage

The minimum capacity of a storm water retention structure shall be 0.5 inch per acre of the potential disturbed portion of the drainage area to account for the volume of sediment expected to be trapped in the structure during the development period and the runoff water from a 2-year frequency, 24-hour duration storm.

Shape of the Basin

The storm water retention basin should have a flow length to width ratio greater than 2:1, where flow length is the distance between the point of inflow and the point of outflow. The purpose of this requirement is to minimize the "short-circuiting" effect of the sediment laden inflow to the riser and thereby increase the effectiveness of the structure.

The required basin shape may be obtained by proper site selection, by excavation, or by constructing baffles in the

basin. The baffle will increase the effective flow length from the inflow point to the riser. Baffles shall be place midway between the inflow point and the riser. The baffle length shall be as required to provide the minimum 2:1 length-width ratio. The effective length shall be the shortest distance the water must flow from the inflow point around the end of the baffle to the outflow point.

Principal (Pipe) Spillway Design

Layout: The spillway shall consist of a vertical riser joined at its bottom to a conduit (barrel) which extends through the embankment. Connections shall be watertight.

Capacity: The maximum capacity of the pipe spillway shall not exceed the peak rate of runoff from the drainage area in its natural undeveloped state for all intensities up to and including the design storm frequency. The minimum inside diameter of the barrel shall be 8 inches. The diameter of the vertical inlet riser should be a minimum of 1.5 times greater than that of the barrel to ensure full barrel flow. The pipe spillway should be adequately sized to remove 50% of the runoff volume of the design storm within a 3 day period.

Inlet Data: The vertical inlet may be one of the following:
1. A full round pipe.
2. A half round pipe fitted for flashboards.
3. A box-type riser fitted with flashboards.

The crest of the inlet shall be set so that no discharge will occur until the storage requirement (runoff 2-year, 24-hour storm and 1/2-inch sediment storage) has been met. The riser shall have a base of sufficient weight to provide a 1.5:1 safety factor against flotation. An approved trash rack and anti-vortex device shall be securely installed on top of the riser.

Anti-Seep Collars: Anti-seep collars shall be installed around all conduits through earth fills according to the following criteria:
1. Collars shall be placed to increase the seepage length along the conduit by a minimum of 15 percent of the pipe length located within the saturation zone.
2. Collar spacing shall be between 5 and 14 times the vertical projection of each collar.
3. All collars shall be placed within the saturation zone.
4. All anti-seep collars and their connection shall be watertight.

Outlet: Protection of outlet shall be provided where needed to prevent outlet scour. A measure such as an excavated plunge pool with rock riprap is suitable for this purpose.

Dewatering the Basin

Dewatering shall be done in such a manner as to remove the relatively clean water without removing any of the sediment that has settled out and without removing any appreciable quantities of floating debris. Usually, the retention pool may be dewatered as shown in Figure RS-1 or by other approved methods.

After disturbed areas contributing runoff water to the basin have been stabilized, the dewatering device shall be removed to allow the basin to operate only as a storm water retention basin. Any accumulation of sediments that would reduce storm water retention storage shall be removed and disposed of in a proper manner.

Emergency Spillways

Layout: Earth emergency spillways for Type 2 and 3 basins shall be in undisturbed earth. Types 1 basins may be located on compacted earth fill selected for erosion resistance qualities. Other erosion control measures such as rock riprap may be required to ensure stable emergency spillways. Each spillway shall have a longitudinal level section at least 20 feet long at its crest and a straight outlet section for at least 25 feet or 1/2 the base width of the embankment fill.

Capacity and Design: Spillways shall be trapezoidal in cross-section with minimum bottom widths of 8 feet and side slopes of 3:1. The elevation of the emergency spillway crest will be determined through routing procedures of the design storm (see Sediment Basin). The capacity of emergency spillways shall be adequate to pass peak discharges of design storms, less capacities of principal spillways and also considering storage. Spillways shall be designed to pass designed discharges at nonerosive velocities for the types of protection used.

Embankment

The minimum top width shall be eight feet. Side slopes shall be no steeper than 2-1/2:1. On sites where relatively impermeable material (clay) is not available for a core, the downstream side slope shall be increased to 4:1. A keyway shall be constructed along the centerline of the dam. It shall be at least 8 feet wide and shall extend at least 2

feet below the normal ground surface. The core of the embankment should be at least 8 feet wide and consist of the most impermeable material available at the site. This core should extend from the bottom of the keyway to the crest of the emergency spillway.

Maintenance

1. Repair all damages caused by soil erosion and construction equipment at or before the end of each working day.

2. Sediment shall be removed from the structure when 1/2 of the designed sediment accumulation has occurred. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment near a stream or flood plain.

3. The owner or operator should inspect the structure on a regular basis and especially after major storm events. Any damage or needed repairs should be promptly attended to.

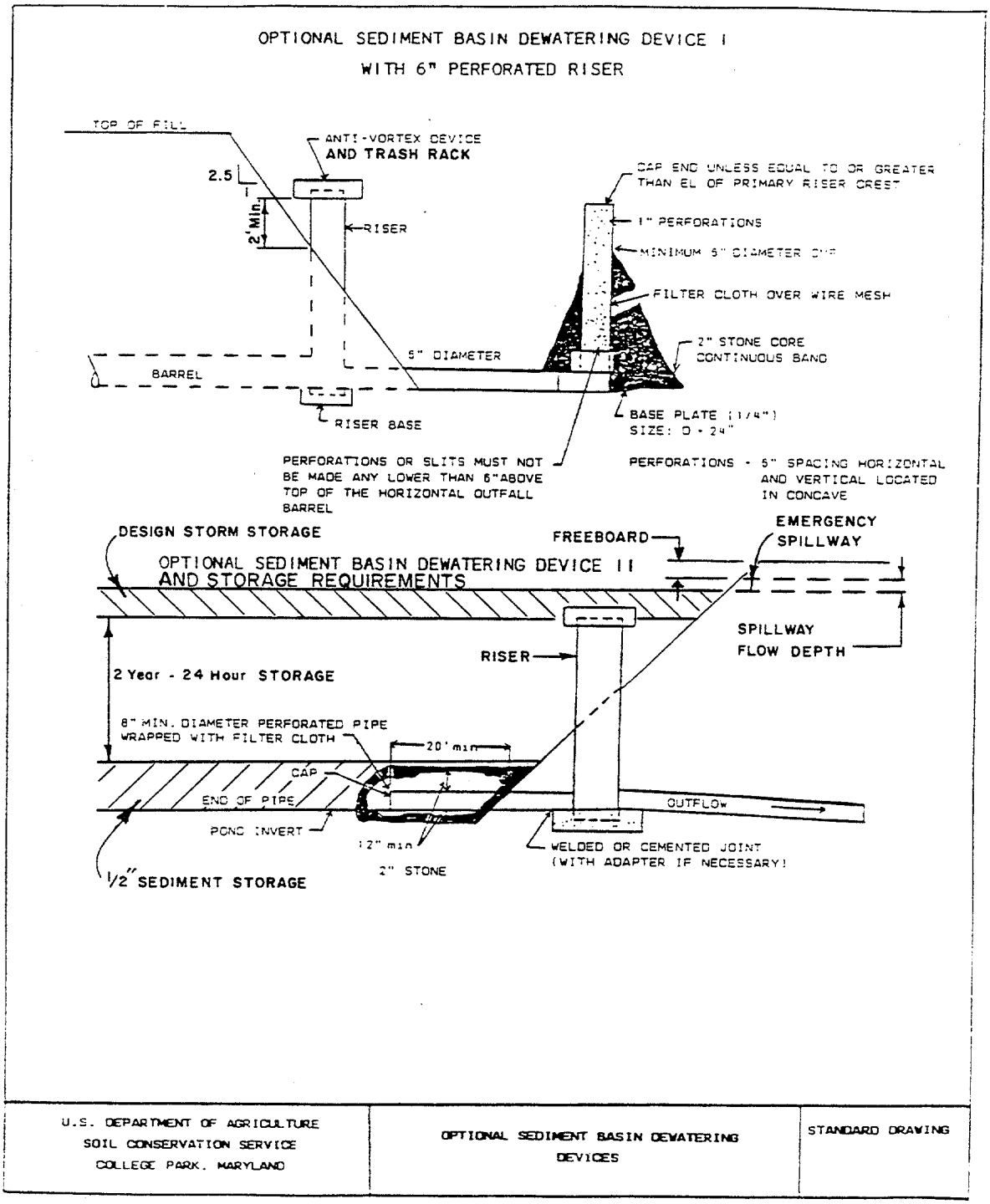


Figure RS-1. Sediment Basin Dewatering Devices.

Construction Specifications
for
Storm Water Retention Structure

Site Preparation: Embankment, impoundment and borrow areas shall be cleared of all woody growth and debris. Embankment and borrow areas shall be cleared of vegetative growth and grubbed of trees, stumps and roots over 2 inches in diameter. Debris shall be disposed of in conformance with all applicable ordinances, rules and regulations.

Borrow Areas: Borrow areas will be confined to the emergency spillway and impoundment areas where suitable material of adequate quantity is available. Borrow areas should not be elsewhere unless the emergency spillway and impoundment area do not have suitable material.

Embankment: Fill material shall be free of woody material, oversized rocks and other objectionable material. Soil moisture must not be too wet or dry to achieve good compaction. Excavations shall be dewatered before filling. Earthfill shall be constructed in 6 to 8 inch horizontal lifts. Compaction shall be achieved by traversing the entire surface of each lift with two tracks of earth hauling equipment or with the use of a roller type compactor. Earth fill shall be considered too wet for placement if free moisture can be seen on the surface of a hand molded sample of the material. Earth fill shall be considered too dry for placement if the material can not be easily molded by hand into a firm ball. Heights of earthfill shall be increased by 10 percent to allow for settlement.

Spillway Installation: The principal and emergency spillways shall be installed as designed. Care shall be taken to surround principal spillway barrels with select plastic material and to carefully hand tamp this material within two feet of the pipe.

Protective Cover: Stabilize embankment, emergency spillway, and borrow areas outside the impoundment area as specified in the appropriate standard.

STREAM CROSSING (SX)

Definition

A temporary structure installed across a flowing watercourse for use by construction traffic. Structures may include spans, pipes, or fords.

Purpose

1. To provide a means for construction traffic to cross flowing streams without damaging the channel or banks or causing flooding.

2. To keep sediment generated by construction traffic out of the stream.

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than 1 square mile. Structures which must handle flow from larger drainage areas should be designed as permanent structures by a professional engineer.

Planning Considerations

Careful planning can minimize the need for stream crossings. Try to avoid crossing streams. Whenever possible, complete the development separately on each side and leave a natural buffer zone along the stream. Temporary stream crossings are a direct source of water pollution; they may create flooding and safety hazards; they can be expensive to construct; and they cause costly construction delays if washed out.

Temporary stream crossings are necessary to prevent construction vehicles from damaging streambanks and continually tracking sediment and other pollutants into the flow regime. However, these structures are also undesirable in that they represent a channel constriction which can cause flow backups or washouts during periods of high flow. For this reason, the temporary nature of stream crossings is stressed. They should be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed.

Fords made of stabilizing material such as rock are often used in steep areas subject to flash flooding, where normal

flow is shallow (less than 3 inches) or intermittent. Fords should only be used where crossings are infrequent. Fords are especially adapted for crossing wide, shallow watercourses. Generally do not use fords where bank height exceeds 5 ft. Rock material used for the ford may be washed out during large storm events and require the rock to be replaced. Mud and other contaminants are brought into the stream on vehicles using ford crossings unless crossings are limited to no flow conditions.

The criteria contained in this standard pertain primarily to flow capacity and resistance to washout of the structure. From a safety and utility standpoint, the designer must also be sure that the structure is capable of withstanding the expected loads from heavy construction equipment. The designer must also be aware that such structures are subject to the rules and regulations of the U. S. Army Corps of Engineers for in-stream modifications (404 permits).

Design Criteria

Culvert Crossings or Spans

1. The structure shall be large enough to convey the flow expected from a 2-year frequency, 24-hour duration storm without appreciably altering the stream flow characteristics. The structure may be a span or culvert. If culverts are used, see Table SX-1 for aid in selecting the appropriate size. (Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert that may be used is 18 inches.

2. Where culverts are installed (Figure SX-1), compacted soil will be used to form the crossing. The depth of soil cover over the culvert shall be equal to one-half the diameter of the culvert or 24 inches, whichever is greater. To protect the sides of the fill from erosion, riprap shall be used and designed in accordance with the standard entitled RIPRAP.

3. The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.

4. The grade of the culvert pipe shall be at least 0.25 inch per foot.

5. The top of the compacted fill shall be covered with 6 inches of Alabama Highway Department course aggregate No. 1 stone (3/4" to 4").

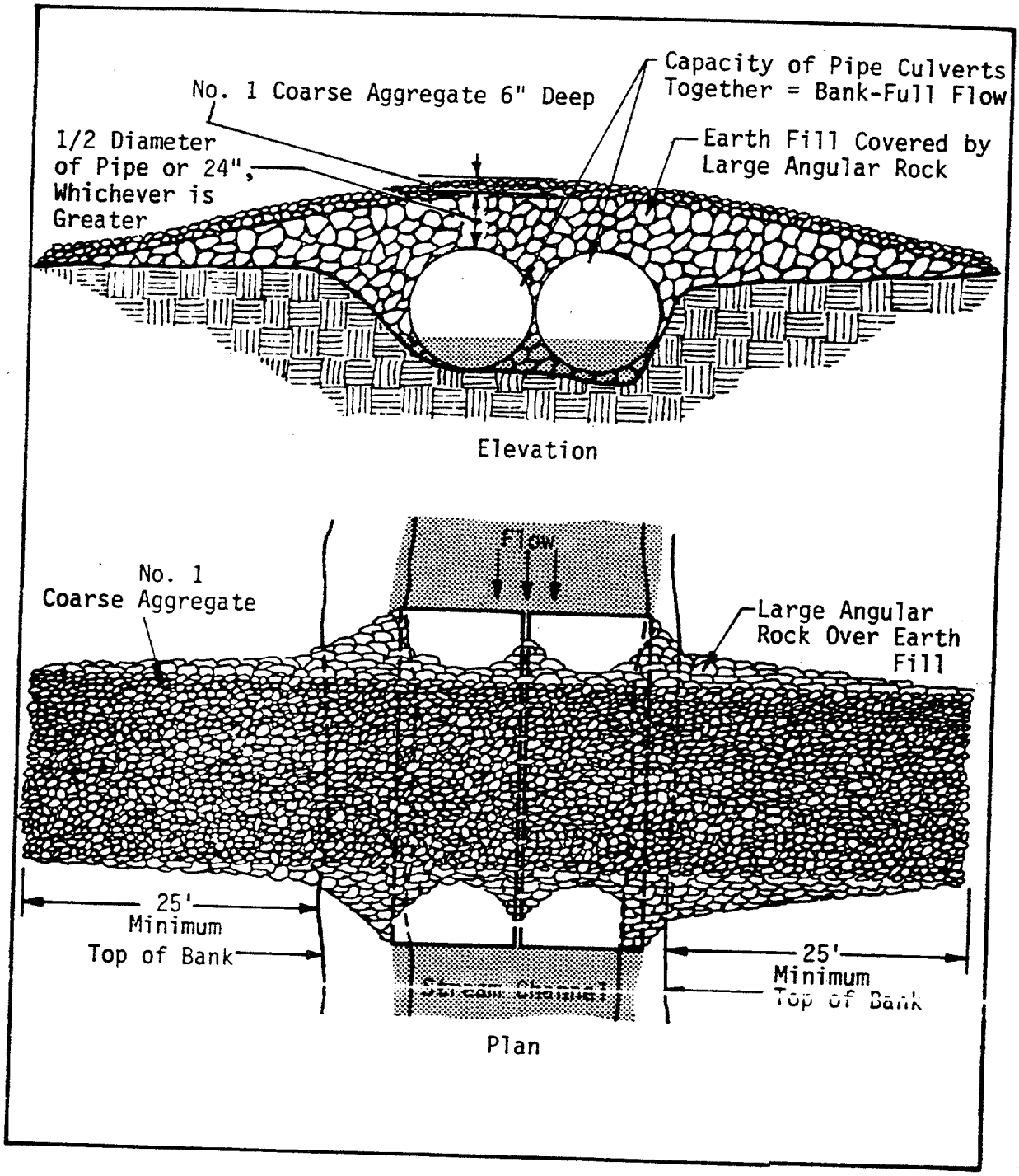


Figure SX-1. Culvert Stream Crossing.

6. The approaches to the structure shall consist of stone pads meeting the following specifications:

   a. Stone: Alabama Highway Department course aggregate No. 1
   b. Minimum thickness: 6 inches
   c. Minimum width: equal to the width of the structure
   d. Minimum approach lengths: 25 feet

7. Spans for stream crossings should be designed by a professional engineer.

Table SX-1. Pipe Diameter for Stream Crossing.

Drainage Area (Acres)	Average Slope of Watershed			
	1%	4%	8%	16%
1-25	30	30	36	36
26-50	30	36	42	48
51-100	36	48	48	54
101-150	42	48	60	60
151-200	42	54	72	72
201-250	48	60	72	72
251-300	48	60	72	72
301-350	48	60	72	2X60
351-400	54	72	2X60	2X60
401-450	54	72	2X60	2X60
451-500	54	72	2X60	2X72
501-550	60	72	2X60	2X72
551-600	60	72	2X60	2X72
601-640	60	72	2X60	2X72

Assumptions for determining the table: USDA-SCS Peak Discharge Method; CN a 70; Rainfall depth (average for Alabama) = 4.3" for 2-year/24-hour storm; No tailwater exists; and the depth of water at the inlet invert is 1.5 X diameter.

<u>Fords</u> (Figure SX-2)

1. Stream banks should be excavated to provide approach sections of 5:1 or flatter.

2. The width of the ford crossings should be wide enough for the construction equipment to safely use.

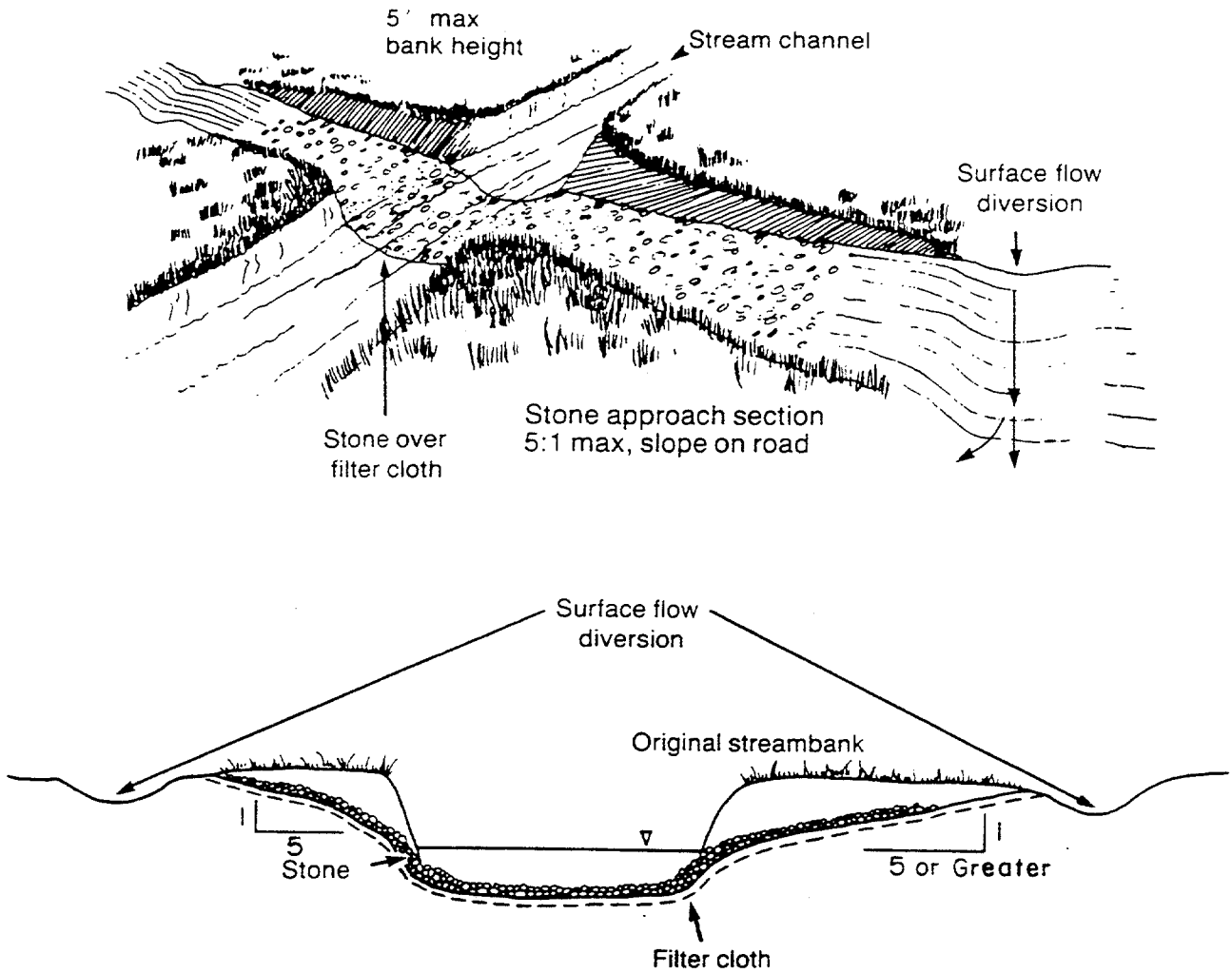


Figure SX-2. Ford Stream Crossing.

3. Filter fabric material designed for use under Riprap should be installed on the excavated surface of the ford according to the manufacturers recommendations. The fabric should extend across the bottom of the stream and at least 25 ft. up each approach section. All edges of the fabric should be keyed in a minimum of 1 ft.

4. Alabama Highway Department course aggregate No. 1 stone, 6 inches thick should be installed on the filter fabric and also should be used to fill the 1 ft. keyed edges of the fabric.

5. The final surface of the stone in the bottom of the watercourse shall be the same elevation as the watercourse bottom in order to eliminate any overfall and possible scour problems.

Maintenance

The structure shall be inspected after every rainfall and at least once a week, whether it has rained or not, and all damages repaired immediately.

Construction Specifications
for
Stream Crossing

1. Clearing and excavation of the stream bed and banks shall be kept to the minimum needed in order to install the structure. Streambank excavation shall be done without excavated material being moved into live streams.

2. Keep stream crossings at right angles to the stream flow. This is particularly important when culverts are used.

3. The span or pipe structure shall be removed as soon as it is no longer necessary for project construction. Ford structures in most cases may be left in place at the end of construction.

4. Upon removal of the structure, the stream shall immediately be reshaped to its original cross-section and properly stabilized.

SURFACE ROUGHENING (SR)

Definition

Providing a rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine-grading them.

Purposes

1. To aid in establishment of vegetative cover with seed.
2. To reduce runoff velocity and increase infiltration.
3. To reduce erosion and provide for sediment trapping.

Conditions Where Practice Applies

1. All slopes steeper than 3:1 require surface roughening, either stairstep grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.
2. Areas with grades flatter than 3:1 should have the soil surface lightly roughened and loose to a depth of 2 to 4 inches prior to seeding.
3. Areas which have been graded and will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.
4. Slopes with a stable rock face do not require roughening or stabilization.

Planning Considerations

Graded areas with smooth, hard surfaces give a false impression of "finished grading" and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished. However, the rough surface encourages water infiltration, speeds the establishment of vegetation, and decreases runoff velocity.

Rough, loose soil surfaces give lime, fertilizer and seed some natural coverage. Niches in the surface provide

microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

1. Disturbed areas which will not require mowing may be stair-step graded, grooved, or left rough after filling.

2. Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material which sloughs from above, and provides a level site where vegetation can become established.

3. Areas which will be mowed (these areas should have slopes flatter than 3:1) may have small furrows left by discing, harrowing, raking, or seed-planting machinery operated on the contour.

4. It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all, but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.

Maintenance

Periodically check the seeded slopes for rills and washes. Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

Construction Specifications
for
Surface Roughening

Cut Slope Applications For Areas Which Will Not Be Mowed

Cut slopes with a gradient steeper than 3:1 shall be stair-step graded or grooved (Figure SR-1 and SR-2).

1. Stair-step grading may be carried out on any material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.

   The ratio of the vertical cut distance to the horizontal distance shall be less than 1:1 and the horizontal portion of the "step" shall slope toward the vertical wall.

   Individual vertical cuts shall not be more than 30 inches on soft soil materials and not more than 40 inches in rocky materials.

2. Grooving consists of using machinery to create a series of ridges and depressions which run perpendicular to the slope (on the contour).

   Grooves may be made with any appropriate implement which can be safely operated on the slope and which will not cause undue compaction. Suggested implements include discs, tillers, spring harrows, and the teeth on a front-end loader bucket. Such grooves shall not be less than 3 inches deep nor further than 15 inches apart.

Fill Slope Applications For Areas Which Will Not Be Mowed

Fill slopes with a gradient steeper than 3:1 shall be grooved or allowed to remain rough as they are constructed. Method (1) or (2) below may be used.

1. Groove according to #2, above.

2. As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface (Figure SR-3).

Colluvial materials (soil deposits at the base of slopes or from old stream beds) shall not be used in fills as they flow when saturated. At no time shall slopes be bladed or scraped to produce a smooth, hard surface.

Cuts, Fills, and Graded Areas Which Will Be Mowed

Mowed slopes should be 3:1 or flatter. Excessive roughness is undesirable where mowing is planned.

These areas may be roughened with shallow grooves such as remain after tilling, discing, harrowing, raking, or use of a cultipacker. The final pass of any such tillage implement shall be on the contour (perpendicular to the slope.)

Grooves formed by such implements shall be not less than one inch deep and not further than 12 inches apart.

Fill slopes which are left rough as constructed may be smoothed with a dragline or pickchain to facilitate mowing.

Roughening With Tracked Machinery (Figure SR-4)

Roughening with tracked machinery on clayey soils is not recommended unless no alternatives are available. Undue compaction of surface soil results from this practice. Sandy soils do not compact severely, and may be tracked. In no case is tracking as effective as the other roughening methods described.

When tracking is the chosen surface roughening technique, it shall be done by operating tracked machinery up and down the slope to leave horizontal depressions in the soil. As few passes of the machinery should be made as possible to minimize compaction.

Seeding

Roughened areas shall be seeded and mulched as soon as possible to obtain optimum seed germination and seedling growth.

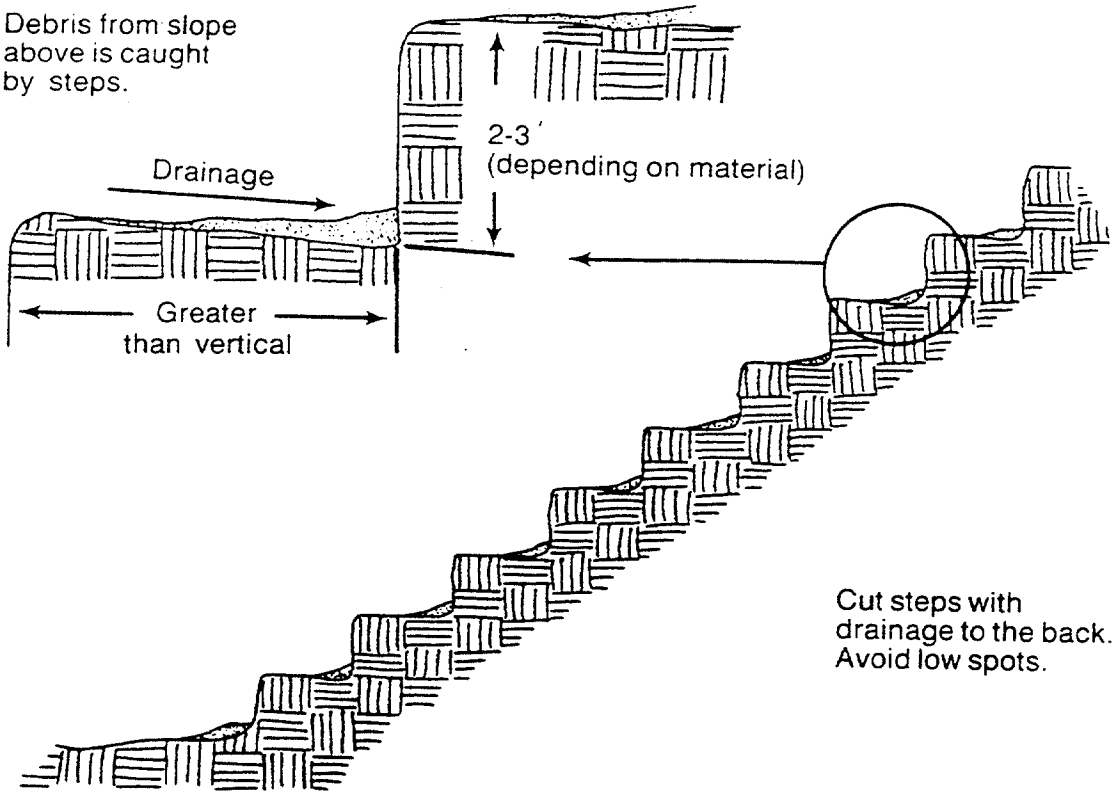


Figure SR-1. Stair-Step Grading.

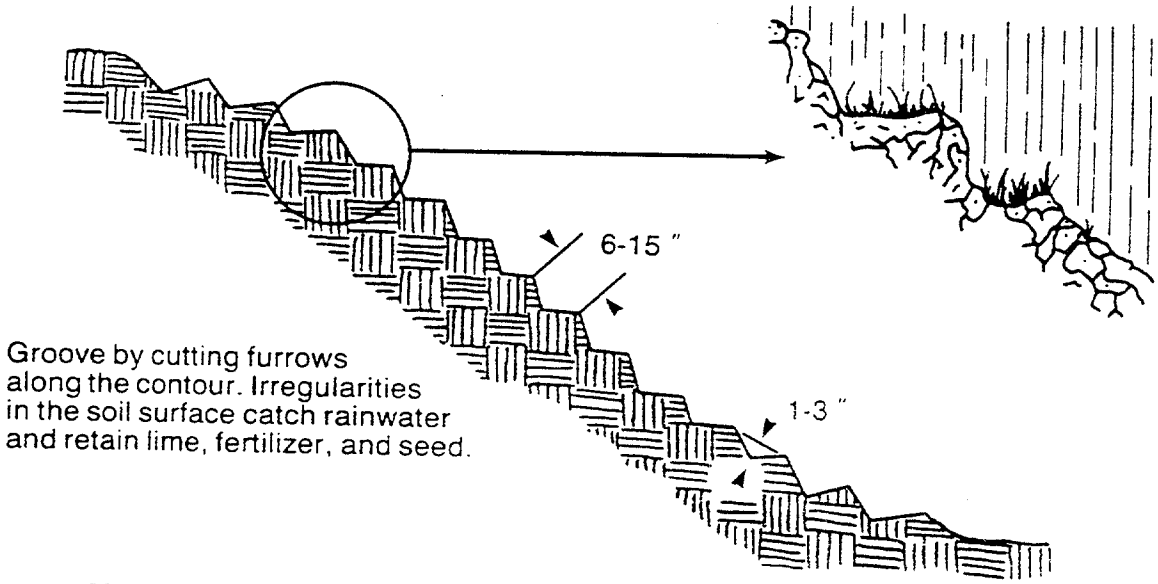


Figure SR-2. Grooving.

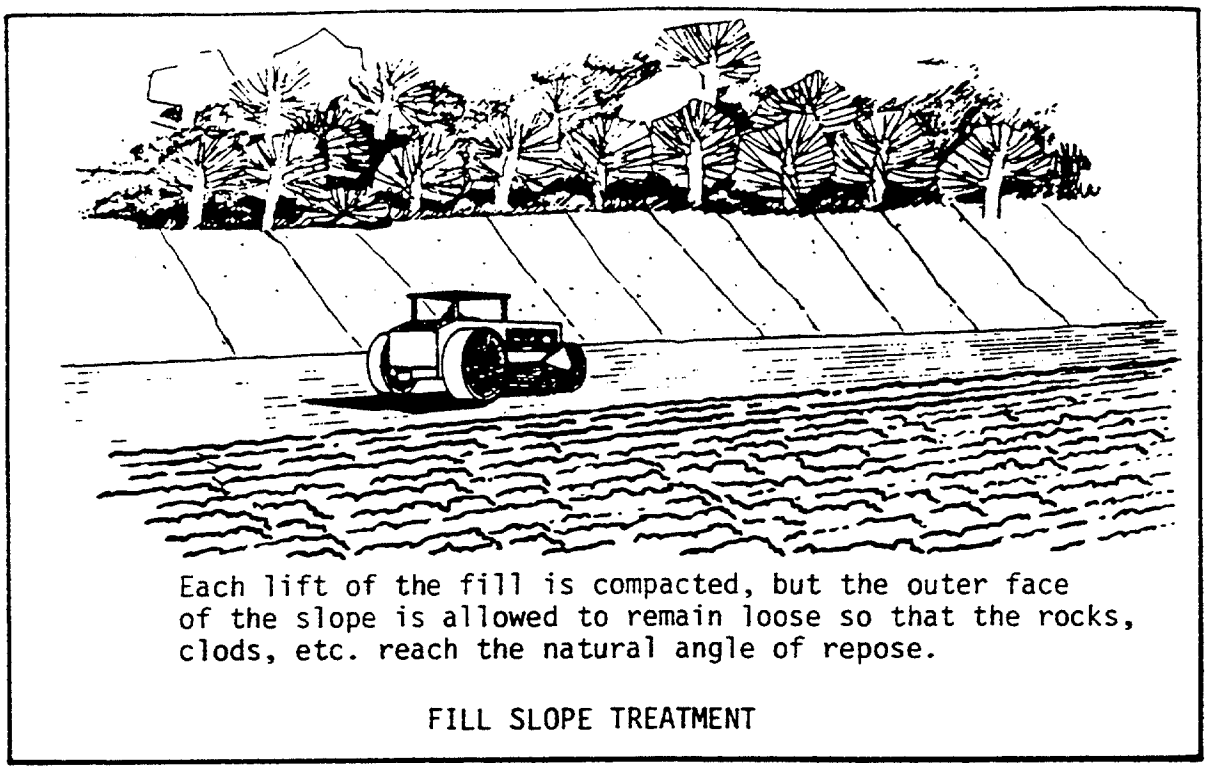


Figure SR-3. Loose Outer Slope Construction.

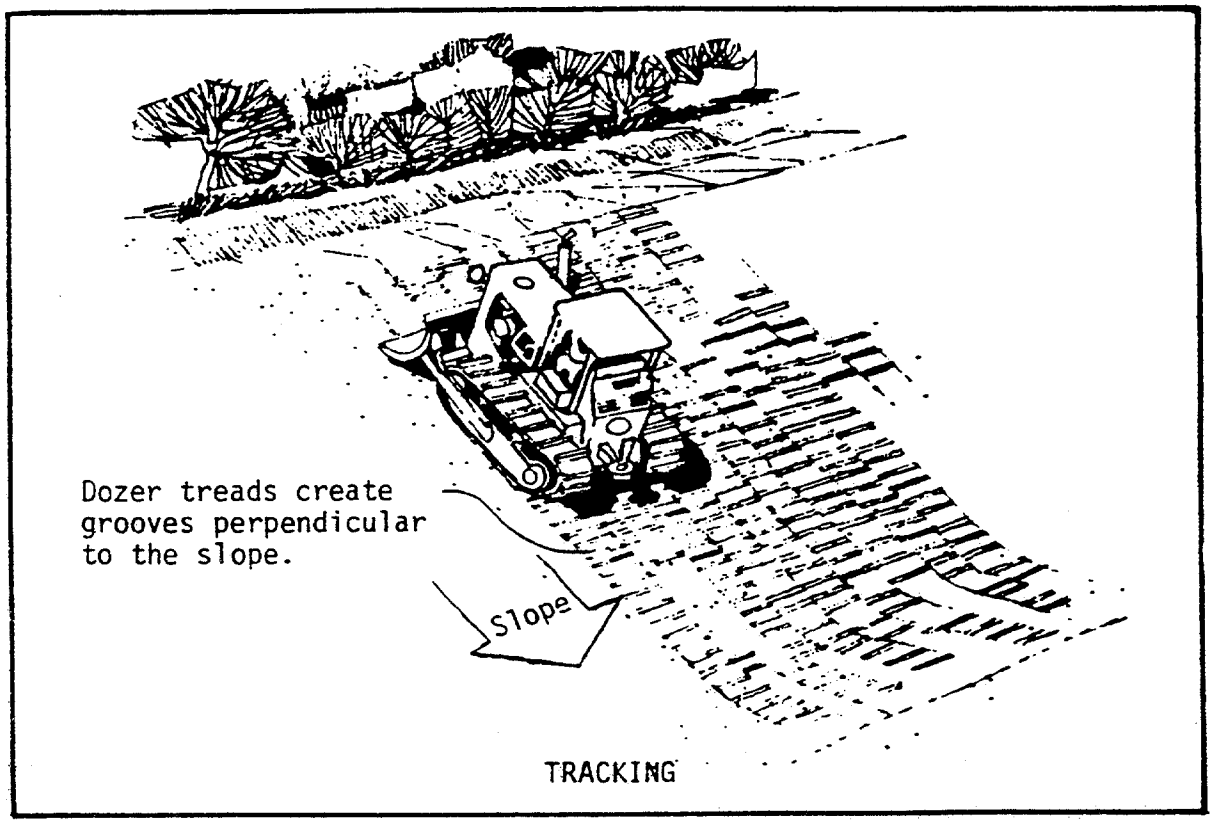


Figure SR-4. Tracked Roughening.

TOPSOIL (TS)

Definition

Removing the more fertile topsoil, storing it and replacing it after final grading to enhance permanent site stabilization with vegetation.

Purpose

To provide a better soil medium for establishing and sustaining permanent vegetation so as to provide better soil cover and minimize future erosion.

Conditions Where Practice Applies

1. Sites where a sufficient quantity of suitable quality topsoil is available.

2. Where the excavated subsoil is not suitable for establishing and sustaining adequate permanent vegetation.

3. Where final graded slopes are 3:1 or flatter and topsoil can be reasonably replaced.

4. Where topsoil replacement is the most economical or expeditious method of providing the proper plant medium to minimize future erosion or to present the desired landscape appearance.

Planning Considerations

Topsoil is the surface layer of the soil profile, generally characterized as darker than the subsoil due to enrichment with organic matter. It is the major zone of root development and biological activity. Microorganisms that enhance plant growth thrive in this layer. Topsoil can usually be differentiated from subsoil by texture as well as color. Clay content usually increases in the subsoil.

The depth of topsoil may be quite variable. On severely eroded sites it may be non-existent.

Advantages of topsoil include its high organic-matter content and friable consistency (soil aggregates can be crushed with only moderate pressure), and its available

water-holding capacity and nutrient content. Most often it is superior to subsoil in these characteristics. The texture and friability of topsoil are usually much more conducive to seedling emergence and root growth.

In addition to being a better growth medium, topsoil is often less erodible than subsoils, and the coarse texture of topsoil increases infiltration capacity and reduces runoff.

Although topsoil provides an excellent growth medium, there are disadvantages to its use. Stripping, stockpiling, and reapplying topsoil, or importing topsoil, may not always be cost-effective. Topsoiling can delay seeding or sodding operations, increasing the exposure time of denuded areas. Most topsoil contains weed seeds, and weeds may compete with desirable species.

In site planning, the option of topsoiling should be compared with that of preparing a seedbed in subsoil. The clay content of subsoils does provide high moisture availability and deter leaching of nutrients. When properly limed and fertilized, subsoils may provide a good growth medium especially if there is adequate rainfall or irrigation water to allow root development in otherwise high density material.

Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a required procedure when establishing vegetation on shallow soils, soils containing potentially toxic materials, and soils of critically low pH (high acid) levels.

If topsoiling is to be done, the following items should be considered:

1. An adequate volume of topsoil should exists on the site. Topsoil will be spread at a compacted depth of 2-4 inches.

2. The topsoil stockpile should be located so that it meets specifications and does not interfere with work on the site, block drainage or release appreciable amounts of sediment.

3. Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding, or planting.

4. <u>Care must be taken not to apply topsoil to subsoil if the two soils have contrasting textures.</u> Clayey topsoil over sandy subsoil is a particularly poor

combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.

5. If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation.

Design Criteria

Materials

Field exploration of the site shall be made to determine if there is sufficient surface soil of good quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). It shall be free of debris, trash, stumps, rocks, roots and noxious weeds, and shall give evidence of being able to support healthy vegetation. It shall contain no substance that is potentially toxic to plant growth.

Potential topsoil should be tested by a recognized laboratory. It should meet the following criteria:

Organic matter content shall be not less than 1.0% by weight.

pH range shall be from 6.0-7.5. If pH is less than 6.0, lime shall be added in accordance with soil test results or in accordance with the recommendations of the vegetative establishment practice being used.

Soluble salts shall not exceed 500 ppm.

If additional off-site topsoil is needed, it must meet the standards stated above.

The depth of material meeting the above qualifications should be at least 2 inches. Soil factors such as rock fragments, slope, depth to water table, and layer thickness affect the ease of excavation and spreading of topsoil.

Generally, the upper part of the soil, which is richest in organic matter, is most desirable; however, material excavated from deeper layers may be worth storing if it meets the other criteria listed above.

Stripping

Strip only those areas that will be affected by construction or development. A normal stripping depth is 4-6 inches but

deeper depths may be satisfactory if the soil is suitable and undercutting is allowable in locations such as buildings, water impoundment structures, roadways, etc. Temporary sediment control measures such as silt fences, sediment basins, diversions hay bale barriers, etc., should be in place before the topsoil is stripped.

Stockpiling

The stockpile location should be out of drainageways and traffic routes. Stockpiles should not be placed on steep slopes where undue erosion will take place. Measures should be taken to prevent erosion of the stockpiles. These would include:

1. Mulching the stockpile when it is left inactive for an appreciable period of time.

2. Planting temporary vegetation when the stockpile is to be inactive over winter or periods of expected heavy rainfall.

3. Covering the stockpile with plastic whenever the piles are small or any soil loss would damage existing buildings or facilities.

4. Planting permanent vegetation when the stockpile use will be inactive over 12 months.

5. Sediment barrier protection should be in place before the stockpile is started.

Site Preparation

Areas to be covered with topsoil shall be excavated, graded, filled and shaped to the proper lines, grades and elevations before topsoil placement is started.

The subgrades should be checked for pH and limed if it is less than 6.0. Liming shall be done in accordance with soil tests and in relation to the seeding mixture to be planted. Incorporate lime to a depth of at least 2 inches by discing.

Applying Topsoil

The subsoil should be disced or scarified to a depth of 4 inches to enhance bonding of the subsoil and topsoil, immediately before placement of topsoil. Topsoil should be uniformly spread to 2 inches on 3:1 slopes and 4 inches on flatter slopes. Required volumes of topsoil may be determined by use of Table TS-1. Topsoil should not be

Construction Specifications
for
Topsoil

1. The materials to be used as topsoil shall be salvaged from the areas designated on the drawings or as approved by the engineer.

2. Any material that is found not suitable for topsoil shall be disposed of as directed by the engineer.

3. Any topsoil brought to the site shall be approved before delivery.

4. Remove topsoil to a depth of 4" from the designated area. Provide erosion control measures on borrow areas to prohibit off-site sediment damage.

5. Install any needed sediment control or erosion prevention measures before removing soil from borrow areas or moving soil into the stockpile area.

6. Place the topsoil in the stockpile area shown on the drawings or at a location mutually agreeable to all parties.

7. Protect any inactive stockpiles as follows:

   a) Mulching when the stockpile will be inactive over 30 days.

   b) Establishing temporary vegetation when the stockpile will be inactive over winter or spring or 120 days.

   c) Establishing permanent vegetation when the stockpile will be inactive over 12 months.

8. Prepare the site in accordance with notes on the drawings or as follows:

   a) Check the pH of the site after grading.

   b) If the pH is below 6.0, take soil samples for liming recommendations.

   c) Apply lime in accordance with soil samples with recommendations for the specified seeding mixture.

   d) Incorporate the lime to a depth of 2 inches.

spread when it or the subgrade is frozen or muddy. Precautions should be taken to prevent layering of the topsoil over the subsoil. Mixing and bonding of the two soils should be enhanced.

Table TS-1. Cubic Yards of Topsoil Required for Application to Various Depths.

Depth (inches)	Per 1,000 Sq. Ft.	Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	537
5	15.5	672
6	18.6	806

Settling of the topsoil is necessary to bond the soils together, but undue compaction should be prevented. Light compaction is necessary to increase soil strength, reduce erosion and enhance vegetation establishment. Excessive compaction should be prohibited as it increases runoff and inhibits seed germination and root development.

Surface irregularities that would impede drainage, increase erosion or otherwise damage the site should be removed in final grading. Areas that will not be maintained by mowing may be left rough in accordance with the Surface Roughening Standard of this manual.

Maintenance

Repair any compacted, eroded or otherwise damaged areas before starting seeding operations.

9. Disc or scarify the subsoil to a depth of 4 inches immediately before topsoiling.

10. Apply topsoil 2 inches deep on 3:1 slopes and 4 inches deep on flatter slopes.

11. Do not apply topsoil when subsoil is frozen or muddy.

12. Lightly compact the placed material to settle the topsoil.

13. Final grade to remove irregularities taking care to preserve the depth of the topsoil.

14. Proper steps to establish vegetation shall be taken immediately after topsoiling.

WATERWAY OR STORM WATER CHANNELS (WW)

Definition

A natural or constructed channel shaped or graded to required dimensions and established in suitable vegetation or structural material for stable conveyance of runoff.

Purpose

To convey surface runoff without damage to the channel from erosion.

Conditions Where Practice Applies

This structure may be applied to sites where erosion and/or scour is a problem due to concentrated flow and inadequate protection.

Planning Considerations

Waterways should be carefully built to the design cross-section, shape and dimensions. Waterways are hydraulic structures and as such depend upon the hydraulic parameters to serve satisfactorily. Vegetated waterways should be well established before large flows are permitted in the channel.

Waterways may be used to:

1. Serve as outlets for diversions and sediment control basins and storm water retention structures.

2. Convey water collected by road ditches or discharged through culverts.

3. Rehabilitate natural draws and gullies carrying concentrations of runoff.

The design of a channel cross-section and lining is based primarily upon the volume and velocity of flow expected in the channel. If conditions are appropriate, grass or riprap channels are generally preferred over concrete. While concrete channels are efficient and easy to maintain, they remove runoff so quickly that channel erosion and flooding often result downstream. Grass or riprap channels reduce this problem by more closely duplicating a natural system.

Besides the primary design considerations of capacity and velocity, a number of other important factors should be taken into account when selecting a cross-section (Figure WW-1) and lining. These factors include land availability, compatibility with land use and surrounding environment, safety, maintenance requirements outlet conditions, etc.

Triangular shaped ditches are generally used where the quantity of water to be handled is relatively small, such as along roadsides. A grass or sod lining will suffice where velocities in the ditch are low. For steeper slopes where high velocities are encountered, a concrete or stone center lining may be appropriate.

Parabolic channels are often used where the quantity of water to be handled is larger and where space is available for a wide, shallow channel with low velocity flow. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of grass and riprap are also useful where there is a continuous low flow in the channel.

Trapezoidal channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity. Trapezoidal ditches are generally lined with concrete or riprap.

Outlet conditions for all channels should be considered. This is particularly important for the transition from a man-made lining such as concrete to a vegetative lining. Appropriate measures must be taken to dissipate the energy of the flow to prevent scour of the receiving channel.

Waterways should be protected from erosion from concentrated flows. The methods of protecting waterways would include, but not be limited to the following:

1. Vegetation
2. Biodegradable linings and vegetation
3. Stone center
4. Riprap
5. Cellular blocks
6. Rock sills
7. Concrete
8. Buried Hay bales

The type and intensity of the protective linings will determine the design of the waterway.

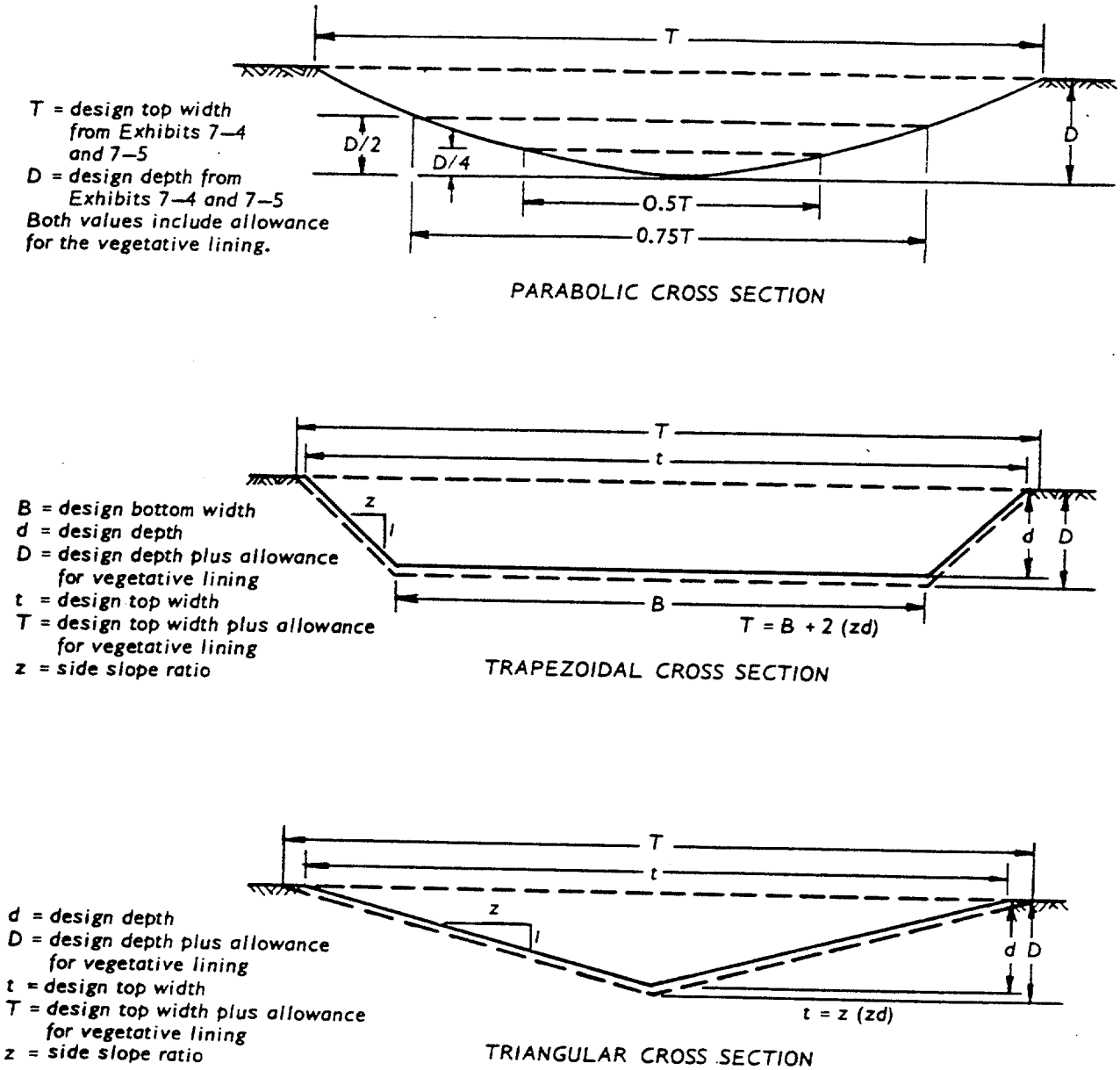


Figure WW-1. Typical Waterway Cross Sections.

The time of the year should be considered when planning vegetated waterways. Waterways that are seeded to establish vegetation should not be planned for construction during late fall, winter or early spring. Waterways constructed during mid-summer to early fall may need temporary seeding established with permanent seeding to follow at the recommended times. The vegetation species should be recommended for the area of the state that it is planned.

Design Criteria

Capacity. Waterways shall be designed to convey the peak rate of runoff from a 10-year/24-hour rainfall event. Adjustments should be made for release rates from structures and other drainage facilities. Waterways shall also be designed to comply with local storm water ordinances. Waterways should be designed for greater capacity whenever there is danger of flooding or out of bank flow cannot be tolerated.

Peak rates of runoff values used in determining the capacity requirements shall be as outlined in the Soil Conservation Service Engineering Field Manual for Conservation Practices, Chapter 2, Estimating Runoff or Soil Conservation Service Technical Release 55, Urban Hydrology for Small Watersheds or Alabama Engineering Field (Design) Manual, Chapter 2 on Estimating Runoff or other comparable methods.

Capacity shall be computed using Manning's equation. An appropriate coefficient of roughness shall be selected based upon the protection material. Recommended "n" values are as follows:

Concrete, trowel finish	0.012 - 0.014
Concrete, float finish	0.013 - 0.017
Concrete, gunite	0.020 - 0.025
Riprap	determined from Figure WW-2

Velocities. Velocities for vegetated waterways shall be limited to those shown in Table WW-1. Waterways lined with riprap, concrete, flagstone or cellular block shall not exceed those shown in Figure WW-3.

Velocities at the outlet of lined sections must not exceed the permissible velocity of the receiving channel. Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical or to a velocity the receiving channel conditions will allow.

Cross-Section

The cross- section may be triangular shaped, parabolic or trapezoidal as discussed in the planning considerations of this standard and the typical waterway cross-sections, Figure WW-1. Side slopes on parabolic waterways shall be eight horizontal to one vertical or flatter.

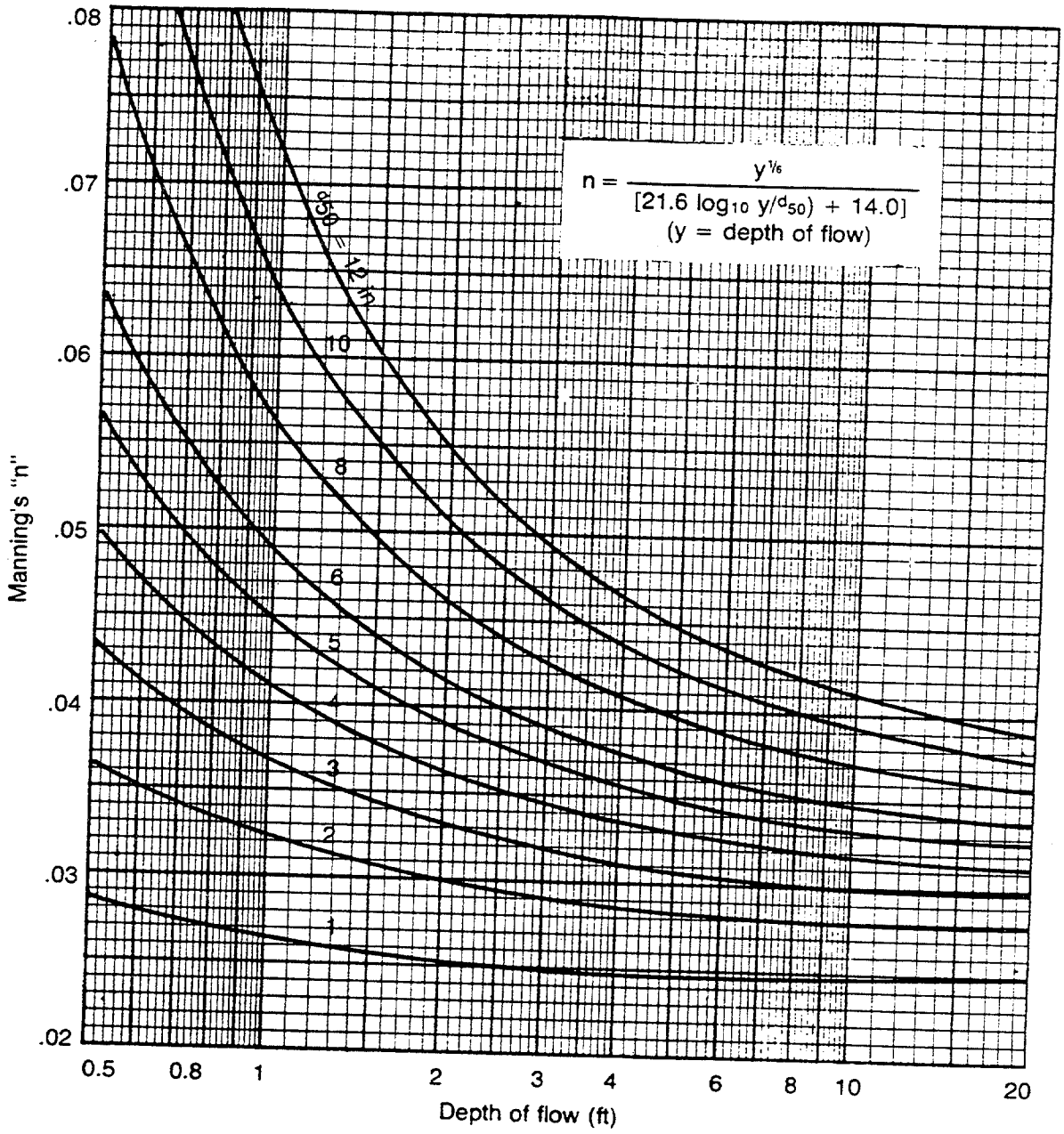


Figure WW-2. Values of "n" for Riprap-Lined Channels. (d_{50} size vs. depth of flow)

Depth

The design water surface elevation of a channel receiving water from other tributary sources shall be equal to or less than the design water surface elevation of the contributing source. The design water surface elevation of contributing and receiving waters should be the same, whenever practical.

A minimum depth may be necessary to provide adequate outlets for subsurface drains and tributary channels.

Table WW-1. Permissible Velocities for Channels Lined with Vegetation.

Cover	Slope range[2]	Permissible velocity[1] Erosion resistant soils[3] (clayey)	Easily eroded soils[4] (sandy)
	percent	*(ft/s)*	*(ft/s)*
Bermudagrass	<5	8	6
	5-10	7	4
	over 10	6	3
Bahiagrass Buffalograss Kentucky bluegrass Smooth brome Blue grama Tall fescue	<5	7	5
	5-10	6	4
	over 10	5	3
Grass mixture	[2]<	5	4
Reed canarygrass	5-10	4	3
Sericea lespedeza Weeping lovegrass Yellow bluestem Redtop Alfalfa Red fescue	[5]<5	3.5	2.5

[1]Use velocities exceeding (5ft/s) only where good covers and proper maintenance can be obtained.
[2]Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
[3]Cohesive (clayey) fine-grain soils and coarse-grain soils with cohesive fines with a plasticity index of 10 to 40 (CL, CH, SC, and CG).
[4]Soils that do not meet requirements for erosion-resistant soils.
[5]Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

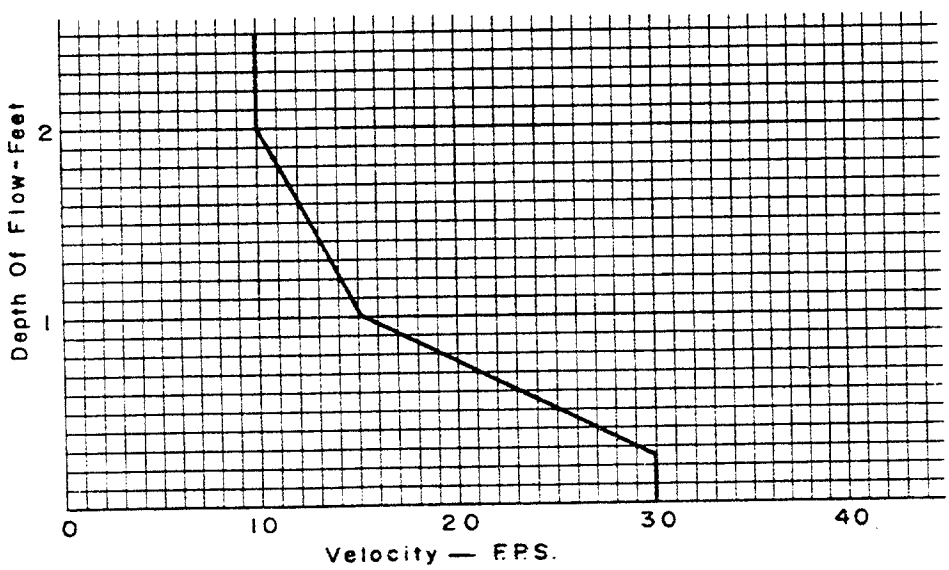


Figure WW-3. Maximum Velocities for Channels Lined with Blocks, Concrete, or Riprap.

Drainage.

Polyethylene drainage tubing, tile or other suitable subsurface drainage measures shall be provided for sites having high water tables or seepage problems. Where there is base flow, a stone center or lined channel will be required.

Freeboard. The minimum freeboard is 0.25 feet. Freeboard is not required on waterways with less than 1% slope and where out-of-bank flow will not be damaging and can be tolerated from an operation point of view.

Filters or Bedding. Filters or bedding to prevent piping, reduce uplift pressures and collect water will be used as required and will be designed in accordance with sound engineering principles. Weep holes and drains will be provided as needed. Geotextiles can be used in lieu of bedding in many cases. Sound engineering principles shall be used in designing and specifying geotextiles.

Maintenance

During the establishment period, check waterways after every rainfall. After grass is established, periodically check the waterway; check it after every heavy rain event. Immediately make repairs. It is particularly important to check the waterway outlet and all road crossings for bank stability and evidence of piping or scour holes. Remove all significant sediment accumulations to maintain the desired carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the waterway. Riprap used for stability of the waterway should also be inspected after major storm events. Any dislocated rock should be immediately replaced to ensure the stability of the waterway.

Construction Specifications
for
Waterways or Stormwater Channels

1. Remove all brush, trees, stumps, roots, loose rocks, obstructions and other objectionable materials from the waterway area.

2. The cross-section shall be excavated to the dimensions, neat lines and grades as shown on the drawings. Over excavated areas shall be backfilled with moist soil and compacted to the density of the surrounding material. The waterway will be free of bank projections or other irregularities which will impede normal flow.

3. The waterway shall have uniform continuous slope with no abrupt deviations in horizontal alignment.

4. All earth material removed and not needed in the construction shall be spread or disposed of so that it will not interfere with waterway functioning. Spoil material shall be blended into surrounding area so that ponding will not be created nor drainage will not be impeded. All disturbed areas shall be smoothed and finished so that vegetation and/or protection linings can be easily installed.

5. Vegetated waterways shall be established to the selected grasses or covers as soon as the waterway is brought to planned dimensions. Applicable vegetative specifications shall be adopted and closely followed. Mulching is highly recommended for establishment of vegetation.

6. Concrete linings shall be placed to the thickness and dimensions shown on the plans and finished and cured in a workman-like manner. Good concreting practices shall be followed. Concrete with a minimum 28-day compressive strength of 3,000 psi or higher shall be used.

7. Rock riprap shall be placed to the depths, widths, thicknesses, lines and grades as shown on the plans. Care shall be taken to install riprap that is well graded without pockets of dust or excessive spalls.

8. Filter bedding shall be placed to the line and grade and in the manner specified. Geotextiles shall be used where specified. Geotextile shall be laid on the subgrade with sufficient slack that it will not suffer

extreme tension during placement of riprap or other protective linings.

9. Construction operations shall be performed in such a manner that erosion, air and water pollution will be minimized.

10. The completed job will present a workmanlike appearance.

CHPT. 4- Vegetation for Erosion and Sediment Control

Chapter 4

VEGETATION FOR EROSION AND SEDIMENT CONTROL

CONTENTS

Page

Introduction.....IV-1

Tree Preservation and Protection.....IV-2

Site Considerations.....IV-5

Site Planning for Tree Protection.....IV-6

Seasonal Considerations.....IV-7

Selection of Vegetation.....IV-7

Selecting the Right Grasses and/or Legumes.....IV-8

Selecting the Right Trees.....IV-13

Selecting Shrubs, Vines, and Groundcovers.....IV-14

Establishing Vegetation.....IV-17

Maintenance.....IV-20

Vegetative Measures

- Buffer Zone (BZ).....IV-BZ-1
- Dust Control (DU).....IV-DU-1
- Irrigation (IR).....IV-IR-1
- Mulching (MU).....IV-MU-1
- Permanent Seeding (PS).....IV-PS-1
- Sodding (SD).....IV-SD-1
- Shrub, Vine and Groundcover Planting (SVG).....IV-SVG-1
- Temporary Vegetation - Seeding (TV).....IV-TV-1
- Tree Planting on Disturbed Areas (TP).....IV-TP-1
- Tree Preservation and Protection (TPP).....IV-TPP-1

VEGETATION FOR EROSION AND SEDIMENT CONTROL

Introduction

A dense, vigorous growing vegetative cover protects the soil surface from raindrop impact, a major force in causing erosion and sedimentation. Also, vegetation will shield the soil surface from the scouring effect of overland flow and decreases the erosive capacity of the flowing water by reducing its velocity.

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

Suitable vegetative cover offers excellent erosion protection and sedimentation control. Vegetative cover is essential to the design and stabilization of many structural erosion control practices. Vegetative cover is relatively inexpensive to achieve and maintain. Also, it is often the only practical, long-term solution to stabilization and erosion control on many disturbed sites.

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

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

Tree Preservation and Protection

It usually takes 20 to 30 years to grow a tree which provides the benefits of an existing tree. Desirable trees should be protected during construction activities. Many building sites are selected because of the presence of desirable trees but unless sufficient care is taken to protect them this valuable resource may be destroyed. Trees provide the following benefits:

- Stabilize the soil and reduce erosion
- Provide shade and moderate temperature
- Reduce wind velocities
- Provide buffers to reduce noise
- Provide visual screens
- Remove carbon dioxide from the air and release oxygen
- Provide habitat and food for wildlife
- Increase property values
- Improve the aesthetics of the urban environment.

Damage To Trees From Construction

Construction activities expose trees to a variety of stresses resulting in injury ranging from superficial wounds to death. Many damages may occur to trees during construction activities. Understanding the types of damages that may occur to trees is important in planning for protection.

Surface Impacts - Natural and man-related forces exerted on trees can cause significant damage. Wind damage can be a problem especially when trees have been removed from a group of trees. This exposes the survivors to greater wind velocities. Trees develop root anchorage where it is needed the most. Isolated trees develop anchorage rather equally all around with stronger root development on the side of the prevailing wind. The more a tree has been protected from the wind the less anchorage it usually has. The result of excessive thinning of trees may be windthrow. Selective thinning in favor of a single tall tree increases the hazard of lightning strike. Excessive pruning of trees to prevent contact with utility lines or buildings may destroy the

visual appeal of the tree, may provide a source of entry for disease causing fungi, or it may kill the tree.

Tree trunks are often damaged during construction activities. Trees are often scarred by construction equipment. Such superficial wounds provide a source of entry for insects and disease.

Root Zone Impacts - Disturbing the relationship between soil and tree roots can damage or kill a tree. The roots of an existing tree are established in an area where soil, water, oxygen, and nutrients are present. The mass of the root system must be the correct size to balance the intake of water from the soil with the transpiration of water from the leaves.

Raising the grade as little as 6 inches can retard the normal exchange of air and gases. Roots may suffocate due to lack of oxygen or be damaged by toxic gases and chemicals released by soil bacteria. Raising the grade may also elevate the water table. This can cause drowning of the deeper roots.

Lowering the grade is usually not as damaging as elevating the grade. Shallow cuts of 6 to 8 inches will remove most of the topsoil and some feeder roots and expose some to drying and freezing. Deep cuts may sever a large portion of the root system, depriving the tree of water and increasing the chance of windthrow. Lowering the grade may also lower the water table.

Trenching or excavating through a tree's root system can eliminate as much as 40 percent of the tree's roots. Trees which lose as much as 40 percent of their root system usually die within 2 to 5 years. Tunneling may be a better alternative in species that do not have tap roots. Soil compaction caused by heavy equipment, materials storage, and paving within the drip line of tree's may restrict air and water from roots.

Selecting Trees to Be Retained

The proper development of a forested site requires a plan for tree retention before construction begins. See Appendix A-IV-TP-1 for tree suitability for disturbed areas and landscaping. Trees should be identified and located on a map. The following criteria should be used to determine which trees to save:

Life expectancy and present age - Trees with long life spans should be favored. Long-lived species that are old may

succumb to the stresses of construction, so younger trees of desirable species are preferred since they are more resilient and will last longer. However, if the cost of preservation is greater than the cost of replacement with a specie of the same age and size, replacement may be preferred.

Health and disease susceptibility - Check for scarring or disease damage, and rotten or broken trunks or limbs.

Structure - Check for structural defects that indicate weakness or reduce the aesthetic value of a tree: trees growing from old stumps, large trees with overhanging limbs that endanger property, trees with brittle wood, misshapen trunks or crowns, and small crowns at the top of tall trunks. Trees growing in the open often have better form than those growing in the forest. Trees with strong tap or fibrous root systems are preferred to trees with weak rooting habits.

Cleanliness - Trees which seed prolifically or sucker profusely are generally less desirable in urban areas. Trees with fruits that have unpleasant odors should be avoided.

Aesthetics - Trees that are attractive and pleasing to the eye are desirable. Trees that have beauty during several seasons of the year are desirable and add value to the site.

Comfort - Trees provide cooling during the summer and buffer the cold winds of winter. Summer temperatures may be 10 degrees cooler under hardwoods than under conifers. Deciduous trees drop their leaves in winter, allowing the sun to warm buildings and soil. Evergreens are more effective wind buffers.

Wildlife - Preference may be given to trees that provide food and cover for wildlife.

Relationship to other trees - Trees growing alone generally are more valuable than trees growing in groups but trees in groups are more effective in preventing erosion and excess stormwater runoff.

Adaptability to other trees - Consider the height and spread of trees and how they may interfere with proposed structures and overhead utilities. Roots may interfere with walls, walks, driveways, patios, parking lots, waterlines, and septic tanks.

Trees must be appropriate for the proposed use of the development. Select trees which are pollution-tolerant for areas with heavy traffic and industrial areas, screen and buffer trees for noise or objectionable views and tolerant species for areas exposed to ocean spray.

Site Considerations

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

Slope

The steeper the slope, the more essential is a vigorous vegetative cover. Good establishment practices, including seedbed preparation, proper planting, lime, fertilizer, mulching, and anchoring of mulch are critical. The degree of slope may limit the equipment that can be used in seedbed preparation, planting, and maintenance.

Woody plants, shrubs, vines, and trees generally provide better erosion control on steep slope. They may be more costly and slower to establish, but can provide substantial savings in maintenance. Also, they can be more desirable in the over all landscape plan.

Aspect

Aspect affects soil temperature and available moisture. South and west facing slopes tend to be warmer and drier, and often require special treatment. For example, mulch may be essential to retain moisture. Also warm-season species tend to do better on south and west facing slopes since they are usually more drought tolerant.

Climate

The regional climate must be considered in selecting well adapted plant species. Species adaptation and seeding dates in Alabama are based on three broad geographical areas: North, Central, and South. Climatic differences determines the appropriate plant selections based on such factors as cold-hardiness, heat tolerance, and tolerance to a cool growing season.

Management

When selecting plant species for erosion control and stabilization, the post-construction land use and the

expected level of maintenance must be considered. In every case, future site management is an important factor in plant selection.

When a site will receive heavy use such as a sports field, select plant species that are wear resistant and have rapid wear recovery. A wear resistant plant that also recovers rapidly from foot traffic is bermudagrass. Bermudagrass also has a fast establishment rate and is adapted to all geographical areas in Alabama.

Where a neat appearance is desired, use plants that respond to frequent mowing and other types of intensives maintenance. Likely choices for quality turf in north Alabama are bermudagrass or tall fescue, while in central or south Alabama bermudagrass, centipede, or zoysia are good choices.

At sites where low maintenance is desired, low fertility requirements and vegetation persistences are particularly important. Sericea lespedeza and tall fescue are good choices in north Alabama while bahiagrass and centipede do well in central and south Alabama.

Soils

Many soils characteristics, including acidity, moisture retention, drainage, texture, organic matter, fertility, and slope influence the selection of plants and their establishment requirements for example, bahiagrass and centipede are suited to droughty soils since they are more drought tolerant than most other grasses. Chapter 2, "Soils and Geology Considerations," contains a general description of soils in Alabama with respect to characteristics that affect stabilization of disturbed sites.

Site Planning For Tree Protection

Select trees to be saved before beginning construction. No tree should be destroyed or altered until the construction plans are final. Areas such as flood plains and wetlands should be left in their natural condition. Locate roadways to cause the least damage to valuable trees. Follow contours where feasible to minimize cuts and fills. Minimize trenching by locating several utilities in the same trench. Excavations for basements and utilities should be kept away from the drip line of trees.

Storage areas for construction materials and worker parking areas should be noted on the site plan, and located where they will not cause soil compacting over roots.

When retaining existing trees in parking areas, leave enough ground ungraded around the tree to allow for its survival. Tree wells may need to be installed.

Locate erosion and sediment control measures at the limits of clearing and not in wooded areas to prevent deposition of sediment within the drip line of trees being preserved. Sediment basins should be constructed in the natural terrain if possible rather than in locations where extensive grading and tree removal will be required.

Seasonal Considerations

Newly constructed slopes and other barren areas should be seeded or sodded as soon as possible after grading. Where feasible, grading operations should be planned around optimal seeding dates for the particular region. The most effective times for planting perennial grasses and legumes generally extend from March through May and from late August through October. Outside these dates the probability of failure is higher. If the time of year is not suitable for seeding permanent cover (perennial species) a temporary cover should be planted or the area may be stabilized with gravel or mulch. Temporary seedings of annual species (small grains, ryegrass, millets etc.) often succeed at times of the year that are unsuitable for seeding permanent (perennial) species. Planting dates may differ for temporary species depending on the geographical area of Alabama.

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

Selection of Vegetation

Plant selection should be considered early in the process of preparing the erosion and sedimentation control plan. A diversity of species can be grown in Alabama due to the variation in both soils and climate. However, for practical, economical stabilization and long-term protection of disturbed sites, plant selection should be made with care. Many plants are inappropriate for soil stabilization

because they do not protect the soil effectively, or they can not be established quick and easy. Some plants may be very effective for soil stabilization, but are not aesthetically acceptable on some sites. Some plants may even become troublesome pests.

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

Trees are an excellent type of permanent vegetation to plant on disturbed areas for long term soil and water protection. Trees may be used on all kinds of areas disturbed during construction activities.

Selecting The Right Grasses and/or Legumes

Mixtures vs Single Species Plantings

Single species plantings are desired in some cases, but most of the time a mixture is more desirable. Mixtures can to selected that may provide protective cover more quickly and can be more enduring than a single species. Mixtures need not be elaborate. The addition of a quick-growing annual or short lived perennial provides early protection and facilitates establishment of a slower growing long lived perennial. It is important to evaluate the merits and weakness of each species in selecting the mixtures for the specific site to be treated.

Companion or "Nurse" Crop

The addition of a companion or "nurse" crop (quick-growing annual or weak perennial added to permanent mixtures) is a good practice on difficult sites, late seeding, or in situations where the development of permanent cover is likely to be slow. The companion crop germinates and grows rapidly, holding the soil until the perennial species becomes established. Seeding rate of the companion crop must be limited to avoid crowding, especially under optimum growing conditions.

Plant Species Selection

Detail Information on plant species adapted for soil stabilization use in Alabama is contained in Appendix IV. Using this information makes plant selection more straight forward for most situations. Specific seeding rates and

planting instructions are given in the specifications of the measures.

Annuals

Annual plants grow rapidly, mature, and die in one growing season. They are useful for quick, temporary cover or as a companion crop for slower growing perennials.

Small Grains - Rye (cereal) is usually superior to other small grains (wheat, oats, or barley) for temporary cover. It has more cold hardiness than other annuals and will germinate and grow at lower temperatures. It will provide more fall and early winter growth and matures earlier than other small grains. Rye germinates quickly and is tolerant of poor soils. Including rye in fall seeded perennial mixtures is particularly helpful on difficult soils and erodible slopes or when seeding is late. However, seeding rates of rye should be limited to the suggested rates because thick stand will suppress the growth of perennial seedlings. No more than 60 lb/acre should be planted when rye is used as a companion crop. Rye does grow fairly tall in the spring which may be undesirable. If this is a problem some of the shorter growing varieties of wheat may be used.

Annual ryegrass is **not recommended** for use as a companion crop in perennial mixtures in Alabama. It is highly competitive and, if included in mixtures, crowds out most other species before it matures in late spring or early summer, leaving little or no lasting cover. It will provide dense cover rapidly, so it can be effective as a temporary seeding, but if allowed to mature the seed volunteers and can seriously interfere with subsequent efforts to establish permanent cover.

Millets (Browntop, Foxtail) are warm season annuals, useful for temporary seeding or as a nurse crop. Browntop millet has early rapid growth, growing two to three feet in height. It is adapted to fine and medium textured soils of moderate productivity. Foxtail is a fine stemmed plant growing to a height of four to five feet. The leaves are broad and flat. Foxtail millets do best under fairly abundant moisture conditions. German millet is a type of foxtail millet.

Sudangrass and sorghum-sudangrass hybrids, like the millets, are warm season annuals which are useful for temporary vegetation. They are better adapted to medium to heavy textured soils. The small stemmed, shorter growing varieties are more satisfactory for temporary vegetation than the tall coarse-stemmed varieties.

Annual lespedeza is a warm-season reseeding annual legume growing to a height of six to twelve inches. It is tolerant of low fertility and is adapted to the climate and most soils throughout Alabama. It is not adapted to alkaline soils of the Black Belt or deep sands. It is a good companion crop for spring planted sericea lespedeza, filling in weak or spotty stands the first season without suppressing the sericea. Annual lespedeza can heal damaged areas in the perennial cover for several years after initial establishment. Two species of annual lespedeza are grown in Alabama. "Common" annual lespedeza volunteers in many parts of Alabama and is sold under the variety name Kobe. Korean lespedeza is a slightly larger, coarser and earlier-maturing plant sold under several variety names. Kobe is superior on sandy soils and generally preferable in south Alabama. Korean is better in north Alabama as the seeds mature earlier.

The preferred seeding dates for annual lespedeza are in the late winter to early spring. It can be mixed with fall seeding, in which case some seeds remain dormant over the winter and germinate the following spring.

Cool-Season Perennials

Perennial plants, once established, will live for more than one year. They may die back during a dormant period, but will grow back from their underground tubers or rhizomes in succeeding years. Stands of perennials will persist for a number of years under proper management and environmental conditions. They are the principal components of permanent vegetative cover.

Cool-season perennials produce most of their growth during the spring and fall and are more cold-hardy than most warm-season species. Tall fescue is the only cool-season perennial grass recommended for vegetating disturbed soils in Alabama. A descriptions of tall fescue follows.

Tall fescue, a cool-season grass, is the most widely used species in north Alabama for erosion control. It is well adapted to all of north Alabama and all but the most droughty soils of central Alabama. Also it can be grown on the Black Belt soils of south Alabama. It thrives in full sun to partial shade and is fairly easy to establish. It will provide stabilization the year of establishment. Because tall fescue has a bunch growth habit it is slow to fill in areas with poor stands. Therefore, some maintenance will be required on washed out areas or areas of spotty stands to prevent further damage.

A number of new varieties of tall fescue are becoming available for lawn and other turf use and several offer definite improvements. However, their higher cost over the old standby, Kentucky 31, is seldom justified solely for purposes of stabilization and erosion control. Also, fescue seed infected with a fungal endophyte are preferred since endophyte infected plants are more hardy and stands persist longer.

Tall fescue is a fall planted grass. Liberal fertilization and proper liming are also essential for prompt establishment, but once established it can tolerate minimal maintenance almost indefinitely. White clover is sometimes planted with tall fescue.

Warm-Season Perennials

Warm-season perennials initiate growth later in the spring than cool-season species and experience their greatest growth during the hot summer months. Most species of warm-season perennials do better in the southern one-half of Alabama, but there are species or varieties that will grow in north Alabama. The following grasses have proven the most useful for soil stabilization.

Bahiagrass is a warm-season perennial grass particularly well adapted for growing on sandy soils in the southern half of Alabama. It will tolerate acid and low fertility soils, grow in full sun to light shade, and persist almost indefinitely with little or no maintenance after it is established. However, bahiagrass seedlings are small and lack the vigor some species of warm-season grasses possess, it usually takes two years to establish a good sod. Bahiagrass is established with seed.

Bahiagrass does produce a fairly dense sod suitable for low maintenance areas. It has a high resistance to wear and recovers fairly fast from wear. It produces rhizomes and will fill in small bare spots fairly fast. Bahiagrass will produce seedheads about one to two feet in height throughout the growing season and, where this is not a problem, it is probably the best choice for stabilizing soil in the southern one half of the state.

Pensacola is the better variety of bahiagrass for soil stabilization. It is more tolerant to upland sites and is more cold tolerant than Argentine bahiagrass.

Common Bermudagrass is a long lived perennial that spreads by creeping stolons and rhizomes that will extend outward

several feet in a growing season. It will survive extreme heat and drought. It is not shade tolerant. Bermudagrass is best adapted to well drained fertile soils. It does poorly on extremely droughty sandy soils and will not grow on poorly drained soils. It responds well to fertilizer and will establish a dense sod quickly from seed. Common bermudagrass will grow in all areas of the state.

Bermudagrass requires more maintenance than bahiagrass and, if a regular maintenance fertility program is not used, it will tend to slowly decline. It has a high resistance to wear and a fast recovery from wear which makes it a good choice for heavy use areas.

There are two types of bermudagrass which are important in soil stabilization. Common bermudagrass, which can be established with seed or sprigs, and turf-type bermudagrasses which must be established from vegetative material. Common has longer internodes and larger leaves than the turf-type hybrid bermudagrass. When common bermudagrass will be used for permanent vegetation, only seed that are 98% pure common bermudagrass should be planted. Common bermudagrass seed are often contaminated with giant-type bermudagrass seed. Giant-type bermudagrass is very competitive and fast growing, but is not cold hardy in Alabama. So when common bermudagrass seed contains even a small percent of giant type bermudagrass seed, they will be "choked out" by the giant-type bermudagrass. Since the giant-type bermudagrass is killed by the cold a good sod the year of establishment becomes nothing the second year.

The turf type hybrid bermudagrasses have fine leaves and short internodes which make them desirable for lawn, golf courses and other areas where a quality turf is desired. However, turf type hybrid bermudas are more costly to establish because they must be planted from sprigs, plugs, or solid sodded. Tifway 419 is the most commonly used turf type hybrid bermudagrass.

The agronomic varieties of hybrid bermudas do not lend themselves to soil stabilization of construction areas. They too must be established with vegetative material which makes them costly to establish.

Perennial Legumes

Sericea lespedeza or sericea is a deep rooted, drought resistant perennial legume, adapted to all but the poorly drained and deep sandy soils of the state. It is long lived, tolerant of low fertility soils, pest free, and will fix nitrogen. It can be a valuable component in most low

maintenance mixtures. Sericea is slow to establish and will not contribute much to prevention of erosion the first year; however, once established it persists indefinitely on suitable sites.

Plantings that include sericea require mulch and should include a companion crop such as browntop millet, annual lespedeza, or common bermudagrass. Sericea should be planted as early as possible within the planting date so as to reduce as much weed competition as possible. Also, sericea may be planted in the late fall and winter months because many of the seeds will lie dormant until germination the following spring.

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

Crownvetch is a deep rooted, perennial legume adapted only to north exposures in the northern tier of counties in Alabama. It is useful on steep slopes and rocky areas that are likely to be left unmoved. It can be seeded in the spring or fall. Crownvetch requires a specific inoculant.

Selecting the Right Trees

In urban areas trees may be exposed to insufficient sunlight and water; high winds; heat radiation from highways and parking lots; pollutants from cars and industries; root amputation because of sewer, water, gas and electric lines; and topping because of power lines and the covering of roots by pavement. Trees should be selected based on their adaptability and growth habits. The selection of tree species depends on the desired function of the tree, whether it be erosion control, shade, privacy screening, noise screening, appearance, enhancement of wildlife habitat or a combination of these. The following characteristics of a tree should be considered when choosing a tree to plant:

Hardiness

Plant trees that are recommended for the area where they are to be planted (See Appendix A-IV-TP).

Mature Height and Spread

The eventual height of a tree must be considered in relation to planting location to avoid future problems with buildings and utility lines (See Appendix A4-TP)

Growth Rate

Some trees attain mature height at an early age, others take many years. Slow growing trees are usually less brittle and usually live longer.

Root System

Avoid trees which have fibrous roots which may cause damage to water lines, septic tanks or sidewalks and driveways.

Cleanliness

Maintenance problems can be avoided by not selecting trees that drop seedpods, cones, flowers, or twigs in large amounts.

Moisture and Fertility Requirements

If suitable soils with adequate fertility are not available, trees tolerant of poor growing conditions should be planted.

Ornamental Effects

If a tree is unusually attractive in appearance, some other shortcomings may be overlooked.

Evergreen vs. Deciduous

Evergreens retain their leaves throughout the year, and are useful for privacy screens and noise barriers. Deciduous trees drop their leaves in the fall. They are preferable for shade trees.

Pest

Insects and disease problems exist among many trees. Each pest is related to the trees species itself, its vigor and the site on which it is planted. Where control techniques are available, the tree owner's commitment and ability to apply them to a pest problem will determine whether the tree should be planted.

Selecting Shrubs, Vines and Groundcovers

As with trees, several plant characteristics and environmental requirements should be considered when selecting shrubs, vines and groundcovers. The closer to meeting the plants requirements, the greater the chance of achieving a successful landscape.

Hardiness

Plants have varying capacities to tolerate cold or heat. Cold tolerance is of most concern. The state of Alabama spans two major plant hardiness zones, Zone 7 (from the central part of the state northward) and Zone 8 (the southern half of the state). The zones are determined by the range of average annual minimum temperatures. The average range of minimum temperatures for Zone 7 in 0 to 10 degrees F; for Zone 8 it is 10 to 20 degrees F (See Appendix A-IV-SVG).

Landscape plants which are not capable of tolerating temperatures below 10 degrees should not be expected to escape injury during an average winter in Zone 7. However, they should be adequately adapted to Zone 8.

Plant hardiness can be greatly influenced by nearby bodies of water since water buffers change in temperature. Other structures or other plants can moderate extreme temperatures and shelter landscape plants, enabling marginal species to better tolerate winter conditions.

Summer Heat Tolerance

A plant's capacity to survive the stress of high temperature is also a concern. Heat interacts with other environmental factors, especially soil moisture conditions and sunlight to influence the range of adaptability of a plant. Usually associated with high temperatures is rapid depletion of soil moisture, especially in late summer. Direct sunlight increases the severity of heat effects on plants. Since Alabama has periods of high temperatures and short winters, spruce, hemlock, and yew are generally poor performers. Other conifers such as deodar cedars and cryptomeria are not hardy further north into zone 6 but offer good substitutes for hemlocks and spruces in the South.

Moisture Requirements and Soil Drainage

Landscape plants vary widely in the amount of moisture they need to thrive. If a drought tolerant plant receives a lot of rain, it can be more susceptible to invasion by normally weak pathogens, especially where the soil drains slowly. On the other hand, plants which require large amounts of water for best performance are easily drought stressed when water is withheld or if planted in very well-drained soils. Such conditions may actually attract insect pests to stressed plants.

Plants that normally require a lot of water can be irrigated so that the ornamental attributes of the plant are maintained. However, this is a use of water resources that can be avoided if consideration is given to appropriate plant selection.

Soil pH

Soil pH can have a profound influence on landscape plant performance. However, most landscape plants perform adequately within a soil pH range of 5.5 to 6.2. Plants listed in Appendix A4-SVG would grow satisfactorily within this pH range.

Plant Pest Susceptibility

It is unwise to use pest-susceptible plants in areas where those particular pests thrive. For example, most species of euonymus are attacked by euonymus scale and Red Tip is highly susceptible to leaf spot. Other landscape options for plant materials might be selected which do not have the same susceptibilities. Plants listed in Appendix A4-SVG have few if any major pest problems.

Nutritional Requirements

Newly set plants often require little additional fertilizer because of the presence of residual fertilizer in the root ball. At this stage, supplying water is far more important than adding fertilizer. Also, most well-established shrubs require less fertilizer to maintain an attractive plant than is usually required by poorly established shrubs.

Light requirement

Plants which require full sun (at least 8 hours of direct sunlight per day) are weakened in low light situations. Plants that need some shade are often vigorous and unattractive in full sun.

Rate of growth and Mature Size

Obviously, for rapid cover, faster-growing plants are desired. However, mature size and other plant characteristics should be considered. For example, where a screen is needed, a slower-growing evergreen shrub may be desired over a fast-growing deciduous plant. Take all plant characteristics into account when selecting plants for a site. If money is available, both needs can be met by planting fast growing, short-lived plants to provide a quick screen and at the same time planting slower growing plants

and allowing them to mature. When the fast-growing plants become over grown, they can be removed to allow the more desirable plants to take their place.

Establishing Vegetation

Topsoiling

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

The need for topsoil should be evaluated, taking into account the amount and quantity of available topsoil and weighing this against the difficulty of preparing a good seedbed on the existing subsoil. Where a limited amount of topsoil is available, it should be reserved for use on the most critical areas.

Soil Amendments

Lime is almost always required on disturbed sites to decrease soil acidly. Lime raises the pH, reduces exchangeable aluminum, and supplies calcium and magnesium for vigorous plant growth. Only the alkaline soils of the Black Belt and north Alabama do not require lime. A soil test should be used to determine the need for liming materials.

Plant nutrients (fertilizer materials) will usually be required even on the best soils. Plant nutrient application rates for a particular species of vegetative cover should be applied according to a soil test report.

Soil amendments should be applied uniformly and well mixed with the top 6 inches of soil during seedbed preparation.

Site Preparation

The soil on a disturbed site must be modified to provide an optimum environment for germination and growth. Addition of

topsoil, soil amendments, and tillage are used to prepare a good seedbed. At planting the soil must be loose enough for water infiltration and root penetration, but firm enough to retain moisture for seedling growth. Tillage generally involves disking, harrowing, chiseling, or some similar method of land preparation. Tillage should be done on the contour where feasible to reduce runoff and erosion. Lime and fertilizer should be incorporated during the tillage.

Planting Methods

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

Uniform seed distribution is essential. This is best obtained using a cyclone seeder, conventional grain drill, cultipacker seeder, or hydraulic seeder. The grain drill and cultipacker seeder are pulled by a tractor and require a fairly clean, smooth seedbed.

On steep slopes where equipment can not safely work hydroseeding may be the most effective seeding method. A rough surface is particularly important when preparing slopes for hydroseeding. In contrast to other seeding methods, a rugged and even trashy seedbed gives the best results.

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

A sod seeder (no-till planter) can plant seed into an existing cover or mulch or be used to restore or repair a weak stand. It can be used on moderately uneven, rough surfaces. It is designed to penetrate the sod, open narrow slits, and deposit seed with a minimum of surface disturbance.

Seeding rates recommended in this handbook have taken into account the "insurance" effect of extra seed. Rates exceeding those given are not recommended because over dense stands are more subject to drought and competitive interference.

Sprigging refers to planting stem fragments consisting of runners (stolons) or lateral, below-ground stems (rhizomes), which are sold by the bushel. Sprigs can be broadcast or planted in furrows using a transplanter. This method works well with bermudagrass. Also sprigs may be broadcast and covered with soil by light disking, or cultipacking. Broadcasting is easier but requires more planting material. Common and forage type hybrid bermudagrass will cover over much more quickly than the lawn type bermudagrass.

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

In sodding, the soil surface is completely covered by laying cut sections of turf. It is limited primarily to lawns, steep slopes, and sod waterways in Alabama. Turf-type bermudas, centipede, and zoysia are usually the types of turf used for sodding. Plantings must be wet down immediately after planting, and kept well watered for a week or two thereafter.

Sodding, though quite expensive, is warranted where immediate establishment is required, as in stabilizing drainage ways and steep slopes, or in the establishment of high quality turf. If properly done, it is the most dependable method and the most flexible in seasonal requirements. Sodding can be done almost anytime of the year in Alabama.

Inoculation of legumes

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

In acid subsoil material, if the specific *Rhizobium* is not already present, it must be supplied by mixing it with the

seed at planting. Cultures for inoculating various legume seed are usually available through seed dealers.

Among the legumes listed for use in this manual, crown vetch is the only one generally requiring inoculation. Lespedeza nodule bacteria are widely distributed in the soils of Alabama unless the site has had all surface soil removed.

Irrigation

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

Mulching

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

Mulch may also protect surfaces that cannot be seeded. Mulch prevents erosion in the same manner as vegetation, by protecting the surface from raindrop impact and by reducing the velocity of overland flow.

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

Maintenance

Satisfactory stabilization and erosion control requires a complete vegetative cover. Even small breaches in vegetative cover can expand rapidly and, if not repaired, can result is excessive soil loss from an otherwise stable site. A single heavy rain will enlarge rills and bare spots

and, the longer repairs are delayed, the more costly they become. Prompt action will keep soil loss, sedimentation damage, and repair cost down. New plantings should be inspected frequently and maintenance performed as needed. If rills and eroded areas develop, they must be repaired, seeded, and mulched as soon as possible.

Maintenance requirements extend beyond the seeding phase. Damage to vegetation from disease, insects, traffic, etc., can occur at any time. Pest control (weed or insect) may be needed at any time. Weak or damaged spots must be fertilized, seeded and mulched as promptly as possible.

Vegetation established on disturbed soils often requires additional fertilization. Frequency and amount of fertilizer to apply can best be determined through periodic soil testing. A fertilization program is required for the maintenance of turf and sod that is mowed frequently. Maintenance requirements should always be considered when selecting plant species for vegetation.

BUFFER ZONE (BZ)

Definition

A strip of undisturbed, original vegetation or established vegetation surrounding the land-disturbing site, or bordering streams, lakes, and wetlands.

Purpose

To provide a buffer zone to reduce storm runoff velocities, filter sediment in runoff water, act as a screen for "vision pollution", reduce construction noise, and improve aesthetics on the land disturbed.

Conditions Where Practice Applies

On construction sites, construction routes, and other disturbed areas where natural vegetation is available and can be preserved for a buffer zone.

Planning Considerations

1. Construction activities that disturb soil can be unsightly, sources of excessive noise, and a significant source of dust and sediment.

2. When planning long term construction projects or when planning future projects buffer zones may be established with thickly planted, fast growing, trees. These trees may be part of the overall landscape of the project.

3. The natural vegetation in buffer zones may be supplemented by planting fast growing, trees and shrubs on long term construction projects.

4. When planning the landscape consider the corporation of all or parts of the natural vegetation or planted trees in the buffer zones.

Specifications

1. Preserve a strip of natural vegetation along permanent and intermittent streams and lakes for bank stabilization and sediment trapping. Minimum width of a buffer zone of natural vegetation for shore line or stream bank protection should be at least 35 feet. However; depending on the size of stream or lake, soil type, existing vegetation, and bank height the width may be increased up to 100 feet. Also, with narrow

buffer zones additional supporting practices will usually be needed.

2. Preserve a strip of natural vegetation between residences, businesses, roads or other areas needing screening from the construction site. Natural vegetation can be supplemented with trees and/or shrubs to improve the screening or effectiveness of the buffer zone. The width should be adequate to permit the buffer zone to serve as an effective screen or its intend purpose. See practice IV-PV, Permanent Vegetation, IV-SVG, Shrub, Vine and Groundcover Planting, or IV-TP, Tree Planting for planting details when is supplementing the natural vegetation. Table BZ-1 list some fast growing trees and large shrubs for use in establishing or supplementing buffer zones or vegetative screens.

3. Establish a strip of fast growing trees between residences, businesses, roads, churches or other areas needing screening from the construction site. Large shrubs may be added to make the buffer zone more effective. The established buffer zone should be a part of the overall landscape plan. Also, planting the buffer zone as soon as possible before construction begins will improve its effectiveness. If sufficient time is lacking for trees to grow, larger plant materials and irrigation can be used. See practices IV-TP, Tree Planting, IV-PV, Permanent Vegetation, and IV-IS, Irrigation Systems for details in establishment. Table BZ-1 list some fast growing trees and large shrubs for use in establishing buffer zones or vegetative screens.

References

1. Chapter III Sediment Barrier/Fence (SF)
2. Chapter IV Irrigation (IR)
3. Chapter IV Permanent Vegetation (PV)
4. Chapter IV Tree Planting on Disturbed Areas (TP)
5. Chapter IV Shrub, Vine and Groundcover Planting (SVG)
6. Chapter IV Tree Preservation and Protection (TPP)

Table BZ-1
Fast Growing Trees and Large Shrubs
for Screens and Buffer Zones

Common Name	Mature Height	Remarks
Green Ash	60-80 ft.	Does best in moist sites and well suited for alkaline soils.
Loblolly Pine	50-85 ft.	Adaptable to more sites and soils than most pine
Yellow Poplar	70-100 ft.	Does best in moist sites but has some insect and disease problems.
Bradford pear	30-60 ft.	Pest resistant, has flowers and good fall color.
Slash Pine	60-100	Best adapted to coastal areas and wet, sandy soils. Limited to south ALabama.
Wax Myrtle	8-15 ft.	Evergreen shrub adapted to coastal plain soils.
Shrub Lespedeza	8-12 ft.	Best adapted to coastal plain soils. Wildlife plant.
Willow	30-50 ft.	Must have a moist site. Good for buffer zones along streams.

DUST CONTROL (DU)

Definition

The control of dust during land disturbing activities.

Purpose

To prevent surface and air movement of dust from disturbed soil surfaces that may cause off site damage, health hazards, and traffic safety problems.

Conditions Where Practice Applies

On construction routes and other disturbed areas subject to surface dust movement and dust blowing where off site damage may occur if dust is not controlled.

Planning Considerations

1. Construction activities that disturb soil can be a significant source of air pollution. Large quantities of dust can be generated, especially in "heavy" construction activities such as land grading for road construction and commercial, industrial or subdivision development.

2. The scheduling of construction operations so that the least amount of area is disturbed at one time is important in planning for dust control.

3. The greatest dust problems occur during dry periods. Therefore, do not expose large areas of bare soil, especially during drought conditions. Also, leave undisturbed buffer areas between graded areas wherever possible.

4. Installing temporary or permanent surface stabilization measures immediately after completing land grading will dust problems.

Specifications

1. Vegetative Cover - For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control. Establish vegetative cover according to practice IV-TV, Temporary Vegetation (Seeding) or practice IV-PV, Permanent Vegetation.

2. Mulches - Mulch offers a fast, effective means of controlling dust when properly applied. Synthetic

resins may be used instead of asphalt to bind straw mulch. Use the resins according to manufacturer's recommendations. See practice IV-MU, Mulching.

3. Calcium chloride may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage. May need to retreat.

4. Spray-on adhesives may be used on mineral soils for dust control. Traffic must be kept off treated areas. Examples of spray-on adhesives for use in dust control are listed in Table DU-1.

Table DU-1
Spray-on Adhesives for Dust Control on Mineral Soil

Material	Water Dilution	Type of Nozzle	Apply Gal/Ac
Anionic asphalt emulsion	7:1	Coarse Spray	1,200
Latex emulsion	12.5:1	Fine Spray	235
Resin in water	4:1	Fine Spray	300

5. Sprinkling or Irrigation - Sprinkling is especially effective for dust control on haul roads and other traffic routes. Sprinkle the site until the surface is wet. Repeat as needed. Also bare areas may be kept wet with irrigation to control dust as an emergency treatment.

6. Stone used to stabilize construction roads can also be effective for dust control.

7. Tillage will roughen the site and bring clods and moist soil to the surface. This is a temporary emergency measure that can be used on large open disturbed areas as soon as soil blowing starts. Begin plowing on the windward edge of the site.

8. Barriers - A board fence, wind fence, sediment fence, hay bales, or similar barriers can control air currents and blowing soil. Place barriers perpendicular to prevailing air currents at intervals about 15 times the barrier height. Where dust is a known problem, preserve windbreak vegetation.

References

1. Chapter III-Sediment Barrier/Fence
2. Chapter III-Surface Roughening
3. Chapter IV-Irrigation
4. Chapter IV-Mulching
5. Chapter IV-Permanent Vegetation
6. Chapter IV-Temporary Vegetation

IRRIGATION (IR)

Definition

The application of water by means of sprinklers, spray devices, emitters or other water application devices in order to develop and/or sustain plant growth.

Purpose

To insure that plants survive and that vegetative cover and/or root development takes place if drought conditions occur after initial planting/establishment.

Conditions Where Practice Applies

On disturbed areas where permanent sod and plant material is planted and on temporary and permanent seeded sites where rapid germination, root development and vegetative growth is essential. Also in areas where prompt use and aesthetics are important, such as, public parks, commercial lawns, golf courses and athletic fields.

Planning Considerations

1. Either permanent or temporary irrigation can be installed. Permanent irrigation is most suited to areas where continued aesthetic value requires a lush, green appearance. These type sites include commercial lawns and landscape areas, golf courses, public parks, and other public areas.

2. Temporary irrigation may be installed on sites where it is important from an erosion standpoint to rapidly develop growth from seed or protect planted vegetation (sod and plants) if drought conditions threaten the survival and/or establishment of such vegetation.

3. A water source must be identified for carrying out any irrigation practice. This source is often a public water supply in the case of new construction. Remote sites may require pumping from surface water or installation of wells near the site. As a planning guide, 27,154 gallons is required to apply 1 inch per acre. Daily requirements of from .05 to .3 inches/acre may be required depending on the type plant, site, stage of growth, and time of year.

4. Proper operation of the irrigation system should be considered during the initial planning phase. For vegetative establishment on newly seeded areas or for establishment of sodded areas or trees, an irrigation system should be planned so that it can be operated frequently to continually maintain favorable soil moisture. As time passes and plant growth occurs, the operating frequency should be decreased or the interval between irrigations should be lengthened to encourage deep rooting of plants. The specific time interval will depend to some extent on the time of year, stage of growth and plants grown. The key is to initially maintain near optimum soil moisture conditions so that plants do not suffer from lack of water, and at the same time, encourage development of a deep root system so that soil erosion possibilities are reduced.

5. Irrigation components should be selected and installed in accordance with recommended irrigation design practices. Systems should be designed to uniformly apply water to the soil's surface in the case of sprinklers and provide equal quantities of water to equal size plants in the case of micro (drip) irrigation. Sprinkler irrigation should be used to establish vegetative cover over large areas.

Specifications

1. Sprinkler systems should be selected such that the application uniformity is at least 70% and sprinklers should be placed such that head to head coverage is achieved, i.e., water from one sprinkler should be thrown to the adjacent sprinkler and visa versa. Sprinklers should be operated at sufficient pressure (as recommended by the manufacturer) to adequately break up and distribute the water over the area.

2. Sprinklers should be selected so that the average application rate (inches per hour) to the soil does not exceed the intake rate of soil. In some cases, especially on new construction sites, this may not be possible and short cycles of frequent irrigation may be necessary to take advantage of rapid intake characteristics of soils during initial wetting.

3. In cases where temporary irrigation must be used at remote sites, irrigation systems should be managed to encourage reliance on natural rainfall in the shortest possible time. This means that after irrigation is used frequently for initial establishment, the irrigation intervals should be lengthened to encourage deep rooting and removal of the temporary irrigation equipment.

4. Appropriate local, state and federal laws/regulations should be abided by related to installation of backflow prevention equipment on irrigation systems.

References

Irrigation, 5th Edition, The Irrigation Association, 1983.

MULCHING (MU)

Definition

Application of a protective layer of straw, other plant residues, stone, or synthetic materials to the soil surface.

Purpose

To protect the soil surface from the forces of raindrop impact and overland flow. Mulch fosters the growth of vegetation, reduces evaporation, insulates the soil, and suppresses weed growth. Mulch is frequently used to accent landscape plantings.

Conditions Where Practice Applies

Mulch temporary or permanent seedings immediately after planting. Mulch around plantings of trees, shrubs, or ground covers to stabilize the soil between plants. Areas that cannot be seeded because of the season should be mulched to provide temporary protection of the soil surface. Use an organic mulch in this case that can be incorporated into the soil during seedbed preparation.

Planning Considerations

1. A surface mulch is the most effective, practical means of controlling runoff and erosion on disturbed land prior to vegetation establishment. Mulch reduces soil moisture loss by evaporation, prevents crusting and sealing of the soil surface, moderates soil temperatures, provides a suitable microclimate for seed germination, and may increase the infiltration rate of the soil.

2. Organic mulches such as straw, wood chips, and shredded bark have been found to be the most effective mulch materials. Materials containing weed and grass seeds which may compete with establishing vegetation should not be used. Also, decomposition of some wood products can tie up significant amounts of soil nitrogen, making it necessary to modify fertilization rates or add fertilizer with the mulch.

3. A variety of erosion control blankets have been developed in recent years for use as mulch, particularly in critical areas such as waterways and channels. Various types of netting materials are also available to anchor organic mulches.

4. Chemical soil stabilizers or soil binders, when used alone, are less effective than other types of mulches. These products are primarily useful for tacking wood fiber or straw mulches.

5. The choice of materials for mulching should be based on soil conditions, season, type of vegetation, and size of the area. A properly applied and tacked mulch is always beneficial. It is especially important when conditions of germination are not optimum, such as midsummer and early winter, and on difficult sites such as cut slopes and drought soils.

6. Organic Mulches

   A. Straw is the most commonly used material in conjunction with seeding. Wheat straw is the mostly commonly used straw, and can be spread by hand or with a mulch blower. If the site is susceptible to blowing wind, the straw should be tacked down to prevent loss.

   B. Wood chips are suitable for areas that will not be closely mowed, and around ornamental plantings. Chips do not require tacking. Because they decompose slowly they must be treated with 12 pounds of nitrogen per ton to prevent nutrient deficiency in plants. They can be an inexpensive mulch if the chips are obtained from trees cleared on the site.

   C. Wood fiber refers to short cellulose fibers applied a as a slurry in hydroseeding operations. Wood fiber hydroseeder slurries may be used to tack straw mulch on steep slopes, critical areas, and where harsh climatic conditions exist. Wood fiber mulch does not provide sufficient erosion protection to be used alone.

   D. Peanut hulls, cotton burs, and pine straw are organic materials that make excellent mulches but may only be available locally or seasonally. Creative use of these materials can reduce costs.

7. Erosion Control Blankets and Netting

   A. Jute mesh or the various types of netting is very effective in holding mulch in place on waterways and slopes before grasses become established.

B. Erosion control blankets promote seedling growth in the same way as organic mulches. They are very useful in establishing grass in channels and waterways. A wide variety of synthetic and organic materials are available such as wood excelsior, small grain straw, coconut fiber, or mixtures of these materials. When installing erosion control blankets, it is critical to obtain a firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion will occur underneath.

Specifications

1. Select a mulch material based on the site and practice requirements, availability of material, and availability of labor and equipment. Table MU-1 lists commonly used mulches.

2. Before mulching, complete the required grading, install sediment control practices, and prepare the seedbed. Also, plant and cover seed before mulching except when seed is applied as part of a hydroseeder slurry containing wood fiber mulch.

3. Uniformly spread organic mulches by hand or with a mulch blower at a rate which provides about 75% ground cover. When spreading straw mulch by hand, divide the area to be mulched into sections of approximately 1000 sq. ft. and place 70-90 pounds of straw (1 1/2 to 2 bales) in each section to facilitate uniform distribution. This will be 1 1/2 to 2 tons of straw per acre. In hydroseeding operations a green dye may be added to the slurry, to assure a uniform application.

4. Anchoring Straw Mulch

   A. When straw mulch is subject to be blown away by wind, it must be anchored immediately after spreading. It can be anchored with a mulch anchoring tool or a regular farm disk, which weight has been added to and the disk set to run straight. The disk should not be sharp enough to cut the straw.

   B. Liquid mulch binders can also be used to tack mulch subject being blown away by wind. Applications of liquid mulch binders and tackifiers should be heaviest at the edges of areas and at crests of ridges and banks, to resist wind. Binders should be applied uniformly to the

rest of the area. Binders may be applied after mulch is spread or may be sprayed into the mulch as it is being blown onto the soil. Applying straw and binder together is the most effective method. Liquid binders include asphalt and an array of commercially available synthetic binders.

C. Emulsified asphalt is the most commonly used mulch binder. Any type thin enough to be blown from spray equipment is satisfactory. Asphalt is classified according to the time it takes to cure. Rapid setting (RS or CRS designation) is formulated for curing in less than 24 hours, even during periods of high humidity; It is bests used in spring and fall. Medium setting (MS or CMS) is formulated for curing within 24 to 48 hours, and slow setting (SS or CSS) is formulated for use during hot, dry weather, requiring 48 hours or more curing time.

D. Apply asphalt at 10 gallons per 1000 sq. ft.(500 gallons per acre). Heavier applications will cause straw to "perch" over rills.

E. Straw mulch may also be anchored with lightweight plastic, cotton, jute, wire or paper netting which are stapled over the mulch. The manufacturer's recommendations on stapling netting should be followed.

5. Installation of Erosion Control Blankets

A. All smoothing, seedbed preparation, and vegetation operations must be completed prior to placing the erosion control blanket. Any rocks, clods, sticks, or other debris which would prevent the blanket form making close contact with the soil should be removed. The erosion control blanket should be placed immediately after planting seed.

B. Unroll the erosion control blanket from the top down, parallel to the direction of flow, in flumes and ditches and perpendicular to the direction of flow on slopes. Allow the blankets to lay loosely on the soil but without wrinkles-do not stretch.

C. To secure the blanket, bury the upslope end in a slot or trench no less than 6 inches deep, cover with soil, and tamp firmly. Staple the blanket every 12 inches across the top end and every 3 feet around the edges and bottom. Where erosion

control blankets are laid side by side, the adjacent edges should be overlapped with the uphill blanket on top and stapled together. Each blanket should also be stapled down the center, every 3 feet. Do not stretch the erosion control blanket when applying staples.

Table MU-1
Mulching Materials and Application Rates

Material	Rate Per Acre	Notes
Straw	1 1/2-2 tons	Spread by hand or machine; tack down when subject to blowing.
Wood chips	5-6 tons	Treat with 12 lbs nitrogen/t.
Bark blower.	35 cu yds	Can apply with mulch Do not use asphalt taack.
Pine straw	1-2 tons	Spread by hand or machine; will not blow like straw.
Peanut hulls	10-20 tons	Will wash off slopes. Treat with 12 lbs nitrogen/ton.

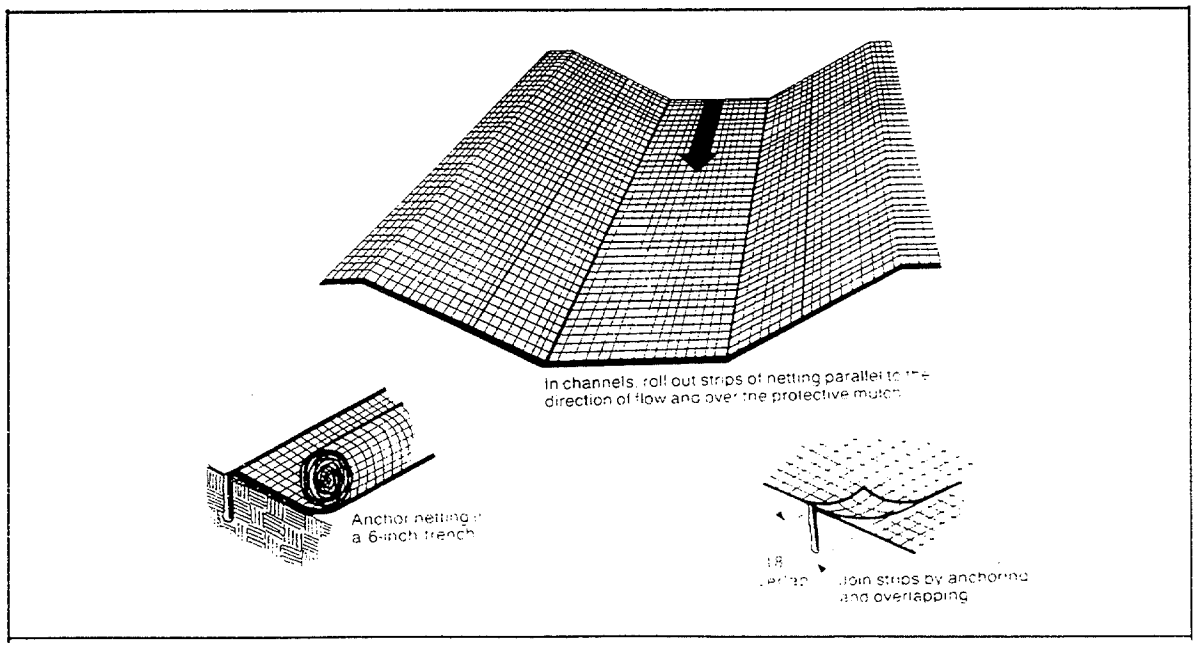


Figure MU-1 Installation of erosion control blankets and netting

Maintenance

Inspect all mulches periodically, and after rainstorms to check for rill erosion, dislocation, or failure. Where erosion is observed, apply additional mulch. If washout occurs, repair the slope grade. reseed , and reinstall mulch. Continue inspectons until vegeration if firmly established.

PERMANENT SEEDING - (PS)

Definition

Controlling runoff and erosion on disturbed areas by establishing perennial vegetative cover with seed.

Purpose

To reduce erosion and decrease sediment yield from disturbed areas, and to permanently stabilize such areas in a manner that is economical, adapts to site conditions, and allows selection of the most appropriate plant materials.

Conditions Where Practice Applies

Disturbed areas where permanent, long-lived vegetative cover is needed or the most effective method of stabilizing the soil. Permanent seeding may also be used on rough-graded areas that will not be brought to final grade for a year or more.

Planning Considerations

1. The most common and economical means of stabilizing disturbed soils is by seeding grasses and legumes. The advantages of seeding over other means of establishing plants include the smaller initial cost, lower labor input, and greater flexibility of method. Disadvantages of seeding include potential for erosion during the establishment stage, seasonal limitations on suitable seeding dates, and weather related problems such as droughts etc.

2. The probability of successful plant establishment can be maximized through good planning. The selection of plants for permanent vegetation must be site specific. Factors that should be considered are type of soils, climate, establishment rate, and management requirements of the vegetation. Other factors that may be important are wear, mowing tolerance, and salt tolerance of vegetation.

3. The use of irrigation (temporary or permanent) will greatly improve the success of vegetation establishment.

4. Endophyte infected tall fescue appears to establish quicker and have better survival under adverse conditions than endophyte free tall fescue.

5. The operation of equipment is restricted on slopes steeper than 3:1, severely limiting the quality of the seedbed that can be prepared. Provisions for establishment of vegetation on steep slopes can be made during final grading. In construction of fill slopes, for example, the last 4-6 inches might not be compacted. A loose, rough seedbed with irregularities that hold seeds and fertilizer is essential for hydroseeding. Cut slopes should be roughened (Practice III-SR, Surface Roughening).

6. Good mulching practices are critical to protect against erosion on steep slopes. When using straw, anchor with netting or asphalt. On slopes steeper than 2:1, jute, excelsior, or synthetic matting may be required to protect the slope.

Specifications

1. Grading and shaping - Minor grading and shaping may be needed to provide a surface on which equipment can safely and efficiently be used for seedbed preparation and seeding.

2. Plant Selection - Plant selection for permanent vegetation should be based on plant characteristics, site and soil conditions, time of year of planting, method of planting, and the intended use of the vegetated area. Climate factors can vary widely in Alabama. To simplify plant selection, a table of the adapted plants, including characteristics, for permanent seeding in each of the physiographic regions of Alabama, is provided (A-IV-PS). Also see *Chapter IV, Vegetation Establishment for Erosion and Sediment Control*, pages 7 to 13.

   Plant selection may include companion plants to provide quick cover on difficult sites, late seedings, or in situations where the desired permanent cover may be slow to establishment. Annuals are usually used for companion plants. The plants used for temporary vegetation may be used for companion plants provided the seeding rate is reduced by one half. See *Chapter IV, Vegetation Establishment for Erosion and Sediment Control*, pages 8 and 9 and practice IV-TV, Temporary Vegetation. Ryegrass or other highly competive plants should not be used as a companion plant.

Table PS-1
Perennial Grasses, Legumes and Mixtures; Seeding Rates; and Planting Dates for Disturbed Areas

Species	Seeding Rates/Ac	Seeding Dates & Adapted Area North	Central	South
Bahiagrass, Pensacola	40 lbs	---	Mar 1-July 1	Feb 1-Nov 1*
Bermudagrass, Common	10 lbs	Apr 1-July 1	Mar 15-July 15	Mar 1-July 15
Bahiagrass, Pensacola Common Bermudagrass	30 lbs 5 lbs	---	Mar 1-July1	Mar 1-July 15
Bermudagrass, Hybrid (Lawn Types)	Solid Sod	Anytime	Anytime	Anytime
Bermudagrass, Hybrid (Lawn Types)	Sprigs 1/sq ft	Mar 1-Aug 1	Mar 1-Aug 1	Feb 15-Sep 1
Fescue, Tall	40-50 lbs	Sep 1-Nov 1	Sep 1-Nov 1	---
Sericea	40-60 lbs	Mar 15-July 15	Mar 1-July 15	Feb 15-July 15
Sericea & Common Bermudagrass	40-60 lbs 10 lbs	Mar 15-July 15	Mar 1-July 15	Feb 15-July 15

* Fall planting of bahia should contain 45 pounds of smallgrain to provide cover during winter months.

Note: Legume seed should be treated with the inoculant specific for the species of legume.

3. Seedbed Requirements - Establishment of vegetation should not be attempted on sites that are unsuitable due to inappropriate soil texture, poor drainage, concentrated overland flow, or steepness of slope, until measures have been taken to correct these problems.

   To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. A good growth medium should have these criteria:

   - Enough fine-grained (silt and clay) soil material to maintain adequate moisture and nutrient supply.

   - Sufficient pore space to permit root penetration.

- Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans should be 12 inches or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.

- A favorable pH range for plant growth, usually 6.0 - 6.5.

- Freedom from large roots, branches, stones, or large clods. Clods and stones may be left on slopes steeper than 3:1 if they are to be hydroseeded.

If any of the above criteria are not met - i.e., if the existing soil is too coarse, dense, shallow or acidic to foster vegetation - special amendments or topsoil should be used to improve soil conditions. The soil conditioners described below may be beneficial or, preferably, topsoil may be applied in accordance with practice III-TS, Topsoil.

4. Soil Conditioners - In order to improve the structure or drainage characteristics of a soil, the following materials may be added. These amendments should only be necessary where soils have limitations that make them poor for plant growth or for turf establishment.

   A. Peat - Appropriate types are sphagnum moss peat, reed-sedge peat, or peat humus, all from fresh-water sources. Peat should be shredded and conditioned in storage piles for at least 6 months after excavation.

   B. Sand - Clean and free of toxic materials.

   C. Vermiculite - Horticultural grade and free of toxic substances.

   D. Rotted manure - Stable or cattle manure not containing undue amounts of straw or other bedding materials.

   E. Thoroughly rotted sawdust - Free of stones and debris. All 6 lbs of nitrogen to each cubic yard.

5. Soil Amendments

   A. Liming Materials

Lime (Agricultural limestone) should have a neutralizing value of not less than 90 percent calcium carbonate equivalent and 90 percent will pass through a 10 mesh sieve and 50 percent will pass through a 60 mesh sieve.

Selma chalk should have a neutralizing value of not less than 80 percent calcium carbonate equivalent and 90 percent will pass through a 10 mesh sieve.

B. Plant Nutrients - Commercial grade fertilizers that comply with current Alabama Fertilizer Laws should be used to supply nutrients required to establish vegetation.

C. Rates of Soil Amendments - Lime and fertilizer needs should be determined by soil tests. Soil testing is performed by the Auburn University Soil Testing Laboratory. The local county Cooperative Extension Service can provide information on obtaining soil tests. Commercial laboratories that make recommendations based on soil analysis may be used.

When soil tests are not available, use the following rates for application of soil amendments.

Lime (Agricultural limestone or equivalent):
- Light-textured, sandy soils: 2 tons/acre
- Heavy-textured, clayey soils: 3 tons/acre (Do not apply lime to alkaline soils)

Fertilizer:
- Grasses alone: 800 to 1200 lbs/acre of 10-10-10 or the equivalent.
- Grass-legume mixtures: 800 to 1200 lbs/acre of 5-10-10 or the equivalent.
- Legumes alone: 800 to 1200 lbs/acre of 0-10-10 or the equivalent.

D. Application of Soil Amendments - Apply lime and fertilizer evenly and incorporate into the top 6 inches of soil by disking, chiseling or other suitable means during seedbed preparation. Operate machinery on the contour.

6. Seedbed Preparation - Install necessary mechanical erosion and sedimentation control practices before

seedbed preparation, and complete grading according to the approved plan.

Complete the seedbed preparation, which began with incorporation of soil amendments with tillage as a minimum, that will adequately loosen the soil to a depth of at least 6 inches. Break up large clods, alleviate compaction, and smooth and firm the soil into a uniform surface. Fill in or level depressions that can collect water.

7. Planting Methods

A. Seeding - Use certified seed for permanent seeding whenever possible. Certified seed is inspected by the Alabama Crop Improvement Association. It meets Alabama standards and will be tagged with a "Certified Seed" tag. All seed sold in Alabama is required by law to be tagged. Seed tags contain important information on seed purity, germination, and presence of weed seeds. Seed must meet State standards for content of noxious weeds. Do not accept seed containing "prohibited" noxious weed seed.

Seeding dates are given in Table PS-1 and Appendix A-IV-PV. Seeding properly carried out within the optimum dates have a higher probability of success. It is also possible to have satisfactory establishment when seeding outside these dates. However, as plantings are deviated from the optimum dates, the probability of failure increases rapidly. Seeding dates should be taken into account in scheduling land-disturbing activates.

Inoculate legume seed with the *Rhizobium* bacteria appropriate to the species of legume (Chapter IV page 19-20).

Plant seed uniformly with a cyclone seeder, drill, cultipacker seeder, or by hand on a fresh, firm, friable seedbed. If the seedbed has been sealed by rainfall, it should be disked so the seed will be sown in freshly prepared seedbed.

When using broadcast-seeding methods, subdivide the area into workable sections and determine the amount of seed needed for each section. Apply one-half the seed while moving back and forth across the area, making a uniform pattern; then

apply the second half in the same way, but moving at right angles to the first pass.

Cover broadcast seed by raking or chain dragging; then firm the surface with a roller or cultipacker to provide good seed contact. Small grains should be planted no more than 1 inch deep and grasses and legume seed no more than 1/2 inch deep.

B. Hydroseeding - Surface roughening is particularly important when hydroseeding, as roughened slope will provide some natural coverage for lime, fertilizer, and seed. The surface should not be compacted or smooth. Fine seeded preparation is not necessary for hydroseeding operations; large clods, stones, and irregularities provide cavities in which seeds can lodge.

Mix seed, inoculant if required, and a seed carrier with water and apply as a slurry uniformly over the area to be treated. The seed carrier should be a cellulose fiber, natural wood fiber or cane fiber mulch material which is dyed an appropriate color to facilitate uniform application of seed. Use the correct legume inoculant at four times the recommended rate when adding inoculant to a hydroseeder slurry. The mixture should be applied within one hour after mixing to reduce damage to seed.

Fertilizer should be not be mixed with the seed-inoculant mixture because fertilizer salts may damage seed and reduce germination and seedling vigor. Fertilizer may be applied with a hydroseeder as a separate operation after seedlings are established.

Lime is not normally applied with a hydraulic seeder because it is abrasive but if necessary it can be added to the seed slurry and applied at seeding or it may be applied with the fertilizer mixture. Also lime can be blown onto steeper slopes in dry form.

C. Sprigging - Hybrid bermudagrass cannot be grown from seed and must be planted vegetatively. Vegetative methods of establishing common and hybrid bermudagrass, centipedegrass, and zoysia include sodding, plugging and sprigging (Practice IV-SD, Sodding). Sprigs are fragments of horizontal stems which include at least one node

(joint). They are normally sold by the bushel and can either be broadcast or planted in furrows using a tractor-drawn transplanter.

Furrows should be 4-6 inches deep and 2 feet apart. Place sprigs about 2 feet apart in the row with one end at or above ground level.

Broadcast sprigs at the specified rate (Table PV-1). Press into the top 1/2 to 2 inches of soil with a cultipacker or with a disk set nearly straight so that the sprigs are not brought back to the surface. A mulch tacking machine may be used to press sprigs into the soil.

8. Mulching - The use of a mulch will help ensure establishment of vegetation under normal conditions and is essential to seeding success under harsh site conditions (Practice IV-MU, Mulching). Harsh site conditions include:

   - Seeding in late fall (wood fiber mulches are not adequate for this use),
   - Slopes steeper than 3:1,
   - Adverse soils (shallow, rocky, or high in clay or sand), and
   - Areas receiving concentrated flow.

9. Irrigation - Moisture is essential for seed germination and vegetation establishment. Supplemental irrigation can be very helpful in assuring adequate stands in dry seasons or to speed development of full cover. It is a requirement for establishment of vegetation from sprigs and should be used elsewhere when feasible. However; irrigation is rarely critical for low-maintenance vegetation planted at the appropriate time of the year.

   Water application rates must be carefully controlled to prevent runoff. Inadequate or excessive amounts of water can be more harmful than no supplemental water (Practice IV-IR, Irrigation).

10. Maintenance - Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for one full year from planting. Inspect vegetated areas for failure and make necessary repairs and vegetate as soon as possible.

If stand has inadequate cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over-seed the stand. Consider seeding temporary cover if the time of year is not appropriate for establishment of permanent vegetation. See Practice IV-TV, Temporary Vegetation - Seeding.

If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.

Fertilization - On the typical disturbed site, full establishment usually requires application of fertilizer in the second growing season. Turf grasses require annual maintenance fertilization. Use soil tests if possible or follow the guidelines given for the specific seeding mixtures.

Protect establishing vegetation from traffic that will be harmful. Use either temporary fences or barriers to protect areas that may be damaged by excessive traffic.

References

1. Chapter III-SR Surface Roughening
2. Chapter III-TS Topsoil
3. Chapter IV-IR Irrigation
4. Chapter IV-MU Mulching
5. Chapter IV-TV Temporary Vegetation - Seeding

SODDING (SD)

Definition

Permanently stabilizing areas by laying a continuous cover of grass sod.

Purpose

To prevent erosion and damage from sediment and runoff by stabilizing the soil surface with permanent vegetation; to provide immediate vegetative cover of critical areas; to stabilize disturbed areas with a suitable plant material that cannot be established by seed; and to stabilize drainage ways and channels and other areas of concentrated flow where flow velocities will not exceed that specified for a vegetated waterway.

Conditions Where Practice Applies

Disturbed areas which require immediate and permanent vegetative cover, or where sodding is preferred to other means of grass establishment such as waterways or sod flumes carrying intermittent flow at acceptable velocities, areas around drop inlets, residential or commercial lawns and golf courses where prompt use and aesthetics are important, and steep critical areas needing immediately cover.

Planning Considerations

1. Advantages of properly installed sod include immediate erosion control, nearly year-round establishment capability, less chance of failure than with seeding, and rapid stabilization of surfaces for traffic areas, channel linings, or critical areas.

2. Initially it is more costly to install sod than to plant seed; however, the higher cost may be justified for specific situations where sod performs better than seed.

3. Sodding for soil stabilization eliminates the seeding and mulching operations, but site preparation is required. Sodding is a more reliable method of producing adequate cover and erosion control than seeding.

4. Sod can be laid during the times of the year when seeded grasses may fail, provided there is adequate water available for irrigation in the early

establishment period. Irrigation is essential, at all times of the year, to install sod.

5. In waterways and sod flumes that carry concentrated flow, properly pegged sod provides immediate protection and is preferable to seeding.

6. Sod placed around drop inlets can protect them from sediment and help maintain the necessary grade around the inlet.

7. The site should be prepared and ready for laying of sod when it is delivered. Leaving sod stacked or rolled can cause severe damage and loss of plant material.

Specifications

1. Selection of appropriate types of sod - The type of sod selected should be adapted to both the site and the intended purpose. In Alabama these are limited to bermuda, zoysia, centipede, St. Augustine, tall fescue, and bahiagrass. Tall fescue and bahiagrass is not readily available but can be obtained from some growers. Species selection is primarily determined by region, availability, and intended use (table SD-1).

Table SD-1
Types of Sod Available in Alabama

Warm Season Grasses:	**Varieties**	**Adaptable Region**
Bermudagrass	Tifway, Tifgreen Tiflawn, common	North Central South
Bahiagrass	Pensacola	Central South
Centipede	No improve varieties	Central South
St. Augustine	Bitterblue, Raleigh, common	South
Zoysia	Emerald, Meyer,	Central South
Cool Season Grasses:		
Tall Fescue	Kentucky 31	North

2. Sod Quality - Sod should be machine cut at a uniform depth of 1/2 to 2 inches (excluding shoot growth and thatch). The sections of sod should be strong enough to support their on weight and retain their size and shape when lifted by one end. Sod should be placed within 36 hours of harvest.

3. Site preparation - Test soil to determine the exact requirements for lime and fertilizer. Soil test may be conducted by Auburn University Soil Testing Laboratory or other laboratories that make recommendations based on soil analysis. When soil test recommendations are unavailable, the following soil amendments may be sufficient:

   Agricultural limestone at a rate of 2 tons per acre (100 lbs per 1000 sq. ft.)

   Fertilizer at a rate of 1000 lbs per acre (25 lbs per 1000 sq. ft.) of 10-10-10.

   Equivalent nutrients may be applied with other fertilizer formulations. The soil amendments should be spread evenly over the treatment area and incorporated into the top 6 inches of soil by disking, chiseling or other effective, means. If topsoil is applied, follow specifications given in practice III-TS, Topsoil

   Prior to laying sod, clear the soil surface of trash, debris, roots, branches, stones, and clods larger than 2 inches in diameter. Fill or level low spots in order to avoid standing water. Rake or harrow the site to achieve a smooth and level final grade.

   Complete soil preparation by rolling or cultipacking to firm the soil. Avoid using heavy equipment on the area, particularly when the soil is wet, as this may cause excessive compaction and make it difficult for the sod to take root.

4. Sod installation - A step-by-step procedure for installing sod is illustrated in Figure SD-1 and described below.

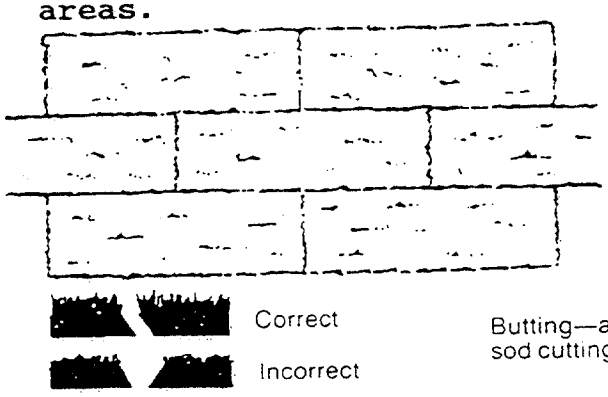
   A. Moistening the sod after it is unrolled helps maintain its viability. Store it in the shade during installation.

   B. Rake the soil surface to break the crust just before laying sod. During the summer, lightly irrigate the soil, immediately before laying the

sod to cool the soil and reduce root burning and dieback.

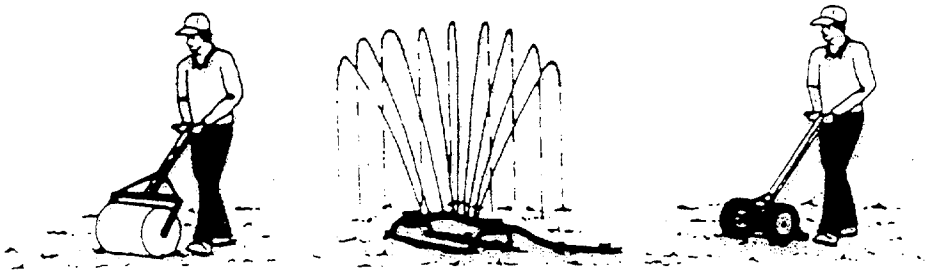
C. Do not lay sod on gravel, frozen soils, or soils that have been recently sterilize or treated with herbicides.

D. Lay the first row of sod in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger strips in a brick-like pattern. Be sure that the sod is not stretched or overlapped and that all joints are butted tightly to prevent voids. Use a knife or sharp spade to trim and fit irregularly shaped areas.



Lay sod in a staggered pattern with strips butted tightly against each other. A sharpened mason's trowel can be used to tuck down the ends and trim pieces.

Butting—angled ends caused by the automatic sod cutting must be matched correctly.



Roll sod immediately to achieve firm contact with the soil.

Water to a depth of 4" as soon as the sod is laid, and continue watering as needed

Mow when the sod is established (2-3 wks). Set the mower high (2-3")

Figure SD-1 Proper installation of grass sod

E. Install strips of sod with their longest dimension perpendicular to the slope. On slopes 3:1 or greater, or wherever erosion may be a problem, secure sod with pegs or staples.

F. As sodding of clearly defined areas is completed, roll sod to provide firm contact between roots and soil.

G. After rolling, irrigate until the soil is wet at least 6 inches below the sod.

H. Keep sodded areas moist to a depth of 4 inches until the grass takes root. This can be determined by gently tugging on the sod. Resistance indicates that rooting has occurred.

I. Mowing should not be attempted until the sod is firmly rooted, usually 2 to 3 weeks.

5. Sodded waterways - Sod provides a resilient channel lining, providing immediate protection from concentrated flow and eliminating the need for installing mats or mulch. The following points apply to the use of sod in waterways:

A. Prepare the soil as described in Practice III-WW, Waterway or Storm Water Conveyance Channels. The sod type must be able to withstand the velocity of flow specified in the channel design.

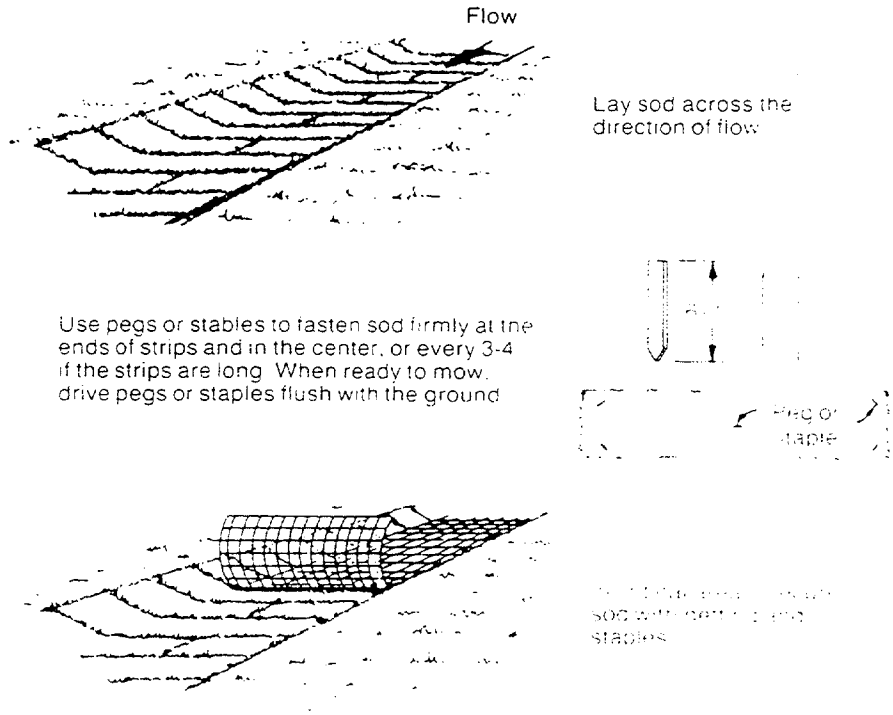


Figure SD-2 Installation of sod in waterways

B. Lay sod strips perpendicular to the direction of flow, with the lateral joints staggered in a brick-like pattern. Edges should butt tightly together (figure SD-2).

C. After rolling or tamping to create a firm contact, peg or staple individual sod strips to resist washout during establishment. Jute or other netting material may be pegged over the sod for extra protection on critical areas.

Maintenance

1. After the first week, water as necessary to maintain adequate moisture in the root zone and prevent dormancy of the sod.

2. Do not remove more than one-third of the shoot in any mowing. Grass height should be maintained between 2 and 3 inches unless otherwise specified.

3. After the first growing season, established sod requires fertilization, and may also require lime. Follow soil test recommendations when possible, or use the rates in table SD-2.

Table SD-2
Characteristics of Grasses Used as Sod in Alabama

Grass	Adaptation					Maintenance	
	Shade	Heat	Cold	Drought	Wear	Mowing Height	Mowing Frequency
Bermudagrass	no	good	poor	excel.	excel.	1 in.	high
Bahiagrass	fair	good	poor	excel.	good	2-3 in.	high
Centipede	fair	good	poor	good	poor	1 1/2 in.	low
Tall fescue	good	fair	good	good	good	3 in.	high
St. Augustine	good	good	poor	poor	poor	2-3 in.	med.
Zoysia	fair	good	fair	excel.	good	1 in.	high

Reference

1. Chapter III-Topsoil
2. Chapter III-Waterway or Storm Water Conveyance Channel
3. Chapter IV-Irrigation

SHRUB, VINE AND GROUNDCOVER PLANTING (SVG)

Definition

Stabilizing disturbed areas by establishing a vegetative cover of shrubs, vines or groundcovers.

Purposes

To aid in stabilizing soil on areas where the shrubs, vines and groundcovers are the vegetation desired to provide food and shelter for wildlife, to provide windbreaks or screens and to improve aesthetics of the area.

Conditions Where Practice Applies

Shrubs, vines and groundcovers may be used on slopes where mowing is not feasible; as ornamentals for landscaping purposes; or in shaded areas where grass establishment is difficult.

Planning Considerations

1. Shrubs, vines and groundcovers provide alternatives to grasses and legumes as low-maintenance, long-term erosion control. However, they are normally planted only for special, high-value applications, or for aesthetic reasons, because there is additional cost and labor associated with their use.

2. Very few of these plants can be dependably planted from seed, and none are capable of providing the rapid cover possible with grasses. Consequently, short-term stabilization efforts must involve using a dependable mulch along with special cultural practices to ensure establishment.

3. There are many different species of shrubs, vines and groundcovers from which to choose. It is essential to select plant material suited to both the intended use and site. Specific characteristics and requirements of recommended species are given in Appendix A-IV-SVG as an aid to their selection. The diversity of available plant material makes it impractical to give planting specifications for even the most common species. Instead, only general planting guidelines are provided.

4. Shrubs vary in form from small trees to sprawling, woody vines and groundcovers. They differ from most trees in that multiple stems arise from a common base. Shrubs can be used to:

   - Increase the aesthetic value of plantings,
   - Provide visual screening and protective barriers,
   - Enhance windbreaks,
   - Provide food and cover for wildlife,
   - Accelerate the transition to a diverse landscape,
   - Provide post-construction landscaping.

5. Vines and groundcovers - As used by landscapers, "groundcover" refers to low-growing, herbaceous or woody plants that spread vegetatively to produce a dense, continuous cover. They are used in landscape plantings or as an alternative to turf. Typically only a few ornamental grasses are included in this category. Many ground covers, such as English ivy, are vines that spread along the ground but also climb on buildings, fences, or other vegetation.

   Groundcovers can differ in growth rate, and shade tolerance. They may be evergreen or deciduous. Some are suitable only as part of a high-maintenance landscape; others can be used to stabilize large areas with little maintenance.

   In addition to stabilizing disturbed soil, vines and groundcovers perform the following functions:

   - They maintain cover in shaded areas where turf will not thrive.
   - They provide attractive cover that does not need mowing
   - They restrict pedestrian traffic.

Specifications

1. Planting Shrubs

   A. When - Late winter (before leaves emerge) is the best time for planting deciduous shrubs and early fall is the best for evergreens. Shrubs grown and

marketed in containers can be planted anytime during the year except when the ground is frozen.

B. Planting Methods, Individual Shrubs - Provide as large an area as possible for initial root development. The hole should be dug to a depth that allows the root ball to extend one inch above the soil surface, and should be as big around as three to five times the diameter of the root ball.

C. Planting Method, Shrubs in Prepared Beds - Bed preparation differs somewhat from planting in individual holes. Bed areas are usually tilled or spaded, typically to a depth of 8 to 12 inches. Contrary to the individual planting, soil amendments, such as peat or compost at a rate of 1 part amendment to 3 parts native soil, are beneficial to shrubs because they provide a uniform root environment across the bed area. This type of soil amendment also enables plants to respond positively to water and fertilizers when they are applied. The hole for the shrub planted in a bed area can be a few inches wider in diameter than the root ball.

D. Container Plants - Remove container plants from their containers, cutting the container if necessary. If the plant is root-bound (roots circling the outside of the root ball), score the roots from top to bottom about four times, cutting about 1/4 inch deep with a knife, or gently massage the root ball until roots point outward.

Place the shrub into the hole. Using only the native backfill, add soil back to the hole until it is 1/2 to 2/3 full. Water in the backfill soil around the root ball. Add soil to ground level and thoroughly water again. A small dike may be formed around the edge of the planting hole to hold water around the root ball if in sandy soils or on slopes. In a tight clay soil trapping additional water in the root zone can be detrimental.

E. Bare Root Plants - For bare root plants, soak roots in water. When planting, spread the roots in the hole and gradually add soil. Firm the soil, being careful to avoid breaking roots. Fill the hole with water, and allow it to drain. Then fill the hole with soil, and water again thoroughly.

F. Burlapped Plants - For burlapped plants, cut any wire or string around the plants' stems. Do not remove the burlap. Fold the burlap back so it will be buried by soil. Burlap which is allowed to remain exposed after planting can act as a wick, causing the root ball to dry out. From this point, follow the same procedure for filling the hole as that described for container plants.

G. Mulch - Once plants are installed, add mulch. Mulch is beneficial to plants at most stages of development but is particularly important for new plantings. Mulch conserves soil moisture, prevents soil crusting, and suppresses weeds. As a result, more water is made available for use by the landscape plant, which helps reduce stress conditions in the first year planting. See practice IV-MU, Mulching.

H. Water - Water is most important for growth in a new planting. For the first few months, water plants frequently in the area over and beyond the root ball if rainfall does not supply one inch of water per week. This will provide the water to areas where it is taken up by plants until the roots begin to establish in the surrounding soil. Be conscious of plants that have been in the ground for less than one year, and water them thoroughly during extended dry periods.

2. Planting vines and Groundcovers

A. When - Ground covers are best planted in early fall or early spring.

B. Site Preparation - Good soil is important in establishing ground covers because their dense growth requires large amounts of nutrients and water. Well-drained soils high in organic matter work best.

Add lime and fertilizer according to soil test. In absence of a soil test incorporate into the top six inches of soil 50 pounds of ground agricultural limestone and 25 pounds of 8-8-8 fertilizer per 1000 square feet. Also, incorporate organic matter in the form of peat, compost, aged sawdust, or well-rotted manure.

On steep slopes, till the soil in contour rows, or dig single holes for each plant. Blend the needed lime, fertilizer, and organic material with the soil removed from each hole or furrow. Mix fertilizer thoroughly with the soil before planting, and use it sparingly to avoid burning roots. To eliminate harmful competition from weeds, an appropriate preemergent herbicide may be useful in weeding is not practical.

C. Planting - Most groundcovers are planted from container-grown nursery stock. Planting density determines how quickly full cover is achieved; a one foot spacing is often used for rapid cover. Large plants such as junipers can be spaced on three foot centers.

Transplanting to the prepared seedbed can be done using a small trowel or a spade. Make a hole large enough to accommodate the roots and soil. Backfill and firm the soil around the plant, water immediately, and keep well watered until established. Water slowly and over longer periods to allow for infiltration end reduce runoff.

D. Mulching - Competition from volunteer plants inhibits development and maintenance of the groundcover. A thick durable mulch such as shredded bark (not chips) or pine straw should prevent erosion and reduce weed competiion.

On steep slopes or highly erodible soils, install erosion control netting or matting prior to planting, and duck plants into the soil through slits in the net. Plant in a staggered pattern.

Maintenance

Shrubs, vines and groundcovers need about an inch of water a week for the first two years after planting. When rain does not supply this need, shrubs should be watered deeply not more than once a week. Once established, fertilizing every three years is generally sufficient. A soil test is the best way to determine what nutrient elements are needed. Fertilizer formulations of 12-4-8 or 15-0-15 can be used in the absence of a soil test. Apply two pounds of fertilizer per 1000 square feet of area. Maintain a layer of mulch around the base of each plant.

References

1. Chapter III-Topsoil (TS)
2. Chapter IV-Irrigation (IR)
3. Chapter IV-Mulching (MU)
4. Chapter IV-Tree Planting on Disturbed Areas (TP)
5. Chapter IV-Tree Preservation and Protection (TPP)
6. Appendix A-IV-SVG-1
7. Appendix A-IV-SVG-2

TEMPORARY VEGETATION - SEEDING (TV)

Definition

Planting rapid growing annual grasses, small grains, or legumes to provide initial, temporary cover for erosion control on disturbed areas.

Purpose

To temporarily stabilize bare areas that will not be brought to final grade for a period of more than 30 working days.

Temporary seedling controls runoff and erosion until permanent vegetation or other erosion control measures can be established. In addition, it provides residue for soil protection and seedbed preparation and reduces problems of mud and dust production from bare soil surfaces during construction.

Conditions Where Practice Applies

On any cleared, bare, or sparsely vegetated soil surface where vegetative cover is needed for less than one year. Application of this practice include diversions, dams, temporary sediment basins, temporary roads banks, and soil stockpiles.

Planning Considerations

1. Temporary vegetative cover can provide short term protection before establishing perennial vegetation. It can control rills and excessive erosion on earthen sediment control structures such as diversions, dams and sediment basins.

2. Temporary vegetation will reduce the amount of maintenance associated with sediment basins. The frequency of sediment basin cleanups will be reduced if watershed areas outside the active construction zone are stabilized.

3. Certain plants species used for temporary vegetation will produce large quantities of residue which can provide mulch for establishment of the permanent vegetation.

4. Proper seedbed preparation and selection of appropriate species are important with this practice. Failure to follow establishment guidelines and recommendations

carefully may result in an inadequate or short-lived stand of vegetation that will not control erosion.

5. Temporary vegetation is used to provide cover for no more than one year. Permanent vegetation should be established at the proper planting time for permanent vegetative cover.

Specifications

1. Grading and shaping - Minor grading and shaping may be needed to provide a surface on which equipment can safely and efficiently be used for seedbed preparation and seeding.

2. Plant Selection - Plant selection for temporary vegetation should be based on plant characteristics, site and soil conditions, time of year of planting, method of planting, and the needed use of the vegetative cover. Plant species commonly used for temporary cover are contained in Table TV-1.

Table TV-1
Commonly Used Plants for Temporary Cover

Species	Seeding Rate/Ac	Seeding Dates		
		North	Central	South
Millet, Browntop or German	40 lbs	May 1-Aug 1	Apr 1-Aug 15	Apr 1-Aug 15
Rye	3 bu	Sep 1-Nov 15	Sep 15-Nov 15	Sep 15-Nov 15
Ryegrass	30 lbs	Aug 1-Sep 15	Sep 1-Oct 15	Sep 1 -Oct 15
Sorghum-Sudan Hybrids	40 lbs	May 1-Aug 1	Apr 15-Aug 1	Apr 1-Aug 15
Sudangrass	40 lbs	May 1-Aug 1	Apr 15-Aug 1	Apr 1-Aug 15
Wheat	3 bu	Sep 1-Nov 1	Sep 15-Nov 15	Sep 15-Nov 15

3. Soil Amendments

   A. Apply lime according to soil test recommendations. If the pH of the soil in not known, use 2 tons of agricultural limestone or equivalent per acre on coarse textured soils and 3 tons per acre on fine

textured soils. Do not apply lime to alkaline soils or to areas which have been limed during the preceding 2 years.

B. Fertilizer application rates should be based on soil test results. When soil test are not possible, apply 500 to 700 pounds of 10-10-10 grade fertilizer.

4. Seedbed Preparation - Complete grading before preparing seedbeds and install all necessary erosion control practices, such as sediment basins. If soils become compacted during grading, loosen them to a depth of 6 to 8 inches using a ripper or chisel plow. Good seedbed preparation is essential to successful plant establishment. A good seedbed is well pulverized, loose, and smooth. Incorporate lime and fertilizer into the top 6 inches of soil during seedbed preparation. If rainfall has caused the surface to become sealed or crusted, loosen it just prior to seeding by disking, raking, harrowing, or other suitable methods. When hydroseeding methods are used, the surface should be left with a more irregular surface of clods.

5. Planting - Evenly apply seed using a cyclone seeder (broadcast), drill, cultipacker seeder, or hydroseeder. Use seeding rates given in Table TV-1. Broadcast seeding and hydroseeding are appropriate for steep slopes where equipment cannot operate safely.

   Small grains should be planted no more than 1 inch deep, and grasses and legumes no more than 1/2 inch deep. Broadcast seed must be covered by raking or chain dragging, and then lightly firmed with a roller or cultipacker, Hydroseeding mixtures should include a wood fiber mulch which is dyed an appropriate color to facilitate uniform application of the seed.

6. Mulching - The use of an appropriate mulch will help ensure establishment of vegetative cover under normal conditions and is essential to seeding success under harsh site conditions (practice IV-MU, Mulching). Harsh site conditions include:

   - seeding in late fall for winter cover (wood fiber mulches are not considered adequate for this use),

   - slopes steeper than 3:1,

- adverse soils (shallow, rocky, or high in clay or sand, and

- areas receiving concentrated flow.

If the area to be mulched is subject to concentrated water flow, as in channels, anchor mulch with netting (practice IV-MU, Mulching)

7. Irrigation - Use irrigation when available and needed to insure establishment. Apply irrigation at a rate that will not cause runoff. See practice IV-IR, Irrigation.

8. Maintenance - Reseed and mulch areas where seedlings emergence is poor or where erosion occurs as soon as possible. Do not mow. Protect from traffic as much as possible.

References

1. Chapter III-SR Surface Roughening

2. Chapter III-TS Topsoil

3. Chapter IV-IR Irrigation

4. Chapter IV-MU Mulching

5. Chapter IV-PV Permanent Vegetation

TREE PLANTING ON DISTURBED AREAS (TP)

Definition

Stabilizing disturbed areas by planting trees.

Purposes

To aid in stabilizing soil on areas where trees are the desired vegetation, to provide food and shelter for wildlife, where wildlife habitat is desired, and to improve the aesthetics of the area.

Conditions Where Practice Applies

On areas where trees are desired for soil conservation, wildlife, or landscaping purposes.

Planning Considerations

1. Trees planted in combination with grasses or legumes should be planted as soon as possible after establishing the grass or legume because of the competition for moisture, nutrients and sunlight.

2. Trees should be adapted to the soil and climate.

3. Trees that have undesirable characteristics should be avoided.

Specifications

Planting Bare-rooted Tree Seedlings

When - Bare-root seedlings should be planted from Dec. 1 to March 15. Planting should be done when the soil is neither too dry not too wet. Planting should be avoided during freezing weather and when the ground is frozen.

Planting methods - Tree seedlings may be planted by hand or machine. Any tool or piece of equipment that gives satisfactory results may be used. Dibble bars, mattocks, augers, post-hole diggers and shovels may be used to plant trees by hand. Wildland tree planting machines should be used on rough areas or areas with clayey or compacted soils.

Old field tree planters should be limited to old field areas with light soils that are not compacted. On sloping land planting should be done on the contour where possible.

Planting rate - To control erosion pines should be planted at a rate of 600 to 700 trees per acre and hardwoods should be planted at a rate of 300 to 500 trees per acre. Severely eroding areas should be planted at the rate of 600 to 900 trees per acre for both pine and hardwood species. Trees planted to enchance wildlife or to improve aesthetics may be planted as scattered individuals or in groups. Trees planted in groups are less susceptible to windthrow.

Depth of planting - Trees should be planted deeper than they grew in the nursery. Plant small stock 1 inch deeper and medium to large stock 1/2 inch deeper. On most soils, longleaf pine seedlings should be planted 1/4 inch deeper than they grew in the nursery.

Condition of roots - Roots should be planted straight down and not twisted, balled, nor U-shaped. Roots that are too long to be planted properly should be pruned.

Firmness - Soil should be packed firmly around the planted seedlings. No air pockets should be left in either machine furrows or holes made by planting tools.

Care of seedlings - The roots of seedlings must be kept moist and cool at all times. After lifting, seedlings should not be exposed to sun, wind, heating, drying or freezing before they are planted. Baled seedlings may be kept up to 3 weeks if they are properly stacked, watered, and kept in a cool place. When planting is delayed longer than 3 weeks, the roots of seedlings should be covered with moist soil (heeled-in) or the seedlings should be put in cold storage.

During planting, the roots of seedlings must be kept moist and only one seedling should be planted at a time. At the end of each day, loose seedlings should be either repacked in wet moss or heeled-in.

Planting Balled and Burlapped and Container-Grown Trees

When - Late winter (before leaves emerge) is the best time for planting deciduous trees and early fall is the best for evergreens. Trees may be planted anytime during the year except when the ground is frozen. Watering is essential during dry periods.

Tree preparation - The proper digging of a tree includes the conservation of as much of the root system as possible, particularly the fine roots. Soil adhering to the roots should be damp when the tree is dug, and kept moist until planting. The soil ball should be 12 inches in diameter for each inch of diameter of the trunk. The tree should be carefully excavated and the soil ball wrapped in burlap and tied with rope. Use of a mechanical tree spade is also acceptable. Containerized trees should be planted when they are young with a trunk diameter of less than 2 inches.

Any trees that are to be transported for a long distance should have the branches bound in with a soft rope to prevent damage.

Site preparation - The planting hole should be dug deep and wide enough to allow proper placement of the root ball. The final level of the root ball's top should be level with the ground surface (See Figure TP-1).

As the hole is dug the topsoil should be kept separate from the subsoil. If possible the subsoil should be replaced with topsoil. If topsoil is unavailable the subsoil can be improved by mixing in 1/3 volume of peat moss or well-rotted manure.

Heavy or poorly drained soils are not good growth media for trees. When it is necessary to transplant trees into such soils, extra care should be taken.

Planting the tree - Depth of planting must be close to the original depth. The tree may be set just a few inches higher than in its former location, especially if soil is poorly drained. Do not set the tree lower than before. Soil to be placed around the root ball should be moist but not wet.

Set the tree in the hole and if the tree is balled and burlapped remove the rope which holds the burlap. Loosen the burlap and remove completely if practical. Do not break the soil of the root ball. Fill the hole with soil half-way and add water to settle the soil and eliminate air pockets. When the water has drained off, fill the hole the remainder of the way. Use extra soil to form a shallow basin around the tree. This will help retain water.

Newly planted trees may need artificial support to prevent excessive swaying.

Stakes and guy wires may be used (See Figure TP-1). Guying should be loose enough to allow some movement of the tree. Following planting much with organic matter (wood chips, bark, pine needles, peanut hulls etc.) to a depth of no more than 3 inches. Mulch should not be placed against the trunk of the tree.

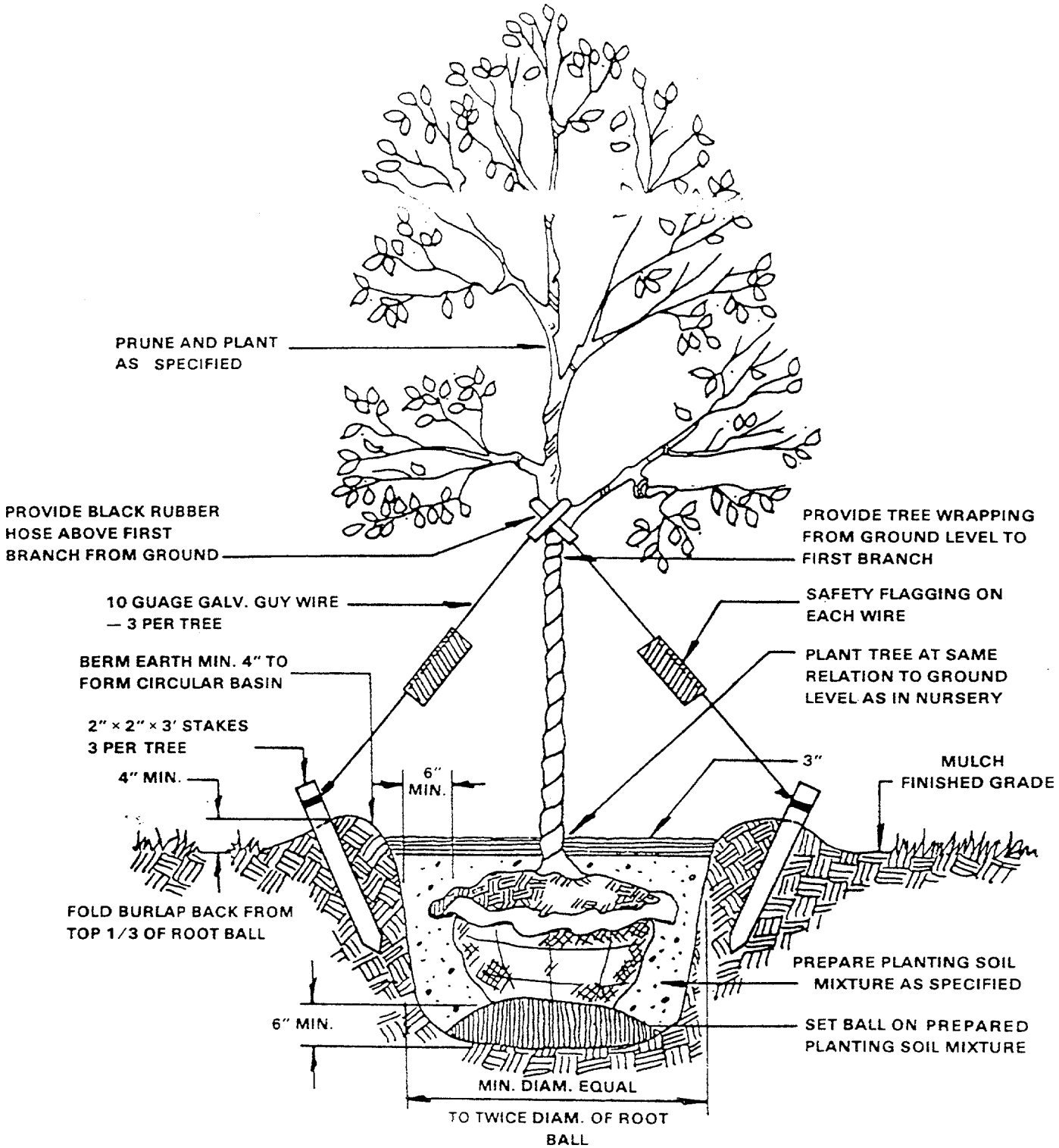


Figure TP-1. Tree Planting Diagram

Maintenance of Tree Plantings

Tree maintenance helps to obtain higher survival and accelerated tree growth. It may not be feasible to provide maintenance to large areas planted to trees to control erosion. However, individual trees or groups of trees planted to enchance wildlife or to improve aesthetics will greatly benefit from a tree maintenance program.

Trees need an inch of water a week for the first two years after planting. When rain does not supply this need, trees should be watered deeply not more than once a week. Transplanted trees should be fertilized one year or so after planting. A soil test is the best way to determine what elements are needed. Fertilizer formulations of 10-8-6 or 10-6-4 can be used in the absence of a soil test. About 2 pounds of fertilizer should be used for each inch of tree diameter measured at 4.5 feet above the ground.

Fertilizer must come in contact with the roots to benefit the tree. The easiest way to apply fertilizer is to simply broadcast it over the root system. As the tree grows, the roots will grow well beyond drip line. This should be taken into account when applying fertilizer by the broadcast method. Another way to apply fertilizer is to make holes in the tree's root area with a bar or auger. Holes should be 18 inches deep, spaced about 2 feet apart, and located around the drip line of the tree. Distribute the fertilizer evenly into these holes and close the holes with the heel of the shoe or by filling with topsoil or peat moss. Trees should be fertilized in late fall or early spring before leaves emerge.

TREE PRESERVATION AND PROTECTION (TPP)

Definition

Protection of desirable trees from mechanical and other injury during land disturbing and construction activity.

Purposes

To insure the survival of desirable trees where they will be effective for erosion and sediment control, watershed protection, landscape beautification, dust and pollution control, noise reduction, shade and other environmental benefits while the land is being converted from forest to urban-type uses.

Conditions Where Practice Applies

Forested areas subject to land disturbing activities.

Planning Considerations

1. Trees to save should be identified prior to any construction activity.

2. It takes newly planted trees 20 to 30 years to provide many of the desired benefits of trees.

Specifications

During the preconstruction conference with the contractor, tree preservation and protection measures should be reviewed.

Groups of trees to be retained should be located on a plan map as well as individual trees to be retained. Limits of clearing should be located outside the drip line of groups or individual trees to be saved. The clearing should never be closer than 5 feet to the trunk of a tree. Trees to be retained should be marked with a highly visible paint or surveyor's ribbon in a band circling the tree at a height visible to equipment operators.

Construction equipment, vehicular traffic, stockpiles of construction materials, topsoil etc, shall not be permitted within the tree drip line of any tree to be retained. Trees being removed shall not be pushed into trees to be retained. Equipment operators shall not clean any of their equipment by slamming it against trees to be retained.

Burning of debris should not be done within 100 feet of the drip line of any trees to be retained. Fires shall be limited in size to prevent damage to any nearby trees.

Toxic material shall not be stored any closer than 100 feet to the drip line of any trees to be retained. Toxic materials shall be disposed of according to state laws.

Tree Armoring

Trees should be protected by fencing or armoring where necessary (See Figure TPP-1). The following types of fencing or armoring may be used:

Board Fence - A board fence may be constructed with 4-inch square posts set securely in the ground and protruding at least 4 feet above the ground. A minimum of two horizontal boards should be placed between the posts. The fence should be placed at the limits of the clearing around the drip line of the tree. If it is not practical to erect a fence at the drip line, construct a triangular fence near the trunk. The limits of clearing will still be the drip line as the root zone within the drip line will still require protection.

Cord Fence - Posts at least 2 inches square or 2 inches in diameter set securely in the ground and protruding at least 4 feet above the ground shall be placed at the limits of clearing with two rows of cord 1/4 inch or thicker at least two feet apart running between posts with strips of surveyor's tape tied securely to the string at intervals of 3 feet or less.

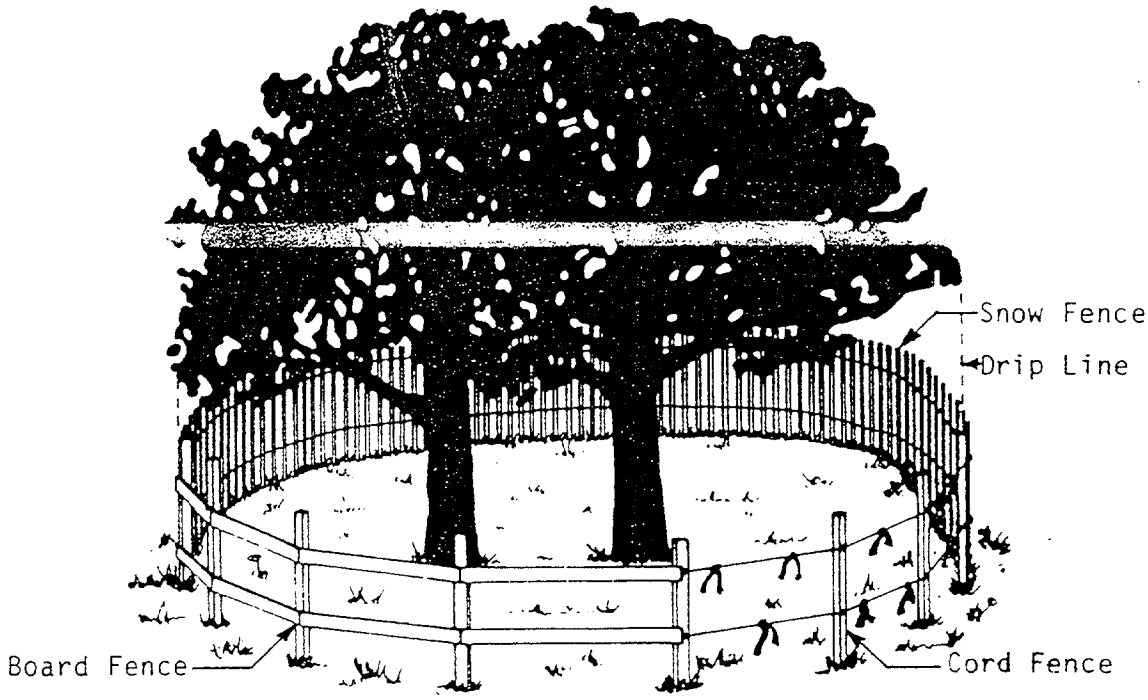
Earth Berms - Temporary earth berms may be constructed. The base of the berm on the tree side should be located along the limits of clearing. Earth berms may not be used for this purpose if their presence will conflict with drainage patterns.

Additional Trees - Additional trees may be left standing as protection between the trees to be retained and the limits of clearing. However, in order for this alternative to be used, trees in the buffer must be no more than 6 feet apart to prevent passage of equipment and material through the buffer.

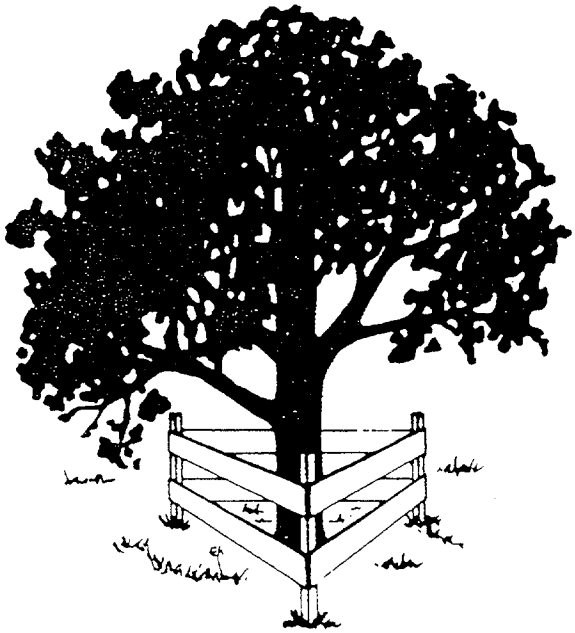
These additional trees shall be reexamined prior to the completion of construction and either given sufficient treatment to insure survival or be removed.

Trunk Armoring - As a last resort, a tree may be armored with burlap wrapping and 2-inch studs wired vertically no more than 2 inches apart to a height of 5 feet. The armoring should encircle the tree trunk. Nothing should never be nailed to a tree. The root zone within the drip line will still require protection.

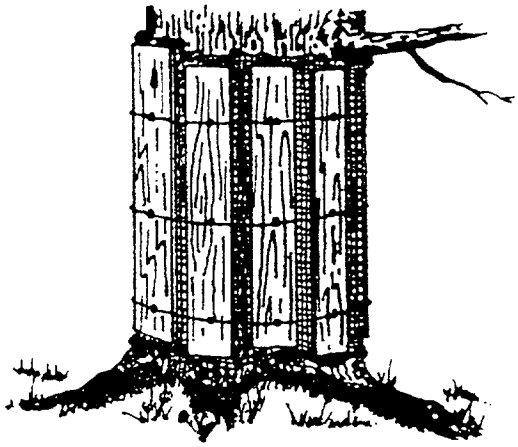
Fencing and armoring devices should be in place before any construction work is done and should be kept in good condition for the duration of construction activities. Fencing and armoring should not be removed until the completion of the construction project.



Correct Methods of Tree Fencing



Triangular Board Fence



Correct Trunk Armoring

Figure TPP-1. Fencing and Armoring

Raising the Grade

When the ground level must be raised around an existing tree or group of trees several methods may be used to insure survival

A well may be created around a group of trees or an individual tree slightly beyond the drip line to retain the natural soil in the area of the feeder roots.

Figure TPP-2. Tree Well

In the case of an individual tree, when the above alternative is not practical or desirable, the following method is recommended to insure survival of the tree. Remove vegetation and organic matter from beneath the tree or trees for a distance of 3 feet beyond the drip line and loosen the surface soil to a depth of approximately 3 inches without damaging the roots.

Apply fertilizer in the root area of the tree to be retained. A soil test is the best way to determine what type of fertilizer to use. In the absence of a soil test, fertilizer should be applied at the rate of 1 to 2 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees under 6 inches dbh and at the rate of 2 to 4 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees over 6 inches dbh.

A dry well shall be constructed so as to allow for tree trunk diameter growth (See Figure TPP-3). A space of at least 1 foot between the tree trunk and the well wall is adequate for old, slow growing trees. Clearance for younger trees shall be at least 2 feet. The well shall be high enough to bring the top just above the level of the proposed fill. The well wall shall taper slightly away from the tree trunk at a rate of 1 inch per foot of wall height.

The well wall shall be constructed of large stones, brick, building tile, concrete blocks, or cinder blocks. Openings should be left through the wall of the well to allow for free movement of air and water. Mortar shall only be used near the top of the well and only above the porous fill.

Drain lines composed of 4-inch high quality drain tiles shall begin at the lowest point inside the well and extend outward from the tree trunk in a wheel and spoke pattern with the trunk as the hub. Radial drain lines shall slope away from the well at a rate of 1/8 inch per foot. The circumference line of tiles should be located beneath the drip line of the trees. Vertical tiles or pipes shall be placed over the intersections of the two tile systems if a fill of more than 2 feet is contemplated. Vertical tiles shall be held in place with stone fill. Tile joints shall be tight. A few radical tiles shall extend beyond each intersection and shall slope sharply downward to insure good drainage. Tar paper or its approved equivalent shall be placed over the tile and/or pipe joints to prevent clogging and large stone shall be placed around and over drain tiles and/or pipes for protection.

A layer of 2 to 6 inches of stone shall be placed over the entire area under the tree from the well outward at least as far as the drip line. For fills up to 2 feet deep. a layer

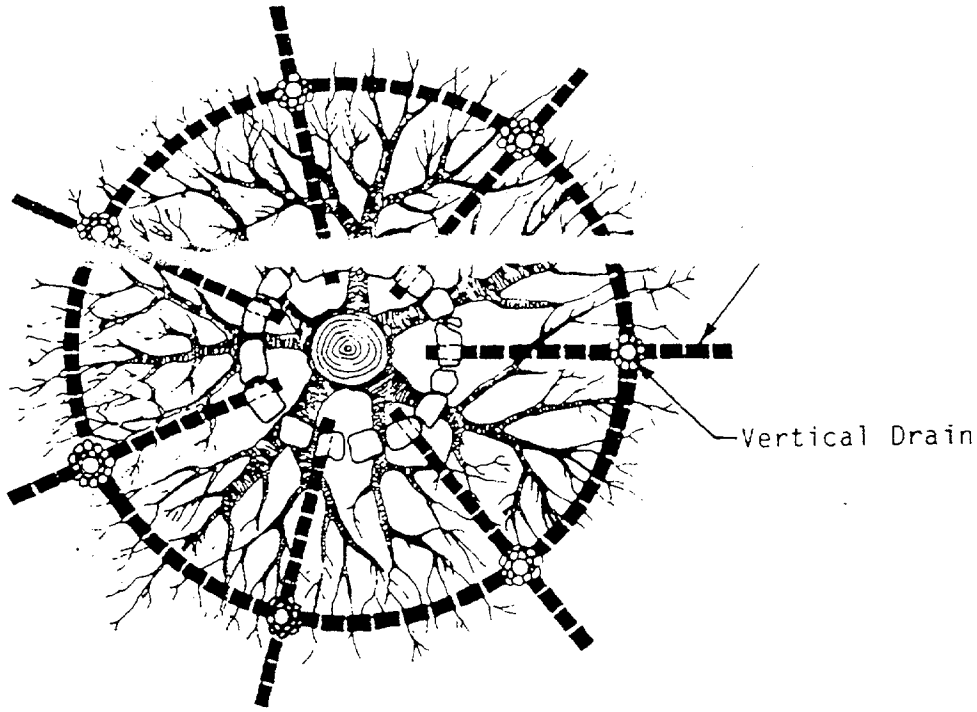
of stone 8 to 12 inches thick should be adequate.

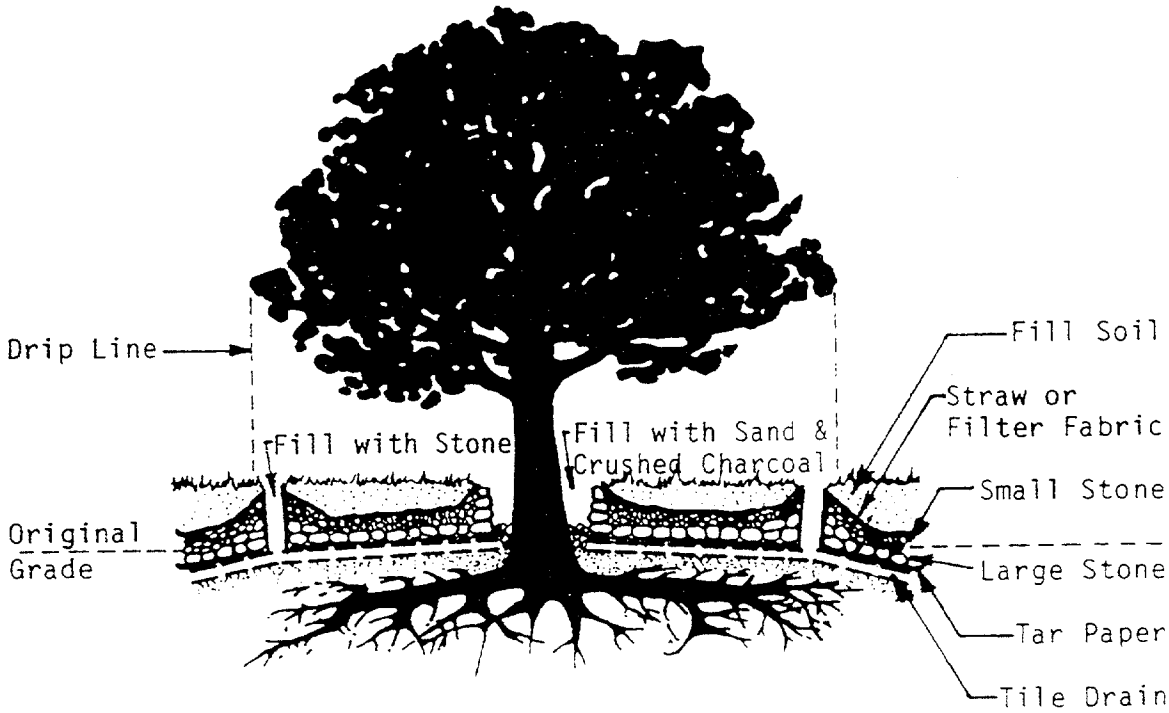
A thick layer of this stone not to exceed 30 inches will be needed for deeper fills. A layer of 3/4-inch to 1-inch stone covered by straw, fiberglass mat or a manufactured filter fabric shall be used to prevent soil from clogging the space between stones. Cinders shall not be used as fill material. Filling shall be completed with porous soil such as topsoil until the desired grade is reached. This soil shall be suitable to sustain specified vegetation.

Crushed stone shall be placed inside the dry well over the openings of the radial tiles to prevent clogging. The area between the trunk and the well wall shall either be covered by an iron grate or filled with a 50-50 mixture of crushed charcoal and sand to prevent anyone from falling into the dry well.

Where water drainage through the soil is not a problem, coarse gravel in the fill may be substituted for the tile. This material has sufficient porosity to ensure air drainage. Instead of the vertical tiles or pipes in the system, stones, crushed rock and gravel may be added so that the upper level of these porous materials slants toward the surface in the vicinity below the drip line.

Raising the grade on only one side of a tree or group of trees may be accomplished by constructing only half of one of these systems.





TREE WELL DETAIL

Figure TPP-3. Tree Well Detail

Lowering the Grade: Trees shall be protected from the harmful grade cuts by the construction of a tree wall (See Figure TPP-4). Following excavation, all tree roots that are exposed and/or damaged shall be trimmed cleanly and covered with moist peat moss, burlap or other suitable material to keep them from drying out.

The wall shall be constructed of large stones, brick, building tile, concrete block or cinder block. The wall should be backfilled with topsoil, peat moss, or other organic matter to retain moisture and aid in root development. Apply fertilizer and water thoroughly. The tree should be pruned to reduce the leaf surface in proportion to the amount of root loss. Drainage should be provided through the wall so water will not accumulate behind the wall. Lowering the grade on one side of the tree or group of trees can be accomplished by constructing only half of this system.

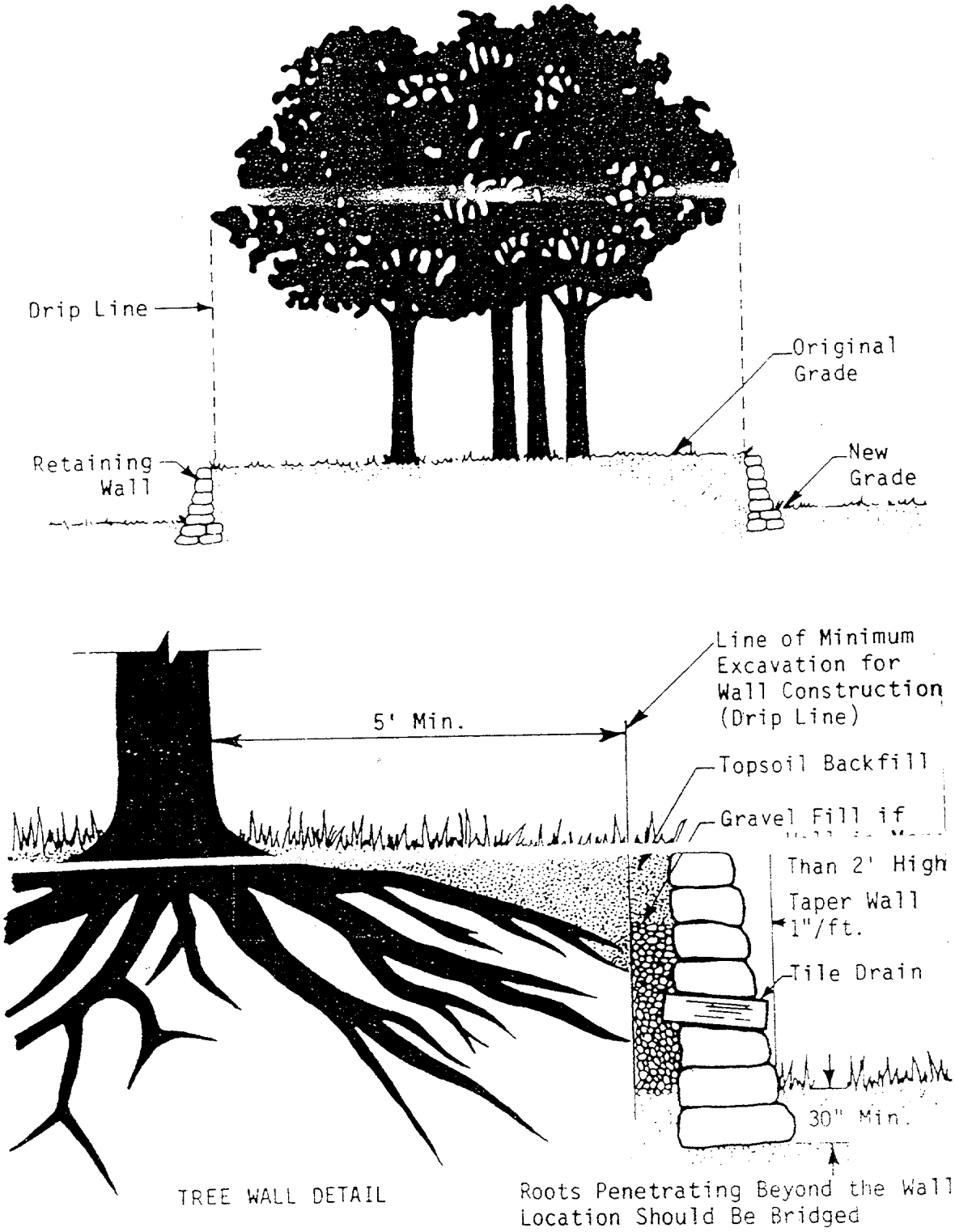
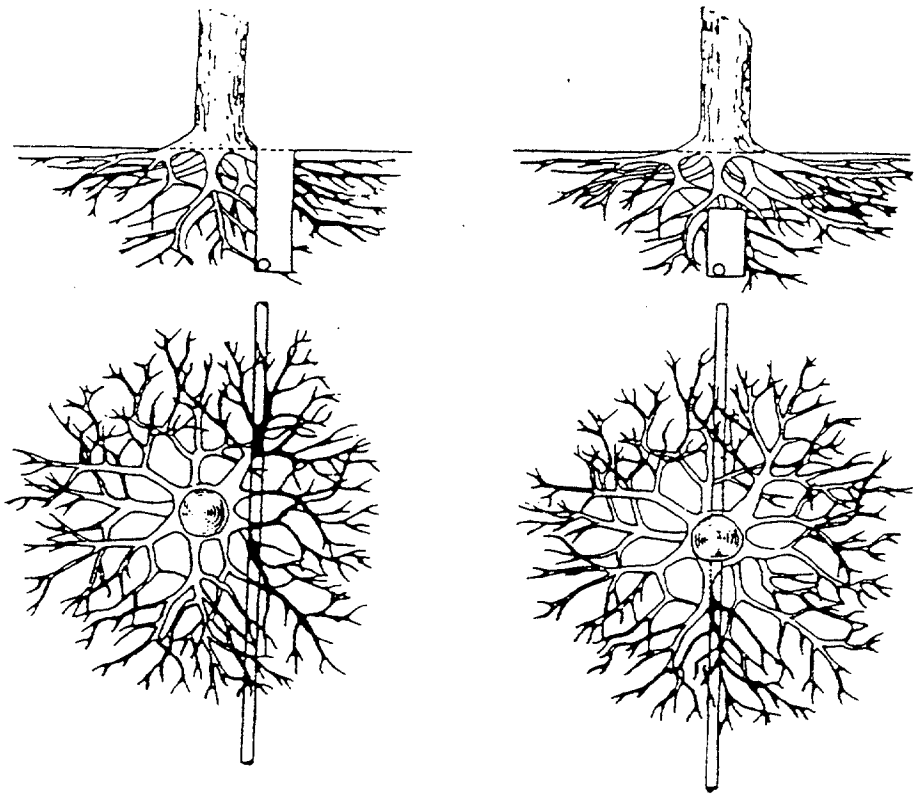


Figure TPP-4. Tree Wall Detail

Trenching and Tunnelling: Trenching should be done as far away from the trunks of trees as possible, preferably outside the branches or crown spreads of trees, to reduce the amount of root area damaged or killed by trenching activities. When possible trenches should avoid large roots or root concentrations. This can be accomplished by curving the trench or by tunneling under large roots and areas of heavy root concentration. Tunneling under a specie that does not have a large tap root may be preferable to trenching beside it as it has less impact on root systems.



Destruction of Feeder Roots Will Probably Kill the Tree

Tunneling Under the Tree Will Preserve Important Feeder Roots

TRENCHING vs TUNNELING

Figure TPP-5. Trenching vs Tunneling

Roots should not be left exposed to the air but should be covered with soil as soon as possible or protected and kept moist with burlap or peat moss until the trench or tunnel can be filled. The ends of damaged and cut roots shall be cut off smoothly and moist peat moss, burlap or topsoil should be placed over the exposed area.

Trenches and tunnels shall be filled as soon as possible. Care should be taken to ensure that air spaces are not left in the soil. Peat moss or other organic matter shall be added to the fill material as an aid to inducing and developing root growth. The tree should be fertilized and mulched to stimulate new root growth and enhance general tree vigor. If a large part of the root system has been damaged the crown leaf surface area should be reduced in proportion to the root damage. This may be accomplished by pruning 20 to 30 percent of the crown foliage. If the roots are damaged during the winter the crown should be pruned before the next growing season. If roots are cut during the growing season, pruning should be done immediately.

Treating Damaged Trees: When trees are damaged during construction activities certain maintenance practices can be applied to protect the health of the tree. Soil aeration may be needed if the soil has been compacted. The soil around trees can be aerated by punching holes 1 foot deep and 18 inches apart under the crown of trees with an iron pipe. Damaged roots should be cut off cleanly and moist peat moss, burlap or topsoil should be placed over the exposed area. Bark damage should be treated by removing loose bark. Tree limbs damaged during construction or removed for any other reason shall be cut off above the collar at the branch junction.

Trees that have been stressed or damaged should be fertilized to aid their recovery. Trees should be fertilized in the spring or fall. Fall applications are preferred. Fertilizer should be applied to the soil over the feeder roots. In no case should it be applied closer than 3 feet to the trunk. Root systems of trees extend some distance beyond the drip line. The area to be fertilized should be increased by 1/4 the area of the crown. A soil test is the best way to determine what type of fertilizer to use. In the absence of a soil test, fertilizer should be applied at the rate of 1 to 2 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees under 6 inches dbh and at the rate of 2 to 4 pounds of 10-8-6 or 10-6-4 per inch of dbh for trees over 6 inches dbh.

A ground cover or organic mulch layer should be maintained around trees to prevent erosion, protect roots and to conserve water.

CHPT. 5- Measures for Stabilizing Coastal Dunes

Chapter 5

MEASURES FOR STABILIZING COASTAL DUNES

CONTENTS

	Page
Introduction	V-1
Selecting Vegetative Measures	V-1
Structural Measures	V-4
Dune Maintenance	V-5
Dune Crosswalk	V-DC-1
Dune Sand Fence	V-DSF-1
Dune Vegetation	V-DV-1

July 1, 1993

MEASURES FOR STABILIZING COASTAL DUNE

Introduction

Dunes are reservoirs of sand that help keep a sea shore intact. They act as flexible barriers to high tides and waves, and dissipate energy that can cause shore recession (beach erosion). Coastal dune ridges block the movement of storm tides and waves into the low-lying areas behind a beach. If they do give way to storm winds and water, these shifting mounds of sand will soon reappear. Dunes are not effective, however, against persistent, continuous beach erosion caused by permanent changes in the shoreline.

Dunes are formed by waves and wind, and when unstable, they are extremely vulnerable to these same forces. They may be stabilized by grasses and woody plants well adapted to this environment.

Dunes stabilized with grasses provide an interesting natural barrier, reducing the velocity of waves and absorbing their energy. These stabilizing plants are tolerant of salt, intense heat, soils lacking humus, and a limited water supply. As sand piles up around beachgrass plants, new shoots emerge from the sand's surface and traps more windblown sand. Structures such as crosswalks and sand fences also catch and hold sand, and either build or repair dunes.

Dune stabilization projects usually require a combination of vegetative and structural measures. They include planting adapted dune grasses, providing adequate moisture during the first growing season (often with an irrigation system), and constructing crosswalks or crossover structures to prevent pedestrian traffic from destroying dune vegetation.

Selecting Vegetative Measures

There are only a few plant species that are tolerant of the stresses of the beach environment. These plants must be able to survive being buried by blowing sand, sand blasting, salt spray, saltwater flooding, drought, heat, and low nutrient supply. Perennial grasses are effective under these conditions. From 1984 to 1989, the USDA, Soil Conservation Service Americus Plant Materials Center (PMC) evaluated seaoats, marshhay cordgrass, and bitter panicum for dune

stabilization on Tybee, Jekyll, and St. Simons Islands in Georgia, and at Gulf Shores Alabama. As a result, the Americus PMC recommends the following plant materials for coastal dune stabilization:

- Sea oats
(Uniola paniculata)

- 'FLAGEO' Marshhay cordgrass
(Spartina patens)

- 'NORTHPA' Bitter panicum
(Panicum amarum)

- 'SOUTHPA' Bitter panicum
(Panicum amarum)

- 'ATLANTIC' Coastal panicgrass
(Panicum amarum var. amarulum)

Sea Oats

Sea oats, a warm-season dune grass ranging throughout the Gulf and south Atlantic coastal region from southeastern Virginia to Mexico, is vigorous, drought and heat tolerant, and relatively free of pests. This perennial is the most important and widespread grass on southern coastal dunes.

The leaves are narrow and pale green, and in northern locations, they die back close to the ground each winter. The seed heads mature in the fall and are compressed spikelets borne at the end of stiff stems 3 feet long or more.

Sea oats can be established by digging and dividing native plants, or from small potted plants grown from seed that are commercially available. Under natural conditions, seed germination is not high and seedling survival is low. When replanting seedlings, set the stock at least a foot deep into the sand and pack it tightly.

'FLAGEO' Marshhay cordgrass

'Flageo' marshhay cordgrass, a new plant for stabilizing coastal areas, was cooperatively released in 1990 by the USDA-SCS plant materials centers in Americus, Georgia and Brooksville, Florida and the Fort Valley State College in Fort Valley, Georgia.

This perennial occurs on dunes throughout the south Atlantic and Gulf regions and in Puerto Rico. Along the Atlantic

coast of northern Florida, marshhay cordgrass is the dominant plant on dunes composed mostly of broken shell and coquina rock. This grass is especially salt tolerant.

The stems of marshhay cordgrass are slender and grow 2 to 3 feet tall and the leaves are rolled inward, resembling rushes. Seed heads are composed of two or more compressed spikes attached at nearly a right angle to the culm. These plants spread by means of a network of slender rhizomes.

Plantings of vegetative material in early spring can be successful. For large plantings, bare root planting stock is recommended. Stems rooted at the base, preferably with a section of rhizome attached, can be planted at a depth of 4 to 5 inches.

'NORTHPA' and 'SOUTHPA' Bitter panicum

'NORTHPA' and 'SOUTHPA' Bitter panicum varieties were released by the Brooksville, Florida Plant Materials Center in 1992. Vegetative plant material is commercially available.

Bitter panicum is a perennial grass found on dunes throughout the south Atlantic and Gulf regions. It is most common in southern Florida and Texas.

These plants grow to an average height of 3 to 4 feet. The leaves are smooth and bluish green and seed heads are narrow, compressed, and generally sparsely seeded. Plants spread from an aggressive, scattered system of rhizomes, but the stands are rather open.

Bitter panicum produces few viable seed, and it is better adapted for transplanting than sea oats. It can be propagated from a stem with part of the rhizome attached or from an 8 to 12 inch length of rhizome without any above-ground parts. Plant the rhizome 4 inches deep in early spring, spaced no more than 6 feet apart.

Another method of propagation is to snap off robust stems at ground level and plant them at an angle of about 45 degrees, so that several nodes are buried.

'ATLANTIC' Coastal panicgrass

'ATLANTIC' coastal panicgrass (Panicum amarum v. amarulum [A. Ritchc. & Chasel P.G. Palmer)) was released by the Cape May, New Jersey Plant Materials Center. Its origin is Princess Ann County, Virginia. Seed is available commercially.

'ATLANTIC' coastal panicgrass is a somewhat dense, upright perennial bunchgrass found on coastal dunes throughout the south Atlantic and Gulf regions. It is a dominant plant at many locations, especially in west Florida, Alabama, and Texas.

The stems are coarse, straight, stiff, and grow up to 4 feet tall. Partially compressed seed heads produce moderate amounts of viable seed each fall. The crowns enlarge slowly from short, almost vertical tillers.

Plant the seed 1 to 3 inches deep in dune sand, and mulch the area for best results. Seedling survival depends on adequate rainfall after germination. Clumps of coastal panicgrass can be dug, divided, and planted with good results during the summer rainy season

Irrigation

Irrigation is required on all dune plantings to provide adequate moisture during the initial establishment period. The irrigation system will consist of mains and laterals, control zones, supports, control valves, fittings, and related hardware that is capable of applying 1/2-inch of water over the entire zone in an eight hour period

Structural Measures

The coastal dune stabilization plan should include structural measures such as dune crosswalks and sand fences.

Dune Cross-Over Structures

A dune protection system requires the construction of wooden dune cross-over structures. Those structures control pedestrian traffic, thus allowing the dune grasses to take hold and protect the dunes from erosion.

Sand Fences

A sand fence is an artificial barrier of evenly spaced wooded slats or approved fabric erected perpendicular to the prevailing wind and supported by posts. It reduces wind velocity at the ground surface and traps blowing sand. These fences are used primarily to build frontal ocean dunes to control erosion and flooding from wave overwash. Use of sand fences is more effective than using vegetation alone, and building dunes vegetatively is less expensive than the use of earth moving by equipment.

Dune Maintenance

Well stabilized dunes will not remain that way unless a reasonable maintenance program is followed. Major considerations include:

Control of Foot and Vehicular Traffic

The primary dune is intolerant of trampling. Traffic must be prohibited! However, since dunes must be crossed to reach the beach, mechanical crossovers must be installed at selected sites. Elevated walks, semi-permanent paved paths and portable roll-up walkways are all satisfactory. These walkways should be curved to reduce wind erosion. The inland, or secondary dune must also be protected from pedestrian and vehicular traffic.

Maintenance of Dune Line

A dune system is like a chain in that it is no stronger than its weakest point. Consequently, to receive maximum protection from dunes, a strong and uniform dune line must be maintained. Blow outs, wash pits, and other natural or human produced damage must be repaired quickly to prevent weakening of the entire protective dune system. Blow outs in a dune system can be repaired by placing sand fences between existing dunes, and tying the ends of the fence into these dunes.

Maintain sand fences and erect additional sand fences as needed, until the eroding area has been permanently stabilized or until the dune has reached the desired height and is properly vegetated. Any loose or damaged boards on cross-over structures should be repaired or replaced.

Maintenance of Vegetation

Maintain plantings by applying fertilizer as needed to keep a desired density. A minimum annual application of 50 pounds per acre of an inorganic nitrogen fertilizer should be made. Sparse areas should be replanted annually.

DUNE CROSSWALK

Definition

A structural measure that is constructed across the dune system to provide access to the beach area.

Purpose

The dune crosswalk structure will prevent pedestrian traffic on dune vegetation and allows the vegetation to establish and thereby protect the dunes from erosion.

Conditions Where Practice Applies

On bare or sparsely vegetated dunes or areas where pedestrian access to the beach is desired.

Planning Considerations

1. Coastal beaches are subject to regulations from a variety of Federal, State, and local agencies. Permits must be requested and granted by all appropriate jurisdiction before work is performed.

2. Coastal areas are affected by many dynamic systems. Detailed studies are often required to determine the possible effects that may result from dune modifications. Environmental assessments are generally required including public review and comment.

Specifications

1. Construct cross-over structures at locations according to landscape plans and engineering drawings for the coastal areas identified.

2. All lumber should be pressure treated #2 yellow pine in accordance with American Wood Preservers Association standard C-2. Treatment should be to 0.40 lbs. CCA per cubic foot, or greater.

3. All nuts, bolts, washers, nails, and other hardware should be hot dipped galvanized metal.

4. Any bolts used in the handrails should have the nut end aiming toward the post. Countersink so that the bolt does not project beyond the post, and trim off any excess metal projecting after fastening.

5. All connections to the post should be made by bolts.

DUNE SAND FENCE

Definition

An artificial barrier of evenly spaced wooden slots or approved fabric erected perpendicular to the prevailing wind and supported by posts.

Purpose

They reduce wind velocity at the ground surface and traps blowing sand. In addition, they are used primarily to build frontal ocean dunes to control erosion and flooding from wave overwash.

Conditions Where Practice Applies

On base or sparsely vegetated dunes or where dune development is desired.

Planning Considerations

1. Coastal beaches are subject to regulations from a variety of Federal, State, and local agencies. Permits must be requested and granted by all appropriate jurisdictions before work is performed.

2. Coastal areas are affected by many dynamic systems. Detailed studies are often required to determine the possible effects that may result from dune modifications. Environmental assessments are generally required including public review and comment.

3. Plans should include details to install an additional set of fence over the existing fence until the barrier dune has reached a protective height.

Specifications

1. Erect the sand fences a minimum of 100 feet (horizontal distance) from the MHT line in two parallel lines 30 feet apart. The fences should be roughly parallel to the water line and yet be as close as possible to a right angle to the prevailing winds.

2. As the fences fill with sand, additional sets of fence can be placed over those until the barrier dune has reached a protective height. To widen an old dune, fencing should be set seaward at a distance of 15 feet from its base.

3. Use standard commercial 4-foot sand fences that consist of wooden slats wired together with spaces between the slats. The distance between slats is 1 1/4 inches or approximately equal to the slat width. The fence should be sound and free of decay, broken wire, and missing or broken slats.

4. The fence should be made from Grade A or better spruce with slats 1 1/4 inches wide and about 1 1/4 inches of space between laths or pickets. The 4-foot wide fence should be woven between five two-wire cables of copper bearing, galvanized wire. The laths or pickets should be hot dipped in a red oxide weather resistant stain.

5. Wooden posts for fence support may be of pressure treated yellow pine or untreated black locust, red cedar, white cedar or other wood of equal life and strength. They should be standard fence posts at least 7 feet long with a minimum diameter of 3 inches, and should be set at least 3 feet deep no further than 10 feet apart. Four wire ties should be used to fasten the fence to the wood posts. Weave the fence between posts so that every other post will have fencing on the ocean side of posts. Tie wires should be no smaller than 12 gauge galvanized wire.

DUNE VEGETATION

Definition

Use of adapted vegetation to catch and hold sand on dunes that are denuded, artificially constructed, or re-nourished.

Purpose

To stabilize soil on dunes allowing them to become more resistant to wind and waves. To maintain a barrier dune system that protects low-lying areas during storms of short duration. Dunes act as barriers to waves, as energy dissipators, and as reservoirs of sand that reduce foreshore recession during storms.

Conditions Where Practice Applies

On bare or sparsely vegetated dunes or areas where dune development is desired.

Planning Considerations

1. Coastal beaches are subject to regulations from a variety of Federal, State and local agencies. Permits must be requested and granted by all appropriate jurisdictions before work is performed.

2. Coastal areas are affected by many dynamic systems. Detailed studies are often required to determine the possible effects that may result from dune modifications. Environmental assessments are generally required including public review and comment.

3. Protection of dunes from human and vehicular traffic is essential if vegetation is to succeed.

4. There are only a few plant species that are tolerant of the stresses of the beach environment. Plants must be able to survive burial by blowing sand, sand blasting, salt spray, saltwater flooding, drought, heat, and low nutrient supply.

5. An irrigation system is required during the first growing season to obtain good plant survival.

Specifications

1. Plant Materials

Commercially available plant materials/varieties that are adapted in Alabama for coastal dune stabilization. These are described under Selecting Vegetative Measures and in Appendix A5.

Planting stock is available from a number of commercial nurserymen. Two to four inch pots are generally adequate for most stabilization and building work. Liners (one inch pots) are recommended for good sites under ideal planting conditions or irrigation. Pots larger than four inches are desirable only where aesthetics or traffic control is important, or erosion is extreme. Bare root stock dug from vigorous stands and planted when fresh gives survival and growth rates equal to potted materials. Unrooted stolons of bitter panicum may be cut after seed is mature and planted at three vertical cuttings per planting space or uncut steams in 3 to 4 inch deep furrows 12 to 18 inches apart. 'Atlantic' coastal panicgrass may be direct seeded at 15 pounds per acre drilled or sown in 2-inch deep furrows.

2. Site Preparation

Tillage or liming are not required for planting on beach sand. Install the dune crossover structures, sand fences and the irrigation system prior to planting.

3. Planting Date

Plant vegetative material in late winter or early spring, usually a period from March 1 to June 1 is suitable with irrigation.

4. Planting Depth

Plants for the dunes should be planted 6-8 inches or deep enough to have adequate soil moisture at the time of planting.

Use freshly dug bare root tillers, rooted stem cuttings on nursery grown (potted) vegetative material.

Use a tree dibble, or spade to plant the vegetative material. Large, flat sites can be planted more

economically using a tractor-drawn transplanter with planting plows necessary to make furrows 8-15 inches deep.

5. Spacing

Widths of planting must consist of at least 10 feet of dune building vegetation. Wider areas may be considered based on the severity of the site. Herbaceous plant spacing ranges from 1 to 3 feet, but is typically 18 inches for 1 to 4 inch potted stock or bare root plugs of the same diameter.

6. Fertilization

Initial fertilization is best done at planting with a complete slow release fertilizer, such as Osmocote 14-14-14, at a rate of one ounce per plant placed under the plant. Initial fertilization may also be provided with 200-300 pounds of mineral 10-10-10 per acre broadcast six weeks after planting. Maintenance fertilization should be provided with 400 pounds of 10-10-10 per acre per year split in two applications during the growing season before September 1. Fertilization is recommended until the plants spread to provide complete cover and after storms damage stands.

7. 2nd Year Fertilization

Apply 400 pounds of 10-10-10 fertilizer per acre in June.

8. Mulching

Mulch protects the soil between the plants from wind erosion and reduces evaporation of moisture available to plants. Mulch usually used with seedings (hay, straw, netting, peg and twine, asphalt) is not recommended due to the difficulty in applying and anchoring the mulch and its untidy appearance. Woodchips and compost are recommended at four inches depth applied to the soil surface or six inches depth incorporated into the top six inches of soil. Ligin soil stabilizers are recommended for surface stabilization applied at the manufacturer's recommended rates and concentration.

9. Irrigation

Irrigation is required on all dune plantings to provide adequate moisture during the initial establishment period.

CHPT. 6- Managing Stormwater

Chapter 6

MANAGING STORMWATER

CONTENTS

	Page
The Stormwater Problem	VI-1
What is Stormwater Management	VI-3
Principles of Stormwater Management	VI-9
Stormwater Management Measures	VI-12
State Requirements for Stormwater Management	VI-14
Construction, Land Disturbance and Associated Areas Stormwater General Permit Requirements	VI-16
Active and Inactive or Abandoned Mining Stormwater General Permit Requirements	VI-17

MANAGING STORMWATER

This chapter is intended to only be an introduction to the subject of Stormwater Management. Other references should be utilized for a complete coverage of the subject.

The Stormwater Problem

Water flowing over the land during and immediately following a rainstorm is called stormwater runoff. The runoff passing a particular point is equal to the total amount of rainfall upstream of that point less the amounts of infiltration, transpiration, evaporation, surface storage and other losses. The amount of these losses is a function of climate, soils, geology, topography, vegetative cover and, most importantly, land use.

There are four distinct yet interrelated effects of land use changes on the hydrology of an area: changes in peak flow characteristics, changes in total runoff, changes in water quality, and changes in the hydrologic amenities (Leopold, 1968). The hydrologic amenities are what might be called the appearance or the impression which the river, its channel and its valleys, leaves with the observer. Of all land use changes affecting the hydrology of an area, urbanization is the most forceful.

As an area becomes urbanized, the peak rate of runoff and volume of runoff increase. These effects are caused by: 1) a reduction in the opportunity for infiltration, evaporation, transpiration and depression storage; 2) an increase in the amount of imperviousness; and, 3) modification of the surface drainage patterns, including the associated development of stormwater management facilities.

The volume of stormwater runoff is governed primarily by infiltration characteristics and is related to the land use, soil type, topography and vegetative cover. Thus, runoff is directly related to the percentage of the area covered by roofs, streets and other impervious surfaces. Water intercepted by vegetation and evaporated or transpired is lost from runoff. A small portion of the water that infiltrates into the soil and groundwater is delivered to the stream as delayed flow and does not contribute directly to peak stormwater runoff. Impervious surfaces normally contribute almost all of the total rain immediately to stormwater runoff.

All forms of land use affect water quality. In an undeveloped area, many ongoing physical, chemical and biological processes interact to recycle most of the materials found in the runoff. As the human land use intensifies, these processes are disrupted. Man's activities add materials to the land surface (pesticides, fertilizers, animal wastes, oil, grease, heavy metals). These materials are then washed off by the rainfall and runoff, thereby increasing the pollutant load carried to receiving waters by stormwater runoff.

Of primary importance to water quality is the "first flush". This term describes the washing action that stormwater has on accumulated pollutants in the watershed. In the early stages of runoff the land surfaces, especially impervious surfaces like streets and parking areas, are flushed clean by the stormwater. This flushing creates a shock loading of pollutants. Extensive studies in Florida have determined that the first flush equates to the first one inch of runoff which carries 90% of the pollution load from a storm (USGS, 1984). Treatment of the first one inch of runoff will help ensure that the water quality effects of stormwater are minimized. First flush effects generally diminish as the size of the drainage basin increases and the amount of impervious area decreases.

Finally, the value of the hydrologic environment as an amenity is primarily affected by three factors: stability of the stream channel, accumulation of trash, and disruption of the stream community. A channel which is gradually enlarged because of increased floods caused by urbanization, tends to have unstable and unvegetated banks, scoured or muddy channel beds, and unusual accumulations of sediment and debris. Together with the accumulation of trash in the channel and floodplain (beer cans, lumber scraps, lawn clippings, concrete, wire) these all tend to severely decrease the visual attractiveness of a stream. Ultimately these factors disrupt the natural balance in the streams' biota resulting from the addition of nutrients, organics, and sediment. These disruptions increase algal growth and turbidity, lower the oxygen content of the water, and thereby change the biological character of the stream.

In summary, each progression toward more intensive land use tends to disrupt the ongoing natural processes which protect and preserve water quality. Therefore, to ensure future protection of water resources, it is imperative that land uses be managed in a responsible way.

What is Stormwater Management?

In an undeveloped area, stormwater runoff is managed by nature through the hydrologic cycle. The cycle begins with rainfall. Rain either stands where it falls, on leaf or plant, and evaporates; or it is absorbed into the ground near the surface, to feed trees and vegetation, ultimately to be returned to the atmosphere by transpiration; or it percolates deeply into the ground replenishing the groundwater supply. The remainder of the rainfall collects into rivulets. This collected runoff increases in quantity as it moves down the watershed, through drainageways, streams, reservoirs and to its ultimate destination, the river and then the sea. Evaporation from the sea surface begins the cycle again.

This simple explanation of the hydrologic cycle belies its complexity. Nature's inability to accommodate severe rainfalls without significant damage, even in undeveloped areas, is very apparent. Nature's stormwater management systems are not static but are constantly changing. Streams meander, banks erode, vegetation and soil permeabilities change with the seasons, lakes fill in with sediment and eventually disappear. The stripping of ground and tree cover by fire can change an entire system forcing new natural accommodations throughout the system.

Historically, urbanization has resulted in the development of stormwater management systems to reduce flooding. These systems were required because man was unwilling to suffer inconvenience where it could be avoided and because he would not tolerate the loss of life or property. Typically such concerns have meant that stormwater management systems were designed for safety and convenience without recognition of other important considerations. Therefore, no matter how large the rainfall or its duration, the stormwater system was expected to remove the runoff as quickly as possible, to restore maximum convenience in the shortest possible time. In other words, until recently, stormwater management was concerned with only the quantitative effects of runoff.

Today, however, stormwater management is far more comprehensive. An effective program involves the implementation of actions to control water in its hydrologic cycle with the objectives of providing: 1) flood control; 2) off-site erosion control; and, 3) non-point source pollution control. Stormwater management applies to rural and urban areas alike; however, the techniques presented in this manual are most relevant to urban or urbanizing situations.

To accomplish the three objectives of stormwater management, it is necessary to ensure that the volume, rate, timing and pollutant load of runoff after development are similar to that which occurred prior to development. The approach suggested in this manual is to minimize the adverse impacts of stormwater through a coordinated system of source controls. Source controls emphasize the prevention and reduction of nonpoint pollution and excess stormwater flow before it ever reaches a collection system or receiving waters. Typical control strategies and management criteria to accomplish the objectives of stormwater management are discussed below.

Flood Control

This has been the most common goal of local stormwater management programs. The property damage, safety hazards, and inconvenience which can result from increased stream flooding in urbanizing watersheds usually get wide public attention and urgent demands for government action. Two levels of drainage systems must be considered in developing a management strategy for flood control: the primary drainage system and the major drainage system.

The primary drainage system consists of the street gutters and ditches, storm sewers, culverts, and open channels which are designed to prevent inconvenience and minor property damages from relatively frequent storm events. Of course, the most effective strategy for flood control at this level is to plan and design the primary drainage system adequately in advance, keeping in mind the future development potential of the drainage area. Unfortunately, many existing drainage systems were designed on a piecemeal, "as needed" basis with little regard for future upstream development. The capacity of such systems often becomes severely inadequate as upstream development progresses, resulting in frequent minor flooding and property damages.

One strategy for dealing with this problem is to replace or modify elements of the primary drainage system to provide the required capacity. This option is often expensive and does not control the source of the problem. However, this may be the only feasible method of correcting existing problems. To prevent future problems, an alternative strategy may be employed. Persons wishing to undertake new development may be required to control runoff from their sites in a manner which will not adversely affect the downstream drainage system. This control is usually accomplished through stormwater detention criteria.

Typical detention criteria will specify that stormwater runoff from a new development must be controlled so that the post-development peak runoff rate does not exceed the pre-development peak rate for some specific frequency design storm or range of design storm events. In many localities, a 10-year design storm is specified to preserve the effectiveness of downstream drainage structures which were originally designed to pass a 10-year pre-development storm. Other localities require that larger storms (i.e., 50-100 year events) must be detained and released at a controlled rate to reduce the downstream effects of major storms.

It should be kept in mind that the larger the storm event which is required to be controlled and the slower the allowable release rate, the greater the storage volume which will be required in the detention facility. The cost of providing this storage volume under local conditions (i.e., land availability and cost, topography, etc.) should be carefully considered in determining detention criteria.

The major drainage system comes into play when the capacity of the primary drainage system is exceeded. This major system consists of the flood plains and surface flow routes which water will follow during major storms. The most effective strategy for dealing with flooding at this level is to insure that stormwater has a route to follow which will not cause major property damage or loss of life. To implement this strategy, flood plain ordinances, zoning regulations or other land use controls should be used to restrict flood plain development. In areas where development has already encroached on the flood plain, land owners should be encouraged to purchase flood insurance, if available.

Off-Site Erosion Control

This goal must be addressed in all local stormwater management programs. The strategies for dealing with this problem are similar to those for flood control. The major difference is in the frequency of the storm which must be controlled.

Studies have shown that most natural stream channels are formed with a bank-full capacity to pass runoff from a storm with a 1.5- to 2-year recurrence interval. As upstream development occurs, the volume and velocity of flow from these relatively frequent storms increase. Even smaller storms with less than 1-year recurrence intervals begin to cause streams to flow full or flood.

Stream channels are often subject to a 3 to 5-fold increase in the frequency of bank-full flows in a typical urbanizing watershed. This increase in the flooding frequency places a stress on the channel to adjust its shape and alignment to accommodate the increased flow. Unfortunately, this adjustment takes place in a very short time period(in, geologic terms) and, the transition is usually not a smooth one. Meandering stream channels which were once parabolic in shape and covered with vegetation typically become straight, wide rectangular channels with barren vertical banks. This process of channel erosion often causes significant-property damage, and the resulting sediment which is generated is transported downstream, further contributing to channel degradation.

One strategy for dealing with this problem is to increase the carrying capacity and stability of affected streams through channel modifications (i.e., straightening, widening, lining with non-erodible material, etc.). This strategy may be employed most effectively on man-made channels or small intermittent streams. Significant modifications to natural, continuous flowing streams, however, can be the subject of intense local controversy and may require special permits such as a 404 permit issued by the Corp of Engineers.

Wherever modifications to natural flowing streams are being considered, extreme care must be taken to weigh the benefits of such modifications against the cost and the concerns of the local citizens. Where channel modifications are necessary, an attempt should be made to incorporate conservation measures which will minimize adverse impacts to fish, wildlife, and the aesthetic quality of the stream.

On-site stormwater retention criteria for new development projects can also be an effective strategy for preventing future increases in channel erosion. However, such criteria should be tied to more frequent storm events than typical flood control criteria. Maintaining the pre-development peak runoff rate from a 10-year storm, for example, will probably not effectively reduce downstream erosion since the majority of storm events will pass right through the detention system unimpeded.

For example, the minimum State or local stormwater management criteria could be tied to a 2-year storm event. Receiving channels would then be capable of passing a 2-year storm without flooding or erosion after development of the site, or, stormwater would be detained on the site so that the pre-development peak flow rate from a 2-year storm is not exceeded after development. While flows from larger,

less frequent storm events may cause erosion problems downstream, it is felt that because such events will occur less often, streams will have more time to recover and restabilize themselves.

Local stormwater detention criteria can be made more restrictive by requiring that storms larger than a 2-year event be detained. However, the allowable release rate should be tied to the actual carrying capacity of the receiving stream or the 2-year pre-development peak runoff rate.

Nonpoint Source Pollution Control

Pollutants which are washed from the land surface and carried into the streams, rivers, and lakes with stormwater runoff have only recently been recognized as major contributors to water quality degradation in urban and urbanizing watersheds. The goal of controlling this problem is therefore relatively new. Nonpoint source pollution control is likely to receive highest priority in watersheds which feed public water supplies or recreation reservoirs; however, this goal should be addressed in all local stormwater management programs.

Public Law 92-500, Section 208, requires that Areawide Waste Treatment Management Plans (208 plans) must be developed for all areas of the country to assure that national water quality goals can be achieved. Where nonpoint source pollution contributes significantly to water quality degradation, the 208 plan must contain provisions for dealing with this problem.

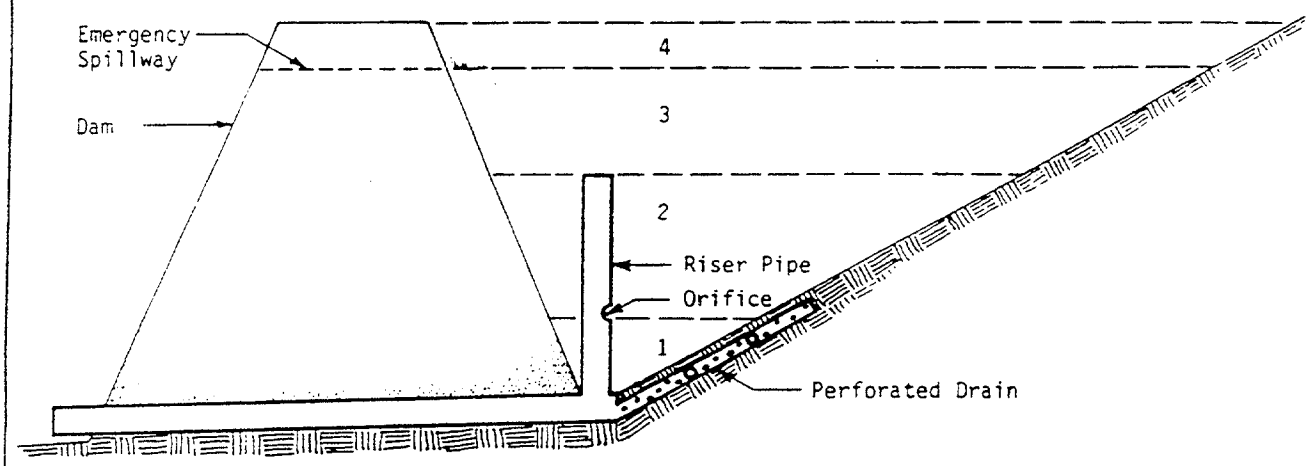
Fortunately, in urban areas most of the stormwater detention practices which are used to control runoff quantity may also be adapted for use as best management practices for nonpoint source pollution control. The design criteria of these practices for this purpose, however, are often different. The primary design strategy for pollution removal is to maximize the detention time of captured runoff. Although there have not been many monitoring studies to produce definitive design criteria, it is believed that basin drawdown times between 30-40 hours will result in significant pollutant removal. The required storage volume of detention facilities can be tied to a first flush capture (i.e., the initial 0.1 inch to 1 inch of runoff).

Multiple-Purpose Criteria

Stormwater management criteria for flood control, erosion control, and pollution control are not necessarily mutually

exclusive. In many cases, stormwater can be managed to accomplish all three goals simultaneously. For example, a stormwater retention basin can be designed as a multipurpose structure by incorporating different release rates at different stages (storage elevations). Figure 6-1 illustrates an example of such a design.

The first stage is designed to capture an initial volume of runoff (i.e., the first flush) and release it very slowly through a subsurface drainage system. The second stage begins with an orifice cut in the riser pipe which has the capacity to pass stormwater runoff at a 2-year pre-development rate when water elevation reaches the top of the riser. The purpose of this stage would be to control



Stage	Purpose
1	Capture the first flush and release it very slowly (via a perforated drain) to settle out pollutants
2	Capture the 2-year storm and release it at the pre-development 2-year rate (via the orifice) to reduce stream channel erosion downstream
3	Capture the 10-year or greater storm and release it at the pre-development 10-year rate (via the top of the riser) for downstream flood protection
4	Release the 100-year storm (via the emergency spillway without damage to the impoundment structure

SCHEMATIC OF A TYPICAL MULTI-STAGE IMPOUNDMENT

Figure 6-1. Typical Impoundment.

downstream channel erosion from frequent storms. The top of the riser pipe could serve as the outlet for the third stage and may be designed to pass a 10-year storm at a pre-development rate for moderate flood protection downstream. The emergency spillway should be designed to pass at least the 100-year storm. While such a multi-purpose design may not be feasible for all detention systems, there are often innovative approaches which can be taken to satisfy two or more local stormwater management goals.

Flexibility

Flexibility is extremely important in stormwater management programs. Each development project has a unique set of conditions and circumstances and a different potential for affecting the downstream drainage system.

Criteria which may be perfectly applicable to one project may be totally unsuitable for another. For example, requiring stormwater detention for flood control may be highly applicable to projects constructed in the upper reaches of a watershed, but may be unnecessary or even undesirable for new projects constructed near the outlet of the watershed.

Project engineers and planners should be given an opportunity to design a drainage system which contributes to the achievement of established local stormwater management goals in the most cost-effective manner. To accomplish this, each project must be considered on an individual basis.

Principles of Stormwater Management

It is much more efficient and cost-effective to prevent problems than to attempt to correct problems after the fact. Sound land use planning decisions based on the site planning principles are essential as the first, and perhaps the most important, step in managing stormwater related problems. All new development plans (e.g., subdivisions, shopping centers, industrial parks, office centers, etc.) and redevelopment plans should include a comprehensive stormwater management system.

Every piece of land is part of a larger watershed. A stormwater management system for each development project should be based on, and should support a plan for the entire drainage basin.

Optimum design of the stormwater management system should mimic (and use) the features and functions of the natural drainage system which is largely capital, energy and maintenance cost free. Every site contains natural features which contribute to the management of stormwater under the existing conditions. Depending upon the site, existing features such as natural drainageways, depressions, wetlands, floodplains, highly permeable soils, and vegetation provide natural infiltration, help control the velocity of runoff, extend the time of concentration, filter sediments and other pollutants, and recycle nutrients. Each development plan should carefully map and identify the existing natural system. "Natural" engineering techniques should be used to preserve and enhance the natural features and processes of a site and to maximize the economic and environmental benefits. Engineering design can and should be used to improve the effectiveness of natural systems, rather than negate, replace or ignore them.

The volume, rate, timing and pollutant load of stormwater after development should closely approximate the conditions which occurred before development. To accomplish these objectives two overall concepts must be considered: (1) the perviousness of the site should be maintained to the greatest extent possible; and (2) the rate of runoff should be slowed. Preference should be given to stormwater management systems which use measures that maintain vegetative and porous land cover and include on-site storage mechanisms. These systems will promote infiltration, filtering and slowing of the runoff.

Maximize on-site storage of stormwater. Provision for storage can reduce peak runoff rates; aid in groundwater recharge; provide settling of pollutants; lower the probability of downstream flooding, stream erosion and sedimentation; and provide water for other beneficial uses.

Stormwater runoff should never be discharged directly into surface or ground waters. Runoff should be routed over a longer distance, through grassed waterways, wetlands, vegetated buffers and other works designed to increase overland flow. These systems increase infiltration and evaporation, allow suspended solids to settle, and remove pollutants before they are introduced to waters of the state.

Stormwater management systems, especially those emphasizing vegetative practices, should be planned, constructed and stabilized in advance of the facilities that will discharge into them. This principle is frequently ignored thereby causing unnecessary off-site impacts, extra maintenance, re-

working of grades, re-vegetation of slopes and grassed waterways, and extra expense to the developer. The stormwater management system, including erosion and sedimentation controls, should be constructed and stabilized at the start of site disturbance and construction activities.

The stormwater management system must be designed beginning with the outlet or point of outflow from the project. The downstream conveyance system should be evaluated to ensure that it contains sufficient capacity to accept the design discharge without adverse downstream impacts such as flooding, streambank erosion and sedimentation. It may be necessary to stabilize the downstream conveyance system, especially near the stormwater system outlet. Another common problem is a restricted outlet which causes stormwater to back up and exceed the storage capacity of the collection and treatment system resulting in temporary upstream flooding. This may lead to hydraulic failure of the stormwater management system causing resuspension of the pollutants and/or expensive repairs to damaged structures or property. In such circumstances it is advisable to use more than one outlet or to increase the on-site storage volume.

Whenever possible, construct the components of the stormwater management system on the contour following the topography. This will minimize erosion and stabilization problems caused by excessive velocities; it will also slow the runoff allowing for greater infiltration and filtering.

Stormwater is a component of the total water resources which should not be casually discarded but used to replenish those resources. Stormwater represents a potential resource out of place, with its location determining whether it is a liability or an asset. Given the water quantity and quality problems facing Alabama, it is imperative that stormwater is considered to be an asset. Treated stormwater has a great potential for providing many beneficial uses such as irrigation (farm, lawn, parks, golf courses), recreational lakes, groundwater recharge, industrial cooling and process water, and other nonpotable domestic uses.

Whenever practical, multiple use temporary storage basins should be an integral component of the stormwater management system. All too often, storage facilities planned as part of the system are conventional, unimaginative ponds which are aesthetically unpleasing. Recreational areas (e.g., ballfields, tennis courts, volleyball courts), greenbelt areas, neighborhood parks and even parking facilities provide excellent settings for the temporary storage of stormwater. Such areas are not usually in use during periods

of precipitation and the ponding of stormwater for short durations does not seriously impede their primary functions.

Storage areas should be designed with sinuous shorelines. Shorelines which are sinuous rather than straight increase the length of the shoreline. The increased shoreline also provides more space for the growth of shoreline vegetation thus providing for greater pollutant filtering and for increased and diversified aquatic habitat.

Vegetated buffer strips should be retained in their natural state or created along the banks of all water bodies. Vegetated buffers prevent erosion, trap sediment, filter runoff, provide public access, enhance the site amenities, and function as a floodplain during periods of high water. They also provide a pervious strip along a shoreline which can accept sheet flow from developed areas and help minimize the adverse impacts of untreated stormwater.

The stormwater management system must receive regular maintenance. Failure to provide proper maintenance reduces the pollutant removal efficiency of the system and reduces the system's hydraulic capacity. Lack of maintenance, especially to vegetative systems which may require revegetating, can increase the pollutant load of stormwater discharges. The key to effective maintenance is the clear assignment of responsibilities to an established agency (local government) or organization (homeowners association) and a regular schedule of inspections to determine maintenance needs. Even better, stormwater system designers should seek ways to make their systems as simple, natural and maintenance free as possible.

Stormwater Management Measures

There are a number of measures and techniques which have been employed to manage both the quantity and quality of urban stormwater runoff. Following is a summary of some of these runoff control measures:

Urban Impoundments: This practice involves the construction or modification of surface water impoundments in a manner which will protect downstream areas from potential water quality degradation, flooding, and stream channel degradation due to upstream urban development. The objective is to detain stormwater and release it at a controlled rate. Downstream water quality is improved through sediment removal, plant uptake of nutrients, chemical transformations, spread-out pollutant loadings and other processes.

Parking Lot Storage: This practice involves the use of impervious parking areas as temporary impoundments during rainstorms. Parking lot drainage systems can be designed to temporarily detain stormwater in special designated areas, and release it at a controlled rate. The objective is to protect downstream areas from increased flooding, stream channel degradation and/or combined sewer overflows caused by urban development. It is important that these facilities be designed to minimize potential safety hazards and inconvenience to motorists and pedestrians.

Rooftop Detention: This practice allows stormwater falling directly onto flat roof surfaces to be temporarily ponded and gradually released by incorporating controlled flow roof drains into building designs. The purpose is to reduce adverse impacts of rooftop runoff on sewer systems and receiving streams. Rooftop detention can be incorporated into the design of most new buildings, and many existing structures also can be modified for this function.

Rooftop Runoff Disposal: This practice encourages the disposal of rooftop runoff by systems and techniques that avoid or replace direct connections of roof drainage systems to sewer systems. The objective is to reduce the frequency of sewer overflows. Proposed alternatives to sewer connection include surface drainage, subsurface infiltrations, and runoff collection and storage.

Cistern Storage: This practice involves the collection and storage of stormwater runoff in a storage tank or chamber above or below the ground. A cistern can serve solely as a stormwater detention device to protect downstream areas from flooding, stream channel degradation and/or sewer over- flows, or it can be used to collect polluted runoff for later treatment. Water collected in a cistern may also be put to use for lawn watering, fire protection or other purposes.

Infiltration Pits and Trenches: This practice involves the excavation of pits or trenches which are backfilled with sand and/or graded aggregates. Stormwater runoff from impervious surfaces can be directed to these facilities for detention and infiltration. Permeable soils are a prerequisite. The potential for groundwater pollution must also be carefully evaluated.

Concrete Grid and Modular Pavement: This measure involves the use of a special pervious paving material in low traffic areas. The pavement consists of concrete grids or other structural units alternated with pervious fillers such as sod, gravel or sand. The resultant pavement provides an adequate bearing surface and yet allows a significant amount of infiltration thereby reducing runoff volume and discharge rate and improving the water quality.

Porous Asphalt Pavement: This practice involves the use of a special asphaltic paving material which allows stormwater to infiltrate at a high rate. Infiltration water is stored below the pavement in a high-void aggregate base. This practice provides for stormwater detention and in some cases increases infiltration into the ground. Use of the practice can contribute to reduced sewer overflows, decreased flooding and stream channel degradation, and improved water quality. This type of pavement offers many other benefits not related to water quality, including enhanced visibility, increased safety and reduced drainage system costs.

Grassed Waterways, Filter Strips, and Seepage Areas: This practice Involves utilizing grassed surfaces to reduce runoff velocities, enhance infiltration and remove runoff contaminants, thus improving runoff quality and reducing the potential for downstream channel degradation and sediment pollution due to urban development. Concepts covered include using grass-lined roadside swales instead of curb and gutter installations; using grass-lined open drainage channels instead of paved channels; using grass-covered surfaces to intercept runoff and filter out some of the contaminants; and using small shallow basins over permeable soils to capture and infiltrate runoff.

State Requirements for Stormwater Management

State law and Alabama Department of Environmental Management (ADEM) regulations require that appropriate, effective Best Management Practices (BMPs) for the control of pollutants in stormwater run-off be fully implemented and maintained for all construction and land disturbance activities to prevent/minimize discharges of sediment and other pollutants to waters of the State of Alabama.

A "water of the state" is broadly defined as any water, surface (perennial or intermittent creek, lake, etc.) or underground, not wholly contained on one individual's property or that crosses a property line. Discharges of

pollutants resulting from failure to implement effective BMPs are considered unpermitted discharges to state waters. Unpermitted discharges to state waters constitute violations of the Alabama Water Pollution Control Act, Code of Alabama 1975, §§22-22-1 through 22-22-14 (1984 & 1989 Cum. Supp.) and the Alabama Environmental Management Act, Code of Alabama 1975, §§22-22A-16 (1984 & 1989 Cum. Supp.), for which civil penalties of up to $25,000.00 per day for each violation may be imposed.

A person, company, or construction operator is required to take all measures necessary to prevent sediment and other pollutants in water used in the construction process or stormwater run-off from disturbed areas, from leaving the construction site or associated areas. Erosion and sediment control measures should be applied throughout the construction process as outlined in the site plan. The plan must include the measures needed for stormwater management during construction and after installation to meet state and local regulations.

If an inspection is performed pursuant to a complaint or as a routine matter, and deficiencies are found, the operator is required to file with the ADEM a full report prepared and certified by a professional engineer registered in the State of Alabama showing the steps that have been taken and are being taken to correct any deficiencies or violations. In addition, the report must address the removal and/or stabilization of sediment deposited offsite.

Failure to file a report as required is a violation of the Alabama Water Pollution Control Act, Code of Alabama 1975, §22-22-9(e) (1989 Cum. Supp.) for which civil penalties of up to $25,000.00 per day may be imposed. In addition, any false statement, representation, or certification knowingly made in such report is a criminal offense and is punishable by a fine of up to $10,000.00 or imprisonment for up to six months, or both.

Follow-up inspections are performed to determine if the proper pollution control measures have been installed. While construction activity is ongoing or until such time as all disturbed areas are stabilized and revegetated, periodic inspections are made as necessary to determine if appropriate BMPs are adequate and if they are being maintained on a daily basis.

If effective BMPs are not installed and maintained, ADEM generally has no recourse but to pursue further formal enforcement actions.

Listed below are several additional BMP guidance documents which should help in complying with ADEM requirements. Copies of these and other helpful BMP guides can be obtained from ADEM.

1. Alabama Nonpoint Source Management Program Document, as amended, Prepared by ADEM, Water Division - Mining and Nonpoint Source Section, in accordance with Section 319 of the Federal Clean Water Act, as amended.

2. EPA Stormwater Pollution Prevention for Construction Activities, Office of Wastewater Enforcement and Compliance, U.S. Environmental Protection Agency, Washington, D.C. 20460, as amended.

3. Best Management Practices Plan - Magnolia Pipeline, Basin Pipeline Corporation, 2101 Sixth Avenue, North, Suite 900, Birmingham, Alabama 32503.

4. Best Management Practices for Nonpoint Source Runoff Control, Mobile & Baldwin Counties, Alabama, South Alabama Regional Planning Commission, January 1989.

5. Best Management Practices for Controlling Sediment and Erosion from Construction Activities, Birmingham, Regional Planning Commission, August 1980.

Construction, Land Disturbance and Associated Areas Stormwater General Permit Requirements

Pursuant to federal Phase I stormwater permitting requirements effective October 1, 1992, an operator is required to apply for a permit from ADEM for construction and land disturbance activities and associated areas that exceed five acres or is part of a larger common plan of development or sale that may eventually exceed five acres.

Phase II of the stormwater regulations are currently under development and may require smaller construction and land disturbance sites to obtain a permit in the future.

On August 1, 1992 ADEM issued a National Pollutant Discharge Elimination System (NPDES) General Permit ALG610000 for stormwater runoff from construction, excavation, land clearing, other land disturbance activities, and associated areas. This general permit was developed and issued to allow industry a simpler method to comply with federal regulations for discharging stormwater and will expire on July 1, 1997. The general permit will be reissued at that

time, with any necessary changes, for a period not to exceed five years.

The construction general permit requires a company or individual to use BMPs to control stormwater runoff. The general permit requires inspections on a monthly basis, in response to rainfall accumulation, and as often as necessary to ensure that adequate BMPs have been implemented. The permittee must also monitor representative discharges from the site a minimum of once every six months. These samples are to be analyzed for pH, TSS, SS, flow, and under some circumstances Oil and Grease, BOD_5, and COD. Upstream and downstream turbidity in the receiving stream must be monitored to ensure compliance with State water quality standards. Onsite precipitation must also be recorded.

To apply for coverage under this general permit a Notice of Intent consisting of ADEM Form 200, EPA Form I, USGS 7.5 minute quad map with the site delineated, individual or one-page BMP plan, and the appropriate fee must be filed with ADEM. The company must also publish a public notice in a local newspaper and submit proof of this to ADEM. Applicable forms, a completed example Notice of Intent, and more specific information may be obtained by contacting the Department.

The federal regulations require that construction sites remain permitted until adequate reclamation and water quality remediation is achieved.

Active and Inactive or Abandoned Mining Stormwater General Permit Requirements

The stormwater regulations also require that a permit be obtained prior to conducting <u>any</u> active mining, mineral processing or mineral transportation operations and for <u>any</u> inactive/abandoned coal sites that do not have a Surface Mining Reclamation Control Act (SMRCA) bond release and noncoal sites that do not have an appropriate state release. In addition, ADEM Administrative Code Rule 6-9-.08(1) requires compliance with ADEM's mining rules prior to commencing any operations.

On August 1, 1992 ADEM issued NPDES General Permit ALG490000 for Active noncoal mining sites (includes "borrow" areas) less than five acres (clay, dirt, sand, chert, etc.) and GP ALG040000 for inactive and/or abandoned mining areas. Active noncoal mining sites greater than five acres must obtain an Individual NPDES permit.

Individual Permit Application Requirements

A complete application for an individual permit must include payment of the appropriate fee, a 1"-500' scale facility map detailing all pollution control structures, a 1"-2000' scale facility location map, a written pollution abatement and/or prevention plan prepared by a registered professional engineer with an explanation of facility operations and pollution control measures as required by ADEM Administrative Code 6-9-.03, EPA Form 1, ADEM Application, and if necessary, a spill prevention, control and countermeasures plan for all on-site storage tanks.

General Permit Notice of Intent Requirement

Active noncoal sites less than five acres and inactive and abandoned mining sites can obtain a General NPDES permit authorization. A complete Notice of Intent for a general permit must be filed with ADEM and consists of the appropriate ADEM form, EPA Form I, USGS 7.5 minute quad map with the site delineated, individual or one-page BMP plan, and the appropriate fee. The company must also publish a public notice in a local newspaper and submit proof of this to ADEM. Applicable forms and more specific information may be obtained by contacting ADEM.

The federal regulations require that inactive/abandoned sites remain permitted until adequate reclamation or water quality remediation is achieved.

Questions concerning BMP implementation or permit requirements for mining or land disturbance and construction activities should be directed to the Mining and Nonpoint Source Section, Water Division, ADEM at (205) 271-7786 or 271-7839.

BIBLIOGRAPHY

Leopold, Luna, 1968. "Hydrology for Urban Planning - A Guidebook on the Hydrologic Effect of Urban Land Use", USGS Circular 554.

Miller, Robert A., 1985. "Percentage Entrainment of Constituent Loads in Urban Runoff, South Florida", USGS WRI 84-4392.

CHPT. 7- Landscape Architecture's Role In Erosion and Sediment Control

Chapter 7

LANDSCAPE ARCHITECTURE'S ROLE IN EROSION AND SEDIMENT CONTROL

July 1, 1993

LANDSCAPE ARCHITECTURE'S ROLE IN EROSION AND SEDIMENT CONTROL

Landscape architecture plays an important role in the planning, development and maintenance of construction sites and urban areas.

The discipline of landscape architecture can contribute significantly in developing sound plans for erosion and sediment control, and storm water management. Landscape architecture involves the application of artistic and scientific principles to the development of sites, including all kinds of construction sites for urban uses.

Landscape architecture may, for the purposes of landscape preservation, development and enhancement, include: investigation, selection, and allocation of land and water resources for appropriate use; feasibility studies; formulation of graphic and written criteria to govern the planning and design of land construction programs; preparation, review, and analysis of master plans for land use and development; production of overall site plans, landscape grading and landscape drainage plans, irrigation plans, planting plans, and construction details; specifications; cost estimates and reports for land development; collaboration in the design of roads, bridges, and structures with respect to the functional and aesthetic requirements of the areas on which they are to be placed; negotiation and arrangement for execution of land area projects; field observation and inspection of land area construction, restoration, and maintenance.

Landscape architecture can contribute the most toward erosion control, sediment control and storm water management when the professional is involved in the very early stages of a development project. The landscape architectural process begins by working with a client in assessing project needs, and in helping to select a site that meets those needs. Once a site has been selected, a landscape architect can help to locate facilities on the site in such a way as to minimize the amount of site disturbance required for development. This is one of the greatest benefits that the profession can provide. By minimizing site disturbance, extensive earthwork can be avoided and stormwater runoff can be reduced by saving existing vegetation.

Landscape architecture can further minimize stormwater runoff by careful siting and design of impervious and pervious surfaces, through creative solutions to site grading, and helping to properly locate and design stormwater retention and detention facilities. Landscape architecture can also help design these "engineered" solutions so that they become attractive amenities on the site.

Landscape architecture also includes extensive knowledge of plant materials. By carefully selecting and siting materials for new plantings, the profession can minimize and control stormwater runoff, erosion and sedimentation, and the need for supplemental irrigation.

Landscape architecture can serve the developer well in addressing stormwater management, and erosion and sedimentation control, whether at the onset of a new construction project, or when correcting problems in an existing development. However, experience has shown the earlier in a project that these issues are addressed, the less they will cost and the greater their chance for success.

CHPT. 8- Applicability of Manual To Regulations

Chapter 8

APPLICABILITY OF MANUAL TO REGULATIONS

July 1, 1993

APPLICABILITY OF MANUAL TO REGULATIONS

The Alabama Handbook for Erosion Control, Sediment Control and Storm Water Management was developed to help landowners, developers, architects, engineers, planners and local officials minimize problems resulting from erosion, sediment, and storm water on development sites, including coastal beaches. The handbook provides an approach to evaluate a site's potential to cause adverse offsite impacts from erosion, sediment and storm water. Also, the handbook provides guidelines for planning appropriate control systems. Finally, the handbook provides criteria for developing the specifications for treatment measures.

In practical application, the information in the handbook will supplement, not replace, the technical expertise of erosion and sediment specialists such as engineering consultants.

The handbook provides information and guidelines that can be adopted by local governments for use in regulations relating to erosion control, sediment control and storm water management.

Where regulations exist the handbook can provide invaluable information to planners and others in planning and installing systems that meet the requirements of the regulations.

Model ordinances are contained in Appendix A8. These provide a format and contents that can be used by local governments that are developing local ordinances addressing erosion control, sediment control and storm water management.

CHPT. 9

ADDITIONAL PRACTICES
FOR EROSION AND SEDIMENT CONTROL

CHPT. 9- Additional Practices for Erosion and Sediment Control

Chapter 9

ADDITIONAL PRACTICES FOR EROSION AND SEDIMENT CONTROL

CONTENTS

	Page
Introduction	IX-1
Anionic Polyacrylamide Erosion Control (PAM)	IX-2
Block and Gravel inlet Protection (BGP)	IX-5
Dust Control (DC)	IX-7
Erosion Control Blanket (ECB)	IX-10
Excavated Drop Inlet Protection (EDP)	IX-13
Land Grading (LG)	IX-15
Outlet Protection (OP)	IX-18
Porous Pavement (PP)	IX-21
Rock Filter (RFD)	IX-25
Straw Bale Sediment Trap (SST)	IX-27
Subsurface Drain (SSD)	IX-29
Temporary Slope Drain (TSD)	IX-32
Temporary Sediment Trap (TST)	IX-35

ADDITIONAL PRACTICES FOR EROSION AND SEDIMENT CONTROL

Chapter 9 contains practices needed for erosion and sediment control that were not included in the original Alabama Handbook (1993).

The content of the additional practices is focused on construction or installation. Detailed planning and design criteria will be added for these practices in the next revision of the Handbook. In the interim, planners and designers will need to use other reliable sources for design criteria such as the Manual for Erosion and Sediment Control in Georgia (Fifth Edition 2000).

Practices in Chapter 9 contain both erosion control and sediment control measures. Some of the measures, such as PAM and Porous Pavement are relatively new technology in Alabama, and will require very close attention to detail in designing and installation by those with limited experience with these practices. Each practice added to Chapter 9 can provide significant benefits in erosion and sediment control when properly used. As was stressed in earlier chapters, construction sites are unique and need site specific attention, including maintenance.

Anionic Polyacrylamide Erosion Control (PAM)

Practice Description

PAM is a water-soluble anionic polyacrylamide product used to minimize soil erosion caused by water and wind. When PAM is used on construction sites in the Southeast it is typically applied with temporary seeding and/or mulching on areas where the timely establishment of temporary erosion control is so critical that seedings and mulching need additional reinforcement. It may be used alone on sites where no disturbances will occur until site work is continued and channel erosion is not a significant potential problem. Permanent grassing applications can be better established using PAM as a tackifier and soil conditioner. **Cationic forms of PAM are not allowed for use under this guideline due to their high levels of toxicity to aquatic organisms.**

General Components of the Practice

Prior to the start of construction, the application of PAM should be designed by a qualified professional and plans and specifications should be available to field personnel.

The application should conform to the design and specifications provided in the plans. Typical applications include the following components.

- Site Preparation
- Equipment Preparation
- PAM Application

Application

Site Preparation

Prepare site following design and specifications.

Equipment Preparation

If using a liquid application system, pump a surfactant through the injection system before and after injecting concentrated liquid PAM into sprinkler irrigation systems to prevent valves and tubing from clogging.

PAM used in hydroseeding applications should be added as the last additive to the mix.

After their use, rinse all PAM mixing and application equipment thoroughly with water to avoid formation of PAM residues. Rinse residue should be applied to soil areas to create binding to the soil structure and increase erosion reduction.

PAM Application

Site testing for a PAM product shall be conducted before PAM application to verify PAM product performance and test reports (recommendations) shall be supplied to the design professional and contractor before product application.

Toxicity reports, following EPA/600/4-90/027F 24 Hr. Acute Static Screen Toxicity Test (daphnia sp.), shall be provided by the supplier to the contractor before application of a PAM product (this is to assure that PAM applications from the recommended product will be non-toxic).

PAM shall be mixed and/or applied in accordance with all Occupational Safety and Health Administration (OSHA) Material Safety Data Sheet (MSDS) requirements and the manufacturer's recommendations for the specified use conforming to all federal, state and local laws, rules and regulations.

Emulsion batches shall be mixed following recommendations of a testing laboratory that determines the proper product and rate to meet site requirements.

Dry form (powder) may be applied by hand spreader or a mechanical spreader. Mixing with dry silica sand will aid in spreading. Pre-mixing of dry form PAM into fertilizer, seed or other soil amendments is allowed when specified in the design plan.

Application method shall insure uniform coverage to the target area.

Common Problems

Consult with a registered design professional for assistance if any of the following occur:

- Problems with application equipment clogging.
- Application specifications for PAM cannot be met; alternatives may be required. Unapproved application techniques could lead to failure.
- Visible erosion occurs after application.

Maintenance

An operation and maintenance plan must be prepared for use by the operator responsible for PAM application. Plan items should include the following items.

- Reapply PAM to disturbed or tilled areas that require continued erosion control.
- Maintain equipment to provide uniform application rates.
- Rinse all PAM mixing and application equipment thoroughly with water to avoid formation of PAM residues and discharge rinse water to soil areas where PAM stabilization may be helpful.

- Downstream deposition from the use of PAM may require periodic sediment removal to maintain normal functions.

Block and Gravel Inlet Protection (BGP)

Practice Description

Block and gravel inlet protection is a sediment control barrier formed around a storm drain inlet by the use of standard concrete block and gravel. The purpose is to help minimize sediment entering storm drains during construction. This practice applies where use of the storm drain system is necessary during construction and inlets have a drainage area of 1-acre or less and an approach slope of 1% or less.

General Components of the Practice

Prior to start of construction, block and gravel inlet protection should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process. The barrier should be built according to planned grades and dimensions.

- Site Preparation
- Installation of Blocks, Wire Mesh and Gravel
- Erosion Control
- Construction Verification

Construction

Site Preparation

Determine exact location of underground utilities.

Clear area of all debris that might hinder excavation and disposal of spoil.

Grade the approach to the inlet uniformly. The top elevation of the structure must be lower than the ground elevation downslope from the inlet. It is important that all storm flows pass over the structure and into the storm drain and not past the structure. Temporary dikes below the structure may be necessary to prevent bypass flow. Material may be excavated from inside the sediment pool for this purpose.

Installation of Blocks, Wire Mesh and Gravel

Lay one block on its side in the bottom row on each side of the structure to allow pool drainage. The foundation should be excavated below the crest of the storm drain to the depth shown on the drawings. Place the bottom row of blocks against the edge of the storm drain for lateral support and to avoid washouts when overflow occurs. If needed, give lateral support to subsequent rows by placing 2 x 4 wood studs through block openings.

Place gravel of the specified gradation around blocks to the lines and dimensions shown on the drawings and smooth to an even grade Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings to hold gravel in place.

Erosion Control

Stabilize disturbed areas in accordance with the vegetation plan.

Construction Verification

Check finished grades and dimensions of block and gravel barrier. Check materials for compliance with specifications.

Common Problems

- Consult with registered design professional if the following occurs:
- Variations in topography on site indicate block and gravel drop inlet protection will not function as intended; changes in plan may be needed.

Maintenance

Inspect the barrier after each rain and make repairs as needed.

Remove sediment promptly following storms to provide adequate storage volume for subsequent rains and prevent sediment entering the storm drain in subsequent rains.

If the gravel becomes clogged with sediment so that barrier does not drain properly, remove gravel and replace with clean gravel of the specified gradation.

When the contributing drainage area has been adequately stabilized, remove all materials and any sediment, bring the disturbed area to proper grade and stabilize it with vegetation or other materials shown in the design plan.

Dust Control (DC)

Practice Description

Dust control includes a wide range of techniques that prevent or reduce movement of wind-borne soil particles (dust) during land disturbing activities. This practice applies to construction routes and other disturbed areas where on-site and off-site damage or hazards may occur if dust is not controlled.

General Components of the Practice

Dust control measures should be designed by a qualified professional and plans and specifications should be made available to field personnel prior to start of construction.

Whenever possible, leave undisturbed vegetated buffer areas between graded areas.
A combination of the following may be used. Typical installations include the following components.

- **Scheduling:** Plan and schedule construction operations so that the smallest area is disturbed at any one time
- **Erosion Control:** Install surface stabilization measures (vegetative cover or mulch) immediately after completing the land grading
- **Other potential components: Sprinkling, Barriers, Spray-on adhesives, Stone and Street Cleaning**

Construction

- **Vegetative Cover:** For areas not subjected to traffic, vegetation provides the most practical method of dust control (See *Temporary* or *Permanent Seeding*).
- **Mulching:** This practice offers a fast and effective means of controlling dust when properly applied. Binders or tackifiers should be used to tack organic mulches (See *Mulching*). Mulching is not recommended for areas with heavy traffic.
- **Sprinkling:** The site can be sprinkled with water until the surface is moist. This practice is effective for dust control on haul roads or other traffic routes, but constant repetition is required for effective control.
- **Barriers:** Board fences placed perpendicular to the prevailing winds at intervals of 15 times the barrier height can control blowing soil. In areas of known dust problems, windbreak vegetation should be preserved.

- **Calcium Chloride:** This material is best used on road surfaces. It can be applied by a mechanical spreader at a rate that keeps the surface moist. ***Consult with a qualified professional if*** *calcium chloride is specified. A permit may be needed.*

- **Note:** This method may cause restrictions for vegetation establishment.

- **Spray-on Adhesives:** Spray-on adhesives are effective on non-organic soils and many will withstand heavy traffic loads. Table 5.13 presents examples of spray-on adhesives that have been used successfully for dust control.

Table 5.13 Application Rates for Spray-on Adhesives used in Dust Control

Adhesive	Water Dilution (adhesive: water)	Type of Nozzle	Application Rate (gallons/acre)
Anionic Asphalt Emulsion	7:1	Coarse	1200
Latex Emulsion	12.5:1	Fine	235
Resin in water	4:1	Fine	300
Acrylic Emulsion (Non-traffic)	7:1	Coarse	450
Non-Acrylic Emulsion (Traffic)	3.5:1	Coarse	350

Source: Virginia Erosion and Sediment Control Handbook, 1993

Consult with a qualified professional if *spray-on adhesives are specified. A permit may be needed.*

- **Stone:** In areas of heavy vehicle traffic, such as access and haul roads, covering the road surface with a layer of graded stone is an effective method of dust control. Stone should be placed to the width and thickness specified in the design.

- **Street Cleaning:** Use of a street sweeper in the area of a development site can aid in controlling dust.

Construction Verification

Check construction site during vehicular traffic or windy conditions to see if measures are working adequately.

Common Problems

Drought conditions result in dry soils and increase in dust problems—use greater precautions during these periods.

Maintenance

Maintain dust control measures continuously throughout dry weather periods, until all disturbed areas have been stabilized.

Erosion Control Blanket (ECB)

Practice Description

An erosion control blanket is a protective covering (blanket) used to establish vegetation on steep slopes, channels or shorelines. Blankets aid in controlling erosion on these critical areas by providing a protective cover made of straw, jute, wood or other plant fibers; plastic, nylon, paper or cotton. This practice is best utilized where the erosion hazard is high, and plant growth is likely to be too slow to provide adequate protective cover. Erosion control blankets are typically used as an alternative to mulching but can also be used to provide structural erosion protection. Some important factors in the choice of a blanket are: soil conditions, steepness of slope, length of slope, type and duration of protection required to establish desired vegetation, and probable sheer stress.

General Components of the Practice

Prior to the start of construction, the application of erosion control blankets should be designed by a qualified professional and plans and specifications should be available to field personnel.

Numerous products designed to control erosion are available. Product installation procedures for manufactured erosion control blanket products should always be available from the manufacturer. Table 9-1 lists some of the more common products available.

Table 9-1 Types of Erosion Control Blankets

Type of Erosion Blanket	Main Use	Comments
Netting	Synthetic or natural fiber mesh installed over disturbed area to hold organic mulch and/or seed in place.	Provides minimal structural erosion resistance. Mulch applied using standard procedures.
Biodegradable Erosion Control Blanket	Natural fiber blanket held together by netting to provide temporary erosion protection on slopes up to 1:1 and channels with permissible shear stress up to 4 lbs./ft.	Provides 1 to 5 years of protection form erosion. Metal staples used as anchors.
Permanent Erosion Control Blanket	Synthetic blanket material which provides permanent erosion control on slopes up to 1:1; channels wit increased water flow velocities and increased shear stress.	Provides minimal protection from wave action around ponds and lakes. Permanent erosion control blankets extend the limits of vegetation. Metal staples used as anchors.
Turf Reinforcement Mat	3-dimensional permanent synthetic mat that provides a matrix to greatly reinforce the root system of the desired vegetation for permanent erosion protection in high flow channels and on critical slopes.	Provides a substantial increase in erosion resistance. May provide erosion protection equivalent to stone or concrete liners.

The field inspector should verify that installation is in accordance with the plans and specifications. Typical installations include the following components.

Site Preparation

Erosion Control Planting

Blanket Installation

Construction

Site Preparation

Grade the site in accordance with the approved design to a smooth and uniform surface, free of debris.

Add and incorporate topsoil where needed.

Make sure seedbed is firm yet friable.

Erosion Control Planting

Incorporate fertilize and lime as described in the design plan.

Spread seed and incorporate as described in the planting specifications.

Blanket Installation

Erosion control blanket products should be installed in accordance with the manufacturers' recommendations and specifications, including check slots and stapling materials.

Anchor product so that a continuous, firm contact (no tenting) with the soil surface/seed bed is maintained. This is best accomplished on slopes by working from the bottom to the top.

Note: Failure to anchor the product as described above could result in soil erosion which would require regrading and reseeding.

Construction Verification

Check finished grade, dimensions and staple spacing of erosion control blankets. Check materials for compliance with specifications.

Common Problems

Consult with a registered design professional if any of the following occur:

- Movement of the blanket or erosion under the blanket is observed.

Poor contact between the soil and the erosion control blanket results in surface water flowing under rather than over the blanket, causing erosion—retrench or reanchor to direct water over blanket.

Blanket inadequately or improperly stapled results in tenting, blanket movement or displacement—reinstall and ensure blanket is properly anchored.

Unstable slope results in blanket or slope failure—determine cause of slope failure, stabilize slope and reinstall blanket.

- Variations in topography on site indicate erosion control mat will not function as intended; changes in plan may be needed, or a blanket with a shorter or longer life may be needed.

- Design specifications for seed variety, seeding dates or erosion control materials cannot be met; substitution may be required. Unapproved substitutions could result in failure to establish vegetation.

Maintenance

Inspect after storm events, until vegetation is established, for erosion or undermining beneath the blankets. If any area shows erosion, pull back that portion of the blanket, add tamped soil and reseed; then resecure the blankets.

If blankets should become dislocated or damaged, repair or replace and resecure immediately.

Excavated Drop Inlet Protection (EDP)

Practice Description

Excavated drop inlet protection is an excavated area in the approach to a storm drain drop inlet to minimize sediment from entering storm drains during construction. This practice applies where early use of the storm drain system is necessary prior to stabilization of the disturbed drainage area. This practice is suitable for inlets with a drainage area of 1 acre or less and an approach slope of 1% or less.

General Components of the Practice

Prior to start of construction, excavated drop inlet protection structures should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process. Installation of an excavated drop inlet protection practice usually includes the following activities.

- **Grading**
- **Drain Holes Installation**
- **Wire Screen and Gravel Installation**
- **Stabilization**
- **Construction Verification**

Construction

Grading

Determine exact location of underground utilities. Excavate the basin to the depth, side slopes and dimensions shown on the plans. Grade the approach to the inlet with the longest dimension oriented toward the longest inflow area to provide maximum sediment trapping efficiency. Spread excavated material evenly over the surrounding land area or store the excess soil in a stockpile. If necessary to prevent bypass, build a temporary dike on the down slope side of the structure.

Drain Holes Installation

Install drain holes in the drop inlet as shown on the plans to drain basin pool slowly.

Wire Screen and Gravel Installation

Cover holes with wire screen and place gravel around sides of inlet to the dimensions shown on the plans.

Erosion Control

Stabilize disturbed areas, including spoil disposal areas, except the excavated pool bottom, in accordance with vegetation plan.

Construction Verification

Check finished grades and dimensions of excavated drop inlet protection structures.

Common Problems

Consult with registered design professional if any of the following occur:

- Variations in topography on site indicate excavated drop inlet protection will not function as intended; change in plan may be needed.
- Sediment producing area too large for basin design, resulting in sediment entering drain; may need to enlarge basin or change type of inlet protection.

Maintenance

Inspect and properly maintain the excavated basin after every storm until the contributing drainage area has been permanently stabilized.

Remove debris that is trapped in the basin. If debris is clogging the storm drain, consider installing a trash rack to prevent debris from reaching the drain inlet.

Remove sediment when the excavated volume is approximately one-half full.

Check the outlet area for piping from the basin along the storm drain.
Note: Piping is a particular hazard where fill slopes are steep and it is difficult to obtain good compaction along the storm drain.

Inspect to ensure that the inlet cover is in place to prevent children from entering the inlet.

When the contributing drainage area has been permanently stabilized, seal drain holes, fill the basin with stable soil to final grading elevations, compact the fill properly, and establish vegetation or provide other means of protection in accordance with the design plan.

Land Grading (LG)

Practice Description

Land grading is reshaping of the ground surface to provide suitable topography for buildings, facilities and other land uses, to control surface runoff, and to minimize soil erosion and sedimentation both during and after construction. This practice applies to sites where the existing topography must be modified to prepare for another land use, or where adapting proposed development to the existing landscape can reduce the erosion potential of the site and the cost of installing erosion and sediment control measures. In some instances other practices such as diversions or benches, can be used to reduce the length of continuous slopes and reduce erosion potential.

General Components of the Practice

Prior to start of construction, the site grading plan should be designed by a qualified professional. The grading plan should show disturbed areas, cuts, fills, and finished elevations for all graded areas. Plans and specifications should be referred to by field personnel throughout the construction process.

- Scheduling
- Outlet
- Sediment Control
- Site Preparation
- Grading
- Erosion Control

Construction

Scheduling

Grading activities should be scheduled to minimize the area disturbed.

Outlet

Runoff from disturbed areas should be controlled at the outlets with proper runoff conveyance practices, such as drop structures, riprap-lined channels, or rock outlets.

Sediment Control

Appropriate sediment control measures should be installed to minimize sediment delivery offsite until other measures can be installed to prevent erosion. The measures should be installed as specified and in the sequence shown in the design plan.

Site Preparation

Determine exact location of underground utilities.

Remove and stockpile topsoil (see *Topsoiling*).

Clear and grub areas by removing trees, vegetation, roots and other debris. Check fill to make sure it is does not contain brush, rubbish, oversized rocks or other objectionable material.

Grading

Place fill in layers and compact as specified by the grading plan

Construct slope breaks as shown on the grading plan.

Keep diversions and other water conveyance measures free of sediment during all phases of development, including grading.

Install subsurface drains (See *Subsurface Drains)* in areas where seepage interferes with the grading operations, or where required to improve slope stability or soil bearing capacity.

The final trip over slopes using equipment with tracks should be made up-and-down the slopes to establish cleat marks on the contour ("tracking').

Erosion Control

Use temporary stabilization measures on graded areas when work is to be interrupted or delayed for 15 working days or longer. A shorter period may be appropriate in critical situations (for example, steep bare slopes close to the drainageway that discharges into sensitive waters).

Stabilize graded areas that have "final grading completed" within 10 working days. Use permanent vegetation or other appropriate stabilization measures. If grading is completed out of season for the desired vegetation, a temporary planting may be made first and the permanent planting made later during the recommended planting period.

Construction Verification

Check all finished grades for conformance with grading plan and correct as necessary.

Common Problems

Consult with design professional if any of the following occur:

- Variations in topography on site indicate grading plan will be ineffective or unfeasible.
- Seepage is encountered during construction. It may be necessary to install drains.

Subgrade is soft or has high organic content; can hinder proper compaction of fill—undercut and replace unsuitable subgrade soil.

- Design specifications for sediment control measures, seed variety, seeding dates or other erosion control measures or materials cannot be met. Substitutions may be required. Unapproved substitutions could result in erosion and lead to failure of sediment and erosion control measures.

Maintenance

Periodically check all graded areas and the related erosion and sediment control practices for damage by equipment and especially after heavy rainfalls for damage by runoff. Repair silt fences and other temporary sediment control measures. Clean sediment out of adjacent diversions and other structures as needed. Repair any failures that occur in surface stabilization measures such as plantings.

Outlet Protection (OP)

Practice Description

This practice is designed to prevent erosion at the outlet of a channel or conduit by reducing the velocity of flow and dissipating the energy. Outlet protection measures–usually consist of a riprap-lined apron, a reinforced concrete flume with concrete baffles or a reinforced concrete box with chambers or baffles. This practice applies wherever high velocity discharge must be released on erodible material.

General Components of the Practice

Prior to start of construction, the practice should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process.

The structure should conform to the dimensions, grades and alignments shown on the
plans and specifications. Typical installations include the following components:

Riprap Structures

- Site preparation
- Subgrade
- Filter
- Placement of rock

Concrete Structures

- Site Preparation
- Subgrade
- Forms
- Reinforcing steel
- Concrete placement
- Curing
- Tests for strength

Construction

Site Preparation

ALSWCC - Revised July 2002

concrete placement. Form work should be left in place until the concrete attains design strength.

Erosion Control

Immediately after construction, stabilize all disturbed areas with vegetation.

Construction Verification

Check finished structures for conformance with design specifications.

Common Problems

Consult with a registered design professional for assistance if any of the following occur:

- Variations in topography on site indicate measure will not function as intended.
- Design specifications for riprap, filter fabric, concrete, reinforcing steel or backfill cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.
- Problems with the structure develop during or after installation.

Maintenance

Inspect riprap outlet structures after heavy rains to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Check concrete structures for cracks and movement. Immediately make all needed repairs to prevent further damage.

Porous Pavement (PP)

Practice Description

Porous pavement is a permeable load-bearing layer that reduces runoff by providing infiltration, and can be underlain by a stone reservoir for stormwater storage. The practice with a stone reservoir is designed to intercept storm runoff and allow it to gradually infiltrate into the subsoil. In addition, porous pavement may provide groundwater recharge, augment low flow in streams during dry periods, reduce downstream flooding and protect water quality. The practice is applicable for areas with low traffic, such as overflow parking lots and lightly used access roads that are on relatively gentle slopes and permeable soils.

Porous pavement falls into three different categories based on the extent of storage provide by the stone reservoir: a full exfiltration system (stores the entire design storm), a partial exfiltration system (stores a portion of the design storm) and a water quality exfiltration system (provides infiltration only or stores the first flush or some portion of a design storm and conveys the excess runoff to a conventional stormwater management facility).

Concrete grids, modular pavement, or similar products will be considered as a part of this practice.

General Components of the Practice

Prior to start of construction, porous pavement should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process.

- Site Preparation
- Product Installation
  Full Exfiltration Systems
  Partial Exfiltration Systems
  Water Quality Exfiltration Systems
  Concrete Grids & Modular Pavements
- Erosion and Sediment Control
- Construction Verification

Construction

Consider the following guidance as construction proceeds.

Site Preparation

Before the site is graded, rope off the porous pavement area to prevent heavy equipment from compacting the underlying soils.

Determine the exact location of underground utilities.

Install Diversions to prevent runoff and sediment from entering the site during construction.

Use earthmoving equipment with tracks or oversized tires to clear, grub and grade the site. Avoid normal rubber tires because they compact the subsoil and reduce its infiltration capabilities. Earthmoving in wet conditions should be avoided.

Remove and stockpile topsoil.

Grade the site to design elevations and dimensions shown for the reservoir subgrade. The subgrade should be reasonably smooth and free of loose rocks and clods, holes, depressions, muddy conditions or flowing water.

Product Installation

For All Products (based on the design plan)

Line the bottom and sides of the reservoir area with filter fabric, and install observation well, filler and filter stone. Typical installations include the following actions:

using anchors to ensure the fabric is secured to the subgrade;

installing the observation well at a designed location and elevation;

placing stone of the specified gradation in uniform layers to the designed thickness and compacting each layer of stone lightly after it is placed;

Additional actions specific for the type of installation include the following actions:

Full Exfiltration System

After stone placement, install an emergency overland channel (curb or swale) to carry flows greater than the design storm.

Partial Exfiltration System

After stone placement, install perforated drainpipe and associated outlet structures at the locations and grades shown in the design plan. Drainpipes should be installed near the top of the stone reservoir.

Water Quality Exfiltration

After stone placement, install perforated drainpipe and associated outlet structures at the locations and grades shown in the design plan. Drainpipes should be installed near the top of the stone reservoir.

Concrete Grids and Modular Pavements

After stone placement, install perforated drainpipe and associated outlet structures at the locations and grades shown in the design plan. Drainpipes should be installed near the top of the stone reservoir.

Install the product and fill the open spaces ~~within the pavement~~ with gravel or other material according to the design plan and manufacturer's recommendations.

Notes relating to Materials Installation

a. Rolling required for permeable asphalt, grid and modular pavement is critical and must be done strictly according to the design plan to prevent problems with infiltration and load bearing strength.

b. After rolling is complete, all traffic should be kept out of the porous pavement area for a minimum of one day to allow proper hardening.

c. If new utility lines are buried beneath the porous pavement site, do not construct the stone reservoir until all trench settlement has taken place.

Erosion and Sediment Control

Sediment control is critical during and after construction; therefore, erosion and sediment control measures planned for the adjacent areas must be effective to prevent loss of infiltration capacity of the porous pavement.

Vegetated filter strips should be placed around the porous pavement, concrete grids and modular pavements.

Reinforced silt fences should be placed around porous pavement, concrete grids and modular pavements while vegetation is being established.

Signs should be posted and construction personnel advised not to enter the parking lot or access area with muddy tires.

Store all construction materials and waste material well away from the porous pavement site.

Provide temporary fencing and post warning signs around the porous pavement until vegetation in the filter strip is established.

Install additional planned measures that are needed to drain and control storm water runoff from the site.

Construction Verification

Check the finished grades and configuration for all earthwork. Check elevations and dimensions of all pipes and structures.

Common Problems

Check with design professional if any of the following occur:

Variations in topography or site geology indicate porous pavement will not function as intended.

Design specifications for fill, pipe, gravel, filter fabric and asphalt paving material cannot be met. Unapproved substitutions could lead to failure.

Maintenance

Inspect the porous pavement after each storm event. Inspectors should check for ponding on the surface which might indicate local or widespread clogging.

The condition of the vegetative filter strip should be inspected.

The observation well should be checked several times in the first few months after construction. Water depth in the well should be measured at 0-, 24-, and 48-hour intervals after a storm.

The porous pavement site should be posted with signs indicating the nature of the surface, and warning against resurfacing the site with conventional pavement or the use of materials which could affect the infiltration capacity of the surface.

Sediment must be kept completely away from a porous pavement site after construction.
Asphalt type porous pavements should be vacuum swept at least four times per year, followed by high-pressure jet hosing to keep the asphalt pores open.

Potholes and cracks in asphalt porous pavement can be repaired using conventional, nonporous patching mixes as long as the cumulative area repaired does not exceed 10% of the parking lot area.

Spot clogging of the asphalt porous pavement layer can be relieved by drilling ½-inch holes through the porous asphalt layer every few feet. In cases where clogging occurs in a low spot in the parking lot, it may be advisable to install a drop inlet to route water into the stone reservoir.

Follow guidelines for porous pavement maintenance to maintain concrete grids and modular pavements. Where vegetation is planted in the grids, mowing, fertilizing and irrigation may be needed.

Rock Filter Dam (RFD)

Practice Description

A rock filter dam is a stone embankment designed to capture sediment in natural drainageways on construction sites and prevent delivery of sediment off-site. This practice can be used as an alternative to a standard sediment basin for locations with a drainage area of 10 acres or less. It may be preferable to standard sediment basins for sites where an earthen embankment would be difficult to construct. It is usually located so that it intercepts runoff primarily from disturbed areas, is accessible for periodic sediment removal and does not interfere with construction activities

General Components of the Practice

Prior to start of construction, rock dams should be designed by a registered design professional. The rock filter dam plan should include details on dam height, dam top width, dam side slopes and rock size(s). Plans and specifications should be referred to by field personnel throughout the construction process. General construction components of the practice include the following activities.

Site Preparation

Rock Placement

Erosion and Sediment Control

Construction

Site Preparation

Determine exact location of underground utilities and avoid construction over and under utilities.

Clear and grub the area under the dam, removing and properly disposing of all root material, brush and other debris.

Divert runoff from undisturbed areas away from the rock dam and basin area.

Smooth the dam foundation.

If specified, cover the foundation with filter fabric, making sure the upstream strips overlap the downstream strips at least 1 foot and the upslope end is embedded into the foundation at least 1 foot.

Rock Placement

Construct the dam by placing well graded, hard, angular, durable rock of the specified size over the foundation to planned dimensions and securely embed into both channel banks.

Once the dam is in place, clear the sediment basin area and dispose of the cleared material.

Set a marker stake to indicate the clean out elevation (i.e., point at which the basin is 50% full of sediment).

Erosion and Sediment Control

Stabilize all disturbed areas with either Temporary or Permanent Seeding.

Construction Verification

Check materials and finished elevations of the rock filter dam for compliance with specifications.

Common Problems

Consult with registered design professional if the following occurs:

Variations in topography on site indicate rock filter dam will not function as intended; changes in plan may be needed.

Materials specified in the plan are not available.

Maintenance

Inspect the rock dam and basin after each storm event.

Check the dam for rock displacement and abutments for erosion and repair immediately when repair is needed. If rock size appears too small or embankment slope is too steep, replace stone with larger size or reduce slope.

Check the drainageway at toe of dam for erosion. If erosion is occurring, a repair involving filter cloth (including another toe-in) and additional rock are probably needed to establish a stable outlet.

Remove sediment from the pond reservoir area when it accumulates to one-half the design volume.

If the basin does not drain between storms because the filter stone (small gravel) on the upstream face has become clogged, the clogged filter stone should be replaced with clean stone.

Once the construction site is permanently stabilized, remove the structure and any unstable sediment. Smooth the basin site to blend with the surrounding area and stabilize. Sediment should be placed in designated disposal areas and stabilized.

Straw Bale Sediment Trap (SST)

Practice Description

A straw bale sediment trap is a temporary catch basin consisting of a row or more of entrenched and anchored straw bales. The purpose is to intercept and detain small amounts of sediment to prevent sediment from leaving the construction site. This practice applies within disturbed areas with small drainage basins that are subject to sheet erosion or in minor swales.

General Components of the Practice

Prior to start of construction, straw bale sediment traps should be designed by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process. The straw bale sediment trap should be built according to planned grades and dimensions.

- Site Preparation
- Installation of Straw Bales
- Erosion Control
- Construction Verification

Construction

Site Preparation

Determine exact location of underground utilities so that locations for digging or placement of stakes can be selected where utilities will not be damaged.

Smooth the construction zone to provide a broad, nearly level area for the row of bales. The area should be wide enough to provide storage of runoff and sediment behind the straw bales.

To facilitate maintenance, provide good access for cleanout of sediment during maintenance period.

Straw Bale Installation

Excavate a trench to the dimensions shown on the drawings. The trench should be long enough that the end bales are somewhat upslope of the sediment pool to ensure that excess flows go over the bales and not around the bales.

Place each bale end to end in the trench so the bindings are oriented around the sides rather than top and bottom.

Anchor the bales by driving two 36-inch long 2- x 2-inch hardwood stakes through each bale at least 18 inches into the ground. Drive the first stake toward the previously laid bale to force the bales together.
Wedge loose straw into any gaps between the bales to slow the movement of sediment-laden water.

Anchor the bales inn place according to the details shown on the drawings. If specific details are not shown, backfill and compact the excavated soil against the bales to ground level on the downslope side and to 4 inches above ground level on the upslope side.

Erosion and Sediment Control

Stabilize disturbed areas in accordance with vegetation plan. If no vegetation plan exists, consider planting and mulching as part of installation and select planting information from either the permanent Seeding or Temporary Seeding practice. Select mulching information from the Mulching practice.

Construction Verification

Check finished grades and dimensions of the straw bale sediment trap. Check materials for compliance with specifications.

Common Problems

Consult with registered design professional if the following occurs:

- Variations in topography on site indicate sediment trap will not function as intended; changes in plan may be needed.
- Design specifications for materials cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

Maintenance

Inspect straw bale barriers after each storm event and remove sediment deposits promptly after it has accumulated to one-half of the original capacity, taking care not to undermine the entrenched bales.

Inspect periodically for deterioration or damage from construction activities. Repair damaged barrier immediately.

After the contributing drainage area has been stabilized, remove all straw bales and sediment, bring the disturbed area to grade and stabilize it with vegetation or other materials shown in the design plan.

Subsurface Drain (SSD)

Practice Description

A subsurface drain is a perforated pipe or continuous layer of porous material installed below the ground surface that intercepts, collects and carries excessive groundwater to a stable outlet. Subsurface drains by themselves do not provide erosion control. The purpose of a subsurface drain is to improve soil moisture conditions, vegetation growth and ground stability. Subsurface drains may reduce wet ground from interfering with construction activities. Drains may be constructed using a gravel-filled trench, perforated pipe in gravel bedding or manufactured drain panel products. This practice applies where groundwater is at or near the ground surface or where adequate drainage cannot be provided for surface runoff.

General Components of the Practice

Prior to start of construction, subsurface drains should be designed by a qualified professional. Materials such as sand, gravel, filter cloth and pipe must be properly designed in order for the subsurface drain system to function properly. Plans and specifications shall be available to field personnel. Installation of subsurface drains usually includes the following activities.

- Site Preparation
- Trench Excavation
- Installation of Drain Pipe, Bedding Material and Filter Cloth
- Backfill Installation
- Installation of Clean-Out Device
- Outlet Installation
- Stabilization
- Safety

Construction Verification

Construction

Site Preparation

Determine exact location of underground utilities. At least three days prior to construction, request Alabama Line Location Center (1-800-292-8525) to mark all underground utilities within the project area.

Locate and mark the alignment of the drains as shown on the design plans.

Clear installation area of debris and obstacles, such as trees and stumps, that might hinder grading and installation of the subsurface drain.

Trench Excavation

Excavate the trench to the specified depth and grade shown in the design plan. To accommodate the gravel bedding or filter material, excavate the trench to at least 3 inches below the design bottom elevation of the pipe (or as shown on the design plans).

Place materials excavated from the trench on the up gradient side of the trench to prevent water from entering the trench during construction.

Grade the trench to prevent siltation into the drain.

Installation of Drain Pipe, Bedding Material and Filter Cloth

Line trench with filter cloth (if specified), providing enough material to overlap over the top of the finished gravel bedding. This helps prevent movement of soil into the gravel.

Spread bedding material specified in the design plan, usually 3 inches of gravel, to fill the over-excavated bottom of the trench.

Lay pipe on the design grade and elevation avoiding reverse grade or low spots after checking to ensure the pipe meets specifications.

Cap the upper end of each drain with a standard cap made for this purpose or with concrete or other suitable material to prevent soil from entering the open end.

Place bedding material around pipe, on all sides, with the amount shown in the design plan.

Fold filter cloth over the top of the gravel bedding.

Backfill Installation

Backfill immediately after placement of the pipe and bedding. Ensure that the material does not contain rocks or other sharp objects and place it in the trench in a manner that will not damage or displace the pipe. Overfill the trench slightly to allow for settlement.

Installation of Clean-Out Device

Install clean-outs for maintenance of the subsurface drain in the locations shown on design plan.

Outlet Installation

Construct the outlet of the subsurface drain at the elevation in the design plan. The outlet section of the drain shall be at least 10 feet of non-perforated corrugated metal, cast iron, steel or heavy-duty plastic pipe. Cover at least half

of the pipe length with well-compacted soil. Place a suitable animal guard securely over the pipe outlet to keep out rodents.

Stabilization

Keep the settled fill over the pipe outlet slightly higher than the surrounding ground to prevent erosion, rills and gullies.
Stabilize all bare areas of the trench with temporary seeding and mulching unless construction will disturb the area within 14 days.

Safety

Narrow trenches are subject to collapse and can be a safety hazard to persons in the trench. No person should enter a trench without shoring protection or properly sloping the sides of the trench.

Construction Verification

Verify the dimensions during construction with those shown on the plans for location, length, depth and cross section of trench.

Verify the dimensions and specifications of the aggregate used in the bedding and manufactured materials such as pipe, tile or panel drain.

Common Problems

Consult with a qualified professional if any of the following occur:

- Variations in topography on site indicate subsurface drains will not function as intended or originally designed.
- Design specifications for aggregate or manufactured products cannot be met; substitutions may be required. Unapproved substitutions could result in failure of the drain to function as intended.
- Pipe is crushed by construction traffic.

Maintenance

Check subsurface drains periodically to ensure that they are free-flowing and not clogged with sediment.

Keep outlet clean and free of debris.

Keep surface inlets open and free of sediment and other debris.

Where drains are crossed by heavy vehicles, check the pipe to ensure that it is not crushed.

Temporary Slope Drain (TSD)

Practice Description

A temporary slope drain is a pipe or other conduit designed to convey concentrated runoff down the face of a cut or fill slope without causing erosion. This practice applies wherever concentrated stormwater runoff must be conveyed down a steep slope.

General Components of the Practice

Prior to start of construction, temporary slope drains should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process. Typically, a temporary slope drain is installed with the following steps.

- Site Preparation
- Erosion Control
- Construction Verification

Construction

Site Preparation

Determine exact location of underground utilities.

Place temporary slope drain on undisturbed soil or well-compacted fill at locations and elevations shown on the plans.

Grade the diversion channel at the top of the slope toward the temporary slope drain according to the design plan. Provide positive grade in the pipe under the ridge.

Hand tamp the soil under and around the pipe in lifts not to exceed 6 inches.

Ensure that the fill over the drain pipe at the top of the slope is placed to the dimensions shown on the design plan.

Ensure that all slope drain connections are secure and watertight.

Ensure that all fill material is well-compacted. Securely anchor the exposed section of the drain according to the design.

Extend the drain beyond the toe of the slope and adequately protect the outlet from erosion.

Make the settled, compacted diversion ridge no less than 1 foot above the top of the pipe at every point.

Erosion Control

Compaction of earthfill around the pipe in the vicinity of the ridge is extremely important to avoid piping failure and blowouts.

Immediately stabilize all disturbed areas following construction according to the design plan (with vegetation or other appropriate means of protection).

Construction Verification

Verify that materials, elevations and installation procedures meet design specifications.

Joints should be carefully inspected for separations or looseness.

Common Problems

Consult with a registered design professional if any of the following occur:

- Variations in topography on site indicate temporary slope drains will not function as intended.
- Pipe separates or is displaced.
- Animals are going into the pipe outlet.

Maintenance

Inspect slope drains and supporting diversions once a week and after every storm event.

Check the inlet for sediment or trash accumulation; clear and restore to proper condition.

Check the fill over the pipe for settlement, cracking or piping holes; repair immediately.

Check for holes where the pipe emerges from the ridge; repair immediately.

Check the conduit for evidence of leaks or inadequate anchoring; repair immediately.

Check the outlet for erosion or sedimentation; clean and repair, or extend if necessary.

Once slopes have been stabilized, remove the temporary diversions and slope drains so that runoff water no longer concentrates but flows uniformly over the protected slope. Stabilize the diversion and slope drain areas.

Temporary Sediment Trap (TST)

Practice Description

A temporary sediment trap is a ponding basin used for smaller drainage areas that is formed by an embankment or excavation and is designed to capture and hold sediment-laden runoff, trapping the sediment. This practice protects receiving streams, lakes, drainage systems and adjacent property from sediment during construction activities. This practice applies where sediment-laden runoff is discharged.

General Components of the Practice

- Site Preparation
- Embankment
- Open Channel (Emergency) Spillway
- Optional Pipe Spillway
- Erosion Control
- Safety
- Construction Verification

Construction

Prior to start of construction, sediment traps should be designed by a registered design professional.

Plans and specifications should be referred to by field personnel throughout the construction process. The sediment trap should be built according to planned grades and dimensions.

Consider the following guidance as construction proceeds.

Site Preparation

Locate all underground utilities before work begins to ensure avoidance.

Clear, grub, and strip the foundation of the dam removing all woody vegetation, rocks and other objectionable material. Dispose of trees, limbs, logs and other debris in designated disposal areas.

Excavate the sediment trap (if necessary), stockpiling any surface soil having high amounts of organic matter for later use.

Embankment

Scarify the base of the embankment before placing fill.

Use fill from predetermined borrow areas. Fill should be clean, stable mineral soil free of organics, roots, woody vegetation, rocks, and other debris and must be wet enough to form a ball without crumbling, yet not so wet that water can be squeezed out.

Place the fill material in 6- to 9-inch continuous uncompacted layers over the length of the dam. Fill should then be compacted to a 4 to 6 inch thick continuous layer (One way is by routing construction equipment over the dam so that each layer is traversed by at least 4 passes of the equipment.)

Place a reference stake at the designed sediment clean-out elevation as shown on the plans (usually 50% of the design trap volume.

Open Channel Spillway Construction

Construct the open channel spillway at the location identified by the plan design (in undisturbed soil around one end of the embankment if an area is available, and so that any flow will return to the receiving channel without damaging the embankment)
Excavate a trapezoidal outlet section in the compacted embankment.

Install geotextile fabric on the base of the channel, extending it up the sides to the top of the embankment.

Place stone of the specified gradation to the lines and grades shown on the drawings, working smaller stones into voids to achieve a dense mass. The spillway crest should be level.

Construct a stone outlet apron, with the dimensions shown on the drawings, below the toe of the dam and, on level grade until a stable condition is reached.

Make the edges and end of the stone apron section flush with the surrounding ground.

Cover the inside face of the stone outlet section with a layer of well graded stone

Principal Spillway Pipe Construction (required if dewatering of the trap is planned)

Prepare the pipe bedding and situate the spillway pipe and riser on a firm, even foundation.

Place around the barrel a 4-inch layer of moist, clayey, workable soil (not pervious material such as sand, gravel or silt), and compact with hand tampers to at least the density of the foundation soil. (Don't raise the pipe from the foundation when compacting under the pipe haunches.) Continue with backfill of the pipe in 4-inch to 6-inch uncompacted layers scarifying the surface between each compacted layer. All backfill material within 2 foot of the pipe (beside the pipe and above the pipe) shall be compacted with hand tampers only.

Perforate the lower half of the riser according to the design plan, (typical plans specify ½-inch diameter holes spaced 3 inches apart.

Embed the riser into the concrete anti-flotation block as shown on the drawings. The concrete block should be constructed to the dimensions shown on the drawings to balance the buoyant force acting on the riser

Surround the riser with 2 feet of clean, uniformly graded stone.

Place a steel trash rack around the riser inlet. Trash rack openings should be 4 to 6 inches square.

At the pipe outlet, install Outlet Protection according to the design plan (if not specified, use a riprap apron at least 5 feet wide to a stable grade).

Erosion Control

Minimize the size of disturbed areas.

Divert sediment-laden water to the upper end of the temporary sediment trap to improve trap effectiveness.

Direct all runoff into the basin as detailed in the plans so that the runoff enters at a low velocity.

Vegetate and stabilize the embankment and all disturbed areas immediately after construction.

Safety

Fence area and post warning signs if trespassing is likely.

Construction Verification

Check finished grades and dimensions of temporary sediment trap. Check materials for compliance with specifications.

Common Problems

Consult with registered design professional if any of the following occur:

- Variations in topography on site indicate sediment basin will not function as intended.
- Design specifications for fill, pipe, seed variety or seeding dates cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

Maintenance

Inspect the temporary sediment trap after each storm event.

Remove and properly dispose of sediment when it accumulates to one-half the design volume, as indicated by the clean-out stake.

Periodically check the embankment, spillway, and outlet apron for erosion damage, settling, seepage or slumping along the toe, and repair immediately.

Replace the spillway gravel facing if it becomes clogged.

Inspect vegetation and reseed if necessary.

Replace any displaced riprap, being careful that no replacement rock is above the design grade.

Remove the temporary sediment trap after the drainage area has been permanently stabilized, inspected, and approved. Do so by draining any water, removing the sediment to a designated disposal area, grading the site to blend with the surrounding area, and then stabilize.

Glossary- Terms and Definitions

Glossary

July 1, 1993

GLOSSARY

This glossary includes terms used in this handbook that are pertinent to erosion and sediment control and stormwater management.

AASHTO classification - The official classification of soil materials and soil aggregate mixtures for highway construction used by the American Association of State Highway and Transportation Officials.

Abutment - The sloping sides of a valley that support the ends of a dam.

Acid soil - A soil with a preponderance of hydrogen ions (and probably of aluminum) in proportion to hydroxyl ions. Specifically, soil with a pH value less than 7.0. For most practical purposes, a soil with a pH value less than 6.6.

Acre-foot - The volume of water that will cover 1 acre to a depth of 1 foot.

Alkaline soil - A soil that has a pH greater than 7.0, particularly above 7.3, throughout most or all of the root zone, although the term is commonly applied to only the surface layer or horizon of a soil.

Alluvial soils - Soils developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes.

Alluvium - A general term for all detrital material deposited or in transit by streams, including gravel, sand, clay, and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

Antecedent moisture conditions(AMC) - The degree of wetness of a watershed at the beginning of a storm.

Anti-seep collar - A device constructed around a pipe or other conduit placed through a dam, levee, or dike for the purpose of preventing soil movement and piping failures.

Anti-vortex device - A facility placed at the entrance to a pipe conduit structure such as a drop inlet spillway or hood inlet spillway to prevent air from entering the structure when the pipe is flowing full.

Apron - A pad of non-erosive material designed to prevent scour holes developing at the outlet ends of culverts, outlet pipes, grade stabilization structures, and other water control devices.

Balled and Burlapped Tree - A tree that has been dug up and the soil around the tree roots has been retained by enclosing it with burlap.

Bare-root - Trees or seedlings that have been removed from the soil and have exposed roots.

Barrel - A conduit placed through a dam, levee, or dike to control the release of water.

Base flow - Stream discharge derived from groundwater sources as differentiated from surface runoff. Sometimes considered to include flows from regulated lakes or reservoirs.

Bearing capacity - The maximum load that a material can support before failing.

Bedrock - The more or less solid rock in place either on or beneath the surface of the earth. It may be soft, medium or hard and have a smooth or irregular surface.

Berm - A narrow shelf or flat area that breaks the continuity of a slope.

Borrow area - A source of earth fill material used in the construction of embankments or other earth fill structures.

Bunchgrass - A grass plant (specie) that forms a distinct clump and does not spread by long, horizontal stems.

Buoyant weight - The downward force exerted by an object with a specific gravity greater than one, when it is submerged in water.

Catch basin - A chamber usually built at the curb line of a street, for the admission of surface water to a storm sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Channel stabilization - Protecting the sides and bed of a channel from erosion by controlling flow velocities and flow directions using jetties, drops or other structures and/or by lining the channel with a suitable liner such as vegetation, riprap, concrete or other similar material.

Chute - A high-velocity, open channel for conveying water down a steep slope without erosion, usually paved.

Clay - (1) Soil fraction consisting of particles less than 0.002 mm in diameter. (2) A soil texture class which is dominated by clay or at least has a larger proportion of clay than either silt or sand.

Compaction - In soil engineering, the process by which the silt grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per cubic foot.

Conservation District - A public organization created under state enabling law as a special-purpose district to develop and carry out a program of soil, water, and related resource conservation, use, and development within its boundaries, usually a subdivision of state government with a local governing body but with limited authorities. Often called a soil conservation district or a soil and water conservation district.

Containerized Tree - A tree that is grown in a container for the purpose of being transplanted.

Contour - An imaginary line on the surface of the earth connecting points of the same elevation.

Critical area - A severely eroded sediment producing area that requires special management to establish and maintain vegetation in order to stabilize soil conditions.

Cut - Portion of land surface or area from which earth has been removed or will be removed by excavating; the depth below the original ground surface to the excavated surface.

Cut-and-fill - Process of earth grading by excavating part of a higher area and using the excavated material for fill to raise the surface of an adjacent lower area.

Cutoff trench - A long, narrow excavation (keyway) constructed along the center line of a dam, dike, levee or embankment and filled with relatively impervious material intended to reduce seepage of water through porous strata.

Dam - A barrier to confine or impound water for storage or diversion, to prevent gully erosion, or for retention of soil, sediment, or other debris.

Debris dam - A barrier built across a stream channel to retain logs, tree limbs, sand, gravel, silt or other material.

Design highwater - The elevation of the water surface at peak flow conditions of the design flood.

Design life - The period of time for which a facility is expected to perform its intended function.

Design storm - A selected rainfall pattern of specified amount, intensity, duration, and frequency that is used as a basis for design.

Dewatering - The removal of water temporarily impounded in a holding basin.

Dibble Bar - A tool used for planting trees consisting of either a flat or pointed blade and a bar with a handle for pushing the blade into the soil.

Dike - An embankment to confine or control water, often built along the banks of a river to prevent overflow of lowlands; a levee.

Discharge - Usually the rate of water flow; a volume of fluid passing a point per unit time commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, or millions of gallons per day.

Diversion - A channel with a supporting ridge on the lower side constructed at the top, across, or at the bottom of a slope for the purpose of controlling surface runoff.

Diversion dike - A barrier built to divert surface runoff.

Divide, Drainage - The boundary between watersheds.

Drainageway - A natural or artificial depression that carries surface water to a larger watercourse or outlet such as a river, lake, or bay.

Drawdown - Lowering of the water surface in an open channel or lake or groundwater.

Drop inlet - Overall structure in which the water drops through a vertical riser connected to a discharge conduit or storm sewer.

Drop spillway - Overall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

Drop structure - A structure for dropping water to a lower level and dissipating its surplus energy without erosion.

Earth dam - A dam constructed of compacted suitable soil materials.

Embankment - A man-made deposit of soil, rock, or other material often used to form an impoundment.

Emergency spillway - Usually a vegetated earth channel used to safely convey flood discharges around an impoundment structure.

Energy dissipator - A device used to reduce the energy of flowing water to prevent erosion.

Environment - The sum total of all the external conditions that may act upon a living organism or community to influence its development or existence.

Erodibility - Susceptibility to erosion.

Erosion - The wearing away of the land surface by water, wind, ice, gravity, or other geological agents. The following terms are used to describe different types of water erosion:

Accelerated erosion - Erosion much more rapid than normal or geologic erosion, primarily as a result of the activities of man.

Channel erosion - The erosion process whereby the volume and velocity of flow wears away the bed and/or banks of a well-defined channel.

Geologic erosion - The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc. See natural erosion.

Gully erosion - The erosion process whereby runoff water accumulates in narrow channels and, over relatively short periods, removes the soil to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.

Rill erosion - An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils.

Splash erosion - The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

Sheet erosion - The gradual removal of a fairly uniform layer of soil from the land surface by runoff water.

Evapotransportation - The combined loss of water from an area by evaporation from the soil surface and by transpiration of plants.

Excess rainfall - The amount of rainfall that runs directly off an area.

Fertilizer - Any organic or inorganic material of natural or synthetic origin that is added to a soil to supply elements essential to plant growth.

Fertilizer analysis - The percentage composition of fertilizer, expressed in terms of nitrogen, phosphoric acid, and potash. For example, a fertilizer with a 6-12-6 analysis contains 6 percent nitrogen (N), 12 percent available phosphoric acid (P_2O_5) and 6 percent water-soluble potash (K_2O). Minor elements may also be included. Recent analysis expresses the percentages in terms of the elemental fertilizer (nitrogen, phosphorus, potassium).

Filter fabric - A woven or non-woven, water-permeable material generally made of synthetic products such as polypropylene and used in erosion and sediment control applications to trap sediment or prevent the movement of fine soil particles. Often used instead of a filter blanket.

Flood peak - The highest stage or greatest discharge attained by a flood event. Thus, peak stage or peak discharge.

Floodplain - The lowland that borders a stream and is subject to flooding when the stream overflows its banks.

Flood stage - The stage at which overflow of the natural banks of a stream begins.

Floodway - A channel, either natural, excavated, or bounded by dikes and levees, used to carry flood flows.

Flume - A constructed channel lined with erosion-resistant materials used to convey water on steep grades without erosion.

Freeboard - A vertical distance between the elevation of the design high-water and the top of a dam, diversion ridge, or other water control device.

Frequency of storm(design storm frequency) - The anticipated period in years that will elapse before another storm of equal intensity and/or total volume will recur: a 10-year storm can be expected to occur on the average once every 10 years.

Froude number(F) - A calculated number for classifying water flow as critical (F=1), supercritical (F>1) or subcritical (f<1).

Gabion - A wire mesh cage, usually rectangular, filled with rock and used to protect channel banks and other sloping areas from erosion.

Gauge - A device for measuring precipitation, water level, discharge, velocity, pressure, temperature, etc., e.g., a rain gauge. A measure of the thickness of metal, e.g., diameter of wire or wall thickness of steel pipe.

Gradation - The distribution of the various sized particles that constitute a sediment, soil, or other material such as riprap.

Grade - (1) The slope of a road, a channel, or natural ground. (2) The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared to a design elevation for the support of construction such as paving or the laying a conduit. (3) To finish the surface of a canal bed, roadbed, top of embankment, or bottom of excavation, or other land area to a smooth, even condition.

Grade stabilization structure - A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head-cutting or lowering of the channel bottom.

Gradient - Change of elevation, velocity, pressure, or other characteristics per unit length; slope.

Grading - The cutting and/or filling of the land surface to a desired slope or elevation.

Grass - A member of the botanical family *Gramineae*, characterized by blade-like leaves that originate as a sheath wrapped around the stem.

Grass or legume, annual - A plant which germinates, grows, reproduces, and dies in one growing season or one year's time.

Grass or legume, cool-season - A grass which is usually planted in the fall or occasionally late winter and it makes it growth during the cool season of the year, (fall, late winter and spring). Flowering and seed production occur in late spring. Cool-season grasses are usually dormant or make little growth during the hot summer months.

Grass or legume, perennial - A plant which, under suitable conditions, has the ability to live for more than one year. A perennial may become dormant at certain times of the year, but will resume growth at the end of its dormant period.

Grass or legume, warm-season - A grass which is usually planted in the spring and it makes it growth during the warm season (late spring and summer months). Flowering and seed production usually occur in late summer or early fall. Warm-season grasses are dormant in the winter months.

Grassed waterway - A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses and used to safely conduct surface water from an area.

Ground water - That water that soaks below the plant root zone and under the influence of gravity continues moving downward until it enters the ground water reservoir.

Head - The height of water above any plain of reference. The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head or velocity head.

Head loss - Energy loss due to friction, eddies, changes in velocity, elevation or direction of flow.

Headwater - The source of a stream. The water upstream from a structure or point on a stream.

Heel-in - A technique used to keep tree seedlings alive when they cannot be planted within 3 weeks where seedlings are

placed on the face of a trench and the roots are covered with soil.

Hydrograph - A graph showing for a given point on a stream the discharge, stage (depth), velocity, or other property of water with respect to time.

Hydrologic cycle - The circuit of water movement from the atmosphere to the earth and back to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrology - The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.

Impact basin - A device used to dissipate the energy of flowing water to reduce erosion. Generally constructed of concrete partially submerged with baffles to dissipate velocities.

Impervious - Not allowing infiltration.

Impoundment - Generally, an artificial water storage area, as a reservoir, pit, dugout, sump, etc.

Infiltration - The gradual downward flow of water from the surface through soil to ground water and water table reservoirs.

Invert - The inside bottom of a culvert or other conduit.

Keyway - A cutoff trench dug beneath the entire length of a dam to cut through soil layers that may cause seepage and possible dam failure.

Laminar flow - Flow at relatively slow velocity in which fluid particles slide smoothly along straight lines everywhere parallel to the axis of a channel or pipe.

Legume - Any member of the pea or pulse family which includes peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, black locust, and kudzu. Practically all legumes are nitrogen-fixing plants.

Liquid limit - The moisture content at which the soil passes from a plastic to a liquid state.

Mean depth - Average depth; cross-sectional area of a stream or channel divided by its surface or top width.

Mean velocity - The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-sectional area of the reach.

Mulch - A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Natural drainage - The flow patterns of stormwater runoff over the land in its pre-development state.

Nonpoint source pollution - Pollution that enters a water body from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.

Normal depth - The depth of flow in an open conduit during uniform flow for the given conditions.

Open drain - A natural watercourse or constructed open channel that conveys drainage water.

Outfall - The point, location, or structure where wastewater or drainage discharges from a sewer to a receiving body of water.

Outlet - The point of water disposal from a stream, river, lake, tidewater, or artificial drain.

Outlet channel - A waterway constructed or altered primarily to carry water from man-made structures, such as smaller channels, tile lines, and diversions.

Peak discharge - The maximum instantaneous flow from a given storm condition at a specific location.

Percolation - The movement of water through soil.

Percolation rate - The rate, usually expressed as inches/hour or inches/day, at which water moves through the soil profile.

Perennial stream - A stream that maintains water in its channel throughout the year.

Pervious - Allowing movement of water.

Pesticides - Chemical compounds used for the control of undesirable plants, animals, or insects. The term includes

insecticides, herbicides, algicides, rodenticides, nematicides, fungicides, and growth regulators.

pH - A numerical measure of hydrogen ion activity. The neutral point is pH 7.0. All pH values below 7.0 are acid and all above 7.0 are alkaline.

Physiographic region (province) - Large-scale unit of land defined by its climate, geology, and geomorphic history and therefore uniform in physiography.

Plastic index - The numerical difference between the liquid limit and the plastic limit of soil; the range of moisture content within which the soil remains plastic.

Plastic limit - The moisture content at which a soil changes from a semi-solid to a plastic state.

Plunge pool - A basin used to dissipate the energy of flowing water usually constructed to a design depth and shape. the pool may be protected from erosion by various lining materials.

Point source - Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. (P.L. 92-500, Section 50(14).

Porosity - The volume of pore space in soil or rock.

Principal spillway - A dam spillway generally constructed of permanent material and designed to regulate the normal water level, provide flood protection and/or reduce the frequency of operation of the emergency spillway.

Rainfall intensity - The rate at which rain is falling at any given instant, usually expressed in inches per hour.

Rational method - A means of computing storm drainage flow rates, Q, by use of the formula Q = CIA, where C is a coefficient describing the physical drainage area, I is the rainfall intensity and A is the area.

Reach - The smallest subdivision of the drainage system consisting of a uniform length of open channel. Also, a discrete portion of river, stream or creek. For modeling purposes, a reach is somewhat homogeneous in its physical characteristics.

Receiving stream - The body of water into which runoff or effluent is discharged.

Retention - The storage of stormwater to prevent it from leaving the development site; may be temporary or permanent.

Rhizome - A modified plant stem that grows horizontally underground. A rhizomatous plant spreads (reproduces) vegetatively and can be transplanted with rhizome fragments.

Rill - A small intermittent watercourse with steep sides, usually only a few inches deep.

Riparian - Of, on, or pertaining to the banks of a stream, river, or pond.

Riparian rights - A principle of common law which requires that any user of waters adjoining or flowing through his lands must so use and protect them that he will enable his neighbor to utilize the same waters undiminished in quantity and undefiled in quality.

Riser - The inlet portions of a drop inlet spillway that extend vertically from the pipe conduit barrel to the water surface.

Runoff - That portion of precipitation that flows from a drainage area on the land surface, in open channel or in stormwater conveyance systems.

Sand - (1) Soil particles between 0.05 and 2.0 mm in diameter. (2) A soil textural class inclusive of all soils which are at least 70% sand and 15% or less clay.

Saturation - In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.

Scarified seed - Seed which has been subjected to abrasive treatment to encourage germination.

Scour - The clearing and digging action of flowing water, especially the downward erosion caused by stream water in sweeping away mud and silt from the stream bed and outside bank of a curved channel.

Sediment - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Sediment delivery ratio - The fraction of the soil eroded from upland sources that actually reaches a stream channel or storage reservoir.

Sediment discharge - The quantity of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

Sediment pool - The reservoir space allotted to the accumulation of sediment during the life of the structure.

Seedbed - The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.

Seedling - A young plant grown from seed.

Sediment basin - An enlargement in the channel of a stream to permit the settling of debris carried in suspension.

Shoot - The above-ground portion of a plant.

Silt - (1) Soil fraction consisting of particles between 0.0002 and 0.05 mm in diameter. (2) A soil textural class indicating more than 80% silt.

Slope - Degree of deviation of a surface from the horizontal; measured as a numerical ratio or percent. Expressed as a ration, the first number is the horizontal distance (run) and the second is the vertical distance (rise), e.g., 2:1. Slope can also be expressed as the rise over the run. For instance, a 2:1 slope is a 50 percent slope.

Sod - A surface layer of turf grass (including roots and surface soil) harvested in blocks or rolls and transported for establishment at another site.

Soil - The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

Soil horizon - A horizontal layer of soil that, through processes of soil formation, has developed characteristics distinct from the layers above and below.

Soil permeability - The quality of a soil that enables water or air to move through it. Usually expressed in inches/hour or inches/day.

Soil profile - A vertical section of the soil from the surface through all horizons.

Soil structure - The relation of particles or groups of particles which impart to the whole soil a characteristic manner of breaking; some types are crumb structure, block structure, platy structure, and columnar structure.

Soil texture - The physical structure or character of soil determined by the relative proportions of the soil separates (sand, silt and clay) of which it is composed.

Spillway - A passage such as a paved apron or channel for surplus water over or around or through a dam or similar structure. An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.

Sprig - The section of plant stem material (rhizome, shoot, or stolon) used in vegetative planting.

Stolon - Modified plant stem that grows horizontally on the soil surface.

Storm frequency - The time interval between major storms of predetermined intensity and volumes of runoff, e.g., a 5-year, 10-year or 20-year storm.

Storm sewer - A sewer that carries stormwater, surface drainage, street wash and other wash waters, but excludes sewage and industrial wastes. Also called a storm drain.

Streambanks - The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

Subcritical flow - Flow at relatively high velocity where the wave from a disturbance can more upstream. Froude No. less than 1.

Subsoil - The B horizons of soils with distinct profiles. In soils with weak profile development the subsoil can be defined as the soil below which roots do not normally grow.

Subsurface drain - A pervious backfilled trench usually containing stone and perforated pipe for intercepting groundwater or seepage.

Subwatershed - A watershed subdivision of unspecified size that forms a convenient natural unit.

Supercritical flow - Flow at relatively high velocity where the wave from a disturbance will always be swept downstream. Froude number is greater than 1.

Surface runoff - Precipitation that falls onto the surfaces of roots, streets, the ground, etc., and is not absorbed or retained by that surface, but collects and runs off.

Swale - An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales conduct stormwater into primary drainage channels and may provide some groundwater recharge.

Tailwater depth - The depth of flow immediately downstream from a discharge structure.

Temporary cover - Temporary vegetative cover of rapid growing annual grasses, small grains, or legumes to provide initial, temporary cover for erosion control on disturbed sites.

Toe of dam - The base or bottom of the sloping faces of a constructed dam at the point of intersection with the natural ground surface--normally a much flatter slope. A dam has an inside toe (the impoundment or upstream side) and an outside toe (the downstream side).

Toe of slope - The base or bottom of a slope at the point where the ground surface abruptly changes to a significantly flatter grade.

Topography - General term to include characteristics of the ground surface such as plains, hills, mountains, degree of relief, steepness of slopes, and other physiographic features.

Topsoil - The dark-colored surface layer or A horizon of a soil. When present it ranges in depth from a fraction of an inch to 2 or 3 ft.; equivalent to the plow layer of cultivated soils. Commonly used to refer to the surface soil layer(s), enriched in organic matter and having textural and structural characteristics favorable for plant growth.

Trash rack - A structural device used to prevent debris from entering a pipe spillway or other hydraulic structure.

Turbidity - Cloudiness of a liquid, caused by suspended solids; a measure of the suspended solids in a liquid.

Turf - Surface soil supporting a dense growth of grass and associated root mat.

Unified soil classification system - A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit.

Uniform flow - A state of steady flow when the mean velocity and cross-sectional area remain constant in all sections of a reach.

Vegetative stabilization - Protection of erodible or sediment-producing areas with:

permanent seeding, producing long-term vegetative cover,

short-term seeding, producing temporary vegetative cover, or

sodding, producing areas covered with a turf of a perennial sod-forming grass.

Watercourse - A definite channel with bed and banks within which concentrated water flows, either continuously or intermittently.

Water quality - A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Watershed - The region drained by or contributing water to a stream, lake, or other body of water.

Watershed area - All land and water within the confines of a drainage divide.

Weir - A device for measuring or regulating the flow of water.

Windthrow - The blow down of a tree from high winds usually because of an inadequate root system.

References

References

July 1, 1993

REFERENCES

The following documents were used by the authors in developing the handbook. A few drawings and sketches were copied without any changes except page numbers. The references were used mainly for determining the best way to present material.

Alabama Department of Environmental Management, 1989. Alabama Nonpoint Source Management Program.

Alabama Forestry Commission. Urban Forestry Note.

Alabama Legislature Code, Soil Conservation District's Law, 1940, Amended by 1949 and 1953 Legislature.

Cuyahoga Soil and Water Conservation District (Ohio). Water Management and Sediment Control For Urbanizing Areas.

Florida Department of Environmental Regulation, 1988. The Florida Development Manual: A Guide To Sound Land And Water Management, Storm Water Management.

Robert E. Pitt, University of Alabama at Birmingham (Alabama), 1991. Non-point Source Water Pollution Management.

Georgia Soil and Water Conservation Commission, 1990. Manual for Erosion and Sediement Control in Georgia.

North Carolina Department of Environment, Health, and Natural Resources, Division of Land Resources, 1988. Erosion and Sediment Control Planning and Design Manual.

Pirone, 1978. Tree Maintenance, 5th edition.

Pirone, 1979. Tree Maintenance.

Soil Conservation Service, Alabama, 1992. Field Office Technical Guide.

Soil Conservation Service, New York, 1988. Guidelines for Urban Erosion and Sediment Control.

Virginia Soil and Water Conservtion Commission, 1980. Virginia Erosion and Sediment Control Handbook, Second Edition.

Appendix A1 – Erosion and Sediment Control Plans

Appendix A1

EROSION AND SEDIMENT CONTROL PLANS

CONTENTS

	Page
Example Erosion and Sediment Control Plan	
Soils and Vegetation	A-I-1
Grading and Drainge Plan	A-I-2
Erosion and Sediment Control Plan	A-I-3
Legend of Measures	A-I-4

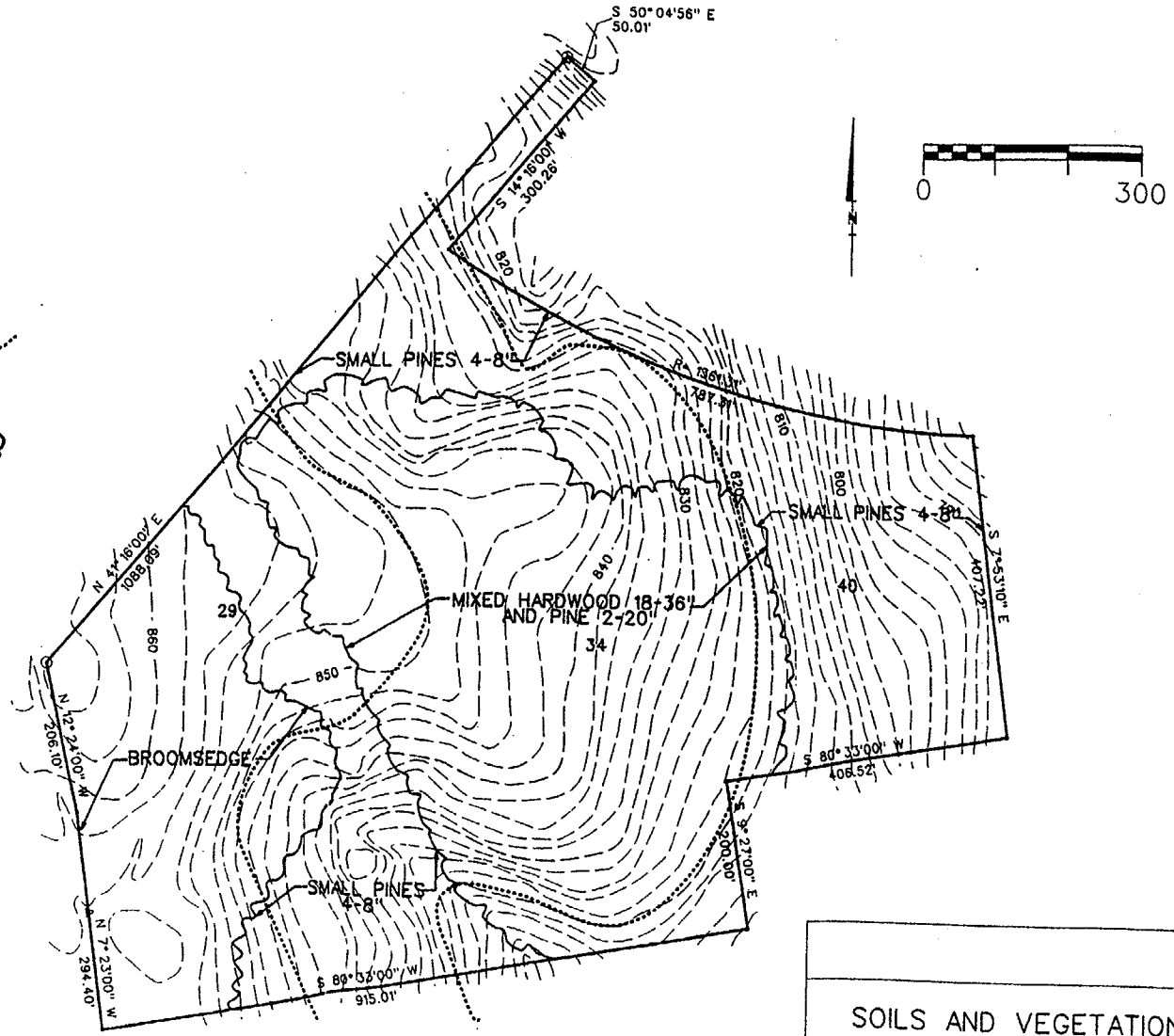
July 1, 1993

SOIL TYPES

MONTEVALLO, NAUVOO	29
MONTEVALLO, NAUVOO	34
TOWNLEY, NAUVOO	40

LEGEND

SITE BOUNDARY	———
SOIL BOUNDARY	~~~~
SOIL SYMBOL	29
VEGETATION	TYPE



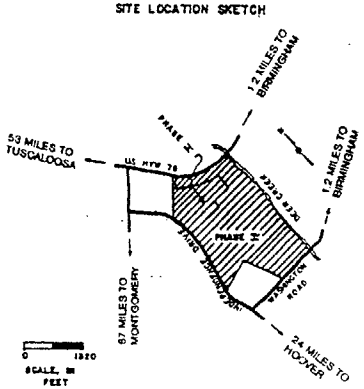
SOILS AND VEGETATION

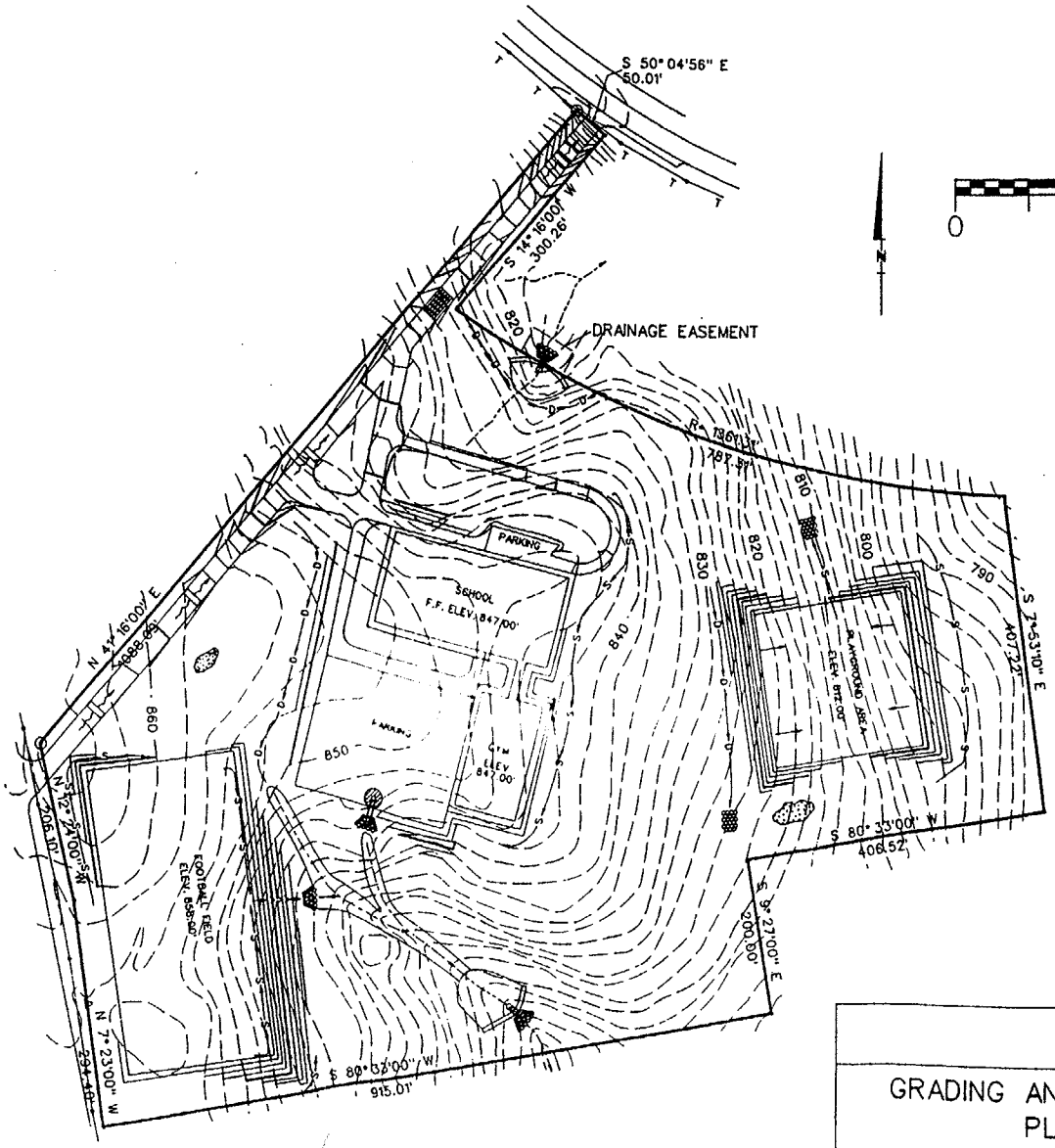
DRAWN BY: J.N.	SCALE: 1"=150'	SHEET NO.
CHECKED BY: D.M.C.	DATE: 3/3/92	1
BOOK NO.:	FILE NO:	

LEGEND

INTERMITTENT STREAM	
IRON PIN FOUND	⊙
SITE BOUNDARY	
TEMPORARY BENCH MARK	△
POWER LINE	
TELEPHONE LINE	T T T T
CONTOUR LINE, EXISTING	860
CONTOUR LINE, FINISH	

SITE LOCATION SKETCH





GRADING AND DRAINAGE PLAN

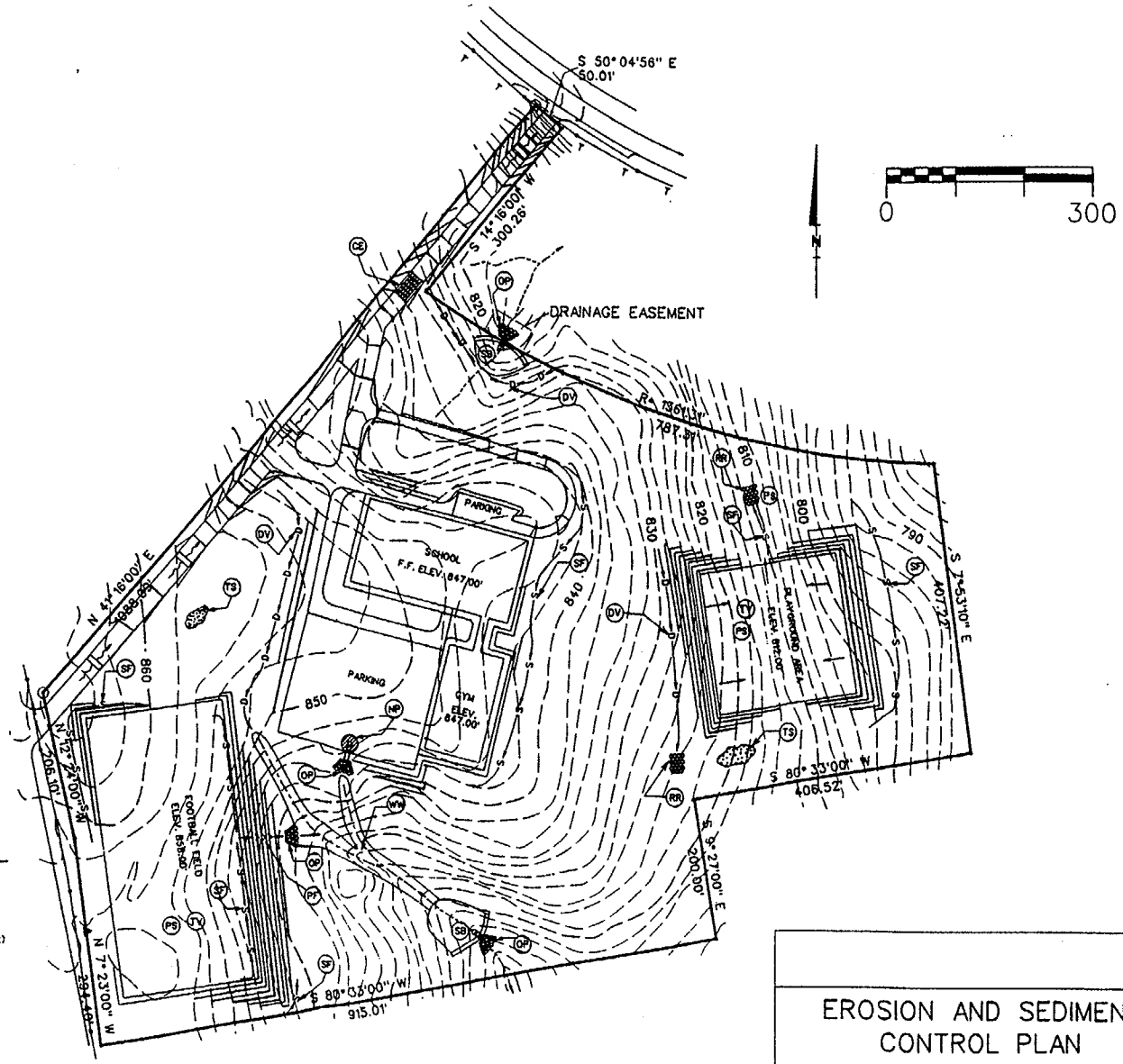
DRAWN BY: J.N.	SCALE: 1"=150'	SHEET NO. 2
CHECKED BY: D.M.C.	DATE: 3/3/92	
BOOK NO.:	FILE NO:	

LEGEND

- INTERMITTENT STREAM
- IRON PIN FOUND
- SITE BOUNDARY
- TEMPORARY BENCH MARK
- POWER LINE
- TELEPHONE LINE
- CONTOUR LINE, EXISTING (860)
- CONTOUR LINE, FINISH
- (DV) DIVERSION
- (SF) SEDIMENT BARRIER/FENCE
- (CE) CONSTRUCTION EXIT
- (SB) SEDIMENT BASIN
- (TS) TOPSOIL
- (WW) WATERWAY
- (NP) INLET PROTECTION
- (CD) CHECK DAMS
- (PF) PAVED FLUME
- (OP) OUTLET PROTECTION
- (PS) PERMANENT SEEDING
- (TV) TEMPORARY VEGETATION
- (RR) RIPRAP

VEGETATION PLAN

LOCATION	SPECIES
FOOTBALL FIELD	
TEMPORARY	RYEGRASS (FALL & WINTER)
PERMANENT	TIFWAY 419 BERMUDAGRASS SPRIGS (SPRING & SUMMER)
OTHER DISTRIBUTED AREAS	
TEMPORARY	RYEGRASS (FALL & WINTER)
PERMANENT	HULLED COMMON BERMUDAGRASS (SPRING & SUMMER)



EROSION AND SEDIMENT CONTROL PLAN

DRAWN BY: J.N.	SCALE: 1"=150'	SHEET NO.
CHECKED BY: D.M.C.	DATE: 3/3/92	3
BOOK NO.:	FILE NO:	

LEGEND OF MEASURES
FOR
EROSION AND SEDIMENT CONTROL PLANS

VEGETATIVE MEASURES

BZ Buffer Zone

DU Dust Control

IR Irrigation

MU Mulching

PS Permanent Seeding

TP Tree Planting on Disturbed Sites

SD Sodding

SVG Shrub, Vine and Groundcover Planting

TV Temporary Vegetation - Seeding

TPP Tree Preservation and Protection

COASTAL DUNE MEASURES

DC Dune Crosswalk

DSF Dune Sand Fence

DV Dune Vegetation

STRUCTURAL MEASURES

CD Check Dam

CS Channel Stabilization

CE Construction Exit

DV Diversion

DN Downdrain Structure

DS Drop Structure

GB Gabion

NP Inlet Protection

OP Outlet Protection

PF Paved Flume

RW Retaining Wall

RT Retrofitting

RR Riprap

SF Sediment Barrier/Fence

SB Sediment Basin

RS Storm Water Retention Structure

SX Stream Crossing

SR Surface Roughening

TS Topsoil

WW Waterway or Storm Water Conveyance Channel

Appendix A2 – Characteristics of Soil in Alabama

Appendix A2

SOIL CHARACTERISTICS

CONTENTS

	Page
Using A Soil Survey	A-II-1
Properties of Soils	A-II-2
Table A-II-1	A-II-4
Table A-II-2	A-II-9
Table A-II-3	A-II-11

July 1, 1993

SOIL CHARACTERISTICS

A basic knowledge of soils is vital in preparing development plans. The type of vegetation selected to be grown for landscape and erosion control requires knowledge about the soil of the area, and selection of other erosion control practices can depend on soil characteristics. In general erosion control can be designed more cost effectively if soils are considered.

Information about the soils of an area can be obtained from a soil survey. However, for detailed planning, the survey should be verified by an on-site investigation. For design purposes an on-site investigation is imperative.

Using A Soil Survey

A soil survey includes soil maps, soil descriptions, and interpretations for many different uses of the soils. Soil surveys for many counties of the state may be obtained from the local Soil Conservation Service office.

In a soil survey, boundaries of the different kinds of soils are delineated, showing their location and extent in relation to streams, roads, and other landscape features. The soils are named according to a nationwide uniform procedure that was developed by the Soil Survey Staff of the U.S. Department of Agriculture and published as Soil Taxonomy. The primary basis for identifying different classes in this system are the properties of soils as found in the field that can be measured quantitatively.

The soils identified on a map in a soil survey are named in terms of soil series. Soil series are made up of soils that have similar properties. This means that the horizons or layers are similar in thickness, arrangement, and other important characteristics.

Interpretation tables with information similar to that shown in table A-II-3 are a part of all recent soil surveys. These tables list properties and typical site conditions that are important in erosion and sedimentation control planning. These include texture, soil erodibility factor (k factor), slope, plasticity index, liquid limit, permeability, and depth to bedrock. The interpretation tables also give other ratings and limitations that are important for site selection and development, such as seasonal high water table, shrink-swell potential, risk of corrosion, engineering classification, and hydrologic soil groups.

In order to make accurate interpretations limitations of the survey must be understood. First, the data generally do not represent soil material below 5 or 6 feet. Also, small areas that differ from the dominant soil identified may mot be delineated on the map because the scale of the map limits the size of areas that can be shown. The ranges given for soil properties are often too wide for the design needs of a small development. Therefore, to evaluate most specific soil characteristics an on-site investigation is essential.

Properties of Soils

Some of the properties of soils commonly mapped in Alabama are given in Table A-II-3. A description of these factors follow.

Additional information on soils can be found in Section II of the Field Office Technical Guide at the local Soil Conservation Service Office.

Soil Texture

The soil survey interpretation sheets indicate the USDA texture class for each soil, expressed as a relative proportion by weight of soil particle size classes finer than 2 mm. Soil texture is defined by the proportions of different size groups of particles. The size limits of the different soil particles are listed below.

Soil Particle	Size
Cobble	0.30 - 0.15 m
Gravel	0.15 - 2.00 mm
Sand	2.00 - 0.05 mm
Silt	0.05 - 0.002 mm
Clay	< 0.002 mm

The Basic texture classes, in decreasing particle size, are sands, loams, and clays. On the basis of these classes, additional class names are used such as loamy sand, sandy clay, and silty clay. Sands, loamy sands, and sandy loams may be further subdivided as very coarse, coarse, fine, or very fine. The physical properties and chemical composition of larger soil particles differ from smaller soil particles. Since most physical and chemical reactions occur on the surface of small particles, clay affects soil properties to a much greater extent than do larger particles. Sand and rock fragments retain water and nutrients poorly, because the voids between particles allow water and air to move freely.

Silt particles are barely visible to the naked eye and are intermediate in many properties between sand and clay. Silt is characterized by its plasticity and stickiness. Silt content is an important characteristic for determining erodibility because silt-sized particles are easily detached and transported in runoff. The small particle size makes silt difficult to capture in traps or basins.

There are two major types of clays, kaolinite and montmorillonite. Kaolinite (referred to as a 1:1 clay) is the most common clay in Alabama soils. It is relatively inactive and fairly stable. Montmorillonite (referred to as a 2:1 clay) is a very active clay that shrinks when dry and swells when wet. These characteristics affect the permeability of soils and are very important to their use and management. Clayey soils retain water that is available for plant growth, but these soils are often dense, hard, wet, airtight, acidic, and infertile. They can restrict root growth even though other factors are favorable.

Texture modifiers and terms used to describe texture are given in Table A-II-1.

Table A-II-1

Texture terms and modifiers:

Texture Modifier		Texture Terms	
CB	Cobbly	COS	Coarse sand
CBA	Angular cobbly	S	Sand
CBV	Very cobbly	FS	Fine sand
CBX	Extremely cobbly	VFS	Very fine sand
CN	Channery	LCOS	Loamy coarse sand
CNV	Very channery	LS	Loamy sand
CNX	Extremely channery	LFS	Loamy fine sand
GR	Gravelly	LVFS	Loamy very fine sand
GRC	Coarse gravelly	COSL	Coarse sandy loam
GRF	Fine gravelly	SL	Sandy loam
GRV	Very gravelly	FSL	Fine sandy loam
GRX	Extremely gravelly	VFSL	Very fine sandy loam
MK	Mucky	L	Loam
PT	Peaty	SIL	Silt loam
SH	Shaly	SI	Silt
SHV	Very shaley	SCL	Sandy clay loam
SHX	Extremely shaley	CL	Clay loam
SR	Stratified	SICL	Silty clay loam
ST	Stony	SC	Sandy clay
STV	Very stony	SIC	Silty clay
STX	Extremely stony	C	Clay

Terms Used In Lieu Of Texture

G	Gravel
MARL	Marl
MPT	Mucky-peat
MUCK	Muck
PEAT	Peat
SG	Sand and Gravel
UWB	Unweathered Bedrock
VAR	Variable
WB	Weathered Bedrock

Note: These are boundary classifications. Soils possessing characteristics of two or more groups are designated by combinations of group symbols. For example, SR-S-FS is a stratified sand/fine sand.

Soil Erodibility Factor (K)

The soil erodibility factor, K , provides a measure or the susceptibility of the soil particles to detachment and transport by runoff from rainfall or irrigation. The principle factors affecting K are texture, organic matter, structure, and permeability. The ability of a soil to erode increases with increasing K. Subsoils exposed during construction, however, may be too deep to be included in the table. In this case, an on-site investigation is necessary to flag erosion-prone areas.

Slope

The erosion potential increases with slope length and gradient. Long and steep slopes have a high potential for soil loss from surface runoff.

Plasticity Index and Liquid Limit

Both the plasticity index (PI) and liquid limit (LL) indicate the affect of water on the strength and consistency of soil. The PI and LL of a soil are most important in fine-grained soils. Soils with greater plasticity generally have a higher cohesion and resistance to erosion than soils with a lower plasticity. These indexes are used in both the Unified and the American Association of State Highway and Transportation Officials (AASHTO) soil classification systems, which are described in more detail later. They are also used as indicators in making general predictions of soil behavior.

Permeability

Permeability is a major factor influencing erosion. It refers to the soil's ability to transmit water or air and depends on both the size and volume of pores. Deep, permeable soils are less erodible because more rainfall soaks in, reducing surface runoff. Because permeability varies with depth, excavation can expose layers that are more or less permeable than the original surface. Compaction reduces permeability.

Depth to Bedrock

The soil survey interpretation sheets, found in the Field Office Technical Guide of the Soil Conservation Service Office, generally provide an estimate of depth to and hardness of bedrock, the solid (fixed) rock underlying the soil. This information is helpful in determining time and cost of excavation as well as potential erodibility of the subsoil material. Hardness classes, "soft" and "hard", indicate the ease of excavating into the bedrock. "Soft" rock is likely to be sufficiently soft, thinly bedded, or fractured so that excavation can be made with trenching machines, backhoes, small rippers, or other equipment common in construction of pipelines, sewer lines, cemeteries, dwellings, or small buildings. "Hard" rock is likely to require blasting or special equipment beyond what is considered normal in this type of construction.

Bedrock at shallow depths limits plant growth by restricting root penetration. In most soils there is a negative correlation between depth to bedrock and water holding capacity.

Soil Reaction, (pH)

Soil Reaction represents the degree of acidity or alkalinity of a soil, expressed as pH. The pH in soils normally is directly related to parent material. The principal value of soil pH measurement is the knowledge it gives about associated soil characteristics, such as phosphorous availability or the base saturation. A pH of approximately 6 to 7 indicates readily available plant nutrients.

Leaching removes bases, causing a pH decline. Therefore, the amount of rainfall, rate of percolation, return movement of moisture by capillary action, and evaporation affect pH. The pH is higher in many of the soils of the Prairie than most other soils in Alabama.

Soil reaction is also used as an indicator of corrosivity. In general, soils that are either very alkaline or very acid are likely to be highly corrosive to steel. Soils that are acid are likely to be corrosive to concrete.

Seasonal High Water Table

A seasonal high water table is a zone of saturation at the highest average depth during the wettest season of the year. It is at least 6 inches thick, persists in the soil for more than a few weeks, and is within 6 feet of the surface of the soil. Soils that have a seasonal high water table are classified according to depth to the water table, kind of water table and time of year when the water table is highest. Depth and duration of high water can limit soils for such uses as septic tank absorption fields, roadfill, and topsoil. A water table near the surface during the growing season is detrimental to many plants and must be considered in vegetation plans.

Hydrologic Group

Hydrologic group identifies soils as having the same runoff potential under similar storm and cover conditions. Soil properties that determine the hydrologic groups include the following: seasonal high water table, water intake rate and permeability after wetting, and depth to a slowly permeable layer. The influence of ground cover is not considered. The soils in the U.S. are placed into four groups (A, B, C, and D) and three dual classes (A/B, B/D, C/D). In the definition of classes, the infiltration rate is controlled by surface conditions. Transmission rate is the rate water moves in the soil, controlled by the permeability of deeper horizons.

Group A (low runoff potential) -- Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of deep, well-drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B -- Soils having moderate infiltration rates when thoroughly wetted, consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C -- Soils having slow infiltration rates when thoroughly wetted. Group C soils commonly have a layer that impedes the downward movement of water or can consist of moderately fine to fine-textures particles. These soils have a slow rate of water transmission.

Group D (high runoff potential) -- Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of clay soils with high swelling potential. These soils frequently have a permanent high water table or a slowly permeable layer at or near the surface. Other soils in this group consist of shallow soils over nearly impervious material. these soils have a very slow rate of water transmission.

Dual hydrologic groups, A/D, B/D, and C/D are indicated for certain wet soils that can be drained. The first letter applies to the drained condition, the second to the undrained condition. Only soils that are rated D in their natural condition are assigned to a dual group.

Engineering Classification

Soils are classified according to engineering properties by two classification systems in the soil survey: (1) the AASHTO system and (2) the Unified Soil Classification System.

ASSHTO System

The ASSHTO system classified soils according to the properties that affect roadway construction and maintenance. The fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in silt and clay. Soils in group A-7 are fine grained. Highly organic soils are in Group A-8 and are classified on the basis of visual inspection.

Unified System

The Unified System classifies soils according to suitability for construction material: grain-size distribution, plasticity index, liquid limit, and organic matter content. This classification is based on that portion of soil having particles smaller than 3 inches in diameter. Classes include coarse-grained soils (GW, GP, GM, GC, SW, SP, SM, SC) fine-grained soils (ML, CL, OL, MH, CH, OH) and highly organic soils (PT). Borderline soils require a dual classification symbol. A description for each class in the Unified System is given in Table A-II-2.

Table A-II-2

Classification of Materials for the Unified System:

Group Symbol	Description of Material Classification
Coarse-grained	
GW	Well-graded gravels and gravel-sand mixture little or no fines. 50% or more retained on No. 4 sieve. More than 95% retained on No 200 sieve. Clean.
GP	Poorly-graded gravels and gravel-sand mixtures, little or no fines. 50% or more retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
GM	Silty gravels, gravel-sand-silt mixtures. 50% or more retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
GC	Clayey gravels, gravel-sand-clay mixtures. 50% or more retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
SW	Well-graded sands and gravelly sands with little or no fines. More than 50% passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
SP	Poorly graded sands and gravelly sands, little or no fines. More than 50% passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
SM	Silty sands, sand-silt mixtures. More than 50% passes No. 4 sieve. More than 50% retained on No. 200 sieve.
SC	Clayey sands, sand-clay mixtures. More than 50% passes No. 4 sieve. More than 50% retained on No. 200 sieve.

Table A-II-2 (cont)

Classification of Materials for the Unified System:

Group Symbol	Description of Material Classification
Fine-grained	
OL	Organic silts and organic silty clays of low plasticity. Liquid limit of 50% or less. 50% or more passes No. 200 sieve.
ML	Inorganic silts, very fine sands, rock flour, silty or clayey sands. Liquid limit of 50% or less. 50% or more passes No. 200 sieve.
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
CH	Inorganic clays of high plasticity, fat clays. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
OH	Organic clays of medium to high plasticity. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
Highly organic	
PT	Peat, muck, and other highly organic soils.

NOTE: These are boundary classifications. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC is a will-graded, gravel-sand mixture with clay binder.

All sieve sizes on this table are U.S. Standard.

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
ADATON	0-6	4.5-5.5	.43	D	NP-10	SIL,L	ML,CL,CL-ML	A-4
	6-66	4.5-5.5	.32		11-30	SIL,SICL,SIC	CL,CH	A-6,A-7
ALAGA	0-6	3.6-6.0	.10	A	NP	S,FS	SM,SP-SM	A-2,A-1-B,A-3
	0-6	3.6-6.0	.10		NP-4	LS,LFS	SM,SW-SM,SP-SM	A-2,A-1-B
	6-80	3.6-6.0	.10		NP-4	LS,LFS,FS	SM,SW-SM,SP-SM	A-2
ALAMUCHEE	0-5	4.5-5.5	.28	B	NP-7	L,FSL,SL	ML,CL-ML,SM,SM-SC	A-2,A-4
	0-5	4.5-5.5	.37		8-25	SIL,SICL	CL,ML,MH	A-4,A-6,A-7
	5-52	4.5-5.5	.28		5-20	SCL,CL,L	CL,CL-ML,SC,SM-SC	A-4,A-6
	52-65	4.5-5.5	.28		5-20	L,SL,SCL	CL,CL-ML,SC,SM-SC	A-2,A-4,A-6
ALBANY	0-48	3.6-6.5	.10	C	NP	LS,LFS	SM	A-2
	0-48	3.6-6.5	.10		NP	S,FS	SM,SP-SM	A-2
	48-56	4.5-6.0	.20		NP	SL	SM	A-2
	56-88	4.5-6.0	.24		NP-17	SCL,SL,FSL	SC,SM,SM-SC	A-2,A-4,A-6
ALBERTVILLE	0-6	4.5-5.5	.20	C	NP-7	SL,FSL	MC,ML,SM-SC	A-4
	0-6	4.5-5.5	.28		NP-7	SIL,L	CL-ML,ML	A-4
	6-15	4.5-5.5	.32		11-16	SIL,SICL,CL	CL	A-6
	15-47	4.5-5.5	.37		14-40	SICL,SIC,C	CL,CH	A-6,A-7
	47-66					WB		
ALCOA	0-7	4.5-6.0	.24	B	11-20	CL	CL,ML	A-6,A-7
	0-7	4.5-6.0	.28		5-10	L,SIL	CL-ML,CL,ML	A-4
	7-20	4.5-5.5	.24		11-20	CL	CL,ML	A-6,A-7
	20-74	4.5-5.5	.24		14-23	CL,C,SC	CL,MH,ML,CH	A-6,A-7
ALLEN	0-12	4.5-5.5	.15	B	NP-10	GR-L,GR-FSL,GR-SL	ML,CL-ML, SM,SM-SC	A-2,A-4
	0-12	4.5-5.5	.20		5-20	CL,SCL	CL-ML,CL,SM-SC,SC	A-4,A-6
	0-12	4.5-5.5	.28		NP-10	L,FSL,SL	ML,CL-ML,SM,SM-SC	A-4
	12-35	4.5-5.5	.20		4-19	CL,SCL,L	CL-ML,CL,SC	A-4,A-6,A-7-6
	35-70	4.5-5.5	.20		5-22	CL,SCL,C	CL-ML,CL,SC,SM-SC	A-4, A-6,A-7-6
ALPIN	0-3	4.5-6.5	.10	A	NP	FS,S,LS	SP-SM,SM	A-3,A-2-4
	3-54	4.5-6.5	.10		NP	FS,S	SP-SM	A-3,A-2-4
	54-99	4.5-6.0	.10		NP	FS,S	SP-SM,SM	A-2-4
ALTAVISTA	0-12	3.6-6.0	.17	C	NP	LS,LFS	SM	A-2
	0-12	3.6-6.0	.24		NP-7	FSL,L,SL	ML,CL-ML,SM,SM-SC	A-4
	0-12	3.6-6.0	.32		4-12	SIL,VFSL	CL-ML, CL	A-4,A-6
	12-42	3.6-6.0	.24		5-28	CL,SCL,L	CL,CL-ML,SC,SM-SC	A-4,A-6,A-7
	42-60					VAR		
AMERICUS	0-7	4.5-5.5	.10	A	NP	LS,S,LFS	SM,SP-SM	A-2
	7-47	4.5-5.5	.17		NP	LS,LFS	SM	A-2
	47-72	4.5-5.5	.20		NP-7	SL,LS,FSL	SM,SM-SC	A-2

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
AMY	0-18	4.5-5.5	.43	D	NP-5	SIL,L,VFSL	ML	A-4
	18-52	4.5-5.5	.43		8-20	SIL,SICL	CL	A-4,A-6
	52-68	4.5-5.5	.43		NP-20	FSL,SIL,SICL	ML,SM,CL-ML,CL	A-4,A-6
ANGIE	0-10	4.5-6.5	.32	D	NP-10	FSL,SL	SM,ML,CL-ML,SM-SC	A-4,A-2
	0-10	4.5-6.5	.49		5-10	VFSL,SIL	ML,CL-ML	A-4
	10-65	3.6-5.5	.32		18-29	SICL,SIC,C	CH,CL	A-7-6
ANNEMAINE	0-9	4.5-6.5	.28	C	NP-5	FSL,L,SL	SM,SM-SC,ML,CL-ML	A-4
	0-9	4.5-6.5	.37		5-20	SIL	CL,CL-ML	A-4,A-6
	9-16	4.5-5.5	.37		10-25	C,CL,SIC	CL	A-6,A-7
	16-37	4.5-5.5	.37		20-35	C,SIC,SICL	CH,MH,CL,ML	A-7
	37-49	4.5-5.5	.37		8-15	SCL,L,CL	SC,CL	A-4,A-6
	49-90	4.5-5.5	.32		NP-10	SCL,FSL,SL	SM,SM-SC,SC	A-2,A-4
ANNISTON	0-7	4.5-5.5	.24	B	NP-10	GR-L,GR-SIL	ML,CL,CL-ML	A-4
	0-7	4.5-5.5	.28		NP-7	SL,FSL	SM,ML,SM-SC	A-4
	0-7	4.5-5.5	.32		NP-13	L,SIL	ML,CL,CL-ML	A-4,A-6
	7-80	4.5-5.5	.32		10-28	CL,C	ML,CL	A-6,A-7
APISON	0-7	4.5-5.5	.37	B	3-10	L,SIL	ML,CL,CL-ML	A-4
	7-28	4.5-5.5	.37		4-18	CL,L,SICL	CL-ML,CL	A-4,A-6
	28-61					WB		
APPLING	0-9	4.5-5.5	.24	B	NP-5	FSL,SL,LS	SM	A-2
	0-9	4.5-5.5	.28		6-20	SCL	CL,SC,CL-ML,SM-SC	A-6,A-4
	0-9	4.5-5.5	.15		NP	GR-SL,GR-COSL	SM	A-2,A-1-B
	9-35	4.5-5.5	.28		15-30	SC,CL,C	MH,ML,CL	A-7
	35-46	4.5-5.5	.28		8-22	SC,CL,SCL	SC,CL	A-4,A-6,A-7
	46-65					VAR		
ARAGON	0-6	4.5-5.5	.32	C	NP-7	FSL,L	ML,CL-ML,SM,SM-SC	A-4
	0-6	4.5-5.5	.32		2-7	SIL	ML,CL-ML	A-4
	6-15	3.6-5.5	.32		3-12	CL,L,SCL	ML,CL,CL-ML	A-4,A-6
	15-42	3.6-5.5	.28		15-35	C,SIC	CH,MH	A-7
	42-52	3.6-5.5	.32		11-30	SIC,SCL,C	ML,CL,MH,CH	A-6,A-7
	52-65					WB		
ARDILLA	0-9	4.5-6.0	.15	C	NP-7	LS,LFS,COS	SM,SP-SM,SM-SC	A-2-4,A-1
	0-9	4.5-6.0	.24		NP-7	SL,FSL	SM,SM-SC	A-2-4
	9-30	4.5-6.0	.28		4-15	SCL,SL	SM,SM-SC,SC	A-4,A-2-6,A-6
	30-60	4.5-5.5	.28		7-20	SCL,SC	SM,SC	A-4,A-6,A-5,A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
ARGENT	0-5	3.6-6.0	.24	D	NP-10	SL,FSL	SM,SC,SM-SC	A-2,A-4
	0-5	3.6-6.0	.24		5-20	L,CL	CL,CL-ML	A-4,A-6,A-7
	0-5	3.6-6.0	.32		3-20	SIL,SICL	CL,CL-ML,ML	A-6,A-4
	5-64	3.6-6.0	.32		11-40	C,SC,SIC	CL,CH	A-6,A-7
	64-76	5.6-8.4	.32		6-28	SCL,CL,SICL	CL,CL-ML,SC,SM-SC	A-4,A-6,A-7
	76-80					VAR		
ARMOUR	0-17	5.1-6.0	.37	B	11-18	SICL	CL	A-6
	0-17	5.1-6.0	.43		5-10	SIL	CL-ML,CL,ML	A-4
	17-48	5.1-6.0	.37		8-18	SICL,SIL	CL	A-4,A-6
	48-75	5.1-6.0	.37		9-23	SICL,SIC,C	ML,MH,GM,GC	A-4,A-6,A-7
ARMUCHEE	0-8	4.5-5.5	.28	C	5-15	SH-SIL,SH-SICL	CL,ML,CL-ML	A-4,A-6
	0-8	4.5-5.5	.37		5-15	SIL,SICL	CL,ML,CL-ML	A-4,A-6
	8-17	4.5-5.5	.37		13-35	SH-SIC,SH-SICL	MH,ML,CL,CH	A-6,A-7
	17-24	4.5-5.5	.32		11-30	SHV-SIC,SHV-SICL	GM,GC,CL,CH	A-2,A-6,A-7
	24-60					WB		
ARUNDEL	0-6	3.6-5.5	.28	C	NP	SL,SL	ML,SM	A-4,A-2-4
	0-6	3.6-5.5	.28		NP	LFS,LS	SM	A-2,A-4
	0-6	3.6-5.5	.37		NP-10	SIL,L	ML,CL,CL-ML	A-4
	6-38	3.6-4.4	.32		22-41	SICL,SIC,C	CL,CH	A-7
	38-45					WB		
ATMORE	0-13	3.6-5.5	.32	B/D	NP-7	FSL,VFSL	SM,ML,CL-ML,SM-SC	A-4
	0-13	3.6-5.5	.37		NP-7	L,SIL	ML	A-4
	13-48	3.6-5.5	.37		NP-7	L,SIL,FSL	ML,CL-ML	A-4
	48-70	3.6-5.5	.32		2-18	SIL,CL,SICL	ML,CL,SM,SC	A-4,A-6
AUGUSTA	0-9	4.5-6.0	.17	C	NP-4	LS,LFS	SM,CL-ML	A-2-4
	0-9	4.5-6.0	.20		NP-7	SL,FSL	SM,SM-SC,ML	A-2,A-4
	0-9	4.5-6.0	.24		NP-10	SIL,L	ML,CL-ML	A-4
	9-60	4.5-6.0	.24		5-25	SCL,CL,L	CL,CL-ML	A-4,A-6,A-7
	60-70					VAR		
AXIS	0-7	6.1-8.4	.24	D	NP-7	SL,FSL,VFSL	CL-ML,SC,SM,SM-SC	A-4
	0-7	6.1-8.4	.24		4-10	MK-SL,MK-SCL	CL-ML,SC,SM-SC	A-4
	0-7	6.1-8.4	.37		4-10	L,SIL	CL,CL-ML	A-4
	7-40	6.1-8.4	.10		4-10	SL,L,SIL	CL-ML,SC,SM-SC,CL	A-4
	40-72	6.1-8.4	.10		NP-7	SL,L,SCL	ML,CL-ML,SM,SM-SC	A-4
BAMA	0-14	4.5-6.0	.24	B	NP-10	FSL,SL,L	SM,SC,SM-SC,CL-ML	A-4
	14-41	4.5-5.5	.32		2-15	L,SCL	SM,SC,SM-SC,CL-ML	A-4,A-6
	41-74	4.5-5.5	.32		8-18	L,SCL,CL	SC,CL	A-4,A-6

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification: USDA	Textural Classification: Unified	Textural Classification: AASHTO
BANKHEAD	0-4	4.5-5.5	.15	B	NP	LS	SM	A-2
	0-4	4.5-5.5	.17		NP	CN-FSL,CN-SL,GR-SL	SM,GM	A-2,A-4
	0-4	4.5-5.5	.20		NP	FSL,SL	SM	A-2,A-4
	4-26	4.5-5.5	.17		NP-3	SL,CN-SL,CB-SL	SM,GM	A-2,A-4
	26-30					UWB		
BARFIELD	0-6	6.1-7.8	.17	D	12-35	ST-SICL,ST-SIC,ST-C	CL,CH,MH	A-6,A-7
	6-18	6.1-7.8	.17		22-40	ST-SICL,ST-SIC	CL,CH,MH	A-7
	18-22					UWB		
BARFIELD	0-6	6.1-7.8	.24	D	12-35	SICL,SIC,C	CL,CH,MH	A-6,A-7
	6-18	6.1-7.8	.17		14-40	SIC,C,SICL	CH,MH,CL	A-7,A-6
	18-22					UWB		
BASIN	0-9	3.6-5.5	.28	C	NP	FSL,SL,L	SM,ML	A-4
	9-22	3.6-5.5	.28		NP-7	L,FSL	SM,ML,CL-ML,SM-SC	A-4
	22-60	3.6-5.5	.28		5-12	L,SL,SCL	CL-ML,SM-SC,CL,SC	A-4,A-6
BASSFIELD	0-7	4.5-5.5	.17	B	NP-3	LS	SM	A-2
	0-7	4.5-5.5	.20		NP-3	SL,FSL,L	SM,ML	A-2,A-4
	7-42	4.5-5.5	.20		NP-10	SL,L	SM,SC,SM-SC	A-2,A-4
	42-80	4.5-5.5	.17		NP-3	LS,S	SP-SM,SM	A-2,A-3
BAXTERVILLE	0-9	4.5-5.5	.24	B	NP-10	SL,FSL,L	SM,SC,SM-SC	A-4
	9-29	4.5-5.5	.37		12-18	SL,SCL	CL	A-6
	29-68	4.5-5.5	.37		12-25	CL,SCL,L	CL	A-6,A-7
BAYBORO	0-14	3.6-5.5	.10	D	NP-7	MK-FSL,MK-L	OL,SM,CL-ML,SM-SC	A-4,A-2-4
	0-14	3.6-5.5	.15		NP-7	FSL	SM-SC,SM,CL-ML,ML	A-4,A-2-4
	0-14	3.6-5.5	.17		3-20	L,CL	CL,ML,CL-ML	A-6,A-7,A-4
	14-64	4.5-5.5	.32		20-40	CL,SC,C	CL,CH	A-7,A-6
BAYOU	0-18	4.5-5.5	.20	D	NP-7	SL,L	SM,SM-SC,ML,CL-ML	A-2,A-4
	18-43	4.5-5.5	.20		NP-7	SL,L	SM,SM-SC,ML,CL-ML	A-2,A-4
	43-66	3.6-6.0	.32		8-15	SCL,CL	SC,CL	A-4,A-6
BEACHES	0-6		.05	D	NP	COS,S,FS	SP	A-1,A-3
	6-60		.05		NP	COS,S,FS	SP	A-1,A-3
BEASON	0-7	4.5-6.0	.37	C	5-15	SIL,SICL	ML,CL,CL-ML	A-4,A-6
	7-18	4.5-5.5	.32		11-20	SICL,SIL	CL	A-6
	18-60	4.5-5.5	.32		11-25	SICL,SIC,C	CL	A-6,A-7
	60-80					VAR		
BEATRICE	0-3	3.6-6.0	.28	D	NP	SL,FSL	SM,ML	A-4
	0-3	3.6-6.0	.37		5-15	L,SIL	CL-ML,CL	A-4,A-6
	3-50	3.6-5.0	.32		24-42	C	MH	A-7
	50-72					SR-C-SCL		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
BENNDALE	0-5	4.5-5.5	.17	B	NP	LS	SM	A-2
	0-5	4.5-5.5	.20		NP-7	SL,SL	ML,SM,CL-ML,SM-SC	A-4,A-2-4
	0-5	4.5-5.5	.20		NP-7	L	ML,CL-ML	A-4
	5-33	4.5-5.5	.28		3-7	L,SL,FSL	ML,SM,CL-ML,SM-SC	A-4
	33-68	4.5-5.5	.32		3-15	L,SL,SCL	ML,SM,CL-ML,SM-SC	A-4,A-6
	68-73	4.5-5.5	.28		NP-5	L,SL,LS	SM,ML,CL-ML,SM-SC	A-2,A-4
BETHERA	0-7	3.6-6.0	.24	D	0-6	FSL,SL	SM,ML,SM-SC,CL-ML	A-4
	0-7	3.6-6.0	.28		12-26	CL	CL,CH	A-6,A-7
	0-7	3.6-6.0	.28		8-14	L,SIL	CL	A-4,A-6
	7-68	3.6-6.0	.32		12-30	C,CL,SC	CL,CH,ML,MH	A-6,A-7
	68-80	3.6-6.0	.32		8-30	C,SC,SCL	CL,CH	A-7,A-6,A-4
BEWLEYVILLE	0-8	4.5-6.5	.37	B	11-18	SICL	CL	A-6
	0-8	4.5-6.5	.43		2-7	SIL	ML,CL-ML	A-4
	8-28	4.5-5.5	.37		11-22	SICL,SIL	CL	A-6,A-7
	28-72	4.5-5.5	.37		12-32	C,CL,SICL	CL,ML,MH,CH	A-6,A-7
BIBB	0-12	4.5-5.5	.15	D	NP	S,LS	SM,SP-SM	A-2,A-3,A-1-B
	0-12	4.5-5.5	.20		NP-7	SL,FSL	SM,SM-SC,ML,CL-ML	A-2,A-4
	0-12	4.5-5.5	.28		NP-7	L,SIL	ML,CL-ML	A-4
	12-37	4.5-5.5	.37		NP-7	SL,L,SIL	SM,SM-SC,ML,CL-ML	A-2,A-4
	37-60	4.5-5.5	.15		NP	S,FS,LS.	SM,SP-SM	A-2,A-3,A-1-B
BIGBEE	0-17	4.5-6.0	.10	A	NP	S,FS	SM,SP-SM	A-2-4,A-3
	0-17	4.5-6.0	.10		NP	LS,LFS	SM	A-2-4
	17-80	4.5-6.0	.17		NP	S,FS	SP-SM,SM	A-2-4,A-3
BINNSVILLE	0-8	7.4-8.4	.37	D	22-32	SICL,SIC	CL,CH	A-7
	8-12	7.4-8.4	.37		22-32	SICL,SIC	CL,CH	A-7
	12-48					WB		
BIRMINGHAM	0-5	4.5-6.5	.24	B	NP-7	CB-L,CB-SL,CB-SIL	GM-GC,GM,SM-SC,SM	A-2,A-4
	5-29	4.5-6.5	.28		4-16	CB-L,CB-CL	SC,SM-SC,GC,GM-GC	A-4,A-2,A-6
	29-49					WB		
	49-55					UWB		
BLADEN	0-14	3.6-5.5	.24	D	NP	FSL,SL	SM	A-2,A-4
	0-14	3.6-5.5	.37		NP-10	L,SIL	CL,ML,CL-ML	A-4
	14-41	3.6-5.5			23-45	C,SC	CL,CH	A-7
	41-62	3.6-5.5			8-35	C,SC,CL	CL,CH,SC	A-4,A-6,A-7
	62-80					VAR		
BLANTON	0-58	4.5-6.0	.10	A	NP	LS,LFS	SM	A-2-4
	0-58	4.5-6.0	.10		NP	S,FS,COS	SP-SM,SM	A-3,A-2-4
	0-58	4.5-6.0	.05		NP	GR-S	SP-SM	A-1, A-2-4,A-3
	58-62	4.5-5.5	.15		NP-3	SL,LS,LCOS	SM	A-2-4
	62-80	4.5-5.5	.20		3-22	SCL,SL,SC	SC,SM-SC,SM	A-4,A-2-4,A-6

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
BODINE	0-8	3.6-5.5	.24	B	NP-7	CRV-SIL,CRV-L	GM,GM-GC	A-1,A-2
	0-8	3.6-5.5	.28		NP-7	CR-SIL,CR-L,CR-SL	ML,CL-ML,GM,SM	A-4,A-2,A-1-B
	0-8	3.6-5.5	.28		NP-7	ST-SIL,ST-L,STV-SIL	SM,SM-SC,GM,GM-GC	A-4,A-2,A-1
	8-24	3.6-5.5	.24		3-15	CR-SIL,CR-SICL,ST-SIL	GM-GC,GC,SC,SM-SC	A-1,A-2,A-4,A-6
	24-72	3.6-5.5	.24		8-16	CR-SICL,CR-CL,CRV-SIL	GC,GM,SC,SM	A-2
BOMAR	0-7	4.5-6.0	.37	C	2-10	SIL,L,SICL	CL,ML,CL-ML	A-4
	7-33	4.5-5.5	.32		11-25	SICL,SIC,CL	CL	A-6,A-7
	33-73	3.6-5.0	.32		11-25	SIC,SICL,CL	CL	A-6,A-7
	73-80	3.6-5.0	.28		11-25	CL,SICL,SIC	CL	A-6,A-7
BONIFAY	0-57	4.5-6.5	.10	A	NP	LS,LFS	SM	A-2-4
	0-57	4.5-6.5	.10		NP	S,FS	SP-SM	A-3,A-2-4
	57-63	4.5-6.5	.24		NP-12	SL,SCL,FSL	SM-SC,SC,SM	A-2-4,A-4,A-6
	63-73	4.5-6.5	.24		5-22	SCL,SC	SM-SC,SC	A-2,A-4,A-6,A-7
BONNEAU	0-22	4.5-6.0	.15	A	NP	LS,LFS	SM	A-2
	0-22	4.5-6.0	.15		NP	S,FS	SM,SP-SM	A-2,A-3
	22-50	4.5-5.5	.20		4-21	SL,SCL,FSL	SC,SM-SC	A-2,A-6,A-4
	50-74	4.5-5.5	.20		4-18	SL,SCL,SC	CL,SC,SM-SC,CL-ML	A-4,A-6,A-2
BOSWELL	0-5	4.5-5.5	.28	D	NP	FSL,SL	SM,ML	A-4
	0-5	4.5-5.5	.37		11-35	CL,SICL,C	CL,CH	A-6,A-7
	0-5	4.5-5.5	.43		3-12	SIL,L	ML,CL,CL-ML	A-4,A-6
	5-70	4.5-5.5	.32		25-40	C,SIC,SICL	CH	A-7
BRADYVILLE	0-6	5.1-6.5	.37	C	12-22	SICL	CL	A-6,A-7
	0-6	5.1-6.5	.43		3-15	SIL	ML,CL,CL-ML	A-4,A-6
	6-20	5.1-6.0	.32		18-28	SICL,SIC,C	CL,MH,CH	A-7,A-6
	20-48	5.1-7.8	.28		26-40	SIC,C	CH,MH	A-7
	48-52					UWB		
BRANTLEY	0-6	4.5-6.5	.28	C	NP-7	FSL,L	SM,SM-SC,ML,CL-ML	A-4
	0-6	4.5-5.5	.28		9-16	CL	CL,ML	A-6,A-7,A-4
	6-35	4.5-6.0	.28		16-22	C,CL,SC	CL,ML	A-7
	35-52	4.5-5.5	.24		7-15	SCL,CL	SC,SM,CL,ML	A-4,A-6
	52-72	4.5-5.5	.20		NP-9	FSL,LFS,SCL	SM,SC,ML	A-2,A-4
BRAXTON	0-6	5.1-6.0	.28	C	7-18	CR-SIL,CR-SICL	CL-ML,CL,GC,GM-GC	A-4,A-6
	0-6	5.1-6.0	.32		7-18	SIL,SICL	CL-ML,CL	A-4,A-6
	6-24	5.1-6.0	.20		20-32	C,SIC	CL,MH,CH	A-7
	24-80	5.1-6.5	.20		22-34	C	CL,CH,MH	A-7
BREMO	0-10	5.1-6.5	.28	C	NP-10	GR-SIL,GR-L	ML,CL,GM,CL-ML	A-2,A-4
	0-10	5.1-6.5	.28		NP-10	SIL,L	ML,CL-ML,CL	A-4
	10-17	5.1-6.5	.20		6-14	GRV-SIL,GRV-L,GR-SIL	CL,CL-ML,GC,SC	A-2,A-4,A-6
	17-25	5.1-6.5	.20		NP-6	GRV-SIL,GRV-L,GR-SL	GM,GM-GC,GP-GM	A-1,A-2,A-4
	25-29					UWB		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification: USDA	Unified	AASHTO
BREWTON	0-21	4.5-5.5	.24	C	NP-5	FSL,L	SM,SM-SC	A-2,A-4
	21-60	4.5-5.5	.28		NP-7	SL,FSL,L	SM,SM-SC	A-2,A-4
	60-96					SR-S-C		
BRILLIANT	0-7	5.6-7.3	.24	B	NP-16	CNV-SL,CNV-L,CNV-SIL	SM,SC,SM-SC,GM	A-2-4,A-2-6,A-1
	0-7	5.6-7.3	.24		NP-16	CNX-SL,CNX-L,CNX-SIL	SM,SC,SP-SM,SM-SC	A-2-4,A-2-6,A-1
	0-7	5.6-7.3	.24		NP-7	CN-SL,CN-L,CN-SIL	SM,SM-SC,GM,GM-GC	A-4,A-2-4
	7-72	5.6-7.3	.24		NP-16	CNX-SL,CNX-L,CNX-SIL	SM,SC,SM-SC,SP-SM	A-2-4,A-2-6,A-1
BROOKSVILLE	0-16	5.1-6.5	.37	D	25-32	SICL,SIC	CL,CH	A-7
	16-80	6.6-8.4	.32		36-65	SIC,C	CH	A-7
BRUNO	0-8	5.1-8.4	.15	A	NP	LS,LFS	SM	A-2
	0-8	5.1-8.4	.17		NP-3	SL,L,FSL	SM, ML	A-4,A-2
	8-42	5.1-8.4	.15		NP	S,LS,LFS	SP-SM,SM	A-2
	42-60	5.1-8.4	.10		NP	S	SP-SM,SM	A-2,A-3
BUNCOMBE	0-10	6.1-6.5	.10	A	NP	LS,LFS,S	SM,SP-SM	A-2,A-3
	10-55	4.5-6.0	.10		NP	LS,LFS,S	SM,SP-SM	A-2,A-3
	55-65					VAR		
BYARS	0-13	3.6-5.5	.20	D	NP-7	SL,FSL	SM,SM-SC,ML,CL-ML	A-4
	0-13	3.6-5.5	.28		11-23	SICL,CL,L	CL	A-6,A-7-6
	0-13	3.6-5.5	.37		11-23	SIL	CL,ML	A-6,A-7-6
	13-43	3.6-5.5	.32		17-42	C,CL,SC	CL,CH	A-7-5,A-7-6,A-6
	43-73	3.6-5.5	.32		8-20	C,SICL,SIC	CL,ML	A-6,A-7,A-4
	73-80					VAR		
CADEVILLE	0-7	3.6-6.0	.32	D	NP-7	FSL	SM,CL-ML,ML,SM-SC	A-4
	0-7	3.6-6.0	.37		2-19	L	ML,CL,CL-ML	A-4,A-6
	0-7	3.6-6.0	.49		2-19	VFSL,SIL	ML,CL-ML,CL	A-4,A-6
	7-23	3.6-5.5	.32		22-35	SIC,C	CH,CL	A-7-6
	23-64	3.6-5.5	.32		12-30	C,SIC,SICL	CH,CL	A-7-6,A-6
CAHABA	0-9	4.5-6.0	.15	B	NP	LS,LFS	SM	A-2
	0-9	4.5-6.0	.24		NP	SL,FSL	SM	A-4,A-2-4
	0-9	4.5-6.0	.28		NP-7	L	ML,CL-ML	A-4
	9-53	4.5-6.0	.28		8-15	SCL,L,CL	SC,CL	A-4,A-6
	53-80	4.5-6.0	.24		NP	S,LS,SL	SM,SP-SM	A-2-4
CANE	0-5	5.6-6.5	.20	C	NP-7	GR-L,GR-FSL,GR-SL	SM	A-2,A-4
	0-5	5.6-6.5	.28		NP-7	L,FSL,SL	ML,SM	A-4
	5-25	4.5-6.0	.37		3-12	SIL,L,CL	ML,CL-ML,CL	A-4,A-6
	25-62	4.5-6.0	.37		3-15	SIL,L,CL	ML,CL-ML,CL	A-4,A-6

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
CANTON BEND	0-7	5.1-6.5	.24	C	NP-6	FSL,SL	ML,SM,CL-ML,SM-SC	A-2,A-4
	0-7	5.1-6.5	.43		NP-10	L,SIL	CL,CL-ML,ML	A-4
	7-52	5.1-5.5	.37		11-25	SICL,CL,SIC	CL	A-6,A-7
	52-80	5.1-5.5	.32		NP-7	L,FSL,SL	SM-SC,SM,CL-ML,ML	A-2,A-4
CANTUCHE	0-4	3.6-5.5	.20	D	4-11	CNV-L,CNV-SIL,CNV-SL	SC,SM-SC,CL,CL-ML	A-4,A-6
	4-9	3.6-5.5	.20		4-11	CNX-L,CNX-SIL,CNV-L	SC,SM-SC,CL,CL-ML	A-4,A-6
	9-20					WB		
CAPSHAW	0-7	5.1-6.0	.37	C	3-10	SIL,L	ML,CL,CL-ML	A-4
	7-19	5.1-6.0	.37		11-20	SICL,SIC,SIL	ML,CL	A-6,A-7
	19-46	5.1-6.0	.24		18-36	C,SIC,SICL	CL,CH,MH	A-7
	46-60	5.6-7.8	.24		18-36	C,SICL,CL	MH,CH,CL	A-7
CARNEGIE	0-5	4.5-6.0	.28	C	NP-5	SL,LS,GR-SL	SM,SM-SC	A-2
	0-5	4.5-6.0	.32		NP-7	SCL	SM,SM-SC,CL-ML,ML	A-4
	5-20	4.0-5.5	.32		13-25	SC,SCL	CL	A-6,A-7
	20-32	4.0-5.5	.28		13-25	SC,C	CL	A-6,A-7
	32-65	4.0-5.5	.28		13-25	SC,C	CL	A-7,A-6
CARTECAY	0-9	5.1-6.5	.24	C	NP	SL,LS	SM	A-2,A-4
	0-9	5.1-6.5	.24		NP-5	VFSL,FSL	SM,SM-SC,ML	A-2,A-4
	0-9	5.1-6.5	.32		NP-15	L,SIL,SICL	ML,CL,CL-ML	A-4,A-6
	9-40	5.1-6.5	.24		NP-10	SL,FSL,L	SM,SC,SM-SC	A-2,A-4
	40-60	5.1-6.5	.15		NP	LS,S,SL	SM,SP-SM	A-2,A-1,A-3
CATALPA	0-6	6.1-8.4	.28	C	24-30	SICL,SIC,C	CL,CH	A-7
	6-60	6.1-8.4	.28		28-50	SIC,C,SICL	CH	A-7
CATAULA	0-7	5.1-6.5	.17	B	NP-7	LS	SM,SM-SC	A-2
	0-7	5.1-6.5	.28		NP-7	SL,FSL	SM,SM-SC	A-2,A-4
	0-7	5.1-6.5	.32		9-20	SCL,CL	CL,ML,SC,SM	A-4,A-6,A-7
	7-27	4.5-6.0	.24		11-30	C,CL,SC	MH,ML,CL	A-7,A-6
	27-55	4.5-6.0	.24		2-30	SCL,SC,CL	MH,ML	A-5,A-7
	55-75	4.5-6.0	.32		2-20	SCL,CL,L	CL,ML,CL-ML,SC	A-4,A-6
CECIL	0-7	4.5-6.0	.28	B	NP-7	SL,FSL,L	SM,SM-SC	A-2,A-4
	0-7	4.5-6.0	.28		3-15	SCL,CL	SM,SC,CL,ML	A-4,A-6
	0-7	4.5-6.0	.15		NP-4	GR-SL,GR-L,GR-FSL	SM,GM	A-2,A-1-B
	7-11	4.5-5.5	.28		3-15	SCL,CL	SM,SC,ML,CL	A-4,A-6
	11-50	4.5-5.5	.28		9-37	C,CL	MH,ML	A-7,A-5
	50-75					VAR		
CEDA	0-9	5.6-6.5	.17	B	NP-7	GR-FSL,GRV-FSL	SM,GM,SM-SC,GM-GC	A-1,A-2,A-4
	0-9	5.6-6.5	.28		2-7	GR-L,GRV-L	SM,GM,ML,GM-GC	A-1,A-2,A-4
	0-9	5.6-6.5	.28		2-7	GR-SIL,GRV-SIL	ML,SM,GM,GM-GC	A-2,A-4
	9-65	5.6-6.5	.28		NP-18	GRV-L,CB-CL,GRV-FSL	GM,GP-GM,GM-GC	A-1,A-2,A-4,A-6

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
CEDARBLUFF	0-9	5.1-6.0	.28	C	NP	FSL,L	ML,SM	A-4
	0-9	5.1-6.0	.37		5-20	SIL	CL-ML,CL	A-6,A-4
	9-18	5.1-6.0	.32		5-10	CL,L	CL-ML,ML,CL	A-4
	18-33	5.1-5.5	.32		11-25	CL,L	CL	A-6
	33-66	5.1-5.5	.32		11-35	CL,L,C	CL,CH	A-6,A-7-6
CHASTAIN	0-5	4.5-6.5	.28	D	12-40	SIC,CL,C	ML,CL,MH,CH	A-6,A-7
	0-5	4.5-6.0	.32		3-18	SICL,SIL,L	ML,CL,CL-ML	A-4,A-6,A-7
	5-52	4.5-6.0	.37		12-40	SICL,SIC,C	CL,CH,ML,MH	A-6,A-7
	52-72	4.5-6.0	.10		NP	LS,S,FS	SP,SM,SP-SM	A-2,A-3
CHEAHA	0-4	4.5-5.5	.20	D	NP-7	ST-FSL,ST-SL	SM,ML,GM	A-4,A-2-4
	0-4	4.5-5.5	.24		NP-7	ST-L,ST-SIL	SM,ML,GM	A-4,A-2-4
	4-35	4.5-5.5	.28		NP-10	ST-SCL,ST-CL,ST-SIL	ML,SM,GM,CL-ML	A-4,A-2-4
	35-50					UWB		
CHENNEBY	0-16	4.5-6.0	.32	C	8-20	SICL	CL,ML,MH,CH	A-6,A-7,A-4
	0-16	4.5-6.0	.37		3-15	L,SIL	CL,ML,CL-ML	A-4,A-6
	16-55	4.5-6.0	.32		8-20	L,SIL,SICL	CL,ML,MH,CH	A-4,A-6,A-7
	55-72	4.5-6.0	.24		NP-8	SR-SL,SICL	SM,ML,SC,CL	A-2-4,A-4
CHEWACLA	0-8	4.5-6.5	.24	C	NP-7	FSL,SL	SM,SM-SC	A-2,A-4
	0-8	4.5-6.5	.28		4-20	SIL,L	ML,CL,CL-ML	A-4,A-6,A-7
	8-24	4.5-6.5	.32		4-22	SIL,SICL,CL	ML,CL	A-4,A-6,A-7
	24-34	4.5-6.5	.28		NP-15	SCL,L,SL	SM,SM-SC,ML,CL	A-4,A-7-6,A-6
	34-58	4.5-7.8	.32		4-28	SIL,CL,SICL	ML,MH,CL,CH	A-4,A-6,A-7
	58-70					VAR		
CHIPLEY	0-6	3.6-6.0	.10	C	NP	S,FS	SP-SM	A-3,A-2-4
	6-77	4.5-6.5	.10		NP	S,FS	SP-SM	A-3,A-2-4
CHISCA	0-5	3.6-5.5	.28	D	NP-7	L,FSL,SL	ML,SM,CL-ML,SM-SC	A-4
	0-5	3.6-5.5	.37		NP-15	SIL,SICL,CL	ML,CL,CL-ML	A-6,A-4
	5-13	3.6-5.5	.32		20-40	SIC,C	CL,CH,MH	A-7
	13-32	3.6-5.5	.32		30-60	C	CH,MH	A-7
	32-55	4.5-8.4	.32		20-40	C,SIC	CL,CH,MH	A-7
	55-65					WB		
CHOCCOLOCCO	0-6	4.5-6.0	.28	B	NP-7	FSL,SL	SM	A-2,A-4
	0-6	4.5-6.0	.32		NP-8	L,SIL	ML	A-4
	6-42	4.5-6.0	.37		7-14	SICL,SIL,L	ML	A-4,A-6,A-7
	42-60	4.5-6.0	.32		NP-7	SL,L	SM,ML,SM-SC,CL-ML	A-2,A-4
CHRYSLER	0-7	4.5-5.5	.28	C	NP-7	FSL,L,SL	SM,ML	A-4
	0-7	4.5-5.5	.37		5-20	SIL	CL,CL-ML	A-4,A-6
	7-72	4.5-5.5	.32		15-35	SICL,SIC,C	CL,ML,CH,MH	A-7
	72-96					VAR		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
CLARENDON	0-15	4.5-6.5	.15	C	NP-3	LS,LFS,S	SM,SP-SM	A-2
	0-15	4.5-6.5	.20		NP-10	SL,FSL	SM,SC,SM-SC	A-2,A-4
	15-40	4.5-5.5	.20		5-15	SCL	SC,CL,SM-SC,CL-ML	A-4,A-6
	40-80	4.5-5.5	.15		NP-15	SCL,SL,SC	SC,CL,SM-SC,CL-ML	A-2,A-4,A-6
CLOUDLAND	0-22	4.5-5.0	.28	C	NP-7	FSL,SL	SM,ML,CL-ML,SM-SC	A-2-4,A-4
	0-22	4.5-6.0	.37		NP-7	L,SIL	CL-ML,ML	A-4
	22-36	4.5-5.5	.32		4-20	L,CL,SICL	CL,CL-ML	A-6,A-4,A-7-6
	36-62	4.5-5.5	.28		4-20	L,CL,SICL	CL,CL-ML	A-6,A-4,A-7-6
COLBERT	0-8	4.5-6.5	.32	D	7-25	SICL	CL	A-4,A-6,A-7
	0-8	4.5-6.5	.37		NP-15	L,SIL	ML,CL,CL-ML	A-4,A-6
	8-26	4.5-6.5	.32		15-35	SICL,SIC,C	CL,CH,ML,MH	A-6,A-7
	26-44	4.5-6.5	.32		25-50	SIC,C	MH,CH	A-7
	44-55	6.1-7.8	.32		25-50	SICL,SIC,C	CL,CH	A-7
	55-59					UWB		
COLFAX	0-12	4.5-5.5	.17	C	NP-10	SL,FSL	SM,SM-SC	A-2,A-4
	0-12	4.5-5.5	.32		NP-10	L,SIL	ML,CL,CL-ML	A-4
	12-30	4.5-5.5	.28		7-25	SCL,CL,L	SC,CL	A-4,A-6,A-7-6
	30-46	4.5-5.5	.28		NP-20	SL,FSL,CL	ML,CL,SM,SC	A-2,A-4,A-6
	46-50	4.5-5.5	.28		NP-10	SL	SM,SC,SM-SC	A-2,A-4
	50-54					WB		
COMPASS	0-16	4.5-5.5	.15	B	NP	LS,LFS	SM	A-2-4
	16-33	4.5-5.5	.20		NP-3	SL,FSL	SM	A-2-4
	33-57	4.5-5.5	.28		NP-15	SL,FSL,SCL	SM,SM-SC,SC	A-2-4,A-2-6,A-6
	57-74	4.5-5.5	.24		11-23	SC,C	SC,CL	A-6,A-7
CONASAUGA	0-4	3.6-6.0	.37	C	12-28	SICL,CL	CL	A-6,A-7
	0-4	3.6-6.0	.43		NP-8	SIL,L	CL-ML,ML,CL	A-4
	4-10	3.6-6.0	.32		4-15	SIL,SICL,CL	CL-ML,CL	A-4,A-6
	10-19	3.6-6.0	.32		18-35	SICL,SIC,C	CL,CH	A-7
	19-30	3.6-6.5	.32		23-40	C,SIC	CL,CH,MH	A-7
	30-60					WB		
CONECUH	0-5	3.6-5.5	.15	D	NP	LS,LFS	SM	A-2,A-4
	0-5	3.6-5.5	.28		NP-5	SL,FSL,SCL	SM,ML,CL-ML,SM-SC	A-4
	0-5	3.6-5.5	.37		5-15	L,SIL	CL-ML,CL	A-4,A-6
	5-9	3.6-5.5	.32		10-30	CL,C,SICL	ML,MH,CL,CH	A-7,A-6
	9-50	3.6-5.5	.32		15-35	C,SIC	ML,MH,CH	A-7
	50-63					VAR		
CONGAREE	0-8	4.5-7.3	.24	B	NP-7	FSL,SL	SM,SM-SC	A-2,A-4
	0-8	4.5-7.3	.37		3-10	L,SIL	CL-ML,ML,CL	A-4
	8-38	4.5-7.3	.37		3-22	SICL,FSL,L	SC,ML,CL,SM	A-4,A-6,A-7
	38-80					VAR		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
COROLLA	0-72	5.6-7.8	.10	D	NP	S,FS	SW,SP-SM,SP	A-2,A-3
COWARTS	0-8	4.5-5.5	.10	C	NP	GR-LS,GR-LFS	SM	A-2
	0-8	4.5-5.5	.20		NP-5	GR-SL,GR-FSL	SM,SM-SC	A-2,A-4
	8-19	4.5-5.5	.28		NP-15	FSL,SL,SCL	SM-SC,SC,SM	A-2,A-4,A-6
	19-25	4.5-5.5	.28		11-25	SCL,SC,CL	SM,SC	A-6,A-7,A-2-6
	25-60	4.5-5.5	.24		5-20	SL,SCL,CL	SM-SC,SC,CL-ML,CL	A-2,A-4,A-6,A-7
COWARTS	0-8	4.5-5.5	.15	C	NP	LS,LFS	SM	A-2
	0-8	4.5-5.5	.24		NP-5	FSL,SL	SM,SM-SC	A-2,A-4
	8-19	4.5-5.5	.28		5-15	FSL,SL,SCL	SM-SC,SC	A-2,A-4,A-6
	19-25	4.5-5.5	.28		11-23	SCL,SC,CL	SM,SC	A-6,A-7,A-2-6
	25-60	4.5-5.5	.28		5-20	SL,SCL,CL	SM-SC,SC,CL-ML,CL	A-2,A-4,A-6,A-7
COXVILLE	0-11	3.6-5.5	.24	D	3-15	FSL,SL,L	SM,ML,CL-ML,CL	A-4,A-6,A-7
	11-72	3.6-5.5	.32		12-35	CL,SC,C	CL,CH	A-6,A-7
	72-80					VAR		
CRAVEN	0-9	3.6-5.5	.37	C	15-35	CL,SICL	CL,CH	A-6,A-7
	0-9	3.6-6.5	.32		NP-15	L,FSL,SIL	ML,CL,SM,SC	A-4,A-6
	9-54	3.6-5.5	.32		24-43	C,SIC,SICL	CH	A-7
	54-80	3.6-5.5	.32		NP-15	SCL,SL,LS	SM,SM-SC,SC	A-2,A-4,A-6
CREVASSE	0-10	5.6-8.4	.15	A	NP	S,FS	SP-SM,SM	A-2-4,A-3
	0-10	5.6-8.4	.17		NP	LFS,LS	SM	A-2
	10-60	5.6-8.4	.15		NP	S,LS,LFS	SP-SM,SM	A-2,A-3
CUMBERLAND	0-8	5.1-6.0	.32	B	8-17	CL,SICL	CL,ML	A-4,A-6,A-7
	0-8	5.1-6.0	.37		3-12	SIL,L	ML,CL-ML,CL	A-4,A-6
	8-14	5.1-6.0	.37		8-17	CL,SICL	CL,ML	A-4,A-6,A-7
	14-48	5.1-6.0	.24		8-35	C,CL,SICL	ML,MH,CH	A-5,A-7
	48-64	5.1-6.5	.24		8-36	C,CL	ML,MH,CH	A-5,A-7
DAVIDSON	0-7	4.5-6.5	.28	B	3-15	L	CL,CL-ML,ML	A-4,A-6
	0-7	4.5-6.5	.28		5-18	CL,SCL	CL,SC,CL-ML,SM-SC	A-6,A-4
	7-12	4.5-6.0	.32		11-25	CL	CL	A-6
	12-53	4.5-6.0	.24		12-33	C	CL,CH,ML,MH	A-7,A-6
	53-72	4.5-6.0	.28		7-30	C,CL,SCL	CL,ML,MH	A-4,A-6,A-7
DECATUR	0-7	4.5-6.0	.28	B	8-22	SIC,C	ML,CL	A-4,A-6,A-7
	0-7	4.5-6.0	.32		NP-12	L,SIL	CL,ML,CL-ML	A-4,A-6
	0-7	4.5-6.0	.32		7-18	SICL	CL,ML	A-4,A-5,A-6
	7-20	4.5-6.0	.28		8-22	SICL,SIC,C	ML,CL	A-7,A-4,A-6,A-5
	20-72	4.5-6.0	.24		11-28	C	CL,ML,MH,CH	A-7,A-6
DELLROSE	0-8	4.5-6.0	.24	B	5-15	CR-SIL,CR-L	CL-ML,SC,CL,GC	A-4,A-6
	8-54	4.5-6.0	.24		8-18	CR-SICL,CR-SIL	ML,CL,GC,SC	A-4,A-6,A-7
	54-70	4.5-6.0	.24		20-35	C	MH,CH	A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
DEMOPOLIS	0-5	7.4-8.4	.24	D	12-20	CB-SIL,CB-L,CB-SICL	CL	A-6,A-7-6
	5-12	7.4-8.4	.24		7-15	CB-L,CB-CL,CBV-SICL	GC,GP-GC	A-2
	12-60					WB		
DEMOPOLIS	0-6	7.4-8.4	.20	C	4-14	CN-L,CN-CL,CN-SICL	GC,GM-GC,GP-GC	A-2,A-1
	0-6	7.4-8.4	.37		6-20	L,CL,SICL	CL,CL-ML	A-4,A-6,A-7
	0-6	7.4-8.4	.43		6-20	SIL	CL,CL-ML	A-4,A-6
	6-13	7.4-8.4	.32		4-14	CN-L,CN-CL,CNX-SICL	GC,GM-GC,GP-GC	A-2,A-1
	13-65					WB		
DEWEY	0-6	4.5-5.5	.28	B	12-20	SICL,SIC,C	CL	A-6
	0-6	4.5-5.5	.32		5-11	SIL,L	CL-ML,CL	A-4,A-6
	6-25	4.5-5.5	.24		12-20	C,SIC,SICL	CL	A-6
	25-50	4.5-5.5	.24		12-34	C,SIC	CH,CL,MH,ML	A-6,A-7
	50-72	4.5-5.5	.24		12-34	C,SIC,CR-C	CH,CL,MH,ML	A-6,A-7
DICKSON	0-7	4.5-5.5	.43	C	2-7	SIL	CL-ML,ML	A-4
	7-25	4.5-5.5	.43		5-17	SIL,SICL	CL-ML,CL	A-4,A-6
	25-45	4.5-5.5	.43		7-20	SIL,SICL	CL,CL-ML	A-4,A-6,A-7
	45-65	4.5-5.5	.28		12-30	C,CR-SICL,CR-C	MH,ML,GC,CL	A-6,A-7
DOCENA	0-4	4.5-6.0	.28	C	4-20	FSL,SL	SM,ML	A-4
	0-4	4.5-6.0	.32		NP-7	SIL,L	ML,CL,CL-ML	A-4,A-6
	4-40	4.5-6.0	.28		5-16	SIL,SICL	ML,CL	A-4,A-6,A-7
	40-58	4.5-6.0	.32		6-25	SIL,SICL,L	ML,CL,MH	A-4,A-6,A-7
	58-65					VAR		
DOROVAN	0-3	3.6-4.4	-	D	-	MPT,MUCK	PT	-
	3-74	3.6-4.4	-		-	MUCK	PT	-
	74-99	4.5-5.5	-		NP-7	S,LS,L	SP-SM,SM-SC,SM	A-1,A-3,A-4,A-2-4
DOTHAN	0-13	4.5-6.0	.15	B	NP	LS,LFS	SM	A-2
	0-13	4.5-6.0	.24		NP-5	FSL,SL	SM,SP-SM	A-2,A-4
	13-33	4.5-5.5	.28		NP-16	SCL,SL	SM-SC,SC,SM	A-2,A-4,A-6
	33-60	4.5-5.5	.28		5-23	SCL,SC	SM-SC,CL,SC,CL-ML	A-2,A-4,A-6,A-7
DOWELLTON	0-12	5.1-7.3	.32	D	6-15	SIL,SICL	CL-ML,CL,ML	A-4,A-6
	12-16	5.1-7.3	.32		22-40	SIC,C	CL,CH,MH	A-7
	16-48	5.1-7.8	.32		28-40	C	CH,MH	A-7
	48-52					UWB		
DUCKSTON	0-8	3.6-8.4	.10	A/D	NP	S,FS	SP-SM,SP	A-2,A-3
	8-80	3.6-8.4	.10		NP	S,FS	SP-SM,SP	A-2,A-3

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
DULAC	0-6	4.5-5.5	.43	C	15-25	SICL	CL	A-6,A-7
	0-6	4.5-5.5	.49		2-7	SIL	ML,CL-ML	A-4
	6-23	4.5-5.5	.43		11-25	SIL,SICL	CL	A-6,A-7
	23-37	4.5-5.5	.43		11-25	SIL,SICL	CL	A-6,A-7
	37-72	4.5-5.5	.20		25-50	C,SIC	CH,MH	A-7
DUNBAR	0-8	4.5-5.5	.32	D	NP	LS,LFS	SM,SP-SM	A-2, A-3
	0-8	4.5-5.5	.32		3-15	SL,FSL,L	SM-SC,SC,SM	A-2-4
	8-14	4.5-5.5			8-22	L,SCL,CL	CL-ML,CL,SC	A-4,A-6
	14-80	4.5-5.5			12-25	SC,CL,C	CL,CH,ML,MH	A-6-7
DUNDEE	0-5	4.5-6.0	.17	C	NP	LS,SL	SM	A-2-4
	0-5	4.5-6.0	.37		NP-7	FSL,L,VFSL	ML,CL-ML	A-4
	0-5	4.5-6.0	.43		3-11	SIL,SICL	CL,CL-ML,ML	A-4,A-6
	5-29	4.5-6.0	.32		12-22	SICL,CL,SCL	CL	A-6,A-7
	29-60	4.5-7.3	.37		NP-8	L,VFSL,SIL	CL,CL-ML,ML	A-4
DURHAM	0-16	4.5-6.0	.17	B	NP-3	LCOS,LS	SM	A-2
	0-16	4.5-6.0	.24		NP-7	SL,FSL	SM,SM-SC	A-2,A-4
	16-36	4.5-5.5	.20		10-25	SCL,CL	SC,CL	A-2,A-6,A-7
	36-42	4.5-5.5	.20		13-28	CL,SC,SCL	SC,CL	A-6,A-7
	42-48	4.5-5.5	.20		NP-10	SCL,SL	SM,SC,SM-SC	A-2,A-4
	48-60	4.5-5.5	.17		NP-7	LS,SL,SCL	SM,SM-SC	A-2,A-4
EGAM	0-22	5.6-7.3	.32	C	4-20	SICL,SIL,L	CL,ML,CL-ML	A-6,A-7,A-4
	22-56	5.6-7.3	.32		15-30	SIC,SICL,C	CL,MH,CH	A-7,A-6
	56-75	5.6-8.4	.37		8-30	SICL,C,SL	CL,ML,CH,CH	A-4,A-6,A-7
ELLISVILLE	0-6	4.5-6.0	.37	B	4-15	SICL,SIL,L	CL,CL-ML,SC,SM-SC	A-6,A-4
	6-75	4.5-6.0	.32		8-15	SIL,SICL	CL	A-6,A-4
EMORY	0-8	5.1-6.0	.37	B	4-15	SIL,SICL	CL,ML,CL-ML	A-4,A-6
	8-42	5.1-6.0	.37		4-15	SIL,SICL	CL,ML,CL-ML	A-4,A-6
	42-60	5.1-6.0	.37		9-20	SICL,SIL,SIC	CL	A-4,A-6,A-7
EMPORIA	0-15	4.5-6.0	.28	C	NP-15	L,FSL,SL	CL,SC,SM,ML	A-2,A-4,A-6
	0-15	4.5-6.0	.28		NP-7	LFS,LS	SM,SM-SC	A-2,A-1,A-4
	15-32	4.5-6.0	.28		8-30	SCL,SL,CL	SC,CL	A-2,A-4,A-6,A-7
	32-57	4.5-6.0	.20		8-30	SCL,CL,SC	SC,CL,CH	A-2,A-4,A-6,A-7
	57-70	4.5-6.0	.20		NP-25	SR-SL-CL	SM,SC,ML,CL	A-1,A-2,A-4,A-6
ENDERS	0-5	3.6-5.5	.32	C	2-10	GR-FSL,GR-L,GR-SIL	ML,SM,SM-SC,CL-ML	A-2,A-4
	0-5	3.6-5.5	.37		2-10	FSL,L ,SIL	ML,SM,SM-SC,CL-ML	A-4
	5-8	3.6-5.5	.43		11-17	CL,SICL,L	CL	A-6
	8-39	3.6-5.5	.37		35-45	SIC,C	CH	A-7
	39-46	3.6-5.5	.37		35-45	SIC,SH-SIC	CH	A-7
	46-62					WB		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
ENNIS	0-10	4.5-6.0	.28	B	NP-12	CR-L,CR-SL,CR-SIL	CL-ML,ML,SM,GM	A-4,A-6
	10-60	4.5-6.0	.28		NP-15	CR-L,CR-CL,CR-SIL	ML,SM,GM,CL-ML	A-4,A-6,A-2
ENOREE	0-7	5.1-7.3	.17	D	NP-7	LS	SM,SM-SC	A-2
	0-7	5.1-7.3	.20		NP-7	SL,FSL	SM,SM-SC	A-2,A-4
	0-7	5.1-7.3	.32		2-20	SIL,L,SICL	CL,ML,CL-ML	A-4,A-6,A-7
	7-27	5.1-7.3	.20		NP-10	SL,L,SCL	SM,SM-SC,ML,CL-ML	A-2,A-4
	27-50	5.1-7.3	.20		NP-10	SL,L,LS	SM,SM-SC,ML,CL-ML	A-2,A-4
ESCAMBIA	0-13	3.6-5.5	.24	C	NP-7	FSL,VFSL,SL	SM,SM-SC,ML,CL-ML	A-4
	0-13	3.6-5.5	.32		NP-7	L,SIL	CL-ML,ML,SM,SM-SC	A-4
	13-35	3.6-5.5	.24		4-15	FSL,L,SIL	SC,SM-SC,CL,CL-ML	A-4,A-6
	35-72	3.6-5.5	.28		4-20	FSL,L,SIL	SC,CL,SM-SC,CL-ML	A-4,A-6
ESTO	0-8	3.6-5.5	.17	B	NP	LS,LFS	SM,SP-SM	A-2
	0-8	3.6-5.5	.28		NP-6	FSL,SL,L	SM,SM-SC,ML,CL-ML	A-4,A-2
	8-13	3.6-5.5	.32		12-25	CL,SC,SCL	CL,SC	A-6,A-7
	13-62	3.6-5.5	.32		18-52	CL,C,SC	CL,CH	A-7
ETOWAH	0-7	4.5-5.5	.32	B	10-15	SICL,CL	CL	A-6
	0-7	4.5-5.5	.32		5-12	CR-SIL,CR-L,CR-SICL	CL-ML,ML,CL	A-4,A-6
	0-7	4.5-5.5	.37		3-10	SIL,L,FSL	ML,CL,SM-SC,CL-ML	A-4
	7-38	4.5-5.5	.32		10-15	SICL,CL,SIL	CL	A-6
	38-70	4.5-5.5	.32		15-25	SICL,CL,C	CL,ML,MH	A-6,A-7
EULONIA	0-13	4.5-6.5	.15	C	NP-4	LS,LFS	SM,SM-SC	A-2
	0-13	4.5-6.5	.24		NP-10	SL,FSL	SM,SC,SM-SC	A-2,A-4
	13-48	4.5-6.5	.24		8-37	SC,C,CL	SC,CL	A-6,A-7,A-4
	48-58	4.5-6.0	.20		3-15	SCL,SL	SC,SM,SM-SC	A-2,A-4,A-6
	58-80					VAR		
EUNOLA	0-10	4.5-5.5	.15	C	NP	LS,LFS,FS	SM,SP-SM	A-2,A-4,A-2-4
	0-10	4.5-5.5	.20		NP	SL,FSL	SM	A-2,A-4
	10-26	4.5-5.5	.28		NP-15	SCL,CL,FSL	SM,SC,SM-SC,CL	A-4,A-2,A-6
	26-52	4.5-5.5	.32		2-15	SCL,SC,CL	SM,SC,ML,CL	A-4,A-6
	52-56	4.5-5.5	.24		NP-10	SL,SCL	SM,SC,SM-SC	A-2,A-4
	56-65	4.5-5.5	.20		NP	S,LS,FS	SM,SP-SM	A-2,A-3
EUSTIS	0-6	4.5-5.5	.10	A	NP	LS,LFS	SP-SM,SM	A-3,A-2-4
	0-6	4.5-5.5	.10		NP	S,FS	SP-SM,SM	A-3,A-2-4
	6-24	4.5-5.5	.17		NP	S,FS,LFS	SP-SM,SM	A-3,A-2-4
	24-76	4.5-5.5	.17		NP	LFS,LS	SM	A-2-4
	76-98	4.5-5.5	.17		NP	S,FS	SP-SM	A-3,A-2-4
EUTAW	0-9	4.5-6.0	.32	D	23-40	SIC,C	CH,MH	A-7
	0-9	4.5-6.0	.37		23-32	SICL	CH,MH	A-7
	9-58	4.5-6.0	.28		25-60	C	CH,MH	A-7
	58-80	4.5-7.8	.28		25-60	C	CH,MH	A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
FACEVILLE	0-5	4.5-5.5	.17	B	NP	LS,LFS	SM	A-2
	0-5	4.5-5.5	.28		NP-7	SL,FSL	SM,SM-SC	A-2,A-4
	0-5	4.5-5.5	.32		NP-7	SCL	SM,CL-ML,ML,SM-SC	A-4
	5-11	4.5-5.5	.37		NP-13	SCL,SC	SC,ML,CL,SM	A-4,A-6
	11-72	4.5-6.0	.37		11-25	SC,C,CL	CL,SC,CH,ML	A-6,A-7
FALAYA	0-50	4.5-5.5	.49	D	NP-10	SIL,SI	ML,CL-ML,CL	A-4
	50-65	4.5-5.5	.43		7-16	SIL,SICL	ML,CL	A-4,A-6,A-7
FALKNER	0-6	4.5-6.0	.43	C	11-20	SICL	CL	A-6,A-7
	0-6	4.5-6.0	.49		5-10	SIL	CL-ML,CL	A-4
	6-21	4.5-6.0	.43		15-30	SIL,SICL	CL	A-6,A-7
	21-65	4.5-6.5	.24		30-50	SIC,C	CH	A-7
FAUNSDALE	0-2	6.6-8.4	.37	D	23-33	CL,SICL	CL,CH	A-7
	0-2	6.6-8.4	.37		33-49	SIC,C	CH	A-7
	2-14	6.6-8.4	.37		30-49	CL,SICL,SIC	CH	A-7
	14-36	6.6-8.4	.32		30-49	CL,SICL,SIC	CH	A-7
	36-49	6.6-8.4	.32		33-49	SIC,C	CH	A-7
	49-65	6.6-8.4	.32		33-49	SIC,C,GR-SIC	CH	A-7
FIRESTONE	0-5	4.5-5.5	.32	C	2-15	GR-SIL,GR-L	ML,CL-ML,CL	A-4,A-6
	0-5	4.5-5.5	.37		2-15	SIL,L	ML,CL-ML,CL	A-4,A-6
	5-9	4.5-5.5	.32		5-30	SICL,CL,SIC	CL,ML,CH,MH	A-6,A-7,A-4
	9-32	4.5-5.5	.32		25-50	C	MH,CH	A-7
	32-36	4.5-6.0	.32		20-45	C,SIC	MH,CH	A-7
	36-60					WB		
FLOMATON	0-9	4.5-6.0	.10	A	NP-4	GR-LS,GR-S	GM,GP-GM,SM,SP-SM	A-1
	0-9	4.5-6.0	.10		NP-4	GRV-LS,GRV-S	GM,GP-GM,SM,SP-SM	A-1
	9-72	4.5-6.0	.17		NP-7	GRV-LS,GR-LS,GR-SL	GP,GM-GC,SM-SC,GM	A-1,A-2
FLORALA	0-8	4.5-5.5	.17	C	NP	LS,LFS	SM	A-2-4
	0-8	4.5-5.5	.20		NP-7	FSL,SL	SM,SM-SC	A-2,A-4
	8-36	4.5-5.5	.24		NP-7	FSL,SL	SM	A-2,A-4
	36-72	4.5-5.5	.28		4-15	FSL,SL,SCL	SC,SM-SC	A-4,A-6
FORESTDALE	0-6	4.5-6.0	.37	D	12-30	SICL	CL,CH	A-6,A-7
	0-6	4.5-6.0	.43		5-15	SIL,VFSL,L	CL,CL-ML	A-4,A-6
	6-26	4.5-6.0	.28		20-40	SIC,C,SICL	CH,CL	A-7
	26-60	4.5-7.8	.37		5-30	SICL,SIL,VFSL	CL,CL-ML	A-6,A-7,A-4
FREEMANVILLE	0-10	5.1-6.0	.24	B	NP-5	FSL,L,SL	SM,SP-SM	A-1,A-2,A-4
	10-17	5.1-6.0	.28		4-15	L,CL,SCL	SC,CL,CL-ML,SM-SC	A-4,A-6
	17-72	4.5-5.5	.28		11-25	C,CL,SC	SC,CL	A-6,A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
FREEST	0-6	4.5-5.5	.28	C	NP-8	SL,FSL,L	SM,CL,ML,CL-ML	A-4
	6-15	4.5-6.0	.32		7-20	L,SCL	CL	A-4,A-6
	15-8	4.5-7.3	.28		20-30	CL,C,SIC	CL,CH	A-7
FRIPP	0-5	5.1-7.8	.10	A	NP	FS,S	SP,SP-SM	A-3
	5-80	5.6-7.8	.10		NP	FS,S	SP,SP-SM	A-3
FRUITHURST	0-10	4.5-5.5	.24	C	NP-7	GR-L,GR-SL,GR-LS	SM,ML,CL-ML	A-4
	0-10	4.5-5.5	.28		NP-7	GR-SIL	ML,CL-ML	A-4
	10-39	4.5-5.5	.32		11-25	L,CL	ML,CL	A-6,A-7
	39-50					WB		
FRUITHURST	0-10	4.5-5.5	.28	C	NP-7	L,FSL ,SL	ML,CL-ML,SM,SM-SC	A-4
	0-10	4.5-5.5	.32		NP-7	SIL	ML,CL-ML	A-4
	10-39	4.5-5.5	.32		11-25	L,CL	ML,CL	A-6,A-7
	39-50					WB		
FULLERTON	0-15	4.5-5.5	.24	B	3-17	CR-SICL	CL,ML,SC,GC	A-2,A-6,A-4
	0-15	4.5-5.5	.28		3-10	CR-SIL,CR-L,CR-FSL	GM-GC,CL-ML,CL,GC	A-2,A-4
	15-19	4.5-5.5	.24		8-17	CR-SICL	CL,GC,SC,ML	A-2,A-4,A-6,A-7
	19-90	4.5-5.5	.20		20-42	CR-C,CR-SIC	MH,ML,GM,SM	A-2,A-7
FUQUAY	0-34	4.5-6.0	.10	B	NP	S,FS	SP-SM,SM	A-1,A-2,A-3
	0-34	4.5-6.0	.15		NP	LS,LFS	SP-SM,SM	A-2,A-3
	34-45	4.5-6.0	.20		NP-13	SL,FSL,SCL	SM,SC,SM-SC	A-2,A-4,A-6
	45-96	4.5-6.0	.20		4-12	SCL	SC,SM-SC,CL-ML	A-2,A-4,A-6
	96-99					VAR		
GARNER	0-5	5.6-7.8	.32	D	18-37	CL,C	CL,CH	A-6,A-7-6
	5-65	5.6-8.4	.32		31-51	C	CH	A-7-6
GAYLESVILLE	0-14	3.6-6.0	.37	D	8-15	SICL,SIL,L	CL,ML	A-4,A-6,A-7
	0-14	5.6-7.3	.37		NP-7	SIL,L,FSL	ML,CL-ML	A-4
	14-33	3.6-6.0	.28		11-20	SIC,C,CL	CL,ML	A-6,A-7
	33-72	3.6-6.0	.28		20-35	SIC,C	CL,CH	A-7
GEORGEVILLE	0-6	4.5-6.0	.43	B	NP-11	SIL,L,VFSL	ML	A-4,A-6
	0-6	4.5-6.0	.49		11-20	SICL,CL	CL,ML	A-6,A-7
	6-10	4.5-5.5	.32		8-20	SICL,CL	CL,ML	A-6,A-7,A-4
	10-53	4.5-5.5	.28		15-35	C,SIC,SICL	MH,ML	A-7
	53-63	4.5-5.5	.32		NP-12	SICL,L,SIL	ML,CL,CL-ML	A-4,A-6
GEORGEVILLE	0-6	4.5-6.0	.24	B	NP-10	GR-L,GR-SIL,GR-VFSL	GM,ML,SM	A-4
	0-6	4.5-6.0	.24		NP-5	SY-SIL,SY-L,SY-VFSL	ML	A-4
	6-10	4.5-5.5	.32		8-20	SICL,CL	CL,ML	A-6,A-7,A-4
	10-53	4.5-5.5	.28		15-35	C,SIC,SICL	MH,ML	A-7
	53-63	4.5-5.5	.32		NP-12	SICL,L,SIL	ML,CL,CL-ML	A-4,A-6

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
GOLDSBORO	0-15	3.6-5.5	.17	B	NP	LS,LFS	SM	A-2
	0-15	3.6-6.0	.20		NP-14	SL,FSL	SM,SM-SC,SC	A-2,A-4,A-6
	15-45	3.6-5.5	.24		4-18	SCL,SL	SM-SC,SC,CL-ML,CL	A-2,A-4,A-6
	45-65	3.6-5.5	.24		6-32	SCL,CL,SC	SC,CL,CL-ML,CH	A-4,A-6,A-7-6
	65-76					VAR		
GORGAS	0-6	4.5-6.5	.15	D	NP-7	LS	SM-SC,SM,ML,GM	A-4,A-2-4,A-1-B
	0-6	4.5-6.5	.20		NP-7	SL,FSL,L	SM,ML,SM-SC,CL-ML	A-4,A-2
	6-14	4.5-5.5	.17		NP-7	SL,GR-SL,L	SM,ML,GM,GM-GC	A-4,A-2
	14-18					UWB		
GRADY	0-5	3.6-5.5	.10	D	NP-10	SL,FSL	SM,SM-SC	A-2,A-4
	0-5	3.6-5.5	.10		NP-10	SL,FSL,FSL	SM,SM-SC,SC	A-2,A-4
	0-5	3.6-5.5	.24		NP-15	L,CL	ML,CL-ML,CL	A-4,A-6
	5-11	3.6-5.5	.10		11-20	CL,SCL,L	CL	A-6
	11-62	3.6-5.5	.10		12-24	C,SC	CL,CH,MH	A-6,A-7
GRASMERE	0-20	4.5-6.0	.32	B	11-20	SICL,SIC	ML,CL	A-6,A-7
	20-31	4.5-6.0	.43		11-20	SIL,SICL	ML,CL	A-6
	31-66	4.5-6.0	.37		13-22	SICL,SIC,C	ML,MH	A-7
GREENVILLE	0-9	4.5-6.0	.15	B	NP	LS,LFS	SM,SP-SM	A-2
	0-9	4.5-6.0	.24		NP-10	SL,FSL	SM,SC,SM-SC,CL-ML	A-2,A-4
	0-9	4.5-6.0	.24		6-15	L,SCL,CL	CL,SC,CL-ML,SM-SC	A-4,A-6
	9-80	4.5-6.0	.17		7-25	CL,SC,C	CL,SC,ML	A-6,A-7,A-4
GRITNEY	0-7	4.5-5.5	.15	C	NP	LS,LFS	SP-SM,SM	A-2-4
	0-7	4.5-5.5	.20		NP-6	SL,FSL	SM,SM-SC	A-2-4,A-4
	7-12	4.5-5.5	.32		15-25	SCL,SC,CL	SC,CL	A-6,A-7
	12-31	4.5-5.5	.32		22-40	SC,C,CL	CH,CL,SC	A-7
	31-50	4.5-5.5	.28		20-35	SCL	CH,CL,SC	A-7
	50-68					VAR		
GROVER	0-9	4.5-6.5	.24	B	NP-10	SL,FSL,COSL	SM,SM-SC,SC	A-4
	0-9	4.5-6.5	.28		7-20	SCL	SC,CL	A-4,A-6
	9-38	4.5-5.5	.20		12-30	SCL,CL	SM,ML,MH	A-6,A-7
	38-68	4.5-5.5	.32		NP-7	SL,L,SCL	SM,SM-SC	A-4
GUTHRIE	0-8	3.6-5.0	.43	D	2-7	SIL	ML,CL-ML	A-4
	8-32	3.6-5.0	.43		5-15	SIL,SICL	ML,CL-ML,CL	A-4,A-6
	32-53	3.6-5.0	.43		5-20	SIL,SICL	CL,CL-ML	A-4,A-6,A-7
	53-68	3.6-5.0	.43		4-25	SICL,SIL	CL,CL-ML	A-6,A-7,A-4
GWINNETT	0-7	5.1-6.5	.17	B	NP-15	GR-SL,GR-SCL	SM,SC,SM-SC	A-2,A-4,A-6
	0-7	5.1-6.5	.28		NP-12	SL,L	SM,SC,SM-SC,ML	A-2,A-4,A-6
	0-7	5.1-6.5	.28		4-12	SCL,CL	SC,ML,SM-SC,CL-ML	A-4,A-6
	7-35	5.1-6.5	.28		16-30	C,SC	MH,ML,CL,CH	A-7,A-6
	35-45					WB		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
HALSO	0-3	3.6-5.5	.28	D	NP	SL,FSL,L	SM,ML	A-4
	0-3	3.6-5.5	.32		5-15	SIL,CL	CL-ML,CL	A-4,A-6
	3-5	3.6-5.5	.32		10-30	CL,C,SICL	ML,MH,CL,CH	A-7,A-6
	5-33	3.6-5.5	.32		15-35	C,SIC	ML,MH	A-7
	33-48	3.6-5.5	.24		4-16	CNV-CL,CNV-C,CN-SCL	GC,CL,CL-ML,GM-GC	A-2,A-4,A-6
	48-60					WB		
HAMBLEN	0-6	4.5-7.3	.28	C	NP-5	FSL	SM-SC,SM	A-2,A-4
	0-6	4.5-7.3	.32		3-14	SIL,L	CL,CL-ML,ML	A-4,A-6
	6-45	4.5-7.3	.32		3-17	SIL,L,CL	CL,CL-ML,ML	A-4,A-6
	45-60	4.5-7.3	.32		3-17	SIL,L,CL	CL,CL-ML,ML,GC	A-4,A-6,A-2
HANCEVILLE	0-8	4.5-6.5	.24	B	NP-10	FSL,L,SL	SM,SC,CL,ML	A-4
	8-54	4.5-5.5	.24		11-25	CL,SC,C	CL	A-6,A-7
	54-63	4.5-5.5	.24		5-20	CL,SCL,FSL	CL,CL-ML,ML	A-4,A-6,A-7
	63-90					WB		
HARLESTON	0-9	3.6-5.5	.20	C	NP-7	SL,FSL,L	ML,SM,CL-ML,SM-SC	A-2,A-4
	0-9	4.5-5.5	.17		NP	LS,LFS	SM	A-2
	9-60	4.5-5.5	.32		5-10	SL,L	SC,CL,CL-ML,SM-SC	A-2,A-4
	60-72	4.5-5.5	.32		5-13	SL,L,SCL	SC,CL,CL-ML,SM-SC	A-2,A-4,A-6
HARTSELLS	0-13	3.6-5.5	.20	B	NP-7	SL,FSL	SM,SM-SC	A-2,A-4
	0-13	3.6-5.5	.28		NP-7	L	SM,ML,SM-SC,CL-ML	A-4
	13-30	3.6-5.5	.32		NP-15	FSL,L,SCL	SC,SM,CL-ML,CL	A-4,A-6
	30-36	3.6-5.5	.32		NP-15	SL,L,SCL	SM-SC,SC,CL-ML,CL	A-2,A-4,A-6
	36-40					UWB		
HECTOR	0-6	5.1-6.5	.24	D	NP-7	FSL,L	SM,ML,SM-SC,CL-ML	A-4,A-2
	0-6	5.1-6.5	.10		NP-7	GRV-FSL,GRV-L	GM,GM-GC	A-2,A-1-B
	0-6	5.1-6.5	.17		NP-7	GR-FSL,GR-L	SM,ML,GM,GM-GC	A-4,A-2
	6-15	4.5-5.5	.17		NP-7	FSL,GR-FSL,GR-L	SM,ML,GM,GM-GC	A-4,A-2
	15-19					UWB		
HEIDEL	0-11	4.5-5.5	.17	B	NP-3	LS,LFS	SM	A-2-4
	0-11	4.5-5.5	.20		NP-4	FSL,SL	SM	A-4
	11-46	4.5-5.5	.20		3-7	FSL,SL,L	CL-ML,SM-SC,SM	A-4
	46-80	4.5-5.5	.20		8-15	SCL,FSL,L	CL,SC	A-4,A-6
HELENA	0-12	3.6-6.0	.15	C	NP	LS,LCOS	SM	A-1-B
	0-12	3.6-6.0	.24		NP-9	SL,FSL,L	SM,SM-SC,SC	A-2,A-4
	0-12	3.6-6.0	.28		15-25	SCL,CL	CL,SC	A-6,A-7
	12-19	3.6-5.5	.28		15-26	SCL,CL	CL,SC	A-6,A-7
	19-43	3.6-5.5	.28		24-50	CL,SC,C	CH	A-7
	43-60					VAR		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
HELENA	0-12	4.5-6.0	.10	C	NP	GR-LCOS,GR-LS,GR-S	SM,SP-SM,GM,GP-GM	A-1-B
	0-12	4.5-6.0	.15		NP-9	GR-FSL,GR-L,GR-COSL	SM,SC,GM,GC	A-2,A-4
	0-12	4.5-6.0	.20		15-25	GR-CL,GR-SCL	CL,SC,GC	A-6,A-7
	12-19	3.6-5.5	.28		15-26	SCL,CL	CL,SC	A-6,A-7
	19-43	3.6-5.5	.28		24-50	CL,SC,C	CH	A-7
	43-60					VAR		
HERNDON	0-9	4.5-6.5	.24	B	NP-5	ST-L,ST-SIL,ST-VFSL	ML	A-4
	0-9	4.5-6.5	.49		11-20	SICL	CL,ML	A-6,A-7
	0-9	4.5-6.5	.43		NP-12	L,SIL,VFSL	ML,CL,CL-ML	A-4,A-6
	9-48	3.6-5.5	.28		13-30	SICL,SIC,C	MH,ML	A-7
	48-68	3.6-5.5	.32		9-36	SIL,L,FSL	MH,ML	A-7,A-5
HIWASSEE	0-7	4.5-6.5	.24	B	5-23	GR-CL,GR-L,GR-SCL	CL,ML,CL-ML	A-4,A-6,A-7-6
	7-61	4.5-6.5	.28		12-36	C,SIC,CL	CL,ML,MH	A-6,A-7-5,A-7-6
	61-70	4.5-6.5	.28		4-20	SL,L,SCL	SM,ML,SM-SC	A-4,A-6,A-7-5
HIWASSEE	0-7	4.5-6.5	.28	B	NP-7	SL,FSL	SM,SM-SC	A-4,A-2
	0-7	4.5-6.5	.28		3-23	CL,SCL,L	CL,ML,CL-ML	A-7-6,A-6,A-4
	0-7	4.5-6.5	.32		4-20	SIL	ML,MH	A-4,A-5,A-6
	7-61	4.5-6.5	.28		12-36	C,SIC,CL	CL,ML,MH	A-6,A-7-5,A-7-6
	61-70	4.5-6.5	.28		4-20	SL,L,SCL	SM,ML,SM-SC	A-4,A-6,A-7-5
HOLLYWOOD	0-4	6.1-8.4	.32	D	11-25	CL,SICL,SIC	CL	A-6,A-7
	4-72	6.6-8.4	.37		25-45	SIC,C	CH	A-7
	72-80					UWB		
HOLSTON	0-8	4.5-5.5	.28	B	NP-6	L,FSL,SL	ML,CL-ML,SM,SM-SC	A-4,A-2
	8-44	4.5-5.5	.32		3-10	L,CL,SCL	ML,CL-ML,SM,SM-SC	A-4,A-2
	44-75	4.5-5.5	.32		7-22	CL,L,GR-CL	ML,CL,GC,SC	A-4,A-6,A-7,A-2
HOULKA	0-8	4.5-5.5	.28	D	25-35	SCL,CL,SICL	CH,CL	A-7
	0-8	4.5-5.5	.32		32-45	SIC,C	CH,CL	A-7
	8-60	4.5-5.5	.32		30-50	C,SIC,CL	CH	A-7
HOUSTON	0-10	6.1-8.4	.37	D	23-37	C	CH,MH	A-7
	10-42	6.1-8.4	.32		25-48	C	CH,MH	A-7
	42-72	6.6-8.4	.32		30-45	C	CH,MH	A-7
HULETT	0-13	4.5-6.0	.15	B	NP-7	GR-FSL,GR-SL,GR-L	SM,SM-SC,ML	A-2,A-4
	0-13	4.5-6.0	.32		NP-7	FSL,SL,L	SM,SM-SC,ML	A-2,A-4
	0-13	4.5-6.0	.32		4-17	SCL,CL	ML,CL,CL-ML	A-4,A-6
	13-36	4.5-5.5	.28		14-30	CL,C	MH,ML	A-7
	36-60					WB		
HUMPHREYS	0-8	4.5-6.0	.28	B	3-10	CR-SIL,CR-L,GR-SIL	ML,CL-ML,CL,GM-GC	A-4
	8-42	4.5-6.0	.24		10-16	CR-SICL,CR-CL,GR-SIL	CL,GC,SC	A-6
	42-60	4.5-6.0	.24		8-15	CR-SICL,CR-CL,CRV-CL	CL,GC,SC	A-4,A-6,A-2

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
HYDE	0-17	3.6-5.5	.17	B/D	NP-7	L,SIL,VFSL	ML	A-4
	0-17	3.6-5.5	.17		2-14	MK-L	OL,ML,CL-ML	A-4,A-6,A-7
	17-54	3.6-5.5	.43		7-20	CL,L,SICL	CL	A-6,A-4,A-7
	54-72					VAR		
IREDELL	0-7	5.1-7.3	.24	C/D	2-10	GR-L,ST-L	SM,SC,ML,GM	A-2-4,A-4
	0-7	5.1-7.3	.28		NP-9	FSL,SL	SM,SM-SC,SC	A-2-4,A-4
	0-7	5.1-7.3	.32		5-12	L,SIL,CL	ML,CL-ML,CL	A-4,A-6
	7-24	5.6-7.3	.20		29-85	C	CH	A-7
	24-27	6.1-7.8	.28		20-39	L,SCL,CL	CL,CH,SC	A-7
	27-62					VAR		
IRVINGTON	0-6	4.5-6.5	.28	C	NP-6	FSL,SL,L	ML,SM,CL-ML,SM-SC	A-2,A-4
	6-33	4.5-5.5	.28		3-12	L,SCL,CL	ML,CL,CL-ML,SC	A-4,A-6
	33-61	4.5-5.5	.28		4-12	L,SCL,CL	CL,CL-ML,SC,SM-SC	A-4,A-6
	61-82	4.5-5.5	.24		4-20	SCL,CL,SC	CL,SC,CL-ML,SM-SC	A-4,A-6
IUKA	0-13	5.1-6.0	.17	C	NP	LS,LFS	SM	A-2
	0-13	5.1-6.0	.24		NP-7	FSL,SL	SM,SM-SC,ML,CL-ML	A-4,A-2
	0-13	5.1-6.0	.37		NP-7	L,SIL	ML,CL-ML	A-4
	13-22	4.5-5.5	.28		NP-7	FSL,L,SL	SM,SM-SC,ML,CL-ML	A-4
	22-60	4.5-5.5	.20		NP-7	SL,FSL,L	SM,ML	A-2,A-4
IZAGORA	0-11	3.6-6.0	.17	C	NP	LS,LFS	SM,SP-SM	A-2,A-4
	0-11	3.6-6.0	.28		NP-5	VFSL,FSL,SL	SM,SM-SC,ML,CL-ML	A-4
	0-11	3.6-6.0	.37		NP-10	L,SIL	CL,CL-ML,ML	A-4
	11-46	3.6-5.5	.32		8-25	L,CL,SICL	CL	A-4,A-6,A-7
	46-91	3.6-5.5	.32		20-40	CL,C	CL,CH	A-6,A-7
JOHNSTON	0-30	4.5-5.5	.17	D	2-14	MK-L	OL,ML,CL-ML	A-4,A-5,A-7-5
	0-30	4.5-5.5	.20		NP-10	L,SL,FSL	ML,SM	A-2,A-4
	30-34	4.5-5.5	.17		NP	SR-LS-S	SM,SP-SM	A-2,A-3
	34-60	4.5-5.5	.17		NP-10	SR-FSL-SL	SM	A-2,A-3
JONES	0-12	5.6-6.5	.17	B	NP	LS,LFS	SM	A-2
	0-12	5.6-6.5	.20		NP-4	FSL,SL	SM,SM-SC	A-2
	12-52	5.1-6.5	.24		NP-7	SL,FSL	SM,SM-SC	A-2
	52-73	5.1-6.5	.10		NP	LS,SL	SM	A-2
KALMIA	0-14	4.5-6.0	.15	B	NP	LS,LFS	SM,SM-SC	A-2
	0-14	4.5-6.0	.20		NP-10	SL,FSL	SM,SC,SM-SC	A-2,A-4
	14-32	4.5-5.5	.24		4-15	SCL,L,SL	SC,SM-SC	A-2,A-4,A-6
	32-60	4.5-5.5	.10		NP	LS,S	SM,SP-SM,SP	A-2,A-3
KAUFMAN	0-6	5.6-8.4	.32	D	33-62	C,SIC	CH	A-7-6,A-7-5
	6-35	5.6-8.4	.32		45-71	C	CH	A-7-6,A-7-5
	35-80	5.6-8.4	.32		45-71	C	CH	A-7-6,A-7-5

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
KETONA	0-6	6.1-8.4	.32	D	10-24	SIL,SICL,SIC	ML,MH	A-6,A-7
	6-50	6.1-8.4	.32		18-34	SIC,C	CL,CH	A-7
	50-54					UWB		
KINSTON	0-12	4.5-6.0	.24	B/D	NP-10	FSL	SM,SC,SM-SC	A-2,A-4
	0-12	4.5-6.0	.37		4-15	L,SIL	ML,CL,CL-ML	A-4,A-6
	12-60	4.5-5.5	.32		8-22	L,CL,SCL	CL	A-4,A-6,A-7
	60-72					VAR		
KIPLING	0-3	3.6-6.0	.28	D	NP-7	FSL	SM-SC,SM,ML,CL-ML	A-4
	0-3	3.6-6.0	.32		NP-10	SIL,L	ML,CL-ML,CL	A-4
	0-3	3.6-6.0	.32		15-25	CL,SICL	CL	A-6,A-7
	3-62	3.6-8.4	.32		22-45	SIC,C,SICL	CH,CL	A-7,A-6
	62-72	5.1-8.4	.32		26-50	C,SIC	CH,CL	A-7
KIRKVILLE	0-9	4.5-5.5	.15	C	NP	LS	SM	A-2
	0-9	4.5-5.5	.28		NP-5	SL,FSL	ML,SM,CL-ML,SM-SC	A-2,A-4
	0-9	4.5-5.5	.37		NP-5	L,SIL	SM,ML,CL-ML,SM-SC	A-2,A-4
	9-72	4.5-5.5	.28		NP-5	L,SL,FSL	ML,SM,CL-ML,SM-SC	A-2,A-4
KOLOMOKI	0-8	4.5-6.5	.17	B	NP	LS,FSL	SM,SP-SM	A-2
	0-8	4.5-6.5	.24		NP-6	FSL,SL,SCL	SM,ML,CL-ML	A-2,A-4
	8-28	4.5-6.0	.32		14-22	SC,C	CL	A-6,A-7
	28-35	4.5-6.0	.28		7-15	SC,SCL	ML,SC,CL,SM	A-4,A-6
	35-42	4.5-6.0	.24		NP-10	SCL,SL	SM,SC,SM-SC	A-4,A-2
	42-65	4.5-6.0	.20		NP	LS,S	SM,SP-SM	A-2
LAFITTE	0-75	3.6-8.4	-	D	-	MUCK	PT	A-8
	75-80					VAR		
LAKELAND	0-43	4.5-6.0	.10	A	NP	S,FS	SP-SM	A-3,A-2-4
	43-80	4.5-6.0	.10		NP	S,FS	SP,SP-SM	A-3,A-2-4
LEADVALE	0-8	4.5-5.5	.43	C	2-10	SIL,L,FSL	ML,CL-ML,CL	A-4
	8-23	4.5-5.5	.43		3-14	SIL,SICL,L	CL-ML,CL,ML	A-4,A-6
	23-48	4.5-5.5	.43		3-18	SIL,SICL	CL-ML,CL,ML	A-4,A-6,A-7
	48-58	4.5-5.5	.24		12-26	SICL,SIC,C	CL,MH,ML,CH	A-6,A-7
LEAF	0-9	3.6-5.5	.28	D	5-12	FSL,L	ML	A-4,A-6
	0-9	3.6-5.5	.32		5-15	SIL,VFSL	ML,CL	A-4,A-6
	9-72	3.6-5.5	.32		20-38	SICL,SIC,C	CL,CH	A-7
LEE	0-7	4.5-6.5	.28	D	3-10	CR-SIL,GR-L,SIL	CL-ML,GM-GC,ML,	A-4
	7-34	4.5-5.5	.28		3-10	CR-SIL,GR-L	CL-ML,GM-GC,GM,ML	A-4
	34-60	4.5-5.5	.28		3-10	CR-SIL,CR-L	CL-ML,GM-GC,SM-SC	A-4,A-2,A-1

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
LEEFIELD	0-23	4.5-6.0	.10	C	NP	LS,S,FS	SM,SW-SM,SP-SM	A-2
	23-33	4.5-5.5	.15		NP-16	SL,SCL	SC,SM,SM-SC	A-2,A-4,A-6
	33-75	4.5-5.5	.10		NP-20	SL,SCL	SC,SM,SM-SC	A-2,A-4,A-6
LEEPER	0-8	5.6-8.4	.28	D	NP-10	FSL	SM	A-2,A-4
	0-8	5.6-8.4	.32		25-35	SICL,CL	CH,CL	A-7
	0-8	5.6-8.4	.32		26-40	SIC,C	CH,MH	A-7
	8-50	5.6-8.4	.32		30-50	C,SIC,SICL	CH	A-7
LEESBURG	0-6	4.5-5.5	.15	B	NP	GR-SL,GR-FSL,GR-L	SM,GM,ML	A-2,A-4,A-1
	0-6	4.5-5.5	.15		NP-7	CB-SL,CB-FSL,CB-L	SM,SM-SC,ML,CL-ML	A-2,A-4
	0-6	4.5-5.5	.15		NP-7	ST-SL,ST-FSL,ST-L	SM,SM-SC,ML,CL-ML	A-2,A-4
	6-24	4.5-5.5	.32		NP-10	GR-L,GR-CL,GR-SICL	SM,ML,CL-ML,CL	A-4
	24-40	4.5-5.5	.32		8-20	GR-CL,GR-SICL,GR-SCL	SC,CL	A-4,A-6
	40-65	4.5-5.5	.32		12-25	GR-CL,GR-SICL,GR-C	SC,CL	A-6,A-7
LENOIR	0-8	3.6-5.5	.28	D	4-10	FSL	SM-SC,SC,CL-ML,CL	A-4
	0-8	3.6-5.5	.37		4-10	L,SIL,VFSL	ML,CL,CL-ML	A-4
	8-75	3.6-5.5	.32		11-35	C,SIC,CL	CL,CH	A-6,A-7
LEON	0-15	3.6-5.5	.10	B/D	NP	FS,S	SP,SP-SM	A-3,A-2-4
	0-15	3.6-6.5	.10		NP	S,FS	SP,SP-SM	A-3,A-2-4
	15-23	3.6-5.5	.15		NP	FS,S,LS	SM,SP-SM,SP	A-3,A-2-4
	23-80	3.6-5.5	.10		NP	FS,S	SP,SP-SM	A-3,A-2-4
LEVY	0-8	3.6-5.5	.20	D	8-30	MK-SICL,MK-C	CL,CH,ML,MH	A-6,A-7,A-4
	0-8	3.6-5.5	.37		12-35	SICL,SIC,C	CL,CH	A-6,A-7
	8-44	3.6-5.5	.32		15-35	SIC,C,SICL	CL,CH	A-6,A-7
	44-60					VAR		
LINKER	0-5	3.6-5.5	.20	B	NP-7	ST-FSL,ST-L	SM,ML	A-4
	0-5	3.6-5.5	.24		NP-7	GR-FSL,GR-L	ML,GM,SM	A-2,A-4
	0-5	3.6-5.5	.28		NP-7	FSL,L	SM,ML	A-4
	5-25	3.6-5.5	.32		NP-18	FSL,SCL,L	CL,SC,SM,ML	A-4,A-6
	25-35	3.6-5.5	.28		NP-18	GR-SCL,GR-FSL,SCL	CL,SC,GC,ML	A-4,A-6
	35-37					UWB		
LOBELVILLE	0-9	4.5-6.0	.28	C	NP-7	CR-SIL,CR-L,GR-SIL	ML,CL-ML,GM,GM-GC	A-4
	9-42	4.5-6.0	.28		3-12	CR-SIL,CR-L,CR-SICL	CL-ML,ML,GM,GM-GC	A-4,A-6
	42-65	4.5-6.0	.28		3-12	CR-SIL,CR-L,CR-SL	ML,CL-ML,GM,GM-GC	A-4,A-2,A-6,A-1
LOCKHART	0-6	5.1-6.5	.15	B	NP	GR-LS,GR-SL	GM,GP-GM,SM,SP-SM	A-1,A-2
	6-54	5.1-6.5	.17		5-15	GR-SCL,GR-L	GC,GM-GC,SC,SM-SC	A-2,A-4,A-6
	54-72					VAR		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
LOCUST	0-8	4.5-5.5	.32	C	NP-7	FSL,SL	SM,ML	A-4,A-2
	0-8	4.5-5.5	.37		4-8	L,SIL	ML,SM	A-4
	8-24	4.5-5.5	.37		12-20	L,SIL,CL	CL	A-6
	24-64	4.5-5.5	.37		2-12	CL,L,SL	CL,ML,CL-ML	A-4,A-6
	64-70	4.5-5.5	.28		2-12	CR-CL,CR-L,CR-SL	SM,SC,SM-SC	A-1,A-2
LOUISA	0-4	4.5-6.0	.17	B	NP	GR-L,GR-SL,GR-FSL	SM	A-1,A-2,A-4
	0-4	4.5-6.0	.28		NP	L,SL,FSL	SM,ML	A-2,A-4
	4-15	4.5-6.0	.24		NP	GR-L,GR-SL	SM	A-2,A-4
	15-60					WB		
LOUISBURG	0-7	4.5-6.0	.24	B	NP-6	SL,FSL	SM,SM-SC	A-2
	0-7	4.5-6.0	.10		NP	LS,LCOS	SM	A-2,A-1-B
	7-24	4.5-6.0	.24		NP-7	SL	SM,SM-SC	A-2,A-4
	24-60					WB		
LOUISBURG	0-7	4.5-6.0	.10	B	NP	GR-LS,GR-LCOS	SM,SP-SM	A-2,A-1-B
	0-7	4.5-6.0	.24		NP-6	GR-SL,GR-FSL,GR-COSL	SM,SM-SC	A-2,A-1-B
	7-24	4.5-6.0	.24		NP-7	SL,GR-SL	SM,SM-SC	A-2,A-4
	24-60					WB		
LOUISBURG	0-7	4.5-6.0	.10	B	NP	ST-SL,ST-LS,ST-LCOS	SM	A-2,A-1-B
	0-7	4.5-6.0	.10		NP	STV-SL	SM	A-2,A-1
	7-24	4.5-6.0	.24		NP-7	ST-SL	SM,SM-SC	A-2,A-4
	24-60					WB		
LUCEDALE	0-8	5.1-6.5	.24	B	NP-3	SL,L,FSL	SM,ML	A-2,A-4
	8-60	4.5-5.5	.24		4-15	SCL,CL,L	CL-ML,SC,CL,SM-SC	A-4,A-6,A-2
LUCY	0-24	5.1-6.0	.10	A	NP	LS,LFS	SM,SP-SM	A-2
	0-24	5.1-6.0	.10		NP	S,FS	SM,SP-SM	A-2
	24-35	4.5-5.5	.24		NP-15	SL,FSL,SCL	SM,SC,SM-SC	A-2,A-4,A-6
	35-70	4.5-5.5	.28		3-20	SCL,CL,SC	SC,SM-SC,SM	A-2,A-6,A-4
LUVERNE	0-7	3.6-5.5	.15	C	NP	LS,LFS	SM	A-2,A-4
	0-7	3.6-5.5	.24		NP	SL,FSL	ML,SM	A-4,A-2
	0-7	3.6-5.5	.28		3-16	SCL,CL	SM,ML,CL,SC	A-6,A-4
	7-30	3.6-5.5	.28		12-34	CL,SC,C	ML,MH	A-7,A-6
	30-40	3.6-5.5	.28		2-14	CL,SCL	ML,MH,SM	A-4,A-5,A-7
	40-80	3.6-5.5	.28		3-16	SR-LS-SCL	SM,ML	A-2,A-4,A-6,A-7
LYERLY	0-6	4.5-6.5	.37	D	3-10	L	ML,CL,CL-ML	A-4
	0-6	4.5-6.5	.43		5-15	SIL,SICL	CL,CL-ML	A-4,A-6
	6-22	4.5-6.5	.32		30-60	C	CH	A-7-6
	22-32	5.1-7.3	.32		40-60	C	CH	A-7-6
	32-36					UWB		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
LYNCHBURG	0-10	3.6-5.5	.15	C	NP-4	LS,LFS	SM,SP-SM	A-2
	0-10	3.6-5.5	.20		NP-7	SL,FSL,L	SM,ML	A-2,A-4
	10-62	3.6-5.5	.20		4-18	SCL,SL,CL	SM-SC,SC,CL,CL-ML	A-2,A-4,A-6
MACON	0-9	4.5-6.0	.28	B	NP-4	FSL,L	SM,ML	A-4
	9-24	4.5-6.0	.28		11-17	CL,SCL,L	CL,SC	A-6
	24-75	4.5-6.0	.24		12-23	CL,SCL,SC	SC,CL	A-6,A-7
MADISON	0-6	4.5-6.0	.15	B	NP-7	GR-FSL,GR-SL	SM	A-2,A-4
	0-6	4.5-6.0	.24		NP-8	FSL,SL	SM	A-2,A-4
	0-6	4.5-6.0	.28		7-20	CL,SCL	CL	A-4,A-6
	6-30	4.5-5.5	.32		12-35	C,CL,SC	MH,ML	A-7
	30-35	4.5-6.0	.28		7-20	L,SCL,CL	CL	A-4,A-6
	35-66					VAR		
MALBIS	0-7	4.5-6.0	.24	B	NP-5	FSL,L,SL	SM,ML	A-4
	7-26	4.5-5.5	.28		5-11	L,SCL,CL	CL-ML,CL	A-4,A-6
	26-54	4.5-5.5	.28		4-15	SCL,CL,L	ML,CL	A-4,A-6,A-7
	54-71	4.5-5.5	.28		4-15	SCL,CL	ML,CL	A-4,A-5,A-6,A-7
MANTACHIE	0-11	4.5-4.5	.28	C	NP-5	FSL,SL,L	CL-ML,SM-SC,SM,ML	A-4
	0-11	4.5-5.5	.28		5-15	CL	CL-ML,CL	A-4,A-6
	0-11	4.5-5.5	.37		NP-10	SIL	ML,CL-ML,CL	A-4
	11-61	4.5-5.5	.28		5-15	L,CL,SCL	CL,SC,SM-SC,CL-ML	A-4,A-6
MARIETTA	0-10	5.6-7.8	.28	C	5-10	L,FSL	CL,CL-ML,SM-SC,SC	A-4
	0-10	5.6-7.8	.28		5-10	SIL,VFSL	CL,CL-ML	A-4
	10-46	5.6-7.8	.28		8-20	SICL,SCL,L	CL,SC	A-6,A-4
	46-62	5.6-7.8	.28		15-30	SICL,SC,L	CL,CH,SC	A-7,A-6
MARLBORO	0-9	5.1-6.5	.15	B	NP-4	LS,LFS	SM	A-2
	0-9	5.1-6.5	.20		NP-7	SL,FSL,VFSL	SM,ML	A-2,A-4
	9-60	4.5-6.0	.20		6-20	SC,CL,C	CL,ML,CL-ML	A-4,A-6,A-7
	60-72	4.5-6.0	.20		6-20	SCL,SC,C	CL,ML,SM,SC	A-4,A-6,A-7
MARVYN	0-7	4.5-6.0	.15	B	NP	LS,LFS	SM	A-2
	0-7	4.5-6.0	.24		NP-5	SL,FSL	SM,SM-SC	A-2,A-4
	7-30	4.5-6.0	.32		3-15	SCL,SL	ML,SM	A-4,A-2,A-6,A-7
	30-53	4.5-6.0	.32		4-19	SCL,SC	ML,MH,SM	A-4,A-5,A-7
	53-72	4.5-6.0	.32		NP-10	LS,SL,SCL	SM,ML	A-1,A-2,A-4
MASADA	0-10	4.5-5.5	.32	C	NP-15	FSL,L	ML,SM,SC,CL	A-4,A-6
	10-55	4.5-5.5	.24		15-35	CL,C,GR-C	CH,CL	A-7,A-6
	55-72	4.5-5.5	.24		7-20	L,CL,GR-SCL	CL,ML	A-6,A-7,A-4
MASHULAVILLE	0-26	4.5-5.5	.24	B	NP-7	SL,FSL	SM,SM-SC	A-2-4,A-4
	0-26	4.5-5.5	.32		NP-7	L,SIL	ML,CL-ML	A-4
	26-62	4.5-5.5	.28		8-20	L,CL,SIL	CL,SC	A-6,A-4

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
MAUBILA	0-8	3.6-5.5	.15	C	NP	FL-LS,FL-LFS	SM,SP-SM	A-2
	0-8	3.6-5.5	.17		NP-6	FL-SL	SM,SP-SM,SM-SC	A-2
	8-15	3.6-5.5	.28		12-25	SCL,CL	SC,CL	A-6,A-7
	15-55	3.6-5.5	.32		20-45	CL,C,SIC	CL,CH	A-6,A-7,A-7-6
	55-69	3.6-5.5	.32		20-45	C,SIC,CL	CH,CL	A-6,A-7,A-7-6
MAXTON	0-12	4.5-6.0	.15	B	NP	LS,LFS	SM,SP-SM	A-2
	0-12	4.5-6.0	.20		NP-7	SL,FSL	SM,SM-SC	A-2
	12-33	4.5-5.5	.24		4-15	SCL,SL	SC,SM-SC	A-4,A-6,A-2
	33-60	4.5-5.5	.10		NP	SR-LS-S	SM,SP-SM,SP	A-2,A-3
MAYHEW	0-7	4.5-6.0	.37	D	15-28	SICL,SIL,L	CL	A-6,A-7
	7-40	4.5-6.0	.32		25-50	SICL,SIC,C	CH,CL	A-7
	40-80	4.5-6.0	.32		25-50	SIC,C,SICL	CH,CL	A-7
MAYTAG	0-7	6.1-8.4	.32	D	20-35	SIC,C	CH,MH	A-7
	0-7	6.1-8.4	.32		3-25	SICL,CL	CL,ML,CL-ML	A-4,A-6,A-7
	7-53	6.6-8.4	.32		30-60	SIC,C,SICL	CH,MH	A-7
	53-65	7.4-8.4	.32		30-60	SIC,C,SICL	CH,MH	A-7
MCLAURIN	0-14	4.5-5.5	.17	B	NP-4	LS,LFS	SM	A-2
	0-14	4.5-5.5	.20		NP-4	SL,FSL	SM	A-4
	14-38	4.5-5.5	.20		NP-10	SL,FSL,L	SM,SC,SM-SC	A-4
	38-49	4.5-5.5	.20		NP-4	LFS,LS,SL	SM	A-2,A-4
	49-60	4.5-5.5	.20		6-15	SL,SCL,L	SC,ML,CL,SM	A-4,A-6
MCQUEEN	0-8	3.6-6.5	.28	C	NP-7	FSL,SL	SM,ML,CL-ML,SM-SC	A-4
	0-8	3.6-6.5	.37		NP-10	SIL,L,SICL	ML,CL-ML	A-4
	8-34	3.6-5.5	.37		10-25	SIC,CL,C	CL	A-7,A-6
	34-56	3.6-5.5	.37		8-20	CL,SICL,SCL	CL	A-6,A-4,A-7
	56-70	3.6-5.5	.32		NP-20	SCL,CL,SL	CL,SM-SC,SC,ML	A-2,A-4,A-6
MECKLENBURG	0-8	5.6-7.3	.17	C	NP-12	GR-L,GR-SL,GR-FSL	GM,SM,GP-GM,SP-SM	A-2,A-1
	0-8	5.6-7.3	.24		NP-15	L,FSL,SL	ML,SM,CL-ML,CL	A-4,A-6
	0-8	5.6-7.3	.28		11-25	CL,SCL	CL	A-6,A-7-6
	8-25	5.6-7.3	.28		20-43	C	CH,MH	A-7
	25-36	5.6-7.3	.32		8-25	L,SCL,CL	CL	A-4,A-6,A-7
	36-60					VAR		
MEGGETT	0-8	4.5-6.5	.24	D	NP	FSL,SL,LS	SM	A-2,A-4
	0-8	4.5-6.5	.28		5-15	L,CL	ML,CL-ML,CL	A-4,A-6
	8-16	5.1-8.4	.32		11-30	C,SC,CL	CH,MH,CL	A-6,A-7
	16-52	6.1-8.4	.32		11-30	C,SC,CL	CH,MH,CL	A-6,A-7
	52-65	6.1-8.4	.28		7-25	SC,SCL,C	SC,SM,ML,MH	A-4,A-6,A-7
	65-72					SR-S-C		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
MIMOSA	0-6	4.5-6.0	.28	C	25-35	SIC	CH,MH	A-7
	0-6	4.5-6.0	.37		7-20	SIL,SICL	CL,ML	A-4,A-6,A-7
	0-6	4.5-6.0	.28		7-20	CR-SIL,CR-SICL	CL,ML	A-4,A-6,A-7
	6-12	4.5-6.0	.28		18-28	SICL,SIC,C	ML,CL,MH,CH	A-7
	12-55	4.5-6.0	.24		25-35	C,SIC	CH,MH	A-7
	55-59					UWB		
MINTER	0-5	4.5-5.5	.32	D	15-28	CL,SICL	CL,CH	A-6,A-7
	0-5	4.5-5.5	.37		8-18	L,SIL	CL,ML	A-4,A-6
	5-72	4.5-5.5	.32		18-32	CL,SIC,C	CL,CH	A-6,A-7
MINVALE	0-13	4.5-5.5	.28	B	NP-10	CR-SIL,CR-L,CR-SICL	ML,CL,GM,GC	A-4
	0-13	4.5-5.5	.37		NP-10	SIL,L,SICL	ML,CL,CL-ML	A-4
	13-30	4.5-5.5	.28		5-15	CR-SICL,CR-SIL,CR-L	CL,CL-ML,GC,GM-GC	A-4,A-6
	30-72	4.5-5.5	.28		7-23	CR-SICL,CR-SIC,CR-C	CL,ML,GC,SC	A-4,A-6,A-7
MONTEVALLO	0-6	4.5-6.0	.20	D	NP-10	CNV-SIL,CNV-L,CNX-L	GM-GC,GC,SM-SC,SC	A-2,A-4,A-1-B
	0-6	4.5-6.0	.28		NP-10	CN-SIL,CN-L	SM-SC,SC,CL-ML,CL	A-4
	6-16	4.5-6.0	.32		2-15	CNV-SIL,CNX-L	GM-GC,GC,SM-SC,SC	A-2,A-4,A-6
	16-36					WB		
MOOREVILLE	0-6	4.5-5.5	.28	C	15-30	SCL,CL	CL,SC	A-6,A-7
	0-6	4.5-5.5	.37		5-10	L,SIL,FSL	CL-ML,CL,SM-SC,SC	A-4
	6-50	4.5-5.5	.28		15-30	SCL,CL,L	CL,SC	A-6,A-7
	50-60	4.5-5.5	.28		15-30	L,SCL,CL	SC,CL	A-6,A-7
MOUNTAINBURG	0-6	5.1-6.0	.24	D	NP	FSL,SL	SM	A-2
	0-6	5.1-6.0	.20		NP	GR-FSL,GR-SL,GR-L	GM,SM	A-1,A-2
	0-6	5.1-6.0	.15		NP	GRV-FSL,GRV-SL,GRV-L	GM	A-1,A-2
	6-18	4.5-5.5	.17		NP-10	GRV-SCL,GRV-SL,GRV-L	GM,GC,GP-GM,GM-GC	A-1,A-2
	18-20					UWB		
MOUNTVIEW	0-8	4.5-5.5	.43	B	2-7	SIL	ML,CL-ML	A-4
	8-30	4.5-5.5	.43		10-23	SIL,SICL	CL	A-6,A-7
	30-78	4.5-5.5	.32		11-32	C,CR-C,CR-SICL	CL,ML,MH,CH	A-6,A-7
MUCKALEE	0-6	5.1-7.3	.20	D	NP	LS,LFS	SM	A-2
	0-6	5.1-7.3	.20		NP-4	SL,FSL	SM	A-2,A-4
	0-6	5.1-7.3	.20		4-15	L	ML,CL,CL-ML	A-4,A-6
	6-64	5.6-8.4	.20		NP-4	SL,LS	SM	A-2,A-4
MUSELLA	0-4	5.1-6.5	.20	B	NP-10	GR-CL,GR-SCL	SM,SC,SM-SC	A-2,A-4
	0-4	5.1-6.5	.32		NP-10	CL,SCL,L	SM,SC,SM-SC,ML	A-4
	0-4	5.6-6.5	.20		NP-10	ST-CL,ST-SCL	SM,SC,SM-SC	A-2,A-4
	4-14	5.1-6.5	.32		11-20	GR-CL,CL	ML,CL,SM,SC	A-6,A-7
	14-18	5.1-6.5	.28		8-15	GRV-CL	SM,SC,GC	A-4,A-6
	18-60					WB		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
MYATT	0-10	4.5-5.5	.20	D	NP-4	LS,LFS	SM,SM-SC	A-2
	0-10	4.5-6.0	.28		NP-5	FSL,SL,VFSL	SM,SM-SC,ML,CL-ML	A-2,A-4
	0-10	4.5-6.0	.32		NP-5	SIL,L	ML,CL-ML	A-4
	10-50	3.6-5.5	.28		NP-10	L,SCL,CL	SM,SC,ML,CL	A-4
	50-72	3.6-5.5	.24		5-20	GR-FSL,SCL,CL	SM-SC,SC,CL-ML,CL	A-6,A-4,A-2
NAHUNTA	0-12	4.5-6.0	.43	C	NP-10	VFSL,L,SIL	ML,CL-ML,CL	A-4
	12-79	3.6-5.5	.43		8-30	L,CL,SICL	CL	A-4,A-6,A-7
NANKIN	0-8	4.5-5.5	.17	C	NP	LS,LFS	SM,SP-SM	A-2
	0-8	4.5-5.5	.28		NP-4	SL,FSL	SM,SM-SC	A-2,A-4
	0-8	4.5-5.5	.32		NP-7	SCL	SM,SM-SC,ML,CL-ML	A-4
	8-13	4.5-5.5	.24		4-15	SCL,SL	SC,SM,SM-SC	A-2,A-4,A-6
	13-38	4.5-5.5	.24		7-20	SC,C,SCL	SC,CL,ML,CL-ML	A-4,A-6,A-7
	38-65	4.5-5.5	.24		4-16	SCL,SL	SC,SM-SC,CL,CL-ML	A-2,A-4,A-6
NAUVOO	0-11	4.5-6.0	.24	B	3-16	SCL	SM,SM-SC,SC	A-4,A-6
	0-11	4.5-6.0	.28		NP-8	FSL,L,SL	SM-SC,CL-ML,SC,CL	A-4,A-2
	11-30	4.5-6.0	.32		8-24	L,SCL,CL	SC,CL,ML	A-4,A-6,A-7
	30-42	4.5-6.0	.32		4-15	FSL,L,SCL	SM-SC,CL-ML,SC,CL	A-4,A-6
	42-60					WB		
NECTAR	0-7	5.1-6.0	.28	C	NP-4	FSL,SL	SM,ML	A-4
	0-7	5.1-6.0	.37		3-7	L,SIL	CL-ML,ML	A-4
	7-27	3.6-5.5	.32		14-40	SICL,SIC,C	CL,CH	A-6,A-7
	27-49	3.6-5.5	.32		15-30	SICL,SIC,CL	CL,CH	A-7
	49-55	3.6-5.5	.28		8-17	SICL,GR-SICL,CN-CL	ML	A-4,A-6,A-7
	55-65					WB		
NELLA	0-8	4.5-5.5	.15	B	NP-8	CB-L,CB-FSL,CB-SCL	ML,CL,SM,SC	A-4
	0-8	4.5-5.5	.15		NP-8	GR-L,GR-FSL,GR-SL	ML,CL,GM,SM	A-4,A-2
	8-36	4.5-5.5	.15		6-20	CB-CL,GR-CL,CB-SCL	CL,SC,CL-ML,SM-SC	A-4,A-6,A-2
	36-70	4.5-5.5	.15		8-27	CB-CL,GR-SCL,CB-C	SC,SM,CL,ML	A-4,A-6,A-7
NOLICHUCKY	0-7	4.5-6.5	.15	B	3-10	GR-L,GR-SL,GR-SIL	SM-SC,SC,GC,GM-GC	A-4,A-2,A-1-B
	0-7	4.5-6.5	.28		3-10	L,SL,SIL	SM-SC,SC,CL,CL-ML	A-4,A-2
	7-15	4.5-5.5	.20		8-15	CL,GR-CL,L	SC,GC,CL	A-4,A-2,A-6
	15-56	4.5-5.5	.20		15-22	CL,GR-CL,SCL	CL,SC,GC	A-6,A-7,A-2
	56-75	4.5-5.5	.20		17-30	CL,C,GR-CL	CL,CH,SC,GC	A-6,A-7,A-2
NORFOLK	0-14	3.6-6.0	.17	B	NP	LS,LFS	SM	A-2
	0-14	3.6-6.0	.20		NP-14	SL,FSL	SM,SM-SC,SC	A-2
	14-38	3.6-5.5	.24		4-15	SL,SCL,CL	SC,SM-SC,CL,CL-ML	A-2,A-4,A-6
	38-70	3.6-5.5	.24		4-23	SCL,CL,SC	SC,SM-SC,CL,CL-ML	A-4,A-6,A-7-6
	70-99					VAR		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
NOTCHER	0-7	5.1-7.3	.17	B	NP	GR-FSL,GR-L,GR-SL	SM	A-2,A-4
	0-7	5.1-7.3	.24		NP	FSL,L,SL	SM	A-2,A-4
	7-44	4.5-5.5	.28		7-20	SCL,CL,GR-L	SC,CL	A-4,A-6
	44-76	4.5-5.5	.28		11-23	SCL,CL	CH,CL,SC,SM	A-6,A-7
NUGENT	0-8	4.5-6.5	.10	A	NP	LS,S,LFS	SM,SP-SM	A-2
	0-8	4.5-6.5	.24		NP-3	FSL,SL	SM,ML	A-4
	0-8	4.5-6.5	.37		NP-7	SIL,L	ML,CL-ML	A-4
	8-60	4.5-6.5	.17		NP-3	SR-LS-FSL	SM,SP-SM	A-2
OCHLOCKONEE	0-6	4.5-5.5	.17	B	NP	LS,LFS	SM	A-2,A-4
	0-6	4.5-5.5	.20		NP-5	FSL,SL	SM,ML,SM-SC,CL-ML	A-4,A-2
	0-6	4.5-5.5	.24		NP-7	SIL,L	ML,CL-ML	A-4
	6-44	4.5-5.5	.20		NP-9	FSL,SL,SIL	SM,ML,SC,CL	A-4
	44-72	4.5-5.5	.17		NP-9	LS,SL,SIL	SM,ML,CL,SC	A-4,A-2
OCILLA	0-28	4.5-5.5	.10	C	NP	LCOS,S,FS	SM,SP-SM	A-2,A-3
	0-28	4.5-5.5	.10		NP	LS,LFS	SM,SP-SM	A-2,A-3
	0-28	4.5-5.5	.10		NP	S,FS	SM,SP-SM	A-2,A-3
	28-59	4.5-5.5	.24		NP-18	SL,SCL,FSL	SM,CL,SC,ML	A-2,A-4,A-6
	59-67	4.5-5.5	.24		7-20	SCL,SC,SL	SC,CL	A-4,A-6,A-7
OKEETEE	0-7	4.5-6.5	.17	D	NP	LS,LFS	SM	A-2
	0-7	4.5-6.5	.24		NP-7	SL,FSL,L	SM,ML	A-2,A-4
	7-50	5.1-6.5	.32		20-30	C,SC	CH,CL	A-7
	50-78	5.1-8.4	.24		8-30	C,SC,SCL	CH,CL	A-4,A-6,A-7
	78-85					VAR		
OKOLONA	0-8	6.6-8.4	.37	D	25-32	SICL,SIC,C	CL,CH	A-7
	8-65	6.6-8.4	.32		36-65	SIC,C	CH	A-7
	65-80					WB		
OKTIBBEHA	0-4	4.5-6.5	.32	D	12-28	CL,SICL	CL	A-6,A-7
	0-4	4.5-6.5	.32		19-34	C,SIC	CL,ML,CH	A-7
	4-41	4.5-6.5	.32		30-40	C	CH	A-7
	41-70	6.6-8.4	.32		25-30	C,SIC	CL	A-7
ORA	0-7	3.6-5.5	.28	C	NP-5	SL,FSL	SM-SC,SM,ML,CL-ML	A-4,A-2
	0-7	3.6-5.5	.37		NP-5	SIL,L	ML,CL-ML	A-4
	7-26	3.6-5.5	.37		8-22	CL,SCL,L	CL	A-6,A-4,A-7
	26-56	3.6-5.5	.32		8-25	SCL,L,SL	CL	A-6,A-7,A-4
	56-70	3.6-5.5	.37		11-30	SCL,L,SL	CL	A-6,A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
ORANGEBURG	0-7	4.5-6.0	.10	B	NP	LS,LFS,S	SM	A-2
	0-7	4.5-6.0	.20		NP	SL,FSL	SM	A-2
	0-7	4.5-6.0	.24		3-16	SCL	SM,SM-SC,SC	A-4,A-6
	7-12	4.5-6.0	.20		NP-4	SL	SM	A-2
	12-54	4.5-5.5	.24		3-19	SCL,SL	SC,CL,SM,SM-SC	A-6,A-4
	54-64	4.5-5.5	.24		8-21	SCL,SC	SC,CL	A-6,A-4,A-7
OSIER	0-8	3.6-6.0	.10	A/D	NP	S,LS,FS	SP-SM	A-2,A-3
	0-8	3.6-6.0	.15		NP	FSL,LFS	SM	A-2
	8-48	3.6-6.0	.10		NP	S,LS,LFS	SP-SM,SM	A-2,A-3
	48-75	3.6-6.0	.05		NP	COS,S,FS	SP,SP-SM	A-1,A-3,A-2-4
PACOLET	0-3	4.5-6.5	.15	B	NP-3	LS	SM	A-2
	0-3	4.5-6.5	.20		NP-7	SL,FSL,L	SM,SM-SC	A-2,A-1-B,A-4
	0-3	4.5-6.5	.24		4-17	CL,SCL	SM-SC,SC	A-4,A-6
	3-29	4.5-6.0	.28		11-30	SC,CL,C	ML,MH	A-6,A-7
	29-52	4.5-6.0	.28		5-15	CL,SCL,SL	CL,CL-ML,SM-SC,SC	A-2,A-4,A-6
	52-70	4.5-6.0	.28		NP-6	SL,FSL,L	SM,SM-SC	A-4,A-2-4
PACOLET	0-3	4.5-6.0	.20	B	4-17	GR-CL,GR-SCL	SM,SM-SC,SC	A-4,A-6
	0-3	4.5-6.5	.15		NP-3	GR-SL,GR-FSL	SM	A-2
	3-29	4.5-6.0	.28		11-30	SC,CL,C	ML,MH	A-6,A-7
	29-52	4.5-6.0	.28		5-15	CL,SCL,SL	CL,CL-ML,SM-SC,SC	A-2,A-4,A-6
	52-70	4.5-6.0	.28		NP-6	SL,FSL,L	SM,SM-SC	A-4,A-2-4
PACTOLUS	0-40	3.6-5.5	.10	A	NP	LS,LFS,S	SM,SP-SM	A-2,A-3
	40-80	3.6-5.5	.10		NP	S LS,LFS	SP-SM,SM	A-2,A-3
PALMERDALE	0-5	3.6-5.5	.24	B	NP-10	CNX-SL,CNX-L,CNX-SIL	GC,SM,GM SC	A-1,A-2,A-3,A-4
	0-5	3.6-5.5	.24		3-16	CNV-SIL,CNV-SICL	GM,SC,GC,SM	A-2,A-4,A-6,A-1
	5-80	3.6-5.5	.24		3-16	CNV-SIL,CNV-L,CNX-L	GC,SM,GM,SC	A-2,A-4,A-6,A-1
PAMLICO	0-24	3.6-4.4	-	D	-	MUCK	PT	-
	24-48	3.6-5.5	.10		NP	FS,LFS,S	SM,SP-SM	A-2,A-3
	48-72	3.6-5.5	.24		2-15	FSL,SCL	SM,SC	A-4,A-2-6
PANSEY	0-10	4.5-5.5	.17	D	NP	LFS,LS	SM	A-2,A-4
	0-10	4.5-5.5	.20		NP-4	FSL,SL	SM,ML	A-2,A-4
	10-20	4.5-5.5	.24		NP-6	SL,SCL	SM	A-2,A-4
	20-35	4.5-5.5	.28		NP-14	SCL	SM-SC,SM,SC	A-2,A-4,A-6
	35-70	4.5-5.5	.28		NP-14	SCL,SC	SM-SC,SM,SC	A-2,A-4,A-6
PAXVILLE	0-15	3.6-6.5	.10	B/D	NP-7	MK-LFS,MK-FSL,MK-L	SM,ML	A-2,A-4
	0-15	3.6-6.5	.15		NP-4	LS,LFS	SM	A-2
	0-15	3.6-6.5	.20		NP-7	SL,FSL,L	SM,ML	A-2,A-4
	15-40	3.6-5.5	.15		5-15	SCL,SL,L	CL-ML,CL,SM-SC,SC	A-2,A-4,A-6
	40-48	3.6-5.5	.10		NP-4	SL,LS,FSL	SM,SP-SM	A-2,A-3
	48-99	3.6-5.5	.10		NP	LS,S,FS	SM,SP-SM	A-2,A-3,A-1

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
PELHAM	0-27	3.6-5.5	.10	B/D	NP	COS,LCOS	SM,SP-SM	A-2,A-3
	0-27	3.6-5.5	.10		NP	LS,LFS	SM	A-2
	0-27	3.6-5.5	.10		NP	S,FS	SM,SP-SM	A-2
	27-56	3.6-5.5	.24		2-12	SCL,SL,FSL	SM,SC,SM-SC	A-2,A-4,A-6
	56-68	3.6-5.5	.24		3-20	SCL,SL,SC	SC,SM,ML,CL	A-2,A-4,A-6,A-7
PHEBA	0-8	4.5-5.5	.43	C	NP-8	SIL,L,FSL	ML,CL,CL-ML	A-4
	8-21	4.5-5.5	.49		NP-8	SIL,L	ML,CL,CL-ML	A-4
	21-60	4.5-5.5	.43		11-16	SIL,L,SICL	CL	A-6
PICKWICK	0-6	4.5-5.5	.37	B	11-8	SICL	CL,ML	A-6,A-7
	0-6	4.5-5.5	.43		2-11	SIL	ML,CL-ML,CL	A-4,A-6
	6-32	4.5-5.5	.37		11-17	SICL,SIL	CL	A-6,A-7
	32-80	4.5-5.5	.37		12-22	SICL,CL,C	CL,ML,MH	A-6,A-7
PIKEVILLE	0-12	4.5-5.5	.24	B	NP-4	FSL,SL,L	SM,ML	A-4
	12-30	4.5-5.5	.37		4-17	SCL,L,GR-L	SC,CL,SM-SC,CL-ML	A-4,A-6
	30-40	4.5-5.5	.10		2-18	GR-SL,GR-L,GR-SCL	SC,SM,GM	A-1-B,A-2,A-6
	40-90	4.5-5.5	.10		2-16	GRV-SL,GRV-L,GRV-SCL	GW-GM,GM,SW-SM,SM	A-1,A-2
PINE FLAT	0-8	5.1-6.5	.15	B	NP	LFS,LS	SM	A-2
	0-8	5.1-6.5	.20		NP	FSL,SL	SM	A-2,A-4
	8-37	5.1-6.0	.20		NP-5	FSL,SL,L	SM,SM-SC	A-2-4,A-4
	37-80	4.5-6.0	.20		NP-5	SCL,L,SL	SM,SM-SC	A-2-4,A-4
PIRUM	0-11	4.5-5.5	.17	B	NP-3	STV-FSL,STV-L	SM,ML	A-4
	0-11	4.5-5.5	.20		NP-3	ST-FSL,ST-L,CB-L	SM,ML	A-4
	11-36	4.5-5.5	.32		5-15	SCL,CL,L	CL,CL-ML	A-4,A-6
	36-40					UWB		
PLUMMER	0-8	3.6-4.4	.10	B/D	-	MUCK	PT	A-8
	0-8	3.6-5.5	.10		NP	LS,LFS	SM	A-2-4
	0-8	3.6-5.5	.10		NP	S,FS	SM,SP-SM	A-2-4,A-3
	8-50	3.6-5.5	.10		NP	S,FS,LS	SM,SP-SM	A-2-4,A-3
	50-72	3.6-5.5	.15		NP-10	SL,SCL,FSL	SM,SC,SM-SC	A-2-4,A-4
POARCH	0-7	4.5-5.5	.20	B	NP-5	FSL,SL	SM,SM-SC	A-4,A-2-4
	0-7	4.5-5.5	.24		NP-5	L,VFSL	ML,CL-ML	A-4
	7-32	4.5-5.5	.24		NP-10	L,FSL,SIL	ML,CL-ML,CL	A-4
	32-66	4.5-5.5	.24		2-10	L,FSL,SIL	ML,CL,CL-ML	A-4
PONZER	0-24	3.6-4.4	-	D	-	MUCK	PT	-
	24-52	3.6-7.8	.24		NP-20	L,SCL,SIL	SM,ML,SC,CL	A-2,A-4,A-6
	52-72					VAR		
PRENTISS	0-26	4.5-5.5	.28	C	NP-10	FSL,SL	SC,SM-SC,SM	A-4
	0-26	4.5-5.5	.37		NP-10	L,SIL	ML,CL,CL-ML	A-4
	26-73	4.5-5.5	.24		4-12	L,SL,FSL	CL-ML,CL,SC,SM-SC	A-6,A-4

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
PRIM	0-7	7.4-8.4	.15	D	8-20	CBX-L,CBX-SICL,CBX-CL	CL,GC,SC	A-4,A-6,A-7
	0-7	7.4-8.4	.24		8-20	CBV-L,CBV-SICL,CBV-CL	CL,GC,SC	A-4,A-6,A-7
	7-15	7.4-8.4	.32		8-20	CBV-L,CBX-SL,CBX-CL	CL,SC	A-4,A-6,A-7,A-2
	15-50					WB		
PRUITTON	0-9	4.5-6.0	.37	B	3-10	SIL,L	ML,CL,CL-ML	A-4
	9-38	4.5-6.0	.32		3-15	SIL,L	ML,CL,CL-ML	A-4,A-6
	38-52	4.5-6.0	.24		0-11	CR-SL,CR-L,CR-SIL	ML,CL,SM,SC	A-1,A-2,A-4,A-6
QUITMAN	0-11	4.5-5.5	.17	C	NP-3	LFS	SM	A-2
	0-11	4.5-5.5	.28		NP-3	FSL,L,SIL	SM,ML	A-4,A-2
	11-18	4.5-5.5	.28		4-15	FSL,L,SCL	SC,CL,CL-ML,SM-SC	A-4,A-6
	18-65	4.5-5.5	.28		11-20	SCL,L,CL	CL,SC	A-6,A-7
RAINS	0-12	3.6-6.5	.15	B/D	NP-4	LS,LFS,S	SM	A-2
	0-12	3.6-6.5	.20		NP-10	SL,FSL	SM,ML	A-2,A-4
	0-12	4.5-6.5	.28		NP-12	VFSL,L	SM,ML,SC,CL	A-4,A-6
	12-40	3.6-5.5	.24		4-20	SCL,CL	SC,SM-SC,CL,CL-ML	A-2,A-4,A-6
	40-62	3.6-5.5	.28		4-28	SCL,CL,SC	SC,SM-SC,CL,CL-ML	A-4,A-6,A-7
	62-79	3.6-5.5	.28		3-18	SL,SCL,SC	SM,SC,ML,CL	A-2,A-4,A-6
	79-85					VAR		
RED BAY	0-6	4.5-6.0	.15	B	NP	LS,LFS	SM	A-2
	0-6	4.5-6.0	.20		NP-10	SCL	SM-SC,SC,SM	A-2,A-4
	0-6	4.5-6.0	.20		NP-4	SL,FSL,L	SM,SM-SC	A-2,A-4
	6-20	4.5-6.0	.15		NP-10	SL,SCL	SM,SC,SM-SC	A-2,A-4
	20-52	4.5-5.5	.17		4-16	SCL	SM-SC,SC	A-2,A-4,A-6
	52-72	4.5-5.5	.24		8-21	SCL,SC	SC,CL	A-6,A-4,A-7
REMBERT	0-5	4.5-6.5	.20	D	0-7	FSL,SL	SM,SM-SC	A-4
	0-5	4.5-6.5	.24		5-15	CL,SCL,L	CL,CL-ML	A-4,A-6
	5-33	4.5-5.5	.20		15-25	C,SC,CL	CL	A-6,A-7
	33-54	4.5-5.5	.17		4-15	SCL,CL,SC	SC,SM-SC,CL,CL-ML	A-2,A-4,A-6
	54-65	4.5-5.5	.17		NP-10	SCL,SL,LS	SC,SM,SM-SC	A-2,A-4
REMLAP	0-7	3.6-5.0	.32	C	8-22	SICL,SIL,L	ML,CL	A-4,A-6,A-7
	7-30	3.6-5.0	.24		30-44	C	MH	A-7
	30-80	3.6-5.0	.24		25-41	C	MH	A-7
RIVERVIEW	0-6	4.5-6.5	.20	B	NP	LS,LFS	SM	A-2,A-4
	0-6	4.5-6.5	.24		NP-7	SL,FSL	ML,SM,CL-ML,SM-SC	A-2,A-4
	0-6	4.5-6.5	.32		3-14	SIL,L,VFSL	CL,CL-ML,ML	A-4,A-6
	6-39	4.5-6.0	.24		3-20	SCL,SICL,L	CL,ML,CL-ML	A-4,A-6
	39-70	4.5-6.0	.17		NP-7	LFS,SL,S	SM,SM-SC	A-2,A-4

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
ROANOKE	0-7	3.6-5.5	.28	D	NP-7	FSL	SM,ML,CL-ML,SM-SC	A-2,A-4
	0-7	3.6-5.5	.37		10-20	SICL,CL	CL	A-6,A-7
	0-7	3.6-5.5	.37		5-16	SIL,L	SM-SC,CL-ML,CL,SC	A-4,A-6
	7-12	3.6-5.5	.24		14-20	CL,SICL	CL	A-6,A-7
	12-50	3.6-5.5	.24		22-40	C,SIC,CL	CH,CL	A-7
	50-72	3.6-6.5	.24		NP-40	SR-S-C	CL-ML,GM-GC,CH,SM	A-1,A-2,A-4
ROBERTSDALE	0-6	4.5-6.0	.24	C	NP-7	FSL,L	SM-SC,CL-ML,SM,ML	A-4
	6-21	4.5-5.5	.28		4-10	CL,SCL,L	CL-ML,CL,SC,SM-SC	A-4
	21-74	4.5-5.5	.28		4-12	SCL,CL,L	SC,CL,CL-ML,SM-SC	A-4,A-6
RUMFORD	0-17	3.6-5.5	.17	B	NP	LFS,LS	SM	A-2,A-1
	0-17	3.6-5.5	.24		NP-6	FSL,SL	SM,SM-SC	A-2,A-4
	17-37	3.6-6.0	.17		NP-12	FSL,SL,SCL	SM,SC,SM-SC	A-2,A-4,A-6
	37-60	3.6-6.5	.17		NP-6	SR-SL-GR-S	SM,SP,GP,GM	A-1,A-2,A-3,A-4
RUSTON	0-16	4.5-6.5	.15	B	NP-3	GR-FSL,GR-SL,GR-L	SM	A-2-4,A-1-B
	0-16	4.5-6.5	.20		NP-3	LFS	SM	A-2-4
	0-16	4.5-6.5	.28		NP-3	FSL,SL	SM,ML	A-4,A-2-4
	16-41	4.5-6.0	.28		11-20	SCL,L,CL	SC,CL	A-6
	41-47	4.5-6.0	.32		NP-7	FSL,SL,LS	SM,ML,CL-ML,SM-SC	A-4,A-2-4
	47-80	4.5-6.0	.28		11-20	SCL,L,CL	SC,CL	A-6
SACUL	0-10	4.5-5.5	.17	C	NP	LFS,LS	SP-SM,SM	A-2
	0-10	4.5-5.5	.20		NP-3	GR-FSL,GR-L,GR-SL	SM,ML	A-4
	0-10	4.5-5.5	.32		NP-3	SL,FSL,L	SM,ML	A-4
	10-44	4.5-5.5	.32		20-40	C,SIC	CH,CL	A-7
	44-72	4.5-5.5	.37		8-32	SICL,SIL,CL	CL,CH,SC	A-6,A-7,A-4
SAFFELL	0-8	4.5-5.5	.10	B	NP	GRV-LS,GRV-LFS	GM,GP-GM	A-1,A-2
	0-8	4.5-5.5	.15		NP-3	GRV-SL,GRV-FSL	GM	A-1,A-2
	8-14	4.5-5.5	.28		4-18	GR-FSL,GR-SCL,GR-L	GC,SC,SM-SC,GM-GC	A-2,A-1
	14-47	4.5-5.5	.28		4-18	GRV-SCL,GRV-FSL,GRV-L	GC,SC,SM-SC,GM-GC	A-2,A-1
	47-72	4.5-5.5	.17		NP-15	GR-SL,GRV-SL,GR-LS	GM,GC,SM,SC	A-1,A-2,A-3
SAFFELL	0-8	4.5-5.5	.20	B	NP-3	GR-FSL,GR-SL,GR-LFS	SM	A-1,A-2,A-4
	0-8	4.5-5.5	.28		NP-3	GR-SIL,GR-L	SM	A-2,A-4
	0-8	4.5-5.5	.24		NP-3	FSL,SL,LFS	SM,ML	A-2,A-4
	8-14	4.5-5.5	.28		4-18	GR-FSL,GR-SCL,GR-L	GC,SC,SM-SC,GM-GC	A-2,A-1
	14-47	4.5-5.5	.28		4-18	GRV-SCL,GRV-FSL,GRV-L	GC,SC,SM-SC,GM-GC	A-2,A-1
	47-72	4.5-5.5	.17		NP-15	GR-SL,GRV-SL,GR-LS	GM,GC,SM,SC	A-1,A-2,A-3
SANGO	0-11	4.5-5.5	.43	C	2-9	SIL	CL-ML,ML	A-4
	11-27	4.5-5.5	.43		5-16	SIL	CL-ML,CL	A-4,A-6
	27-66	4.5-5.5	.43		5-20	SIL,SICL	CL,CL-ML	A-4,A-6,A-7
	66-99	4.5-5.5	.28		12-3	C,CR-C,SICL	MH,CH,GC,CL	A-6,A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
SAUCIER	0-12	3.6-5.5	.24	C	NP-4	FSL,SL	SM,ML,SM-SC	A-4
	0-12	3.6-5.5	.24		2-10	L	ML,CL-ML,CL	A-4
	12-48	3.6-5.5	.32		5-15	L,CL,SCL	CL,SM-SC,SC,CL-ML	A-6,A-4
	48-60	3.6-5.5	.32		6-25	SICL,CL,SCL	CL,SM-SC,SC,CL-ML	A-7,A-6,A-4
	60-72	3.6-5.5	.32		22-34	C,SIC,CL	CH,CL	A-7
SAVANNAH	0-11	3.6-5.5	.24	C	NP-4	FSL,SL	SM,ML	A-2-4,A-4
	0-11	3.6-5.5	.28		9-16	CL	CL	A-6,A-4
	0-11	3.6-5.5	.37		NP-7	L,SIL	ML,CL-ML	A-4
	11-28	3.6-5.5	.28		7-19	SCL,CL,L	CL,SC,CL-ML	A-4,A-6
	28-68	3.6-5.5	.24		7-19	L,CL,SCL	CL,SC,CL-ML	A-4,A-6,A-7
SAWYER	0-5	4.5-5.5	.43	C	NP-7	SIL,L	ML,CL-ML	A-4
	5-29	4.5-5.5	.37		10-20	SICL,L,SIL	CL	A-6,A-4
	29-80	4.5-5.5	.32		20-35	SIC,C	CH,CL	A-7
SCRANTON	0-7	4.5-6.5	.10	A/D	NP	S,FS	SP-SM,SM	A-2,A-3,A-1
	0-7	4.5-6.5	.15		NP	LS,LFS	SM,SP-SM	A-2,A-4
	7-41	4.5-6.0	.10		NP	LS,S,FS	SP-SM,SM	A-2,A-3,A-1
	41-72	4.5-6.0	.10		NP	S,FS	SP-SM,SM,SP	A-2,A-3,A-1
SEARCY	0-3	3.6-6.0	.20	C	NP-7	S,FSL	SM,ML,CL-ML	A-4,A-2
	0-3	3.6-6.0	.24		3-16	L,CL,SCL	CL,ML,SM-SC	A-4,A-6
	3-8	3.6-6.0	.24		11-17	CL,SCL,C	CL,SC	A-6,A-4
	8-37	3.6-6.0	.28		15-22	C,SC	CH,SC	A-7
	37-65	3.6-6.0	.28		20-35	C,SC,SIC	CH,SC	A-7
SEQUATCHIE	0-12	4.5-5.5	.32	B	2-10	L,FSL,SIL	ML,CL-ML,CL,SM	A-2,A-4
	12-46	4.5-5.5	.24		5-15	CL,L,SIL	CL-ML,CL	A-4,A-6
	46-72	4.5-5.5	.24		2-10	SL,L,FSL	ML,CL-ML,CL,SM	A-2,A-4
SHADYGROVE	0-6	4.5-5.5	.24	C	NP-7	FSL,SL	SM,SM-SC	A-2,A-4
	0-6	4.5-5.5	.37		5-16	SIL,L	CL-ML,CL	A-4,A-6
	0-6	4.5-5.5	.37		7-26	SICL	CL	A-4,A-6,A-7
	6-23	4.5-5.5	.32		22-40	C,CL,SC	CL,CH	A-7
	23-65	4.5-5.5	.24		22-40	FL-C,FLV-C,FLV-CL	GC,SC,CL,CH	A-7,A-2-7
SHATTA	0-6	5.1-6.5	.37	C	3-7	SIL,L,VFSL	ML,CL-ML	A-4
	6-30	4.5-6.0	.37		11-18	SICL,L,SIL	CL	A-6
	30-70	4.5-5.5	.37		8-14	L,SIL,SICL	CL	A-6,A-4
SHUBUTA	0-8	4.5-6.0	.17	C	NP	LS	SM	A-2
	0-8	4.5-6.0	.28		NP-10	SL,FSL,L	SM,ML,CL-ML,CL	A-2,A-4
	0-8	4.5-6.0	.28		10-18	CL,SCL	CL	A-6
	8-52	4.5-5.5	.28		16-40	C,SC,CL	CH,CL,SC	A-7
	52-70	4.5-5.5	.28		15-40	C,SC,SCL	CH,CL,SC	A-6,A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
SIPSEY	0-16	4.5-6.0	.15	B	NP	LS	SM	A-2
	0-16	4.5-6.0	.24		NP-7	FSL,SL	SM,SM-SC	A-2,A-4
	16-31	4.5-6.0	.32		NP-15	SL,L,SCL	SM-SC,SC,CL-ML,CL	A-4,A-6
	31-60					WB		
SMITHDALE	0-11	4.5-5.5	.17	B	NP	LS,LFS	SM	A-2
	0-11	4.5-5.5	.28		NP-5	SL,FSL,L	SM,SM-SC	A-4,A-2
	11-38	4.5-5.5	.24		7-16	CL,SCL,L	SM-SC,SC,CL,CL-ML	A-6,A-4
	38-80	4.5-5.5	.28		NP-10	L,SL	SM,ML,CL,SC	A-4
SMITHTON	0-10	4.5-5.5	.32	D	NP	FSL,SL	ML,SM	A-2,A-4
	0-10	4.5-5.5	.32		NP-7	L,VFSL	SM,ML,CL-ML	A-2,A-4
	10-38	4.5-5.5	.32		2-7	FSL,L	ML,CL-ML	A-4
	38-72	4.5-5.5	.37		5-15	FSL,L,SIL	CL-ML,CL	A-4,A-6
SPADRA	0-8	4.5-6.0	.37	B	NP-3	FSL,L,SIL	ML,SM	A-2,A-4
	8-39	4.5-6.0	.37		NP-15	L,SCL,CL	CL,CL-ML,ML	A-4,A-6
	39-72	4.5-6.0	.24		NP-10	FSL,SL,GR-FSL	ML,CL,SM,SC	A-4,A-2,A-1
SPRINGHILL	0-5	4.5-5.5	.15	B	NP	LS,LFS	SM	A-2
	0-5	4.5-5.5	.20		NP	SL,FSL	SM	A-2
	0-5	4.5-5.5	.24		3-16	SCL	SM,SM-SC,SC	A-4,A-6
	5-11	4.5-5.5	.20		NP-4	SL,FSL	SM	A-2
	11-45	4.5-5.5	.24		8-21	SL,SCL	SC,CL,SM-SC	A-6,A-4
	45-65	4.5-5.5	.20		3-16	LS,SL	SM,SM-SC	A-2,A-4
STARR	0-10	5.1-6.5	.24	C	NP-7	SL,FSL	SM,SM-SC	A-4,A-2
	0-10	5.1-6.5	.28		3-12	L	ML,CL-ML,CL	A-4,A-6
	0-10	5.1-6.5	.28		3-23	SIL,SICL,SCL	ML,CL-ML,CL	A-4,A-6,A-7
	10-53	5.1-6.5	.28		3-23	CL,SCL,SICL	ML,CL-ML,CL	A-4,A-6,A-7
	53-70	5.1-6.5	.28		NP-15	GR-SL,SCL,CL	SM,SM-SC,SC	A-2,A-4,A-6
STASER	0-35	5.6-7.3	.32	B	3-15	SIL,L,FSL	CL,CL-ML,ML	A-4,A-6
	35-52	5.6-7.3	.28		5-15	SIL,L,FSL	CL,CL-ML,SC,SM-SC	A-4,A-6,A-2
STATE	0-10	3.6-5.5	.28	B	NP-15	SIL,L	SM,SC,ML,CL	A-4,A-6
	0-10	3.6-5.5	.28		NP-6	LS,LFS	SM,SM-SC	A-2,A-1
	0-10	3.6-5.5	.28		NP-7	FSL,SL	SM,ML,CL-ML,SM-SC	A-2,A-4
	10-45	3.6-5.5	.28		8-22	L,CL,SCL	CL,SC	A-4,A-6
	45-60	3.6-5.5	.17		NP-7	SR-S-FSL	SM,SM-SC,SP-SM	A-1,A-2,A-3,A-4
STEMLEY	0-7	5.1-6.5	.20	C	NP-4	CR-SL,CR-FSL	SM,SM-SC	A-2,A-1
	0-7	5.1-6.5	.24		NP-7	CR-L,CR-SIL	ML,SM,CL-ML,GM	A-4,A-2,A-1
	7-17	3.6-5.5	.28		12-20	CR-L,CR-SIL	SC,CL,GC	A-6,A-2
	17-33	3.6-5.5	.24		2-10	CR-L,CR-SIL,CR-SCL	GM-GC,GM,GC,SC	A-2,A-1
	33-65	3.6-5.5	.28		2-10	CR-L,CR-SIL,CR-SCL	CL,GM-GC,GM,SC	A-1,A-2,A-4

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
STERRETT	0-8	4.5-6.0	.24	D	NP-7	FSL,SL	ML,SM	A-4,A-2-4
	0-8	4.5-6.0	.37		NP-7	SIL,SICL	ML	A-4
	8-14	4.5-5.5	.32		3-20	SIL,L	ML,CL-ML,CL	A-4,A-6
	14-58	4.5-5.5	.32		5-20	L,CL,SICL	CL,CL-ML	A-4,A-6
	58-74	5.6-7.8	.32		3-20	L,SL,SCL	CL,SM,SC,ML	A-4,A-6
STOUGH	0-20	4.5-5.5	.28	C	NP-7	FSL,SL	SM-SC,SM,ML,CL-ML	A-4
	0-20	4.5-5.5	.37		NP-7	L	ML,CL-ML	A-4
	20-26	4.5-5.5	.37		NP-8	L,FSL,SL	ML,CL,CL-ML	A-4
	26-68	4.5-5.5	.37		8-15	SL,SCL,L	SC,CL	A-4,A-6
SUBRAN	0-6	4.5-6.5	.20	C	NP-7	FSL,SL	SM,ML,CL-ML	A-4,A-2
	0-6	4.5-6.5	.24		9-16	L,CL	CL,ML	A-4,A-6
	6-33	4.5-6.0	.28		16-40	CL,C	CL,CH	A-7
	33-65	4.5-6.0	.28		16-40	CL,C,SIC	CL,CH	A-7
SUCARNOOCHEE	0-22	6.6-8.4	.32	D	15-35	SIC,C	CL,CH,MH	A-7
	0-22	6.6-8.4	.32		7-25	SICL	CL	A-4,A-6,A-7
	22-32	6.6-8.4	.32		20-40	SIC,C	MH,CH,CL	A-7
	32-65	6.6-8.4	.32		25-45	SIC,C	CH,MH	A-7
SUFFOLK	0-11	3.6-5.5	.24	B	NP-6	LFS,LS	SM,SM-SC	A-1,A-2,A-4
	0-11	3.6-5.5	.28		NP-7	FSL,SL,L	SM,SM-SC,ML,CL-ML	A-2,A-4
	11-38	3.6-5.5	.24		10-25	SCL,CL,SL	SC,CL	A-2,A-6
	38-65	3.6-6.0	.17		NP-7	LFS,FSL,GR-S	SP,SM,SM-SC	A-1,A-2,A-3,A-4
SULLIVAN	0-46	5.1-7.3	.32	B	3-10	L,SIL,FSL	ML,CL,CL-ML,SM	A-4
	46-58	5.1-7.3	.32		3-10	GR-FSL,GR-L,SIL	SM,SM-SC,SC,GM	A-4,A-2
SUMTER	0-10	6.6-8.4	.37	C	16-25	SIC,C,SICL	CL	A-7,A-6
	0-10	6.6-8.4	.37		4-20	SIL	ML,CL-ML,CL	A-6,A-4
	10-21	7.4-8.4	.37		16-32	SIC,C,SICL	CH,CL	A-7,A-6
	21-28	7.4-8.4	.32		16-32	CN-SICL,SICL,SIC	CH,CL	A-6,A-7
	28-60					WB		
SUNLIGHT	0-3	4.5-5.5	.24	D	NP-10	CN-SL,CN-SIL,CN-L	SM,ML,GM	A-4
	0-3	4.5-5.5	.28		NP-10	SL,SIL,L	SM,ML	A-4
	3-5	4.5-5.5	.24		4-15	CN-SL,CN-SICL,CN-L	SM-SC,GC,GM-GC,CL	A-4,A-6
	5-12	4.5-5.5	.17		4-15	CNV-SIL,CNV-SICL,CN-L	GC,GM-GC	A-2,A-4,A-6
	12-24					WB		
SUNSWEET	0-4	4.5-5.5	.20	C	NP	GR-SL,GR-LS	SM,GM	A-2,A-1-B
	0-4	4.5-5.5	.24		NP	SL,LS	SM	A-2,A-1-B
	4-11	4.5-5.5	.37		8-16	C,SC,SCL	CL,SC	A-6,A-7,A-4
	11-60	4.5-5.5	.28		13-24	C,SC	CL	A-6,A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
SUSQUEHANNA	0-5	4.5-5.5	.17	D	NP	LS	SM	A-2
	0-5	4.5-5.5	.28		NP	FSL,SL	ML,SM	A-4
	0-5	4.5-5.5	.37		5-15	SIL,L	CL-ML,CL	A-4,A-6
	5-77	4.5-5.5	.32		28-56	C,SICL,SIC	CH	A-7
SYLACAUGA	0-5	4.5-6.0	.37	D	5-12	SIL,L,VFSL	CL,CL-ML	A-4,A-6
	5-50	4.5-6.0	.32		12-20	SIL,SICL,CL	CL	A-6
	50-60	4.5-6.0	.17		5-10	SR-S-GR-L	SM-SC,SC	A-2
TADLOCK	0-5	4.5-6.5	.24	B	NP-7	FSL,L	SM,SM-SC,ML,CL-ML	A-4
	5-72	4.5-6.5	.17		16-25	C,CL	CL	A-7
TAFT	0-9	4.5-5.5	.43	C	2-10	SIL	CL-ML,ML	A-4
	9-24	4.5-5.5	.43		5-16	SIL,SIC	CL-ML,CL	A-4,A-6
	24-64	4.5-5.5	.43		5-20	SIL,SICL	CL-ML,CL	A-4,A-6,A-7
	64-80	4.5-5.5	.37		12-22	SICL,C,CR-SICL	ML,GC,CL	A-6,A-7
TALBOTT	0-6	5.1-6.0	.32	C	12-32	SICL,C,SIC	CL,CH,ML,MH	A-6,A-7
	0-6	5.1-6.0	.37		8-16	SIL	CL,ML	A-4,A-6
	6-37	5.1-7.8	.24		20-45	C,SIC	CL,MH,CH	A-6,A-7
	37-41				UWB			
TALLADEGA	0-9	4.5-5.5	.28	C	NP-10	CN-SIL,CN-L	SM,SC,SM-SC,GM	A-4,A-2,A-1
	0-9	4.5-5.5	.32		NP-10	SIL,L	SM,SC,ML,SM-SC	A-4
	9-22	4.5-5.5	.28		7-15	CN-CL,CN-SIL,CN-SICL	GM,GC,SC,SM	A-4,A-6,A-2
	22-26					VAR		
	26-30					WB		
TALLAPOOSA	0-4	4.5-5.0	.20	C	NP-7	GR-FSL,GR-SL	SM,GM	A-4,A-2
	0-4	4.5-5.0	.24		1-9	GR-L,GR-SIL	SM,GM	A-4,A-5,A-2-5
	4-10	4.5-5.0	.37		8-14	GR-L,GR-SICL,GR-CL	SC,ML,CL,GC	A-4,A-6
	10-19	4.5-5.0	.20		NP-6	GR-L	SM,ML,GM	A-4
	19-60					WB		
TALLAPOOSA	0-4	4.5-5.0	.28	C	NP-7	FSL,SL	SM,ML,SM-SC,CL-ML	A-4,A-2
	0-4	4.5-5.0	.32		1-9	L,SIL	SM,ML	A-4,A-5
	4-10	4.5-5.0	.37		3-14	SICL,CL,L	ML,CL	A-4,A-6
	10-19	4.5-5.0	.20		NP-6	L	ML,SM	A-4
	19-60					WB		
TANYARD	0-6	5.1-6.0	.28	C	NP-7	SL,FSL	SM,ML	A-4
	0-6	5.1-6.0	.32		4-20	SIL,L	CL,CL-ML	A-4,A-6
	6-10	4.5-6.0	.32		4-20	L,SIL,CL	CL,CL-ML	A-4,A-6
	10-59	4.5-6.0	.28		12-28	SIL,L,SICL	CL	A-6,A-7
	59-72	5.6-7.8	.24		7-24	SCL,CL,L	SC,CL	A-4,A-6,A-7
TARBORO	0-40	4.5-6.5	.10	A	NP	LS,S	SM,SP-SM,SW-SM	A-2,A-3,A-1
	40-80	4.5-6.5	.10		NP	S,COS,LS	SP,SP-SM,SW-SM,SM	A-2,A-3,A-1

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
TASSO	0-8	4.5-5.5	.32	B	3-9	CR-SIL,CR-L	ML,CL,CL-ML	A-4
	0-8	4.5-5.5	.37		3-9	SIL,L	ML,CL-ML,CL	A-4
	8-23	4.5-5.5	.32		9-15	SIL,L,SICL	CL	A-4,A-6
	23-34	4.5-5.5	.32		9-15	SICL,CL,CR-SICL	CL	A-4,A-6
	34-60	4.5-5.5	.28		14-25	C,CL,SICL	CL,ML,MH,CH	A-6,A-7
TATUM	0-6	4.5-5.5	.15	B	NP-10	GR-FSL	ML,GC,SM	A-4
	0-6	4.5-5.5	.15		20-40	GR-SICL,GR-CL	CL,GC,SC,CH	A-7
	0-6	4.5-5.5	.20		NP-10	GR-SIL,GR-L,GR-VFSL	GM,ML,SM	A-4
	6-42	4.5-5.5	.28		20-45	SICL,SIC,GR-C	MH,GM,SM,GC	A-7
	42-46					WB		
TATUM	0-6	4.5-5.5	.20	B	NP-10	FSL	ML,CL,CL-ML,SM	A-4
	0-6	4.5-5.5	.32		12-20	SICL,CL	CL	A-6,A-7
	0-6	4.5-5.5	.37		5-15	SIL,L,VFSL	ML,CL,CL-ML	A-4,A-6
	6-42	4.5-5.5	.28		20-45	SICL,SIC,C	MH,CH	A-7
	42-46					WB		
TELLICO	0-8	4.5-5.5	.24	B	12-20	CL	CL	A-6,A-7
	0-8	4.5.5.5	.24		3-15	L,SL	CL,CL-ML,ML	A-4,A-6
	8-44	4.5-5.5	.28		15-27	CL,C,SC	CL,CH	A-6,A-7
	44-58	4.5-5.5	.28		4-20	SL,CL,CN-CL	GM-GC,SM-SC,SC,GC	A-4,A-6,A-2,A-1
	58-62				UWB			
TIFTON	0-10	4.5-6.0	.10	B	NP	LS,S,FS	SM,SP-SM	A-2
	0-10	4.5-6.0	.17		NP-6	SL,FSL,LFS	SM,SM-SC	A-2
	10-18	4.5-6.0	.24		NP-7	SL,GR-SL,FSL	SM,SM-SC	A-2
	18-33	3.6-6.0	.24		8-22	SCL,GR-SCL	SC,CL	A-2,A-6,A-4
	33-64	4.5-5.5	.17		8-23	SCL,SC	SC,CL	A-2,A-6,A-7,A-4
	64-85	4.5-5.5	.17		8-23	SCL,SC	SC,CL	A-4,A-6,A-7
TOCCOA	0-10	5.1-6.5	.10	B	NP-4	SL,LS	SM	A-2,A-4
	0-10	5.1-6.5	.24		NP-4	FSL,L,SIL	SM,ML	A-2,A-4
	10-60	5.1-6.5	.10		NP-4	SL,L	SM,ML	A-2,A-4
TOWNLEY	0-6	3.6-5.5	.24	C	12-30	GR-CL,CN-CL,CN-C	CL,CH,GC,SC	A-6,A-7
	0-6	3.6-5.5	.28		NP-10	GR-SL,GR-L,GR-SIL	ML,CL,CL-ML,GM	A-2,A-4
	0-6	3.6-5.5	.28		NP-7	CN-SL,CN-L,CN-SIL	ML,CL-ML,SM,GM	A-2,A-4
	6-22	3.6-5.5	.28		14-37	SICL,SIC,C	CL,ML,CH,MH	A-7
	22-35					VAR		
	35-40					UWB		
TOWNLEY	0-6	3.6-5.5	.28	C	NP-7	SL,FSL	SM,CL-ML,ML	A-2,A-4
	0-6	3.6-5.5	.32		12-30	SICL,CL,C	CL,CH	A-6,A-7
	0-6	3.6-5.5	.37		NP-10	L,SIL	ML,CL,CL-ML	A-4
	6-22	3.6-5.5	.28		14-37	SICL,SIC,C	CL,ML,CH,MH	A-7
	22-35					VAR		
	35-40					UWB		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
TRINITY	0-6	7.4-8.4	.32	D	35-60	C	CH	A-7-6
	6-64	7.4-8.4	.32		35-60	C	CH	A-7-6
	64-75	7.4-8.4	.32		35-60	C	CH	A-7-6
TROUP	0-53	4.5-6.0	.10	A	NP	LS,LFS	SM,SP-SM	A-2,A-4
	0-53	4.5-6.0	.10		NP	S,FS,COS	SM,SP-SM	A-2
	53-80	4.5-5.5	.20		4-20	SCL,SL,FSL	SC,SM-SC,CL-ML,CL	A-4,A-2,A-6
TUMBLETON	0-4	4.5-6.5	.15	C	NP	GR-SL,GR-LS	SM	A-1,A-2,A-4
	0-4	4.5-6.5	.20		NP-6	SL,LS	SM,SM-SC,ML,CL-ML	A-2-4,A-4
	4-10	3.6-5.5	.32		15-25	SC,SCL	SC,CL	A-6,A-7
	10-49	3.6-5.5	.32		22-45	SC,C	CH,CL,SC	A-7,A-7-5
	49-56	3.6-5.5	.32		16-47	SC,C,SCL	CH,CL,SC,MH	A-6,A-7
	56-72					VAR		
TUPELO	0-8	4.5-6.0	.32	D	8-20	SICL,CL	CL,ML	A-4,A-6,A-7
	0-8	4.5-6.0	.37		3-10	SIL,L	CL-ML,CL,ML	A-4
	8-15	4.5-6.0	.32		9-27	SICL,SIC,SIL	CL,CH,MH	A-6,A-7,A-4
	15-65	5.1-8.4	.28		17-40	C,SIC,SICL	CH,MH,CL	A-7
TUSCUMBIA	0-4	5.1-8.4	.32	D	15-25	SIC,C	CL	A-7,A-6
	0-4	5.1-8.4	.32		15-25	SICL,CL,SCL	CL	A-6,A-7-6
	4-50	5.1-8.4	.28		30-50	C,SIC,SICL	CH	A-7
TUSQUITEE	0-13	4.5-6.5	.24	B	NP-7	FSL,SL	SM,SM-SC	A-2,A-4
	0-13	4.5-6.5	.28		NP-7	L,SIL	ML,CL-ML,CL,SM	A-4,A-5
	13-26	4.5-6.0	.20		6-15	L,SL,FSL	SM-SC,SM,ML,CL-ML	A-4,A-6
	26-47	4.5-6.0	.17		6-15	ST-L,ST-FSL,ST-SL	SM,SM-SC	A-2,A-4
	47-65	4.5-6.0	.15		NP-7	STV-L,STV-FSL,STV-SL	SM,SM-SC,GM	A-2,A-4,A-1
UCHEE	0-26	4.5-5.5	.10	A	NP	LS,S,LFS	SM	A-2,A-1-B
	26-39	4.5-5.5	.24		6-20	SL,SCL	SC,SM-SC	A-2,A-4,A-6
	39-47	4.5-5.5	.28		18-38	SCL,SC,C	MH,CH,CL,SC	A-7
	47-66	4.5-5.5	.28		15-35	SL,SCL,SC	MH,CH,CL,SC	A-6,A-7,A-2-7
	66-84	4.5-5.5	.24		NP-7	SL,LS	SP-SM,SM,SM-SC	A-2,A-1-B
UNA	0-6	4.5-5.5	.32	D	20-40	C,SICL,SIC	CH,CL	A-7
	0-6	4.5-5.5	.32		3-22	CL,L,SCL	CL,ML,SC,CL-ML	A-6,A-4
	6-57	4.5-5.5	.28		20-40	C,SICL,SIC	CH,CL	A-7
URBO	0-9	4.5-5.5	.28	D	20-36	CL,SIC,C	CL,CH	A-7
	0-9	4.5-5.5	.49		15-25	SICL,SIL	CL	A-6
	9-71	4.5-5.5	.28		20-36	SIC,CL,SICL	CL,CH	A-7
VAIDEN	0-4	4.5-6.5	.32	D	20-30	SIC,C,SICL	MH,CH	A-7
	4-26	4.5-6.0	.32		30-50	C	CH,MH	A-7
	26-80	4.5-7.8	.32		30-52	C	CH	A-7

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
VANCE	0-5	4.5-6.0	.15	C	NP-7	GR-SL,GR-COSL	SM,GM,GM-GC,SM-SC	A-1,A-2
	0-5	4.5-6.0	.24		NP-7	FSL,SL,COSL	SM,SM-SC	A-2,A-4
	0-5	4.5-6.0	.28		8-20	SCL,CL	CL,SC	A-6,A-4
	5-29	4.5-5.5	.28		25-48	CL,SC,C	CH	A-7
	29-72					VAR		
VARINA	0-14	4.5-6.5	.15	C	NP-3	LS	SM,SP-SM	A-2
	0-14	4.5-6.5	.17		NP-7	SL	SM,SM-SC	A-2,A-4
	14-38	4.5-5.5	.28		11-25	SC,CL,C	SC,MH,ML,SM	A-6,A-7
	38-80	4.5-5.5	.28		8-26	SC,CL,C	CL,SC,CH	A-4,A-6,A-7
WAGRAM	0-24	4.5-6.0	.10	A	NP	FS,S	SP-SM,SM	A-1,A-2,A-3
	0-24	4.5-6.0	.15		NP	LS,LFS	SM,SP-SM	A-2,A-3
	24-75	4.5-6.0	.20		8-25	SCL,SL	SC	A-2,A-4,A-6,A-7
WAHEE	0-11	4.5-6.0	.24	D	NP-7	SL,FSL	SM,SM-SC	A-2,A-4
	0-11	4.5-6.0	.28		2-10	L,SIL,VFSL	ML,CL-ML,CL	A-4
	11-56	3.6-5.5	.28		16-54	C,CL,SIC	CL,CH	A-6,A-7
	56-65					VAR		
WATSONIA	0-3	4.5-6.5	.32	D	16-31	C,SIC	CL,CH	A-7,A-6
	3-12	4.5-6.5	.32		45-60	C,SIC	CH	A-7
	12-16	7.4-8.4	.37		40-60	C,SIC	CH	A-7
	16-30					MARL		
WAX	0-10	4.5-6.0	.32	C	NP-7	FSL	SM,SM-SC,ML	A-2,A-4
	0-10	4.5-6.0	.37		NP-7	L,SIL	SM,SM-SC,ML,CL-ML	A-4
	10-30	4.5-5.5	.37		6-18	CL,L,SICL	CL,CL-ML	A-6,A-4
	30-60	4.5-5.5	.15		4-10	CR-CL,CR-L,CR-SCL	GM-GC,SM-SC,GC,SC	A-2-4,A-4,A-1-B
WAYNESBORO	0-10	4.5-5.5	.28	B	2-9	L,FSL,CL	ML,CL-ML,CL,SM	A-4
	0-10	4.5-5.5	.37		5-15	SIL,SICL	CL-ML,CL	A-4,A-6
	10-16	4.5-5.5	.28		9-17	CL,L,SCL	CL,ML,SC	A-4,A-6,A-7
	16-60	4.5-5.5	.28		9-32	CL,SC,C	MH,CL,ML	A-4,A-6,A-7
WEDOWEE	0-10	4.5-5.5	.24	B	NP-6	SL,FSL,L	SM,SM-SC	A-4,A-2-4
	0-10	4.5-5.5	.15		NP-6	GR-SL,GR-FSL,GR-L	SM,SM-SC	A-4,A-2,A-1
	0-10	4.5-5.5	.28		5-15	SCL,CL	SC,CL,CL-ML,SM-SC	A-4,A-6
	10-14	4.5-5.5	.28		NP-15	L,SCL	SM,SC,CL,ML	A-4,A-6
	14-32	4.5-5.5	.28		10-25	SC,CL,C	SC,ML,CL,MH	A-6,A-7
	32-60	4.5-5.5	.28		5-15	SCL,CL,SL	SC,SM-SC,CL,CL-ML	A-2,A-4,A-6
WEHADKEE	0-8	4.5-6.5	.24	D	NP-10	FSL,L,SL	SM,SC,SM-SC	A-2,A-4
	0-8	4.5-6.5	.32		10-24	SIL,SICL	CL,MH,ML	A-6,A-7
	8-40	4.5-6.5	.32		7-25	L,SCL,CL	ML,CL,CL-ML	A-6,A-7,A-4
	40-50					VAR		

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
WEOGUFKA	0-4	4.5-6.0	.17	C	NP-10	CNV-SL,CNV-SIL,CNV-L	GMM,SM,ML	A-2,A-4
	0-4	4.5-6.0	.20		NP-10	CN-SL,CN-SIL,CN-L	SM,ML,GM	A-2,A-4
	4-10	4.5-5.5	.20		NP-10	CNV-L,CNV-SICL,CNV-CL	GM,GM-GC,SM,SM-SC	A-2,A-1-B,A-1-A
	10-28					WB		
	28-32					UWB		
WESTON	0-9	4.5-6.0	.20	D	NP-3	LFS	SM	A-2,A-4
	0-9	4.5-6.0	.24		NP-3	FSL,SL	ML,SM	A-4
	9-44	4.5-5.0	.24		NP-5	SL,L,FSL	SM,SM-SC,ML,CL-ML	A-4
	44-54	4.5-5.0	.32		NP-15	SR-S-C	SM,ML,CL,CL-ML	A-4,A-6
WHITWELL	0-9	4.5-6.0	.32	C	3-10	L,SIL	ML,CL-ML,CL	A-4
	0-9	4.5-6.0	.32		3-10	SL	SM,SC,SM-SC	A-2,A-4,A-1-B
	9-72	4.5-5.5	.32		3-15	CL,L,SIL	CL,CL-ML,ML,SC	A-4,A-6
WICKHAM	0-9	4.5-6.0	.15	B	NP	LS,LFS	SM	A-2
	0-9	4.5-6.0	.24		NP-7	SL,FSL,L	SM,SM-SC,ML,CL-ML	A-4
	0-9	4.5-6.0	.24		5-15	SCL,CL	CL-ML,CL,SC,SM-SC	A-2,A-4,A-6
	9-40	4.5-6.0	.24		5-15	SCL,CL,L	CL-ML,CL,SC,SM-SC	A-2,A-4,A-7-6
	40-70					VAR		
WICKSBURG	0-26	4.5-6.0	.05	B	NP	GR-COS	SP,SP-SM	A-1
	0-26	4.5-6.0	.10		NP	LS,LFS	SM	A-2
	0-26	4.5-6.0	.10		NP	S,FS	SM,SP-SM	A-2,A-3
	26-30	4.5-5.5	.20		NP-15	SCL,CL	SC,SM-SC,CL,CL-ML	A-4,A-6
	30-65	4.5-5.5	.24		12-20	CL,SC,C	CL	A-6,A-7
WILCOX	0-5	4.5-5.5	.37	D	15-30	SICL,CL,SIL	CL,CH	A-7,A-6
	0-5	4.5-5.5	.37		25-40	SIC	CH	A-7
	5-50	3.6-5.5	.32		22-46	C,SIC,SICL	CH,MH	A-7
	50-57	3.6-5.5	.28		39-55	C	CH	A-7
	57-73					WB		
WILKES	0-6	5.1-6.5	.15	C	NP-7	STX-SL,STX-L	SM,SM-SC	A-2,A-4,A-1-B
	0-6	5.1-6.5	.17		NP-7	GR-SL,GR-L,GR-FSL	SM,SM-SC	A-2,A-4,A-1-B
	0-6	5.1-6.5	.17		NP-7	STV-SL,STV-L	SM,SM-SC	A-2,A-4,A-1-B
	6-13	5.6-7.8	.28		11-35	SICL,ST-C,ST-SCL	CL,CH,MH	A-6,A-7
	13-48					WB		
WILKES	0-6	5.1-6.5	.24	C	NP-7	SL,L,FSL	ML,SM	A-2,A-4
	0-6	5.1-6.5	.28		10-25	SCL,CL	CL,SC	A-6,A-7
	6-13	6.1-7.8	.32		11-35	CL,C,SCL	CL,CH	A-6,A-7
	13-48					WB		
WOLFTEVER	0-7	4.5-5.5	.37	C	3-12	SICL,SIL	CL-ML,CL,ML	A-4,A-6
	7-15	4.5-5.5	.32		7-15	SIC,SICL,SIL	ML,CL	A-4,A-6
	15-53	4.5-5.5	.32		11-20	SIC,SICL,C	ML,MH	A-7
	53-89	4.5-5.5	.32		5-20	L,CL,SICL	CL-ML,CL	A-6,A-7,A-4

Table A-II-3

Soil Characteristics for Principal Soils in Alabama 1/

Name	Depth (In)	pH	K	Hydr. Group	P.I.	Textural Classification USDA	Unified	AASHTO
WORSHAM	0-8	4.5-5.5	.28	D	NP-9	FSL,SL	SM,SC,ML,CL	A-2,A-4
	0-8	4.5-5.5	.37		4-12	L,SIL	CL,CL-ML	A-4,A-6
	8-50	4.5-5.5	.28		22-40	SCL,SC,C	SC,CH,CL	A-2,A-7
	50-70	4.5-5.5	.28		8-30	SL,SCL,CL	SC,CL	A-2,A-4,A-6,A-7
WYNNVILLE	0-7	3.6-5.5	.24	C	NP-7	FSL,L,SL	SM,SM-SC,ML,CL-ML	A-4
	0-7	3.6-5.5	.28		2-14	SIL	ML,CL-ML,CL	A-4,A-6
	7-23	3.6-5.5	.24		3-10	L,SCL,SIL	SM-SC,SC,CL-ML,CL	A-4
	23-48	3.6-5.5	.20		3-13	L,SCL,SL	SM-SC,SC,CL-ML,CL	A-4,A-6
	48-72	3.6-5.5	.20		3-13	L,SCL,CL	SM-SC,SC,CL-ML,CL	A-4,A-6
YEMASSEE	0-12	3.6-6.0	.15	C	NP-4	LS,LFS	SM	A-2
	0-12	3.6-6.0	.20		NP-7	SL,FSL	SM	A-2,A-4
	12-50	3.6-5.5	.20		4-18	SCL,CL,FSL	CL,SC,CL-ML,SM-SC	A-2,A-4,A-6
	50-75	3.6-5.5	.20		NP-20	SCL,FSL,SC	SC,SM,CL-ML,SM-SC	A-2,A-4,A-6
	75-90					VAR		
YONGES	0-14	5.1-7.8	.15	D	NP-7	LFS	SM,ML	A-2,A-4
	0-14	5.1-7.8	.20		NP-7	SL,FSL	SM,SM-SC,ML	A-4
	0-14	5.1-7.8	.28		3-15	L,SIL	CL-ML,CL,ML	A-4,A-6
	14-42	5.1-8.4	.17		6-28	SCL,CL,SC	CL-ML,CL,SC,SM-SC	A-4,A-6,A-7
	42-60	6.1-8.4	.20		3-22	FSL,SCL	CL,ML,SC,SM	A-4,A-6

1/ These values can vary throughout the state. The Field Office Technical Guide of the local Soil Conservation Service should be checked for correct or specific county values.

Appendix A3 – Standard Drawings Of Structural Measures

Appendix A3

STANDARD DRAWINGS OF STRUCTURAL MEASURES

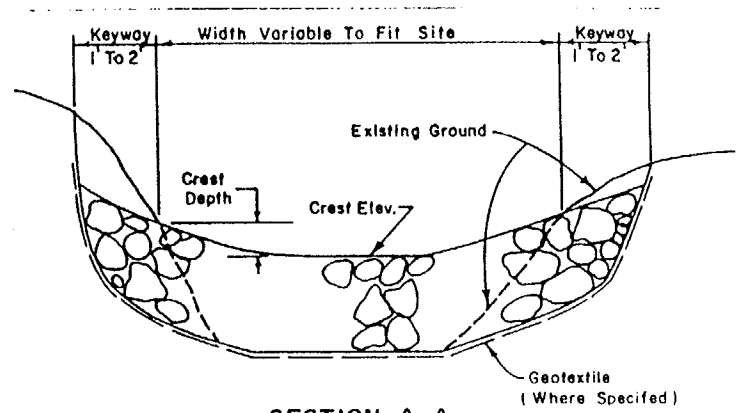
CONTENTS

	Page
Checkdam	A-III-1
Diversion	A-III-2
Hay Bale	A-III-3
Concrete Flume	A-III-4
Silt Fence	A-III-5

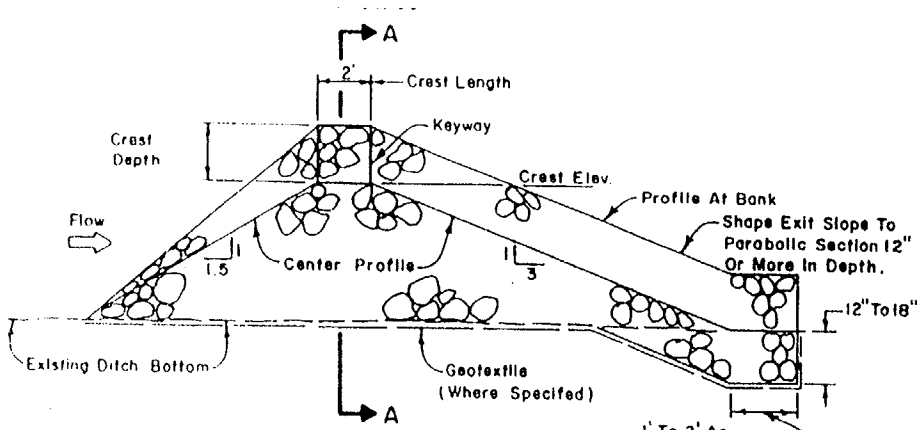
July 1, 1993

ROCK DITCH CHECK SUMMARY

LOCATION		CREST ELEVATION	RIPRAP VOLUME (CU. YD.)	RIPRAP QUANTITY (TONS)	GEOTEXTILE (SQ. YD.)
SITE	STATION OR NUMBER				



SECTION A-A
(Not To Scale)



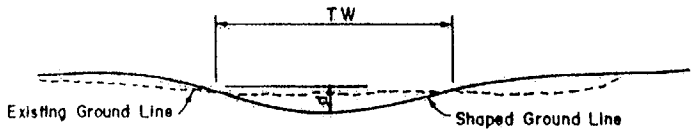
℄ PROFILE ROCK DITCH CHECK
(Not To Scale)

NOTE: Shape Checks To Fit The Ditch At Each Site.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

INDEX NO. AL-IIR-08/85

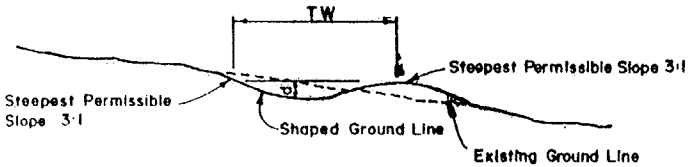
SCS-ENG-313A REV 8-75



VEGETATED WATERWAY SECTION
(TYPICAL)

NOTE:

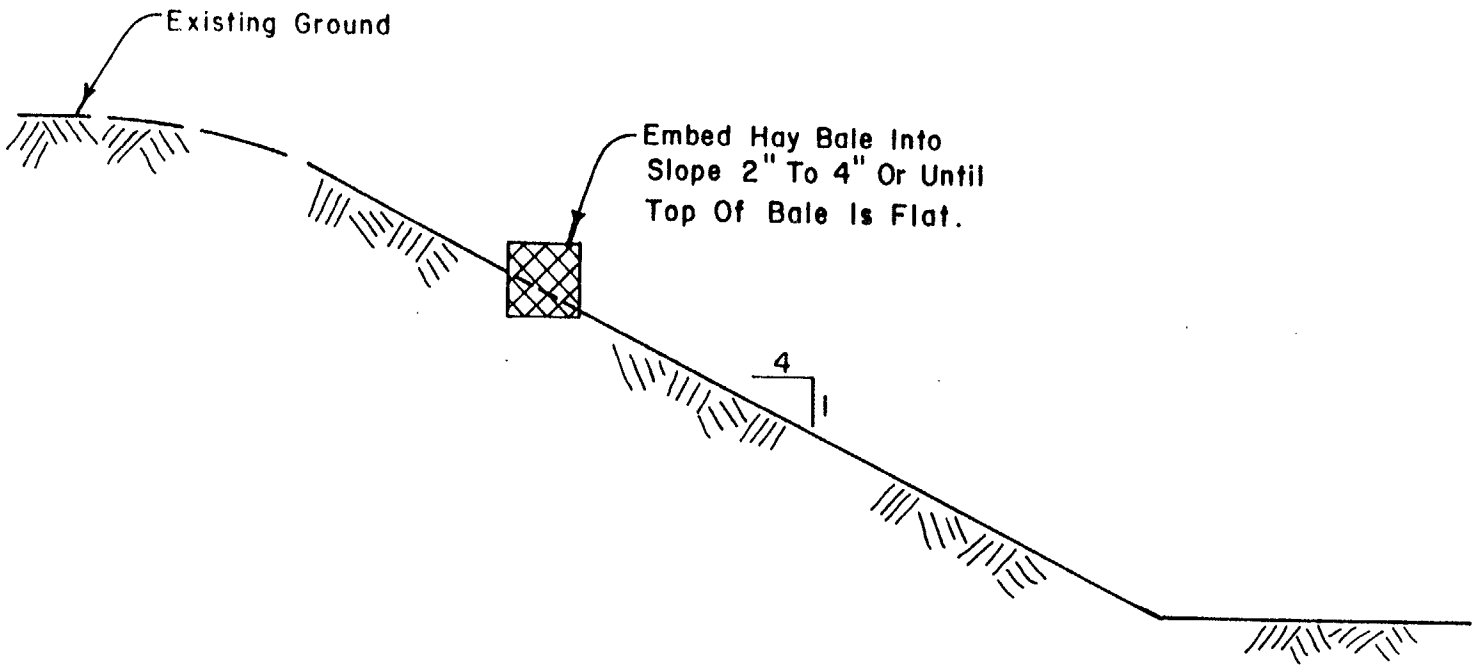
1. The Exact Alignment And Grade Of Waterway And Diversions Will Be Staked By The Engineer.



DIVERSION SECTION
(TYPICAL)

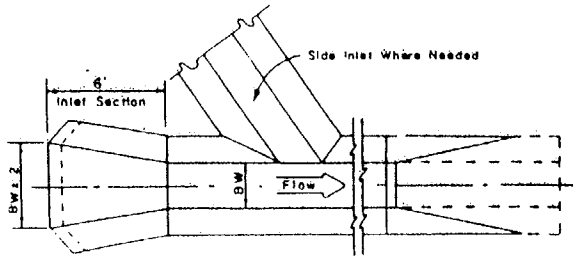
WATERWAY AND DIVERSION SUMMARY

	WATERWAY				DIVERSIONS			
SCHOOL	WATERWAY NO.	MIN. TW.FT.	MIN. d.FT.	LENGTH	DIVERSION NO.	MIN. TW.FT.	MIN. d.FT.	LIN. FT.

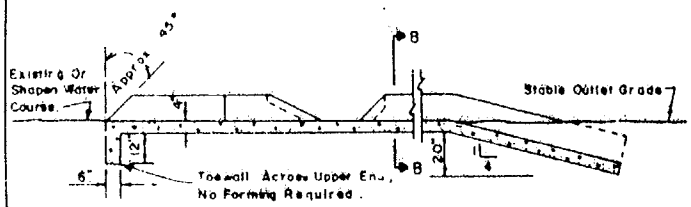


HAY BALE DETAIL

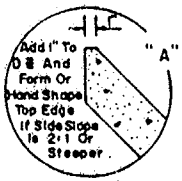
(Not To Scale)



PLAN OF CONCRETE FLUME
(TYPICAL)



SECTION ALONG ℄ OF FLUME
(TYPICAL)



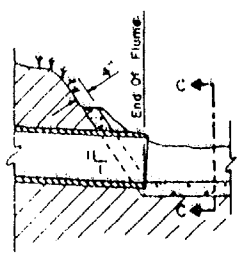
DETAIL "A"

CONCRETE FLUME SUMMARY

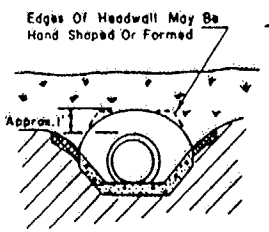
SCHOOL	FLUME NO.	D FT.	BW FT.	Z	VOL / FT. CU. YD. / FT.	LENGTH FT.	INLET OR HEADWALL CU. YD.	TOT. VOL. CU.YD.	BLOCK SOD SQ.YD.

NOTES:

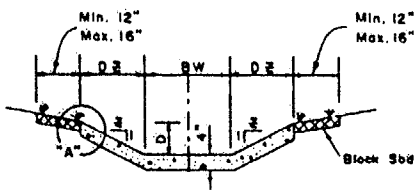
1. Unless otherwise specified, transverse expansion joints of 1/2" preformed joint filler will be placed at maximum intervals of 20'. Joint filler shall conform to ASTM D1751.
2. Where placement of fill is required to prepare subgrade for the flumes, the fill shall be compacted to a density approximately equal to that of the surrounding in place material by methods acceptable to the engineer.
3. Lengths shown for flumes are approximate. Minor adjustments of length may be made by the engineer to fit site conditions.
4. Lengths shown do not include headwalls or the 6' inlet section.
5. The location of side inlets shall be determined by the engineer.
6. Sod shall slope toward flume. Ground line beyond sod shall be sloping toward the flume or level.
7. Block sod quantities are based on 16" width.



℄ SECTION OF PIPE
AT END OF FLUME



SECTION C-C



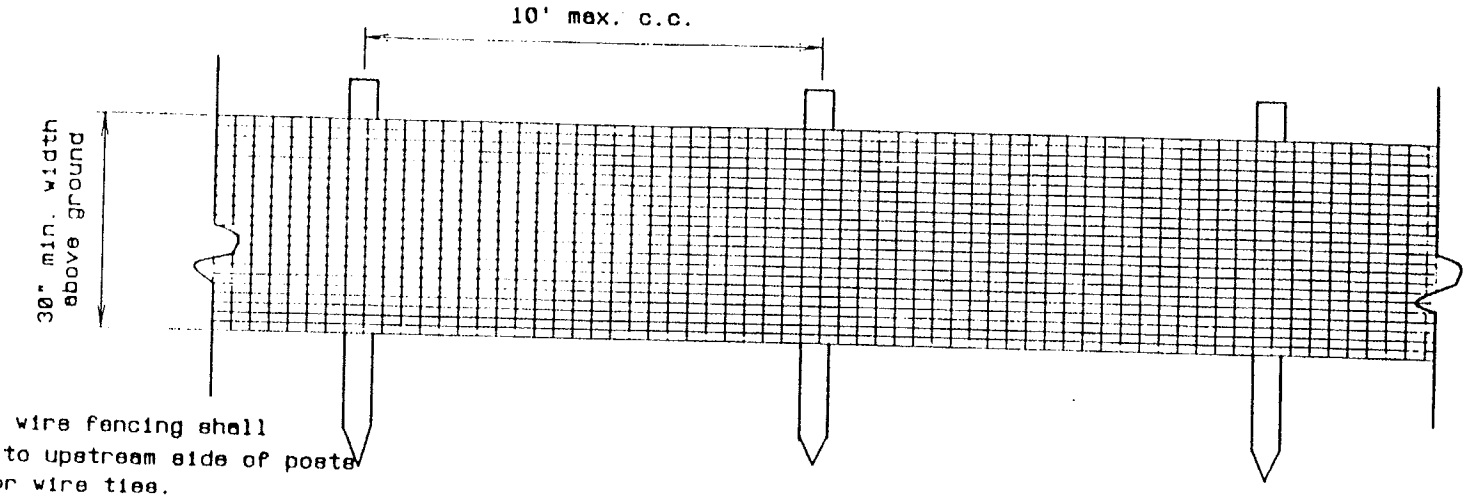
SECTION B-B

CONCRETE FLUME DETAILS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

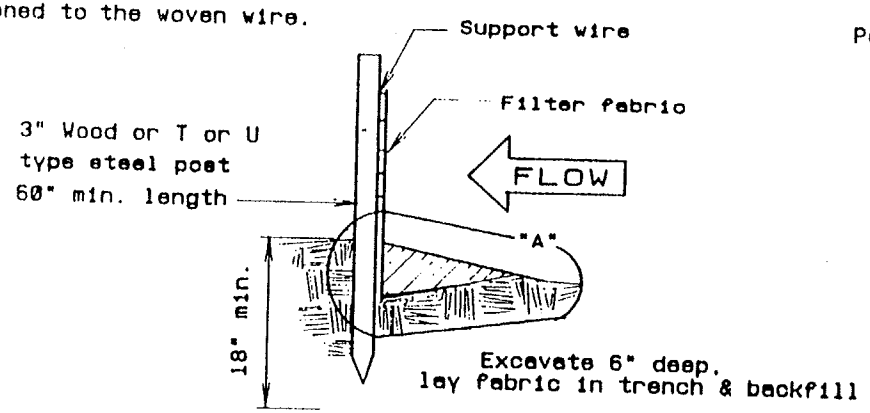
Drawn: Eng. Design Section Auburn, Al. 7/84

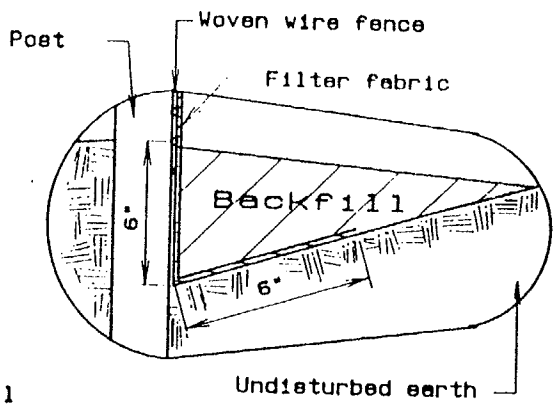
Sheet (1) of (2) INDEX NO. AL-07C-07/84 SCS-ENG-313A REV 8-75



NOTES:

1. The woven wire fencing shall be fastened to upstream side of posts by staples or wire ties.
2. Filter fabric shall be securely fastened to the woven wire.





DETAIL "A"

SILT FENCE DETAIL

Appendix A4 – Information on Installing Vegetative Measures

Appendix A4

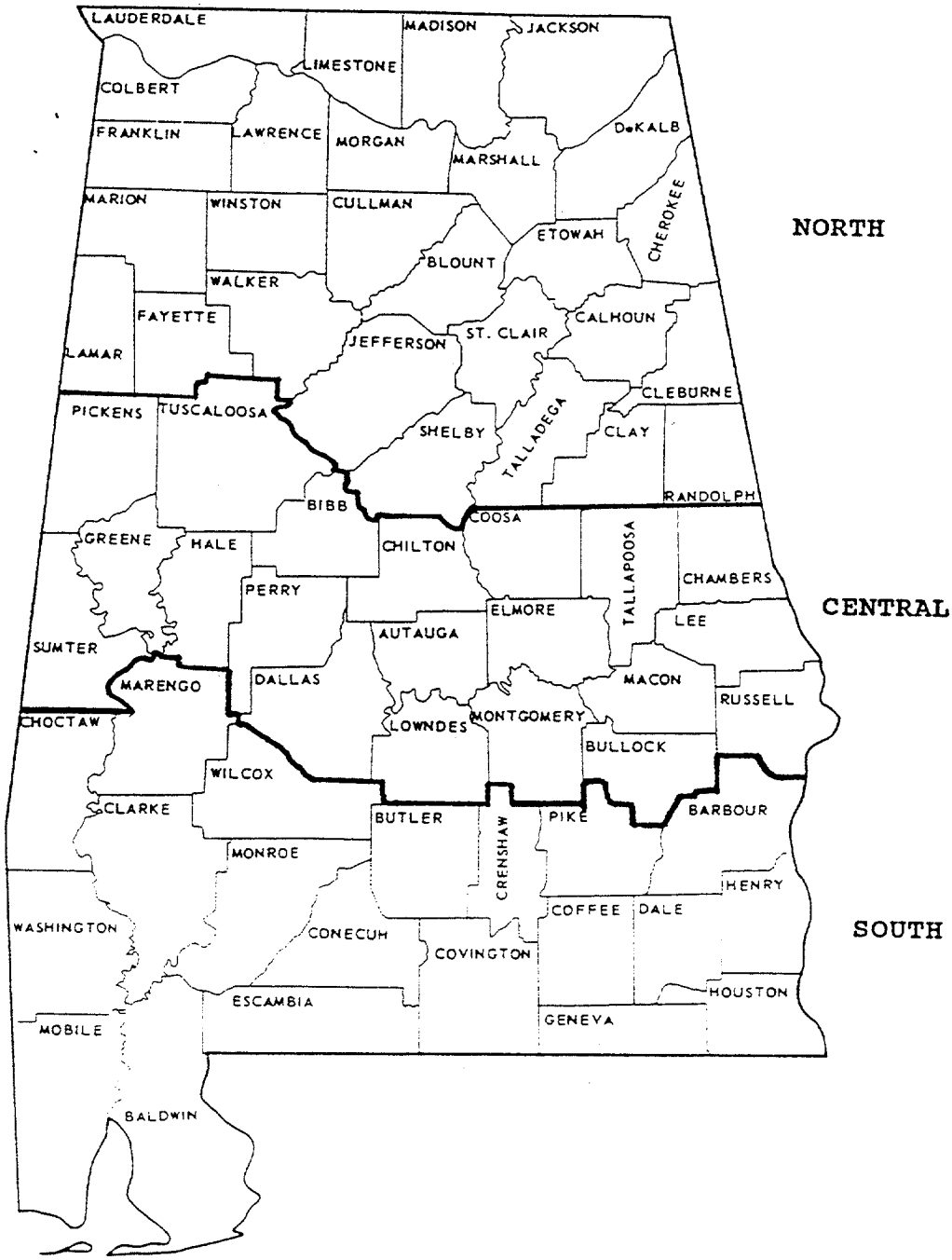
INFORMATION ON INSTALLING VEGETATIVE MEASURES

CONTENTS

	Page
Geographical Areas For Species Adaptation and Seeding Dates	A-IV-PS-1
Perennial Grasses, Legumes and Mixtures; Seeding Rates; and Planting Dates For Disturbed Areas	A-IV-PS-2
Average Annual Minimum Temperature	A-IV-SVG-1
Shrubs, Vines and Groundcovers Suitable for Disturbed Areas to Landscaping	A-IV-SVG-2
Trees Suitable For Disturbed Areas and Landscaping	A-IV-TP-1

July 1, 1993

GEOGRAPHICAL AREAS FOR SPECIES ADAPTATION AND SEEDING DATES



July 1, 1993

PERENNIAL GRASSES, LEGUMES AND MIXTURES; SEEDING RATES; AND PLANTING DATES FOR DISTURBED AREAS

SPECIES	SEEDING RATE/ACRE	PLANTING DEPTH	PLANTING DATES AND ADAPTED AREA			REMARKS
			NORTH	CENTRAL	SOUTH	
		(Inches)				
Bahiagrass, Pensacola	40 lbs	1/4 to 1/2	---	March 1 to July 1	Feb 1 to Nov 1*	Low growing, sod forming & slow to establish. Tolerant to droughty, low fertility sites.
Bermudagrass, Common	10 lbs	1/4 to 1/2	April 1 to July 15	March 15 to July 15	March 1 to July 15	Quick cover, Low growing and sod forming. Intolerant of shade, low fertility & poor management.
Bahiagrass, Pensacola & Common Bermudagrass	30 lbs 5 lbs	1/4 to 1/2	---	March 1 to July 15	March 1 to July 15	Bermuda will provide quick cover until bahia is established.
Bermudagrass, Sprigs Hybrid (Forage Type) or Common	30 bu	2 to 6	April 1 to July 15	March 15 to July 15	March 1 to Aug 15	All hybrids not adapted for North Alabama. Intolerant to low fertility & poor mgt.
Bermudagrass, Hybrid (Lawn Types)	Solid Sod	---	Anytime During year	Anytime During year	Anytime During year	Usually needs irrigation to establish.
Bermudagrass, Hybrid (Lawn Types)	Sprigs - 1 ft.	1/4 to 1/2	March 15 to Aug 1	March 1 to Aug 15	Feb 15 to Sept 1	Usually need irrigation to establish.
Fescue, Tall	D - 40 lbs** B - 50 lbs	1/4 to 1/2	March 1 to April 15 Sept 1 to Nov 1	--- Sept 1 to Nov 1	---	Good shade tolerance & does well on wet sites. Slow to establish. Does not establish well from Spring planting.

(con't)

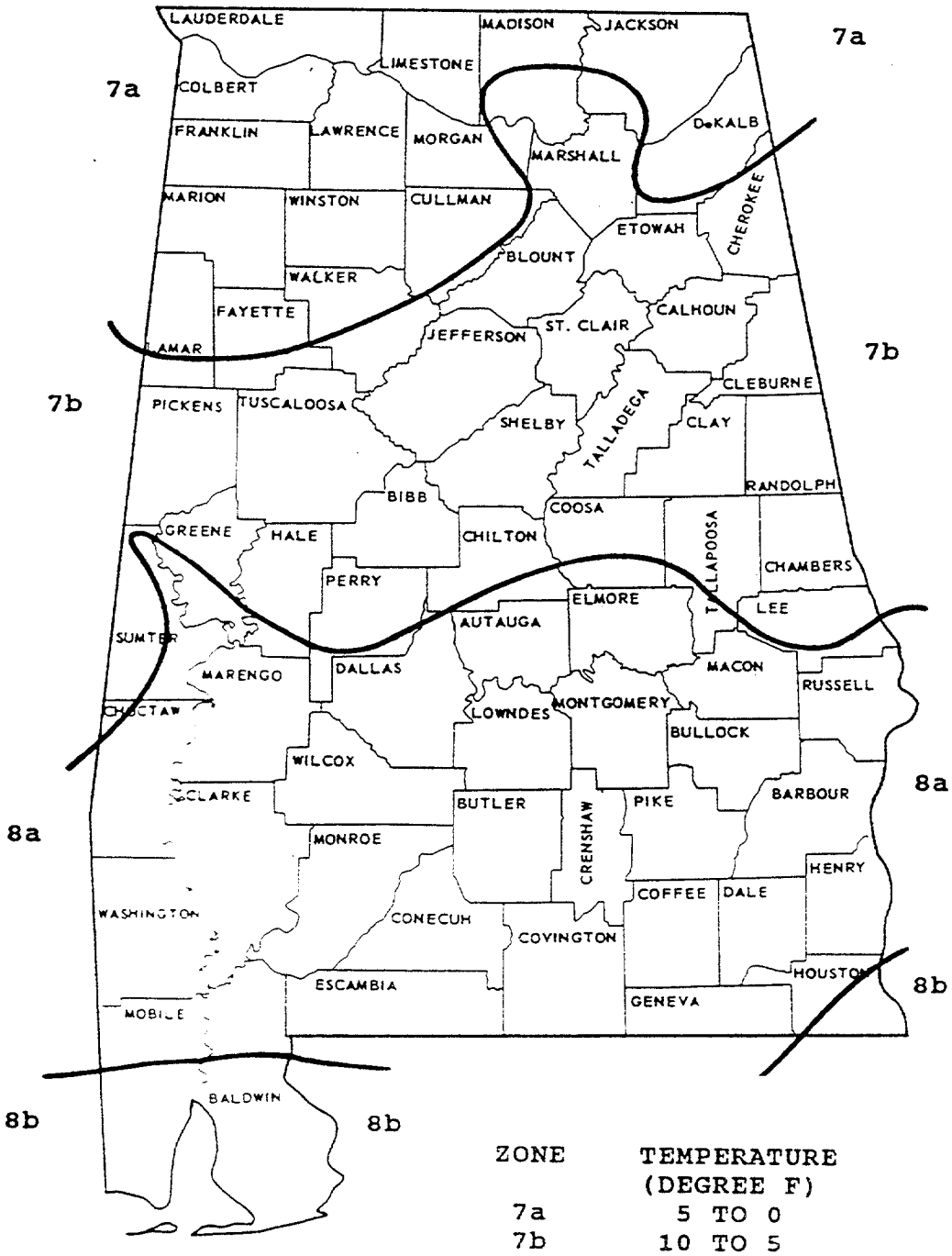
SPECIES	SEEDING RATE/ACRE	PLANTING DEPTH	PLANTING DATES AND ADAPTED AREA			REMARKS
			NORTH	CENTRAL	SOUTH	
Sericea	D - 40 lbs B - 60 lbs	1/4	March 15 to May 15 June 15 to July 15	March 1 to May 15 June 15 to July 15	Feb 15 to May 1 June 15 to July 15	Suited for low maintenance. Well adapted to low fertility soils. Slow to establish.
Sericea & Common Bermudagrass	D-40 lbs, B-60 lbs D & B - 10 lbs	1/4	March 15 to May 15 June 15 to July 15	March 1 to May 15 June 15 to July 15	Feb 15 to May 1 June 15 to July 15	Bermudagrass will provide quick cover until sericea is established.

* Fall planting of bahia should contain 45 pounds of small grain to provide cover during winter months.

** D - drilled, B - broadcast

Notes: 1. Legume seed will be treated with the inoculant specific for the species of legume.

AVERAGE ANNUAL MINIMUM TEMPERATURE



ZONE	TEMPERATURE (DEGREE F)
7a	5 TO 0
7b	10 TO 5
8a	15 TO 10
8b	20 TO 15

A-IV-SVG-1

July 1, 1993

VINES AND GROUNDCOVERS

Botanical Name and Common Name	Normal Height	Growth Rate[1]	Group[2]	Exposure[3]
Akebia quinata Akebia	12-18 in.	F	E	S-PS
Galeobdolon lutea Yellow Archangel	12-14 in.	F	D	PS-Sh
Hedera helix English Ivy	6-8 in.	S-M	E	Sh
Hemerocallis sp. Daylily	1-4 ft.	M	D	S-PS
Hypericum calycinum St. Johnswort	12-18 in.	M	E	S-PS
Juniperus conferta 'Blue Pacific' Shore Juniper	12-18 in.	F	E	S
Juniperus horizontalis Creeping Juniper	12-24 in.	M	E	S
Liriope muscari Liriope	8-15 in.	M	E	S
Ophiopogon japonicus Dwarf Lilyturf or Mondograss	5-6 in.	M	E	Sh
Phlox subulata Moss Phlox or Thrift	4-6 in.	M	E	S
Polygonum aubertii Silver Lace Vine	12-18 in.	F	D	S-PS
Trachelospermum asiaticum Asiatic Jasmine	4-6 in.	M	E	PS
Vinca minor Common Periwinkle	5-6 in.	F	E	Sh
Vinca major Big Leaf Periwinkle	12-24 in.	M	E	PS

[1] Growth Rate: S=slow, M=Medium, F=Fast
[2] Group: D=Deciduous, E=Evergreen
[3] Exposure: S=Sun, PS=Part Shade, Sh=Shade

ORNAMENTAL GRASSES

Botanical Name and Common Name	Height and Spread	Exposure[1]
Carex morrowii Japanese Sedge Grass	1 ft/1 ft.	S to PS
Cortaderia selloana* Pampas Grass	8 ft/6 ft.	S
Cortaderia selloana 'Pumila' Dwarf Pampas Grass	3 ft/4 ft.	S
Erianthus ravennae** Ravenna Grass	9 ft/4 ft.	S
Miscanthus sinensis Chinese Silver Grass	6 ft/3 ft.	S
Miscanthus sinensis 'Gracillimus' Maiden Grass	6 ft/3 ft.	S
Miscanthus sinensis 'Strictus' Porcupine Grass	7 ft/4 ft.	S
Miscanthus sinensis 'Variegatus' Variegated Equalia	6 ft/3 ft.	S
Miscanthus sinensis 'Zebrinus' Zebra Grass	6 ft/3 ft.	S
Pennisetum alopecuroides Australian Fountain Grass	3 ft/2 ft.	S
Pennisetum villosum Feathertop Grass	3 ft/2 ft.	S
Phalaris arundinacea 'Picta' Ribbon Grass/Gardeners-Garters	2 ft/3 ft.	S

* For use only in the southern half of the state.
** For use only in the northern half of the state.

[1] Exposure: S=Sun, PS=Part Shade, Sh=Shade

SMALL SHRUBS (2 FT-5 FT)

Botanical Name and Common Name	Normal Height	Growth Rate[1]	Group[2]	Exposure[3]
Abelia Prostrata Prostrate Abelia	2-3 ft.	M	E	S
Berberis thunbergii Japanese Barberry	4-5 ft.	M	E	Sh to PS
Ilex cornuta 'Carissa' Carissa Holly	3-4 ft.	S	E	S-PS
Ilex cornuta 'Rotunda' Rotunda Holly	3-4 ft.	S	E	S-PS
Ilex crenata 'Compacta' Compacta Holly	3-4 ft.	S	E	S-PS
Ilex crenata 'Green Lustre' Green Lustre Holly	4-5 ft.	M	E	S-PS
Ilex vomitoria 'Nana' Dwarf Yaupon Holly	3-4 ft.	S	E	S-PS
Jasminum floridum* Showy Jasmine	4-5 ft.	M	E	S-PS
Juniperus horizontalis 'Plumosa' Andorra Juniper	2-3 ft.	S	E	S
Nandina domestica 'Harbour Dwarf' or 'Gulf Steam' Dwarf Nandina	2-3 ft.	M	E	S-Sh
Raphiolepis indica* Indian Hawthorne	3-4 ft.	S	E	S
Santolina chamaecyparissus Lavender cotton	2-4 ft.	S-M	E	S
Spirea x bumalda 'Anthony waterer' Anthony Waterer Spirea	3-4 ft.	F	D	S-PS
Spirea thunbergii 'Little Princess' Little Princess Spirea	2-3 ft.	M	D	S

*For use only in southern half of the state

[1] Growth Rate: S=slow, M=medium, F=fast
[2] Group: D=Deciduous, E=Evergreen
[3] Exposure: S=Sun, PS=Part Shade, Sh=Shade

MEDIUM SHRUBS (5-8 FT)

Botanical Name and Common Name	Normal Height	Growth Rate[1]	Group[2]	Exposure[3]
Abelia x grandiflora Abelia	4-5 ft.	S	E	S-PS
Berberis julianae Wintergreen Barberry	5-6 ft.	S-M	E	S
Euonymus alatus 'Compactus'** Dwarf Winged Euonymus	5-6 ft.	S	D	S-PS
Forsythia intermedia Border Forsythia	6-7 ft.	F	D	S
Hydrangea quercifolia Oakleaf Hydrangea	6-8 ft.	M	D	S
Ilex cornuta 'Burfordii Nana' Dwarf Burford Holly	7-8 ft.	S	E	S-PS
Ilex glabra Inkberry Holly	6-8 ft.	M	E	S-Sh
Spiraea prunifolia 'Plena' Bridalwreath Spirea	5-7 ft.	M-F	D	S
Spiraea vanhouttei Vanhoutte Spirea	5-7 ft.	M-F	D	S

[1] Growth Rate: S=slow, M=medium, F=fast
[2] Group: D=Deciduous, E=Evergreen
[3] Exposure: S=Sun, PS=Part Shade, Sh=Shade

** For use only in the northern half of the state.

LARGE SHRUBS (8 FT AND UP)

Botanical Name and Common Name	Normal Height	Growth Rate[1]	Group[2]	Exposure[3]
Buddleia davidii Butterfly Bush	10-15 ft.	M	D	S/Sh
Calycanthus floridus Sweetshrub	8-10 ft.	M	D	S/PS
Elaeagnus pungens 'Reflexa' Bronze Elaeagnus	10-12 ft.	F	E	S/PS
Euonymus alatus Winged Euonymus	12-15 ft.	S	D	S to Sh
Hibiscus syriacus Shrub Althea (Rose of Sharon)	8-12 ft.	M	D	S
Ilex cornuta 'Burfordii' Burford Holly	8-12 ft.	M	E	PS
Myrica cerifera* Southern Waxmyrtle	8-10 ft.	M	E	S-PS
Ternstroemia gymnanthera Cleyera	8-10 ft.	S-M	E	S-PS
Viburnum lantana Wayfaringtree Viburnum	10-15 ft.	M	D	S-PS
Viburnum plicatum var. tomentosum Doublefile Viburnum	8-10 ft.	M	D	S-PS
Viburnum x pragense Prague Viburnum	8-10 ft.	M	D	S-PS

* For use in southern half of the state.

[1] Growth Rate: S=slow, M=medium, F=fast
[2] Group: D=Deciduous, E=Evergreen
[3] Exposure: S=Sun, PS=Part Shade, Sh=Shade

TREES SUITABLE FOR DISTURBED AREAS AND LANDSCAPING

Common Name	pH Range	Mature Height (feet)	Remarks
American Sycamore	4.4-7.5	70-100	Fast growing and good shade
Green Ash	3.5-7.5	60-80	Grows well on alkaline soils
Baldcypress	4.6-7.5	50-70	Grows on wet areas and upland areas
Bradford Pear	5.5-7.5	30-60	Fast growing with spring flowers and fall color
Cherrybark Oak	4.5-6.2	60-100	Good form and shade
Eastern Redcedar	6.0-7.5	30-50	Grows on alkaline soils
Florida Maple	4.5-6.5	50-60	Good fall color in Central and South Alabama
lowering Dogwood	6.0-8.0	15-30	Excellent flowering tree but irrigation is essential for survival of new plantings
Ginkgo	6.0-6.5	50-80	Slow growing, plant only male trees
Live Oak	6.0-7.5	40-80	Evergreen well suited to coastal areas
Loblolly Pine	4.5-6.5	60-100	Best for erosion control
Longleaf Pine	4.5-6.5	50-85	Good for erosion control
Pin Oak	5.0-6.0	60-70	Best suited to North Alabama
Red Maple	4.4-7.5	40-60	Good fall color
Scarlet Oak	6.0-7.0	70-75	Brilliant fall color

Common Name	pH Range	Mature Height (feet)	Remarks
Shumard Oak	4.4-7.5	60-80	Moderate fast growing, tolerates urban conditions
Slash Pine	4.5-6.5	60-100	Good for erosion control but limited to South Alabama
Southern Magnolia	5.0-6.0	60-80	Produces large white flowers
Southern Red Oak	5.0-6.0	60-80	Good form and shade
Sugar Maple	4.5-7.5	60-75	Good fall color in North Alabama
Swamp Chestnut Oak	3.6-6.2	60-80	Good shade, form & color
Water Oak	3.6-6.3	60-100	Fast growing and good shade
White Oak	4.5-6.2	60-80	Good form and shade
Willow Oak	3.6-6.3	60-100	Good shade but small leaves are hard to rake
Virginia Pine	4.5-6.5	60-85	Good for erosion control
Yellow-Poplar	4.5-7.0	70-100	Fast growing, good form with spring flowers

Appendix A5 – Standard Drawing For Measures Used in Stabilizing Coastal Dunes

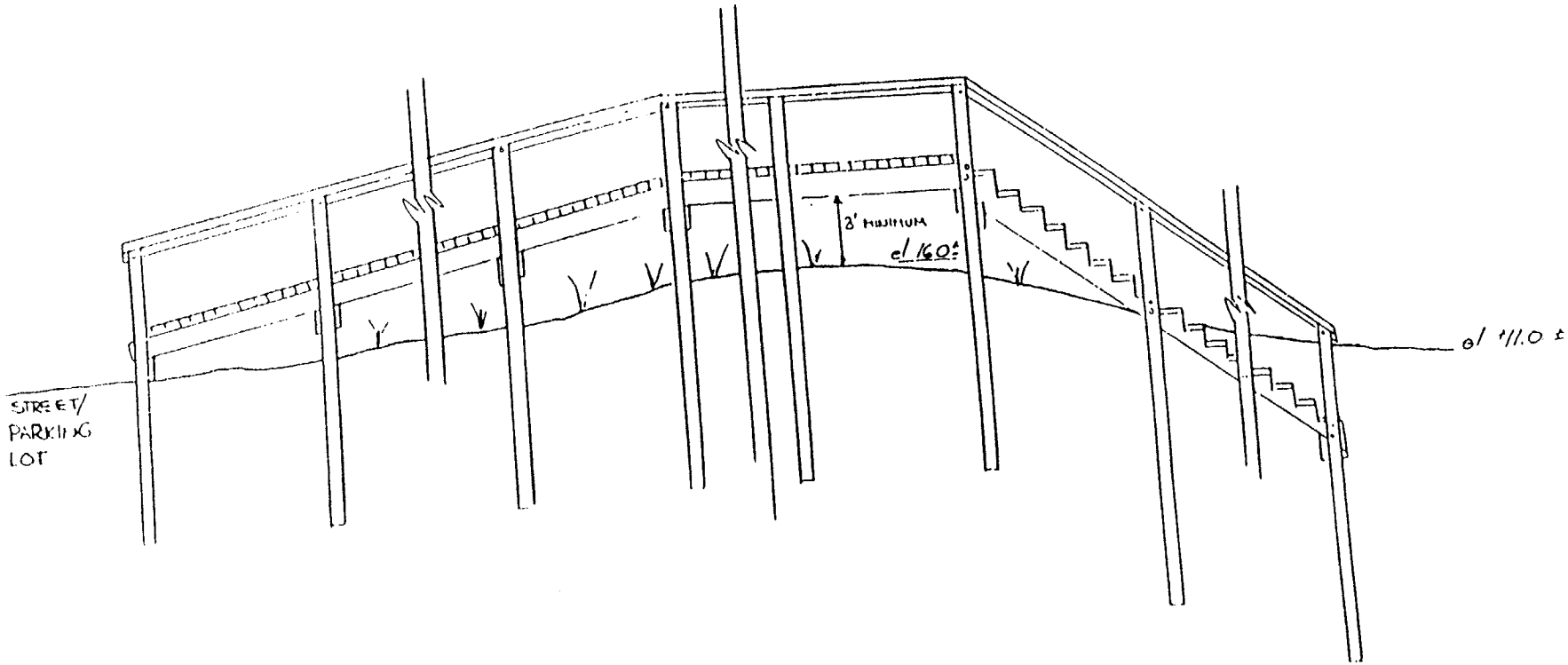
Appendix A5

STANDARD DRAWINGS FOR MEASURES USED IN STABILIZING COASTAL DUNES

CONTENTS

	Page
Dune Crosswalk	A-V-DC-1
Dune Sand Fence	A-V-DSF-1
Plant Guide for Sea Oats (Uniola paniculata)	A-V-DV-1
Planting Guide for 'FLAGEO' Marshhay cordgrass (Spartine patens)	A-V-DV-2
Planting Guide for 'NORTHPA' and 'SOUTHPA' Bitter panicum (Panicum amarum)	A-V-DV-3
Planting Guide for 'ATLANTIC' Coastal panicgrasss (panicum amarum var. amaralum)	A-V-DV-4

July 1, 1993



DUNE CROSSWALK

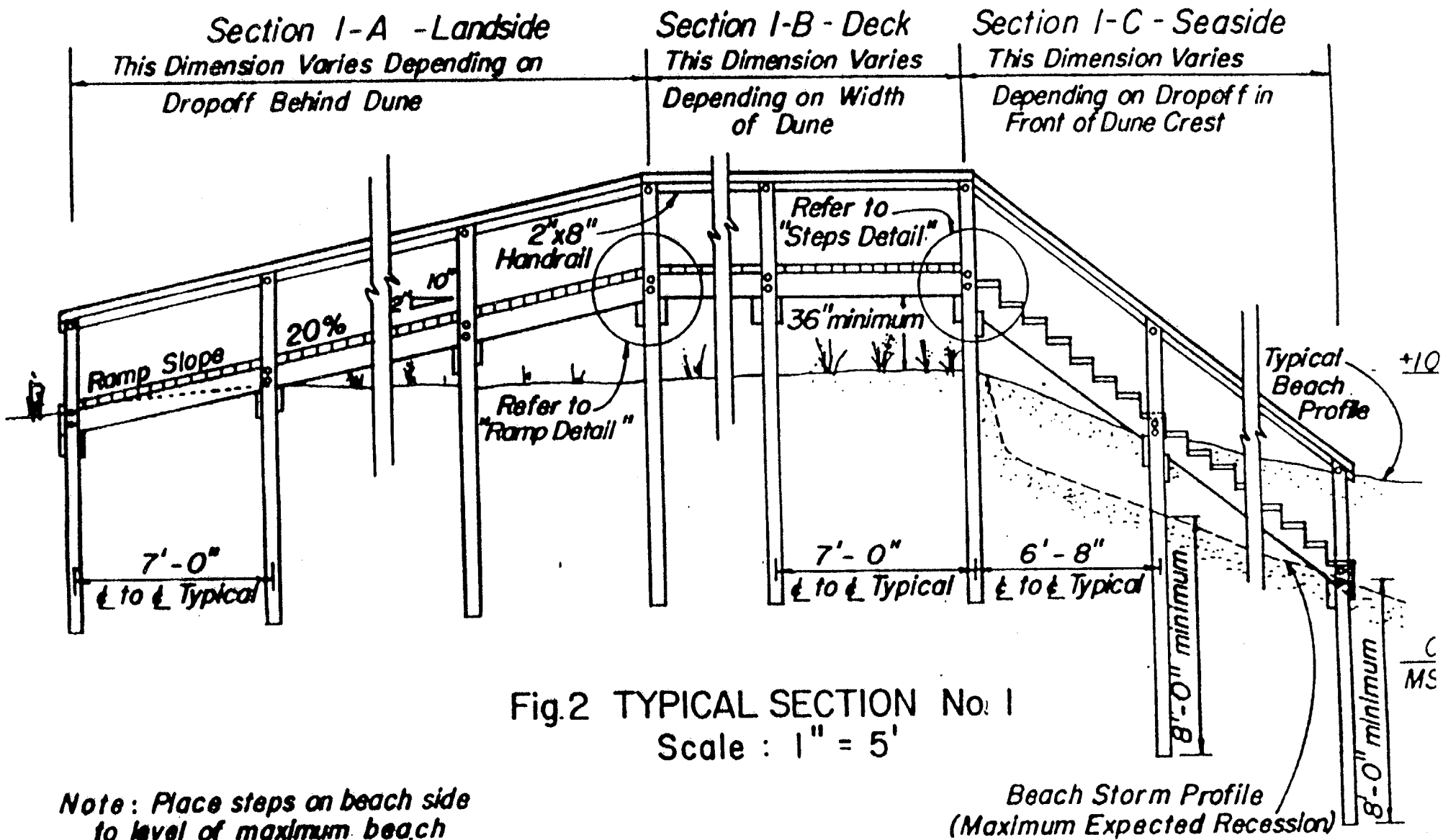
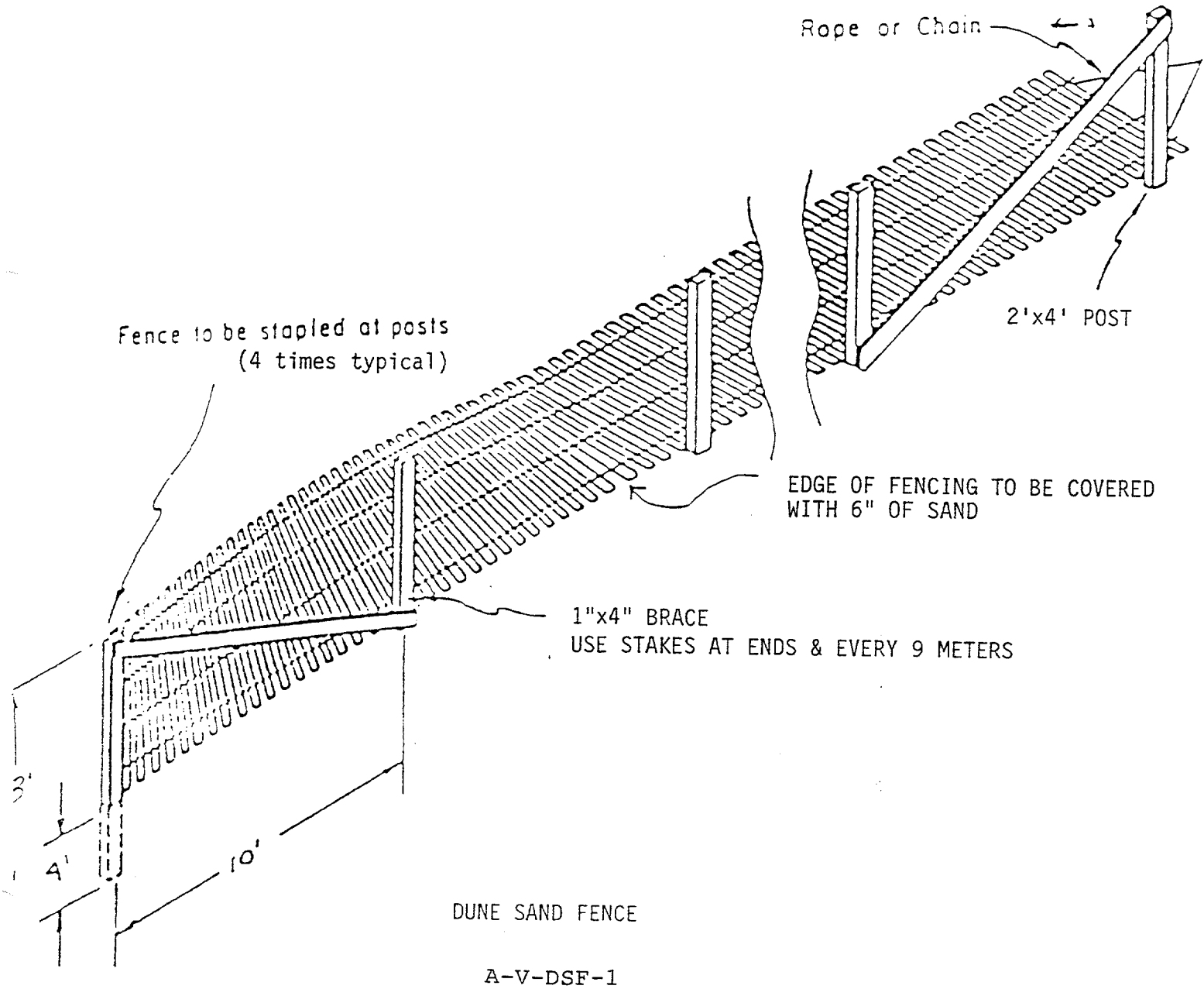


Fig.2 TYPICAL SECTION No. I
Scale : 1" = 5'

Note: Place steps on beach side to level of maximum beach recession during a severe storm or tropical hurricane

A-V-DC-2



DUNE SAND FENCE

A-V-DSF-1

July 1, 1993

PLANTING GUIDE

Sea oats *(Uniola paniculata)*

Description: Perennial, erect, strong, rhizomatous, colonizing grasses native to the coastal sands and dunes of Florida and the southeastern United States. This grass forms in dense, rather stiff, bunches 40 to 60 inches tall and 30 to 120 inches in diameter. Leaves are less than 1/2-inch in width, 16 to 28 inches long, and are usually flat. Leaves are rolled or involute on drying. Panicles of the seedhead are 8 to 12 inches long with numerous spikelets less than 1-inch long, each having 8 to 15 florets. Very little to no seed is produced by most seedheads and is readily eaten by birds. Only rarely is natural reproduction by germination of seed observed. Lateral spread and colony increase is accomplished by moderate to strong rhizome development.

Sea oats

- **Native Habitat and Range:** Sand dunes from southern Virginia to Florida and Texas.

- **Conservation Use:** Critical area stabilization of saline coastal sands and sand dunes.

- **Site Preparation:** Generally none required.

- **Plant Material:** Potted plants and bare root stock are available commercially and from vigorous stands. Use transplants with a minimum 30-inch stem height.

- **Time of Planting:** Late winter to early spring, and at the beginning of the rainy season in Florida.

- **Spacing:** Place plants 12 to 36 inches apart, depending on the pot size and severity of the site. Use 18-inch spacing for an average site using 2- to 4-inch pots.

- **Depth:** Place plants 8 to 12 inches, or deeper, in moist soil.

- **Fertilizer:** Place one ounce of slow release fertilizer such as **Osmocote* in each hole as material is planted, or apply 200 to 300 pounds of 10-10-10 per acre 3 to 4 weeks after planting. To maintain and/or develop the stand, apply 200 to 300 pounds of 10-10-10 (or equivalent) per acre annually June 1 to June 15 and repeated August 1 to August 15.

- **Maintenance:** Minimize foot traffic and remove debris from planting.

** Other commercial fertilizers of the same analysis and with a slow release formulation may also be used.*

PLANTING GUIDE

'FLAGEO' Marshhay cordgrass *(Spartina patens)*

Description: Perennial, warm season grass with erect stems, mostly less than 40 inches tall. It spreads by long slender rhizomes. Leaves are less than 1/8-inch wide and are sometimes flat, but usually roll inward from the edges with the upper surface inside. There are 2 to 7 spikes on the seedhead. These 3/4- to 2-inch spikes are born against or away from the stem.

- **Native Habitat and Range:** Salt marshes and sandy meadows from Quebec, Canada to Florida and Texas, and saline marshes inland from New York to Michigan.

- **Conservation Use:** Saltmeadow cordgrass is used for coastal erosion control in backdune areas, along tidal river banks, and on salt marshes above the high tide line. Inland uses include stabilizing waterways, gullies, roadsides, and minespoil and saline oil seep areas. The 'salt hay' is used as a mulch and is fed to cattle.

- **Site Preparation:** None required, but removal of trash on tidal areas will prevent burial of plants.

- **Plant Material:** Potted plants or bare root stock are available commercially and from vigorous stands. Use transplants tht have 5 to 10 stems each.

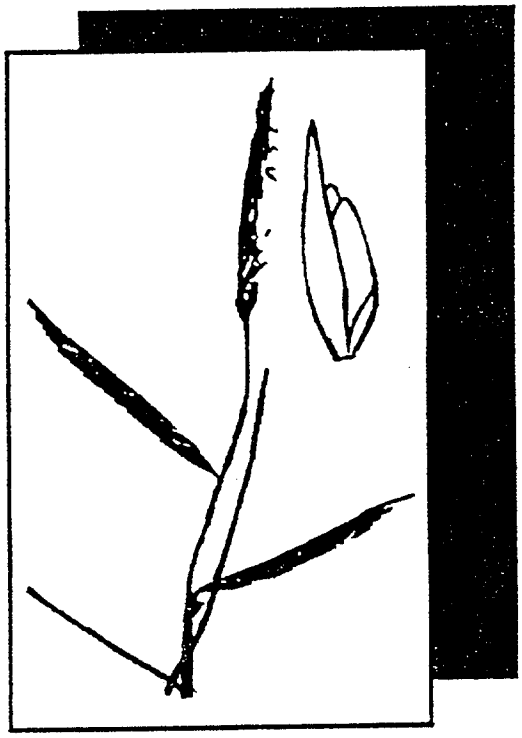
- **Time of Planting:** Late winter and early spring, and at the beginning of the rainy season in Florida.

- **Spacing:** Place plants 12 to 24 inches apart, depending on severity of site.

- **Depth:** Plant 6 to 8 inches, or deeper, in moist soil.

- **Fertilizer:** On critical area plantings, place one ounce of slow release fertilizer such as **Osmocote* per plant at planting, or apply 200 to 300 pounds of 10-10-10 per acre several weeks after planting. Apply 200 to 300 pounds of 10-10-10 per acre annually in June until the stand fills in the spacing. Do not fertilize rangeland plantings.

- **Maintenance:** Minimize foot traffic and remove debris from planting.



Marshhay cordgrass

** Other commercial fertilizers of the same analysis and with a slow release formulation may also be used.*

PLANTING GUIDE

'NORTHPA' and 'SOUTHPA' Bitter panicum (*Panicum amarum*)

Description: Perennial, warm season grass growing to a height of 7 feet with a growth habit ranging from erect to prostrate. The leaves are 1/4- to 1/2-inch wide, 7 to 20 inches long, smooth without hair, and bluish in color. This robust grass spreads slowly from short, strong rhizomes, forming open clumps. Small quantities of poor quality seed are produced on compact panicles 6 to 12 inches long and 2 to 4 inches wide.

Bitter panicum

- **Native Habitat and Range:** Coastal dunes and sandy shores from New Jersey to Florida and Texas.

- **Conservation Use:** The principal use is in coastal dune erosion control and it may have a role in stabilizing other dry, sterile areas such as roadsides and minespoils.

- **Site Preparation:** Generally none required.

- **Plant Material:** Potted and bare root plants are available commercially. Freshly dug bare root tillers, rooted stem cuttings, and uprooted stem cuttings can also be obtained from vigorous stands.

- **Time of Planting:** Late fall with stem cuttings; late winter or early spring with potted plants; late spring with young tillers (when it coincides with the rainy season).

- **Spacing:** Plant potted and bare root material 2 feet apart in 2 to 3 foot staggered rows. Plant stem cuttings three to a hole 2 feet apart in 2 to 3 foot staggered rows.

- **Depth:** Place plants 4 to 10 inches, or deeper, in moist soil. Plant stem cuttings at a 45-degree angle, deep enough to bury several nodes and leaving the top 6 to 10 inches of stem exposed.

- **Fertilizer:** Place one ounce of slow release fertilizer such as **Osmocote* in each hole as material is planted, or apply 200 to 300 pounds of 10-10-10 per acre 3 to 4 weeks after planting. Apply this same rate annually in June and repeat in August, until the stand fills in the spacing.

- **Maintenance:** Restrict traffic and livestock. Overgrazing and high palatibility were responsible for the decrease of this plant in the 19th century.

* *Other commercial fertilizers of the same analysis and with a slow release formulation may also be used.*

PLANTING GUIDE

'ATLANTIC' Coastal panicgrass (*Panicum amarum var. amarulum*)

Description: A strong, perennial, short rhizomatous, salt-spray tolerant grass with numerous medium textured, erect stems 3 to 7 feet or more in height. Produces moderate to abundant numbers of medium textured bluish-green leaves 3/4 to 1 inch wide by 12 to 20 inches long. Radial lateral spread is 4 to 8 inches annually. Seedheads 4 to 8 feet in height are produced in late July through August or September. The seed is eagerly sought by doves and quail. Volunteer seedlings occasionally occur without soil disturbance.

- **Native Habitat and Range:** Coastal dunes throughout the south Atlantic and Gulf regions.

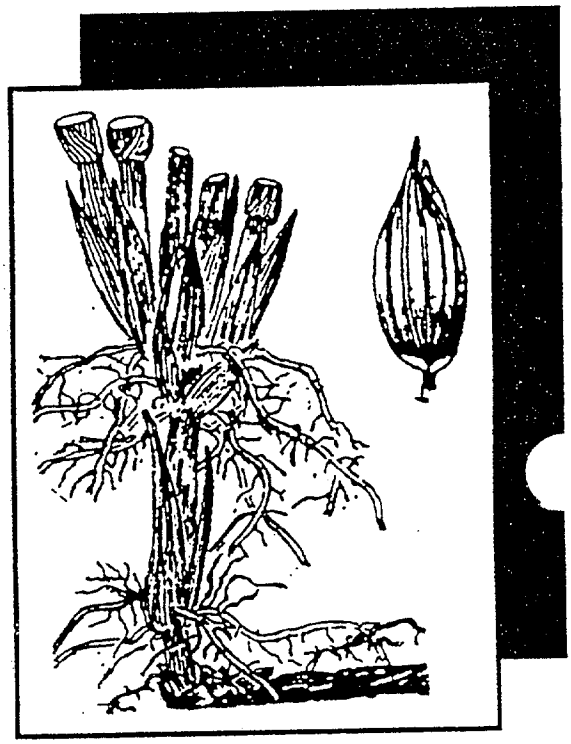
- **Conservation Use:** Coastal panicgrass is used primarily in coastal dune stabilization, but has shown promise in vegetating other droughty, sterile areas such as sandpits and minespoils.

- **Site Preparation:** To prepare a seedbed, the soil should be plowed, disked, and packed. Bare soil can be broadcast seeded followed by harrowing or light disking to cover the seed. Vegetative plantings into bare soil can be made using a shovel or dibble.

- **Plant Material:** Freshly dug bare root tillers (sprigs) or seed are available commercially.

- **Time of Planting:** Plantings should be made November 1 to March 1, or June 1 to September 1 when it coincides with the rainy season.

- **Spacing and Seeding Rates:** Tillers (sprigs) should be planted in rows 6 to 8 feet apart and spaced about 18 inches apart in the rows. About 5,000 tillers per acre are required for this type of planting. Use 10 to 15 pounds of seed per acre drilled or 20 pounds per acre broadcast.



Coastal panicgrass

- **Depth:** Seed at 1 to 3 inches depth. Plant tillers so the roots are well distributed in moist soil and the crowns are covered with 1/2- to 1-inch soil. Pack firmly.

- **Fertilizer:** Fertilize winter plantings at planting time. Apply 400 pounds of 10-10-10 per acre or equivalent, plus minor elements, in the spring. Repeat this fertilization in mid- to late summer. For summer plantings, place one ounce of slow release fertilizer such as **Osmocote* in each hole as material is planted, or apply 200 to 300 pounds of 10-10-10 per acre 3 to 4 weeks after planting. Apply the same rate and kind June 1 through 15 and August 1 through 15, annually, until the stand fills in the spacing.

- **Maintenance:** Minimize foot traffic and remove debris from planting.

** Other commercial fertilizers of the same analysis and with a slow release formulation may also be used.*

Appendix A6 – Information for Designing Stormwater Management Measures

Appendix A6

INFORMATION FOR DESIGNING STORMWATER MANAGEMENT MEASURES

CONTENTS

Page

Chapter 2
Alabama Engineering Field Design Manual .....

TR-55
Urban Hydrology for Small Watersheds .....

Diversion Design A-VI-DV-1

Outlet Protection Design A-VI-OP-1

Riprap Design in Channels A-VI-RR-1

Sediment Basin Design A-VI-SB-1

Design Procedures for Vegetated Waterway
or Stormwater Conveyance Channel A-VI-WW-1

July 1, 1993

ALABAMA ENGINEERING FIELD (DESIGN) MANUAL

Chapter 2. Estimating Runoff

Contents

	Page
Steps In Estimating Runoff	2-1
1. Watershed Area	2-1
2. Watershed Slope Factor	2-1
3. Runoff Curve Number (RCN)	2-1
A. Determine soil types in watershed	2-1
B. Land use and treatment or practice	2-1
C. Hydrologic conditions	2-1
D. Select appropriate runoff curve number	2-3
E. Weighted curve number	2-3
4. Job Class	2-3
5. Minimum Hydrologic Criteria for Design	2-3
6. Rainfall Amount	2-4
7. Runoff	2-4
8. Peak Discharge	2-4
9. Alternate Method using AL-ENG-28	2-4
9b. Alternate Method Using Rainfall Distribution Type III	2-15
10. Adjustment Factors for Various Slopes and Drainage Areas for Peak Discharge	2-21
11. Adjustment Factors for Swampy and Ponding Areas	2-21
A. Land on slopes of 0-2%	2-21
B. On flat watersheds	2-24
12. Urban Hydrology	2-25
Procedure for Computing runoff for Drainage Areas Less Than Five (5) Acres	2-27

Figures

Figure 2- 1	Soil Map or Aerial Photograph for The Design of A Pond	2-2
Figure 2- 2	Estimating Direct Runoff Amounts from Storm Rainfall in Inches	2-9
Figure 2- 3	Estimating Direct Runoff Amounts from Storm Rainfall in Inches	2-10
Figure 2- 4	Tentative Rainfall Distribution	2-16
Figure 2- 5	Peak Discharge For SCS Type III Rainfall Flat Slope	2-17
Figure 2- 6	Peak Discharge For SCS Type III Rainfall Moderate Slope	2-18

Figures Cont.

		Page
Figure 2-7	Peak Discharge For SCS Type III Rainfall Steep Slope	2-19
Figure 2-8	Peak discharge rates for flatland areas	2-26

Tables

Table 2-1	Slope Factors for Peak Discharge	2-4
Table 2-2	Hydrologic Soil Groups For Alabama	2-5
Table 2-3	Runoff curve numbers for hydrologic soil-cover complexes and management practices	2-8
Table 2-4	Rainfall (Inches) - Frequency for 24-hour Periods	2-11
Table 2-5	Rainfall-Runoff Relation	2-13
Table 2-6	Determination of Peak Discharges Obtained From Exhibit 2-1 For Runoff Curve Numbers _ 60	2-14
Table 2-7	IA/Rainfall For Selected Curve Numbers	2-15
Table 2-8	Interpolation Factors for Various Slopes and Drainage Areas	2-20
Table 2-9	Interim Peak Discharge in CFS Per Inch of Runoff	2-22
Table 2-10	Adjustment factors where ponding and swampy areas occur at the design point	2-23
Table 2-11	Adjustment factors where ponding and swampy areas are spread throughout the watershed or occur in central parts of the watershed	2-23
Table 2-12	Adjustment factors where ponding and swampy areas are located only in upper reaches of the watershed	2-23
Table 2-13	Runoff curve numbers for selected agricultural, suburban, and urban land use	2-27

Exhibits

Exhibit 2-1	Peak Rates of Discharge for Small Watersheds Type II Storm Distribution	2-28

ALABAMA ENGINEERING FIELD (DESIGN) MANUAL

CHAPTER 2. ESTIMATING RUNOFF

STEPS IN ESTIMATING RUNOFF

1. Watershed Area

Scale, or planimeter total watershed area contributing runoff.

Example: Small, earth-fill dam is proposed. Delineate the watershed area on an aerial photograph and by scaling or planimetering, determine that 45 acres contribute runoff above the proposed dam site. See Figure 2-1.

2. Watershed Slope Factor

Use topographic maps, soil survey, level, and/or visual inspection to determine average watershed slope. Slope as used in this method for computing peak discharge means primarily average watershed slope in the direction of overland flow. Slope is readily available at most locations from existing soil survey data. (See Fig. 2-1) On large watersheds the gradient of the stream channel becomes an additional consideration in determining the average slope and estimating time of concentration. With the average slope enter Table 2-1, and determine the slope factor.

Example: The average slope for a 45-acre watershed is 6 percent. From Table 2-1, the slope factor is moderate.

3. Runoff Curve Number (RCN)

A. Determine soil types in watershed

Enter Table 2-2 to find hydrologic soil group for each type soil.

Example: A watershed has 45 acres of Pacolet soil. The hydrologic soil group, from Table 2-2 is B.

B. Land use and treatment or practice

Example: A 45-acre watershed consists of 25 acres of pasture on Pacolet soil which is contoured and terraced. The remaining 20 acres are in woods on Pacolet soil.

C. Hydrologic conditions

Classify good, fair, or poor based on visual inspection of crop residues, farming methods, residual root systems, foliage and its litter. In grassland, a good vegetative cover exists if 75% or more of the ground is covered.

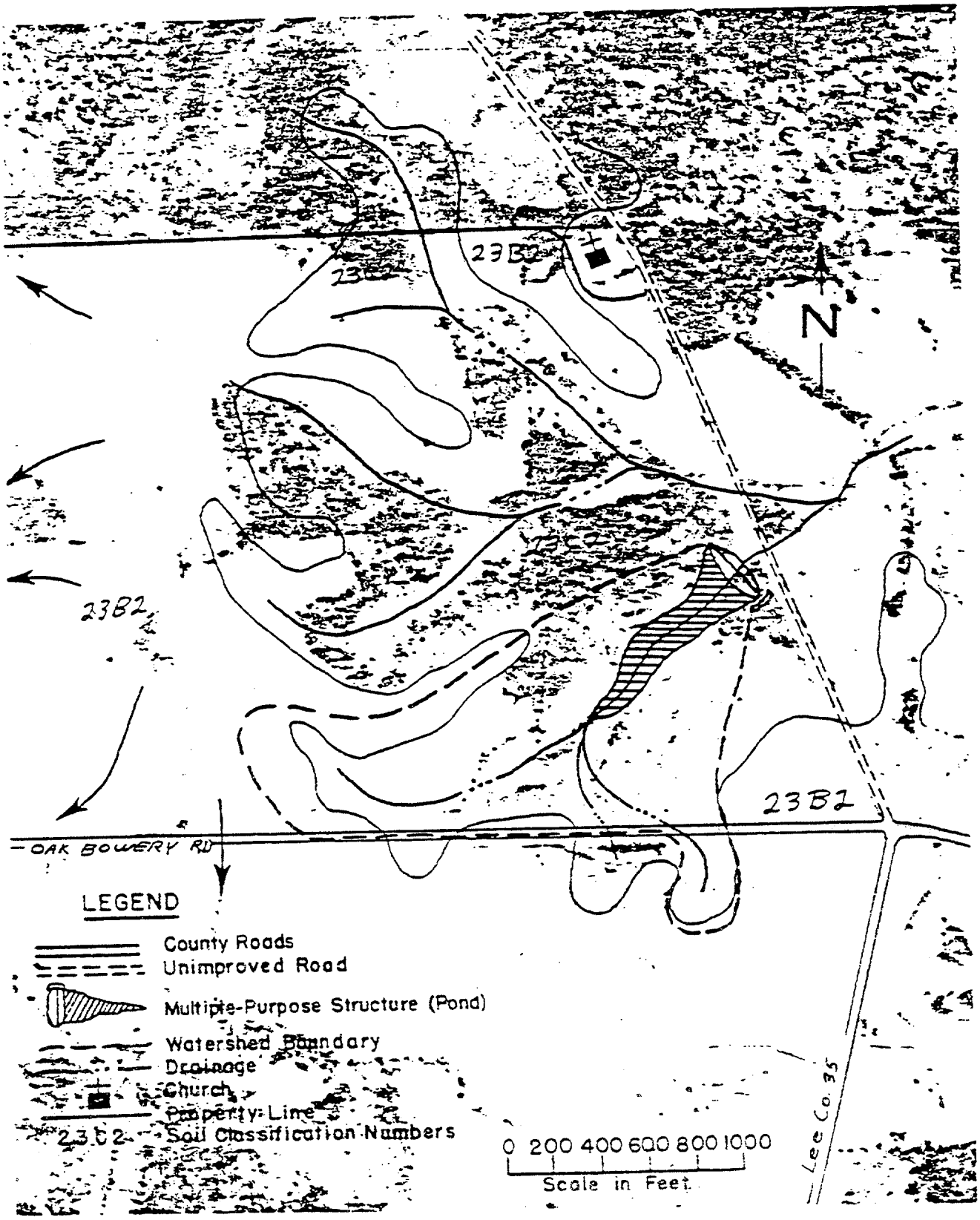


Figure 2-1 SOIL MAP OR AERIAL PHOTOGRAPH FOR THE DESIGN OF A POND

Fair condition exists when 50 to 75% of the ground is covered. A poor condition exists if less than 50% of the ground is covered.

Example: If the farmer rotates crops, deep plows, and uses minimum tillage techniques, the row cropland is in good hydrologic condition.

D. Select appropriate runoff curve number

Enter Table 2-3 with factors obtained previously in Steps 3A, 3B, and 3C.

Example: 25 acres of pasture, contoured and terraced, with fair hydrologic conditions and hydrologic soil group B gives a runoff curve number of 59.

E. Weighted curve number

Example: A 45-acre watershed has 20 acres of woods on Hydrologic soil group B. The hydrologic condition is fair. The remaining 25 acres are contoured and terraced pasture on Hydrologic soil group B. The hydrologic condition is fair. Enter Table 2-3 to obtain curve numbers. Record data on AL-ENG 28

20 acres @ CN 60 = 60 x 20 = 1200
20 acres @ CN 59 = 59 x 25 = 1475
Total = 2675

$$\text{Weighted curve No.} = \frac{2675}{45} = 59.4 \text{ Use } 60$$

4. Job Class

Use Engineering Job Approval Classification Chart, and personal knowledge of the situation such as roads, building, etc. to determine job class.

5. Minimum Hydrologic Criteria for Design

For dams use National Engineering Manual or standards. For other structures use design criteria in the appropriate Engineering Standard.

Example: For a grassed waterway or outlet, check Engineering Standard 412. Use the peak runoff expected from a 10-year, 24-hour frequency storm. For a Class I pond to be used for fish production, check Engineering Standard 378, design the principal spillway and the emergency spillways for the 5-year and 25-year, 24-hour frequency storm, respectively.

6. Rainfall Amount

With location and minimum hydrologic criteria (Step 5) enter Table 2-4 to determine rainfall amount.

Example: A pond is to be designed in Lee County. From Table 2-4, the rainfall amount for a 5-year and 25-year, 24-hour frequency storm is 5.4 and 7.3 inches, respectively.

7. Runoff

Use the runoff curve number determined in Step 3 and the rainfall amount from Step 6. Enter Table 2-5 or Figure 2-2 or 2-3 to determine runoff.

Example: The watershed for a pond has a CN of 60. The rainfall amount in this county for a 5-year, 24-hour storm is 5.4 inches. From Table 2-5, the runoff will be 1.54 inches. Also see alternate method example problems.

8. Peak Discharge

To determine the peak discharge for a particular watershed, use the Drainage Area (Step 1), Watershed Slope Factor (Step 2), Runoff Curve Number (Step 3), and Rainfall Amount (Step 6). Enter the appropriate sheet of Exhibit 2-1 to determine peak discharge.*

Example: Determine peak discharge for the following watershed - DA - 45 acres, slope factor (4%) - moderate, runoff curve - No. 60, rainfall amount - 7.3 inches. Enter sheet 8 of 21, Exhibit 2-1. Peak discharge is 72 cfs.

*For watersheds having a curve number less than 60, use 60. When unusual conditions occur for large drainage areas and the curve number is less than 60, refer to Table 2-6 for ratio and example.

Table 2-1 Slope Factors for Peak Discharge

Average Slope Range in Percent	Slope Factors
0-3	Flat
3-8	Moderate
8 and above	Steep

9. Alternate Method for determining peak rate of runoff and volume of runoff using AL-ENG 28 Peak Runoff Computation Work Sheet.

TABLE 2-2

HYDROLOGIC SOIL GROUPS FOR ALABAMA

Alaga A
Albany C
Albertville C
Aloca B
Allen B
Alpin A
Altavista C
Americus A
Amite B
Amy D
Angie C
Annemaine C
Anniston B
Apison B
Appling B
Ardilla C
Armour B
Atkins D
Atmore B/D
Augusta C
Aycock B
Bama B
Barbourville B
Barfield D
Barth C
Basin C
Bassfield B
Baxter B
Banterville B
Bayboro D
Beason D
Benndale B
Bewleyville B
Bibb C
Bigbee A
Binnsville D
Bladen D
Blaney B
Blanton A
Bodine B
Bomar C
Boswell D
Bowie B
Bradley B
Brantley C
Bremo C
Brewton C
Brilliant B
Bruno A
Buncombe A
Butusha C
Byars D
Cahaba B
Camp B
Cane C
Canton Bend C
Capshaw C
Captina C
Carnegie C
Cartecay C
Catalpa C
Cecil B
Cedarbluff C
Chandler B
Chastain D
Chattahoochee B
Cheaha D
Chenneby C
Chesterfield B
Chewacla C
Chipley C
Christian C
Choccolocco B
Clarkesville B
Cloudland C
Colbert D
Colfax C
Conasauga C
Congaree B
Cowarts C
Coxville D
Craven C
Crevassee A
Crossville B
Cumberland B
Cuthbert C
Davidson B
Decatur B
DeKalb C
Dellrose B
Demopolis C
Dewey B
Dickson C
Dierks B
Doravan D
Dothan B
Dowellton D
Ducker B
Dulac C
Dunbar D
Dunning D
Duplin C
Durham B
Edgemont B
Egam C
Ellisville B
Emory B
Enders C
Ennis B
Escambia C
Esto B
Etowah B
Eunola C
Eustis A
Eutaw D
Exum C
Faceville B
Fairhope C
Falaya D
Fannin B
Firestone C
Flint C
Flomaton A
Forestdale D
Freemanville B
Fruithurst C
Fullerton B
Fuquay B
Garner D
Gaylesville D
Geiger D
Georgeville B
Gilead C
Goldsboro B
Gorgas D
Grady D
Grasmere B
Greendale B
Greenville B
Grover B

B/D = Drained-Undrained Condition.

TABLE 2-2

Guin A	Leefield C	Newark C
Gunter B	Leesburg B	Nolichucky B
Guthrie D	Leeper D	Norfolk B
Gwinnett B	Lehew C	Notcher B
Hamblen C	Lenoir D	Ochlockonee B
Hanceville B	Leon B/D	Ocilla C
Harleston C	Lindside C	Okenee D
Hartsells B	Linker B	Oktibbeha D
Hayesville B	Litz C	Ora C
Hector D	Lloyd B	Orangeburg B
Heidel B	Lobelville C	Osier A/D
Helena C	Locust C	Pace B
Henderson B	Louisa B	Pacolet B
Herndon B	Louisburg B	Palmerdale B
Hiwassee B	Lucedale B	Pansey D
Hoffman C	Lucy A	Paraloma C
Hokesbluff B	Luverne C	Pearman C
Hollywood D	Lynchburg C	Pelham B/D
Holston B	Macon B	Pheba C
Houlka D	Madison B	Philco C
Houston D	Magnolia B	Pikeville B
Hulett B	Malbis B	Pine Flat B
Humphreys B	Mallory C	Pinson B
Huntington B	Mantachie C	Pirum B
Huxford C	Marietta C	Plummer B/D
Hyde B/D	Marlboro B	Poarch B
Iredell C/D	Masada C	Ponzer D
Irvington C	Mashulaville B/D	Pope B
Iuka C	Maury B	Portsmouth B/D
Izagora C	Maxton B	Pottsville D
Jefferson B	Mayhew D	Prader D
Johns C	NcLaurin B	Prentiss C
Johnsburg D	McQueen C	Purdy D
Johnston D	Mecklenburg C	Quitman C
Jones B	Melvin D	Rains B/D
Kalmia B	Mimosa C	Ramsey D
Kaufman D	Minter D	Rarden C
Kenansville A	Minvale B	Red Bay B
Kershaw A	Molena A	Remlap C
Ketona D	Monongahela C	Riverview B
Kipling D	Montevallo D	Roanoke D
Kirvin D	Mora Bay D	Robertsdale C
Klej B	Mooresville C	Robertsville D
Lakeland A	Mountainburg D	Rumford B
Lakewood A	Muse B	Ruston B
Latonia B	Musella B	Rutlege B/D
Lauderdale D	Muskingum C	Sacul C
Lawrence B/D	Myatt D	Saffell B
Leadvale C	Nauvoo B	Sango C
Leaf D	Nectar C	Saucier C
Lee D	Nella B	

A/D - B/D = Drained - Undrained Condition

Sheet 2 of 3

TABLE 2-2

Savannah C
Sawyer C
Scranton A/D
Seneca B
Sequatchie B
Sequoia C
Shadygrove C
Sharkey D
Shubuta C
Shuster C
Smithdale B
Smithton D
Spadra B
Starr B
Staser B
State B
Stemley C
Stendell C
St. Johns B/D
St. Lucie A
Stough C
Sumter C
Sun Shine C
Sunsweet C
Susquehanna D
Swain C
Sylacauga D
Tadlock B
Taft C
Talbott C
Talladega C
Tallapoosa C
Tarklin C
Tate B
Tatum B
Tellico B
Tifton B
Tilden C
Tilsit C
Toccoa B
Tombigbee A
Townley C
Trinity D
Troup A
Tupelo D
Tuscumbia D
Tuskegee C
Tyler D
Una D
Urbo D
Vaiden D
Vance C
Varina C
Vaucluse C
Wagram A
Wahee D
Warner C/D
Watauga B
Watsonia D
Waugh C
Waynesboro B
Wedowee D
Wehadkee D
Weston D
West Point D
Wickham B
Wicksburg B
Wilcox D
Wilkes C
Wolftever C
Worsham D
Wynnville C
York C

A/D - B/D - C/D = Drained-Undrained Condition

Table 2-3 Runoff curve numbers for hydrologic soil-cover complexes and management practices. (Antecedent moisture condition II, and $I_2 = 0.2\ S$)

Land Use	Cover: Treatment or practice and cover type	Hydrologic Condition	Type Tillage and/or cover	Hydrologic soil group A	B	C	D
A. Fallow	Straight row						
	1. Poor residue cover	----	CV-P	76	85	90	93
	2. Good residue cover	----	CS-G	74	83	88	90
B. Row Crops	Straight row						
	1. Poor residue cover	poor	CV	71	80	87	90
	2. Poor residue cover	good	CV-G	66	77	84	88
	3. Good residue cover	poor	CS-P	69	78	84	87
	4. Good residue cover	good	CS-G	64	75	82	85
	Contoured						
	5. Poor residue cover	poor	CV-CS-P	70	79	84	88
	6. Poor residue cover	good	CV-CS-G	69	78	83	87
	7. Good residue cover	poor	CS-P	65	75	82	86
	8. Good residue cover	good	CS-G	64	74	81	85
	Contoured and terraced						
	9. Poor residue cover	poor	CV-CS-P	66	74	80	82
	10. Poor residue cover	good	CV-CS-G	65	73	79	81
	11. Good residue cover	poor	CS-P	62	71	78	81
	12. Good residue cover	good	CS-G	61	70	77	80
C. Small Grain	Straight row						
	1. Poor residue cover	poor	CV	64	75	83	87
	2. Poor residue cover	good	CV-P	62	74	82	86
	3. Good residue cover	poor	CS-P	62	73	81	85
	4. Good residue cover	good	CS-G	60	72	80	84
	Contoured						
	5. Poor residue cover	poor	CV-CS-P	63	74	82	85
	6. Poor residue cover	good	CV-CS-P	62	73	81	84
	7. Good residue cover	poor	CS-P	61	73	81	84
	8. Good residue cover	good	CS-G	60	72	80	83
	Contoured and terraced						
	9. Poor residue cover	poor		51	72	79	82
	10. Poor residue cover	good		60	71	78	81
	11. Good residue cover	poor		59	70	78	81
	12. Good residue cover	good		58	69	77	80
D. Close-seeded legumes or rotations meadow	1. Straight row	poor		66	77	85	89
	2. Straight row	good		58	72	81	85
	3. Contoured	poor		64	75	83	85
	4. Contoured	good		55	69	78	83
	5. Contoured & terraced	poor		63	73	80	83
	6. Contoured & terraced	good		51	67	76	80
E. Pasture or range	1. No mechanical treatment	poor		68	79	86	89
	2. No mechanical treatment	fair		49	69	79	84
	3. No mechanical treatment	good		39	61	74	80
	4. Contoured	poor		47	67	81	88
	5. Contoured	fair		25	59	75	83
	6. Contoured	good		6	35	70	79
F. Meadow	1. ----------	good		30	58	71	78
G. Woods	1. ----------	poor		45	66	77	83
	2. ----------	fair		36	60	73	79
	3. ----------	good		25	55	70	77
H. Farmsteads	1. ----------	----		59	74	82	86
I. Roads	1. Dirt	----		72	82	87	89
	2. Hard surface	----		74	84	90	92

Poor residue cover --Less than 25% of the surface is covered with residue. (750 #/acre rowcrops and 300 #/acre small grain).
Fair residue cover--Between 25% and 50% of the surface is covered with residue.
Good residue cover--More than 75% of the surface is covered with residue.

NOTE: Percent cover should be estimated for the time of year storms occur.

Type tillage and/or cover - CV - Conventional tillage; CS - Conservation tillage and residue management; p = poor cover; f = fair cover; g = good cover.

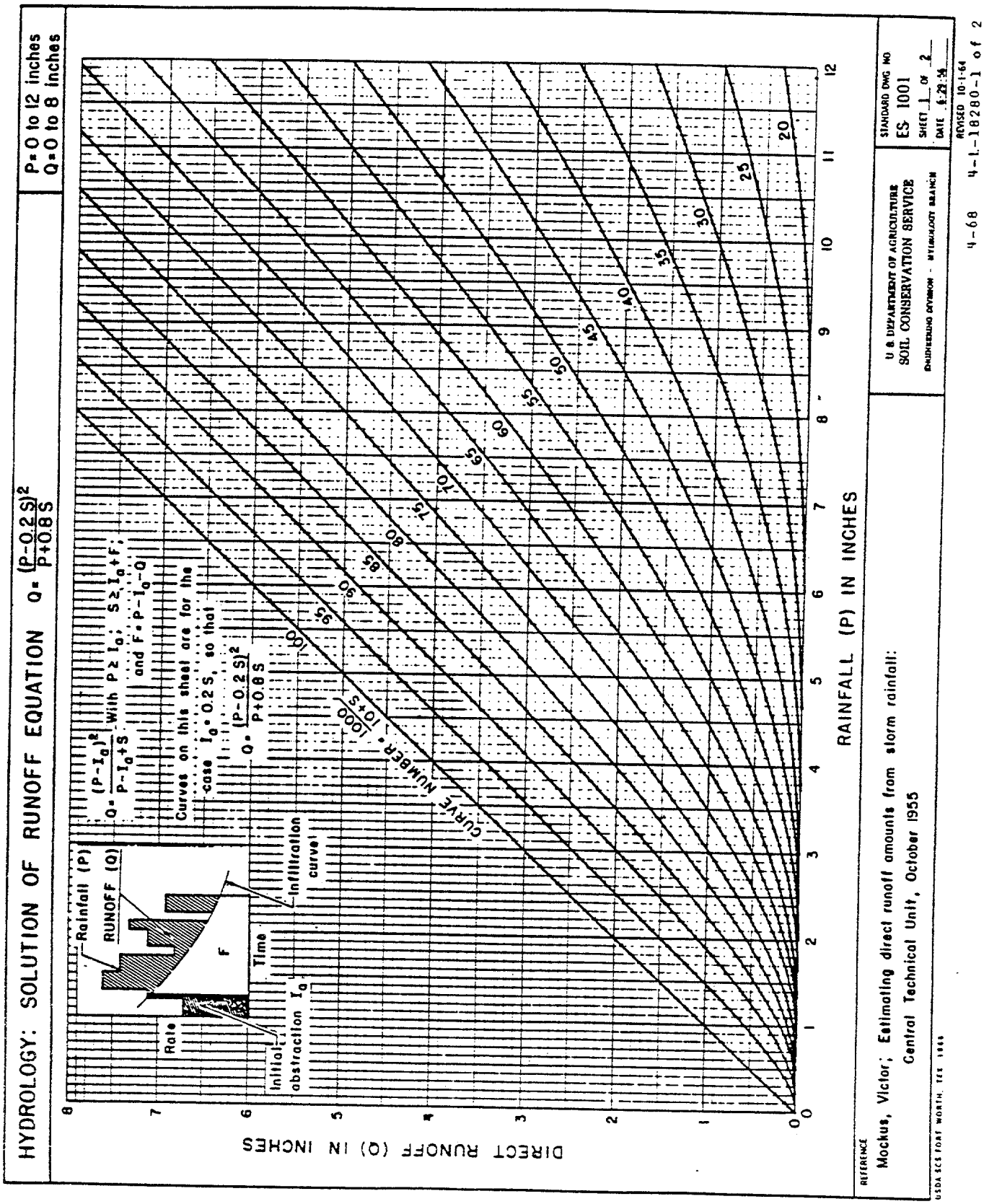


Figure 2-2 - Estimating Direct Runoff Amounts from Storm Rainfall IN INCHES

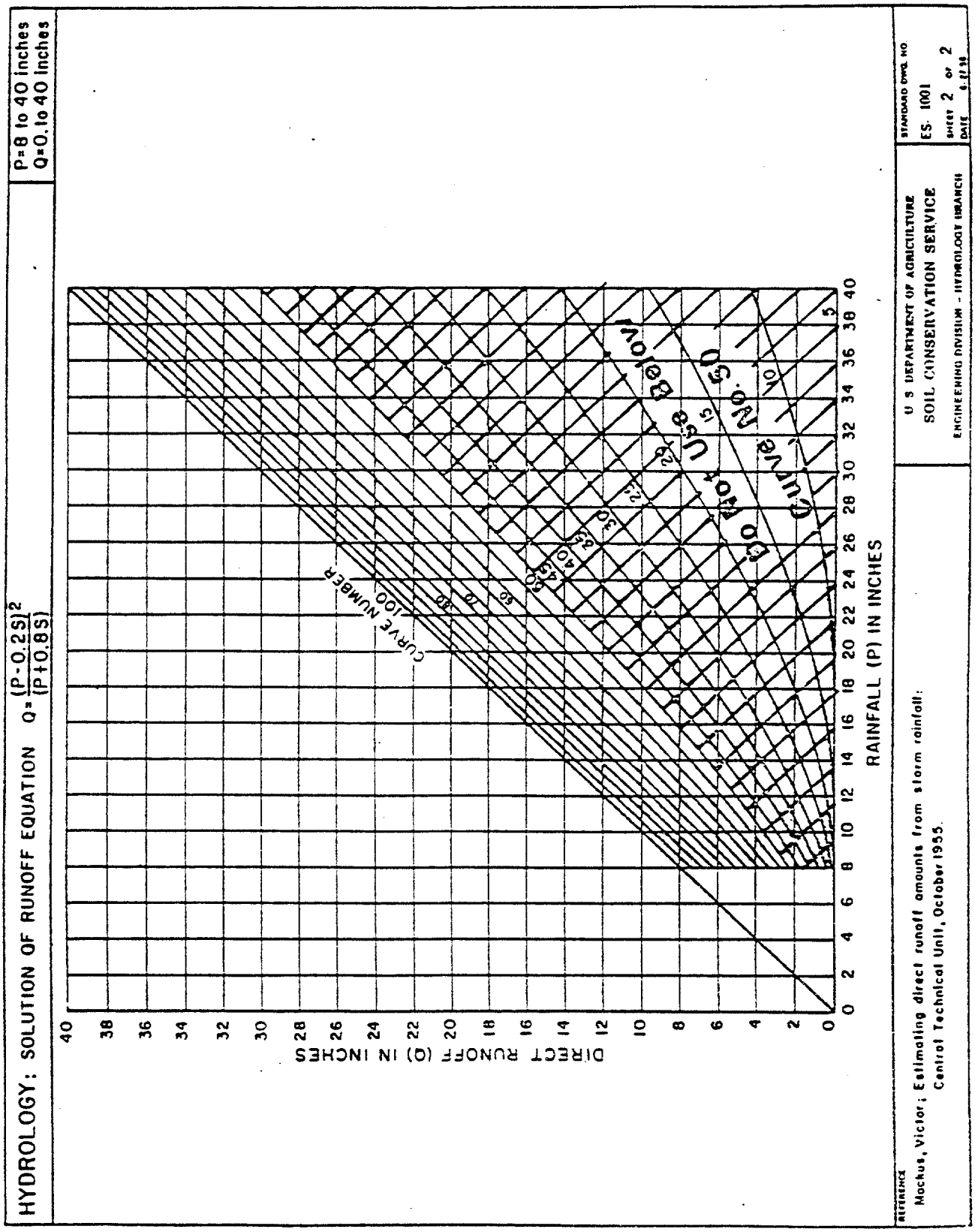


FIGURE 2-3 - Estimating Direct Runoff Amounts From Storm Rainfall in Inches

Sept. 1983

TABLE 2-4

Rainfall (Inches) - Frequency for 24-hour Periods
(From TP #40)
(USE: Ponds - Tile Outlet Waterways - etc.)

County	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
AREA I							
Colbert	3.3	3.9	4.9	5.6	6.3	7.0	7.6
Cullman	3.4	3.9	5.0	5.8	6.6	7.2	8.0
Franklin	3.3	3.9	5.0	5.7	6.5	7.1	7.8
Jackson	3.3	3.8	4.7	5.4	6.2	6.8	7.5
Lauderdale	3.3	3.8	4.8	5.5	6.3	6.9	7.5
Lawrence	3.3	3.9	4.9	5.6	6.4	7.0	7.6
Limestone	3.3	3.8	4.8	5.5	6.3	6.9	7.5
Madison	3.3	3.8	4.8	5.5	6.2	6.9	7.5
Marshall	3.3	3.9	4.9	5.6	6.4	7.0	7.7
Morgan	3.3	3.8	4.9	5.6	6.4	7.0	7.6
Winston	3.4	3.9	5.0	5.8	6.6	7.2	8.0
Marion	3.4	3.9	5.0	5.8	6.7	7.3	8.0
FOCAS USE	3.3	3.8	4.8	5.6	6.4	7.0	7.7
AREA II							
Blount	3.4	3.9	5.0	5.8	6.6	7.3	8.0
Calhoun	3.4	3.9	5.1	5.8	6.7	7.4	8.2
Cherokee	3.3	3.8	4.9	5.8	6.5	7.3	7.8
Clay	3.5	4.1	5.2	6.1	7.0	7.7	8.5
Chambers	3.5	4.1	5.3	6.2	7.1	7.8	8.6
Cleburne	3.4	3.9	5.0	5.8	6.7	7.5	8.1
Coosa	3.6	4.3	5.5	6.4	7.2	8.0	8.8
DeKalb	3.3	3.8	4.8	5.6	6.3	7.0	7.5
Elmore	3.6	4.4	5.6	6.5	7.5	8.3	9.0
Etowah	3.4	3.9	5.0	5.7	6.6	7.2	8.0
Lee	3.5	4.2	5.4	6.3	7.3	8.0	8.9
Randolph	3.4	4.0	5.1	5.9	6.7	7.5	8.4
St. Clair	3.4	4.0	5.1	5.9	6.7	7.5	8.0
Talladega	3.5	4.2	5.3	6.2	7.0	7.7	8.2
Tallapoosa	3.6	4.2	5.4	6.3	7.3	7.9	8.8
FOCAS USE	3.5	4.0	5.2	6.0	7.0	8.0	8.3
Area III							
Autauga	3.7	4.5	5.8	6.7	7.8	8.6	9.5
Bibb	3.6	4.4	5.5	6.4	7.3	8.0	8.8
Chilton	3.6	4.4	5.6	6.2	7.4	8.1	8.9
Greene	3.7	4.5	5.5	6.5	7.5	8.7	9.0
Hale	3.7	4.5	5.6	6.2	7.6	8.2	9.0
Fayette	3.5	4.1	5.2	6.0	6.8	7.5	8.3

Table 2-4 cont.

(USE: Ponds - Tile Outlet Waterways - etc.)

County	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Jefferson	3.5	4.1	5.2	6.1	6.9	7.6	8.4
Lamar	3.5	4.1	5.2	6.0	6.9	7.6	8.3
Perry	3.7	4.5	5.7	6.6	7.6	8.4	9.1
Pickens	3.6	4.3	5.4	6.3	7.2	8.0	8.8
Shelby	3.5	4.2	5.4	6.2	7.1	7.8	8.6
Sumter	3.7	4.6	5.7	6.7	7.7	8.5	9.3
Tuscaloosa	3.6	4.3	5.4	6.3	7.1	7.8	8.6
Walker	3.5	4.0	5.1	5.9	6.8	7.5	8.2
FOCUS USE	3.6	4.3	5.4	6.3	7.3	8.0	8.8
AREA IV							
Baldwin	5.0	6.0	7.8	9.3	10.4	11.6	13.0
Escambia	4.5	5.5	7.2	8.4	9.6	11.2	12.0
Mobile	4.7	5.8	7.6	9.0	10.4	11.5	12.7
FOCUS USE	4.7	5.8	7.6	9.0	10.1	11.4	12.6
Butler	3.9	4.8	6.2	7.3	8.5	9.4	10.4
Choctaw	3.8	4.7	6.1	7.0	8.0	9.0	10.0
Clark	4.0	4.9	6.5	7.5	8.6	9.7	10.8
Conecuh	4.0	5.0	6.6	7.8	9.0	10.2	11.0
Dallas	3.8	4.6	5.8	6.8	7.9	8.7	9.5
Lowndes	3.8	4.6	5.9	6.9	7.9	8.8	10.0
Marengo	3.8	4.7	5.9	6.8	7.9	8.8	9.6
Monroe	4.0	5.0	6.5	7.7	8.8	10.0	11.0
Washington	4.0	5.0	6.7	7.7	8.9	10.2	11.0
Wilcox	3.9	4.8	6.0	7.0	8.2	9.0	10.0
FOCUS USE	3.9	4.8	6.2	7.3	8.4	9.4	10.3
AREA V							
Covington	4.2	5.2	6.7	7.9	9.4	10.5	11.0
Geneva	4.0	5.0	6.5	7.6	9.0	10.3	11.0
FOCUS USE	4.1	5.1	6.6	7.8	9.2	10.4	11.0
Barbour	3.7	4.5	5.8	6.8	8.0	8.8	9.5
Bullock	3.7	4.5	5.8	6.7	7.8	8.6	9.5
Coffee	3.9	4.9	6.4	7.4	8.9	9.7	10.6
Crenshaw	3.9	4.8	6.2	7.2	8.4	9.4	10.0
Dale	3.9	4.8	6.2	7.2	8.5	9.5	10.4
Henry	3.8	4.6	6.0	7.0	8.3	9.0	10.0
Houston	3.9	4.8	6.3	7.4	8.7	9.5	10.5
Macon	3.6	4.4	5.6	6.5	7.6	8.3	9.0
Montgomery	3.8	4.6	5.8	6.7	7.8	8.7	9.7
Pike	3.8	4.7	6.0	7.0	8.2	9.0	9.8
Russell	3.6	4.3	5.5	6.5	7.5	8.2	8.9
FOCUS USE	3.8	4.7	6.0	7.0	8.2	9.0	9.8

TABLE 2-5

RAINFALL-RUNOFF RELATION

Rainfall (Inches)	RUNOFF CURVE NUMBER (II CN) 50	55	60	65	70	75	80	85
2.7	.05	.12	.23	.37	.55	.77	1.03	1.34
2.9	.09	.15	.30	.46	.65	.89	1.17	1.51
3.1	.11	.22	.37	.55	.77	1.02	1.33	1.68
3.3	.15	.28	.45	.65	.89	1.16	1.48	1.85
3.4	.17	.31	.49	.70	.95	1.23	1.56	1.93
3.5	.20	.34	.53	.75	1.01	1.30	1.64	2.02
3.6	.22	.37	.57	.80	1.07	1.37	1.72	2.11
3.7	.25	.41	.62	.86	1.13	1.44	1.80	2.20
3.8	.27	.45	.67	.91	1.19	1.52	1.88	2.28
3.9	.30	.49	.72	.97	1.25	1.59	1.96	2.37
4.0	.33	.53	.76	1.03	1.33	1.67	2.04	2.46
4.1	.36	.57	.81	1.09	1.40	1.74	2.12	2.55
4.2	.40	.61	.86	1.15	1.46	1.82	2.20	2.64
4.3	.43	.65	.91	1.21	1.53	1.89	2.29	2.73
4.4	.46	.69	.97	1.27	1.60	1.97	2.38	2.82
4.5	.50	.73	1.03	1.33	1.67	2.04	2.46	4.91
4.6	.54	.78	1.08	1.39	1.74	2.12	2.55	3.00
4.7	.57	.83	1.13	1.45	1.81	2.20	2.63	3.09
4.8	.61	.88	1.19	1.52	1.88	2.28	2.72	3.19
4.9	.65	.93	1.25	1.58	1.96	2.36	2.81	3.28
5.0	.69	.98	1.30	1.65	2.04	2.44	2.89	3.37
5.1	.73	1.03	1.36	1.72	2.11	2.52	2.98	3.47
5.2	.78	1.08	1.42	1.78	2.19	2.61	3.07	3.56
5.3	.82	1.13	1.48	1.85	2.26	2.69	3.16	3.65
5.4	.86	1.18	1.54	1.92	2.33	2.77	3.25	3.74
5.5	.91	1.23	1.61	1.99	2.41	2.85	3.34	3.84
5.6	.95	1.28	1.67	2.06	2.49	2.94	3.43	3.93
5.7	1.00	1.34	1.73	2.13	2.57	3.02	3.52	4.03
5.8	1.05	1.40	1.80	2.20	2.64	3.11	3.61	4.12
5.9	1.09	1.46	1.86	2.28	2.72	3.19	3.69	4.21
6.0	1.14	1.52	1.92	2.35	2.80	3.27	3.78	4.31
6.2	1.24	1.63	2.06	2.50	2.96	3.45	3.96	4.50
6.4	1.34	1.75	2.19	2.64	3.13	3.62	4.14	4.69
6.6	1.45	1.37	2.33	2.80	3.29	3.79	4.32	4.87
6.8	1.56	1.99	2.47	2.94	3.45	3.97	4.51	5.06
7.0	1.67	2.12	2.61	3.10	3.61	4.15	4.69	5.26
7.2	1.78	2.24	2.75	3.25	3.79	4.32	4.88	5.45
7.4	1.89	2.38	2.89	3.41	3.95	4.49	5.06	5.64
7.6	2.01	2.51	3.04	3.57	4.12	4.67	5.25	5.84
7.8	2.13	2.64	3.18	3.73	4.28	4.86	5.44	6.03
8.0	2.25	2.78	3.34	3.89	4.46	5.04	5.62	6.22
8.2	2.37	2.92	3.49	4.05	4.64	5.22	5.81	6.41
8.4	2.50	3.06	3.64	4.22	4.81	5.40	6.00	6.60
8.6	2.62	3.20	3.79	4.38	4.98	5.58	6.19	6.80
8.8	2.75	3.34	3.95	4.54	5.16	5.76	6.38	6.99
9.0	2.88	3.48	4.10	4.71	5.33	5.94	6.57	7.19
9.2	3.01	3.63	4.26	4.88	5.51	6.13	6.76	7.38
9.4	3.15	3.78	4.42	5.05	5.69	6.32	6.95	7.57
9.6	3.28	3.92	4.58	5.22	5.87	6.50	7.14	7.77
9.8	3.42	4.07	4.74	5.39	6.05	6.68	7.33	7.97
10.0	3.56	4.22	4.90	5.56	6.23	6.87	7.52	8.16
10.5	3.91	4.61	5.31	5.99	6.68	7.34	8.00	8.65
11.0	4.26	4.99	5.73	6.43	7.13	7.82	8.49	9.14
11.5	4.63	5.39	6.14	6.87	7.58	8.29	8.97	9.63
12.0	5.00	5.79	6.57	7.31	8.05	8.76	9.45	10.12

TABLE 2-4

Rainfall (Inches) - Frequency for 24-hour Periods
(From TP #40)
(USE: Ponds - Tile Outlet Waterways - etc.)

County	0.5 Year	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
AREA I								
Colbert		3.3	3.9	4.9	5.6	6.3	7.0	7.6
Cullman		3.4	3.9	5.0	5.8	6.6	7.2	8.0
Franklin		3.3	3.9	5.0	5.7	6.5	7.1	7.8
Jackson		3.3	3.8	4.7	5.4	6.2	6.8	7.5
Lauderdale		3.3	3.8	4.8	5.5	6.3	6.9	7.5
Lawrence		3.3	3.9	4.9	5.6	6.4	7.0	7.6
Limestone		3.3	3.8	4.8	5.5	6.3	6.9	7.5
Madison		3.3	3.8	4.8	5.5	6.2	6.9	7.5
Marshall		3.3	3.9	4.9	5.6	6.4	7.0	7.7
Morgan		3.3	3.8	4.9	5.6	6.4	7.0	7.6
Winston		3.4	3.9	5.0	5.8	6.6	7.2	8.0
Marion		3.4	3.9	5.0	5.8	6.7	7.3	8.0
FOCAS USE	2.7	3.3	3.8	4.8	5.6	6.4	7.0	7.7
AREA II								
Blount		3.4	3.9	5.0	5.8	6.6	7.3	8.0
Calhoun		3.4	3.9	5.1	5.8	6.7	7.4	8.2
Cherokee		3.3	3.8	4.9	5.8	6.5	7.3	7.8
Clay		3.5	4.1	5.2	6.1	7.0	7.7	8.5
Chambers		3.5	4.1	5.3	6.2	7.1	7.8	8.6
Cleburne		3.4	3.9	5.0	5.8	6.7	7.5	8.1
Coosa		3.6	4.3	5.5	6.4	7.2	8.0	8.8
DeKalb		3.3	3.8	4.8	5.6	6.3	7.0	7.5
Elmore		3.6	4.4	5.6	6.5	7.5	8.3	9.0
Etowah		3.4	3.9	5.0	5.7	6.6	7.2	8.0
Lee		3.5	4.2	5.4	6.3	7.3	8.0	8.9
Randolph		3.4	4.0	5.1	5.9	6.7	7.5	8.4
St. Clair		3.4	4.0	5.1	5.9	6.7	7.5	8.0
Talladega		3.5	4.2	5.3	6.2	7.0	7.7	8.2
Tallapoosa		3.6	4.2	5.4	6.3	7.3	7.9	8.8
FOCAS USE	2.8	3.5	4.0	5.2	6.0	7.0	8.0	8.3
Area III								
Autauga		3.7	4.5	5.8	6.7	7.8	8.6	9.5
Bibb		3.6	4.4	5.5	6.4	7.3	8.0	8.8
Chilton		3.6	4.4	5.6	6.2	7.4	8.1	8.9
Greene		3.7	4.5	5.5	6.5	7.5	8.7	9.0
Hale		3.7	4.5	5.6	6.2	7.6	8.2	9.0
Fayette		3.5	4.1	5.2	6.0	6.8	7.5	8.3

Table 2-4 cont.

(USE: Ponds - Tile Outlet Waterways - etc.)

County	0.5 Year	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Jefferson		3.5	4.1	5.2	6.1	6.9	7.6	8.4
Lamar		3.5	4.1	5.2	6.0	6.9	7.6	8.3
Perry		3.7	4.5	5.7	6.6	7.6	8.4	9.1
Pickens		3.6	4.3	5.4	6.3	7.2	8.0	8.8
Shelby		3.5	4.2	5.4	6.2	7.1	7.8	8.6
Sumter		3.7	4.6	5.7	6.7	7.7	8.5	9.3
Tuscaloosa		3.6	4.3	5.4	6.3	7.1	7.8	8.6
Walker		3.5	4.0	5.1	5.9	6.8	7.5	8.2
FOCUS USE	2.8	3.6	4.3	5.4	6.3	7.3	8.0	8.8
AREA IV								
Baldwin		5.0	6.0	7.8	9.3	10.4	11.6	13.0
Escambia		4.5	5.5	7.2	8.4	9.6	11.2	12.0
Mobile		4.7	5.8	7.6	9.0	10.4	11.5	12.7
FOCUS USE	3.6	4.7	5.8	7.6	9.0	10.1	11.4	12.6
Butler		3.9	4.8	6.2	7.3	8.5	9.4	10.4
Choctaw		3.8	4.7	6.1	7.0	8.0	9.0	10.0
Clark		4.0	4.9	6.5	7.5	8.6	9.7	10.8
Conecuh		4.0	5.0	6.6	7.8	9.0	10.2	11.0
Dallas		3.8	4.6	5.8	6.8	7.9	8.7	9.5
Lowndes		3.8	4.6	5.9	6.9	7.9	8.8	10.0
Marengo		3.8	4.7	5.9	6.8	7.9	8.8	9.6
Monroe		4.0	5.0	6.5	7.7	8.8	10.0	11.0
Washington		4.0	5.0	6.7	7.7	8.9	10.2	11.0
Wilcox		3.9	4.8	6.0	7.0	8.2	9.0	10.0
FOCUS USE	3.0	3.9	4.8	6.2	7.3	8.4	9.4	10.3
AREA V								
Covington		4.2	5.2	6.7	7.9	9.4	10.5	11.0
Geneva		4.0	5.0	6.5	7.6	9.0	10.3	11.0
FOCUS USE	3.1	4.1	5.1	6.6	7.8	9.2	10.4	11.0
Barbour		3.7	4.5	5.8	6.8	8.0	8.8	9.5
Bullock		3.7	4.5	5.8	6.7	7.8	8.6	9.5
Coffee		3.9	4.9	6.4	7.4	8.9	9.7	10.6
Crenshaw		3.9	4.8	6.2	7.2	8.4	9.4	10.0
Dale		3.9	4.8	6.2	7.2	8.5	9.5	10.4
Henry		3.8	4.6	6.0	7.0	8.3	9.0	10.0
Houston		3.9	4.8	6.3	7.4	8.7	9.5	10.5
Macon		3.6	4.4	5.6	6.5	7.6	8.3	9.0
Montgomery		3.8	4.6	5.8	6.7	7.8	8.7	9.7
Pike		3.8	4.7	6.0	7.0	8.2	9.0	9.8
Russell		3.6	4.3	5.5	6.5	7.5	8.2	8.9
FOCUS USE	3.0	3.8	4.7	6.0	7.0	8.2	9.0	9.8

9b. Alternate Method Using Rainfall Distribution Type III

Select appropriate method to use by referring to Figure 2-4 and determine that design site falls within rainfall distribution type II or type III. If design site is type III proceed as follows:

Example: Use data from section 8 above for Lee County, Alabama check Table 2-7 see if rainfall and CN bracket in Ratio Zone.

Step A. Select I_A/rainfall (Ia/p) Number from Table 2-7 using CN=60 and rainfall = 7.3 inches, read Ia/p = 0.18. If rainfall and curve number result in Ia/p which falls outside numbered area on Table 2-7 use the appropriate value of 0.10 or o.50 as shown on the table.

Step B. Determine Peak Discharge (CFS/ACRE/IN. RUNOFF) refer to Fig. 2-5 , 2-6 , or 2-7 for flat, moderate, or steep slope. From step 2 - slope is moderate, therefore, refer to Fig. 2-6 . For D.A. = 45 acres, CN = 60, and Ia/P = 0.18, read Peak Discharge = 0.49 cfs/acre/inch runoff.

Step C. From Table 2-5 for 7.3 inches of rainfall and CN = 60, runoff = 2.82 inches. Peak Discharge = 0.49 cfs/ac/in. runoff x 2.82 inches runoff x 45 acres = 62.2 cfs. Slope Adjustment - From Table 2-8 for 6% slope read slope factor of 1.07. Thus, Peak Discharge = 62.2 cfs x 1.07 = 66.5 = 67 cfs.

TABLE 2-7 IA/RAINFALL FOR SELECTED CURVE NUMBERS

RAIN FALL (IN.)	CURVE NUMBER 55	60	65	70	75	80	85	90	95
1.0						0.50	0.35	0.22	0.11
1.5					0.44	0.33	0.24	0.15	
2.0	0.5			0.43	0.33	0.25	0.18	0.11	
2.5			0.43	0.34	0.27	0.20	0.14		
3.0		0.44	0.36	0.29	0.22	0.17	0.12		
3.5	0.47	0.38	0.31	0.24	0.19	0.14	0.10		
4.0	0.41	0.33	0.27	0.21	0.17	0.13			
4.5	0.36	0.30	0.24	0.19	0.15	0.11			
5.0	0.33	0.27	0.22	0.17	0.13	0.10			
6.0	0.27	0.22	0.18	0.14	0.11				
7.0	0.23	0.19	0.15	0.12	0.10				
8.0	0.20	0.17	0.13	0.11					
9.0	0.18	0.15	0.12	0.10			0.10		
10.0	0.16	0.13	0.11						
11.0	0.15	0.12	0.10						
12.0	0.14	0.11							
13.0	0.13	0.10							
14.0	0.12	0.10							
15.0	0.11								

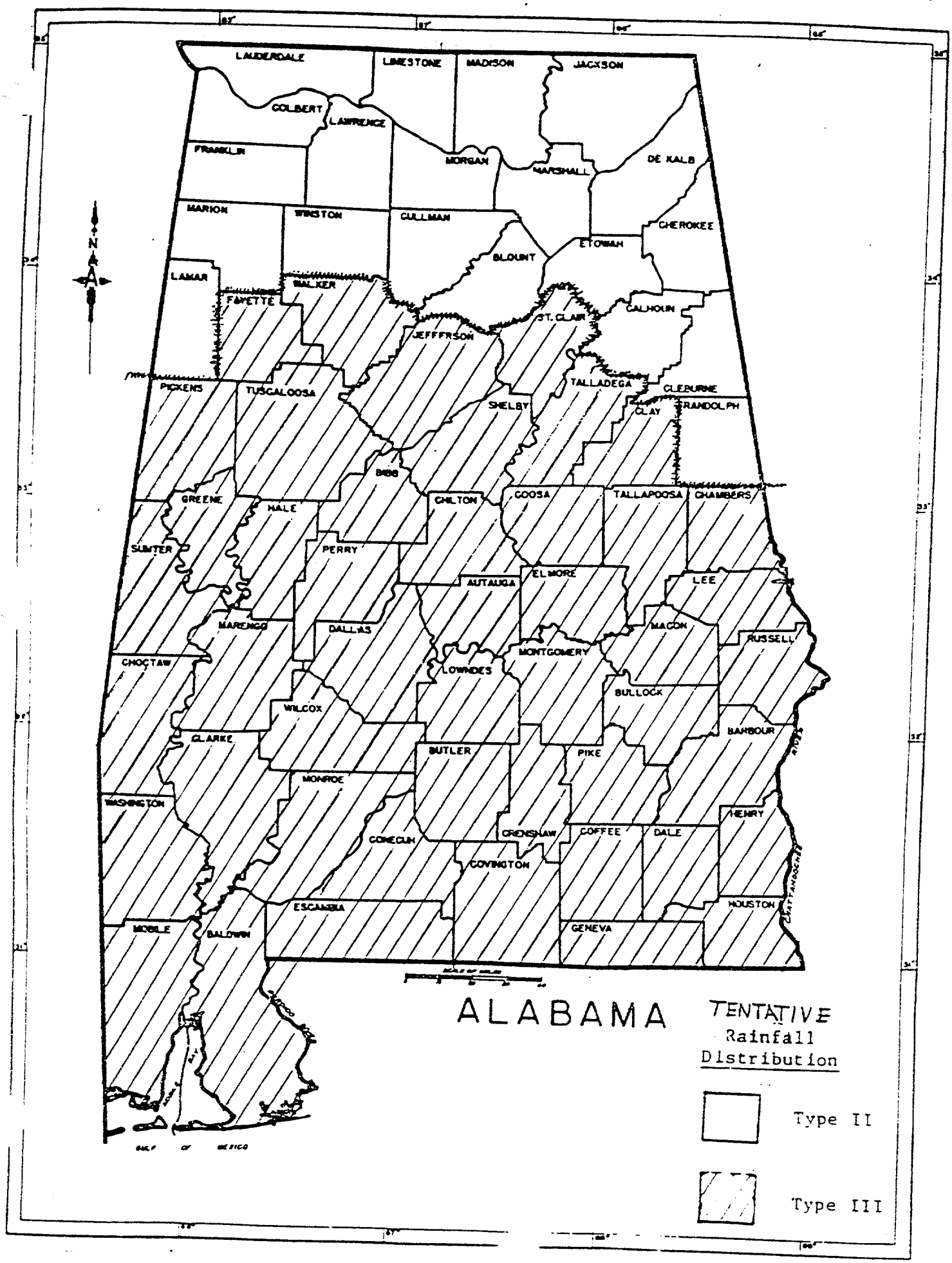
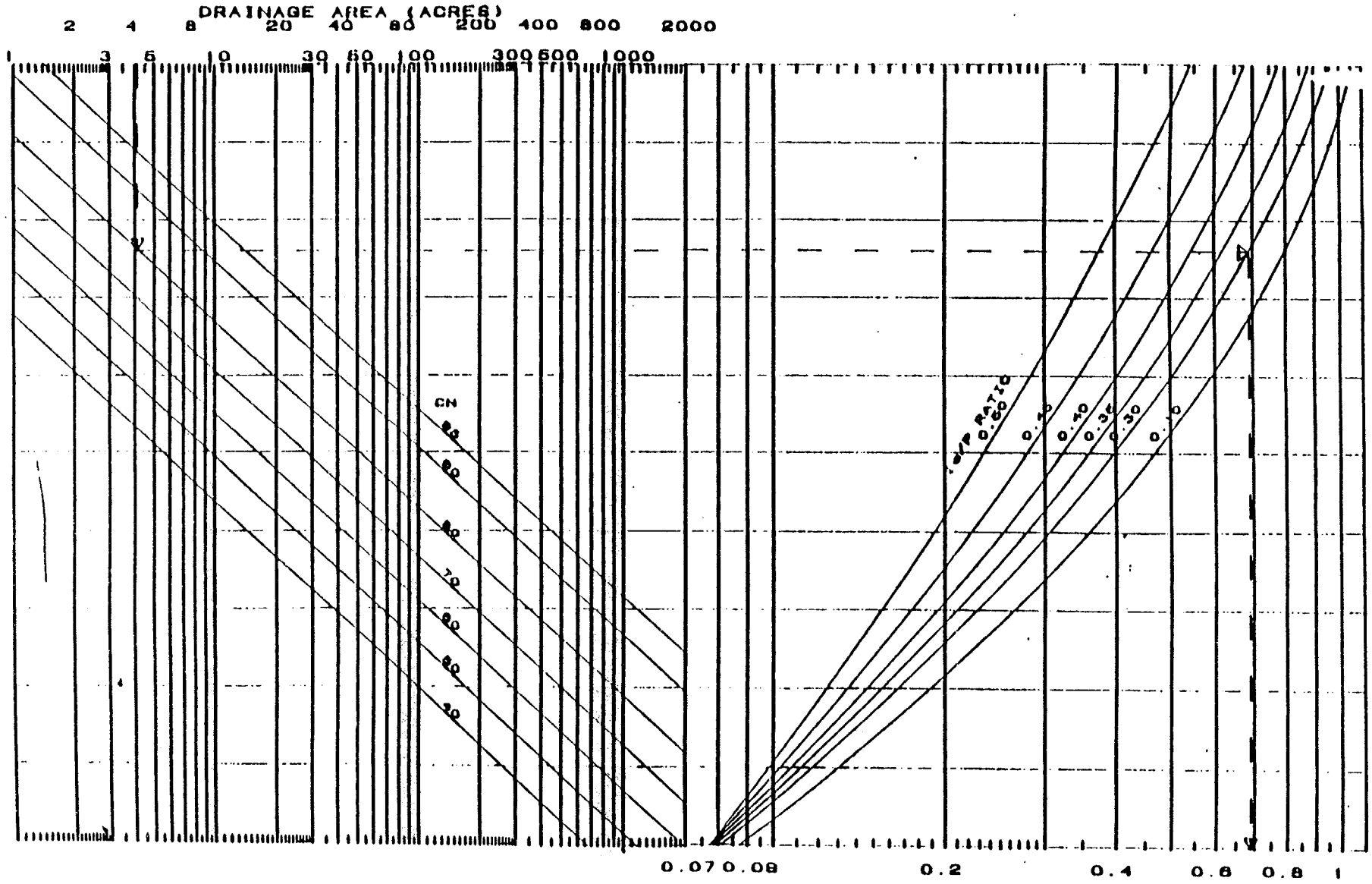
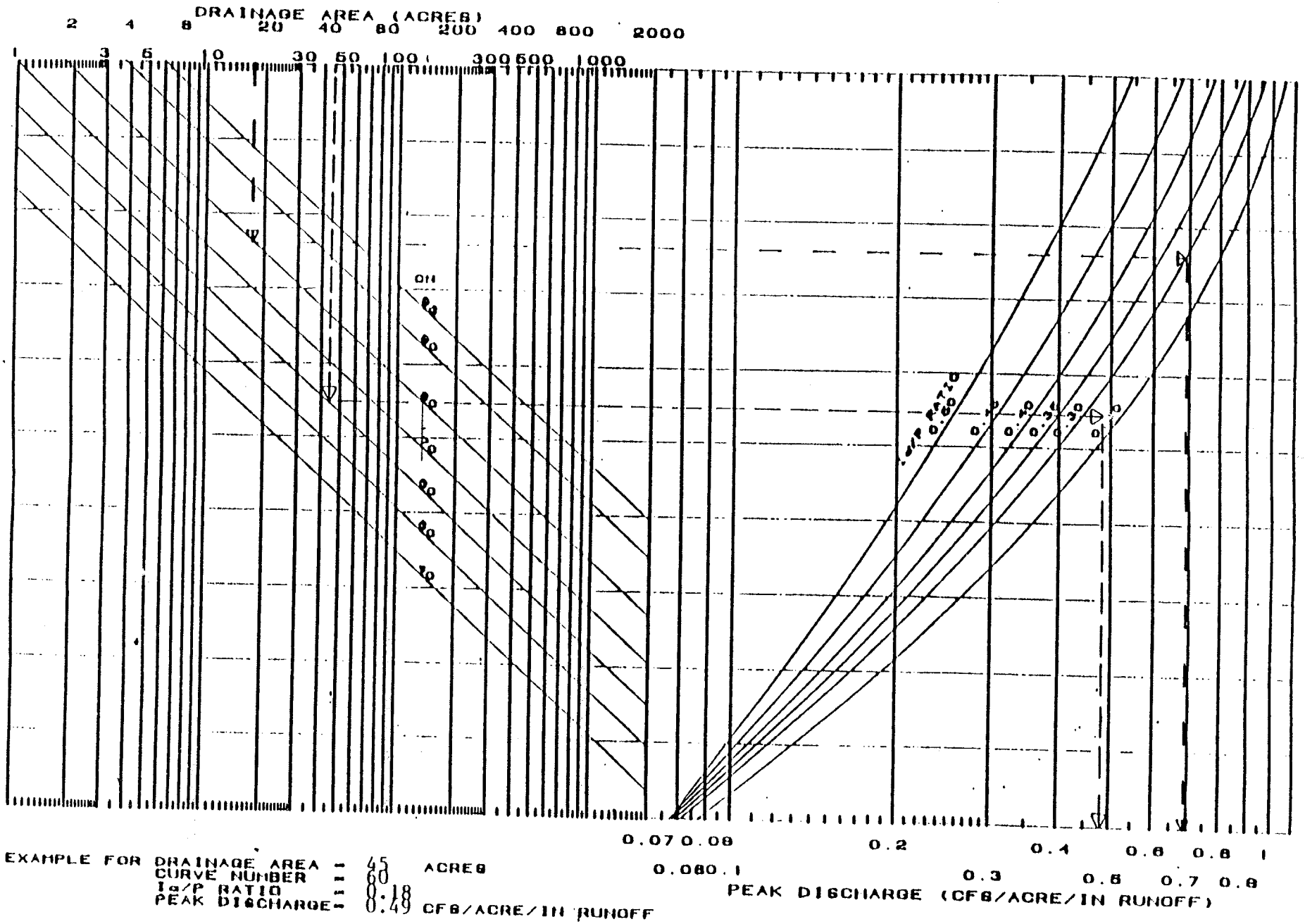

LAUDERDALE
LIMESTONE
MADISON
JACKSON
COLBERT
LAWRENCE
FRANKLIN
MORGAN
MARSHALL
DE KALB
MARION
WINSTON
CULLMAN
CHEROKEE
ETOWAH
BLOUNT
LAMAR
WALKER
FAYETTE
ST. CLAIR
CALHOUN
JEFFERSON
PICKENS
TUSCALOOSA
TALLADEGA
CLEBURNE
SHELBY
CLAY
RANDOLPH
BIBB
GREENE
HALE
CHILTON
COOSA
TALLAPOOSA
CHAMBERS
SUMTER
PERRY
AUTAUGA
ELMORE
LEE
MARENGO
DALLAS
MACON
RUSSELL
MONTGOMERY
CHOCTAW
LOWNDES
BULLOCK
WILCOX
BARBOUR
CLARKE
BUTLER
PIKE
MONROE
WASHINGTON
HENRY
CRENSHAW
COFFEE
DALE
CONECUH
COVINGTON
ESCAMBIA
HOUSTON
MOBILE
BALDWIN
GENEVA
N
ALABAMA
TENTATIVE
Rainfall
Distribution
Type II
Type III

Figure - 2-5 - PEAK DISCHARGE FOR SCS TYPE III RAINFALL FLAT SLOPE



EXAMPLE FOR DRAINAGE AREA = 4.1 ACRES
CURVE NUMBER = 80
Ia/P RATIO = 0.30
PEAK DISCHARGE= 0.68 CFS/ACRE/IN RUNOFF

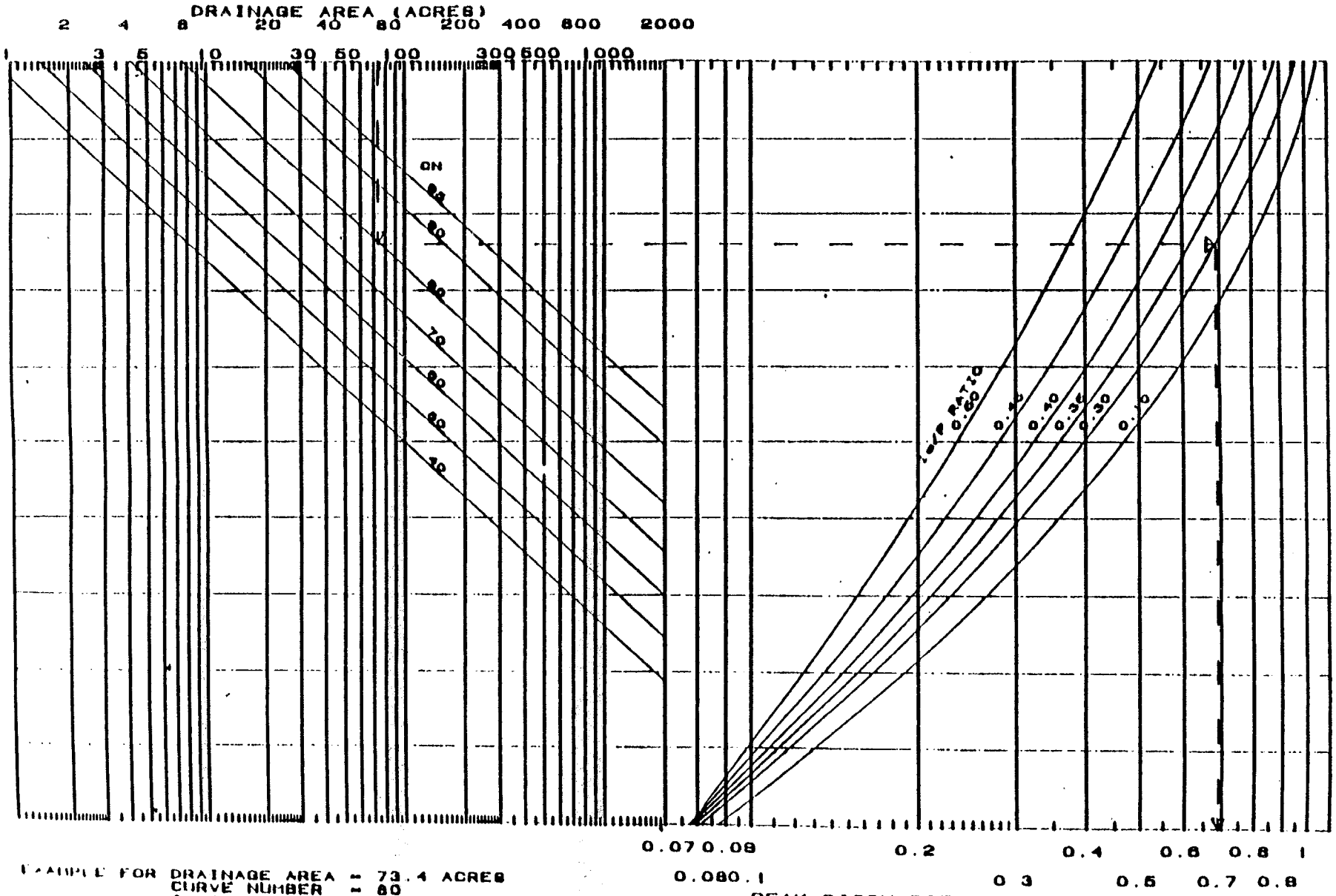
e 2-6 - PEAK DISCHARGE FC ,CS TYPE III RAINFALL MODEF SLOPE



EXAMPLE FOR DRAINAGE AREA = 45 ACRES
CURVE NUMBER = 60
Ia/P RATIO = 0.18
PEAK DISCHARGE= 0.49 CFS/ACRE/IN RUNOFF

REVISED 6/22/83

Figure 2-7 - PEAK DISCHARGE FOR SCS TYPE III RAINFALL STEEP SLOPE



EXAMPLE FOR DRAINAGE AREA = 73.4 ACRES
CURVE NUMBER = 80
Ia/P RATIO = 0.30
PEAK DISCHARGE= 0.68 CFS/ACRE/IN RUNOFF

REVISED 8/22/83

INTERPOLATING FACTORS FOR VARIOUS SLOPES AND DRAINAGE AREAS

Flat Slopes - round to nearest % slope shown

(Use discharge values from ES sheets labeled "Flat")

Slope %	Acres 1-50	51-500	501-2000
.1	.47	.43	.40
.2	.58	.55	.53
.3	.66	.64	.62
.4	.74	.71	.70
.5	.79	.77	.76
.7	.89	.88	.87
1.0	1.00	1.00	1.00
2.0	1.13	1.16	1.18

Steep Slopes - round to nearest % slope shown

(Use discharge values from ES sheets labeled "Steep")

Slope %	Acres 1-50	51-500	501-2000
8	.92	.88	.83
9	.93	.90	.85
10	.94	.91	.87
11	.95	.93	.89
12	.96	.94	.91
13	.97	.96	.94
14	.98	.97	.96
15	.99	.99	.98
16	1.00	1.00	1.00
17	1.01	1.02	1.02
18	1.02	1.03	1.04
19	1.03	1.05	1.06
20	1.04	1.08	1.08
25	1.08	1.14	1.17
30	1.11	1.20	1.23
35	1.13	1.24	1.28
40	1.16	1.29	1.33
45	1.18	1.31	1.37
50	1.21	1.34	1.40
55	1.23	1.35	1.43
60	1.26	1.37	1.46
65	1.28	1.39	1.48
70	1.30	1.40	1.50
75	1.32	1.42	1.52

Moderate Slopes - round to nearest % slope shown

(Use discharge values from ES sheets labeled "Moderate")

Slope %	Acres 1-50	51-500	501-2000
3	.96	.95	.94
4	1.00	1.00	1.00
5	1.04	1.05	1.06
6	1.07	1.10	1.11
7	1.09	1.13	1.15

Example:

Given

1. D.A. = 20 Acres
2. Rainfall = 8.2 Inches
3. C.N. = 65
4. Slope = 2%
5. Runoff = 4.05 Inches

Determine

Peak flow

Solution

1. 2% slope is in the flat category.
   From Table 2-6, slopes, flat; CN 65 - peak discharge = 9 cfs/in runoff
   = 9 x 4.05 = 36.5 cfs
2. From table for flat slopes and under 1-50 acres drainage area and on line with 2.0%, find factor 1.13.
3. Peak flow = 36.5 x 1.13 = 41.2 cfs use 40 cfs

REFERENCE SCS - TP-149 RTSC-NE-ENG 210	U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	

TABLE 2-8 Interpolation Factors for Various Slopes and Drainage Areas

10. Adjustment Factors for Various Slopes and Drainage Areas for Peak Discharge

Table 2-8 provides interpolation factors for use in determining peak rates of discharge for specific slopes and range of drainage areas. Table 2-1 for FLAT slope is based on 1-percent slope, for MODERATE slope on 4-percent slope, and for STEEP slope on 16-percent slope. For slopes other than 1, 4, and 16 percent, use the factors shown in Table 2-8 to modify peak discharges.

Example: Use of Table 2-8. Compute the peak discharge for a 22-acre watershed with an average slope of 6% and a runoff curve number of 70 using 5.8 inches of rainfall. Determine the peak discharge with a moderate slope from Exhibit 2-1 to be 47 cfs. From Table 2-8 find 6% under the Moderate Slopes heading and read a slope interpolation value of 1.07 for 1-50 acres, then calculate the adjusted peak discharge as 47 cfs x 1.07 = 50.3 or 50 cfs.

Alternative Method: From Table 2-9 with CN = 70, moderate slope and drainage area = 22 acres, read 15 cfs/inch of runoff. From Table 2-5 with 5.8 inches of rainfall and CN= 70, read 2.64 inches. From Table 2-8 with 6% slope and 22 acres under 1-50 acres, read factor 1.07. Peak Discharge (Q) = 15.0 cfs/in x 2.64 inches 1.07 = 42.4 cfs, use 42 cfs.

11. Adjustment Factors for Swampy and Ponding Areas

Peak flows determined by the use of Exhibit 2-1 assume that the topography is such that surface flow into ditches, drains, and streams is approximately uniform. On very flat areas and where ponding or swampy areas occur in the watershed, a considerable amount of the surface runoff can be reduced to reflect this condition. Tables 2-10, 2-11, and 2-12 provide adjustment factors to determine this reduction based on the ratio of the ponding or swampy area to the total watershed area for a range of storm frequencies.

Table 2-10 contains adjustment factors to be used when the ponding or swampy areas are located in the path of flow in the vicinity of the design point. Table 2-11 contains adjustment factors to be used when a significant amount of the flow from the total watershed passes through ponding or swampy areas and these areas are spread throughout the watershed. Table 2-12 contains adjustment factors to be used when a significant amount of the flow passes through ponding or swampy areas that are located only in the upper reaches of the watershed.

The following guidelines and examples are provided for clarifying the use of this procedure.

A. Land on slopes of 0-2% should be considered as having the characteristics of being contoured and the appropriate runoff curve number for contoured land should be used. Where identifiable ponds or swampy areas occur in the path of major runoff, determine the ratio of drainage area to pond and swampy area. Use this factor to enter Table 2-10, 2-11 or 2-12.

Table 2-9 - Interim Peak Discharge in CFS Per Inch of Runoff

ALABAMA INTERIM PEAK DIS : cfs/inch of runoff

SLOPE	CN#	DRAINAGE AREA IN ACRES 2	4	6	8	10	20	40	60	80	100	200	400	600	800	1000	1200	1400	1600	1800	2000
FLAT																					
	60	1	3	3	4	5	8	14	18	22	25	39	61	78	93	107	120	131	142	153	163
	65	2	3	4	5	5	9	15	19	24	27	43	67	87	103	119	133	146	158	170	181
	70	2	3	4	5	6	10	16	21	26	30	48	74	96	115	132	148	162	176	189	202
	75	2	3	4	5	6	10	17	23	28	33	53	83	107	128	147	165	181	197	212	226
	80	2	3	4	6	7	11	19	25	31	36	58	92	120	144	166	186	204	222	239	255
	85	2	3	5	6	7	12	21	28	34	40	65	104	135	163	188	211	232	253	272	290
	90	2	3	5	6	8	13	23	31	38	45	74	118	155	187	216	243	269	292	315	337
	95	2	4	5	7	8	15	26	35	43	51	85	138	182	220	255	288	318	347	374	400
MODERATE																					
	60	2	3	5	6	7	12	21	28	34	40	64	102	133	160	185	208	229	249	268	286
	65	2	3	5	6	7	13	22	30	37	43	70	112	146	176	204	229	252	275	296	316
	70	2	3	5	6	8	14	23	32	40	47	76	123	161	194	225	253	279	304	327	350
	75	2	4	5	7	8	14	25	34	43	50	83	135	177	215	249	280	309	337	364	389
	80	2	4	5	7	8	15	27	37	46	54	91	148	196	238	276	312	345	376	406	435
	85	2*	4	5	7	9	16	29	40	50	59	100	164	218	266	310	350	388	424	458	491
	90	2*	4	6	7	9	17	31	43	54	65	110	184	246	301	351	397	441	483	523	561
	95	2*	4*	6	8	9	18	33	47	59	71	123	208	281	345	405	460	512	562	609	655
STEEP																					
	60	2*	4	5	7	9	16	28	39	49	59	98	162	215	262	305	345	382	417	451	483
	65	2*	4	6	7	9	17	30	42	52	62	106	175	234	285	333	376	418	457	494	530
	70	2*	4	6	7	9	17	31	44	55	66	113	189	253	310	362	411	457	500	541	581
	75	2*	4*	6	8	9	18	33	46	58	70	121	204	275	338	396	449	500	548	594	638
	80	2*	4*	6*	8	9	18	34	48	61	74	129	221	299	369	433	493	550	604	655	705
	85	2*	4*	6*	8*	9	19	35	50	65	78	139	240	326	404	476	544	608	668	726	782
	90	2*	4*	6*	8*	9*	19	36	53	68	83	149	261	359	447	528	605	677	747	813	877
	95	2*	4*	6*	8*	9*	19*	37	55	72	88	161	287	398	498	592	681	765	846	923	998

TABLE 2-10 Adjustment factors where ponding and swampy areas occur at the design point

Ratio of drainage area to ponding and swampy area	Percentage of ponding and swampy area	Storm frequency (Years)					
		2	5	10	25	50	100
500	0.2	0.92	0.94	0.95	0.96	0.97	0.98
200	.5	.86	.87	.88	.90	.92	.93
100	1.0	.80	.81	.83	.85	.87	.89
50	2.0	.74	.75	.76	.79	.82	.86
40	2.5	.69	.70	.72	.75	.78	.82
30	3.3	.64	.65	.67	.71	.75	.78
20	5.0	.59	.61	.63	.67	.71	.75
15	6.7	.57	.58	.60	.64	.67	.71
10	10.0	.53	.54	.56	.60	.63	.68
5	20.0	.48	.49	.51	.55	.59	.64

TABLE 2-11-Adjustment factors where ponding and swampy areas are spread throughout the watershed or occur in central parts of the watershed

Ratio of drainage area to ponding and swampy area	Percentage of ponding and swampy area	Storm frequency (years)					
		2	5	10	25	50	100
500	0.2	0.94	0.95	0.96	0.97	0.98	0.99
200	.5	.88	.89	.90	.91	.92	.94
100	1.0	.83	.84	.86	.87	.88	.90
50	2.0	.78	.79	.81	.83	.85	.87
40	2.5	.73	.74	.76	.78	.81	.84
30	3.3	.69	.70	.71	.74	.77	.81
20	5.0	.65	.66	.68	.72	.75	.78
15	6.7	.62	.63	.65	.69	.72	.75
10	10.0	.58	.59	.61	.65	.68	.71
5	20.0	.53	.54	.56	.60	.63	.68
4	25.0	.50	.51	.53	.57	.61	.66

TABLE 2-12--Adjustment factors where ponding and swampy areas are located only in upper reaches of the watershed

Ratio of drainage area to ponding and swampy area	Percentage of ponding and swampy area	Storm frequency (years)					
		2	5	10	25	50	100
500	0.2	0.96	0.97	0.98	0.98	0.99	0.99
200	.5	.93	.94	.94	.95	.96	.97
100	1.0	.90	.91	.92	.93	.94	.95
50	2.0	.87	.88	.88	.90	.91	.93
40	2.5	.85	.85	.86	.88	.89	.91
30	3.3	.82	.83	.84	.86	.88	.89
20	5.0	.80	.81	.82	.84	.86	.88
15	6.7	.78	.79	.80	.82	.84	.86
10	10.0	.77	.77	.78	.80	.82	.84
5	20.0	.74	.75	.76	.78	.80	.82

B. On flat watersheds (Watersheds with average slope of 0.0 to 0.5%) assume that ponding characteristics will occur over the majority of the watershed unless the watershed has an improved drainage system installed, including land smoothing and field drains, to provide positive drainage toward the channels. In these cases the ratio of D.A. to Ponding and Swampy Area to be used in Table 2-11 are: case (1) four for a watershed with unimproved drainage area; case (2) five for a watershed with improved drainage channels; and case (3) 50 for a watershed with complete improvement (channels and land grading).

Example 1

A pond is located at the lower end of a 500-acre watershed: The C.N. = 70: the 25-year, 24-hour frequency rainfall = 6.00 inches: and the average slope of watershed = 0.4%. Determine the peak flow if (1) it is an unimproved watershed; (2) drainage channels only have been improved; and (3) drainage channels have been improved and land has been graded.

Solution: From Exhibit 2-1 (revised) peak flow = 250 cfs
From Table 2-8 adjustment for land slope = 0.71

Part 1: A case 1 ratio applies; therefore the adjustment for ponding (from Table 2-11 where D.A./Ponding and Swampy Area = 4) is 0.57

Adjusted Peak Flow = 250 x 0.71 x 0.57 = 101 cfs

Part 2: A case 2 ratio applies; therefore the adjustment for ponding (from Table 2-11 where D.A./Ponding and Swampy Area = 5) is 0.60

Adjusted Peak Flow = 250 x 0.71 x 0.60 = 106 cfs

Part 3: A case 3 ratio applies; therefore the adjustment for ponding (from Table 2-11 where D.A./Ponding and Swampy Areas = 50) ix 0.83

Adjusted Peak Flow = 250 x 0.71 x 0.83 = 147 cfs

Example 2

Determine adjusted peak rate of flow from a 500-acre watershed having a peak rate of flow from 25-year, 24-hour frequency storm of 800 cfs for the following conditions:

5-acre swampy area located immediately above a proposed pond site, with no other significant storage areas in watershed.

Solution: Ratio D.A./Swampy Area = 500/5 = 100
Adjustment factor from Table 2-8 = 0.85
Adjusted Peak Flow = 800 x 0.85 = 680 cfs

NOTE: In this case, design the pond to control a peak inflow rate of 680 cfs. By using flood routing procedures a further reduction in peak rate of discharge may be obtained for emergency spillway design.

Example 3

Determine the adjusted peak flow for the design of a grassed waterway (10-year, 24-hour frequency) with an 80-acre watershed if this watershed has 2 ponds located in the upper reaches with a total of 2.0 acres of surface area. Peak rate of flow for a 10-year frequency storm = 75 cfs. Slope is 3 percent.

Solution: Ratio D.A./Pond Area = 80/2 = 40
Adjustment Factor from Table 2-10 = 0.86
From Table 2-8 slope factor = 0.96
Adjusted Peak Flow = 75 x 0.86 x 0.96 = 62 cfs.

Figure 2-8 specifies a quick method for estimating peak discharge requirements for structural measures in very flat areas. Correction for ponding and swampy areas will not be used in conjunction with this figure. Such storage was taken into account in the procedure development. For use, follow example 4.

Example 4

Determine the adjusted peak flow for a channel using the 2-year, 24-hour rainfall with a drainage area of 1.5 square miles, slope of 1.0 foot per mile (0.00019 ft/ft) and curve number of 80.

Solution: From Table 2-4 for Escambia County the 2-year, 24-hour rainfall is 5.5 inches. Using Table 2-5 and curve number 80, the runoff is 3.34 inches. From Figure 2-8 the peak rate is 64 cfs per 1.0 inch of runoff. therefore, the peak is 3.34 x 64 = 214 cfs.

12. Urban Hydrology

When hydrology is developed for the evaluation of watershed protection, flood prevention, and drainage in urban area development, more specific curve numbers may be desired than are used on our regular conservation measures. The curve numbers for specific hydrologic conditions as shown in Table 2-13 are recommended.

The runoff curve numbers in Table 2-13 are to be used for fully developed urban areas with good sod or with sufficient season remaining to establish good sod forming vegetation. Additional information on the more complex urban hydrology can be secured from Technical Release - 55, Urban Hydrology for Small Watersheds, filed in the Field Office Technical Guide, Section 1-A.12, Engineering References. Also see Procedure for Computing Runoff for Drainage Areas Less Than Five (5) Acres in this Chapter.

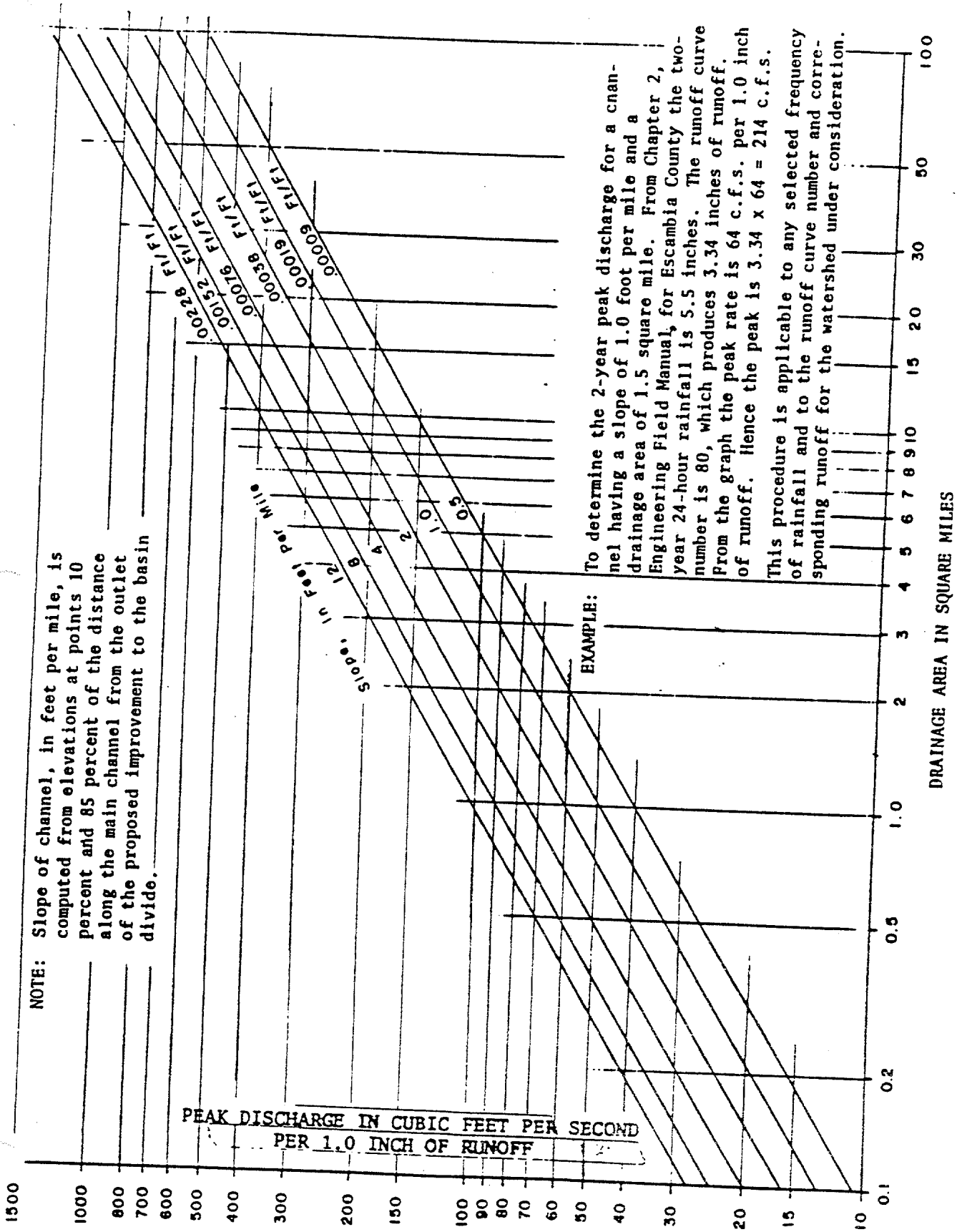


Figure 2-8 Peak discharge rates for flatland areas

TABLE 2-13 Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION		HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land: without conservation treatment		72	81	88	91
: with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	71	78	81
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover		25	55	70	77
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential:					
Average lot size	Average % Impervious				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

PROCEDURE FOR COMPUTING RUNOFF FOR DRAINAGE AREAS LESS THAN FIVE (5) ACRES

The peak discharge for areas less than five (5) acres is determined by use of the following procedure.

When computing runoff for areas less than five (5) acres:

(1) Compute the discharge from Exhibit 2-1 for five (5) acres using the appropriate curve number and slope.

(2) Modify or interpolate peak discharge for average watershed slopes between and greater than flat, moderate, and steep.

(3) Use the following table to reduce the discharge obtained in steps 1 or 2 above by the appropriate factor.

Drainage Area (Acres)	Factor
5.0	1.00
4.0	0.86
3.0	0.71
2.0	0.54
1.0	0.34
0.5	0.21
0.0	0.00

(4) Example:

Given - 2 acre drainage area.
Soils are Pacolet, group B.
Pasture no mech. treatment under good condition.
10-yr., 24-hr storm at Opelika is 6.3 inches.
Slope - 4% - Moderate
CN - 61 use 60

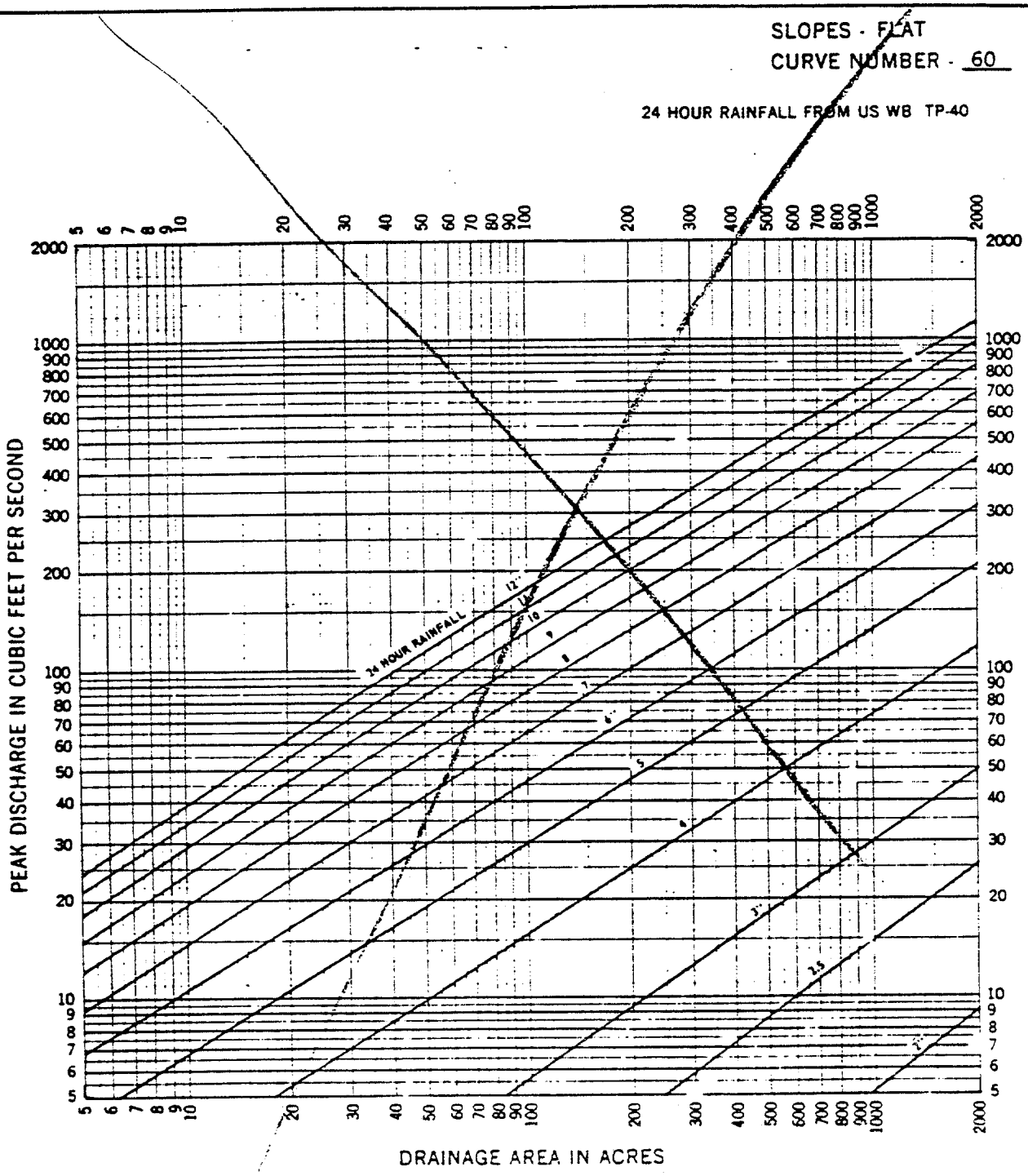
Compute - Discharge from 2 acre drainage area

From Exhibit 2-1, for a CN 60, moderate slope, rainfall 6.3 in. and 5 acre drainage area, find a discharge of 11.2 cfs.

From Table 2-8, find 4% factor to be 1.0
From the table above, obtain a modification factor of 0.54 for a 2 acre drainage area. Therefore, Q_{10} = 11.2 cfs x 0.54 x 1.0 = 6.0 cfs.

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION



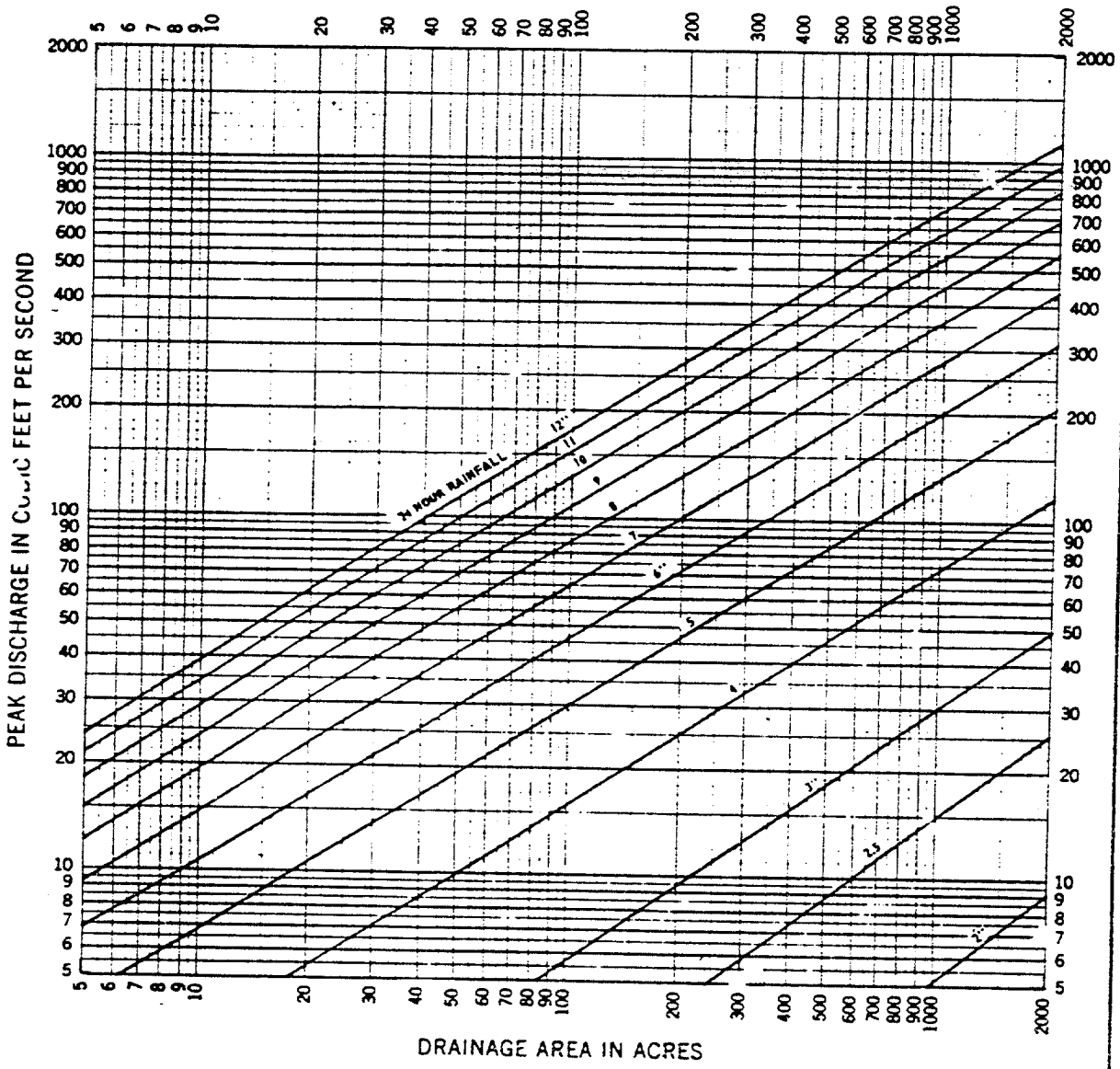
REFERENCE		STANDARD DWG. NO.
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION HYDROLOGY BRANCH	ES-1027 SHEET 1 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - FLAT
CURVE NUMBER - 60

24 HOUR RAINFALL FROM US WB TP-40



REFERENCE

"Chapter 2, Engineering Field Manual for Conservation Practices"

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

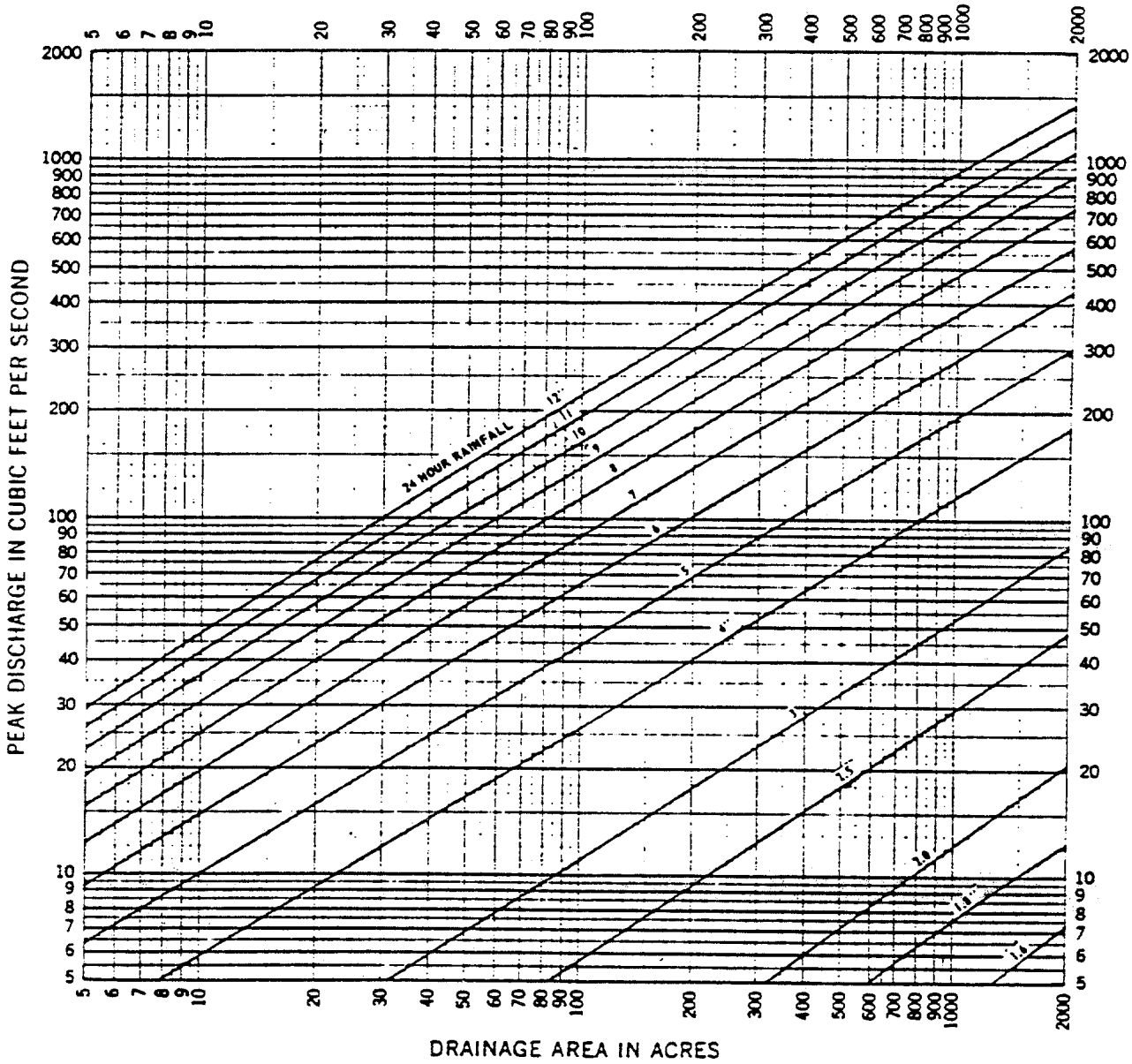
STANDARD DWG. NO.
ES-1027
SHEET 1 OF 21
DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - FLAT
CURVE NUMBER - 65

24 HOUR RAINFALL FROM US WB TP-40



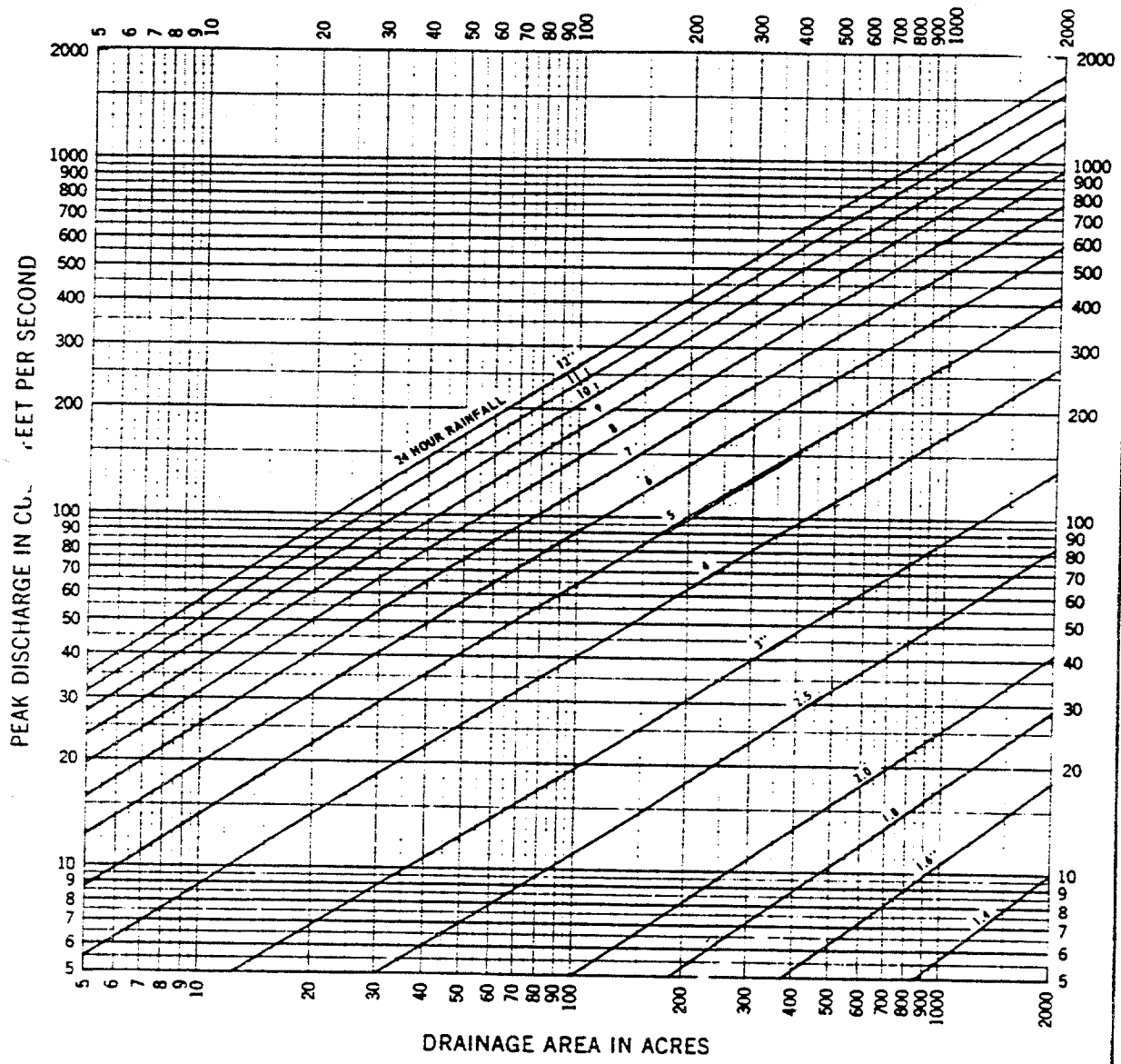
REFERENCE		
"Chapter 2. Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	STANDARD DWG. NO. ES-1027 SHEET 2 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - FLAT
CURVE NUMBER - 70

24 HOUR RAINFALL FROM US WB TP-40



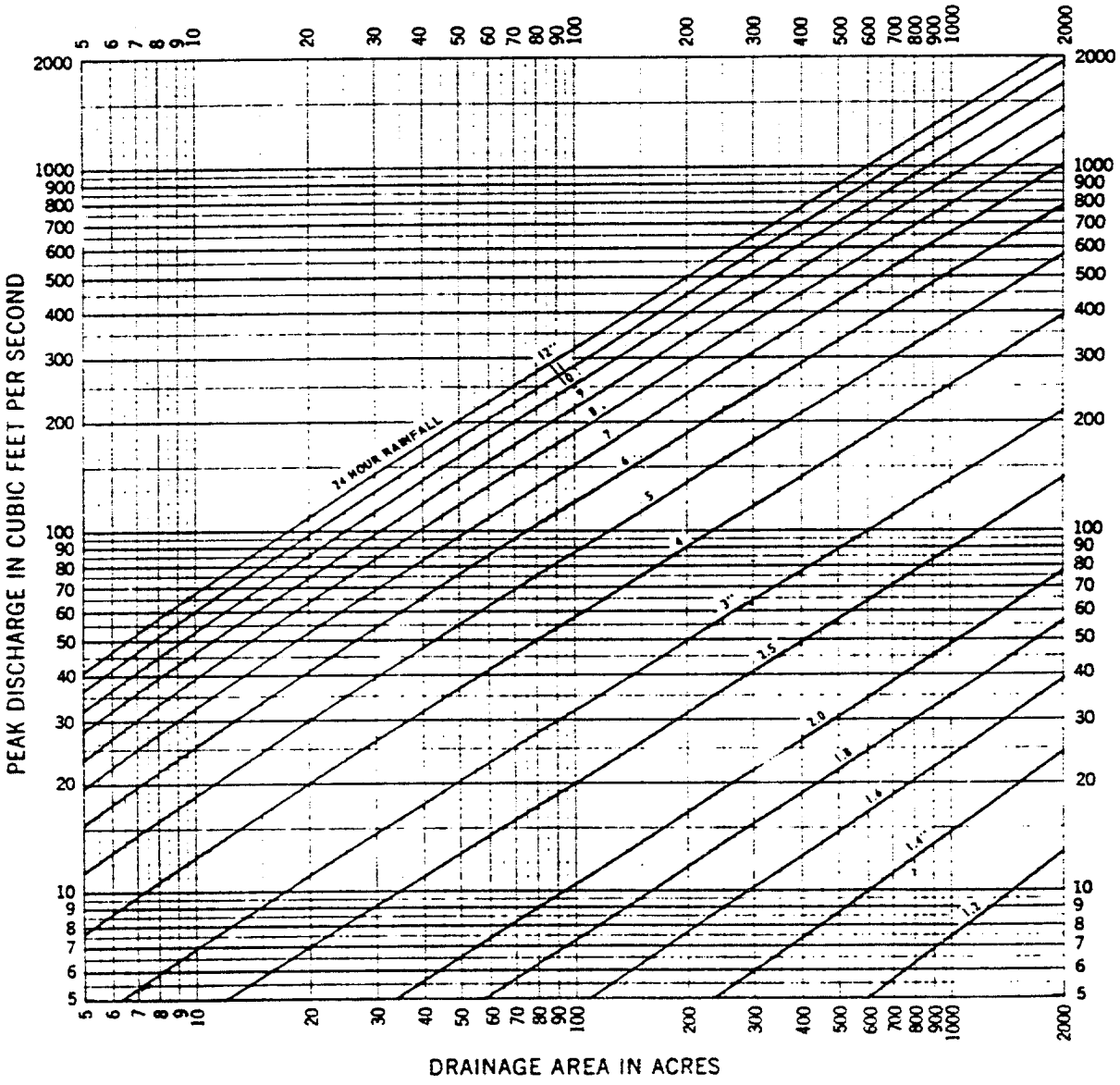
ENCE Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	STANDARD DWG. NO. ES-1027 SHEET 3 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - FLAT
CURVE NUMBER - 75

24 HOUR RAINFALL FROM US WB TP-40



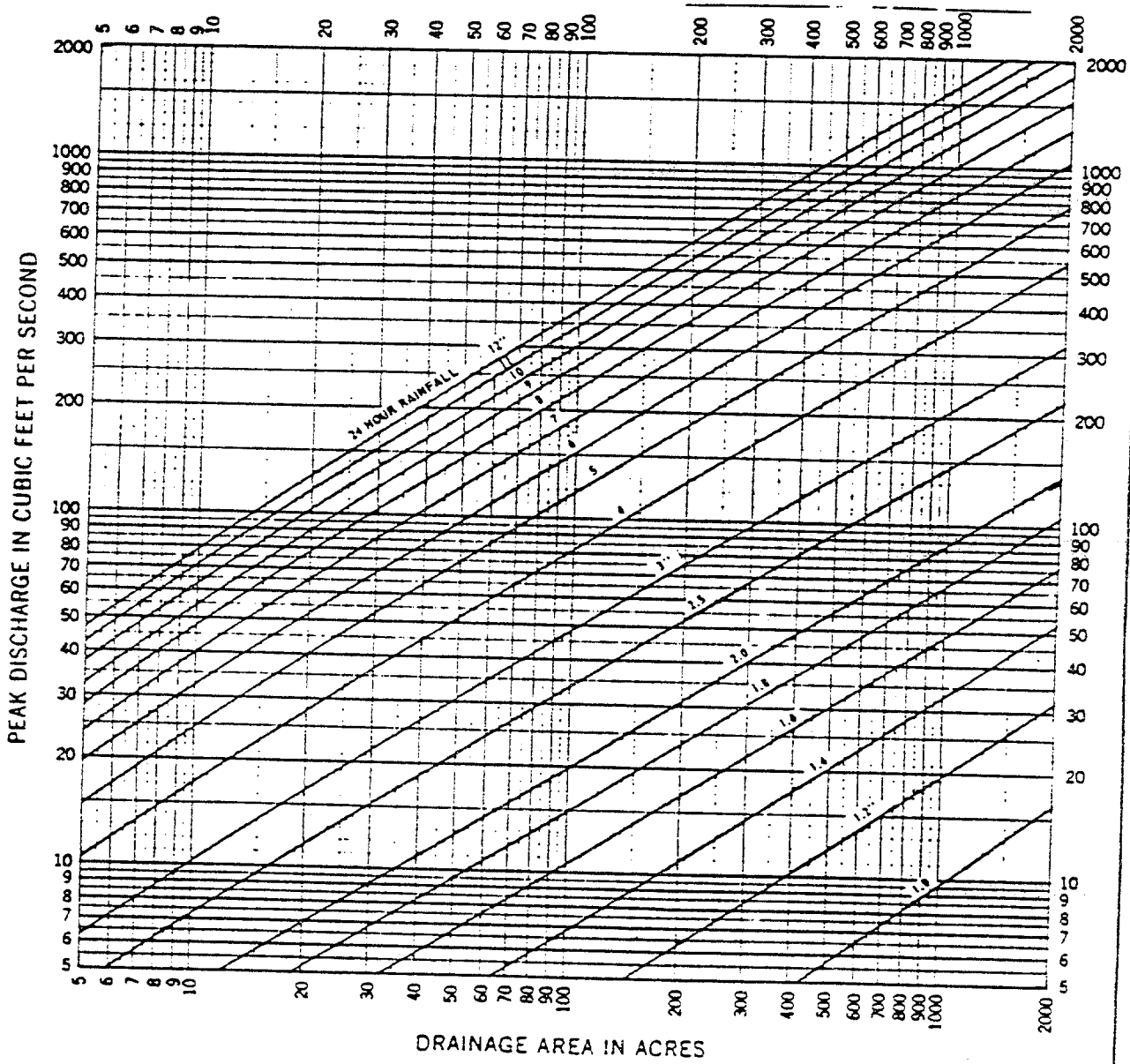
REFERENCE		STANDARD DWG. NO.
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	ES-1027 SHEET 4 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - FLAT
CURVE NUMBER - 80

24 HOUR RAINFALL FROM US WB TP-40



EFERENCE

"Chapter 2. Engineering Field Manual for Conservation Practices"

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

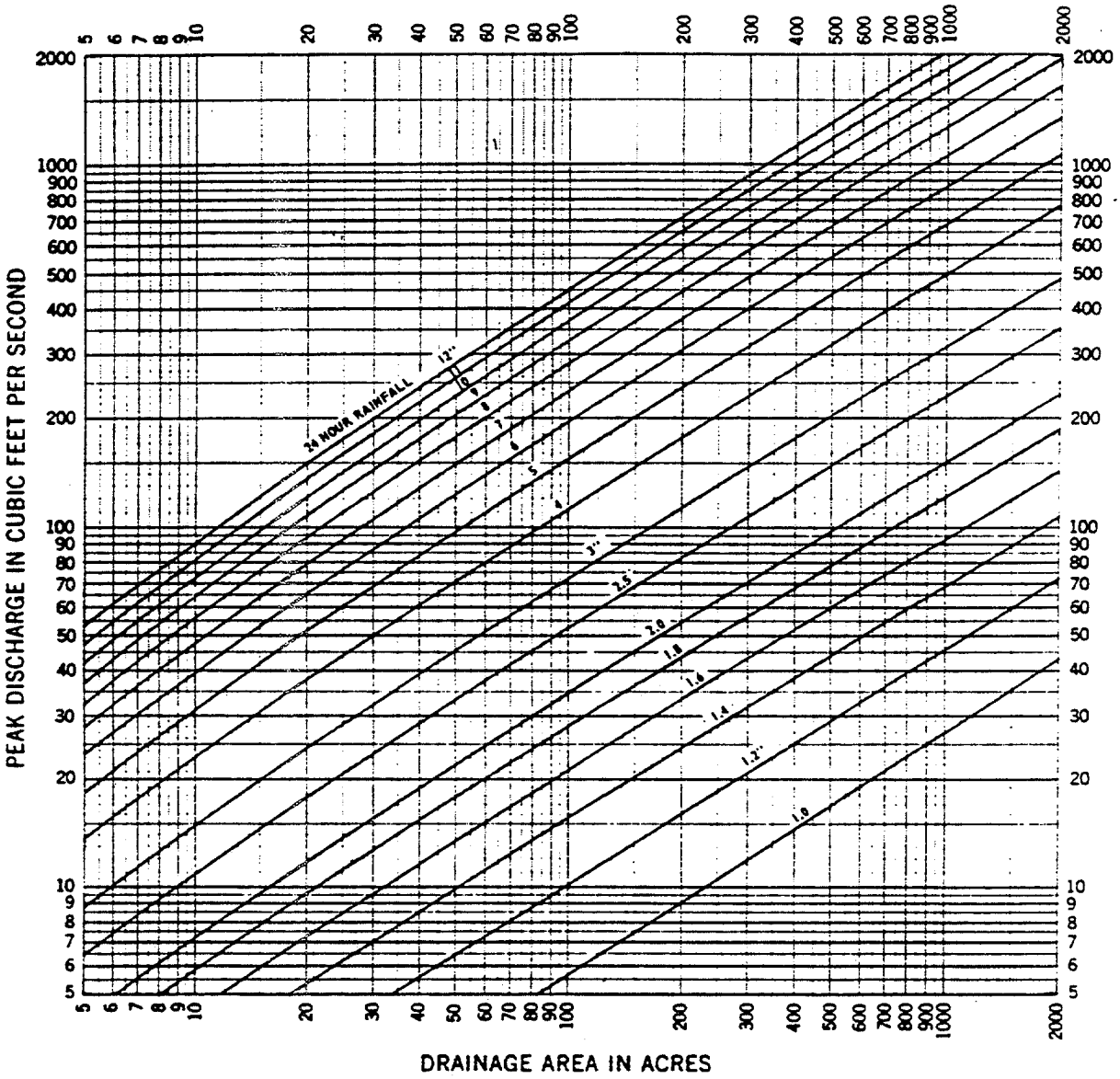
STANDARD DWG. NO.
ES-1027
SHEET 5 OF 21
DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - FLAT
CURVE NUMBER - 85

24 HOUR RAINFALL FROM US WB TP-40



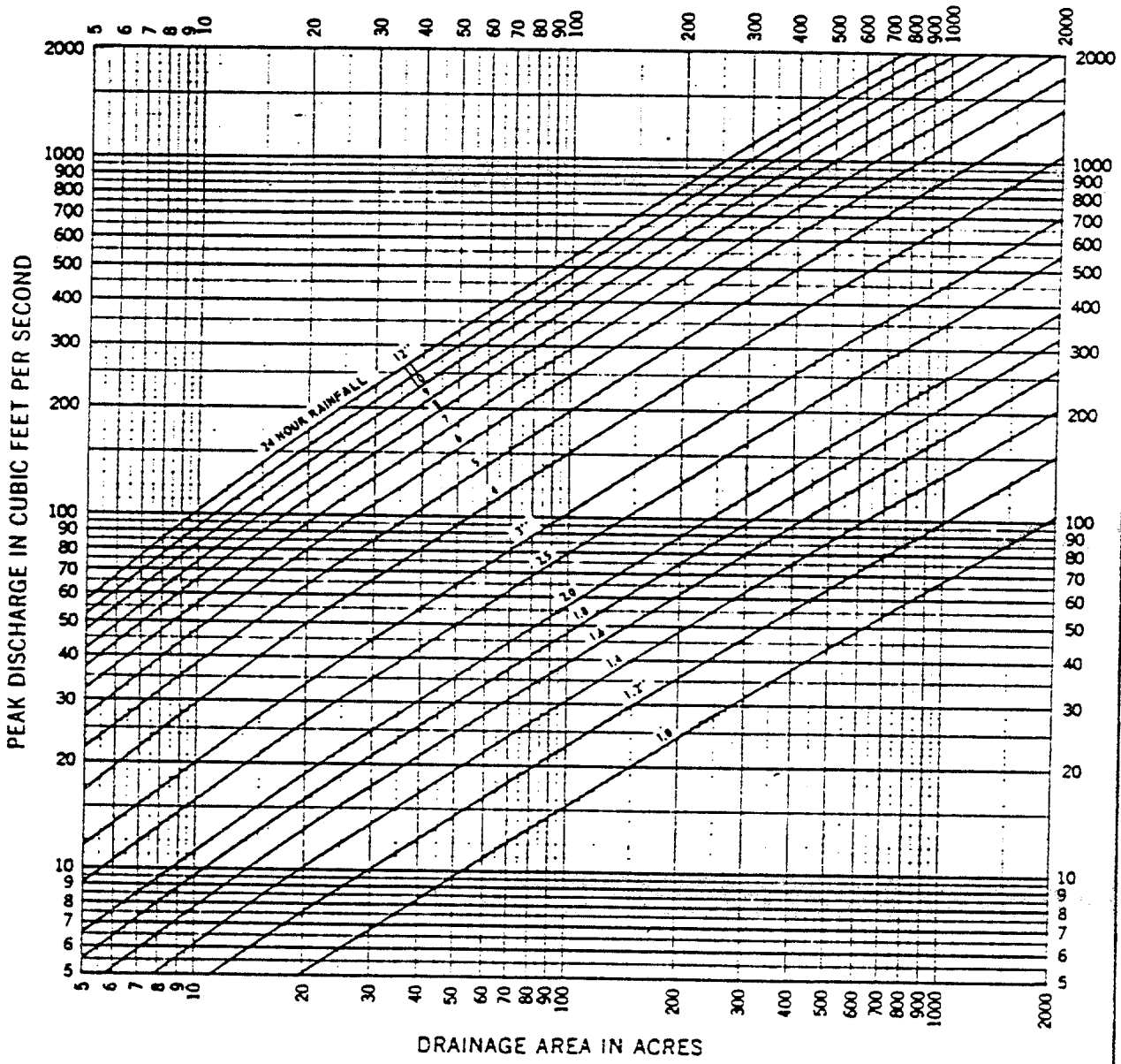
REFERENCE		STANDARD DWG. NO.
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	ES-1027 SHEET 6 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - FLAT
CURVE NUMBER - 90

24 HOUR RAINFALL FROM US WB TP-40



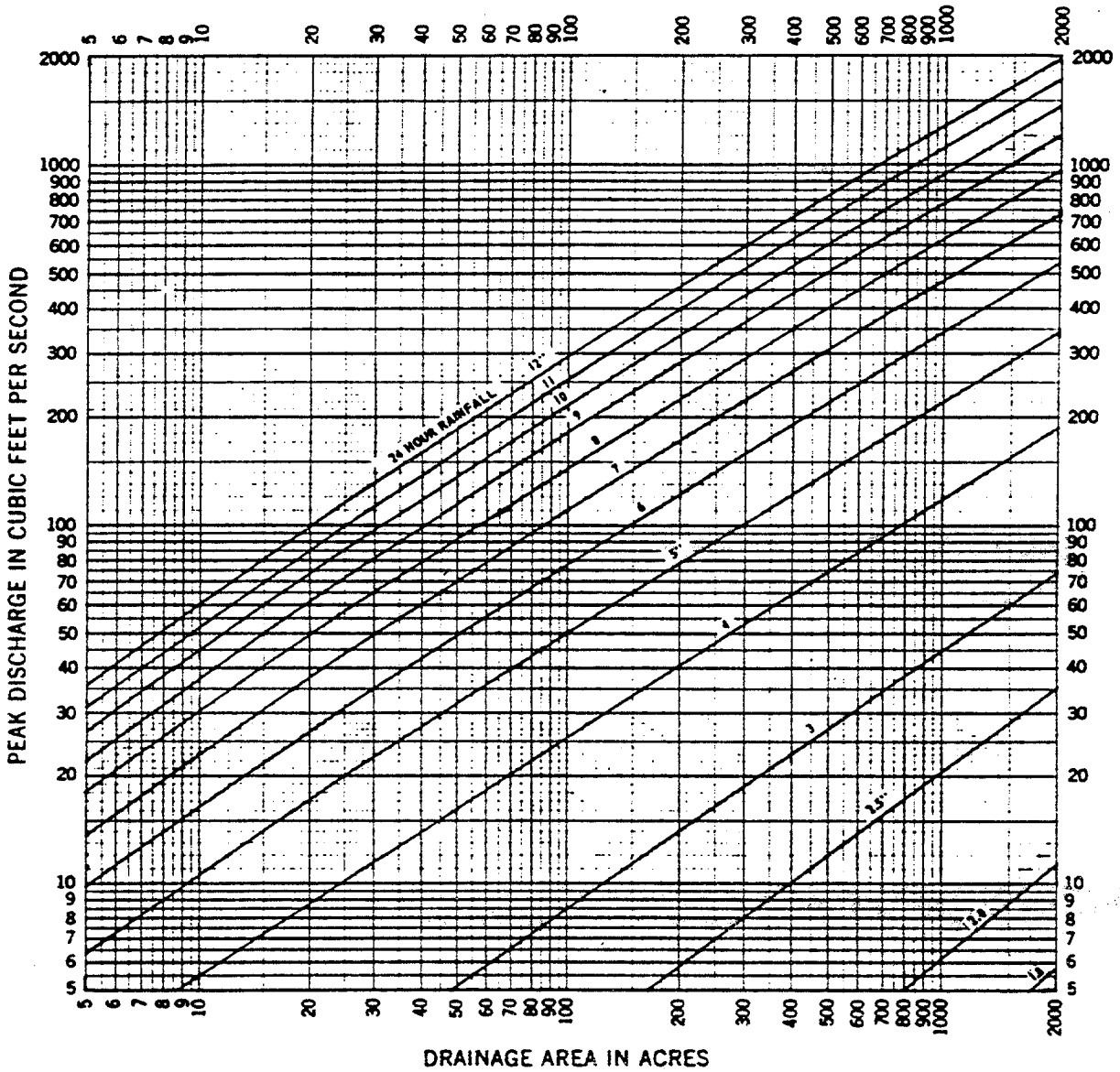
REFERENCE		
"Chapter2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	STANDARD DWG. NO. ES-1027 SHEET 7 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - MODERATE
CURVE NUMBER - 60

24 HOUR RAINFALL FROM US WB TP-40



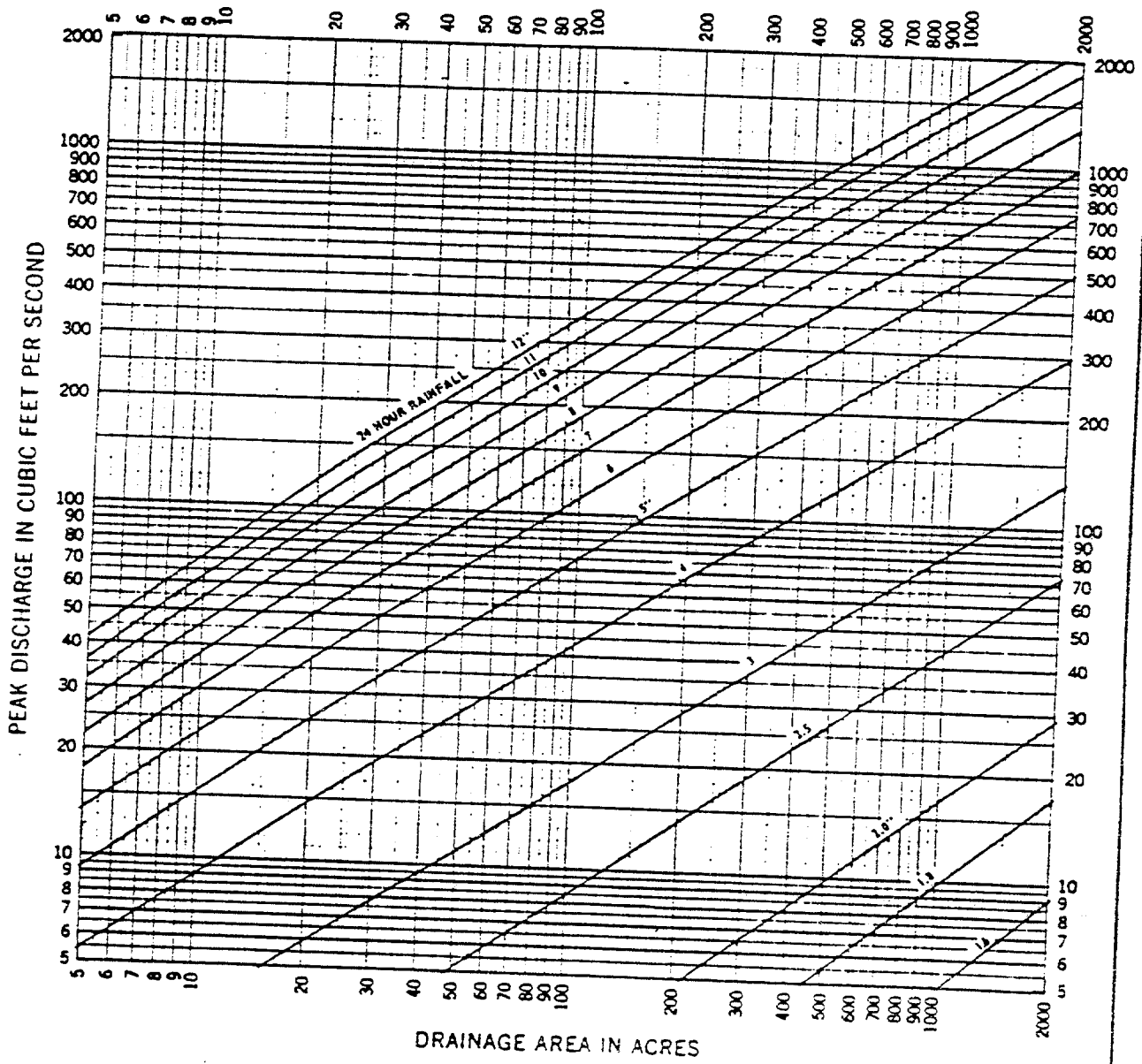
REFERENCE		STANDARD DWG. NO.
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	ES-1027 SHEET 8 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - MODERATE
CURVE NUMBER - 65

24 HOUR RAINFALL FROM US WB TP-40



REFERENCE

"Chapter 2, Engineering Field Manual for Conservation Practices"

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

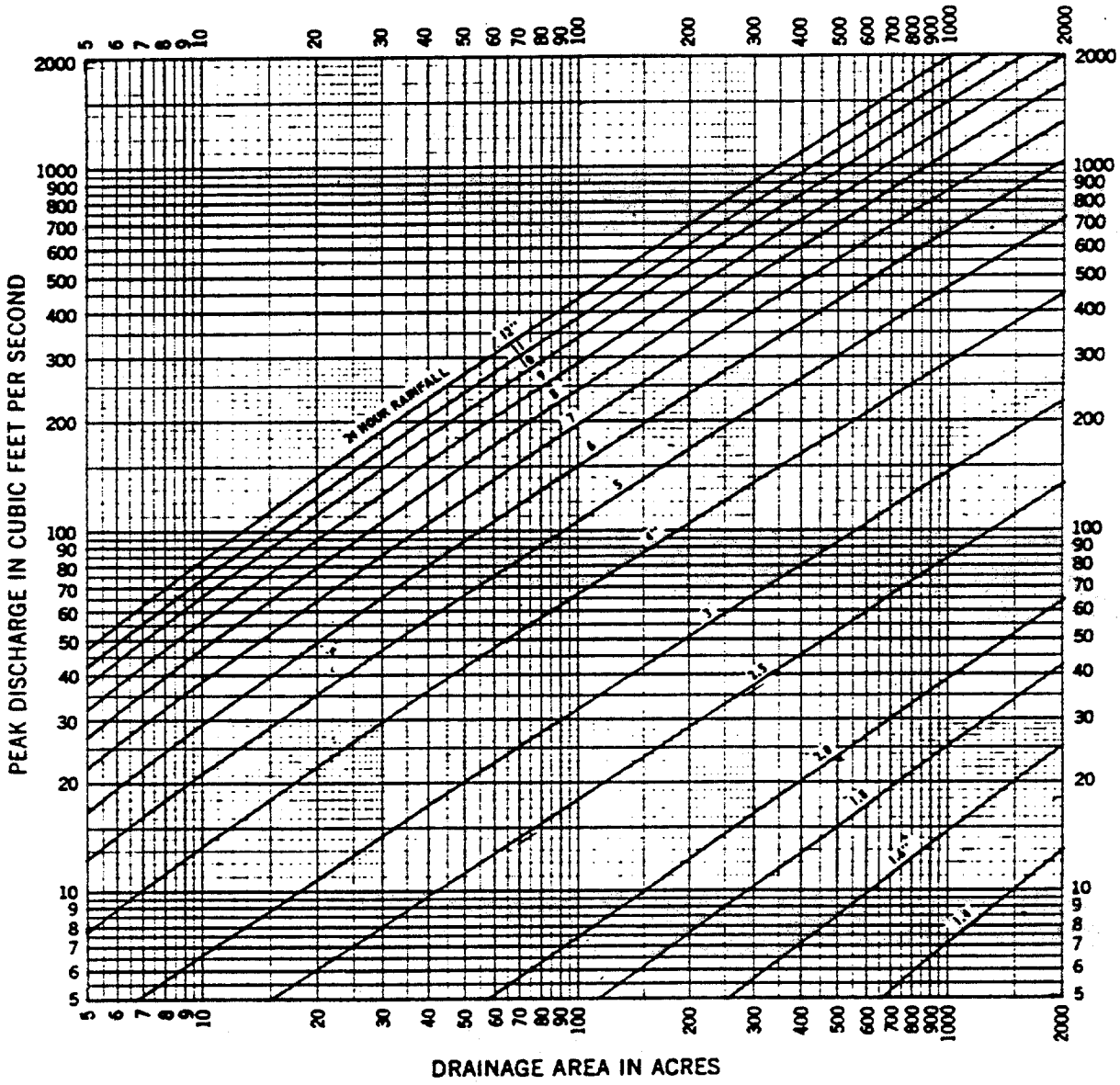
STANDARD DWG. NO.
ES-1027
SHEET 9 OF 21
DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - MODERATE
CURVE NUMBER - 70

24 HOUR RAINFALL FROM US WB TP-40



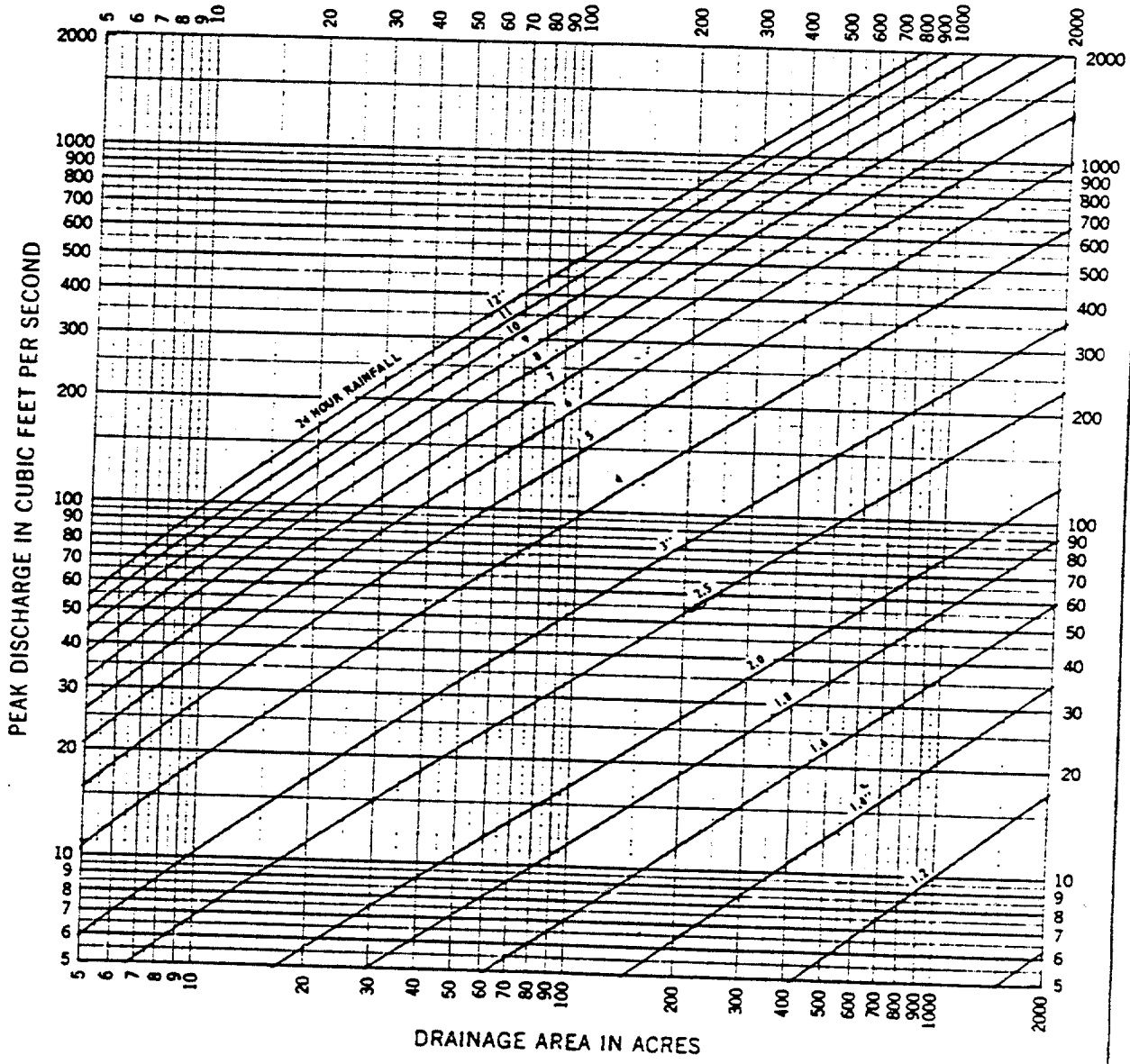
REFERENCE		STANDARD DWG. NO.
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	ES-1027 SHEET 10 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - MODERATE
CURVE NUMBER - 75

24 HOUR RAINFALL FROM US WB TP-40



REFERENCE

"Chapter 2, Engineering Field Manual for Conservation Practices"

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

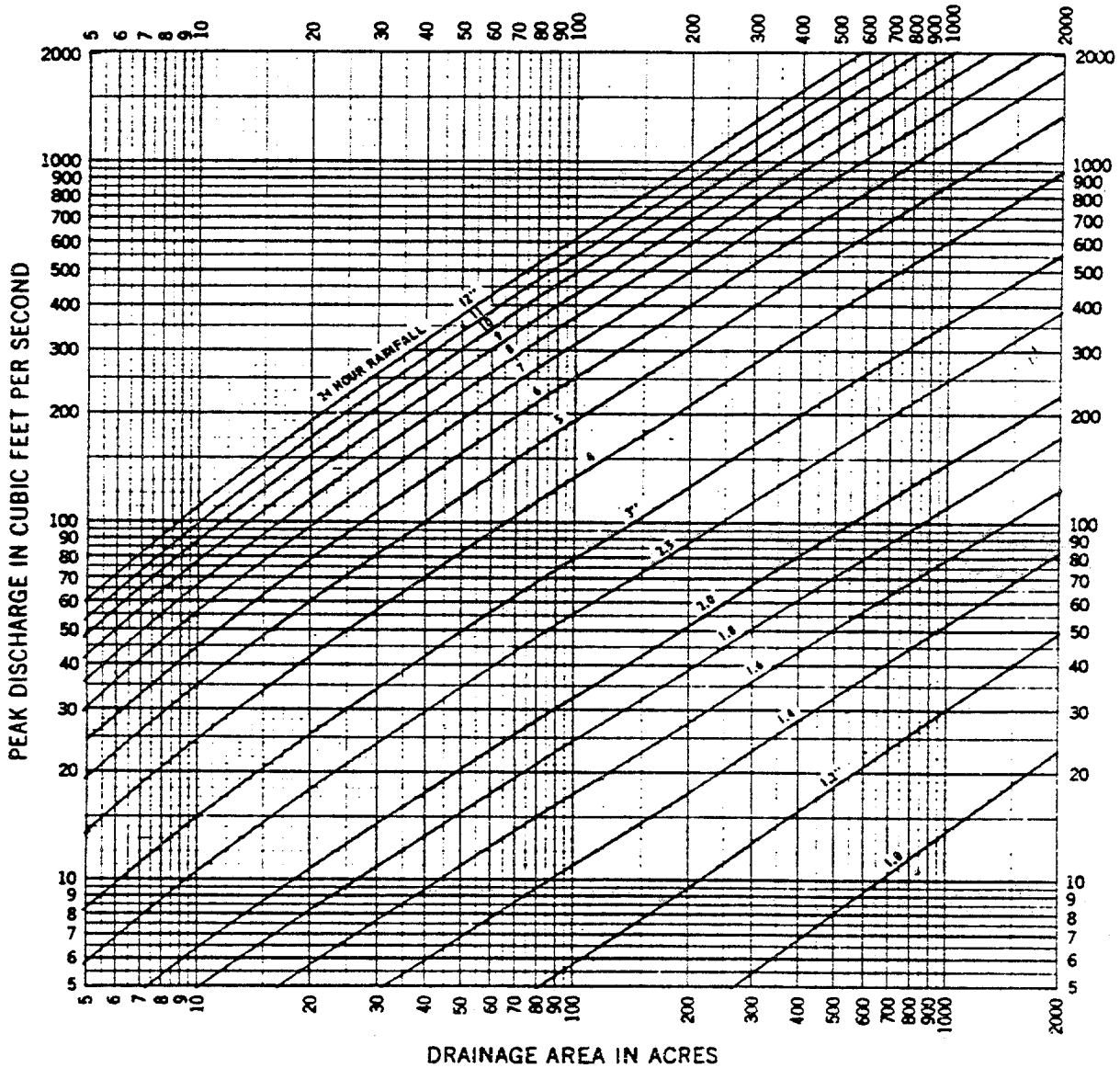
STANDARD DWG. NO.
ES-1027
SHEET 11 OF 21
DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - MODERATE
CURVE NUMBER - 80

24 HOUR RAINFALL FROM US WB TP-40



REFERENCE

"Chapter 2, Engineering Field Manual for Conservation Practices"

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

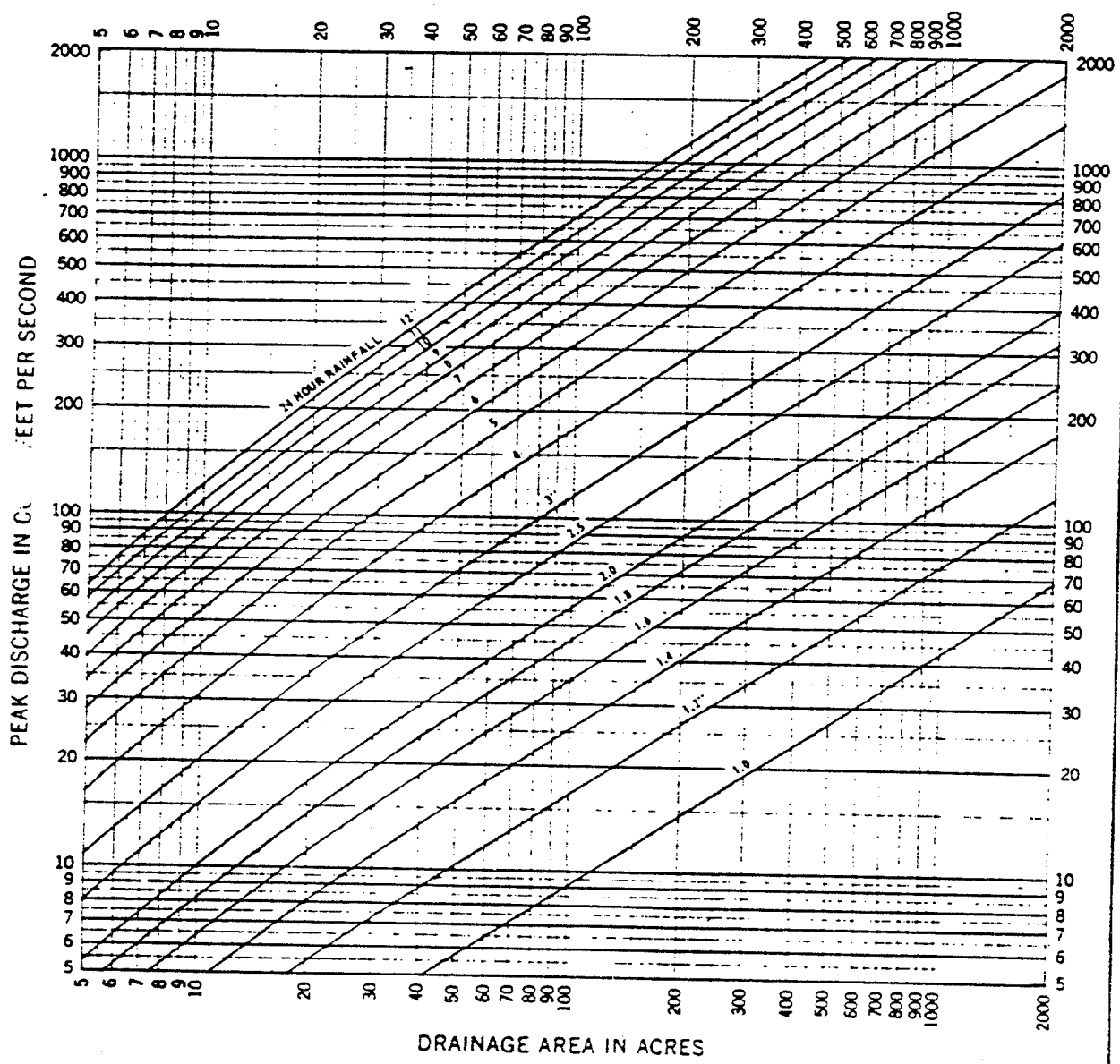
STANDARD DWG. NO.
ES-1027
SHEET 12 OF 21
DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - MODERATE
CURVE NUMBER - 85

24 HOUR RAINFALL FROM US WB TP-40



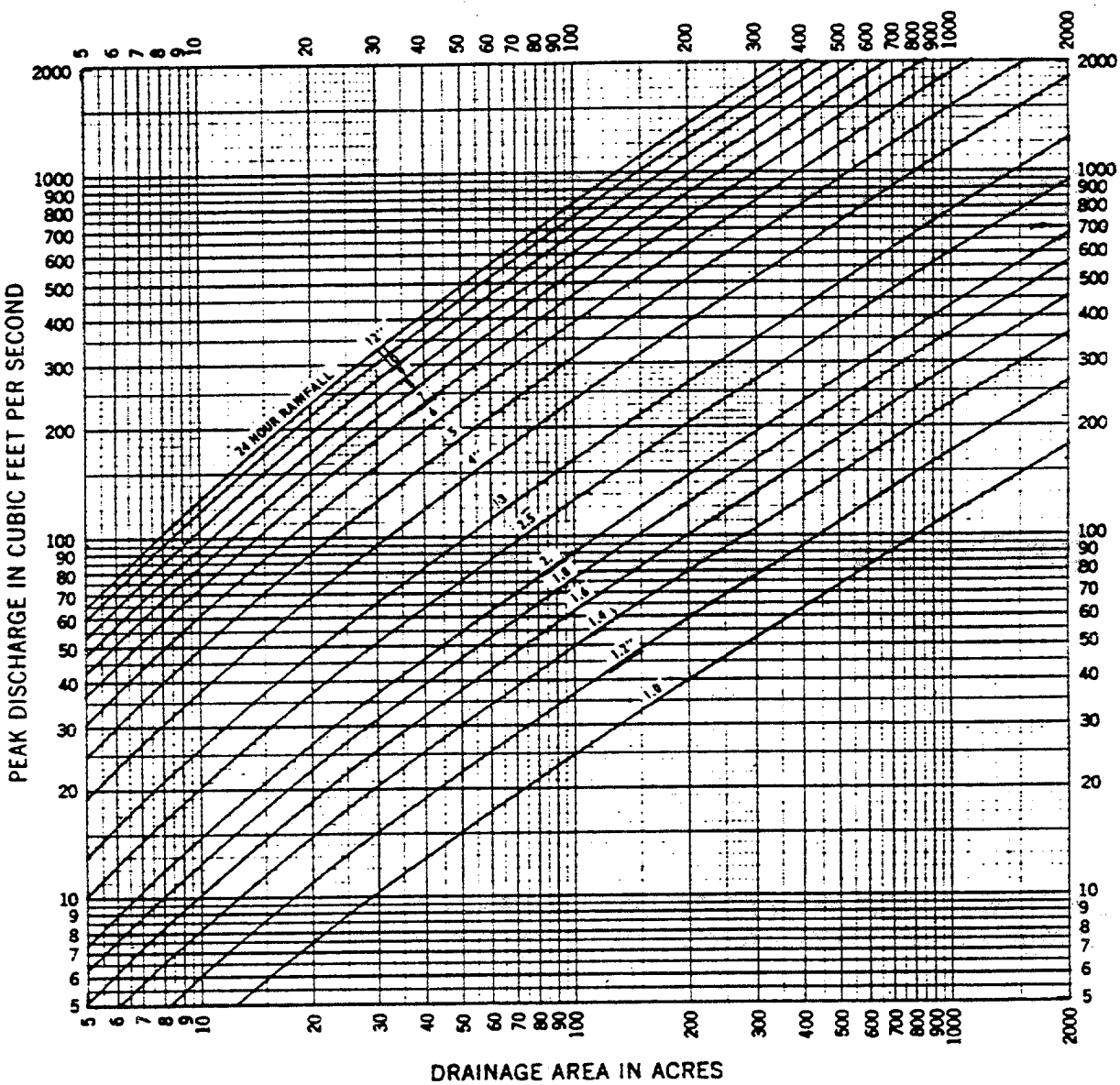
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	STANDARD DWG. NO. ES-1027 SHEET 13 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - MODERATE
CURVE NUMBER - 90

24 HOUR RAINFALL FROM US WB TP-40



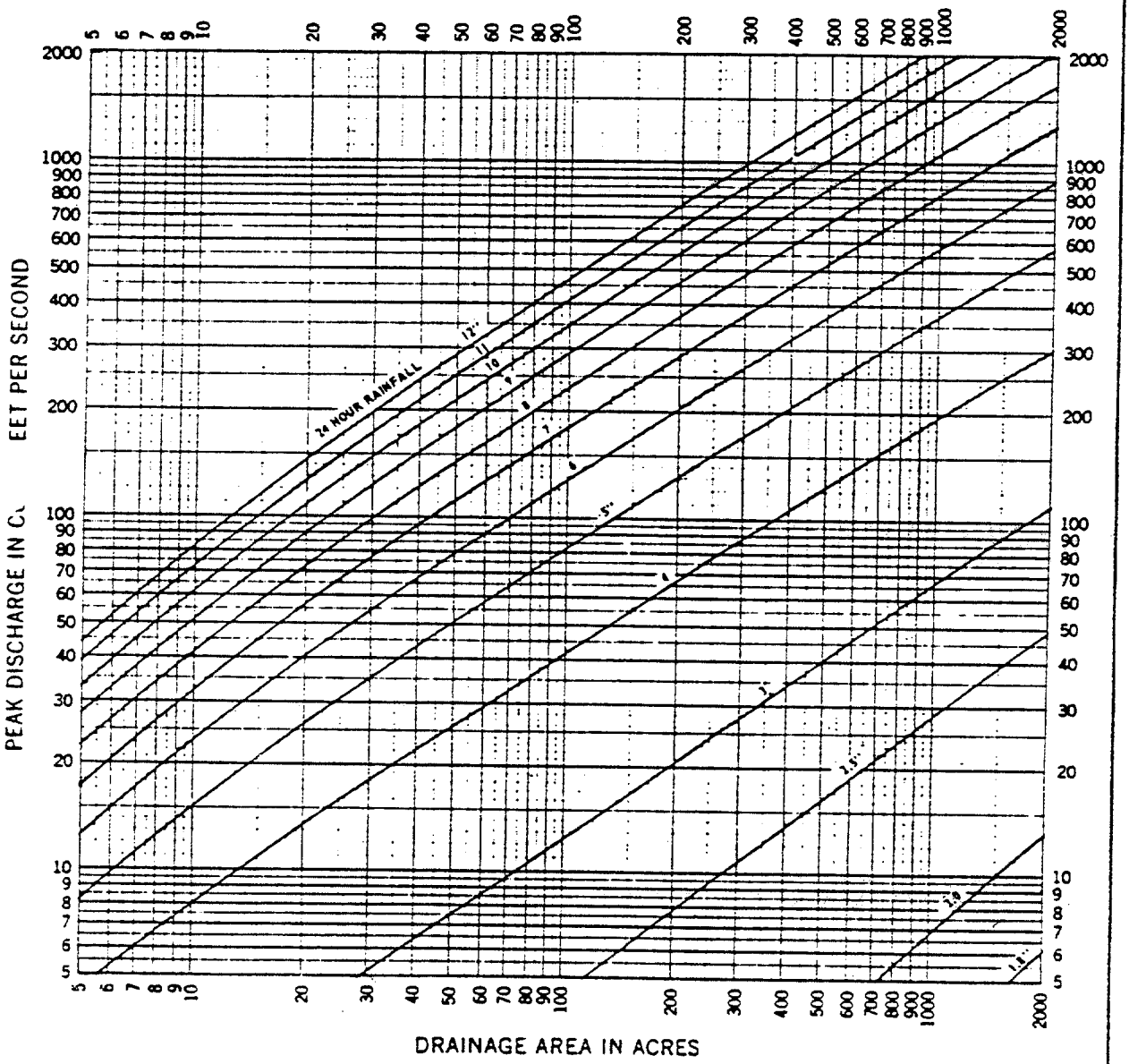
REFERENCE		
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	STANDARD DWG. NO. ES-1027 SHEET 14 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - STEEP
CURVE NUMBER - 60

24 HOUR RAINFALL FROM US WB TP-40



"Chapter 2, Engineering Field Manual for Conservation Practices"

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

STANDARD DWG. NO.
ES-1027
SHEET 15 OF 21
DATE 2-15-71

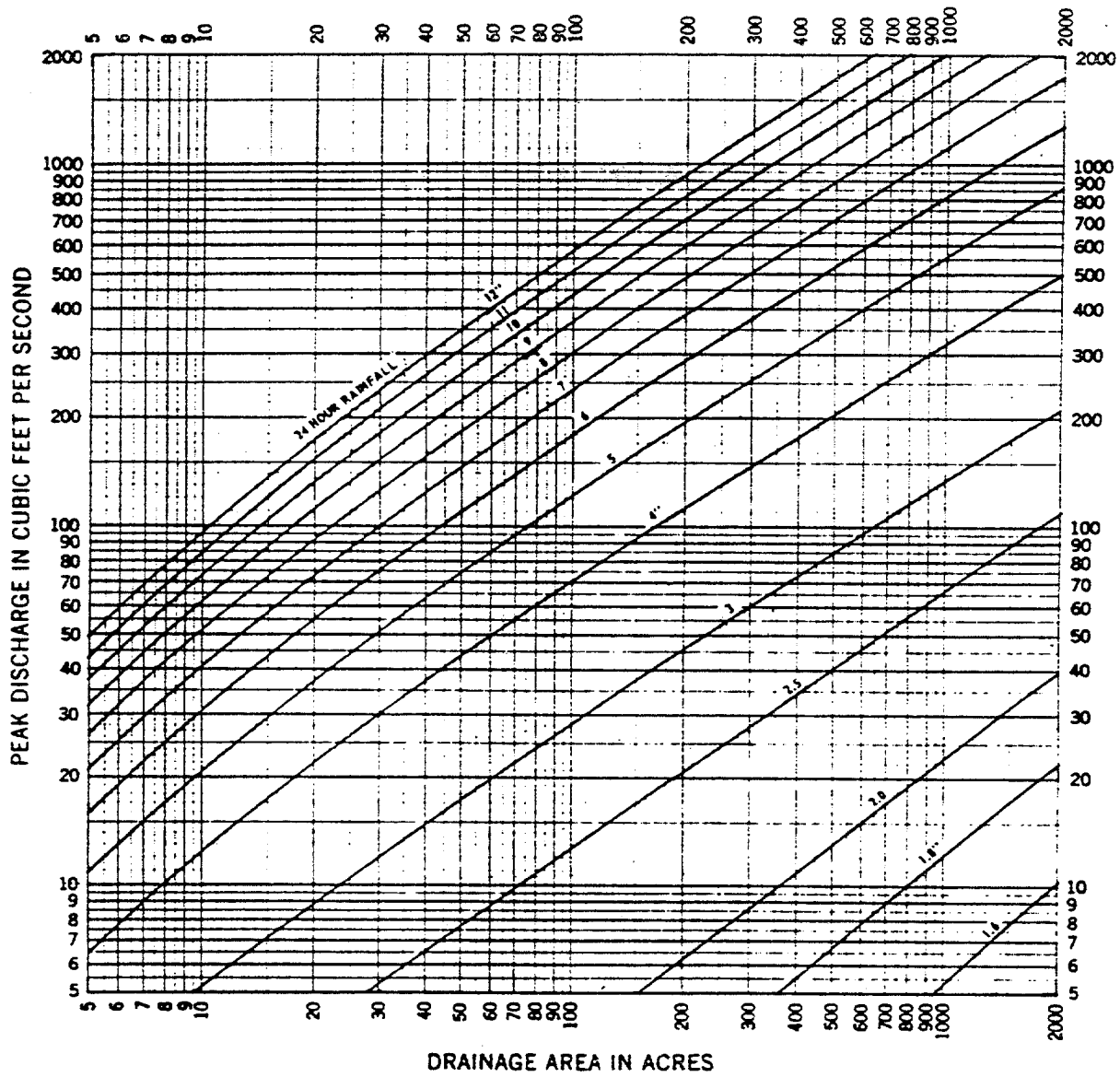
EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - STEEP

CURVE NUMBER - 65

24 HOUR RAINFALL FROM US WB TP-40



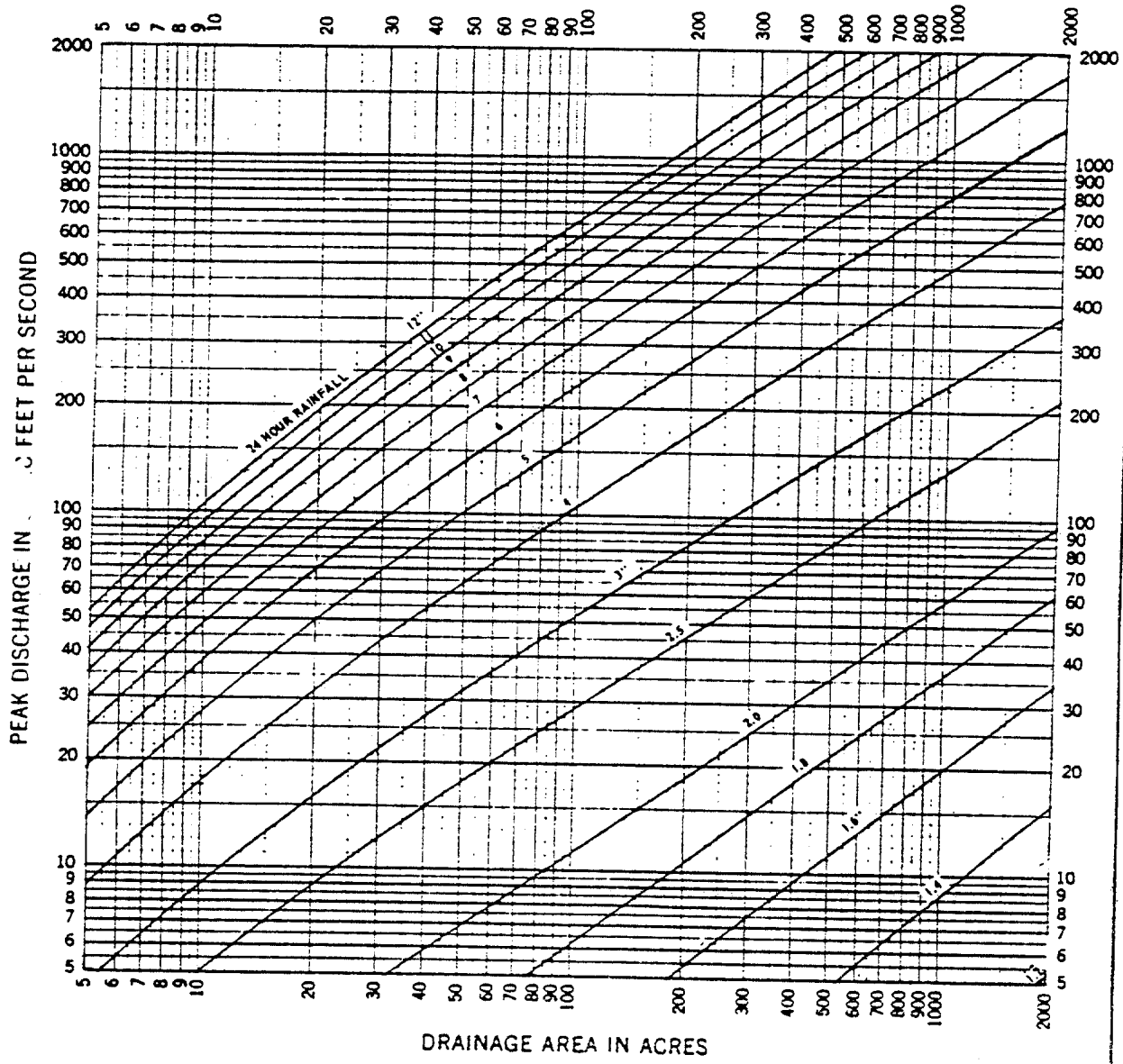
REFERENCE		STANDARD DWG. NO.
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	ES-1027 SHEET 16 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - STEEP
CURVE NUMBER - 70

24 HOUR RAINFALL FROM US WB TP-40



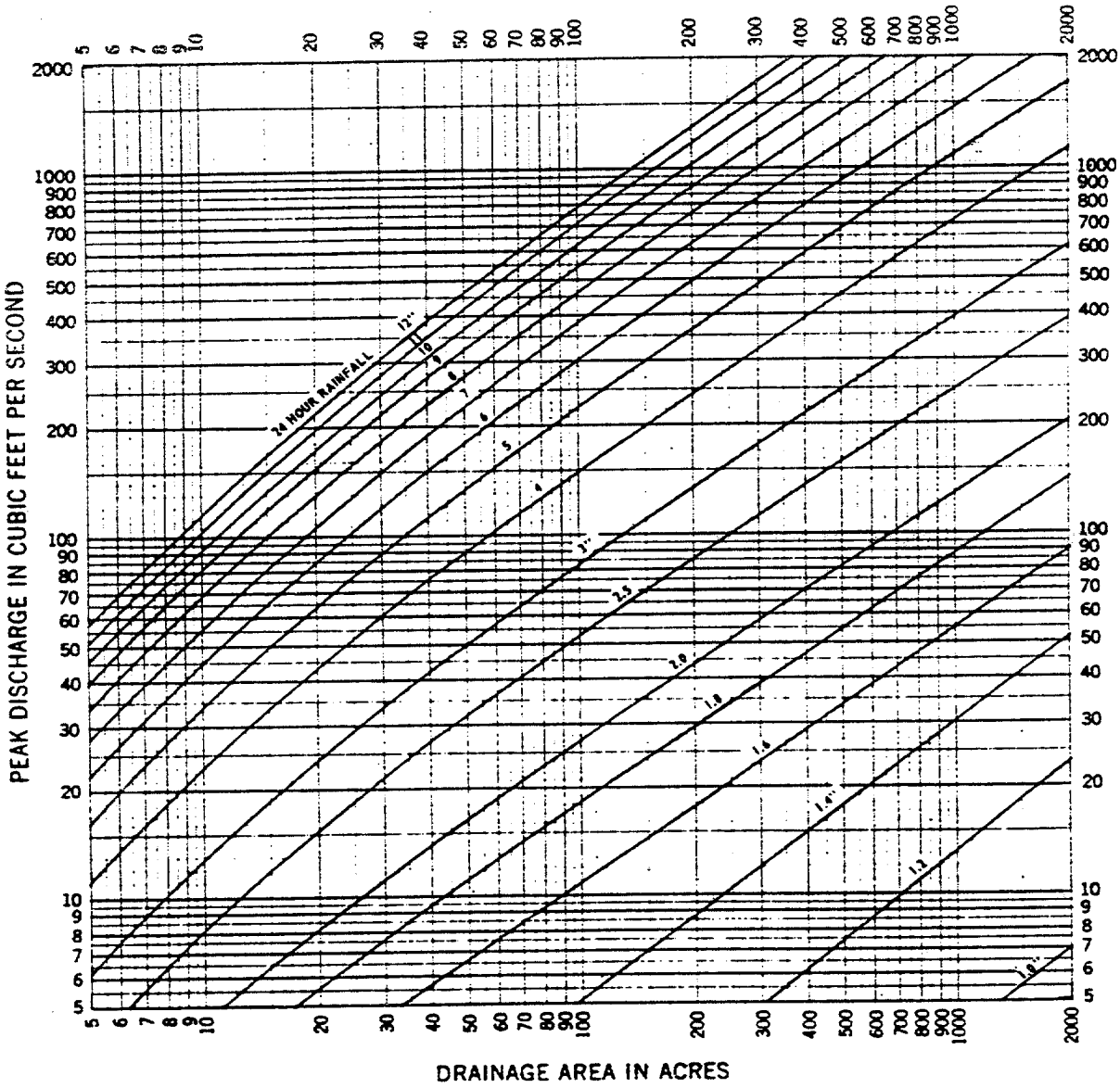
...ERENCE ...pter 2. Engineering Field Manual ...r Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	STANDARD DWG. NO. ES-1027 SHEET 17 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - STEEP
CURVE NUMBER - 75

24 HOUR RAINFALL FROM US WB TP-40



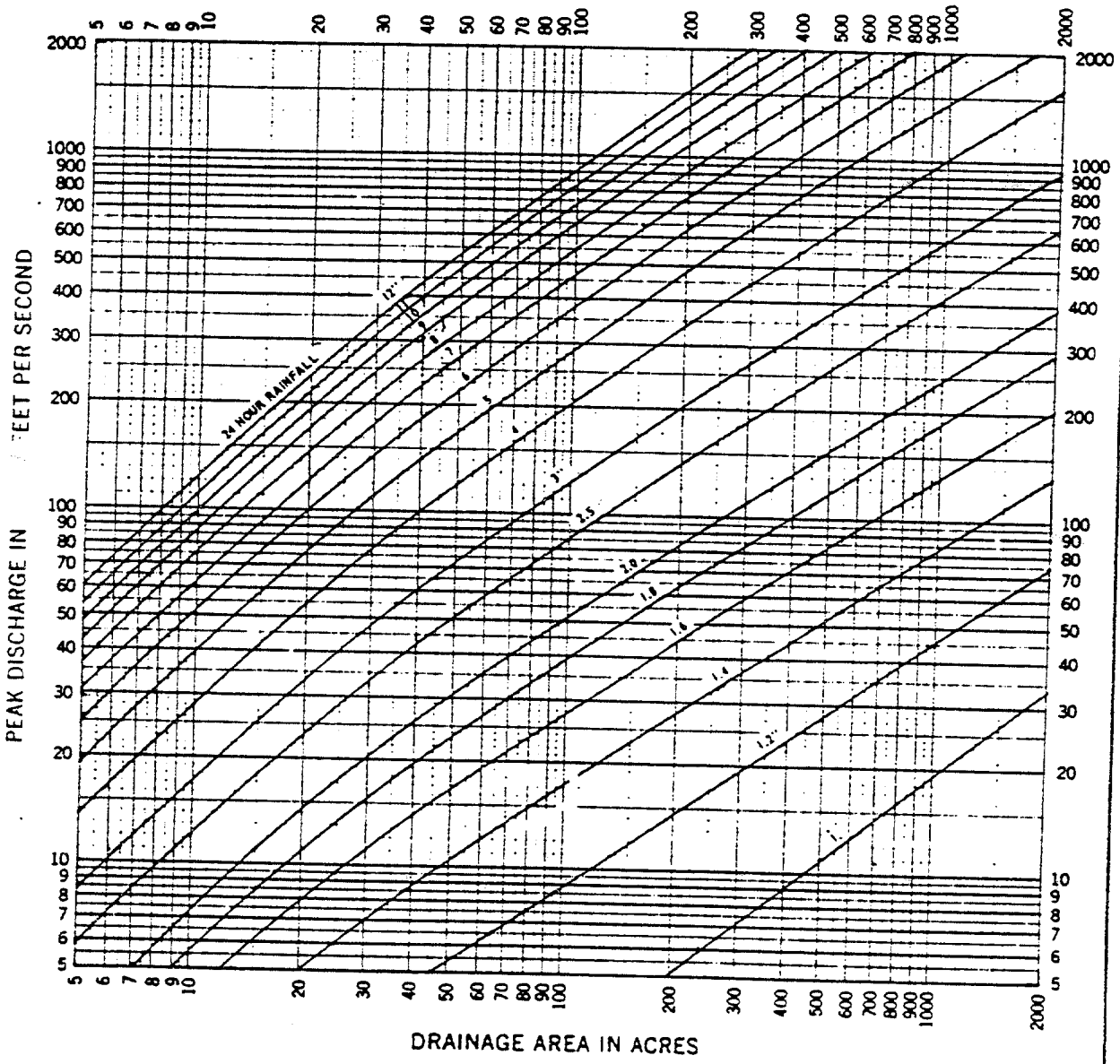
REFERENCE		STANDARD DWG. NO.
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	ES-1027 SHEET 18 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - STEEP
CURVE NUMBER - 80

24 HOUR RAINFALL FROM US WB TP-40



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

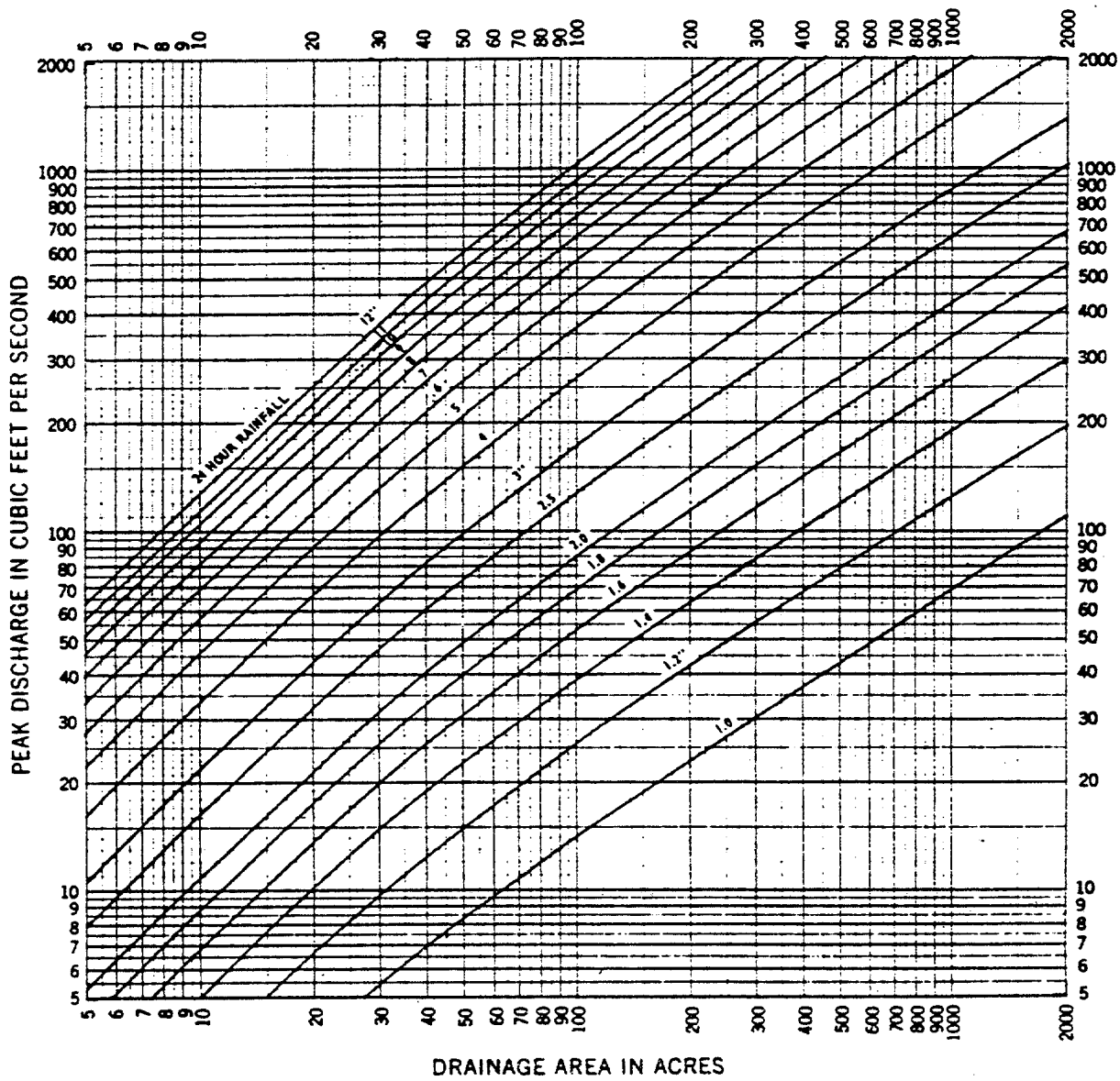
STANDARD DWG. NO.
ES-1027
SHEET 19 OF 21
DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - STEEP
CURVE NUMBER - 85

24 HOUR RAINFALL FROM US WB TP-40



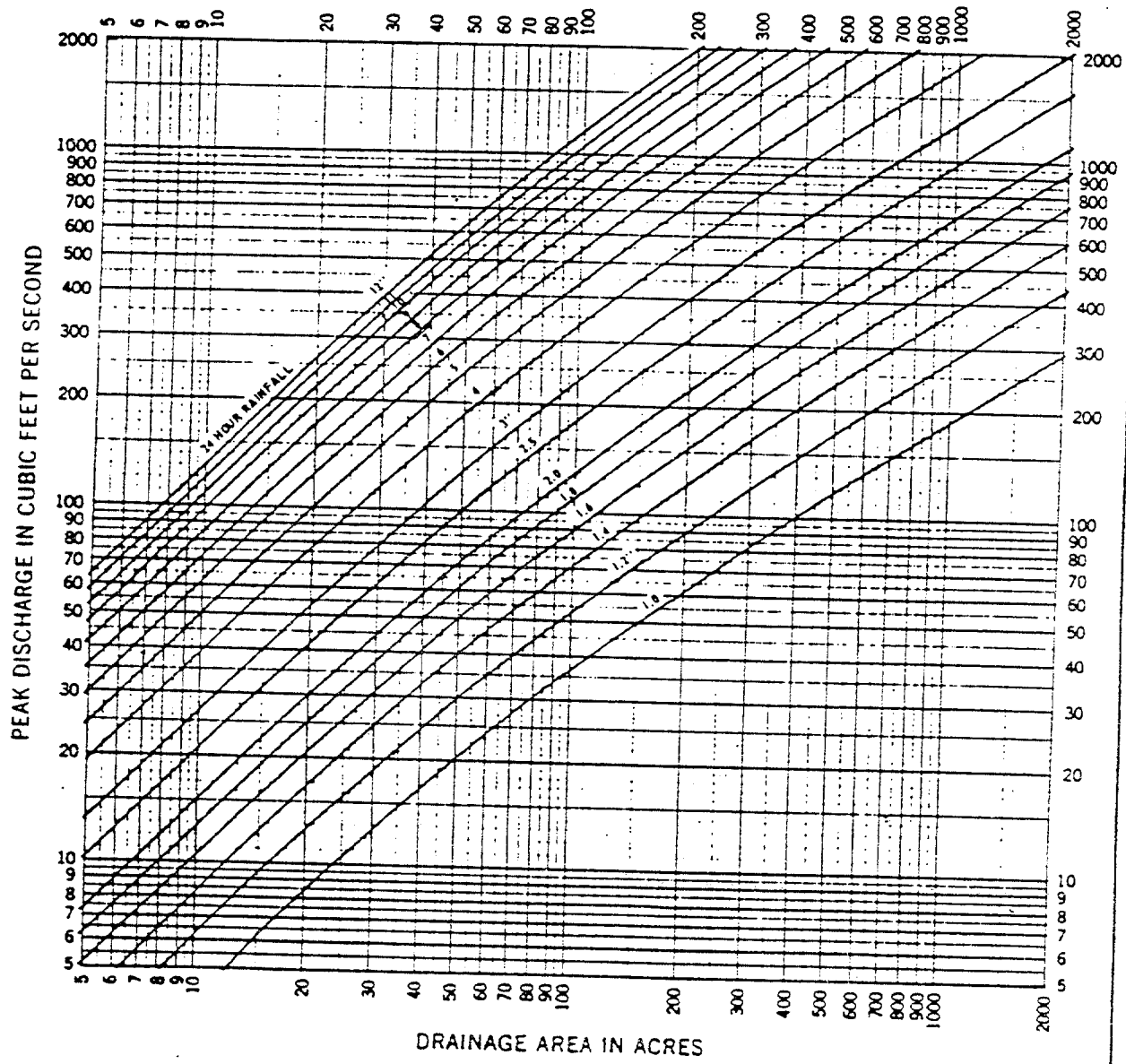
REFERENCE		
"Chapter 2, Engineering Field Manual for Conservation Practices"	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - HYDROLOGY BRANCH	STANDARD DWG. NO. ES-1027 SHEET 20 OF 21 DATE 2-15-71

EXHIBIT 2-1

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
TYPE II STORM DISTRIBUTION

SLOPES - STEEP
CURVE NUMBER - 90

24 HOUR RAINFALL FROM US WB TP-40



REFERENCE

"Chapter 2, Engineering Field Manual for Conservation Practices"

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - HYDROLOGY BRANCH

STANDARD DWG. NO.
ES-1027
SHEET 21 OF 21
DATE 2-15-71

ENG REF
No. 18-1

United States
Department of
Agriculture

Soil
Conservation
Service

Engineering
Division

Technical
Release 55

June 1986

Urban Hydrology for Small Watersheds

Preface

Technical Release 55 (TR-55) presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. These procedures are applicable in small watersheds, especially urbanizing watersheds, in the United States. First issued by the Soil Conservation Service (SCS) in January 1975, TR-55 incorporates current SCS procedures. This revision includes results of recent research and other changes based on experience with use of the original edition.

The major revisions and additions are—

1. A flow chart for selecting the appropriate procedure;
2. Three additional rain distributions;
3. Expansion of the chapter on runoff curve numbers;
4. A procedure for calculating travel times of sheet flow;
5. Deletion of a chapter on peak discharges;
6. Modifications to the Graphical Peak Discharge method and Tabular Hydrograph method;
7. A new storage routing procedure;
8. Features of the TR-55 computer program; and
9. Worksheets.

This revision was prepared by Roger Cronshey, Hydraulic Engineer, Hydrology Unit, SCS, Washington, DC; Dr. Richard H. McCuen, Professor of Civil Engineering, University of Maryland, College Park, MD; Norman Miller, Head, Hydrology Unit, SCS, Washington, DC; Dr.Walter Rawls, Hydrologist, Agricultural Research Service, Beltsville, MD; Sam Robbins (deceased), formerly Hydraulic Engineer, SCS, South National Technical Center (NTC), Fort Worth, TX; and Don Woodward, Hydraulic Engineer, SCS, Northeast NTC, Chester, PA. Valuable contributions were made by John Chenoweth, Stan Hamilton, William Merkel, Robert Rallison (ret.), Harvey Richardson, Wendell Styner, other SCS hydraulic engineers, and Teresa Seeman.

Revised June 1986

Contents

	Page
Chapter 1: Introduction	1-1
Effects of urban development	1-1
Rainfall	1-1
Runoff	1-2
Time parameters	1-2
Peak discharge and hydrographs	1-2
Storage effects	1-2
Selecting the appropriate procedures	1-2
Limitations	1-4
Chapter 2: Estimating runoff	2-1
SCS Runoff Curve Number method	2-1
Factors considered in determining runoff curve numbers	2-1
Runoff	2-11
Limitations	2-11
Examples	2-11
Chapter 3: Time of concentration and travel time	3-1
Factors affecting time of concentration and travel time	3-1
Computation of travel time and time of concentration	3-1
Limitations	3-4
Example 3-1	3-4
Chapter 4: Graphical Peak Discharge method	4-1
Peak discharge computation	4-1
Limitations	4-2
Example 4-1	4-2
Chapter 5: Tabular Hydrograph method	5-1
Tabular Hydrograph method exhibits	5-1
Information required for Tabular Hydrograph method	5-1
Development of composite flood hydrograph	5-2
Limitations	5-3
Examples	5-4
Chapter 6: Storage volume for detention basins	6-1
Estimating the effect of storage	6-1
Input requirements and procedures	6-2
Limitations	6-3
Examples	6-4
Appendix A: Hydrologic soil groups	A-1
Disturbed soil profiles	A-1
Drainage and group D soils	A-1
Appendix B: Synthetic rainfall distributions and rainfall data sources	B-1
Synthetic rainfall distributions	B-1
Rainfall data sources	B-3
Appendix C: Computer program	C-1
Appendix D: Worksheets	D-1
Appendix E: References	E-1
Appendix F: Equations for figures and exhibits	F-1
List of figures	iii
List of tables	iii
List of exhibits	iii
List of worksheets	iv
Metric conversions	iv
Definitions of symbols	iv

Figures

		Page
1-1.	Flow chart for selecting the appropriate procedures in TR-55	1-3
2-1.	Solution of runoff equation	2-2
2-2.	Flow chart for selecting the appropriate figure or table for determining runoff curve numbers	2-4
2-3.	Composite CN with connected impervious area	2-10
2-4.	Composite CN with unconnected impervious areas and total impervious area less than 30%	2-10
2-5.	Worksheet 2 for example 2-1	2-13
2-6.	Worksheet 2 for example 2-2	2-14
2-7.	Worksheet 2 for example 2-3	2-15
2-8.	Worksheet 2 for example 2-4	2-16
3-1.	Average velocities for estimating travel time for shallow concentrated flow	3-2
3-2.	Worksheet 3 for example 3-1	3-5
4-1.	Variation of I_a/P for P and CN	4-1
4-2.	Worksheet 4 for example 4-1	4-3
5-1.	Worksheet 5a for example 5-1	5-5
5-2.	Worksheet 5b for example 5-1	5-6
5-3.	Worksheet 5a for example 5-2	5-7
5-4.	Worksheet 5b for example 5-2	5-8
6-1.	Approximate detention basin routing for rainfall types I, IA, II, and III	6-2
6-2.	Worksheet 6a for example 6-1	6-5
6-3.	Worksheet 6a for example 6-2	6-7
6-4.	Worksheet 6b for example 6-3	6-9
6-5.	Worksheet 6a for example 6-4	6-11
B-1.	SCS 24-hour rainfall distributions	B-1
B-2.	Approximate geographic boundaries for SCS rainfall distributions	B-2
B-3.	Two-year, 24-hour rainfall	B-4
B-4.	Five-year, 24-hour rainfall	B-5
B-5.	Ten-year, 24-hour rainfall	B-6
B-6.	Twenty-five-year, 24-hour rainfall	B-7
B-7.	Fifty-year, 24-hour rainfall	B-8
B-8.	One-hundred-year, 24-hour rainfall	B-9

Tables

		Page
2-1.	Runoff depth for selected CN's and rainfall amounts	2-3
2-2a.	Runoff curve numbers for urban areas	2-5
2-2b.	Runoff curve numbers for cultivated agricultural lands	2-6
2-2c.	Runoff curve numbers for other agricultural lands	2-7
2-2d.	Runoff curve numbers for arid and semi-arid rangelands	2-8
3-1.	Roughness coefficients (Manning's n) for sheet flow	3-3
4-1.	I_a values for runoff curve numbers	4-1
4-2.	Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed	4-2
5-1.	I_a values for runoff curve numbers	5-2
F-1.	Coefficients for the equation used to generate exhibits 4-I through 4-III	F-2
F-2.	Coefficients for the equation used to generate figure 6-1	F-2

Exhibits

4-I:	Unit peak discharge (q_u) for SCS type I rainfall distribution	4-4
4-IA:	Unit peak discharge (q_u) for SCS type IA rainfall distribution	4-5
4-II:	Unit peak discharge (q_u) for SCS type II rainfall distribution	4-6
4-III:	Unit peak discharge (q_u) for SCS type III rainfall distribution	4-7
5-I:	Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution	5-9
5-IA:	Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution	5-19
5-II:	Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution	5-29
5-III:	Tabular hydrograph unit discharges (csm/in) type III rainfall distribution	5-39
A-1:	Hydrologic soil groups for United States soils	A-3

Worksheets

		Page
2:	Runoff curve number and runoff	D-2
3:	Time of concentration (T_c) or travel time (T_t)	D-3
4:	Graphical Peak Discharge method	D-4
5a:	Basic watershed data	D-5
5b:	Tabular hydrograph discharge summary	D-6
6a:	Detention basin storage, peak outflow discharge (q_o) known	D-7
6b:	Detention basin peak outflow, storage volume (V_s) known	D-8

Metric conversions

The English system of units is used in this TR. To convert to the International System of units (metric), use the following factors:

From English unit	To metric unit	Multiply by
Acre	Hectare	0.405
Square mile	Square kilometer	2.59
Cubic feet per second	Cubic meters per second	0.0283
Inch	Millimeter	25.4
Feet per second	Meters per second	0.3048
Acre-foot	Cubic meter	1233.489
Cubic foot	Cubic meter	0.0283

Perform rounding operations as appropriate to indicate the same level of precision as that of the original measurement. For example:

1. A stream discharge is recorded in cubic feet per second with three significant digits.
2. Convert stream discharge to cubic meters per second by multiplying by 0.0283.
3. Round to enough significant digits so that, when converting back to cubic feet per second, you obtain the original value (step 1) with three significant digits.

Definitions of symbols

Symbol	Unit	Definition
a	ft^2	Cross sectional flow area
A_m	mi^2	Drainage area
CN		Runoff curve number
CN_c		Composite runoff curve number
CN_p		Pervious runoff curve number
E_{max}		Maximum stage
F_p		Pond and swamp adjustment factor
H_w	ft	Head over weir crest
I_a	in	Initial abstraction
L	ft	Flow length
L_w	ft	Weir crest length
m		Number of flow segments
n		Manning's roughness coefficient
P	in	Rainfall
P_{imp}		Percent imperviousness
P_2	in	Two-year frequency, 24-hour rainfall
p_w	ft	Wetted perimeter
q	cfs	Hydrograph coordinate
q_i	cfs	Peak inflow discharge
q_o	cfs	Peak outflow discharge
q_p	cfs	Peak discharge
q_t	csm/in	Tabular hydrograph unit discharge
q_u	csm/in	Unit peak discharge
Q	in	Runoff
r	ft	Hydraulic radius
R		Ratio of unconnected impervious area to total impervious area
s	ft/ft	Slope of hydraulic grade line
S	in	Potential maximum retention after runoff begins
t	hr	Hydrograph time
T_c	hr	Time of concentration
T_p	hr	Time to peak
T_t	hr	Travel time
V	ft/s	Average velocity
V_r	acre-ft, ft^3, or water-shed-inch	Runoff volume
V_s	acre-ft, ft^3, or water-shed-inch	Storage volume

Chapter 1: Introduction

The conversion of rural land to urban land usually increases erosion and the discharge and volume of storm runoff in a watershed. It also causes other problems that affect soil and water. As part of programs established to alleviate these problems, engineers increasingly must assess the probable effects of urban development, as well as design and implement measures that will minimize its adverse effects.

Technical Release 55 (TR-55) presents simplified procedures for estimating runoff and peak discharges in small watersheds. In selecting the appropriate procedure, consider the scope and complexity of the problem, the available data, and the acceptable level of error. While this TR gives special emphasis to urban and urbanizing watersheds, the procedures apply to any small watershed in which certain limitations are met.

Effects of urban development

An urban or urbanizing watershed is one in which impervious surfaces cover or will soon cover a considerable area. Impervious surfaces include roads, sidewalks, parking lots, and buildings. Natural flow paths in the watershed may be replaced or supplemented by paved gutters, storm sewers, or other elements of artificial drainage.

Hydrologic studies to determine runoff and peak discharge should ideally be based on long-term stationary streamflow records for the area. Such records are seldom available for small drainage areas. Even where they are available, accurate statistical analysis of them is usually impossible because of the conversion of land to urban uses during the period of record. It therefore is necessary to estimate peak discharges with hydrologic models based on measurable watershed characteristics. Only through an understanding of these characteristics and experience in using these models can we make sound judgments on how to alter model parameters to reflect changing watershed conditions.

Urbanization changes a watershed's response to precipitation. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff. Runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, soil moisture, antecedent rainfall, cover type, impervious surfaces, and surface retention. Travel time is determined primarily by slope, length of flow path, depth of flow, and roughness of flow surfaces. Peak discharges are based on the relationship of these parameters and on the total drainage area of the watershed, the location of the development, the effect of any flood control works or other natural or manmade storage, and the time distribution of rainfall during a given storm event.

The model described in TR-55 begins with a rainfall amount uniformly imposed on the watershed over a specified time distribution. Mass rainfall is converted to mass runoff by using a runoff curve number (CN). CN is based on soils, plant cover, amount of impervious areas, interception, and surface storage. Runoff is then transformed into a hydrograph by using unit hydrograph theory and routing procedures that depend on runoff travel time through segments of the watershed.

For a description of the hydrograph development method used by SCS, see chapter 16 of the SCS National Engineering Handbook, Section 4—Hydrology (NEH-4) (SCS 1985). The routing method (Modified Att-Kin) is explained in appendixes G and H of draft Technical Release 20 (TR-20) (SCS 1983).

Rainfall

TR-55 includes four regional rainfall time distributions. See appendix B for a discussion of how these distributions were developed.

All four distributions are for a 24-hour period. This period was chosen because of the general availability of daily rainfall data that were used to estimate 24-hour rainfall amounts. The 24-hour duration spans most of the applications of TR-55.

One critical parameter in the model is time of concentration (T_c), which is the time it takes for runoff to travel to a point of interest from the hydraulically most distant point. Normally a rainfall duration equal to or greater than T_c is used. Therefore, the rainfall distributions were designed to contain the intensity of any duration of rainfall for the frequency of the event chosen. That is, if the 10-year frequency, 24-hour rainfall is used, the most intense hour will approximate the 10-year, 1-hour rainfall volume.

Runoff

To estimate runoff from storm rainfall, SCS uses the Runoff Curve Number (CN) method (see chapters 4 through 10 of NEH-4, SCS 1985). Determination of CN depends on the watershed's soil and cover conditions, which the model represents as hydrologic soil group, cover type, treatment, and hydrologic condition. Chapter 2 of this TR discusses the effect of urban development on CN and explains how to use CN to estimate runoff.

Time parameters

Chapter 3 describes a method for estimating the parameters used to distribute the runoff into a hydrograph. The method is based on velocities of flow through segments of the watershed. Two major parameters are time of concentration (T_c) and travel time of flow through the segments (T_t). These and the other parameters used are the same as those used in accepted hydraulic analyses of open channels.

Many methods are empirically derived from actual runoff hydrographs and watershed characteristics. The method in chapter 3 was chosen because it is basic; however, other methods may be used.

Peak discharge and hydrographs

Chapter 4 describes a method for approximating peak rates of discharge, and chapter 5 describes a method for obtaining or routing hydrographs. Both methods were derived from hydrographs prepared by procedures outlined in chapter 16 of NEH-4 (SCS 1985). The computations were made with a computerized SCS hydrologic model, TR-20 (SCS 1983).

The methods in chapters 4 and 5 should be used in accordance with specific guidelines. If basic data are improperly prepared or adjustments not properly used, errors will result.

Storage effects

Chapter 6 outlines procedures to account for the effect of detention-type storage. It provides a shortcut method to estimate temporary flood storage based on hydrologic data developed from the Graphical Peak Discharge or Tabular Hydrograph methods.

By increasing runoff and decreasing travel times, urbanization can be expected to increase downstream peak discharges. Chapter 6 discusses how flood detention can modify the hydrograph so that, ideally, downstream peak discharge is reduced approximately to the predevelopment condition. The shortcuts in chapter 6 are useful in sizing a basin even though the final design may require a more detailed analysis.

Selecting the appropriate procedures

Figure 1-1 is a flow chart that shows how to select the appropriate procedures to use in TR-55. In the figure, the diamond-shaped box labeled "Subareas required?" directs the user to the appropriate method based on whether the watershed needs to be divided into subareas. Watershed subdivision is required when significantly different conditions affecting runoff or timing are present in the watershed—for example, if the watershed has widely differing curve numbers or nonhomogeneous slope patterns.

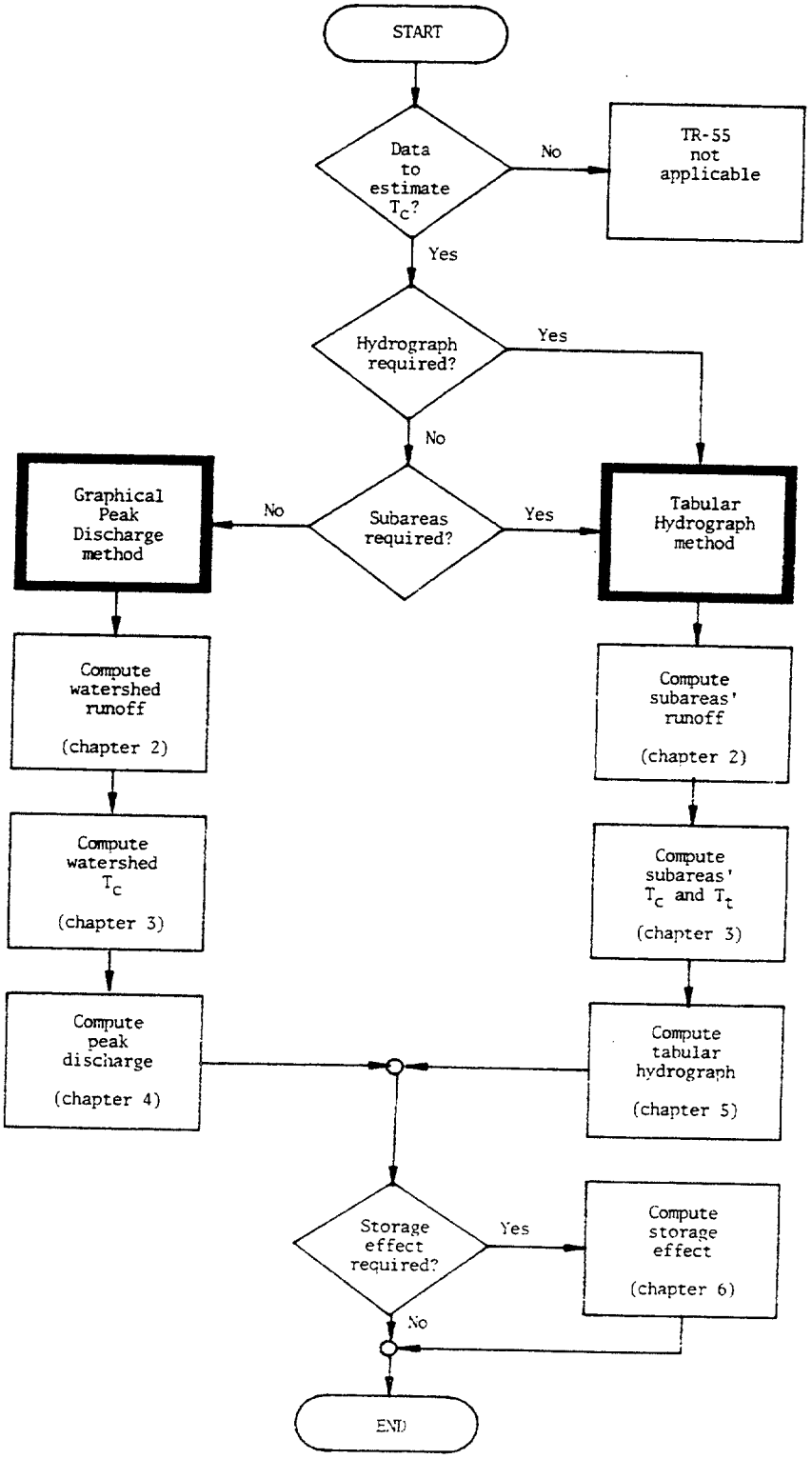


Figure 1-1.—Flow chart for selecting the appropriate procedures in TR-55.

Limitations

To save time, the procedures in TR-55 are simplified by assumptions about some parameters. These simplifications, however, limit the use of the procedures and can provide results that are less accurate than more detailed methods. The user should examine the sensitivity of the analysis being conducted to a variation of the peak discharge or hydrograph. To ensure that the degree of error is tolerable, specific limitations are given in chapters 2 through 6. Additional general constraints to the use of TR-55 are as follows:

- The methods in this TR are based on open and unconfined flow over land or in channels. For large events during which flow is divided between sewer and overland flow, more information about hydraulics than is presented here is needed to determine T_c. After flow enters a closed system, the discharge can be assumed constant until another flow is encountered at a junction or another inlet.

- Both the Graphical Peak Discharge and Tabular Hydrograph methods are derived from TR-20 (SCS 1983) output. Their accuracy is comparable; they differ only in their products. The use of T_c permits them to be used for any size watershed within the scope of the curves or tables. The Graphical method (chapter 4) is used only for hydrologically homogeneous watersheds because the procedure is limited to a single watershed subarea. The Tabular method (chapter 5) can be used for a heterogeneous watershed that is divided into a number of homogeneous subwatersheds. Hydrographs for the subwatersheds can be routed and added.

- The approximate storage-routing curves (chapter 6) should not be used if the adjustment for ponding (chapter 4) is used. These storage-routing curves, like the peak discharge and hydrograph procedures, are generalizations derived from TR-20 routings.

Chapter 2: Estimating runoff

SCS Runoff Curve Number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[Eq. 2-1]}$$

where

Q = runoff (in),
P = rainfall (in),
S = potential maximum retention after runoff begins (in), and
I_a = initial abstraction (in).

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S. \qquad \text{[Eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}. \qquad \text{[Eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by

$$S = \frac{1000}{CN} - 10. \qquad \text{[Eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil

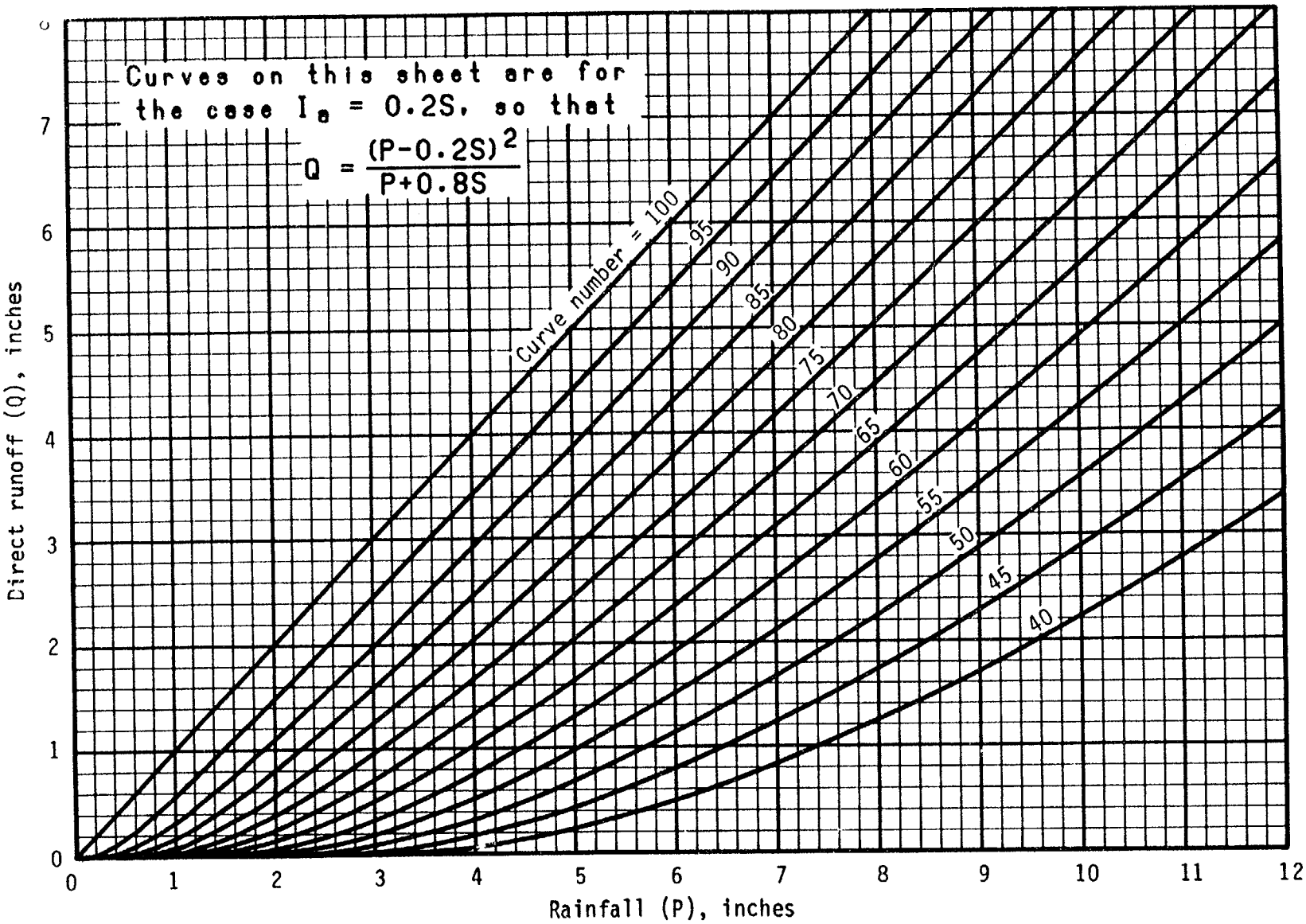


Figure 2-1.—Solution of runoff equation.

texture is given in appendix A for determining the HSG classification for disturbed soils.

Cover type

Table 2-2 addresses most cover types, such as vegetation, bare soil, and impervious surfaces. There are a number of methods for determining cover type. The most common are field reconnaissance, aerial photographs, and land use maps.

Treatment

Treatment is a cover type modifier (used only in table 2-2b) to describe the management of cultivated agricultural lands. It includes mechanical practices, such as contouring and terracing, and management practices, such as crop rotations and reduced or no tillage.

Hydrologic condition

Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant and residue cover on sample areas. *Good* hydrologic condition indicates that the soil usually has a low runoff potential for that specific hydrologic soil group, cover type, and treatment. Some factors to consider in estimating the effect of cover on infiltration and runoff are (a) canopy or density of lawns, crops, or other vegetative areas; (b) amount of year-round cover; (c) amount of grass or close-seeded legumes in rotations; (d) percent of residue cover; and (e) degree of surface roughness.

Table 2-1.—Runoff depth for selected CN's and rainfall amounts[1]

	Runoff depth for curve number of—												
Rainfall	40	45	50	55	60	65	70	75	80	85	90	95	98
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

[1]Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

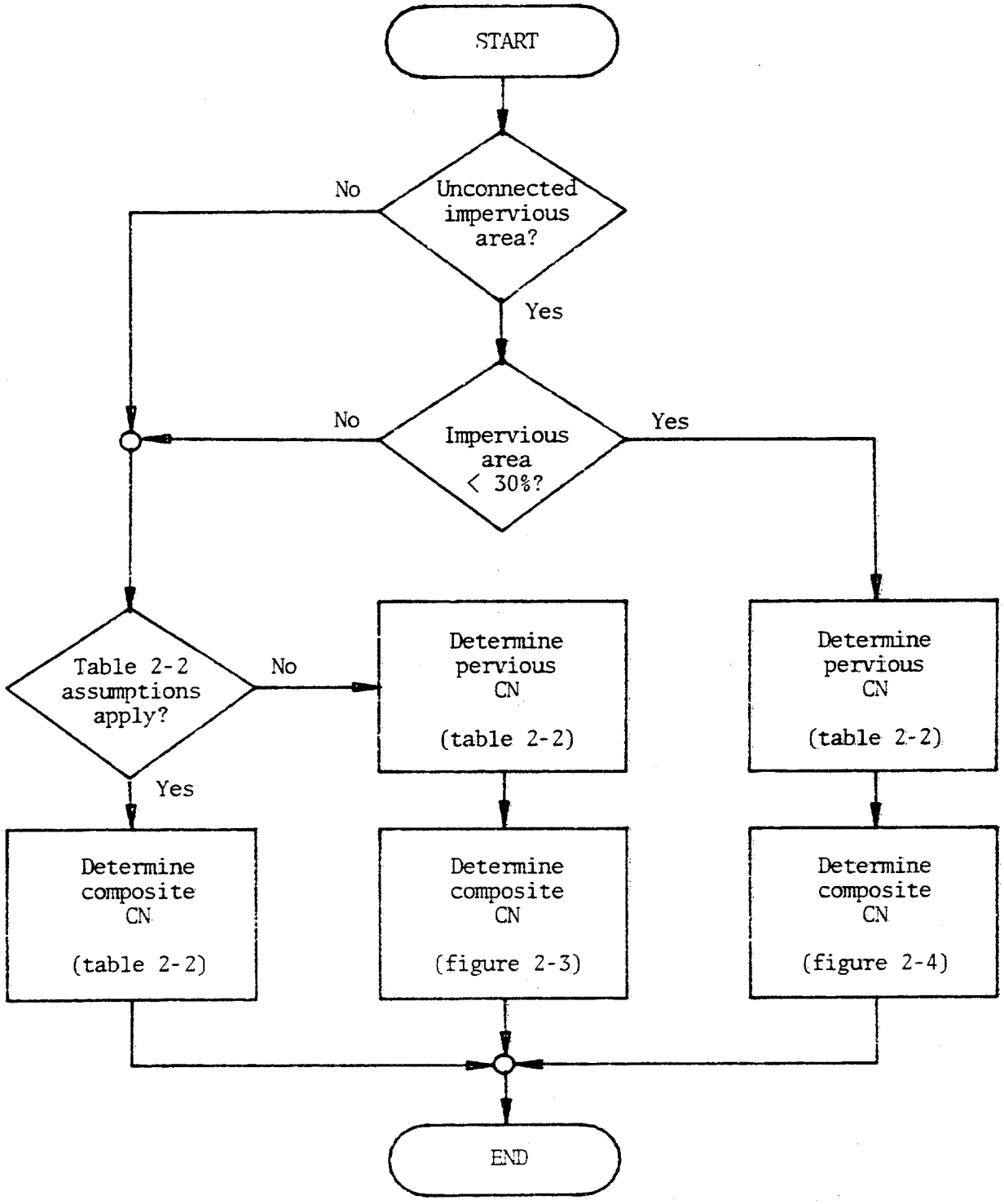


Figure 2-2.—Flow chart for selecting the appropriate figure or table for determining runoff curve numbers.

Table 2-2a.—Runoff curve numbers for urban areas[1]

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

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

Table 2-2b.—Runoff curve numbers for cultivated agricultural lands[1]

Cover description			Curve numbers for hydrologic soil group—			
Cover type	Treatment[2]	Hydrologic condition[3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1]Average runoff condition, and $I_a = 0.2S$.
[2]*Crop residue cover* applies only if residue is on at least 5% of the surface throughout the year.
[3]Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.
Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c.—Runoff curve numbers for other agricultural lands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element.[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	[4]30	48	65	73
Woods—grass combination (orchard or tree farm).[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	[4]30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1]Average runoff condition, and $I_a = 0.2S$

[2]*Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.

[3]*Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]*Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d.—Runoff curve numbers for arid and semiarid rangelands[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type	Hydrologic condition[2]	A[3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1]Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use table 2-2c.

[2]*Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.

[3]Curve numbers for group A have been developed only for desert shrub.

Antecedent runoff condition

The index of runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm. CN for the average ARC at a site is the median value as taken from sample rainfall and runoff data. The CN's in table 2-2 are for the average ARC, which is used primarily for design applications. See NEH-4 (SCS 1985) and Rallison and Miller (1981) for more detailed discussion of storm-to-storm variation and a demonstration of upper and lower enveloping curves.

Urban impervious area modifications

Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for urban areas (Rawls et al., 1981). For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

Connected impervious areas

An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area and then into a drainage system.

Urban CN's (table 2-2a) were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN values were developed on the assumptions that (a) pervious urban areas are equivalent to pasture in good hydrologic condition and (b) impervious areas have a CN of 98 and are directly connected to the drainage system. Some assumed percentages of impervious area are shown in table 2-2a.

If all of the impervious area is directly connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in table 2-2a are not applicable, use figure 2-3 to compute a composite CN. For example, table 2-2a gives a CN of 70 for a ½-acre lot in HSG B, with an assumed impervious area of 25 percent. However, if the lot has 20 percent impervious area and a pervious area CN of 61, the composite CN obtained from figure 2-3 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area.

Unconnected impervious areas

Runoff from these areas is spread over a pervious area as sheet flow. To determine CN when all or part of the impervious area is not directly connected to the drainage system, (1) use figure 2-4 if total impervious area is less than 30 percent or (2) use figure 2-3 if the total impervious area is equal to or greater than 30 percent, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 2-4 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN. For example, for a ½-acre lot with 20 percent total impervious area (75 percent of which is unconnected) and pervious CN of 61, the composite CN from figure 2-4 is 66. If all of the impervious area is connected, the resulting CN (from figure 2-3) would be 68.

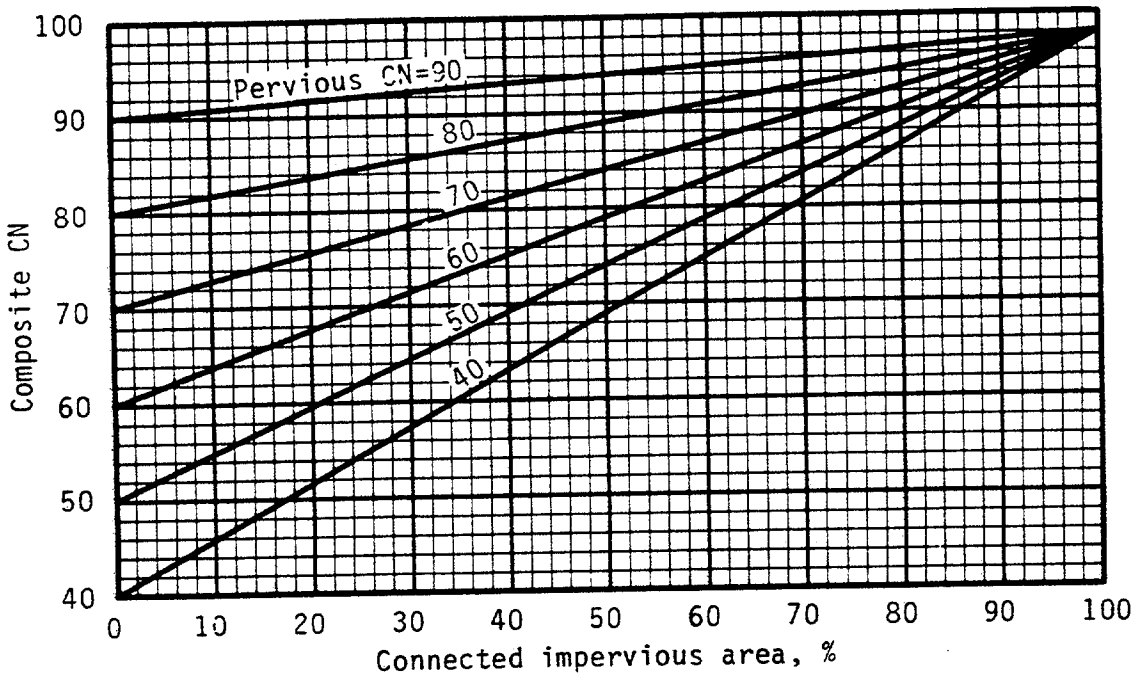


Figure 2-3.—Composite CN with connected impervious area.

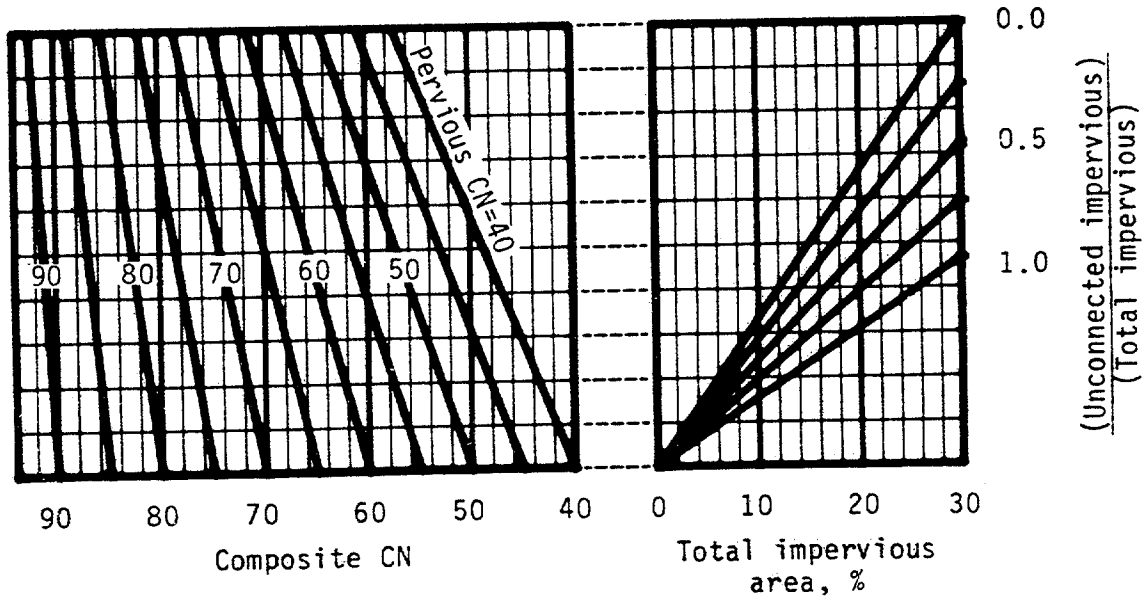


Figure 2-4.—Composite CN with unconnected impervious areas and total impervious area less than 30%.

Runoff

When CN and the amount of rainfall have been determined for the watershed, determine runoff by using figure 2-1, table 2-1, or equations 2-3 and 2-4. The runoff is usually rounded to the nearest hundredth of an inch.

Limitations

- Curve numbers describe average conditions that are useful for design purposes. If the rainfall event used is a historical storm, the modeling accuracy decreases.

- Use the runoff curve number equation with caution when recreating specific features of an actual storm. The equation does not contain an expression for time and, therefore, does not account for rainfall duration or intensity.

- The user should understand the assumption reflected in the initial abstraction term (I_a) and should ascertain that the assumption applies to the situation. I_a, which consists of interception, initial infiltration, surface depression storage, evapotranspiration, and other factors, was generalized as 0.2S based on data from agricultural watersheds (S is the potential maximum retention after runoff begins). This approximation can be especially important in an urban application because the combination of impervious areas with pervious areas can imply a significant initial loss that may not take place. The opposite effect, a greater initial loss, can occur if the impervious areas have surface depressions that store some runoff. To use a relationship other than $I_a = 0.2S$, one must redevelop equation 2-3, figure 2-1, table 2-1, and table 2-2 by using the original rainfall-runoff data to establish new S or CN relationships for each cover and hydrologic soil group.

- Runoff from snowmelt or rain on frozen ground cannot be estimated using these procedures.

- The CN procedure is less accurate when runoff is less than 0.5 inch. As a check, use another procedure to determine runoff.

- The SCS runoff procedures apply only to direct surface runoff: do not overlook large sources of subsurface flow or high ground water levels that contribute to runoff. These conditions are often related to HSG A soils and forest areas that have been assigned relatively low CN's in table 2-2. Good judgment and experience based on stream gage records are needed to adjust CN's as conditions warrant.

- When the weighted CN is less than 40, use another procedure to determine runoff.

Examples

Four examples illustrate the procedure for computing runoff curve number (CN) and runoff (Q) in inches. Worksheet 2 in appendix D is provided to assist TR-55 users. Figures 2-5 to 2-8 represent the use of worksheet 2 for each example. All four examples are based on the same watershed and the same storm event.

The watershed covers 250 acres in Dyer County, northwestern Tennessee. Seventy percent (175 acres) is a Loring soil, which is in hydrologic soil group C. Thirty percent (75 acres) is a Memphis soil, which is in group B. The event is a 25-year frequency, 24-hour storm with total rainfall of 6 inches.

Cover type and conditions in the watershed are different for each example. The examples, therefore, illustrate how to compute CN and Q for various situations of proposed, planned, or present development.

Example 2-1

The present cover type is pasture in good hydrologic condition. (See figure 2-5 for worksheet 2 information.)

Example 2-2

Seventy percent (175 acres) of the watershed, consisting of all the Memphis soil and 100 acres of the Loring soil, is ½-acre residential lots with lawns in good hydrologic condition. The rest of the watershed is scattered open space in good hydrologic condition. (See figure 2-6.)

Example 2-3

This example is the same as example 2-2, except that the ½-acre lots have a total impervious area of 35 percent. For these lots, the pervious area is lawns in good hydrologic condition. Since the impervious area percentage differs from the percentage assumed in table 2-2, use figure 2-3 to compute CN. (See figure 2-7.)

Example 2-4

This example is also based on example 2-2, except that 50 percent of the impervious area associated with the ½-acre lots on the Loring soil is "unconnected," that is, it is not directly connected to the drainage system. For these lots, the pervious area CN (lawn, good condition) is 74 and the impervious area is 25 percent. Use figure 2-4 to compute the CN for these lots. CN's for the ½-acre lots on Memphis soil and the open space on Loring soil are the same as those in example 2-2. (See figure 2-8.)

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked JKL Date 10/3/85

Circle one: (Present) Developed

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☐ acres ☐ mi² ☒ %	Product of CN x area
Memphis, B	Pasture, good condition	61			30	1830
Loring, C	Pasture, good condition	74			70	5180
					Totals = 100	7010

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{7010}{100} = 70.1$; Use CN = 70

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	2.81		

Figure 2-5.—Worksheet 2 for example 2-1.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked WM Date 10/3/85

Circle one: Present (Developed) 175 acres residential

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☒ acres ☐ mi² ☐ %	Product of CN x area
Memphis, B	25% impervious ½ acre lots, good condition	70			75	5250
Loring, C	25% impervious ½ acre lots, good condition	80			100	8000
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	18,800

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18,800}{250} = 75.2$; Use CN = 75

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.28		

Figure 2-6.—Worksheet 2 for example 2-2.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked MM Date 10/3/85

Circle one: Present (Developed)

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☒ acres ☐ mi² ☐ %	Product of CN x area
Memphis, B	35% impervious ½ acre lots, good condition		74		75	5550
Loring, C	35% impervious ½ acre lots, good condition		82		1000	8200
Loring, C	Open space, good condition	74			75	5550
					Totals = 250	19,300

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{19,300}{250} = 77.2$; Use CN = 77

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.48		

Figure 2-7.—Worksheet 2 for example 2-3.

Worksheet 2: Runoff curve number and runoff

Project Heavenly Acres By WJR Date 10/1/85

Location Dyer County, Tennessee Checked YW Date 10/3/85

Circle one: Present (Developed)

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☒ acres ☐ mi² ☐ %	Product of CN x area
Memphis, B	25% connected impervious 1/2 acre lots, good condition	70			75	5250
Loring, C	25% impervious with 50% unconnected 1/2 acre lots, good condition			78	00	7800
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	18,600

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18,600}{250} = 74.4$; Use CN = 74

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	6.0		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	3.19		

Figure 2-8.—Worksheet 2 for example 2-4.

Chapter 3: Time of concentration and travel time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\ V} \qquad \text{[Eq. 3-1]}$$

where

T_t = travel time (hr),
L = flow length (ft),
V = average velocity (ft/s), and
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[Eq. 3-2]}$$

where

T_c = time of concentration (hr) and
m = number of flow segments.

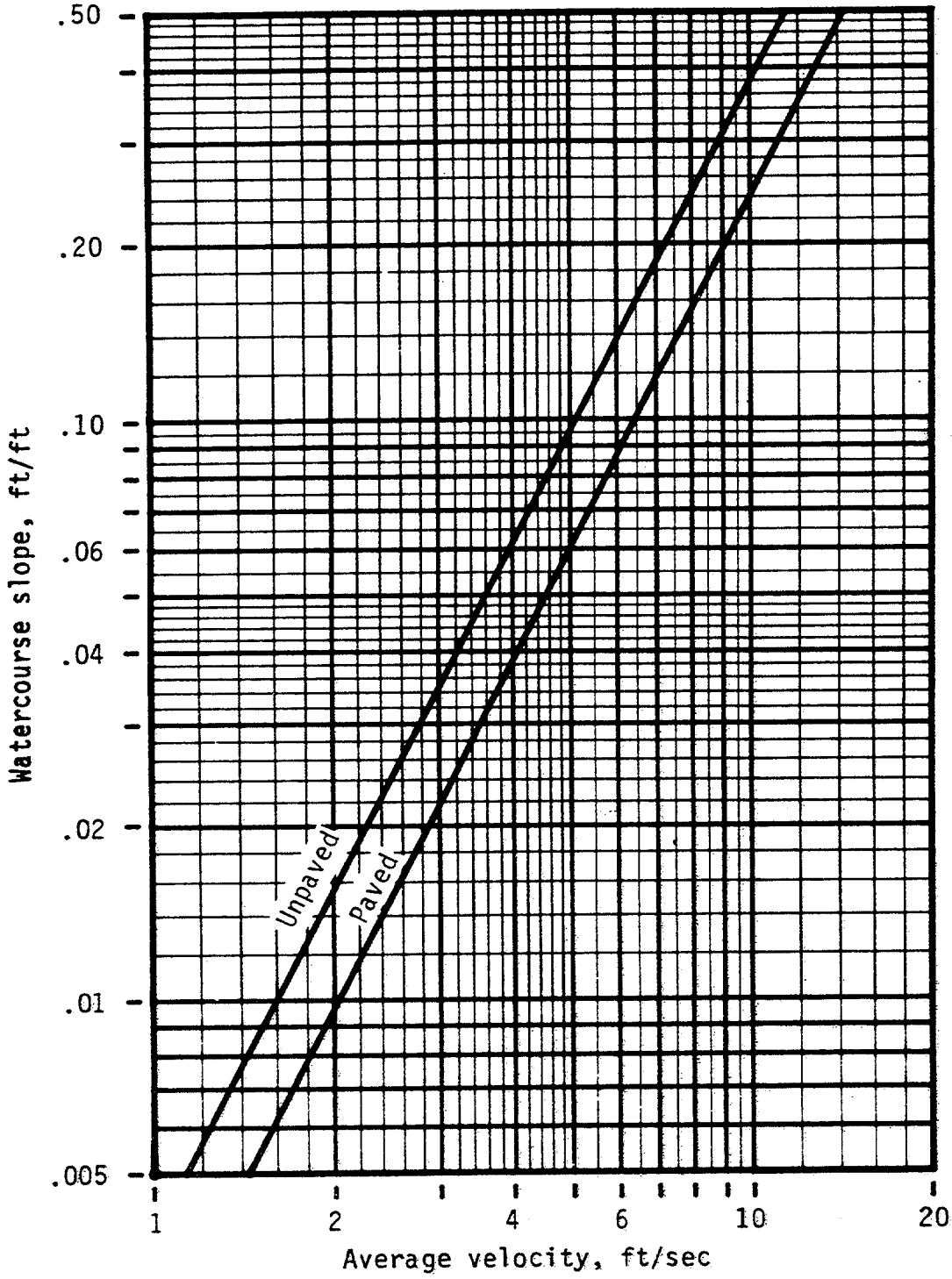


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning's equation is

$$V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n} \qquad \text{[Eq. 3-4]}$$

where

- V = average velocity (ft/s),
- r = hydraulic radius (ft) and is equal to a/p_w,
- a = cross sectional flow area (ft^2),
- p_w = wetted perimeter (ft),
- s = slope of the hydraulic grade line (channel slope, ft/ft), and
- n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, T_t for the channel segment can be estimated using equation 3-1.

Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.

- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

- The minimum T_c used in TR-55 is 0.1 hour.

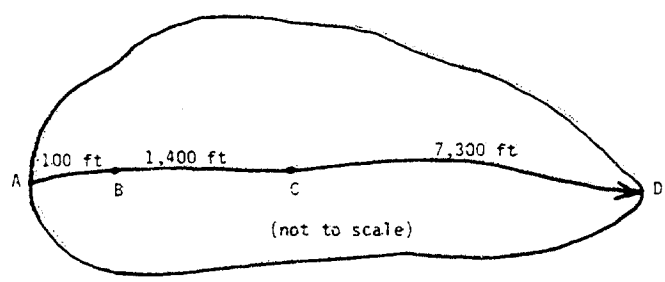
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:

Segment AB:	Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft.
Segment BC:	Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1400 ft.
Segment CD:	Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (p_w) = 28.2 ft; s = 0.005 ft/ft; and L = 7300 ft.

See figure 3-2 for the computations made on worksheet 3.



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Heavenly Acres By DW Date 10/6/85

Location Dyer County, Tennessee Checked XXX Date 10/8/85

Circle one: Present (Developed)

Circle one: (T_c) T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)		Segment ID	AB	
1. Surface description (table 3-1)			DENSE GRASS	
2. Manning's roughness coeff., n (table 3-1) ..			0.24	
3. Flow length, L (total L ≤ 300 ft)	ft		100	
4. Two-yr 24-hr rainfall, P_2	in		3.6	
5. Land slope, s	ft/ft		0.01	
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		0.30 +	= 0.30

Shallow concentrated flow		Segment ID	BC	
7. Surface description (paved or unpaved)			Unpaved	
8. Flow length, L	ft		1400	
9. Watercourse slope, s	ft/ft		0.01	
10. Average velocity, V (figure 3-1)	ft/s		1.6	
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		0.24 +	= 0.24

Channel flow		Segment ID	CD	
12. Cross sectional flow area, a	ft^2		27	
13. Wetted perimeter, P_w	ft		28.2	
14. Hydraulic radius, $r = \frac{a}{P_w}$ Compute r	ft		0.957	
15. Channel slope, s	ft/ft		0.005	
16. Manning's roughness coeff., n			0.05	
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s		2.05	
18. Flow length, L	ft		7300	
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		0.99 +	= 0.99
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			1.53

Figure 3-2.—Worksheet 3 for example 3-1.

Chapter 4: Graphical Peak Discharge method

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 1983). The peak discharge equation used is

$$q_p = q_u A_m Q F_p \qquad \text{[Eq. 4-1]}$$

where

q_p = peak discharge (cfs);
q_u = unit peak discharge (csm/in);
A_m = drainage area (mi^2);
Q = runoff (in); and
F_p = pond and swamp adjustment factor.

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction (I_a) from table 4-1. I_a/P is then computed.

If the computed I_a/P ratio is outside the range shown in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of I_a/P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using T_c (chapter 3), rainfall distribution type, and I_a/P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

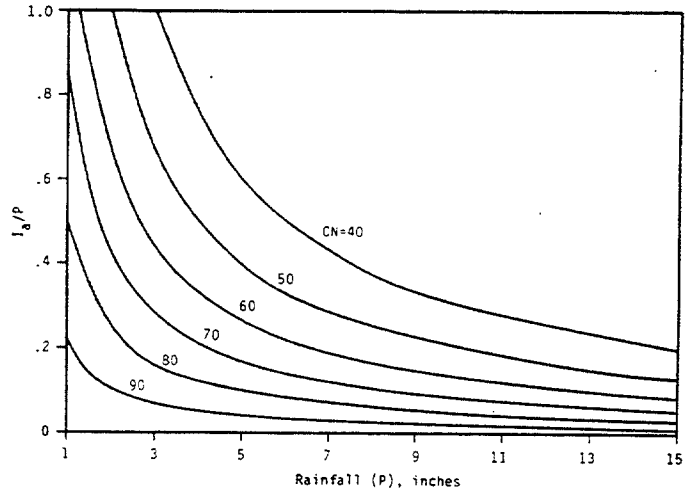


Figure 4-1.—Variation of I_a/P for P and CN.

Table 4-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Table 4-2.—Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed

Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Limitations

The Graphical method provides a determination of peak discharge only. If a hydrograph is needed or watershed subdivision is required, use the Tabular Hydrograph method (chapter 5). Use TR-20 if the watershed is very complex or a higher degree of accuracy is required.

- The watershed must be hydrologically homogeneous, that is, describable by one CN. Land use, soils, and cover are distributed uniformly throughout the watershed.
- The watershed may have only one main stream or, if more than one, the branches must have nearly equal T_c's.
- The method cannot perform valley or reservoir routing.
- The F_p factor can be applied only for ponds or swamps that are not in the T_c flow path.
- Accuracy of peak discharge estimated by this method will be reduced if I_a/P values are used that are outside the range given in exhibit 4. The limiting I_a/P values are recommended for use.
- This method should be used only if the weighted CN is greater than 40.
- When this method is used to develop estimates of peak discharge for both present and developed conditions of a watershed, use the same procedure for estimating T_c.
- T_c values with this method may range from 0.1 to 10 hours.

Example 4-1

Compute the 25-year peak discharge for the 250-acre watershed described in examples 2-2 and 3-1. Figure 4-2 shows how worksheet 4 is used to compute q_p as 345 cfs.

Worksheet 4: Graphical Peak Discharge method

Project Heavenly Acres By RHM Date 10/15/85

Location Dyer County, Tennessee Checked [illegible] Date 10/17/85

Circle one: Present (Developed)

1. Data:

Drainage area ..... A_m = 0.39 mi^2 (acres/640)

Runoff curve number .... CN = 75 (From worksheet 2), Figure 2-6

Time of concentration .. T_c = 1.53 hr (From worksheet 3), Figure 3-2

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ..... = -- percent of A_m (-- acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	6.0		
4. Initial abstraction, I_a ..... (Use CN with table 4-1.)	in	0.667		
5. Compute I_a/P		0.11		
6. Unit peak discharge, q_u ..... (Use T_c and I_a/P with exhibit 4-II)	csm/in	270		
7. Runoff, Q ..... (From worksheet 2). Figure 2-6	in	3.28		
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9. Peak discharge, q_p ..... (Where $q_p = q_u A_m Q F_p$)	cfs	345		

Figure 4-2.—Worksheet 4 for example 4-1.

Exhibit 4-I: Unit peak discharge (q_u) for SCS type I rainfall distribution

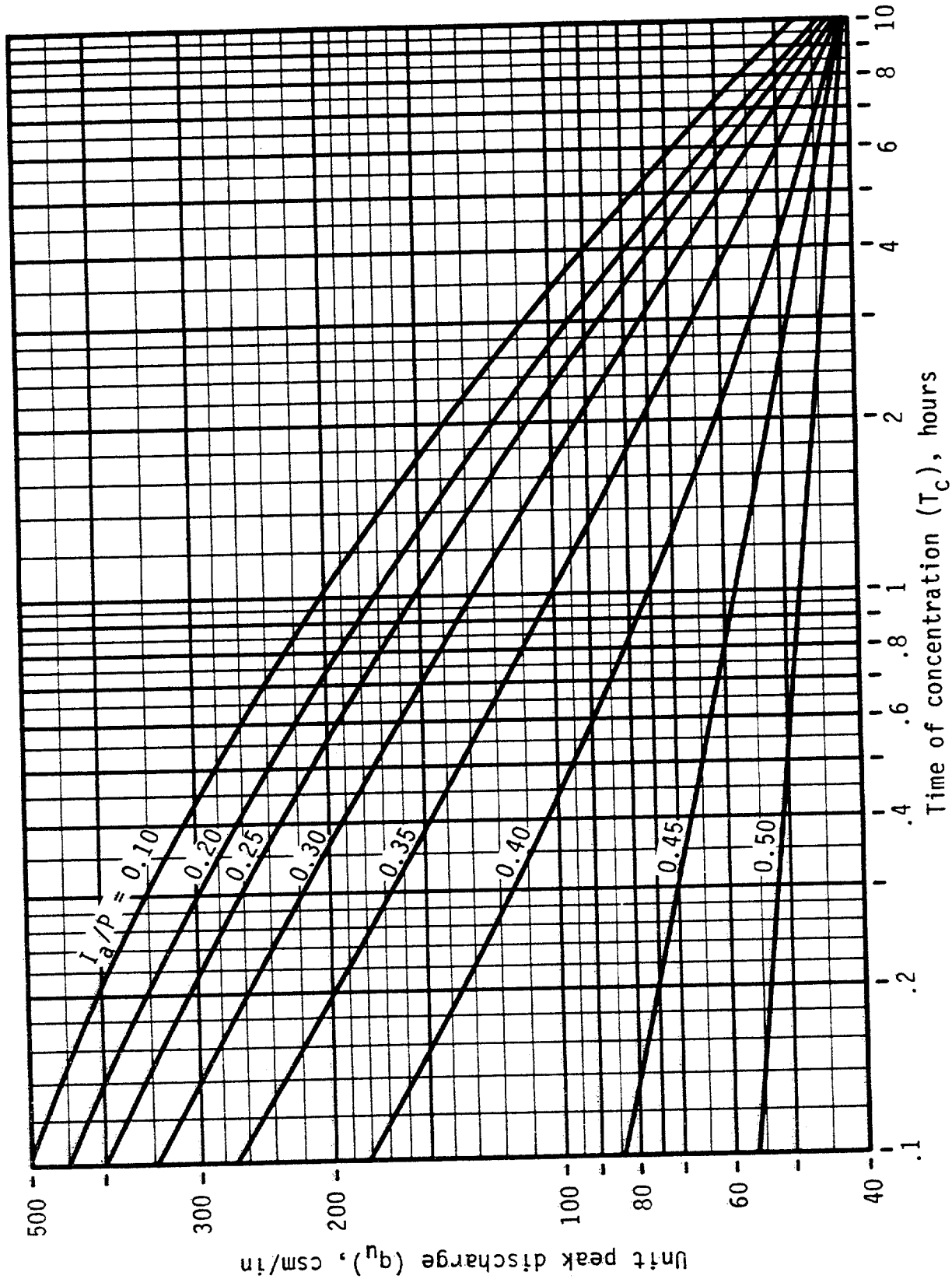


Exhibit 4-IA: Unit peak discharge (q_u) for SCS type IA rainfall distribution

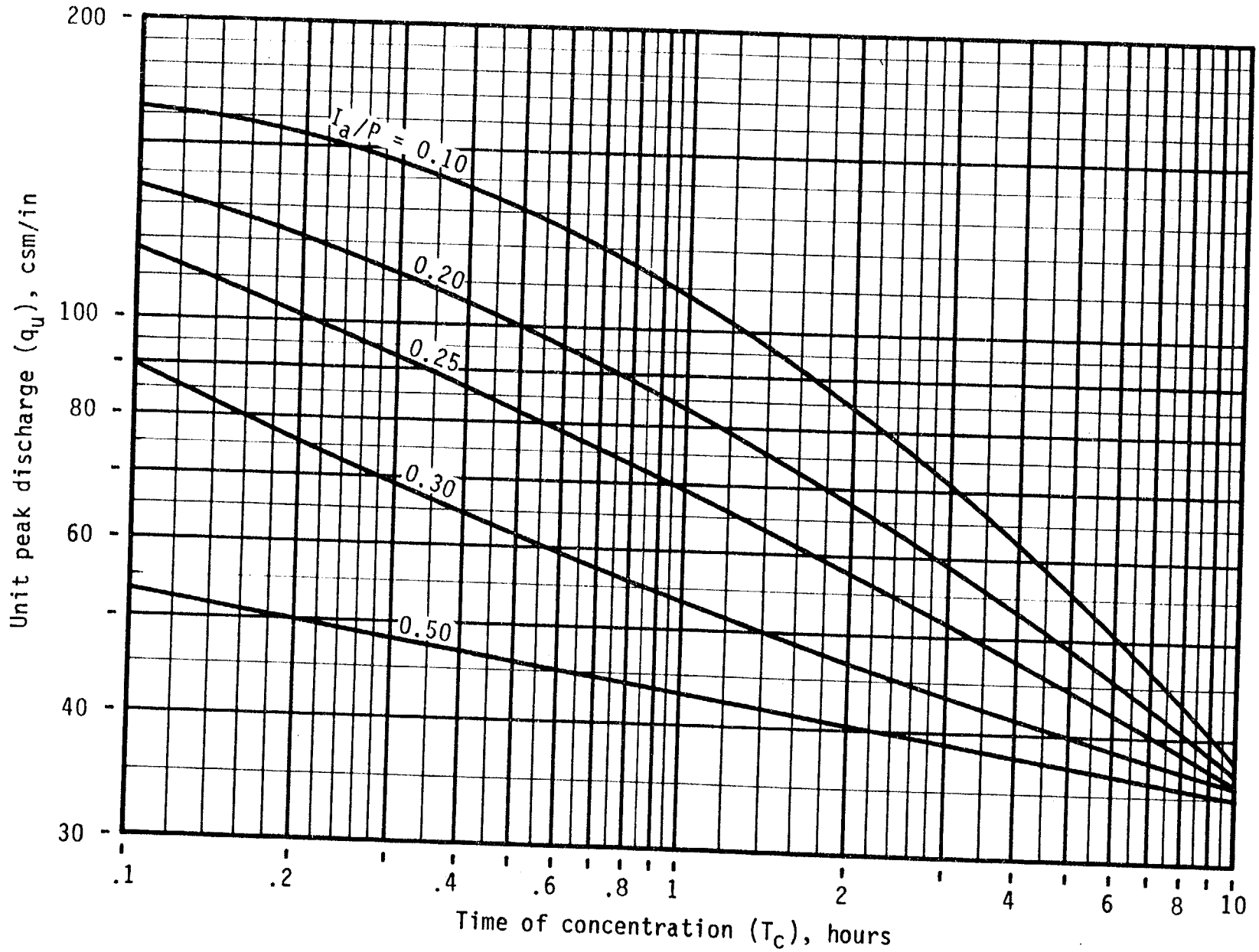


Exhibit 4-II: Unit peak discharge (q_u) for SCS type II rainfall distribution

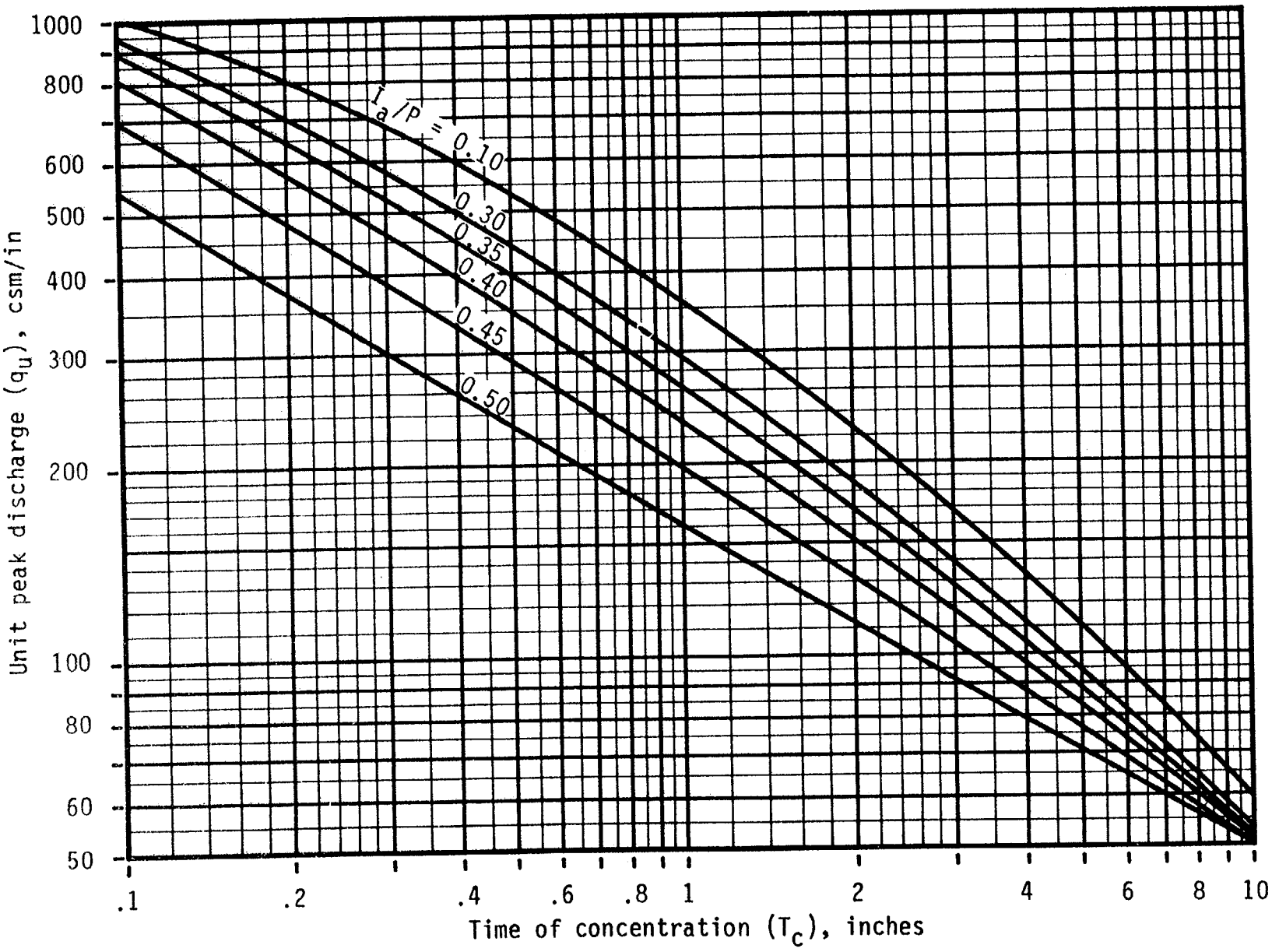
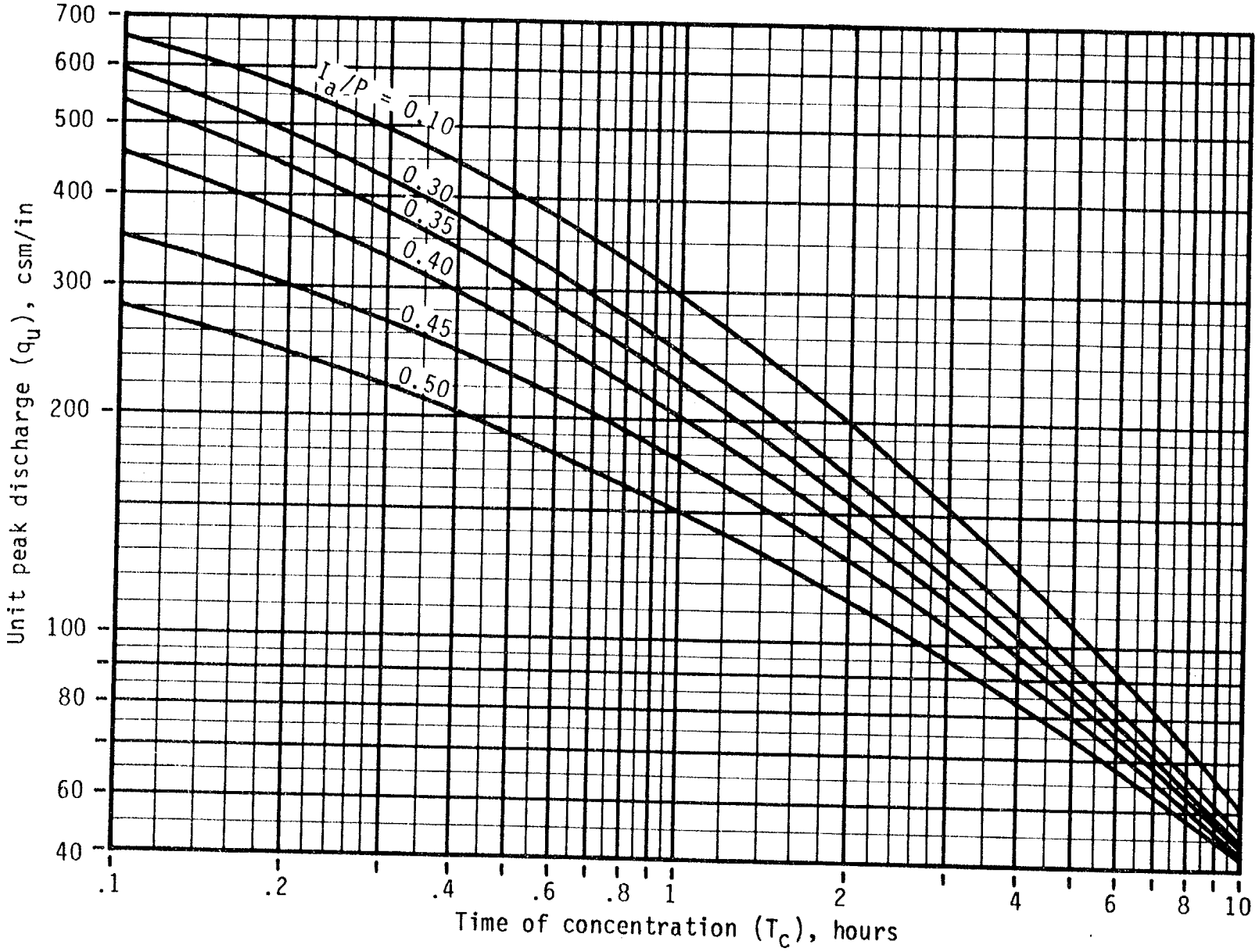


Exhibit 4-III: Unit peak discharge (q_u) for SCS type III rainfall distribution



Chapter 5: Tabular Hydrograph method

This chapter presents the Tabular Hydrograph method of computing peak discharges from rural and urban areas, using time of concentration (T_c) and travel time (T_t) from a subarea as inputs. This method approximates TR-20, a more detailed hydrograph procedure (SCS 1983).

The Tabular method can develop partial composite flood hydrographs at any point in a watershed by dividing the watershed into homogeneous subareas. In this manner, the method can estimate runoff from nonhomogeneous watersheds. The method is especially applicable for estimating the effects of land use change in a portion of a watershed. It can also be used to estimate the effects of proposed structures.

Input data needed to develop a partial composite flood hydrograph include (1) 24-hour rainfall (in), (2) appropriate rainfall distribution (I, IA, II, or III), (3) CN, (4) T_c (hr), (5) T_t (hr), and (6) drainage area (mi^2).

Tabular Hydrograph method exhibits

Exhibit 5 (5-I, 5-IA, 5-II, and 5-III) shows tabular discharge values for the various rainfall distributions. Tabular discharges expressed in csm/in (cubic feet of discharge per second per square mile of watershed per inch of runoff) are given for a range of subarea T_c's from 0.1 to 2 hours and reach T_t's from 0 to 3 hours.

The exhibit was developed by computing hydrographs for 1 square mile of drainage area for selected T_c's and routing them through stream reaches with the range of T_t's indicated. The Modified Att-Kin method for reach routing, formulated by SCS in the late 1970's, was used to compute the tabular hydrographs (Comer et al., 1981). A CN of 75 and rainfall amounts generating appropriate I_a/P ratios were used. The resulting runoff estimate was used to convert the hydrographs in exhibits 5-I through 5-III to cubic feet per second per square mile per inch of runoff.

An assumption in development of the tabular hydrographs is that all discharges for a stream reach flow at the same velocity. By this assumption, the subarea flood hydrographs may be routed separately and added at the reference point. The tabular hydrographs in exhibit 5 are prerouted hydrographs. For T_t's other than zero, the tabular discharge values represent the contribution from a single subarea to the composite hydrograph at T_t downstream.

Information required for Tabular Hydrograph method

The following information is required for the Tabular method:

1. Subdivision of the watershed into areas that are relatively homogeneous and have convenient routing reaches.
2. Drainage area of each subarea in square miles.
3. T_c for each subarea in hours. The procedure for estimating T_c is outlined in chapter 3. Worksheet 3 (appendix D) can be used to calculate T_c.
4. T_t for each routing reach in hours. The procedure for estimating T_t is outlined in chapter 3. Worksheet 3 can be used to calculate T_t through a subarea for shallow concentrated and open channel flow.
5. Weighted CN for each subarea. Table 2-2 shows CN's for individual hydrologic soil cover combinations. Worksheet 2 can be used to calculate the weighted runoff curve number.
6. Appropriate rainfall distribution according to figure B-2 (appendix B).
7. The 24-hour rainfall for the selected frequency. Appendix B contains rainfall maps for various frequencies (figures B-3 to B-8).
8. Total runoff (Q) in inches computed from CN and rainfall.
9. I_a for each subarea from table 5-1, which is the same as table 4-1.
10. Ratio of I_a/P for each subarea. If the ratio for the rainfall distribution of interest is outside the range shown in exhibit 5, use the limiting value.

Development of composite flood hydrograph

This section describes the procedure for developing the peak discharge and selected discharge values of a composite flood hydrograph.

Selecting T_c and T_t

First, use worksheet 5a to develop a summary of basic watershed data by subarea. Then use worksheet 5b to develop a tabular hydrograph discharge summary; this summary displays the effect of individual subarea hydrographs as routed to the watershed point of interest. Use ΣT_t for each subarea as the total reach travel time from that subarea through the watershed to the point of interest. Compute the hydrograph coordinates for selected ΣT_t's using the appropriate sheets in exhibit 5. The flow at any time is

$$q = q_t A_m Q \qquad \text{[Eq. 5-1]}$$

where

q = hydrograph coordinate (cfs) at hydrograph time t;
q_t = tabular hydrograph unit discharge from exhibit 5 (csm/in);
A_m = drainage area of individual subarea (mi²); and
Q = runoff (in).

Since the timing of peak discharge changes with T_c and T_t, interpolation of peak discharge for T_c and T_t values for use in exhibit 5 is not recommended. Interpolation may result in an estimate of peak discharge that would be invalid because it would be lower than either of the hydrographs. Therefore, round the actual values of T_c and T_t to values presented in exhibit 5. Perform this rounding so that the sum of the selected table values is close to the sum of actual T_c and T_t. An acceptable procedure is to select the results of one of three rounding operations:

1. Round T_c and T_t separately to the nearest table value and sum;
2. Round T_c down and T_t up to nearest table value and sum; and
3. Round T_c up and T_t down to nearest table value and sum.

From these three alternatives, choose the pair of rounded T_c and T_t values whose sum is closest to the sum of the actual T_c and T_t. If two rounding methods produce sums equally close to the actual sum, use the combination in which rounded T_c is closest to actual T_c. An illustration of the rounding procedure is as follows:

Table 5-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

	Actual values	Table values by rounding method—		
		1	2	3
T_c	1.1	1.0	1.0	1.25
T_t	1.7	1.5	2.0	1.5
Sum	2.8	2.5	3.0	2.75

In this instance, the results from method 3 would be selected because the sum 2.75 is closest to the actual sum of 2.8.

Selecting I_a/P

The computed I_a/P value can be rounded to the nearest I_a/P value in exhibits 5-I through 5-III, or the hydrograph values (csm/in) can be linearly interpolated because I_a/P interpolation generally involves peaks that occur at the same time.

Summing for the composite hydrograph

The composite hydrograph is the summation of prerouted individual subarea hydrographs at each time shown on worksheet 5b. Only the times encompassing the expected maximum composite discharge are summed to define a portion of the composite hydrograph.

If desired, the entire composite hydrograph can be approximated by linear extrapolation as follows:

1. Set up a table similar to worksheet 5b. Include on this table the full range of hydrograph times displayed in exhibit 5.
2. Compute the subarea discharge values for those times and insert them in the table.
3. Sum the values to obtain the composite hydrograph.
4. Apply linear extrapolation to the first two points and the last two points of the composite hydrograph. The volume under this approximation of the entire composite hydrograph may differ from the computed runoff volume.

Limitations

The Tabular method is used to determine peak flows and hydrographs within a watershed. However, its accuracy decreases as the complexity of the watershed increases. If you want to compare present and developed conditions of a watershed, use the same procedure for estimating T_c for both conditions.

Use the TR-20 computer program (SCS 1983) instead of the Tabular method if any of the following conditions applies:

- T_t is greater than 3 hours (largest T_t in exhibit 5).
- T_c is greater than 2 hours (largest T_c in exhibit 5).
- Drainage areas of individual subareas differ by a factor of 5 or more.
- The entire composite flood hydrograph or entire runoff volume is required for detailed flood routings. The hydrograph based on extrapolation is only an approximation of the entire hydrograph.
- The time of peak discharge must be more accurate than that obtained through the Tabular method.

The composite flood hydrograph should be compared with actual stream gage data where possible. The instantaneous peak flow value from the composite flood hydrograph can be compared with data from USGS curves of peak flow versus drainage area.

Examples

A developer proposes to put a subdivision, Fallswood, in subareas 5, 6, and 7 of a watershed in Dyer County, northwestern Tennessee (see sketch below). Before approving the developer's proposal, the planning board wants to know how the development would affect the 25-year peak discharge at the downstream end of subarea 7. The rainfall distribution is type II (figure B-2), and the 24-hour rainfall (P) is 6.0 inches (figure B-6).

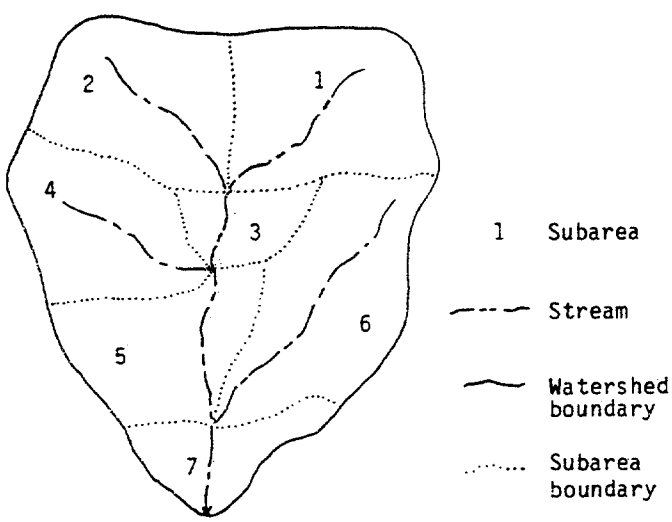
Example 5-1

Compute the 25-year frequency peak discharge at the downstream end of subarea 7 for present conditions, using worksheets 5a and 5b. To do this, first calculate the present condition CN, T_c, and T_t for each subarea, using the procedures in chapters 2 and 3. Enter the values on worksheet 5a (figure 5-1).

Next, compute the prerouted hydrograph points for each subarea hydrograph over a range of time near the peak discharge using worksheet 5b (figure 5-2) and the appropriate exhibit 5. For example, for subarea 4, in which $T_c = 0.75$ hr, refer to sheet 6 of exhibit 5-II. With ΣT_t of 2.00 hr (the sum of downstream travel time through subareas 5 and 7 to the outlet) and I_a/P of 0.1, the routed peak discharge of subarea 4 at the outlet of subarea 7 occurs at 14.6 hr and is 274 csm/in. Solving equation 5-1 with appropriate values provides the peak discharge (q) for subarea 4 at 14.6 hr:

$$q = q_t(A_m Q) = (274)(0.70) = 192 \text{ cfs.}$$

Once all the prerouted subarea hydrographs have been tabulated on worksheet 5b, sum each of the time columns to obtain the composite hydrograph. The resulting 25-year frequency peak discharge is 720 cfs at 14.3 hr (figure 5-2).



Example 5-2

Compute the 25-year frequency peak discharge at the downstream end of subarea 7 for the developed conditions, using worksheets 5a and 5b.

First, calculate the developed condition CN, T_c, and T_t for each subarea, using the procedures in chapters 2 and 3. Enter the values on worksheet 5a (figure 5-3).

Next, compute the prerouted hydrograph points for each subarea hydrograph over a range of time near the peak discharge using worksheet 5b (figure 5-4) and the appropriate exhibit 5. For example, for subarea 6, in which $T_c = 1.0$ hr, refer to sheet 7 of exhibit 5-II. With ΣT_t of 0.5 hr (downstream travel time through subarea 7 to the outlet) and I_a/P of 0.1, the peak discharge of subarea 6 at the outlet of the watershed occurs at 13.2 hr and is 311 csm/in. Solving equation 5-1 provides the peak discharge (q):

$$q = q_t(A_m Q) = (311)(1.31) = 407 \text{ cfs.}$$

Once all the prerouted subarea hydrographs have been tabulated on worksheet 5b, sum each of the time columns to obtain the composite hydrograph. The resulting 25-year frequency peak discharge is 872 cfs at 13.6 hr (figure 5-4).

Comparison

According to the results of the two examples, the proposed subdivision at the downstream end of subarea 7 is expected to increase peak discharge from 720 to 872 cfs and to decrease the time to peak from 14.3 to 13.6 hr.

Worksheet 5a: Basic watershed data

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: (Present) Developed _____ Frequency (yr) 25 Checked [illegible] Date 10/3/85

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Runoff Q (in)	A_mQ (mi^2-in)	Initial abstraction I_a (in)	I_a/P
1	0.30	1.50	--	3,5,7	2.50	6.0	65	2.35	0.71	1.077	0.18
2	0.20	1.25	--	3,5,7	2.50	6.0	70	2.80	0.56	0.857	0.14
3	0.10	0.50	0.50	5,7	2.00	6.0	75	3.28	0.33	0.667	0.11
4	0.25	0.75	--	5,7	2.00	6.0	70	2.80	0.70	0.857	0.14
5	0.20	1.50	1.25	7	0.75	6.0	75	3.28	0.66	0.667	0.11
6	0.40	1.50	--	7	0.75	6.0	70	2.80	1.12	0.857	0.14
7	0.20	1.25	0.75	--	0	6.0	75	3.28	0.66	0.667	0.11

From worksheet 3 From worksheet 2 From table 5-1

Figure 5-1.—Worksheet 5a for example 5-1.

Worksheet 5b: Tabular hydrograph discharge summary

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: (Present) Developed Frequency (yr) 25 Checked [illegible] Date 10/3/85

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours from exhibit 5-II 2/											
	Sub-area T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5
					Discharges at selected hydrograph times 3/ (cfs)											
1	1.50	2.50	0.10	0.71	4	4	5	6	6	8	10	13	24	49	100	149
2	1.25	2.50	0.10	0.56	3	4	4	6	7	8	11	16	32	64	110	127
3	0.50	2.00	0.10	0.33	5	5	6	8	12	21	41	67	98	92	60	29
4	0.75	2.00	0.10	0.70	8	9	11	14	20	34	62	106	172	192	149	81
5	1.50	0.75	0.10	0.66	21	28	50	83	118	147	158	154	127	98	67	44
6	1.50	0.75	0.10	1.12	36	47	85	140	200	249	269	261	216	166	114	75
7	1.25	0	0.10	0.66	169	187	205	176	140	108	85	69	51	40	31	24
Composite hydrograph at outlet					246	284	366	433	503	575	636	686	720	701	631	529

1/ Worksheet 5a. Rounded as needed for use with exhibit 5.
2/ Enter rainfall distribution type used.
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5.

Figure 5-2.—Worksheet 5b for example 5-1.

Worksheet 5a: Basic watershed data

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: Present (Developed) Frequency (yr) 25 Checked JM Date 10/3/85

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Runoff Q (in)	$A_m Q$ (mi^2-in)	Initial abstraction I_a (in)	I_a/P
1	0.30	1.50	--	3,5,7	2.00	6.0	65	2.35	0.71	1.077	0.18
2	0.20	1.25	--	3,5,7	2.00	6.0	70	2.80	0.56	0.857	0.14
3	0.10	0.50	0.50	5,7	1.50	6.0	75	3.28	0.33	0.667	0.11
4	0.25	0.75	--	5,7	1.50	6.0	70	2.80	0.70	0.857	0.14
5	0.20	1.50	1.00	7	0.50	6.0	85	4.31	0.86	0.353	0.06
6	0.40	1.00	--	7	0.50	6.0	75	3.28	1.31	0.857	0.14
7	0.20	0.75	0.50	--	0	6.0	90	4.85	0.97	0.222	0.04

From worksheet 3 From worksheet 2 From table 5-1

Figure 5-3.—Worksheet 5a for example 5-2.

Worksheet 5b: Tabular hydrograph discharge summary

Project Fallswood Location Dyer County, Tennessee By DW Date 10/1/85

Circle one: Present (Developed) Frequency (yr) 25 Checked XW Date 10/3/85

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours from exhibit 5-II 2/											
	Sub-area T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5
					Discharges at selected hydrograph times 3/ -(cfs)-											
1	1.50	2.00	0.10	0.71	6	6	7	9	11	16	24	40	78	122	155	133
2	1.25	2.00	0.10	0.56	6	6	7	9	12	20	33	55	96	132	132	87
3	0.50	1.50	0.10	0.33	8	9	14	29	58	89	106	102	74	46	25	16
4	0.75	1.50	0.10	0.70	13	14	19	32	63	114	169	207	193	143	83	46
5	1.50	0.50	0.10	0.86	51	69	117	167	205	214	202	175	132	99	70	48
6	1.00	0.50	0.10	1.31	149	208	331	407	393	329	255	195	134	97	69	52
7	0.75	0	0.10	0.97	398	358	244	167	119	90	72	59	48	40	34	30
Composite hydrograph at outlet					631	670	739	820	861	872	861	833	755	679	568	412

1/ Worksheet 5a. Rounded as needed for use with exhibit 5.
2/ Enter rainfall distribution type used.
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5.

Figure 5-4.—Workshe or example 5-2.

Exhibit 5-I: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =0.1 HR * * *																		IA/P = 0.10
0.0	30	40	56	183	337	504	326	155	122	107	93	81	73	66	60	56	54	52	49	46	44	40	36	32	30	29	28	27	26	24	20	13
.10	26	35	48	93	153	276	428	360	223	156	123	103	88	72	65	59	56	54	51	47	45	42	37	33	30	29	28	28	26	24	21	13
.20	23	30	41	60	82	129	227	361	360	269	194	147	118	85	71	63	58	55	53	49	46	43	39	35	31	29	29	28	26	24	21	14
.30	22	29	39	56	73	111	188	303	341	293	227	173	136	94	75	65	60	56	54	50	47	43	39	35	31	29	29	28	26	25	21	14
.40	18	25	34	46	53	66	96	157	255	312	300	251	199	126	90	73	64	59	56	52	48	44	40	36	32	30	29	28	26	25	21	14
.50	13	24	32	44	50	61	84	133	214	280	293	265	221	144	99	77	66	60	56	52	49	45	41	37	32	30	29	28	27	25	21	14
.75	14	19	25	34	38	43	49	62	88	134	190	234	252	221	162	115	87	71	63	56	52	47	43	39	35	31	29	29	27	25	22	15
1.0	11	14	19	26	28	31	34	38	44	52	68	98	141	222	238	191	139	101	79	63	56	51	45	41	37	33	30	29	27	26	22	15
1.5	9	10	13	17	18	20	22	25	27	30	34	38	44	74	132	191	211	190	151	101	73	58	50	45	41	37	33	30	28	27	23	16
2.0	6	7	9	11	12	13	14	15	16	18	20	22	24	29	38	58	97	148	193	193	141	89	61	51	46	41	37	33	29	27	24	17
2.5	4	5	7	8	9	9	10	11	11	12	13	14	16	19	23	29	39	58	93	154	181	147	87	61	51	45	41	37	30	28	25	18
3.0	2	3	5	6	6	7	7	8	9	9	10	10	11	13	15	19	23	28	39	72	124	170	138	86	61	50	45	40	33	29	26	19
IA/P = 0.30														* * * TC =0.1 HR * * *																		IA/P = 0.30
0.0	0	0	0	61	195	343	232	129	113	103	91	81	76	71	66	64	62	61	59	56	54	51	47	43	40	40	39	39	37	36	31	21
.10	0	0	0	12	45	145	277	247	169	131	112	98	87	76	70	65	64	62	60	57	55	53	49	44	40	40	39	39	38	36	32	21
.20	0	0	0	9	33	107	220	238	192	151	125	107	94	79	71	66	64	62	61	58	56	53	49	45	41	40	40	39	38	36	32	21
.30	0	0	0	1	6	24	79	173	216	200	168	139	118	90	77	70	66	64	62	59	57	54	50	46	41	40	40	39	38	36	32	22
.40	0	0	0	1	4	17	59	135	189	196	177	152	129	97	81	72	67	64	63	60	57	54	51	46	42	40	40	39	38	36	32	22
.50	0	0	0	0	0	3	12	43	104	161	185	180	161	121	93	79	71	66	64	61	58	55	52	48	43	40	40	39	38	37	33	22
.75	0	0	0	0	0	1	5	18	49	92	130	153	159	142	114	92	79	71	66	63	60	56	53	49	44	41	40	40	38	37	33	23
1.0	0	0	0	0	0	0	0	0	2	9	27	56	92	144	152	128	103	86	75	67	63	59	55	51	47	43	40	40	39	37	34	24
1.5	0	0	0	0	0	0	0	0	0	0	0	2	6	32	79	121	136	127	109	85	72	64	58	55	51	47	43	40	39	38	34	25
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	33	70	105	126	118	97	75	63	58	54	50	46	42	40	39	35	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	32	63	105	118	100	75	63	58	54	50	46	40	39	36	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	12	43	84	112	96	74	63	58	54	50	42	40	37	28
IA/P = 0.50														* * * TC =0.1 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	3	13	28	39	44	45	46	46	48	49	51	53	54	54	55	56	55	53	50	50	49	49	49	49	48	45	32
.10	0	0	0	0	0	2	9	22	33	41	44	45	46	48	49	50	52	54	54	54	56	55	53	50	50	49	49	49	49	48	45	32
.20	0	0	0	0	0	0	1	7	17	28	36	41	44	46	48	49	51	53	54	54	56	56	54	51	50	50	49	49	49	48	45	32
.30	0	0	0	0	0	0	0	1	5	13	23	32	38	44	47	48	50	51	53	54	54	55	54	52	50	50	49	49	49	48	46	33
.40	0	0	0	0	0	0	0	0	3	10	18	27	34	43	46	48	49	51	53	54	54	55	54	52	50	50	49	49	49	48	46	33
.50	0	0	0	0	0	0	0	0	0	2	7	15	23	36	43	46	48	50	51	53	54	55	55	53	50	50	49	49	49	48	46	34
.75	0	0	0	0	0	0	0	0	0	1	3	7	13	27	37	43	46	48	50	52	54	55	55	54	51	50	50	49	49	48	46	34
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	20	32	40	45	47	50	52	54	55	54	52	50	50	49	49	49	47	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	23	33	42	47	51	54	55	54	53	50	50	49	49	48	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	25	37	46	51	54	55	54	52	50	49	49	48	39
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	15	31	45	51	53	55	54	52	50	49	48	41
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14	32	45	51	53	54	54	51	49	48	42

RAINFALL TYPE = I

* * * TC = 0.1 HR * * *

SHEET 1 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =0.2 HR * * *																		IA/P = 0.10
0.0	28	37	52	126	220	379	405	267	168	129	108	92	80	69	62	58	55	53	50	47	44	41	37	33	30	29	28	27	26	24	21	13
.10	24	32	44	71	108	182	313	375	303	213	157	124	103	78	68	61	57	55	52	49	46	42	38	34	30	29	29	28	26	24	21	14
.20	21	28	38	53	65	94	153	260	336	314	247	137	145	97	77	67	60	57	54	50	47	44	39	35	31	30	29	28	26	25	21	14
.30	20	27	36	50	60	82	129	216	296	308	267	214	168	110	82	69	62	58	55	51	47	44	40	36	32	30	29	28	26	25	21	14
.40	17	23	31	42	47	56	74	111	181	258	291	275	234	152	103	79	68	61	57	53	49	45	41	37	33	30	29	28	27	25	22	14
.50	16	22	30	40	45	52	66	96	153	223	269	273	247	171	115	86	71	63	58	54	50	46	42	37	33	30	29	28	27	25	22	14
.75	13	17	24	32	35	39	44	52	68	99	145	194	229	240	183	132	97	77	66	58	53	48	44	39	35	31	30	29	27	26	22	15
1.0	11	13	17	24	26	29	32	35	39	45	56	75	107	189	229	206	158	115	88	67	58	52	46	42	38	34	31	29	28	26	23	15
1.5	8	10	12	15	17	19	21	23	25	28	31	35	39	60	106	166	204	197	165	112	79	60	51	46	42	37	33	30	28	27	23	16
2.0	5	7	9	10	11	12	13	14	15	17	18	20	22	27	34	49	79	126	169	188	152	97	64	52	46	42	38	34	29	28	24	17
2.5	3	5	6	8	8	9	10	10	11	12	13	14	15	18	22	26	34	49	77	136	176	155	95	64	52	46	42	37	31	28	25	18
3.0	2	3	4	5	6	6	7	7	8	8	9	9	10	11	13	16	19	23	29	49	91	154	167	102	67	53	47	42	34	29	26	19
IA/P = 0.30														* * * TC =0.2 HR * * *																		IA/P = 0.30
0.0	0	0	0	22	76	206	258	207	144	119	104	92	82	74	68	65	63	62	60	57	55	52	48	44	40	40	39	39	38	36	32	21
.10	0	0	0	3	16	56	156	224	213	167	135	114	99	81	73	67	65	63	61	58	56	53	50	45	41	40	40	39	38	36	32	22
.20	0	0	0	2	11	41	118	189	205	179	150	126	108	85	75	69	65	63	62	59	56	54	50	46	41	40	40	39	38	36	32	22
.30	0	0	0	0	2	8	30	58	155	188	182	161	138	103	83	74	68	65	63	60	57	55	51	47	42	40	40	39	38	36	32	22
.40	0	0	0	0	1	6	22	66	126	167	177	166	147	111	88	76	69	66	63	61	58	55	51	47	43	40	40	39	38	37	33	22
.50	0	0	0	0	0	1	4	16	50	100	145	167	166	136	105	85	75	69	65	62	59	56	53	49	44	41	40	40	38	37	33	23
.75	0	0	0	0	0	0	2	7	22	50	87	119	140	148	124	101	85	74	69	64	61	57	54	50	45	42	40	40	38	37	33	23
1.0	0	0	0	0	0	0	0	0	1	3	11	28	55	114	142	135	113	93	80	69	64	60	56	52	48	44	41	40	39	37	34	24
1.5	0	0	0	0	0	0	0	0	0	0	0	1	2	17	52	97	124	129	115	91	75	65	59	55	52	48	43	41	39	38	35	25
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	19	49	84	111	120	102	79	65	59	55	51	47	43	40	39	36	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	20	45	89	113	104	78	65	59	55	51	47	41	39	36	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	30	68	108	99	77	65	58	54	50	43	40	37	29
IA/P = 0.50														* * * TC =0.2 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	4	15	28	38	43	45	45	48	49	50	52	53	53	53	53	53	53	50	50	50	49	49	49	48	45	32
.10	0	0	0	0	0	0	3	11	22	32	40	43	45	47	48	50	52	53	53	53	53	53	53	50	50	50	49	49	49	48	45	32
.20	0	0	0	0	0	0	2	8	17	27	36	41	43	46	48	49	51	53	53	53	53	53	53	51	50	50	49	49	49	48	45	33
.30	0	0	0	0	0	0	1	6	13	23	31	38	41	45	48	49	51	52	53	53	53	53	53	51	50	50	49	49	49	48	46	33
.40	0	0	0	0	0	0	1	4	10	19	27	34	39	44	47	49	50	52	53	53	53	53	53	51	50	50	49	49	49	48	46	33
.50	0	0	0	0	0	0	1	3	8	15	23	30	36	43	46	48	50	51	53	53	53	53	53	52	50	50	49	49	49	48	46	33
.75	0	0	0	0	0	0	0	0	3	8	14	20	27	37	43	46	48	50	52	53	53	53	53	52	50	50	50	49	49	48	46	34
1.0	0	0	0	0	0	0	0	0	0	0	0	2	4	14	26	36	42	46	48	51	52	53	53	53	52	50	50	49	49	49	47	35
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	23	33	40	46	49	52	53	53	53	51	50	50	49	49	48	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	16	26	37	44	50	52	53	53	53	51	50	49	49	48	38
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	19	31	43	50	52	53	53	52	51	50	49	48	39
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	25	41	49	52	53	53	52	50	49	48	41

RAINFALL TYPE = I * * * TC = 0.2 HR * * * SHEET 2 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL TIME (HR) — HYDROGRAPH TIME (HOURS)

IA/P = 0.10 — * * * TC =0.3 HR * * * — IA/P = 0.10

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
0.0	25	34	46	87	138	242	349	346	256	182	141	115	97	76	66	60	57	54	52	48	45	42	38	34	30	29	28	28	26	24	21	13
.10	24	32	44	77	118	200	299	330	281	215	166	132	109	82	69	62	58	55	52	49	46	42	38	34	30	29	29	28	26	24	21	14
.20	21	28	38	54	69	102	167	255	305	289	240	190	152	103	79	67	61	57	54	50	47	44	40	35	31	30	29	28	26	25	21	14
.30	20	27	36	51	63	89	141	217	276	285	255	212	172	115	85	71	63	58	55	51	48	44	40	36	32	30	29	28	26	25	21	14
.40	17	23	31	42	48	58	79	120	185	246	272	260	228	156	108	82	69	62	57	53	49	45	41	37	33	30	29	28	27	25	22	14
.50	16	22	30	40	45	54	70	104	158	216	253	258	238	173	120	89	72	63	58	54	50	46	42	37	33	30	29	28	27	25	22	14
.75	13	17	24	32	35	39	45	54	72	104	147	189	219	231	182	135	100	79	67	58	53	48	44	40	35	32	30	29	27	26	22	15
1.0	11	13	17	24	26	29	32	35	40	46	58	79	110	184	221	202	158	118	90	68	58	52	46	42	38	34	31	29	28	26	23	15
1.5	8	10	12	15	17	19	21	23	25	28	31	35	40	62	107	163	199	193	165	114	81	61	52	46	42	37	33	31	28	27	23	16
2.0	5	7	9	10	11	12	13	14	15	17	18	20	22	27	35	50	80	125	165	184	152	99	64	53	47	42	38	34	29	28	24	17
2.5	3	5	6	8	8	9	10	10	11	12	13	14	15	18	22	27	35	50	78	134	173	154	96	64	52	46	42	37	31	28	25	18
3.0	2	3	4	6	6	7	7	8	8	9	9	10	11	12	14	17	21	26	34	61	107	164	145	94	64	52	46	41	33	29	26	19

IA/P = 0.30 — * * * TC =0.3 HR * * * — IA/P = 0.30

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
0.0	0	0	0	8	32	98	198	217	192	148	125	108	95	79	72	67	64	63	61	58	56	53	49	45	41	40	40	39	38	36	32	22
.10	0	0	0	1	6	23	73	156	197	194	164	138	118	91	77	70	66	64	62	59	57	54	50	46	41	40	40	39	38	36	32	22
.20	0	0	0	1	4	17	54	122	172	187	171	149	128	98	81	72	67	64	63	60	57	54	51	46	42	40	40	39	38	36	32	22
.30	0	0	0	0	0	3	12	40	95	146	173	172	157	120	94	79	71	67	64	61	58	55	52	48	43	40	40	39	38	37	33	23
.40	0	0	0	0	0	2	9	30	73	122	156	167	160	128	100	83	73	68	65	62	59	56	52	48	44	41	40	39	38	37	33	23
.50	0	0	0	0	0	1	6	22	56	100	137	157	159	135	107	87	76	69	65	62	59	56	53	49	44	41	40	40	38	37	33	23
.75	0	0	0	0	0	0	1	3	9	26	53	86	115	143	134	113	93	80	72	65	62	58	54	51	46	42	40	40	39	37	33	23
1.0	0	0	0	0	0	0	0	0	1	5	14	32	57	111	138	132	113	94	81	69	64	60	56	52	48	44	41	40	39	37	34	24
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	8	34	74	111	126	121	99	80	67	61	56	53	49	44	41	39	38	35	26
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	33	66	97	118	108	84	67	60	56	52	48	44	40	39	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12	32	74	106	112	83	67	60	56	52	48	41	39	37	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	21	54	98	107	81	67	60	55	51	43	40	37	29

IA/P = 0.50 — * * * TC =0.3 HR * * * — IA/P = 0.50

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
0.0	0	0	0	0	0	0	1	6	16	27	36	41	44	46	48	49	51	52	52	52	52	52	52	51	50	50	49	49	48	46	33
.10	0	0	0	0	0	0	1	4	12	22	31	38	42	45	48	49	51	52	52	52	52	52	52	51	50	50	49	49	49	48	46	33
.20	0	0	0	0	0	0	0	3	9	18	27	34	39	44	47	49	50	51	52	52	52	52	52	51	50	50	49	49	49	48	46	33
.30	0	0	0	0	0	0	0	2	7	14	23	30	36	43	46	48	50	51	52	52	52	52	52	51	50	50	49	49	49	48	46	33
.40	0	0	0	0	0	0	0	1	5	11	19	26	33	41	46	48	49	51	52	52	52	52	52	52	50	50	49	49	49	48	46	33
.50	0	0	0	0	0	0	0	1	4	9	15	23	30	39	44	47	49	50	51	52	52	52	52	52	50	50	49	49	49	48	46	33
.75	0	0	0	0	0	0	0	0	2	4	8	14	20	31	40	44	47	49	51	52	52	52	52	52	50	50	50	49	49	48	46	34
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	9	20	31	39	44	47	50	51	52	52	52	52	50	50	50	49	49	47	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	18	28	36	44	48	51	52	52	52	51	50	50	49	49	48	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	12	21	33	42	48	51	52	52	52	51	50	49	49	48	38
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	15	27	40	48	51	52	52	52	51	50	49	48	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	25	41	48	51	52	52	51	50	49	48	41

RAINFALL TYPE = I — * * * TC = 0.3 HR * * * — SHEET 3 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =0.4 HR * * *																		IA/P = 0.10
0.0	23	31	42	66	96	157	250	310	304	244	186	149	122	89	73	64	59	56	53	49	46	43	39	35	31	29	29	28	26	25	21	14
.10	22	29	40	61	84	133	211	277	295	261	211	170	138	98	78	66	60	56	54	50	47	43	39	35	31	29	29	28	26	25	21	14
.20	19	26	34	47	56	75	114	178	244	278	267	230	190	128	93	75	65	59	56	52	48	44	40	36	32	30	29	28	27	25	21	14
.30	18	24	33	45	53	67	98	152	213	257	263	241	207	143	102	80	68	61	57	52	49	45	41	37	32	30	29	28	27	25	21	14
.40	15	21	28	38	43	49	61	86	130	185	233	253	245	188	132	97	77	66	60	55	51	46	42	38	34	30	29	28	27	25	22	14
.50	15	20	27	36	41	46	56	76	112	161	209	238	243	201	146	106	82	69	61	55	51	47	42	38	34	31	29	29	27	25	22	14
.75	12	16	21	29	32	35	39	46	57	77	108	147	184	220	200	157	118	91	74	61	55	50	45	40	36	32	30	29	27	26	22	15
1.0	10	12	16	21	24	26	29	32	36	40	48	61	83	147	202	212	178	138	105	75	62	54	47	43	39	35	31	29	28	26	23	16
1.5	8	9	11	14	16	17	19	21	23	25	28	31	35	50	83	134	179	193	177	131	92	65	53	47	42	38	34	31	29	27	24	16
2.0	5	6	8	10	10	11	12	13	14	15	17	18	20	25	31	42	64	102	144	179	163	111	70	55	48	43	39	35	30	28	25	17
2.5	3	4	6	7	8	8	9	9	10	11	12	13	14	16	20	24	30	42	63	114	160	170	107	70	54	47	43	38	31	29	25	18
3.0	2	3	4	5	6	6	7	7	8	8	9	9	10	11	13	16	19	23	30	51	90	148	161	104	69	54	47	42	34	29	26	19
IA/P = 0.30														* * * TC =0.4 HR * * *																		IA/P = 0.30
0.0	0	0	0	3	14	48	115	184	192	178	148	127	111	88	77	70	66	64	62	59	56	54	50	46	41	40	40	39	38	36	32	22
.10	0	0	0	0	2	10	35	89	152	179	178	158	137	105	85	75	69	65	63	60	58	55	51	47	42	40	40	39	38	36	32	22
.20	0	0	0	0	2	7	26	68	124	161	172	163	146	113	90	78	70	66	64	61	58	55	52	47	43	40	40	39	38	37	33	22
.30	0	0	0	0	1	5	19	52	100	140	162	162	151	120	96	81	72	67	64	61	59	55	52	48	43	41	40	39	38	37	33	23
.40	0	0	0	0	0	1	4	14	39	80	120	148	158	142	114	92	79	71	67	63	60	57	53	49	45	41	40	40	38	37	33	23
.50	0	0	0	0	0	1	3	10	29	63	101	132	152	145	120	97	82	73	68	63	60	57	53	50	45	41	40	40	38	37	33	23
.75	0	0	0	0	0	0	0	1	4	13	31	58	87	130	138	123	103	87	77	68	63	59	55	51	47	43	41	40	39	37	34	24
1.0	0	0	0	0	0	0	0	0	0	2	7	18	36	86	125	134	122	104	88	73	66	61	57	53	49	45	41	40	39	38	34	24
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	10	36	75	109	124	120	100	81	68	61	56	53	49	44	41	40	38	35	26
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	22	50	83	116	116	91	70	61	57	53	49	45	40	39	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	22	60	97	111	88	70	61	56	53	48	42	39	37	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	43	89	106	86	69	61	56	52	44	40	37	29
IA/P = 0.50														* * * TC =0.4 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	2	8	17	27	34	40	44	47	49	50	51	51	51	51	51	51	51	50	50	49	49	49	48	46	33
.10	0	0	0	0	0	0	0	0	2	6	13	22	30	40	45	47	49	50	51	51	51	51	51	51	50	50	50	49	49	48	46	34
.20	0	0	0	0	0	0	0	0	0	1	4	10	18	33	41	45	48	49	51	51	51	51	51	51	50	50	50	49	49	49	46	34
.30	0	0	0	0	0	0	0	0	0	0	1	3	8	22	35	42	46	48	50	51	51	51	51	51	51	50	50	49	49	49	47	35
.40	0	0	0	0	0	0	0	0	0	0	1	2	6	19	32	40	45	47	49	51	51	51	51	51	51	50	50	49	49	49	47	35
.50	0	0	0	0	0	0	0	0	0	0	0	0	2	9	23	34	41	45	48	50	51	51	51	51	51	50	50	49	49	49	47	35
.75	0	0	0	0	0	0	0	0	0	0	0	0	1	5	14	26	35	42	46	49	50	51	51	51	51	50	50	50	49	49	47	36
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	14	25	35	44	48	50	51	51	51	51	50	50	49	49	48	37
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	27	39	47	50	51	51	51	51	50	49	49	48	39
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	21	36	47	50	51	51	51	51	50	49	48	40
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	19	37	47	50	51	51	51	50	49	48	42
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	25	40	48	50	51	51	50	50	49	43

RAINFALL TYPE = I * * * TC = 0.4 HR * * * SHEET 4 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =0.5 HR * * *																		IA/P = 0.10
0.0	21	28	38	56	73	111	175	247	282	271	229	186	152	108	84	71	63	58	55	51	47	44	40	35	31	30	29	28	26	25	21	14
.10	20	27	36	52	66	96	149	214	259	267	242	204	169	119	90	74	65	59	55	51	48	44	40	36	32	30	29	28	26	25	21	14
.20	17	23	31	42	49	60	84	127	185	234	256	247	219	156	112	86	72	63	58	53	49	45	41	37	33	30	29	28	27	25	22	14
.30	16	22	30	40	46	55	74	110	160	210	241	245	227	171	123	93	76	66	59	54	50	46	42	38	33	30	29	28	27	25	22	14
.40	14	19	26	35	38	43	51	67	95	138	186	222	237	210	157	115	89	73	64	57	52	47	43	39	35	31	29	29	27	25	22	15
.50	14	18	25	33	37	41	48	61	84	120	164	203	229	216	170	126	96	77	66	58	53	48	43	39	35	31	30	29	27	25	22	15
.75	11	14	19	26	29	32	35	40	48	61	83	114	148	202	210	176	137	106	84	66	57	51	46	41	37	33	30	29	28	26	22	15
1.0	10	11	15	19	21	24	26	29	32	36	41	50	65	116	176	203	190	156	122	85	67	56	49	44	40	35	32	30	28	26	23	16
1.5	7	9	11	13	14	16	17	19	21	23	25	28	31	42	67	110	157	187	133	146	104	72	55	48	43	39	35	32	29	27	24	17
2.0	4	6	7	9	10	10	11	12	13	14	15	17	18	22	27	36	53	33	123	175	175	124	77	57	49	44	40	35	30	28	25	18
2.5	3	4	5	7	7	8	8	9	9	10	11	12	13	15	18	22	27	36	53	97	146	166	119	76	57	49	44	39	32	29	25	18
3.0	1	2	3	5	5	6	6	6	7	8	8	9	9	11	12	15	17	21	27	43	76	135	158	114	75	57	48	43	35	30	26	19
IA/P = 0.30														* * * TC =0.5 HR * * *																		IA/P = 0.30
0.0	0	0	0	1	6	22	64	123	168	174	165	143	126	100	84	74	68	65	63	60	57	54	51	47	42	40	40	39	38	36	32	22
.10	0	0	0	1	5	16	48	98	144	164	165	150	134	106	87	77	70	66	63	60	58	55	51	47	42	40	40	39	38	36	32	22
.20	0	0	0	0	1	3	12	36	77	122	150	160	154	126	101	85	75	69	65	62	59	56	52	48	44	41	40	39	38	37	33	23
.30	0	0	0	0	0	2	9	27	60	101	134	151	153	132	107	89	77	70	66	63	60	56	53	49	44	41	40	40	38	37	33	23
.40	0	0	0	0	0	0	2	6	20	47	83	117	140	148	125	102	86	76	69	64	61	57	54	50	46	42	40	40	39	37	33	23
.50	0	0	0	0	0	0	1	5	15	36	68	101	127	144	130	108	90	78	71	65	62	58	54	50	46	42	40	40	39	37	33	23
.75	0	0	0	0	0	0	0	2	6	17	36	60	87	125	133	121	103	88	78	68	63	59	55	52	47	43	41	40	39	37	34	24
1.0	0	0	0	0	0	0	0	0	0	1	3	9	21	62	106	130	126	112	96	78	69	62	57	54	50	46	42	40	39	38	34	25
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	6	23	56	92	115	120	106	87	71	62	57	53	49	45	42	40	38	35	26
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14	36	67	104	113	96	74	63	58	54	50	46	40	39	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	15	47	85	109	93	73	63	57	53	49	42	40	37	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	32	77	105	90	72	62	57	53	45	40	38	30
IA/P = 0.50														* * * TC =0.5 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	1	4	10	18	26	33	41	45	47	49	50	50	50	50	50	50	50	50	50	50	49	49	48	46	33
.10	0	0	0	0	0	0	0	1	3	8	15	22	30	39	44	47	49	50	50	50	50	50	50	50	50	50	50	49	49	48	46	34
.20	0	0	0	0	0	0	0	0	2	6	12	19	26	37	43	46	48	50	50	50	50	50	50	50	50	50	50	49	49	48	46	34
.30	0	0	0	0	0	0	0	0	1	4	9	16	23	34	41	45	48	49	50	50	50	50	50	50	50	50	50	49	49	49	46	34
.40	0	0	0	0	0	0	0	0	1	3	7	13	19	31	39	44	47	49	50	50	50	50	50	50	50	50	50	49	49	49	46	34
.50	0	0	0	0	0	0	0	0	1	2	6	10	16	28	37	43	46	48	50	50	50	50	50	50	50	50	50	49	49	49	46	34
.75	0	0	0	0	0	0	0	0	0	1	3	6	10	20	30	38	43	46	48	50	50	50	50	50	50	50	50	49	49	49	47	35
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	20	30	38	43	47	49	50	50	50	50	50	50	50	49	49	47	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	14	23	31	41	46	49	50	50	50	50	50	50	49	49	48	38
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	25	36	45	49	50	50	50	50	50	49	49	48	39
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	23	37	46	49	50	50	50	50	50	49	48	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	21	37	46	49	50	50	50	50	49	48	42

RAINFALL TYPE = I

* * * TC = 0.5 HR * * *

SHEET 5 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =0.75 HR * * *																		IA/P = 0.10
0.0	16	22	30	41	47	59	82	119	167	209	229	233	212	161	122	97	80	69	62	56	51	46	42	38	33	31	29	28	27	25	22	14
.10	14	19	26	35	39	44	54	72	104	146	188	215	227	197	150	116	93	77	68	59	53	48	43	39	35	31	30	29	27	25	22	15
.20	13	16	22	30	33	37	42	50	65	91	128	168	200	218	183	142	110	89	75	63	56	49	44	40	36	32	30	29	27	26	22	15
.30	12	16	21	28	31	35	39	46	59	80	112	149	183	214	191	151	118	94	79	65	57	50	45	41	36	32	30	29	27	26	22	15
.40	12	15	20	27	30	33	37	43	54	71	98	132	166	207	197	161	126	100	83	67	58	51	45	41	37	33	30	29	27	26	22	15
.50	11	13	18	24	26	29	32	36	41	49	64	87	117	178	204	186	152	120	96	74	62	53	47	42	38	34	31	29	28	26	23	15
.75	10	12	15	21	23	25	28	31	35	40	49	63	83	136	180	190	171	142	115	85	69	57	49	44	39	35	32	30	28	26	23	16
1.0	8	10	12	16	17	19	21	23	25	28	31	35	42	66	110	158	186	180	157	116	86	65	53	46	42	38	34	31	28	27	23	16
1.5	5	7	8	10	11	12	13	14	15	17	18	20	22	27	35	52	83	124	159	174	147	102	69	54	47	42	38	34	30	28	24	17
2.0	3	5	6	8	8	9	9	10	11	12	13	14	15	18	22	27	36	52	80	131	165	148	99	68	54	47	42	38	31	28	25	18
2.5	2	3	4	5	6	6	7	7	8	9	9	10	11	12	14	17	21	26	35	63	107	157	141	96	67	54	46	42	34	29	26	19
3.0	1	1	2	3	4	4	4	5	5	6	6	7	7	8	10	11	13	15	19	26	42	86	151	141	101	71	55	47	38	31	27	20
IA/P = 0.30														* * * TC =0.75 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	1	4	14	35	69	105	131	143	146	124	104	89	79	72	68	64	60	56	53	49	44	41	40	40	38	37	33	23
.10	0	0	0	0	0	1	3	10	27	55	88	117	134	142	118	100	87	77	71	66	62	58	54	50	46	42	40	40	39	37	33	23
.20	0	0	0	0	0	0	2	7	20	43	73	102	123	137	123	105	90	80	73	66	62	58	54	50	46	42	40	40	39	37	33	23
.30	0	0	0	0	0	0	0	1	5	15	34	60	88	128	134	118	101	88	78	69	64	60	55	52	48	43	41	40	39	37	34	24
.40	0	0	0	0	0	0	0	1	4	12	27	49	75	118	131	121	105	91	80	71	65	60	56	52	48	44	41	40	39	37	34	24
.50	0	0	0	0	0	0	0	0	1	3	9	21	39	87	122	128	116	101	88	75	68	62	57	53	49	45	42	40	39	38	34	24
.75	0	0	0	0	0	0	0	0	0	1	4	10	21	56	95	118	121	110	98	82	72	64	58	54	50	46	42	41	39	38	34	25
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	12	39	76	106	119	115	98	82	69	61	57	53	49	44	42	40	38	35	26
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14	37	67	95	112	105	85	69	61	56	52	48	44	40	39	36	27
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	15	35	74	102	107	84	69	61	56	52	48	41	39	37	28
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	23	55	94	103	82	68	60	56	52	44	40	37	29
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	50	93	100	81	68	60	55	47	41	38	30
IA/P = 0.50														* * * TC =0.75 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	1	2	5	10	17	29	37	42	45	48	49	49	49	49	49	49	49	49	49	49	49	49	47	34
.10	0	0	0	0	0	0	0	0	0	2	4	8	14	26	35	41	45	47	49	49	49	49	49	49	49	49	49	49	49	49	47	35
.20	0	0	0	0	0	0	0	0	0	1	3	7	11	23	33	39	44	47	48	49	49	49	49	49	49	49	49	49	49	49	47	35
.30	0	0	0	0	0	0	0	0	0	1	2	5	9	20	30	38	43	46	48	49	49	49	49	49	49	49	49	49	49	49	47	35
.40	0	0	0	0	0	0	0	0	0	1	2	4	8	17	28	36	41	45	47	49	49	49	49	49	49	49	49	49	49	49	47	35
.50	0	0	0	0	0	0	0	0	0	0	1	3	6	15	25	34	40	44	47	48	49	49	49	49	49	49	49	49	49	49	47	35
.75	0	0	0	0	0	0	0	0	0	0	1	1	3	9	18	27	35	40	44	47	48	49	49	49	49	49	49	49	49	49	47	36
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	18	27	35	40	45	48	49	49	49	49	49	49	49	49	49	48	37
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	21	29	38	44	48	49	49	49	49	49	49	49	49	48	38
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	15	26	36	44	48	49	49	49	49	49	49	49	48	39
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	21	34	44	48	48	48	48	48	48	48	48	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	19	35	44	48	48	48	48	48	48	48	42

RAINFALL TYPE = I

* * * TC = 0.75 HR * * *

SHEET 6 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =1.0 HR * * *																		IA/P = 0.10
0.0	14	19	25	34	38	46	58	79	106	136	165	186	202	185	153	122	101	85	74	63	56	50	44	40	35	32	30	29	27	26	22	15
.10	13	18	24	32	36	42	53	70	94	122	151	174	194	188	160	130	106	89	77	65	57	50	44	40	36	32	30	29	27	26	22	15
.20	12	15	21	28	31	34	40	49	63	83	109	137	162	190	180	152	124	102	86	70	61	53	46	41	37	33	31	29	27	26	22	15
.30	12	15	20	26	29	33	37	45	57	75	98	124	149	187	183	159	131	107	90	73	62	53	47	42	37	33	31	29	28	26	23	15
.40	10	13	17	23	25	28	31	35	42	52	67	88	112	160	183	176	151	125	103	81	67	56	48	43	39	35	31	30	28	26	23	15
.50	10	13	16	22	24	27	30	33	39	48	61	79	101	148	181	181	157	131	108	84	69	58	49	43	39	35	32	30	28	26	23	16
.75	9	11	14	19	21	23	26	29	33	38	47	59	75	115	153	172	167	148	125	96	77	62	51	45	40	36	33	30	28	27	23	16
1.0	8	9	11	15	16	17	19	21	23	26	29	33	40	61	95	134	162	169	157	126	97	72	57	49	43	39	35	32	29	27	24	16
1.5	5	6	8	10	10	11	12	13	14	16	17	19	21	25	33	48	74	107	138	160	148	111	76	59	50	44	39	35	30	28	25	17
2.0	3	4	6	7	8	8	9	9	10	11	12	13	14	17	20	25	33	48	71	115	153	153	108	75	58	49	43	39	32	29	25	18
2.5	2	3	4	5	5	6	6	7	7	8	9	9	10	12	14	16	20	25	33	56	94	139	147	104	74	58	49	43	34	30	26	19
3.0	1	1	2	3	3	4	4	4	5	5	6	6	7	8	9	10	12	14	17	24	38	76	131	143	108	78	60	50	39	32	27	20
IA/P = 0.30														* * * TC =1.0 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	1	2	7	17	34	55	79	99	114	128	114	100	89	80	74	68	63	59	54	51	46	43	41	40	39	37	33	23
.10	0	0	0	0	0	0	2	5	13	27	46	68	89	116	124	110	98	87	79	71	65	60	56	52	48	43	41	40	39	37	34	24
.20	0	0	0	0	0	0	1	4	10	21	37	58	78	109	121	113	101	90	81	72	66	61	56	52	48	44	41	40	39	37	34	24
.30	0	0	0	0	0	0	0	1	3	8	17	31	49	87	113	118	109	98	87	76	69	63	57	53	49	45	42	40	39	38	34	24
.40	0	0	0	0	0	0	0	1	2	6	13	25	41	78	107	117	111	101	90	78	70	63	58	54	50	45	42	41	39	38	34	25
.50	0	0	0	0	0	0	0	0	2	5	10	20	34	69	100	115	113	103	93	80	71	64	58	54	50	46	42	41	39	38	34	25
.75	0	0	0	0	0	0	0	0	0	1	2	5	10	31	61	90	107	110	104	90	79	69	61	56	52	48	44	41	40	38	35	25
1.0	0	0	0	0	0	0	0	0	0	0	0	1	3	12	33	61	89	105	109	99	86	73	64	58	54	50	45	42	40	38	35	26
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	31	55	80	104	104	88	73	63	58	53	49	45	41	39	36	27
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	20	51	82	100	90	74	64	58	54	50	42	40	37	28
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	13	37	76	98	88	73	64	58	53	45	41	38	30
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	34	77	95	86	73	63	58	49	42	38	31
IA/P = 0.50														* * * TC =1.0 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	1	3	5	9	18	28	35	40	44	47	48	48	48	48	48	48	48	48	48	48	48	47	35
.10	0	0	0	0	0	0	0	0	0	1	2	4	7	16	25	33	39	43	46	48	48	48	48	48	48	48	48	48	48	48	47	35
.20	0	0	0	0	0	0	0	0	0	1	2	3	6	14	23	31	38	42	45	47	48	48	48	48	48	48	48	48	48	48	47	36
.30	0	0	0	0	0	0	0	0	0	0	1	3	5	12	21	29	36	41	44	47	48	48	48	48	48	48	48	48	48	48	47	36
.40	0	0	0	0	0	0	0	0	0	0	1	2	4	10	19	27	34	40	44	47	48	48	48	48	48	48	48	48	48	48	47	36
.50	0	0	0	0	0	0	0	0	0	0	1	2	3	8	16	25	33	38	43	46	48	48	48	48	48	48	48	48	48	48	47	36
.75	0	0	0	0	0	0	0	0	0	0	1	2	3	8	15	23	30	36	41	45	47	48	48	48	48	48	48	48	48	48	47	36
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	19	27	33	41	45	47	48	48	48	48	48	48	48	48	48	37
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	11	17	28	37	44	47	48	48	48	48	48	48	48	48	39
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	16	26	38	45	47	48	48	48	48	48	48	48	40
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	24	38	45	47	47	47	47	47	47	47	41
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	14	29	40	46	47	47	47	47	47	47	42

RAINFALL TYPE = I * * * TC = 1.0 HR * * * SHEET 7 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =1.25 HR * * *																		IA/P = 0.10
0.0	12	16	22	29	33	38	47	61	80	103	127	149	164	180	163	138	115	98	85	71	62	53	47	41	37	33	31	29	27	26	22	15
.10	11	14	19	25	28	31	36	44	55	72	92	116	138	167	175	156	132	111	95	77	66	56	48	43	38	34	31	30	28	26	23	15
.20	11	14	18	24	27	30	34	40	50	65	83	105	127	160	172	160	138	116	99	80	68	57	49	43	39	34	31	30	28	26	23	15
.30	10	12	16	21	23	25	28	32	38	46	58	75	95	136	164	169	154	132	112	89	74	61	51	45	40	36	32	30	28	26	23	16
.40	9	12	15	20	22	24	27	30	35	42	53	68	86	126	157	167	157	137	117	92	76	62	52	46	40	36	33	30	28	26	23	16
.50	9	11	13	17	19	21	23	26	29	33	39	49	61	97	134	160	165	152	132	104	84	67	55	47	42	37	33	31	28	27	23	16
.75	7	9	11	14	15	17	18	20	22	25	28	32	38	59	90	124	150	159	152	126	101	77	60	51	45	40	35	32	29	27	24	17
1.0	6	8	10	12	13	14	15	17	19	20	23	25	29	40	60	91	123	148	157	144	118	88	66	54	47	41	37	33	29	27	24	17
1.5	4	6	7	9	9	10	11	12	13	14	15	16	18	22	28	40	59	85	114	145	150	121	86	65	54	46	41	37	31	28	25	18
2.0	2	3	5	6	6	7	7	8	9	9	10	11	11	13	16	19	24	33	47	80	119	144	124	90	68	55	47	42	33	29	26	19
2.5	1	2	3	4	4	5	5	6	6	7	7	8	8	10	11	13	16	19	24	38	65	111	140	120	88	67	54	47	37	31	27	20
3.0	1	1	2	2	3	3	3	4	4	5	5	5	6	7	8	9	11	13	15	21	32	62	114	136	116	86	66	54	41	33	27	20
IA/P = 0.30														* * * TC =1.25 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	1	4	10	21	35	53	71	86	106	115	104	94	86	79	72	66	61	56	52	48	44	41	40	39	37	34	24
.10	0	0	0	0	0	0	1	3	8	16	29	45	62	92	107	113	101	92	84	75	69	63	58	53	49	45	42	41	39	38	34	24
.20	0	0	0	0	0	0	1	2	6	13	23	37	54	84	104	110	104	94	86	77	70	64	58	54	49	45	42	41	39	38	34	24
.30	0	0	0	0	0	0	0	0	2	4	10	19	31	62	90	106	109	101	92	81	73	66	60	55	51	46	43	41	39	38	34	25
.40	0	0	0	0	0	0	0	0	1	3	8	15	26	55	83	102	107	103	94	83	74	67	60	56	51	47	43	41	39	38	35	25
.50	0	0	0	0	0	0	0	0	0	1	3	6	12	33	62	88	103	106	100	88	78	69	62	57	53	48	44	42	40	38	35	25
.75	0	0	0	0	0	0	0	0	0	0	0	1	3	12	31	56	80	97	103	97	87	75	65	59	55	50	46	43	40	39	35	26
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	32	56	79	95	101	94	80	69	61	56	52	48	44	40	39	36	27
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	30	51	81	98	94	79	68	61	56	52	47	42	39	36	28
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	37	66	95	95	78	68	61	56	51	44	40	37	29
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	26	61	93	89	77	67	60	55	47	41	38	30
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	24	64	91	87	76	66	60	50	43	39	31
IA/P = 0.50														* * * TC =1.25 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	1	2	3	6	13	21	29	35	40	43	47	47	47	47	47	47	47	47	47	47	47	47	36
.10	0	0	0	0	0	0	0	0	0	0	1	3	5	11	19	27	34	39	42	47	47	47	47	47	47	47	47	47	47	47	47	36
.20	0	0	0	0	0	0	0	0	0	0	1	2	4	9	17	25	32	37	41	46	47	47	47	47	47	47	47	47	47	47	47	36
.30	0	0	0	0	0	0	0	0	0	0	1	2	3	8	15	23	30	36	40	45	47	47	47	47	47	47	47	47	47	47	47	36
.40	0	0	0	0	0	0	0	0	0	0	0	1	2	7	13	21	28	35	39	45	47	47	47	47	47	47	47	47	47	47	47	37
.50	0	0	0	0	0	0	0	0	0	0	0	1	2	6	12	19	27	33	38	44	46	47	47	47	47	47	47	47	47	47	47	37
.75	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	14	21	28	34	41	45	47	47	47	47	47	47	47	47	47	47	37
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	11	17	24	34	41	46	47	47	47	47	47	47	47	47	47	38
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	19	29	39	45	47	47	47	47	47	47	47	47	40
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	18	30	41	46	47	47	47	47	47	47	47	41
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	17	31	41	46	47	47	47	47	47	47	42
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	18	32	42	46	47	47	47	47	47	43

RAINFALL TYPE = I * * * TC = 1.25 HR * * * SHEET 8 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10 * * * TC =1.5 HR * * * IA/P = 0.10																																
0.0	11	14	19	25	28	32	39	48	60	76	94	112	129	151	163	147	130	112	97	81	69	59	50	44	39	35	32	30	28	26	23	15
.10	10	12	16	22	24	27	30	36	44	55	69	86	103	135	152	159	143	125	108	88	75	62	52	46	41	36	32	30	28	26	23	16
.20	9	11	14	19	21	23	25	29	34	41	50	63	78	112	140	155	152	138	121	98	81	67	55	48	42	37	33	31	28	27	23	16
.30	9	11	14	18	20	22	24	27	31	38	46	57	71	104	133	151	154	141	125	101	84	68	56	48	43	38	34	31	29	27	23	16
.40	8	10	13	17	19	21	23	26	30	35	42	52	65	96	126	147	152	144	129	105	87	70	57	49	43	38	34	31	29	27	23	16
.50	8	9	12	15	17	18	20	22	25	28	33	39	48	73	104	131	148	151	140	117	95	75	60	51	45	40	35	32	29	27	24	17
.75	7	8	11	13	15	16	18	19	21	24	27	32	38	56	82	110	133	146	144	127	106	83	65	54	47	41	36	33	29	27	24	17
1.0	5	7	9	11	11	12	13	15	16	18	19	22	24	32	47	69	96	122	139	145	127	99	74	60	51	44	39	35	30	28	24	17
1.5	4	5	6	8	8	9	10	10	11	12	13	14	16	19	24	32	46	66	90	124	139	128	97	73	59	50	44	39	32	29	25	18
2.0	2	3	4	5	5	6	6	7	7	8	9	9	10	12	14	17	21	27	38	63	96	135	129	100	76	61	51	44	35	30	26	19
2.5	1	2	2	3	4	4	4	5	5	6	6	7	7	8	10	11	14	16	20	31	51	91	132	124	98	75	60	51	39	32	27	20
3.0	0	1	1	2	2	2	2	3	3	3	4	4	5	6	7	8	9	10	12	16	23	42	86	123	128	101	77	62	45	35	28	21
IA/P = 0.30 * * * TC =1.5 HR * * * IA/P = 0.30																																
0.0	0	0	0	0	0	1	3	7	13	21	33	46	60	83	97	106	97	90	84	76	70	64	59	54	50	45	43	41	39	38	34	25
.10	0	0	0	0	0	0	1	2	5	10	18	28	40	66	86	98	103	95	88	80	73	66	60	55	51	47	43	41	39	38	35	25
.20	0	0	0	0	0	0	0	1	4	8	14	23	34	60	81	95	101	97	90	81	74	67	61	56	52	47	44	41	40	38	35	25
.30	0	0	0	0	0	0	0	0	1	3	6	12	19	41	65	85	98	100	95	85	77	69	62	57	53	48	44	42	40	38	35	25
.40	0	0	0	0	0	0	0	0	1	2	5	9	16	36	59	80	94	99	96	87	79	70	63	58	53	49	45	42	40	38	35	26
.50	0	0	0	0	0	0	0	0	1	2	4	8	13	31	54	75	91	98	97	88	80	71	64	58	54	49	45	42	40	38	35	26
.75	0	0	0	0	0	0	0	0	0	0	1	2	4	13	28	49	69	85	95	95	87	76	67	61	56	51	47	44	40	39	36	26
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	29	49	69	84	95	92	81	71	63	58	53	49	45	41	39	36	27
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	20	35	63	84	92	83	72	64	58	54	49	43	40	37	28
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	25	50	79	90	81	71	63	58	53	45	41	38	29
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	18	46	79	88	80	70	63	57	49	42	38	31
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	17	50	79	87	79	70	62	52	45	39	32
IA/P = 0.50 * * * TC =1.5 HR * * * IA/P = 0.50																																
0.0	0	0	0	0	0	0	0	0	0	0	1	2	3	8	15	22	29	34	39	44	46	46	46	46	46	46	46	46	46	46	46	37
.10	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	17	24	30	35	41	46	46	46	46	46	46	46	46	46	46	46	37
.20	0	0	0	0	0	0	0	0	0	0	0	1	1	4	9	15	22	28	34	40	45	46	46	46	46	46	46	46	46	46	46	37
.30	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	20	27	33	39	44	46	46	46	46	46	46	46	46	46	46	38
.40	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	18	25	31	38	44	46	46	46	46	46	46	46	46	46	46	38
.50	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	17	23	30	37	43	46	46	46	46	46	46	46	46	46	46	38
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	12	19	25	33	40	45	46	46	46	46	46	46	46	46	46	38
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	15	25	33	42	46	46	46	46	46	46	46	46	46	39
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	14	23	34	43	46	46	46	46	46	46	46	46	40
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	11	22	35	43	46	46	46	46	46	46	46	42
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	23	36	43	46	46	46	46	46	46	43
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	14	27	38	44	46	46	46	46	46	44

RAINFALL TYPE = I * * * TC = 1.5 HR * * *

SHEET 9 OF 10

Exhibit 5-I, continued: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	9.0	9.3	9.6	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.3	12.6	13.0	13.5	14.0	14.5	15.0	15.5	16.0	17.0	18.0	20.0	24.0
IA/P = 0.10														* * * TC =2.0 HR * * *																		IA/P = 0.10
0.0	9	11	14	19	21	24	28	33	40	49	59	70	82	106	123	138	138	125	115	97	83	70	59	50	44	39	35	32	29	27	23	16
.10	8	10	13	17	18	20	23	26	31	37	45	54	65	89	110	125	135	130	123	106	90	75	62	53	46	40	36	33	29	27	24	16
.20	8	10	12	16	17	19	22	25	29	34	41	50	60	83	105	121	132	131	125	109	92	77	63	53	46	41	36	33	29	27	24	17
.30	7	9	11	14	15	17	18	21	23	27	32	38	46	66	89	109	123	131	129	117	100	82	66	56	48	42	38	34	30	28	24	17
.40	7	8	10	13	15	16	18	20	22	25	30	35	43	61	83	104	120	131	131	119	103	84	68	57	49	43	38	34	30	28	24	17
.50	6	8	10	13	14	15	17	19	21	24	28	33	39	56	78	99	116	127	130	121	106	86	69	58	50	44	39	35	30	28	24	17
.75	5	7	8	11	12	13	14	15	16	18	20	23	27	38	53	73	93	111	123	127	118	98	77	63	54	47	41	37	31	28	25	17
1.0	4	5	7	8	9	10	11	12	13	14	15	17	18	24	32	45	63	83	102	122	126	113	89	71	59	51	44	39	32	29	25	18
1.5	3	4	5	6	7	7	8	8	9	10	10	11	12	15	18	23	32	44	60	88	111	123	110	87	70	58	50	44	35	30	26	19
2.0	1	2	3	4	5	5	5	6	6	7	7	8	9	10	12	14	18	23	31	49	74	106	121	107	86	69	58	49	38	32	27	20
2.5	1	1	2	2	3	3	3	4	4	4	5	5	6	7	8	9	11	13	16	22	35	62	101	118	108	88	71	59	44	35	28	21
3.0	0	0	1	1	1	2	2	2	3	3	3	3	4	5	5	6	8	9	10	14	19	34	67	103	116	105	86	70	50	39	29	21
IA/P = 0.30														* * * TC =2.0 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	0	1	3	6	10	16	23	31	49	65	77	84	92	86	80	75	69	63	58	53	49	45	43	40	38	35	26
.10	0	0	0	0	0	0	0	1	2	5	9	13	19	35	53	68	79	85	90	83	77	71	64	59	55	50	46	43	40	39	35	26
.20	0	0	0	0	0	0	0	0	1	2	4	7	11	24	40	57	71	81	89	89	80	73	66	61	56	51	47	44	41	39	35	26
.30	0	0	0	0	0	0	0	0	1	1	3	6	9	20	36	53	68	78	84	88	81	74	67	61	56	52	48	44	41	39	36	26
.40	0	0	0	0	0	0	0	0	0	0	1	2	5	12	24	40	57	70	80	87	84	76	69	63	58	53	49	45	41	39	36	27
.50	0	0	0	0	0	0	0	0	0	0	1	2	4	10	21	36	53	67	77	87	85	77	69	63	58	54	49	46	41	39	36	27
.75	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	26	41	56	69	82	85	80	72	65	60	55	51	47	42	40	36	27
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	20	34	49	68	81	85	77	69	63	58	53	49	43	40	37	28
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	19	38	58	78	83	76	68	62	57	53	45	41	37	29
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	13	29	55	77	82	75	68	62	57	48	43	38	30
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	22	51	75	81	75	68	62	53	45	39	32
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	25	54	75	80	75	68	57	48	40	33
IA/P = 0.50														* * * TC =2.0 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	13	18	24	29	36	41	46	46	46	46	46	46	46	46	46	46	38
.10	0	0	0	0	0	0	0	0	0	0	0	1	1	3	7	12	17	22	28	35	40	45	46	46	46	46	46	46	46	46	46	38
.20	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	13	18	24	31	38	44	46	46	46	46	46	46	46	46	46	39
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	7	12	17	22	30	37	43	45	46	46	46	46	46	46	46	46	39
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	11	16	21	29	36	42	45	46	46	46	46	46	46	46	46	39
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	9	14	20	28	35	42	45	45	45	45	45	45	45	45	45	39
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	13	18	26	33	41	45	45	45	45	45	45	45	45	45	39
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	9	16	24	33	42	45	45	45	45	45	45	45	45	40
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	15	25	36	43	45	45	45	45	45	45	45	42
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	26	37	43	45	45	45	45	45	45	43
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	15	27	37	43	45	45	45	45	45	44
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	19	30	39	44	45	45	45	45	45

RAINFALL TYPE = I * * * TC = 2.0 HR * * * SHEET 10 OF 10

Exhibit 5-IA: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10														* * * TC =0.1 HR * * *																		IA/P = 0.10
0.0	28	36	50	143	154	163	140	103	87	76	68	67	65	61	54	49	45	44	44	41	40	39	36	33	32	32	31	30	30	29	26	21
.10	27	32	43	104	130	146	157	145	117	97	83	73	69	65	59	53	48	45	45	42	40	39	37	34	33	32	32	31	30	29	27	22
.20	26	29	37	59	89	116	136	150	147	127	107	91	79	68	63	57	52	47	45	44	41	39	37	35	33	32	32	31	30	29	27	22
.30	25	28	35	53	77	103	125	142	145	133	116	99	86	71	65	59	53	48	46	44	41	39	38	35	33	32	32	31	30	29	27	22
.40	24	26	31	41	49	68	91	114	132	141	136	122	107	82	70	63	57	52	48	45	43	40	38	36	33	32	32	31	30	29	27	22
.50	24	26	30	39	46	60	81	103	123	135	135	127	114	88	73	65	59	53	49	45	43	40	39	36	33	33	32	31	30	29	27	22
.75	20	24	27	32	35	39	47	60	76	94	111	122	125	114	94	79	68	61	55	48	45	42	39	37	35	33	32	32	30	30	27	22
1.0	16	20	24	27	28	30	32	36	41	49	62	77	94	118	122	104	86	74	65	55	49	44	41	39	36	34	33	32	31	30	28	23
1.5	12	15	18	22	23	24	25	27	28	30	32	36	42	61	86	107	112	104	91	73	60	50	44	41	38	36	34	33	31	30	28	23
2.0	7	10	12	15	16	18	19	20	21	22	24	25	26	30	36	50	69	90	106	103	87	67	52	45	41	39	36	34	32	31	29	24
2.5	4	6	8	11	12	13	14	15	16	17	18	19	21	23	26	30	36	49	66	91	101	89	66	51	44	41	38	36	33	31	29	25
3.0	2	3	5	7	8	9	10	11	11	12	13	14	16	18	20	23	25	29	36	55	79	98	86	65	51	44	41	38	34	32	30	25
IA/P = 0.30														* * * TC =0.1 HR * * *																		IA/P = 0.30
0.0	0	0	1	45	65	89	78	64	59	54	54	53	51	50	48	45	44	43	43	43	42	42	41	40	40	40	40	40	39	39	38	33
.10	0	0	0	18	36	55	78	78	69	62	57	55	53	51	50	47	44	44	43	43	42	42	41	40	40	40	40	40	39	39	38	34
.20	0	0	0	13	29	46	67	74	71	65	60	56	54	52	50	48	45	44	43	43	43	42	41	41	40	40	40	40	39	39	38	34
.30	0	0	0	10	22	38	58	69	70	67	62	58	56	52	51	48	46	44	44	43	43	42	41	41	40	40	40	40	39	39	38	34
.40	0	0	0	2	7	17	31	49	62	67	67	64	60	55	52	50	48	45	44	43	43	42	42	41	40	40	40	40	39	39	38	34
.50	0	0	0	1	5	13	25	41	55	63	66	64	61	56	53	51	48	46	44	43	43	42	42	41	40	40	40	40	39	39	38	34
.75	0	0	0	0	0	2	6	13	24	36	47	55	61	61	57	54	51	49	47	44	43	43	42	41	41	40	40	40	39	39	38	34
1.0	0	0	0	0	0	1	3	8	15	25	36	46	53	60	59	55	53	50	48	45	44	43	42	42	41	40	40	40	40	39	38	35
1.5	0	0	0	0	0	0	0	0	1	2	5	9	15	31	47	55	57	56	53	50	46	44	43	42	41	41	40	40	40	39	39	35
2.0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	15	28	42	51	55	54	51	47	44	43	42	41	41	40	40	39	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	14	26	38	50	54	52	47	44	43	42	41	40	40	39	39	36
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	29	43	53	51	47	44	43	42	41	40	40	39	37
IA/P = 0.50														* * * TC =0.1 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	12	14	18	21	23	26	30	32	33	37	38	41	42	46	48	53	49
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	9	12	15	19	22	25	29	32	32	35	39	41	42	45	48	53	49
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	11	14	18	22	24	28	32	32	35	39	41	42	45	48	53	49
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	8	12	15	20	23	27	31	31	34	39	40	41	45	48	53	49
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	13	18	22	25	30	31	33	37	39	41	44	47	53	49
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	10	15	20	24	29	31	32	36	39	41	44	47	53	53
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	16	21	26	30	31	34	38	40	43	46	53	53
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	11	17	23	28	31	32	35	39	42	45	53	53
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	17	23	28	31	32	35	40	43	49	52
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	17	23	28	31	32	38	42	48	52
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	18	24	28	31	36	40	47	52
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	11	18	24	28	33	39	45	52

RAINFALL TYPE = IA

* * * TC = 0.1 HR * * *

SHEET 1 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
	HYDROGRAPH TIME (HOURS)																															
IA/P = 0.10														* * * TC =0.2 HR * * *																		IA/P = 0.10
0.0	27	34	46	124	143	153	153	127	103	87	76	68	67	63	57	51	47	45	44	42	40	39	36	33	33	32	32	31	30	29	27	21
.10	27	33	44	108	131	146	151	135	113	96	83	73	69	65	59	53	48	45	45	42	40	39	37	33	33	32	32	31	30	29	27	22
.20	26	29	38	67	95	119	137	146	139	122	105	90	79	69	63	57	52	47	45	44	41	39	37	34	33	32	32	31	30	29	27	22
.30	25	27	33	45	60	83	107	127	140	139	128	112	97	76	68	62	56	50	47	45	42	40	38	35	33	33	32	31	30	29	27	22
.40	24	27	32	43	54	73	96	117	132	137	131	118	104	81	70	63	57	52	48	45	43	40	38	36	33	33	32	32	30	29	27	22
.50	23	25	29	37	41	50	65	86	106	124	132	131	123	98	79	69	62	56	51	46	44	41	39	37	34	33	32	32	30	29	27	22
.75	20	24	27	33	36	41	50	63	80	97	112	121	123	111	93	78	68	61	55	48	45	42	39	37	34	33	32	32	30	30	27	22
1.0	16	20	24	27	29	31	33	37	43	52	65	81	96	120	120	102	85	73	64	55	49	44	41	39	36	34	33	32	31	30	28	23
1.5	12	15	19	22	23	24	26	27	28	30	33	37	44	63	88	107	111	102	89	72	60	50	44	41	38	36	34	33	32	30	28	23
2.0	7	10	12	16	17	18	19	20	22	23	24	25	27	30	38	52	71	91	105	101	86	66	52	45	41	39	36	34	32	31	29	24
2.5	4	6	9	11	12	13	14	15	16	17	19	20	21	23	26	30	38	50	68	92	101	88	65	51	44	41	38	36	33	31	29	25
3.0	2	3	5	7	7	8	9	10	11	12	13	14	15	17	19	22	24	28	33	49	72	97	89	68	53	45	41	39	34	32	30	25
IA/P = 0.30														* * * TC =0.2 HR * * *																		IA/P = 0.30
0.0	0	0	0	26	45	64	76	74	65	59	55	53	52	51	49	46	44	44	43	43	42	42	41	40	40	40	40	40	39	39	38	33
.10	0	0	0	20	37	55	69	72	67	62	57	54	53	52	50	47	44	44	43	43	42	42	41	40	40	40	40	40	39	39	38	34
.20	0	0	0	5	15	30	47	61	68	68	64	59	56	53	52	49	46	44	44	43	43	42	42	41	40	40	40	40	39	39	38	34
.30	0	0	0	4	11	23	39	54	64	66	65	61	58	54	52	50	47	45	44	43	43	42	42	41	40	40	40	40	39	39	38	34
.40	0	0	0	3	8	18	32	47	58	64	64	62	59	55	52	50	48	45	44	43	43	42	42	41	40	40	40	40	40	39	38	34
.50	0	0	0	0	2	6	14	26	40	52	60	63	62	58	54	52	50	47	45	44	43	42	42	41	40	40	40	40	40	39	38	34
.75	0	0	0	0	1	3	7	14	24	35	45	53	57	59	56	54	51	49	47	44	43	43	42	41	41	40	40	40	40	39	38	34
1.0	0	0	0	0	0	0	1	4	8	15	25	35	44	56	58	56	54	51	49	46	44	43	42	42	41	40	40	40	40	39	39	35
1.5	0	0	0	0	0	0	0	0	0	1	2	5	9	23	38	50	55	56	54	51	47	44	43	42	42	41	40	40	40	39	39	35
2.0	0	0	0	0	0	0	0	0	0	0	0	1	1	6	15	27	40	49	54	54	51	47	44	43	42	41	41	40	40	40	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	14	25	36	49	53	51	47	44	43	42	41	41	40	40	39	36
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	28	42	52	51	47	44	43	42	41	40	40	39	37
IA/P = 0.50														* * * TC =0.2 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	13	16	19	23	25	29	32	33	36	39	41	42	46	48	50	49
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	10	14	17	21	24	28	31	32	35	40	41	42	45	48	50	49
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	11	15	19	23	26	31	31	34	39	40	41	45	48	50	49
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	12	17	21	25	30	31	33	37	39	41	44	47	50	50
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	9	15	19	23	28	31	32	35	39	41	44	47	50	50
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	6	12	17	22	27	31	32	34	39	40	43	46	50	50
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	14	20	25	30	31	33	37	39	42	46	50	50
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	16	22	27	31	32	35	38	42	45	49	50
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	17	23	28	31	32	35	40	43	49	50
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	17	23	28	31	32	38	42	48	50
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	16	22	27	30	35	40	46	50
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	17	23	27	33	38	45	50

RAINFALL TYPE = IA * * * TC = 0.2 HR * * * SHEET 2 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
	HYDROGRAPH TIME (HOURS)																															
IA/P = 0.10														* * * TC =0.3 HR * * *																		IA/P = 0.10
0.0	26	31	41	92	120	138	145	144	125	105	90	78	71	66	60	54	49	46	45	43	40	39	37	34	33	32	32	31	30	29	27	22
.10	26	30	39	80	106	128	139	142	131	113	98	85	76	68	62	56	51	47	45	43	41	39	37	34	33	32	32	31	30	29	27	22
.20	25	28	34	51	70	94	117	131	139	133	120	105	92	74	67	60	54	49	46	44	42	40	38	35	33	33	32	31	30	29	27	22
.30	24	26	31	40	47	62	84	106	123	133	133	124	112	87	73	65	59	53	49	45	43	40	39	36	33	33	32	32	30	29	27	22
.40	23	26	30	38	44	56	75	95	114	127	131	127	117	93	76	67	60	55	50	46	43	40	39	36	34	33	32	32	30	29	27	22
.50	21	25	28	34	37	42	51	67	86	104	119	127	127	110	88	74	66	59	53	47	45	41	39	37	34	33	32	32	30	30	27	22
.75	19	23	26	31	33	36	42	51	64	80	96	109	119	116	102	85	73	65	58	50	46	43	40	38	35	33	33	32	31	30	28	23
1.0	15	19	23	26	27	29	31	33	37	44	53	66	80	106	116	109	93	79	69	58	51	45	41	39	37	34	33	32	31	30	28	23
1.5	11	14	17	21	22	23	24	26	27	29	31	34	38	53	75	97	109	106	96	78	64	52	45	41	39	36	34	33	32	30	28	24
2.0	6	9	11	14	16	17	18	19	20	21	23	24	25	28	34	44	61	81	97	103	91	71	54	46	42	39	37	34	32	31	29	24
2.5	4	5	8	10	11	12	13	14	15	16	17	19	20	22	25	28	34	44	58	84	99	92	70	54	46	41	39	36	33	32	29	25
3.0	2	3	5	7	7	8	9	10	11	12	13	14	15	17	19	22	24	28	33	49	71	96	89	68	53	45	41	39	34	32	30	25
IA/P = 0.30														* * * TC =0.3 HR * * *																		IA/P = 0.30
0.0	0	0	0	13	28	45	63	69	69	65	60	55	53	53	51	48	45	44	43	43	42	42	42	40	40	40	40	40	39	39	38	34
.10	0	0	0	9	21	37	54	64	67	65	62	57	54	53	51	49	46	44	43	43	42	42	42	41	40	40	40	40	40	39	38	34
.20	0	0	0	7	17	30	46	58	64	65	63	59	56	53	52	49	46	44	44	43	42	42	42	41	40	40	40	40	40	39	38	34
.30	0	0	0	1	5	13	25	39	52	60	63	63	60	55	53	51	49	46	44	43	43	42	42	41	40	40	40	40	40	39	38	34
.40	0	0	0	1	4	10	20	33	45	55	61	62	61	56	54	52	49	46	45	43	43	42	42	41	40	40	40	40	40	39	38	34
.50	0	0	0	1	3	7	15	27	39	50	57	60	61	57	54	52	50	47	45	44	43	42	42	41	40	40	40	40	40	39	38	34
.75	0	0	0	0	1	3	8	15	24	34	43	51	55	58	56	54	52	49	47	44	43	43	42	41	41	40	40	40	40	39	38	34
1.0	0	0	0	0	0	0	0	2	4	9	16	25	34	49	56	57	55	53	50	47	44	43	42	42	41	40	40	40	40	39	39	35
1.5	0	0	0	0	0	0	0	0	0	1	3	5	10	23	37	49	54	55	54	51	47	44	43	42	42	41	40	40	40	39	39	35
2.0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	21	33	44	51	54	52	48	44	43	42	41	41	40	40	40	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	19	30	45	53	53	48	44	43	42	41	41	40	40	39	37
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	23	37	50	52	47	44	43	42	41	40	40	39	37
IA/P = 0.50														* * * TC =0.3 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	11	14	18	22	24	28	32	32	35	40	41	42	45	48	48	48
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	12	15	20	23	27	31	31	34	39	40	41	45	48	48	48
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	13	18	21	25	30	31	33	37	39	41	44	47	48	48
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	12	17	21	25	30	31	33	37	39	41	44	47	48	48
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	9	14	19	23	28	31	32	35	39	41	44	47	48	48
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	15	21	26	30	31	33	38	40	43	46	48	48
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	19	24	29	31	33	36	39	42	46	48	48
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	16	22	27	31	32	35	38	42	45	48	48
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	16	23	27	31	32	35	40	43	48	48
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	16	22	27	30	32	38	42	47	48
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	16	22	27	30	35	40	46	48
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	17	23	27	33	38	45	48
RAINFALL TYPE = IA														* * * TC = 0.3 HR * * *																		SHEET 3 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
	HYDROGRAPH TIME (HOURS)																															
IA/P = 0.10														* * * TC =0.4 HR * * *																		IA/P = 0.10
0.0	26	29	37	67	93	117	134	137	136	121	105	91	81	70	64	58	52	48	46	44	41	40	37	34	33	33	32	31	30	29	27	22
.10	25	29	36	60	82	105	124	133	135	126	112	98	87	73	66	59	53	49	46	44	41	40	38	34	33	33	32	31	30	29	27	22
.20	24	27	32	43	55	73	94	114	127	132	128	117	104	83	71	64	58	52	48	45	43	40	38	35	33	33	32	32	30	29	27	22
.30	24	26	31	41	50	65	85	104	119	128	128	121	110	88	74	66	59	54	49	46	43	40	39	35	34	33	32	32	30	29	27	22
.40	22	25	28	35	39	46	59	76	95	111	122	126	122	104	85	72	64	58	52	47	44	41	39	37	34	33	32	32	30	29	27	22
.50	20	23	26	31	34	37	43	54	69	86	103	116	123	117	98	82	71	63	56	49	46	42	40	38	34	33	33	32	30	30	27	22
.75	16	20	24	27	29	31	33	37	43	53	65	80	94	116	116	101	86	74	65	56	49	44	41	39	36	34	33	32	31	30	28	23
1.0	14	18	22	25	26	27	29	31	34	38	45	54	67	93	111	113	101	87	75	62	53	47	42	40	37	34	33	33	31	30	28	23
1.5	10	13	16	20	21	22	23	24	26	27	29	31	34	45	64	86	102	107	101	84	69	55	46	42	39	37	34	33	32	30	28	24
2.0	6	8	11	13	14	16	17	18	19	20	21	23	24	27	31	39	52	71	88	102	96	76	57	47	42	40	37	35	33	31	29	24
2.5	3	5	7	9	10	11	12	13	14	15	16	17	18	21	23	26	31	38	51	75	94	98	74	57	47	42	39	37	33	32	30	25
3.0	1	2	4	6	7	7	8	9	10	11	12	13	14	16	18	20	23	26	30	43	64	89	95	72	56	47	42	39	34	33	30	25
IA/P = 0.30														* * * TC =0.4 HR * * *																		IA/P = 0.30
0.0	0	0	0	6	15	29	46	60	65	65	63	59	56	53	52	49	47	44	44	43	42	42	42	41	40	40	40	40	40	39	38	34
.10	0	0	0	4	12	23	38	53	61	63	63	60	57	54	53	50	47	45	44	43	42	42	42	41	40	40	40	40	40	39	38	34
.20	0	0	0	3	9	19	32	46	56	61	62	61	59	55	53	51	48	45	44	43	43	42	42	41	40	40	40	40	40	39	38	34
.30	0	0	0	2	7	15	26	39	50	57	61	61	59	56	53	51	49	46	44	44	43	42	42	41	40	40	40	40	40	39	38	34
.40	0	0	0	0	2	5	11	21	33	44	53	58	60	58	55	53	51	48	45	44	43	42	42	41	40	40	40	40	40	39	38	34
.50	0	0	0	0	1	4	9	17	28	39	48	55	59	59	56	53	51	49	46	44	43	42	42	41	40	40	40	40	40	39	38	34
.75	0	0	0	0	0	2	4	9	16	25	34	43	49	57	57	55	53	50	48	45	44	43	42	41	41	40	40	40	40	39	39	35
1.0	0	0	0	0	0	0	1	2	5	10	17	25	34	48	55	56	55	53	50	47	45	43	42	42	41	40	40	40	40	39	39	35
1.5	0	0	0	0	0	0	0	0	0	0	1	3	6	16	30	43	51	55	55	52	49	45	43	42	42	41	40	40	40	40	39	36
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	15	27	39	47	53	53	49	45	43	42	42	41	40	40	40	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	7	14	25	40	50	52	49	45	43	42	41	41	40	40	39	37
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	18	32	47	52	48	45	43	42	41	40	40	39	37
IA/P = 0.50														* * * TC =0.4 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	13	16	20	23	27	31	32	34	39	40	42	45	47	47	47
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	10	13	18	22	26	30	31	33	38	39	41	45	47	47	47
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	16	20	24	29	31	33	36	39	41	44	47	47	47
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	13	18	23	28	31	32	35	39	41	43	47	47	47
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	16	21	26	30	32	34	38	40	43	46	47	47
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	13	19	25	29	31	33	37	39	42	46	47	47
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	17	23	28	31	32	35	39	42	45	47	47
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12	20	25	29	31	33	37	41	44	47	47
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	20	26	30	31	34	40	43	47	47
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	14	21	26	30	32	37	41	47	47
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	15	21	26	30	34	40	46	47
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	15	22	27	32	38	45	47

RAINFALL TYPE = IA * * * TC = 0.4 HR * * * SHEET 4 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10 * * * TC =0.5 HR * * *																																
0.0	25	28	34	53	72	94	115	129	130	129	117	104	92	76	68	61	55	50	47	44	42	40	38	34	33	33	32	31	30	29	27	22
.10	24	27	33	49	64	84	105	121	127	128	121	109	98	80	70	63	57	51	48	45	42	40	38	34	33	33	32	32	30	29	27	22
.20	23	26	30	39	46	58	75	95	112	122	126	123	114	93	78	69	61	55	50	46	44	41	39	36	34	33	32	32	30	29	27	22
.30	21	24	27	34	37	43	53	68	86	103	116	123	123	108	89	76	67	60	54	48	45	42	39	37	34	33	33	32	30	30	27	22
.40	20	24	27	32	35	40	49	61	78	95	109	118	121	111	93	79	69	62	55	49	45	42	40	37	34	33	33	32	30	30	27	22
.50	18	22	25	29	31	34	38	45	56	70	87	101	113	118	106	89	77	67	60	52	47	43	40	38	35	33	33	32	31	30	28	23
.75	15	19	23	26	27	29	31	34	38	45	54	67	80	104	112	106	93	80	70	59	51	46	41	39	36	34	33	33	31	30	28	23
1.0	13	16	20	24	25	26	27	29	31	34	39	46	56	80	102	110	105	93	81	66	56	48	43	40	38	35	33	33	31	30	28	23
1.5	9	12	15	18	20	21	22	23	24	26	27	29	31	39	55	75	94	104	103	89	74	58	48	43	40	37	35	33	32	31	29	24
2.0	5	7	10	12	13	14	15	17	18	19	20	21	23	25	29	35	45	62	79	100	100	81	61	49	43	40	38	35	33	31	29	25
2.5	3	4	6	8	9	10	11	12	13	14	15	16	17	20	22	25	28	34	45	67	88	96	79	60	49	43	40	37	33	32	30	25
3.0	1	2	3	5	6	7	7	8	9	10	11	12	13	15	17	19	21	24	28	38	56	83	93	77	59	48	43	40	35	33	30	26
IA/P = 0.30 * * * TC =0.5 HR * * *																																
0.0	0	0	0	2	8	18	31	46	57	61	61	61	58	54	53	51	48	45	44	44	43	42	42	41	40	40	40	40	40	39	38	34
.10	0	0	0	2	6	14	25	39	51	58	60	61	59	55	53	51	49	46	44	44	43	42	42	41	40	40	40	40	40	39	38	34
.20	0	0	0	0	1	4	11	21	33	45	54	58	60	58	55	53	51	48	46	44	43	42	42	41	40	40	40	40	40	39	38	34
.30	0	0	0	0	1	3	8	16	27	39	49	55	59	59	55	53	51	49	46	44	43	42	42	41	40	40	40	40	40	39	39	34
.40	0	0	0	0	1	2	6	13	23	34	44	51	56	58	56	54	52	49	47	44	43	42	42	41	40	40	40	40	40	39	39	34
.50	0	0	0	0	0	0	2	5	10	18	29	39	47	56	57	55	53	51	49	45	44	43	42	41	41	40	40	40	40	39	39	35
.75	0	0	0	0	0	0	1	2	5	10	17	25	34	48	54	56	55	53	50	47	45	43	42	42	41	40	40	40	40	39	39	35
1.0	0	0	0	0	0	0	0	0	0	1	3	6	11	26	41	51	55	55	54	50	47	44	43	42	41	41	40	40	40	40	39	35
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	23	36	47	52	54	52	48	44	43	42	41	40	40	40	40	39	36
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	16	27	38	49	53	51	47	44	42	42	41	40	40	40	39	36
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	15	30	43	52	50	46	44	42	42	41	40	40	39	37
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	23	40	51	50	46	44	42	42	40	40	39	37
IA/P = 0.50 * * * TC =0.5 HR * * *																																
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	14	19	22	26	30	31	34	38	40	41	45	46	46	46
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	8	12	17	21	25	29	31	33	37	39	41	44	46	46	46
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	9	14	19	23	28	31	32	35	39	41	43	46	46	46
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	17	22	27	31	32	34	38	40	43	46	46	46
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	16	21	26	30	32	34	38	40	43	46	46	46
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	13	19	25	29	31	33	37	39	42	46	46	46
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	17	23	28	31	32	35	39	42	45	46	46
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	18	24	29	31	33	36	41	44	46	46	46
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	19	24	29	31	33	39	42	46	46	46
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	19	25	29	31	37	41	46	46	46
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	13	20	25	29	34	39	45	46	46
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	14	20	26	32	37	44	46	46	46

RAINFALL TYPE = IA

* * * TC = 0.5 HR * * *

SHEET 5 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR) — HYDROGRAPH TIME (HOURS)

IA/P = 0.10 — * * * TC =0.75 HR * * * — IA/P = 0.10

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
0.0	22	25	29	38	45	56	71	87	103	114	117	117	111	95	81	72	65	58	53	48	45	41	39	36	33	33	33	32	30	29	27	22
.10	21	25	28	36	42	51	64	79	95	108	114	116	113	99	85	74	66	60	54	48	45	42	39	37	34	33	33	32	30	30	27	22
.20	19	23	26	32	35	39	47	58	72	87	101	110	114	109	95	82	72	65	58	51	47	43	40	38	34	33	33	32	31	30	27	23
.30	19	22	26	31	33	37	44	54	66	80	94	104	112	110	98	85	75	67	60	52	47	43	40	38	34	33	33	32	31	30	28	23
.40	17	21	24	28	30	32	36	41	49	61	74	87	99	111	106	94	82	73	65	56	49	45	41	39	35	33	33	33	31	30	28	23
.50	16	20	23	27	29	31	34	39	46	56	68	81	93	109	107	97	85	75	67	57	50	45	41	39	36	33	33	33	31	30	28	23
.75	15	18	22	25	27	28	31	34	38	45	54	64	75	95	104	102	93	83	74	62	54	47	42	40	37	34	33	33	31	30	28	23
1.0	12	15	18	22	23	24	25	27	29	31	34	39	46	65	85	100	103	98	88	74	62	52	45	41	39	35	33	33	32	30	28	23
1.5	7	10	12	15	17	18	19	20	21	22	24	25	26	31	39	53	71	87	99	99	85	68	53	46	41	39	36	34	33	31	29	24
2.0	4	6	8	11	12	13	14	15	16	17	18	19	21	23	26	31	39	51	67	88	95	86	67	53	45	41	38	36	33	32	29	25
2.5	2	3	5	7	8	9	10	11	11	12	13	14	16	18	20	23	26	30	38	56	77	93	84	66	52	45	41	38	34	33	30	25
3.0	0	1	2	4	4	5	6	6	7	8	8	9	10	12	14	16	18	21	24	30	42	67	90	84	68	54	46	42	36	33	30	26

IA/P = 0.30 — * * * TC =0.75 HR * * * — IA/P = 0.30

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
0.0	0	0	0	0	2	4	10	19	29	39	48	53	56	56	54	53	51	49	46	44	44	42	42	40	40	40	40	40	40	39	39	34
.10	0	0	0	0	1	3	8	15	24	34	43	50	54	56	54	53	52	49	47	45	44	42	42	41	40	40	40	40	40	39	39	34
.20	0	0	0	0	0	1	2	6	12	20	30	39	46	54	55	54	53	51	49	46	44	43	42	41	40	40	40	40	40	39	39	35
.30	0	0	0	0	0	1	2	5	10	17	25	34	42	52	55	54	53	51	49	46	44	43	42	42	40	40	40	40	40	39	39	35
.40	0	0	0	0	0	0	1	4	8	14	21	30	38	50	55	55	53	52	50	47	45	43	42	42	40	40	40	40	40	39	39	35
.50	0	0	0	0	0	0	1	3	6	11	18	26	34	47	53	54	54	52	50	47	45	43	42	42	40	40	40	40	40	39	39	35
.75	0	0	0	0	0	0	0	1	3	6	10	16	23	37	47	52	53	53	52	49	46	44	42	42	41	40	40	40	40	40	39	35
1.0	0	0	0	0	0	0	0	0	0	1	2	4	7	17	30	42	50	53	53	51	49	45	43	42	41	40	40	40	40	40	39	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	21	33	43	49	52	51	48	45	43	42	41	40	40	40	40	39	36
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	20	30	43	50	51	48	45	43	42	41	40	40	40	39	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	10	23	36	48	51	47	44	43	42	41	40	40	39	37
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	17	34	48	50	47	44	43	42	40	40	39	38

IA/P = 0.50 — * * * TC =0.75 HR * * * — IA/P = 0.50

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	10	15	19	23	28	31	32	36	39	41	44	44	44	44
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	7	12	17	22	27	30	32	34	38	40	43	44	44	44
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	15	20	25	30	31	33	37	39	43	44	44	44
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	12	18	24	29	31	33	36	39	42	44	44	44
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	10	16	22	27	30	32	35	38	42	44	44	44
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	14	21	26	30	31	34	38	41	44	44	44
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	19	24	29	31	33	36	41	44	44	44
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	16	22	27	30	32	35	40	43	44	44
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	16	23	27	30	32	38	42	44	44
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	17	23	28	30	36	40	44	44
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	18	23	28	33	39	44	44
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	17	23	30	36	43	44

RAINFALL TYPE = IA — * * * TC = 0.75 HR * * * — SHEET 6 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10														* * * TC =1.0 HR * * *																		IA/P = 0.10
0.0	19	23	26	33	37	43	52	63	76	88	97	104	108	102	91	81	72	65	59	52	48	43	40	38	34	33	33	32	31	30	28	23
.10	19	22	26	32	35	41	48	58	70	82	92	100	105	103	94	83	75	67	61	53	48	44	40	38	35	33	33	32	31	30	28	23
.20	17	21	24	28	30	34	38	45	54	65	76	87	96	104	100	91	81	73	66	57	51	45	41	39	36	33	33	33	31	30	28	23
.30	16	20	23	27	29	32	36	42	50	60	71	81	91	103	101	93	84	75	67	58	52	46	42	39	36	34	33	33	31	30	28	23
.40	15	18	22	25	27	29	31	35	40	46	55	65	76	94	102	99	91	81	73	63	55	48	43	40	37	34	33	33	31	30	28	23
.50	14	18	21	25	26	28	30	33	37	43	51	61	71	90	101	101	93	84	75	64	56	49	43	40	37	34	33	33	31	30	28	23
.75	13	16	19	23	24	25	27	29	32	37	42	49	58	76	91	98	96	89	81	70	60	51	45	41	38	35	34	33	32	30	28	23
1.0	10	13	16	19	20	22	23	24	26	27	30	33	37	50	67	83	94	97	93	81	70	58	48	43	40	37	34	33	32	31	29	24
1.5	6	8	10	13	14	15	16	18	19	20	21	22	24	27	33	42	56	71	84	93	89	75	59	49	44	40	37	35	33	31	29	24
2.0	3	5	7	9	10	11	12	13	14	15	16	17	18	21	23	27	32	41	53	74	88	91	74	59	49	43	40	37	34	32	30	25
2.5	1	2	4	6	7	7	8	9	10	11	11	12	13	16	18	20	23	26	32	45	64	84	89	72	58	48	43	40	34	33	30	26
3.0	0	1	2	3	3	4	4	5	6	6	7	8	9	10	12	14	16	18	21	26	35	55	81	87	73	59	50	44	37	34	31	26
IA/P = 0.30														* * * TC =1.0 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	1	2	5	10	16	23	31	38	44	51	53	52	52	50	48	46	44	43	42	41	40	40	40	40	40	40	39	35
.10	0	0	0	0	0	1	2	4	8	13	20	27	35	46	51	53	52	51	50	47	45	44	42	42	40	40	40	40	40	40	39	35
.20	0	0	0	0	0	0	1	3	6	11	17	24	31	43	50	52	52	51	50	47	45	44	42	42	40	40	40	40	40	40	39	35
.30	0	0	0	0	0	0	1	2	5	9	14	21	28	40	48	52	52	52	50	48	46	44	43	42	40	40	40	40	40	40	39	35
.40	0	0	0	0	0	0	0	1	2	4	7	12	18	31	42	49	52	52	51	49	47	45	43	42	41	40	40	40	40	40	39	35
.50	0	0	0	0	0	0	0	1	1	3	6	10	15	28	39	47	51	52	51	49	47	45	43	42	41	40	40	40	40	40	39	35
.75	0	0	0	0	0	0	0	0	1	1	3	6	9	19	31	41	47	50	51	50	48	46	43	42	41	40	40	40	40	40	39	36
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	25	36	44	49	51	50	47	45	43	42	41	40	40	40	40	39	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	23	33	44	49	50	47	44	43	42	41	40	40	40	39	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	25	38	48	50	47	44	43	42	41	40	40	39	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	19	36	48	49	47	44	43	42	40	40	39	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	18	37	47	49	46	44	43	41	40	40	38
IA/P = 0.50														* * * TC =1.0 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	7	11	16	21	26	30	32	34	38	40	43	43	43	43
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	14	19	25	29	31	33	37	39	42	43	43	43
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	17	23	28	30	32	36	39	42	43	43	43
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	15	21	27	30	32	35	38	41	43	43	43
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	20	25	29	31	34	37	41	43	43	43
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	18	24	28	31	33	36	41	43	43	43
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	16	22	27	30	32	35	40	43	43	43
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	20	25	29	31	34	39	42	43	43
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	14	20	25	29	31	37	41	43	43
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	14	20	26	29	34	39	43	43
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	15	21	26	32	37	43	43
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	14	20	29	34	42	43

RAINFALL TYPE = IA * * * TC = 1.0 HR * * * SHEET 7 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10														* * * TC =1.25 HR * * *																		IA/P = 0.10
0.0	17	21	24	29	33	37	43	52	61	71	81	89	95	100	94	86	78	71	64	57	51	46	42	39	35	34	33	33	31	30	28	23
.10	16	19	23	27	29	31	35	41	48	57	66	76	85	96	99	92	84	76	69	60	54	47	43	40	36	34	34	33	31	30	28	23
.20	15	19	22	26	28	30	33	38	45	53	62	71	80	93	97	93	86	78	71	62	55	48	43	40	37	34	34	33	31	30	28	23
.30	14	17	20	24	25	27	29	32	36	42	49	58	67	84	95	96	91	84	76	66	58	50	44	41	38	35	34	33	31	30	28	23
.40	13	16	20	23	25	26	28	31	34	39	46	54	62	80	92	96	93	86	78	68	59	51	45	41	38	35	34	33	31	30	28	23
.50	12	15	18	21	23	24	25	27	29	33	37	43	50	67	83	93	95	91	84	73	63	54	46	42	39	36	34	33	32	30	28	23
.75	10	13	16	20	21	22	23	25	27	29	32	36	42	55	71	84	93	93	88	78	68	57	49	43	40	37	34	34	32	31	28	24
1.0	8	10	13	16	17	19	20	21	22	23	25	27	29	37	49	63	78	88	92	88	78	65	53	46	42	39	36	34	33	31	29	24
1.5	5	7	9	12	13	14	15	16	17	18	19	20	22	25	29	36	47	60	73	87	89	79	64	53	46	42	38	36	33	32	29	25
2.0	2	4	6	8	9	10	10	11	12	13	14	15	16	19	21	24	29	36	45	64	80	87	77	63	52	46	41	38	34	32	30	25
2.5	1	2	3	4	5	6	6	7	8	8	9	10	11	13	15	17	19	22	26	35	49	72	85	78	65	53	46	42	36	33	30	26
3.0	0	1	1	2	3	3	4	4	5	5	6	7	7	9	11	12	14	17	19	23	31	47	73	84	76	63	53	46	38	34	31	26
IA/P = 0.30														* * * TC =1.25 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	1	3	6	10	15	22	28	34	43	48	51	51	51	49	47	45	44	43	42	40	40	40	40	40	40	39	35
.10	0	0	0	0	0	0	1	2	5	8	13	19	25	36	45	49	51	50	50	48	46	44	43	42	40	40	40	40	40	40	39	35
.20	0	0	0	0	0	0	1	2	4	7	11	16	22	34	43	48	50	50	50	48	46	44	43	42	41	40	40	40	40	40	39	35
.30	0	0	0	0	0	0	1	1	3	5	9	14	19	31	40	46	49	50	50	48	46	45	43	42	41	40	40	40	40	40	39	35
.40	0	0	0	0	0	0	0	1	2	4	8	12	17	28	38	45	49	50	50	49	47	45	43	42	41	40	40	40	40	40	39	35
.50	0	0	0	0	0	0	0	1	2	4	6	10	14	25	36	43	48	50	50	49	47	45	43	42	41	40	40	40	40	40	39	35
.75	0	0	0	0	0	0	0	0	0	1	2	3	6	13	23	33	41	46	49	50	48	46	44	43	42	40	40	40	40	40	39	36
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	14	23	32	40	46	49	49	47	45	43	42	41	40	40	40	40	39	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	21	30	41	47	49	47	45	43	42	41	40	40	40	39	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	23	35	45	48	47	45	43	42	41	40	40	40	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	18	33	45	48	46	44	43	42	40	40	40	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	17	34	45	48	46	44	43	41	40	40	38
IA/P = 0.50														* * * TC =1.25 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	9	14	19	24	28	31	33	37	39	42	42	42	42
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	11	17	23	27	30	32	36	38	42	42	42	42
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	15	21	26	29	32	35	38	41	42	42	42
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	19	25	29	31	34	37	41	42	42	42
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	17	23	28	30	33	36	40	42	42	42
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	15	22	26	30	32	35	40	42	42	42
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	7	13	20	25	29	31	34	39	42	42	42
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	17	23	27	30	33	38	42	42	42
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	11	18	23	28	30	36	40	42	42
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	12	18	24	28	33	39	42	42
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	13	19	24	31	37	42	42
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12	18	28	33	42	42

RAINFALL TYPE = IA * * * TC = 1.25 HR * * * SHEET 8 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	7.0	7.3	7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
IA/P = 0.10														* * * TC =1.5 HR * * *																		IA/P = 0.10
0.0	15	19	22	27	29	32	37	42	49	57	65	73	80	89	94	89	83	76	70	62	55	49	44	40	37	35	34	33	31	30	28	23
.10	14	17	20	24	26	28	31	35	40	46	53	61	69	82	90	92	87	81	74	65	58	51	45	41	38	35	34	33	31	30	28	23
.20	13	16	20	23	25	27	29	33	37	43	50	57	65	79	88	91	88	82	76	67	59	52	46	42	38	35	34	33	32	30	28	23
.30	12	15	18	22	23	24	26	28	31	35	41	47	54	69	81	89	90	86	81	71	63	54	47	43	39	36	34	34	32	30	28	24
.40	11	14	18	21	22	24	25	27	30	34	38	44	51	65	78	87	90	87	82	73	64	55	48	43	40	36	34	34	32	30	28	24
.50	10	13	16	19	20	22	23	24	26	29	32	36	41	54	69	81	88	89	86	77	68	58	50	44	41	37	35	34	32	31	29	24
.75	9	11	14	18	19	20	21	22	24	26	28	31	35	46	58	71	82	88	88	81	73	62	52	46	42	38	35	34	32	31	29	24
1.0	7	9	11	14	15	16	18	19	20	21	22	24	26	32	40	52	65	76	84	87	81	70	58	49	44	40	37	35	33	31	29	24
1.5	4	6	8	10	11	12	13	14	15	16	17	18	19	22	26	31	39	50	62	77	85	81	69	57	49	44	40	37	34	32	30	25
2.0	2	3	5	7	7	8	9	10	11	12	12	13	14	17	19	22	25	31	38	53	69	83	80	68	56	48	43	40	35	33	30	25
2.5	1	1	2	3	4	5	5	6	6	7	8	9	9	11	13	15	17	20	23	30	41	61	82	82	69	58	49	44	37	34	31	26
3.0	0	0	1	2	2	2	3	3	4	4	5	5	6	8	9	11	13	15	17	21	27	40	63	80	78	68	57	49	40	35	31	27
IA/P = 0.30														* * * TC =1.5 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	1	2	4	6	10	14	19	24	34	41	46	48	49	48	47	46	44	43	42	41	40	40	40	40	40	39	35
.10	0	0	0	0	0	0	1	1	3	5	8	12	17	27	36	42	46	48	49	48	46	45	43	42	41	40	40	40	40	40	39	36
.20	0	0	0	0	0	0	0	1	2	4	7	10	15	24	33	41	45	48	49	48	47	45	43	43	41	40	40	40	40	40	39	36
.30	0	0	0	0	0	0	0	1	2	3	6	9	13	22	31	39	44	47	48	48	47	45	44	43	41	40	40	40	40	40	39	36
.40	0	0	0	0	0	0	0	0	1	1	3	5	7	15	24	33	40	45	47	48	47	46	44	43	42	40	40	40	40	40	39	36
.50	0	0	0	0	0	0	0	0	0	1	2	4	6	13	22	31	38	44	47	48	48	46	44	43	42	40	40	40	40	40	39	36
.75	0	0	0	0	0	0	0	0	0	1	1	2	4	9	16	24	33	39	44	47	48	47	45	43	42	41	40	40	40	40	39	36
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	12	20	29	36	44	47	48	46	44	43	42	40	40	40	40	40	36
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	19	30	39	46	47	46	44	43	42	40	40	40	40	37
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	17	28	40	46	47	45	44	42	41	40	40	40	37
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	13	26	40	47	47	45	43	42	40	40	40	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	28	41	46	46	45	43	41	40	40	38
IA/P = 0.50														* * * TC =1.5 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	7	11	16	22	27	30	32	35	38	42	42	42	42
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	7	13	19	24	28	31	34	37	41	42	42	42
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	12	19	24	28	31	33	36	41	42	42	42
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	18	23	28	30	33	36	40	42	42	42
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	11	17	23	27	30	33	36	40	42	42	42
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	17	22	27	30	32	36	40	41	41	41
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	10	16	22	26	29	32	35	40	41	41	41
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	17	23	27	30	33	38	41	41	41
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	12	18	23	27	30	36	40	41	41
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	12	18	24	28	33	39	41	41
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	13	19	24	31	36	41	41
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	19	28	34	41	41

RAINFALL TYPE = IA

* * * TC = 1.5 HR * * *

SHEET 9 OF 10

Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	7.0	7.3/ 7.6	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	9.0	9.2	9.4	9.6	9.8	10.0	10.3	10.6	11.0	11.5	12.0	12.5	13.0	13.5	14.0	15.0	16.0	18.0	22.0
	HYDROGRAPH TIME (HOURS)																														
	IA/P = 0.10												* * * TC =2.0 HR * * *																		IA/P = 0.10
0.0	12	15	18	22	24	26	28	32	36	41	46	52	58	68	76	80	84	79	76	68	62	55	48	44	40	37	35	34	32	31	28	24
.10	11	13	16	20	21	23	25	27	30	34	38	43	49	60	70	77	83	83	78	72	65	57	50	45	41	38	36	34	32	31	29	24
.20	9	12	15	18	19	21	22	24	26	29	32	36	41	52	63	72	78	82	81	75	68	60	52	46	42	39	36	35	32	31	29	24
.30	9	12	14	18	19	20	21	23	25	28	31	34	39	49	60	70	77	81	81	76	70	61	53	47	43	39	36	35	33	31	29	24
.40	9	11	14	17	18	19	21	22	24	26	29	33	37	47	57	67	75	80	81	77	71	62	53	47	43	39	37	35	33	31	29	24
.50	7	10	12	15	17	18	19	20	21	23	25	28	31	39	49	60	69	76	81	79	74	65	56	49	44	40	37	35	33	31	29	24
.75	6	9	11	14	15	16	17	18	20	21	23	25	27	34	42	52	62	70	76	79	76	68	59	51	46	41	38	36	33	31	29	24
1.0	5	6	9	11	12	13	14	15	16	17	18	20	21	25	30	38	47	57	66	76	79	75	64	55	49	44	40	37	34	32	29	25
1.5	3	4	6	8	8	9	10	11	12	13	14	15	16	18	21	24	30	37	45	59	71	78	73	63	55	48	43	40	35	33	30	25
2.0	1	2	3	4	5	5	6	7	7	8	9	10	10	12	14	16	19	22	26	36	48	65	77	73	64	56	49	44	37	34	31	26
2.5	0	1	1	2	3	3	4	4	5	5	6	6	7	8	10	12	14	16	18	23	31	46	66	76	72	63	55	48	40	35	31	27
3.0	0	0	1	1	1	2	2	2	3	3	3	4	4	5	7	8	10	11	13	17	21	30	49	67	75	71	63	54	43	37	32	27
	IA/P = 0.30												* * * TC =2.0 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	0	1	2	3	5	7	10	13	20	27	34	39	42	44	47	45	45	44	43	42	40	40	40	40	40	39	36
.10	0	0	0	0	0	0	0	1	1	2	4	6	8	15	22	29	35	40	43	45	46	45	44	43	42	41	40	40	40	40	40	36
.20	0	0	0	0	0	0	0	0	1	1	2	3	5	10	17	24	31	36	41	44	46	45	44	43	42	41	40	40	40	40	40	36
.30	0	0	0	0	0	0	0	0	0	1	2	3	4	9	15	22	29	35	39	44	46	45	44	43	42	41	40	40	40	40	40	36
.40	0	0	0	0	0	0	0	0	0	1	1	2	4	8	14	20	27	33	38	43	46	46	44	43	42	41	40	40	40	40	40	36
.50	0	0	0	0	0	0	0	0	0	0	1	1	2	5	9	15	22	29	35	41	44	45	45	44	43	42	40	40	40	40	40	36
.75	0	0	0	0	0	0	0	0	0	0	0	1	1	3	6	11	17	24	30	38	42	45	45	44	43	42	41	40	40	40	40	37
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	9	14	21	30	38	43	45	44	44	43	41	40	40	40	40	37
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	16	25	36	43	45	44	43	42	41	40	40	40	38
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	6	12	24	36	43	45	44	43	42	40	40	40	38
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	25	37	43	45	44	43	41	40	40	38
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	26	37	43	44	44	42	40	40	39
	IA/P = 0.50												* * * TC =2.0 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	7	12	18	23	27	30	33	36	40	40	40	40
.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	10	16	21	26	29	32	35	40	40	40	40
.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	8	14	20	25	28	31	34	39	40	40	40
.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	12	18	23	27	30	33	38	40	40	40
.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	5	11	16	22	26	29	32	38	40	40	40
.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	9	15	20	25	28	31	37	40	40	40
.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	7	13	19	24	27	30	36	40	40	40
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	8	14	20	24	28	34	39	40	40
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	10	16	21	25	32	37	40	40
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	11	16	21	29	35	40	40
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	17	26	32	40	40
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	11	21	29	39	40
	RAINFALL TYPE = IA												* * * TC = 2.0 HR * * *																		SHEET 10 OF 10

Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 * * * TC =0.1 HR * * * IA/P = 0.10																																
0.0	24	34	53	334	647	1010	628	217	147	123	104	86	76	66	57	51	46	42	38	34	32	29	26	23	21	20	19	18	15	13	12	0
.10	21	29	43	134	267	520	847	701	378	224	157	122	98	75	64	56	50	45	41	36	33	30	27	24	21	20	19	18	16	13	12	0
.20	18	25	35	61	110	215	418	704	702	486	312	209	151	94	73	62	54	49	44	38	34	31	28	25	22	21	19	18	16	14	12	0
.30	17	23	33	56	92	174	337	582	662	545	389	269	190	109	79	65	56	50	45	39	35	32	29	25	22	21	20	18	16	14	12	0
.40	15	20	28	41	51	78	142	272	478	601	563	447	328	172	104	76	63	55	49	42	37	33	29	26	23	21	20	19	17	14	12	0
.50	14	19	26	39	47	68	117	220	392	531	553	482	380	209	121	84	67	57	51	43	38	33	30	27	23	21	20	19	17	14	12	0
.75	12	15	21	29	33	38	49	73	126	224	343	432	464	385	252	156	103	76	62	50	43	36	31	28	25	22	21	19	17	15	12	0
1.0	9	12	15	21	23	26	29	33	40	55	86	148	238	406	434	317	205	130	89	62	50	41	34	30	27	24	22	20	18	16	12	0
1.5	7	8	10	14	15	16	18	20	22	25	29	34	45	101	220	339	373	320	234	131	80	53	40	34	30	27	24	21	19	17	12	2
2.0	4	6	7	9	9	10	11	12	13	15	16	18	20	25	37	72	150	252	336	312	216	109	58	42	34	30	27	24	20	18	13	8
2.5	3	4	5	6	7	7	8	8	9	10	11	12	13	16	19	25	39	75	142	262	303	229	108	58	41	34	30	27	22	19	14	11
3.0	1	2	3	4	4	5	5	6	6	7	7	8	8	10	12	14	17	22	31	76	169	288	236	122	64	43	35	30	24	20	16	11
IA/P = 0.30 * * * TC =0.1 HR * * * IA/P = 0.30																																
0.0	0	0	0	154	568	936	524	217	172	149	126	107	97	86	76	69	63	58	53	48	46	42	38	34	31	30	28	27	24	20	19	0
.10	0	0	0	19	109	415	762	603	346	230	176	143	119	96	84	74	68	62	57	50	47	44	40	35	32	30	29	27	24	21	19	0
.20	0	0	0	0	13	77	302	609	605	432	297	217	167	115	94	81	73	66	60	53	48	45	41	37	33	31	29	28	25	21	19	0
.30	0	0	0	0	9	54	219	479	563	476	357	263	199	129	99	85	75	68	62	54	49	45	41	37	33	31	29	28	25	21	19	0
.40	0	0	0	0	0	6	38	159	372	500	484	399	309	183	123	96	82	73	66	58	51	46	42	38	34	31	30	28	25	22	19	0
.50	0	0	0	0	0	4	27	115	287	429	465	421	346	213	138	103	86	76	68	59	52	47	43	39	34	32	30	29	25	22	19	0
.75	0	0	0	0	0	0	1	10	46	132	246	338	381	341	243	165	119	94	80	67	58	50	45	41	37	33	31	29	26	23	19	0
1.0	0	0	0	0	0	0	0	1	4	22	69	149	241	357	331	246	170	122	96	76	64	54	47	42	38	34	32	30	27	24	19	0
1.5	0	0	0	0	0	0	0	0	0	0	0	1	4	41	142	258	310	285	224	142	97	71	55	47	43	39	35	32	29	25	20	4
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	49	130	221	279	255	182	108	70	55	47	42	38	34	30	27	20	11
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	52	119	224	256	193	107	70	55	47	42	38	32	28	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	52	141	240	199	117	74	56	48	43	35	30	24	18
IA/P = 0.50 * * * TC =0.1 HR * * * IA/P = 0.50																																
0.0	0	0	0	0	70	539	377	196	171	154	134	117	108	99	89	83	77	72	67	61	59	56	51	46	43	42	40	38	34	30	28	0
.10	0	0	0	0	47	375	376	256	199	169	146	126	114	102	92	85	79	73	68	62	59	56	52	47	43	42	40	38	34	30	28	0
.20	0	0	0	0	0	31	260	338	283	227	189	160	138	112	99	90	83	77	72	64	60	57	53	48	44	42	41	39	35	30	28	0
.30	0	0	0	0	0	0	21	180	285	284	246	208	176	131	110	97	88	82	76	68	62	59	54	50	45	43	41	39	36	31	28	0
.40	0	0	0	0	0	0	14	125	232	266	253	223	192	142	115	100	91	83	77	69	63	59	55	50	45	43	41	40	36	31	28	0
.50	0	0	0	0	0	0	9	86	183	239	248	231	205	154	122	104	93	85	79	71	64	59	55	51	46	43	41	40	36	32	28	0
.75	0	0	0	0	0	0	3	31	87	147	190	211	213	184	147	121	103	92	84	75	67	61	57	52	47	44	42	40	37	32	28	0
1.0	0	0	0	0	0	0	0	0	1	13	45	92	141	205	197	165	134	112	98	84	75	65	59	55	50	46	43	41	38	34	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	2	9	51	118	170	183	167	143	111	92	77	65	59	54	50	45	43	39	35	28	2
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15	51	103	148	168	156	127	96	76	65	58	54	49	45	41	37	29	12
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	31	69	131	159	140	101	78	66	59	54	50	43	39	31	24
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	46	101	151	134	99	77	65	59	54	45	41	33	26

RAINFALL TYPE = II * * * TC = 0.1 HR * * *

SHEET 1 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL TIME (HR) — HYDROGRAPH TIME (HOURS)

	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =0.2 HR * * *																		IA/P = 0.10
0.0	23	31	47	209	403	739	800	481	250	166	128	102	86	70	61	54	49	44	40	35	33	30	27	24	21	20	19	18	16	13	12	0
.10	19	26	39	86	168	325	601	733	565	355	229	161	122	83	69	59	53	47	43	37	34	31	28	25	22	21	19	18	16	14	12	0
.20	17	23	32	49	74	136	262	488	652	594	435	298	207	115	81	67	58	51	46	40	35	32	29	26	23	21	20	19	16	14	12	0
.30	16	22	30	46	64	112	212	396	566	585	485	360	258	139	90	71	60	53	48	41	36	32	29	26	23	21	20	19	16	14	12	0
.40	14	19	25	37	43	57	94	173	322	485	551	507	409	227	129	87	68	58	52	44	38	33	30	27	24	21	20	19	17	14	12	0
.50	13	18	24	35	40	52	80	142	262	410	504	506	441	269	153	98	73	61	53	45	39	34	30	27	24	22	20	19	17	15	12	0
.75	10	13	17	23	26	30	34	40	55	86	150	247	349	438	360	240	151	101	75	57	47	39	33	29	26	23	21	20	18	15	12	0
1.0	9	11	14	19	21	24	26	30	35	44	62	101	167	337	413	353	245	157	104	68	53	42	35	31	28	24	22	20	18	16	12	0
1.5	6	8	10	13	14	15	17	19	21	23	26	30	37	73	166	288	356	337	264	154	91	57	42	35	30	27	24	22	19	17	13	3
2.0	4	5	7	8	9	10	10	11	12	14	15	16	18	23	31	55	114	206	291	324	239	125	63	44	35	31	28	24	20	18	14	9
2.5	3	4	5	6	6	7	7	8	9	9	10	11	12	15	18	22	32	58	111	227	298	246	122	63	43	35	31	27	22	19	15	11
3.0	1	2	3	4	4	4	5	5	6	6	7	7	8	9	11	13	16	19	27	59	138	280	248	137	70	46	36	31	25	21	16	11
IA/P = 0.30														* * * TC =0.2 HR * * *																		IA/P = 0.30
0.0	0	0	0	39	180	545	697	497	276	198	158	130	110	93	81	73	67	61	56	49	46	43	39	35	32	30	29	27	24	21	19	0
.10	0	0	0	2	27	129	407	600	532	361	252	190	150	108	90	79	71	65	59	52	48	44	41	36	32	31	29	28	25	21	19	0
.20	0	0	0	2	19	92	302	501	521	415	306	228	176	119	95	82	73	67	61	53	48	45	41	37	33	31	29	28	25	21	19	0
.30	0	0	0	0	1	13	66	223	408	484	438	350	269	163	114	93	80	72	65	57	51	46	42	38	34	31	30	28	25	22	19	0
.40	0	0	0	0	1	9	47	164	327	431	436	379	306	189	127	98	83	74	67	58	52	47	43	38	34	31	30	28	25	22	19	0
.50	0	0	0	0	0	0	6	33	120	258	374	415	391	271	173	121	95	81	72	62	55	48	44	40	35	32	30	29	26	22	19	0
.75	0	0	0	0	0	0	2	13	50	126	221	302	348	323	240	167	121	96	81	68	59	50	45	41	37	33	31	29	26	23	19	0
1.0	0	0	0	0	0	0	0	0	1	6	24	69	139	285	331	280	204	145	109	82	68	56	48	43	39	35	32	30	27	24	19	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	16	79	186	271	288	247	165	110	76	58	49	44	40	35	32	29	26	20	5
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	24	80	163	235	262	202	123	76	58	49	43	39	35	30	27	21	13
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	28	77	179	242	207	120	75	57	48	43	39	32	29	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	30	101	207	227	130	80	59	49	44	35	30	24	18
IA/P = 0.50														* * * TC =0.2 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	7	98	371	322	221	182	158	137	120	104	94	86	80	74	69	62	60	57	52	47	44	42	40	39	35	30	28	0
.10	0	0	0	0	4	67	270	305	249	204	174	149	130	108	97	88	82	76	71	64	60	57	53	48	44	42	41	39	35	30	28	0
.20	0	0	0	0	0	3	45	195	268	255	221	189	163	125	106	95	87	80	75	67	62	58	54	49	45	43	41	39	35	31	28	0
.30	0	0	0	0	0	2	31	140	226	245	229	203	176	134	111	98	89	82	76	68	62	59	55	50	45	43	41	39	36	31	28	0
.40	0	0	0	0	0	1	21	101	184	225	228	211	188	144	117	101	91	84	78	69	63	59	55	50	45	43	41	40	36	31	28	0
.50	0	0	0	0	0	0	1	14	72	146	199	218	213	175	137	113	99	89	82	73	66	60	56	52	47	43	42	40	36	32	28	0
.75	0	0	0	0	0	0	0	5	28	71	121	162	186	193	161	133	112	98	88	78	70	62	57	53	48	44	42	41	37	33	28	0
1.0	0	0	0	0	0	0	0	0	0	2	13	38	77	154	186	174	147	122	105	89	78	68	60	56	51	46	43	42	38	34	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	2	22	71	129	163	168	150	120	98	80	67	60	55	51	46	43	40	36	28	4
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25	65	112	146	157	134	103	79	67	60	55	50	46	41	38	29	14
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	26	60	117	148	136	101	79	66	59	54	50	43	39	31	24
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	40	90	142	130	99	78	66	59	54	45	41	33	26

RAINFALL TYPE = II — * * * TC = 0.2 HR * * *

SHEET 2 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 * * * TC =0.3 HR * * * IA/P = 0.10																																
0.0	20	28	41	118	235	447	676	676	459	283	196	146	114	80	66	57	51	46	42	37	33	31	28	24	22	20	19	18	16	13	12	0
.10	19	26	39	99	189	361	571	641	520	362	251	181	136	89	70	60	53	48	43	37	34	31	28	25	22	21	19	18	16	14	12	0
.20	17	23	32	53	83	154	292	478	587	542	422	308	223	127	86	68	58	52	46	40	35	32	29	26	23	21	20	19	16	14	12	0
.30	16	22	30	49	72	127	237	398	524	536	460	359	268	151	97	73	61	53	48	41	36	32	29	26	23	21	20	19	16	14	12	0
.40	14	19	25	37	45	63	105	193	330	459	510	477	398	237	139	92	70	59	52	44	38	34	30	27	24	21	20	19	17	14	12	0
.50	13	18	24	35	42	56	89	158	272	397	472	475	424	274	163	104	76	62	54	46	39	34	30	27	24	22	20	19	17	15	12	0
.75	11	14	19	26	30	34	42	59	95	160	250	339	417	398	299	196	128	89	69	54	45	37	32	29	26	23	21	20	17	15	12	0
1.0	9	11	14	19	21	24	27	30	36	46	68	109	174	328	396	346	248	163	109	70	54	43	35	31	28	24	22	20	13	16	12	0
1.5	6	8	10	13	14	15	17	19	21	23	26	31	38	77	169	282	347	330	264	158	94	58	42	35	31	27	24	22	19	17	13	3
2.0	4	5	7	8	9	10	10	11	12	14	15	16	18	23	32	57	116	205	285	317	239	128	64	44	36	31	28	25	20	18	14	9
2.5	2	4	5	6	6	7	7	8	9	9	10	11	12	15	18	23	33	60	113	223	293	245	125	65	44	35	31	27	22	19	15	11
3.0	1	2	3	4	4	4	5	5	6	6	7	7	8	9	11	13	16	20	27	61	138	275	246	139	72	46	36	31	25	21	16	11
IA/P = 0.30 * * * TC =0.3 HR * * * IA/P = 0.30																																
0.0	0	0	0	11	64	251	525	574	454	303	221	173	140	104	88	77	70	64	58	51	47	44	40	36	32	31	29	28	24	21	19	0
.10	0	0	0	0	7	45	183	411	520	476	360	268	205	133	101	85	76	69	62	55	49	45	41	37	33	31	30	28	25	21	19	0
.20	0	0	0	0	5	32	132	318	452	468	396	310	240	151	109	90	78	70	64	56	50	46	42	38	33	31	30	28	25	22	19	0
.30	0	0	0	0	0	3	22	96	244	383	440	411	344	217	142	105	87	76	69	60	53	47	43	39	35	32	30	29	26	22	19	0
.40	0	0	0	0	0	2	16	69	186	317	399	407	365	246	160	115	92	79	71	61	54	48	43	39	35	32	30	29	26	22	19	0
.50	0	0	0	0	0	0	2	11	50	140	258	352	389	327	223	149	110	89	77	66	57	50	45	41	36	33	31	29	26	23	19	0
.75	0	0	0	0	0	0	1	4	20	63	135	219	290	335	281	205	146	110	89	72	62	52	46	42	38	34	31	30	27	23	19	0
1.0	0	0	0	0	0	0	0	0	0	2	9	32	78	216	320	306	243	176	128	90	72	59	49	44	40	36	33	31	28	24	19	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	2	20	84	185	264	281	246	168	112	77	58	49	44	40	36	32	29	26	20	5
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	12	50	121	200	257	224	141	83	61	50	44	40	36	31	28	21	14
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	51	145	239	223	137	82	60	50	44	40	33	29	22	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	19	74	184	224	146	89	63	51	45	36	31	24	18
IA/P = 0.50 * * * TC =0.3 HR * * * IA/P = 0.50																																
0.0	0	0	0	0	1	25	151	299	277	219	187	162	141	113	100	90	84	78	72	65	61	58	53	48	44	42	41	39	35	31	28	0
.10	0	0	0	0	1	17	106	235	263	234	202	175	152	120	104	93	85	79	73	66	61	58	54	49	44	42	41	39	35	31	28	0
.20	0	0	0	0	0	0	12	75	182	236	234	213	188	144	116	101	91	84	78	70	63	59	55	50	45	43	41	40	36	31	28	0
.30	0	0	0	0	0	0	8	52	138	203	224	217	197	154	123	105	94	86	79	71	64	59	55	51	46	43	42	40	36	32	28	0
.40	0	0	0	0	0	0	5	37	105	170	206	213	203	164	131	110	97	88	81	72	65	60	56	51	46	43	42	40	36	32	28	0
.50	0	0	0	0	0	0	0	4	26	78	140	184	203	191	155	126	107	95	86	76	69	62	57	53	48	44	42	41	37	33	28	0
.75	0	0	0	0	0	0	0	1	10	34	73	117	153	184	173	146	122	105	94	82	73	64	58	54	49	45	43	41	37	33	28	0
1.0	0	0	0	0	0	0	0	0	0	0	4	17	42	114	168	178	159	134	114	94	82	70	61	57	52	47	44	42	39	35	28	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	10	44	98	144	163	157	130	105	84	69	61	56	52	47	44	40	36	29	6
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	44	87	127	153	141	110	83	69	61	56	51	47	42	38	30	17
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	16	42	97	138	145	107	82	68	60	55	51	43	40	32	25
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	27	71	127	139	105	81	68	60	55	46	41	33	27

RAINFALL TYPE = II * * * TC = 0.3 HR * * * SHEET 3 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =0.4 HR * * *																		IA/P = 0.10
0.0	18	25	36	77	141	271	468	592	574	431	298	216	163	104	77	63	55	49	44	38	34	31	28	25	22	21	20	18	16	14	12	0
.10	18	24	34	67	116	219	385	523	557	473	357	263	196	119	84	67	57	51	46	39	35	32	29	25	22	21	20	19	16	14	12	0
.20	15	20	28	44	59	97	179	316	454	523	489	401	309	178	112	81	65	56	49	42	37	33	30	26	23	21	20	19	17	14	12	0
.30	15	20	27	41	53	82	147	260	389	478	486	429	349	210	129	89	69	58	51	43	38	33	30	27	24	21	20	19	17	14	12	0
.40	13	17	23	33	38	48	71	121	214	331	429	467	442	308	189	120	85	66	56	47	41	35	31	28	24	22	20	19	17	15	12	0
.50	12	16	22	31	36	44	62	102	176	279	379	438	440	339	218	137	94	71	59	49	42	35	31	28	25	22	21	19	17	15	12	0
.75	10	13	17	24	26	30	35	45	65	106	170	251	326	393	341	245	164	112	81	59	48	39	33	30	26	23	21	20	18	15	12	0
1.0	8	10	13	17	19	21	24	27	31	37	50	75	118	251	360	376	292	205	138	83	60	45	36	32	28	25	22	21	18	16	12	1
1.5	6	7	9	12	13	14	15	17	19	21	23	26	31	56	121	224	311	333	293	192	115	66	45	36	31	28	25	22	19	17	13	4
2.0	4	5	6	8	8	9	10	10	11	12	14	15	16	20	27	43	85	159	243	306	264	154	74	47	37	32	28	25	21	18	14	9
2.5	2	3	4	5	6	6	7	7	8	9	9	10	11	13	16	20	27	46	85	184	285	262	147	74	47	37	32	28	22	19	15	11
3.0	1	2	2	3	4	4	4	5	5	6	6	7	7	8	10	12	14	17	23	47	109	227	268	160	83	50	38	32	25	21	16	11
IA/P = 0.30														* * * TC =0.4 HR * * *																		IA/P = 0.30
0.0	0	0	0	4	26	113	296	480	495	413	306	234	186	127	100	84	74	67	61	54	49	45	41	37	33	31	29	28	25	21	19	0
.10	0	0	0	0	2	18	81	224	395	462	430	347	272	172	121	96	82	73	66	57	51	46	42	38	34	31	30	28	25	22	19	0
.20	0	0	0	0	2	13	59	169	320	414	424	373	305	196	134	103	85	75	67	59	52	47	43	39	34	32	30	29	25	22	19	0
.30	0	0	0	0	0	1	9	42	127	255	361	403	383	274	181	127	99	83	73	63	55	48	44	40	36	32	30	29	26	23	19	0
.40	0	0	0	0	0	1	6	30	94	202	308	372	379	298	203	141	106	87	76	65	56	49	44	40	36	32	31	29	26	23	19	0
.50	0	0	0	0	0	0	0	4	21	70	158	258	334	364	270	187	133	102	85	70	60	51	46	41	37	33	31	30	26	23	19	0
.75	0	0	0	0	0	0	0	2	8	30	76	145	219	321	305	241	177	130	102	78	65	55	47	43	38	34	32	30	27	24	19	0
1.0	0	0	0	0	0	0	0	0	0	1	4	15	42	150	267	308	272	209	154	103	79	62	51	45	41	37	33	31	28	25	19	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	10	51	136	226	274	263	195	131	85	62	51	45	41	36	33	29	26	20	6
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	31	86	162	252	239	162	93	64	52	45	41	37	31	28	21	15
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	33	112	202	235	155	92	64	52	45	41	33	29	23	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	21	76	182	221	148	90	63	51	45	36	31	24	18
IA/P = 0.50														* * * TC =0.4 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	7	59	168	245	257	213	186	163	128	109	96	88	81	75	67	62	58	54	50	45	43	41	39	35	31	28	0
.10	0	0	0	0	0	0	5	41	125	205	240	222	198	154	123	106	94	86	79	71	64	60	56	51	46	43	42	40	36	32	28	0
.20	0	0	0	0	0	0	3	28	93	168	216	220	205	164	131	110	97	88	81	72	65	60	56	51	46	43	42	40	36	32	28	0
.30	0	0	0	0	0	0	0	2	20	69	135	189	209	192	155	126	107	95	86	77	69	62	57	53	48	44	42	41	37	33	28	0
.40	0	0	0	0	0	0	0	1	14	50	106	161	193	202	163	133	112	98	89	78	70	62	58	53	48	44	42	41	37	33	28	0
.50	0	0	0	0	0	0	0	1	9	37	83	135	174	194	171	140	117	102	91	80	71	63	58	54	49	45	43	41	37	33	28	0
.75	0	0	0	0	0	0	0	0	0	3	15	40	76	147	177	169	146	124	107	90	79	68	60	56	51	47	43	42	38	34	28	0
1.0	0	0	0	0	0	0	0	0	0	0	1	7	21	78	141	173	167	146	125	101	86	73	63	58	53	48	45	42	39	35	28	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	26	71	121	153	159	139	113	89	72	63	57	53	48	44	40	37	29	7
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	45	86	138	150	125	93	74	64	58	53	48	42	39	31	20
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	17	59	112	143	121	91	73	63	57	53	45	40	32	26
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	11	40	101	138	117	90	73	63	57	48	42	34	27

RAINFALL TYPE = II * * * TC = 0.4 HR * * * SHEET 4 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL TIME (HR) — HYDROGRAPH TIME (HOURS)

	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =0.5 HR * * *																		IA/P = 0.10
0.0	17	23	32	57	94	170	308	467	529	507	402	297	226	140	96	74	61	53	47	41	36	32	29	26	23	21	20	19	16	14	12	0
.10	16	22	30	51	80	140	252	395	484	499	434	343	265	162	108	80	65	55	49	42	36	33	29	26	23	21	20	19	16	14	12	0
.20	14	19	25	38	47	69	116	207	332	434	477	449	378	238	149	101	77	62	53	45	39	34	30	27	24	22	20	19	17	14	12	0
.30	13	18	24	35	43	60	97	170	278	382	446	448	401	270	171	114	83	66	56	46	40	34	31	27	24	22	20	19	17	15	12	0
.40	12	15	21	29	33	40	53	83	141	233	332	408	434	361	243	157	107	79	64	51	43	36	32	28	25	22	21	20	17	15	12	0
.50	11	15	20	28	31	37	48	71	118	194	286	367	412	378	271	178	119	86	68	53	44	37	32	29	25	23	21	20	17	15	12	0
.75	9	11	14	19	21	24	27	31	37	49	74	118	182	319	374	328	244	169	117	76	56	43	35	31	28	25	22	21	18	16	12	1
1.0	7	9	12	16	17	19	21	24	27	32	40	55	83	188	309	359	322	245	172	102	68	49	38	32	29	26	23	21	19	16	12	1
1.5	5	7	8	11	12	13	14	15	17	19	21	23	27	43	89	175	269	322	309	225	140	77	49	38	32	29	25	23	20	17	13	5
2.0	3	4	6	7	8	8	9	10	10	11	12	14	15	18	23	35	65	123	202	297	280	181	88	52	39	33	29	26	21	19	14	10
2.5	2	3	4	5	5	6	6	7	7	8	9	[illegible]	10	12	15	18	24	36	66	150	244	278	171	87	52	39	33	29	23	20	15	11
3.0	1	1	2	3	3	4	4	4	5	5	6	6	7	8	9	11	13	16	20	37	86	198	263	182	96	56	40	33	26	21	16	11
IA/P = 0.30														* * * TC =0.[illegible] HR * * *																		IA/P = 0.30
0.0	0	0	0	1	9	53	157	314	433	439	379	299	237	159	118	95	81	71	65	56	50	46	42	38	34	31	30	29	25	22	19	0
.10	0	0	0	0	1	6	37	117	248	372	416	391	330	218	150	113	92	79	70	60	53	47	43	39	35	32	30	29	26	22	19	0
.20	0	0	0	0	1	4	26	87	194	313	382	388	349	244	167	122	97	82	72	62	54	48	43	39	35	32	30	29	26	22	19	0
.30	0	0	0	0	0	0	3	19	64	151	259	341	372	316	223	156	117	94	80	67	58	50	45	41	36	33	31	29	26	23	19	0
.40	0	0	0	0	0	0	2	13	47	116	211	298	354	328	245	172	127	100	83	69	59	51	45	41	37	33	31	29	26	23	19	0
.50	0	0	0	0	0	0	0	1	9	34	89	170	255	341	303	225	161	120	96	76	64	54	47	42	38	34	31	30	27	24	19	0
.75	0	0	0	0	0	0	0	1	4	14	41	89	152	270	305	268	207	155	118	87	70	57	48	44	39	35	32	30	27	24	19	0
1.0	0	0	0	0	0	0	0	0	0	0	2	7	22	98	212	295	285	237	181	120	88	67	53	46	42	38	34	31	28	25	19	2
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	30	95	183	249	265	217	152	96	66	53	46	41	37	34	30	26	20	8
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	18	59	125	221	245	182	105	69	54	47	42	38	32	28	22	16
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	21	84	174	230	172	103	69	54	46	42	34	30	23	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	56	157	217	163	101	68	53	46	37	31	25	18
IA/P = 0.50														* * * TC =0.5 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	2	26	89	170	217	229	200	179	144	119	104	93	85	78	70	64	59	55	51	46	43	41	40	36	32	28	0
.10	0	0	0	0	0	0	1	18	65	135	190	216	205	170	137	115	101	91	83	74	67	61	56	52	47	44	42	40	36	32	28	0
.20	0	0	0	0	0	0	1	12	47	106	162	198	203	178	145	121	105	94	85	76	68	61	57	52	48	44	42	40	37	32	28	0
.30	0	0	0	0	0	0	0	1	8	34	82	135	177	194	168	139	117	102	92	80	71	63	58	54	49	45	43	41	37	33	28	0
.40	0	0	0	0	0	0	0	0	6	25	63	111	155	189	174	146	122	106	94	82	73	64	58	54	50	45	43	41	37	33	28	0
.50	0	0	0	0	0	0	0	0	4	18	48	90	133	184	177	152	128	110	97	84	74	65	59	55	50	45	43	41	38	33	28	0
.75	0	0	0	0	0	0	0	0	1	7	22	47	80	142	169	164	144	124	108	91	79	68	61	56	51	47	44	42	38	34	28	0
1.0	0	0	0	0	0	0	0	0	0	0	1	3	11	51	112	155	166	154	134	109	91	76	65	59	54	49	45	43	39	35	28	2
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16	50	97	136	154	145	121	95	75	64	58	54	49	45	41	37	29	10
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	18	47	86	134	146	125	94	75	64	58	53	49	42	39	31	21
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	11	44	95	140	127	97	77	65	58	54	45	41	33	26
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	29	86	135	122	95	76	65	58	49	43	35	27

RAINFALL TYPE = II — * * * TC = 0.5 HR * * * — SHEET 5 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL ---------- HYDROGRAPH TIME (HOURS) ----------

TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =0.75 HR * * *																		IA/P = 0.10
0.0	13	18	24	36	46	68	115	194	294	380	424	410	369	252	172	123	93	74	61	49	41	35	31	27	24	22	20	19	17	15	12	0
.10	13	17	23	34	42	59	97	162	250	337	395	405	381	279	191	135	100	79	65	51	42	36	31	28	25	22	21	19	17	15	12	0
.20	11	15	20	28	32	39	52	82	135	211	295	362	391	351	255	178	127	95	75	57	46	38	32	29	26	23	21	20	17	15	12	0
.30	11	14	19	26	30	36	47	70	113	179	256	326	379	360	277	196	140	103	80	60	48	38	33	29	26	23	21	20	18	15	12	0
.40	10	12	16	22	25	28	33	42	61	96	151	221	291	367	336	255	182	131	98	69	54	42	34	30	27	24	22	20	18	16	12	0
.50	9	12	16	21	24	27	31	39	53	82	128	190	258	358	343	274	200	144	106	74	56	43	35	30	27	24	22	20	18	16	12	0
.75	8	10	13	17	18	21	23	26	31	39	55	82	122	230	314	329	281	217	161	104	72	51	38	33	29	26	23	21	19	16	12	1
1.0	6	8	10	13	14	15	17	19	21	23	27	32	42	89	177	272	319	303	249	163	105	66	45	36	31	27	24	22	19	17	13	3
1.5	4	6	7	9	10	10	11	12	14	15	16	18	20	27	46	90	163	241	295	275	204	119	66	45	35	31	27	24	20	18	13	7
2.0	3	4	5	6	7	7	8	9	9	10	11	12	13	16	20	28	48	89	151	245	274	213	115	65	44	35	30	27	22	19	14	10
2.5	1	2	3	4	4	5	5	6	6	7	7	8	8	10	12	14	17	24	37	86	170	260	219	127	71	47	36	31	24	20	16	11
3.0	1	1	2	3	3	3	4	4	4	5	5	5	6	7	8	10	11	14	17	30	64	157	247	205	122	70	46	36	27	22	17	12
IA/P = 0.30														* * * TC =0.75 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	1	6	30	86	174	266	326	348	328	246	181	138	110	92	79	66	57	49	44	40	36	32	31	29	26	23	19	0
.10	0	0	0	0	0	1	4	22	65	137	223	292	329	303	228	170	131	106	89	73	61	52	46	41	37	33	31	29	26	23	19	0
.20	0	0	0	0	0	0	3	15	48	108	185	256	305	321	245	184	141	112	93	75	63	53	46	42	37	34	31	30	27	23	19	0
.30	0	0	0	0	0	0	2	11	36	84	151	221	277	308	260	199	152	120	98	78	65	54	47	42	38	34	31	30	27	23	19	0
.40	0	0	0	0	0	0	0	1	8	27	65	122	188	286	301	243	187	144	114	87	71	57	48	43	39	35	32	30	27	24	19	1
.50	0	0	0	0	0	0	0	1	6	20	50	98	158	263	292	254	200	155	122	91	74	59	49	44	40	35	32	30	27	24	19	1
.75	0	0	0	0	0	0	0	0	0	2	8	23	51	140	231	269	253	211	167	119	90	68	53	46	42	37	34	31	28	25	19	2
1.0	0	0	0	0	0	0	0	0	0	0	0	1	4	29	96	186	249	261	231	169	120	84	61	50	44	40	36	33	29	26	20	5
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	34	91	163	220	241	197	131	83	61	50	44	40	35	31	27	21	12
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	36	85	174	226	200	127	82	60	49	44	39	32	29	22	17
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	37	105	196	214	135	87	62	51	44	36	31	24	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	24	96	205	189	130	85	62	50	39	32	26	18
IA/P = 0.50														* * * TC =0.75 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	2	16	45	92	137	166	185	170	146	125	110	98	89	79	70	63	58	53	48	44	42	41	37	33	28	0
.10	0	0	0	0	0	0	0	1	11	34	73	115	149	180	163	141	122	107	96	84	74	65	59	54	50	45	43	41	38	33	28	0
.20	0	0	0	0	0	0	0	1	8	25	57	96	131	173	166	146	126	111	99	86	76	66	59	55	50	46	43	41	38	34	28	0
.30	0	0	0	0	0	0	0	0	1	5	18	44	79	143	170	160	141	122	108	92	81	69	61	56	52	47	44	42	38	34	28	1
.40	0	0	0	0	0	0	0	0	0	4	14	34	64	127	166	162	145	127	111	95	82	70	62	57	52	47	44	42	38	34	28	1
.50	0	0	0	0	0	0	0	0	0	0	2	10	26	82	138	162	157	140	123	103	88	75	64	58	53	49	45	43	39	35	28	2
.75	0	0	0	0	0	0	0	0	0	0	1	4	12	47	98	139	154	148	135	113	96	80	67	60	55	50	46	43	39	36	29	3
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	30	73	119	146	151	134	113	91	74	63	58	53	48	45	41	37	29	7
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	30	66	105	143	143	117	90	73	63	57	52	48	42	39	30	18
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	30	77	121	137	114	88	72	63	57	52	44	40	32	25
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	19	55	111	132	111	87	71	62	56	47	42	34	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	51	112	128	108	86	71	62	51	44	36	27

RAINFALL TYPE = II * * * TC = 0.75 HR * * * SHEET 6 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =1.0 HR * * *																		IA/P = 0.10
0.0	11	15	20	29	35	47	72	112	168	231	289	329	357	313	239	175	133	103	83	63	50	40	33	29	26	23	21	20	17	15	12	0
.10	10	13	17	24	27	33	42	62	95	144	202	260	306	340	293	222	165	126	98	72	56	43	35	30	27	24	22	20	18	15	12	0
.20	10	13	17	23	26	30	38	54	82	123	176	232	281	332	303	238	179	136	105	76	59	45	35	30	27	24	22	20	18	16	12	1
.30	9	12	16	22	24	28	35	48	70	105	152	205	256	323	310	254	193	146	113	81	61	46	36	31	27	24	22	20	18	16	12	1
.40	8	11	14	19	21	23	27	32	42	61	91	132	181	276	318	294	237	181	138	95	70	51	39	32	28	25	23	21	18	16	12	1
.50	8	10	13	18	20	22	25	30	38	53	78	114	159	253	311	300	251	195	149	102	74	53	40	33	29	25	23	21	18	16	12	1
.75	7	8	11	14	16	17	19	21	25	30	38	53	76	146	228	284	293	256	208	143	99	66	46	36	31	27	24	22	19	17	13	2
1.0	5	7	8	11	12	13	14	16	17	19	22	25	31	57	111	188	256	286	272	208	144	90	56	41	33	29	26	23	20	17	13	4
1.5	4	5	6	8	8	9	10	11	12	13	14	15	17	22	33	59	107	171	231	268	235	157	88	56	41	33	29	25	21	18	14	8
2.0	2	3	4	5	5	6	6	7	7	8	9	9	10	12	15	19	27	44	78	157	231	252	167	96	59	42	34	29	23	20	15	11
2.5	1	2	2	3	4	4	4	5	5	6	6	7	7	8	10	12	15	19	27	58	120	214	241	159	94	59	42	34	26	21	16	11
3.0	0	1	1	2	2	3	3	3	4	4	4	5	5	6	7	8	10	12	14	22	44	113	214	231	152	91	58	42	29	23	17	12
IA/P = 0.30														* * * TC =1.0 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	1	4	16	42	83	137	195	243	271	292	227	178	143	117	98	79	66	55	47	42	38	34	31	30	27	23	19	0
.10	0	0	0	0	0	0	3	12	32	66	113	168	218	279	260	213	169	136	113	88	72	59	49	43	39	35	32	30	27	24	19	1
.20	0	0	0	0	0	0	2	9	24	52	93	143	193	271	271	225	180	145	119	92	75	60	50	44	39	35	32	30	27	24	19	1
.30	0	0	0	0	0	0	1	6	18	41	75	120	169	246	264	234	191	153	125	96	78	62	51	44	40	36	33	31	27	24	19	1
.40	0	0	0	0	0	0	0	1	4	14	32	61	100	190	251	259	222	181	146	109	86	67	53	46	41	37	33	31	28	25	19	2
.50	0	0	0	0	0	0	0	1	3	10	24	49	83	168	237	254	230	191	155	115	90	69	54	47	42	37	34	31	28	25	19	2
.75	0	0	0	0	0	0	0	0	0	1	4	12	25	76	150	213	239	228	198	149	112	82	61	50	44	39	35	32	29	26	20	4
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	15	51	113	182	226	234	197	150	104	72	56	47	42	38	34	30	27	20	7
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	18	51	104	162	220	210	158	102	71	56	47	42	37	31	28	22	13
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	20	49	121	187	209	152	100	70	55	47	41	34	29	23	17
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	32	87	171	199	146	98	69	54	46	37	31	24	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	62	158	192	151	103	73	56	41	34	26	18
IA/P = 0.50														* * * TC =1.0 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	1	7	21	42	71	101	126	160	154	138	123	110	100	87	77	67	60	55	50	46	43	41	38	34	28	1
.10	0	0	0	0	0	0	0	1	5	15	33	58	87	134	156	149	134	120	108	93	82	71	62	57	52	47	44	42	38	34	28	1
.20	0	0	0	0	0	0	0	1	4	12	26	48	74	123	153	153	137	123	111	95	84	72	63	57	52	47	44	42	38	34	28	1
.30	0	0	0	0	0	0	0	0	3	9	20	38	62	111	143	150	140	127	114	98	86	73	63	58	53	48	45	42	39	35	28	1
.40	0	0	0	0	0	0	0	0	0	2	6	16	31	75	120	145	148	137	123	106	91	77	66	59	54	49	45	43	39	35	29	2
.50	0	0	0	0	0	0	0	0	0	1	5	12	25	64	109	139	146	139	127	108	94	79	67	60	55	50	46	43	39	36	29	3
.75	0	0	0	0	0	0	0	0	0	0	2	5	12	39	78	115	136	140	134	117	101	84	70	62	56	51	47	44	40	36	29	4
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	26	59	96	125	139	133	117	97	78	66	59	54	49	46	41	37	29	8
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	26	54	86	123	133	119	95	77	66	59	54	49	43	39	31	17
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	25	64	104	129	116	93	76	65	58	53	45	41	33	24
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	34	84	125	117	96	78	66	59	49	43	35	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	32	89	122	114	94	77	66	53	45	37	27

RAINFALL TYPE = II * * * TC = 1.0 HR * * * SHEET 7 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =1.25 HR * * *																		IA/P = 0.10
0.0	10	13	18	25	29	38	54	81	118	163	213	256	284	311	266	212	163	129	104	78	61	47	37	31	27	24	22	20	18	16	12	1
.10	10	13	17	23	27	34	47	69	102	143	189	234	267	297	274	226	175	138	111	82	64	48	38	31	27	24	22	20	18	16	12	1
.20	9	11	15	20	22	26	31	42	60	88	124	168	212	280	292	261	212	166	131	95	72	53	40	33	28	25	23	21	18	16	12	1
.30	8	11	14	19	21	24	29	38	53	76	108	148	190	263	288	268	224	177	140	101	76	55	41	34	29	25	23	21	18	16	12	2
.40	8	10	13	18	20	23	27	34	46	66	94	130	170	245	282	273	235	188	149	107	80	58	42	34	29	26	23	21	19	16	12	2
.50	7	9	12	16	17	19	22	25	31	41	58	82	114	190	256	279	262	222	178	127	93	65	46	36	31	27	24	22	19	17	13	2
.75	6	8	10	14	15	17	19	21	25	31	41	56	78	139	207	254	265	245	208	152	110	75	51	39	32	28	25	22	19	17	13	3
1.0	5	6	8	10	11	13	14	15	17	19	22	26	33	60	109	173	230	261	255	208	153	100	64	46	36	30	26	24	20	18	13	5
1.5	3	4	5	7	7	8	9	9	10	11	12	13	15	19	27	45	79	130	186	247	239	180	108	68	48	37	31	27	22	19	14	10
2.0	2	3	4	5	6	6	7	7	8	8	9	10	11	13	16	22	35	59	98	171	236	236	156	95	62	44	35	30	23	20	15	11
2.5	1	2	2	3	4	4	4	5	5	5	6	6	7	8	10	12	14	19	28	58	114	197	226	163	102	65	46	36	26	21	16	11
3.0	0	1	1	2	2	2	2	3	3	3	4	4	4	5	6	7	9	10	13	19	35	88	184	218	169	109	70	49	31	24	18	12
IA/P = 0.30														* * * TC =1.25 HR * * *																		IA/P = 0,30
0.0	0	0	0	0	0	2	9	25	50	86	130	174	208	253	235	201	164	136	115	92	76	61	51	44	39	35	32	30	27	24	19	1
.10	0	0	0	0	0	0	1	6	19	40	71	110	153	217	247	227	191	157	131	103	84	66	53	46	41	36	33	31	28	24	19	2
.20	0	0	0	0	0	0	1	4	14	31	58	93	133	202	239	231	199	165	138	108	87	68	55	47	41	37	33	31	28	25	19	2
.30	0	0	0	0	0	0	0	1	3	10	24	46	77	152	210	236	222	190	158	122	97	74	58	49	43	38	34	32	28	25	20	3
.40	0	0	0	0	0	0	0	0	2	8	19	37	64	134	196	232	225	198	166	127	101	77	59	50	43	38	35	32	28	25	20	3
.50	0	0	0	0	0	0	0	0	0	2	6	14	30	82	151	206	228	217	189	146	113	85	64	52	45	40	36	33	29	26	20	5
.75	0	0	0	0	0	0	0	0	0	1	2	7	15	49	105	164	205	218	205	166	129	95	69	55	47	41	37	33	29	26	20	6
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	32	77	134	185	214	203	166	120	83	63	52	45	39	35	30	27	21	10
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	33	72	121	184	203	171	117	82	62	51	44	39	32	29	22	15
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	21	67	132	194	174	123	86	64	52	45	35	31	24	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	46	121	187	166	119	84	63	52	39	32	25	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	44	129	180	160	116	83	63	44	35	27	18
IA/P = 0.50														* * * TC =1.25 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	1	5	13	26	44	68	91	125	142	142	128	117	107	94	83	72	63	57	52	47	44	42	38	34	28	2
.10	0	0	0	0	0	0	0	0	3	10	20	36	57	100	129	140	136	125	114	100	88	76	65	59	54	49	45	43	39	35	29	3
.20	0	0	0	0	0	0	0	0	2	7	16	30	48	90	122	139	139	127	117	102	90	77	66	60	54	49	45	43	39	35	29	3
.30	0	0	0	0	0	0	0	0	0	2	5	12	24	59	98	126	137	134	125	109	96	82	69	61	56	51	46	44	40	36	29	4
.40	0	0	0	0	0	0	0	0	0	1	4	10	19	51	89	119	134	136	127	112	98	83	70	62	56	51	47	44	40	36	29	5
.50	0	0	0	0	0	0	0	0	0	1	3	7	15	43	79	112	131	135	129	114	100	85	71	63	57	52	47	44	40	36	29	6
.75	0	0	0	0	0	0	0	0	0	0	0	1	3	15	39	71	102	123	130	125	112	94	78	67	60	54	49	46	41	37	29	9
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	17	40	71	101	121	129	121	103	84	71	62	56	51	47	42	38	30	13
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	26	51	92	119	125	105	86	72	63	57	52	44	40	32	23
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	35	72	112	122	103	85	71	63	56	47	42	34	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	24	66	111	119	101	83	71	62	51	44	36	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	23	71	110	116	99	82	70	55	46	37	27

RAINFALL TYPE = II * * * TC = 1.25 HR * * * SHEET 8 OF 10

Exhibit 5-II, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 * * * TC =1.5 HR * * *																																
0.0	9	11	15	21	25	31	41	58	82	112	147	184	216	255	275	236	198	159	129	98	76	57	43	35	30	25	23	21	18	16	12	1
.10	8	10	13	18	20	23	28	37	51	72	98	131	166	226	265	254	226	187	151	113	86	63	46	37	31	26	23	21	19	16	13	2
.20	8	10	13	17	19	22	26	33	45	63	87	116	149	212	259	259	233	197	160	119	90	66	48	38	32	27	24	22	19	16	13	2
.30	7	9	12	16	18	21	24	30	40	55	76	103	134	197	244	255	238	206	169	125	95	68	49	38	32	27	24	22	19	17	13	2
.40	7	8	11	14	15	17	19	23	28	36	49	67	91	151	208	247	252	230	196	146	109	77	54	41	34	29	25	22	19	17	13	3
.50	6	8	10	13	15	16	18	21	26	33	43	59	80	136	194	238	249	235	204	154	115	81	56	42	34	29	25	23	20	17	13	3
.75	5	7	8	11	12	13	14	16	18	21	25	32	42	76	125	179	222	240	233	193	148	102	67	48	38	32	27	24	20	18	13	5
1.0	4	5	7	8	9	10	11	12	13	14	16	18	22	34	59	101	152	201	236	230	193	135	86	59	44	35	30	26	21	18	14	7
1.5	3	4	5	6	6	7	8	8	9	10	11	12	13	16	22	34	58	95	141	203	226	197	131	84	58	43	35	29	23	20	15	10
2.0	1	2	3	4	4	5	5	6	6	7	7	8	9	10	12	16	22	34	56	110	172	218	187	126	82	57	43	34	25	21	16	11
2.5	1	1	2	2	3	3	3	4	4	4	5	5	6	7	8	9	11	14	18	34	69	141	210	190	133	87	60	44	30	23	17	12
3.0	0	0	1	1	2	2	2	2	3	3	3	3	4	5	5	6	8	9	11	16	27	66	149	204	181	128	85	58	35	25	18	12
IA/P = 0.30 * * * TC =1.5 HR * * *																																
0.0	0	0	0	0	0	1	6	15	31	53	80	112	144	193	225	208	186	157	134	108	89	70	56	48	42	37	34	31	28	25	20	2
.10	0	0	0	0	0	0	1	4	12	25	43	68	97	157	198	219	203	178	151	120	98	77	60	50	44	38	35	32	28	25	20	3
.20	0	0	0	0	0	0	0	1	3	9	19	35	57	114	168	201	213	196	171	135	108	84	64	53	46	40	36	33	29	26	20	4
.30	0	0	0	0	0	0	0	1	2	7	15	29	48	100	155	193	210	200	177	140	113	87	66	54	46	41	36	33	29	26	20	5
.40	0	0	0	0	0	0	0	0	2	5	12	23	39	87	141	184	207	202	182	146	117	89	68	55	47	41	36	33	29	26	20	5
.50	0	0	0	0	0	0	0	0	0	1	4	9	18	51	101	153	190	205	197	164	131	99	73	58	49	43	38	34	30	26	20	7
.75	0	0	0	0	0	0	0	0	0	0	2	4	9	30	68	116	160	189	197	179	147	110	80	62	52	45	39	35	30	27	21	8
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	20	49	92	138	175	195	178	137	97	72	57	48	42	37	31	28	21	12
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	21	47	85	145	187	178	133	95	71	57	48	42	34	29	23	16
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	45	97	162	180	138	99	74	58	49	38	32	25	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	31	89	161	174	133	97	72	58	42	34	26	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	29	98	160	169	129	95	71	48	37	28	19
IA/P = 0.50 * * * TC =1.5 HR * * *																																
0.0	0	0	0	0	0	0	0	3	8	16	27	42	59	92	116	128	130	121	112	100	90	78	67	60	55	50	46	43	39	35	29	4
.10	0	0	0	0	0	0	0	2	6	12	22	35	51	84	110	125	128	123	114	102	91	79	68	61	55	50	46	43	39	35	29	4
.20	0	0	0	0	0	0	0	0	1	4	10	18	29	60	91	114	126	128	120	108	97	83	71	63	57	52	47	44	40	36	29	5
.30	0	0	0	0	0	0	0	0	1	3	8	14	24	52	83	108	123	126	122	110	98	85	72	63	57	52	48	44	40	36	29	6
.40	0	0	0	0	0	0	0	0	0	1	2	6	12	31	60	90	112	124	126	116	104	90	75	66	59	54	49	45	41	37	29	8
.50	0	0	0	0	0	0	0	0	0	0	2	4	9	26	53	83	106	121	125	118	106	91	77	67	60	54	49	46	41	37	29	8
.75	0	0	0	0	0	0	0	0	0	0	1	2	5	16	36	62	88	108	119	122	112	97	81	69	62	56	51	47	42	38	30	11
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	26	49	75	98	118	121	108	90	76	66	59	54	49	43	39	31	16
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	11	25	45	80	107	118	106	89	75	65	59	53	45	41	32	23
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	11	32	63	100	115	104	87	74	65	58	48	42	34	26
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	16	48	94	113	105	89	76	66	53	45	36	27
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	54	96	111	103	88	75	58	48	38	28

RAINFALL TYPE = II

* * * TC = 1.5 HR * * *

SHEET 9 OF 10

Exhibit 5-11, continued: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =2.0 HR * * *																		IA/P = 0.10
0.0	7	9	12	16	18	21	27	36	49	64	82	104	127	171	201	226	208	193	171	132	105	79	58	45	36	30	26	23	20	17	13	3
.10	6	8	10	14	15	17	20	25	33	43	57	74	94	139	179	204	218	205	188	150	118	88	63	48	38	32	27	24	20	17	13	4
.20	6	8	10	13	14	16	19	23	29	39	51	66	84	128	169	198	213	207	192	157	123	91	65	49	39	33	28	24	20	17	13	4
.30	6	7	9	12	14	15	18	21	27	35	45	59	76	117	159	191	211	208	196	163	128	95	68	51	40	33	28	25	20	18	13	4
.40	5	6	8	11	12	13	15	17	20	24	31	41	53	87	128	167	197	209	205	180	145	106	75	55	43	35	30	26	21	18	14	5
.50	5	6	8	10	11	13	14	16	18	22	28	37	48	78	118	158	190	208	208	185	151	111	77	57	44	36	30	26	21	18	14	5
.75	4	6	7	9	10	11	12	13	15	18	22	27	35	58	91	129	164	191	202	194	167	125	87	63	48	38	32	27	22	18	14	6
1.0	3	4	6	7	8	8	9	10	11	12	14	16	18	28	46	74	110	147	178	201	193	156	108	76	56	43	35	30	23	19	14	8
1.5	2	3	3	5	5	5	6	6	7	8	8	9	10	12	16	23	36	57	86	137	178	195	160	113	79	58	45	36	26	21	16	11
2.0	1	2	2	3	3	4	4	4	5	5	6	6	7	8	10	12	16	23	35	67	112	169	190	154	110	78	57	44	30	23	17	11
2.5	0	1	1	2	2	2	3	3	3	4	4	4	5	6	7	8	9	12	16	28	52	105	170	185	149	107	76	56	35	26	18	12
3.0	0	0	1	1	1	1	1	2	2	2	2	3	3	3	4	5	6	7	8	12	18	41	99	161	180	152	112	80	45	30	19	12
IA/P = 0.30														* * * TC =2.0 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	1	3	8	15	25	38	54	74	115	148	168	185	170	159	131	110	89	70	57	49	42	38	34	29	26	20	5
.10	0	0	0	0	0	0	0	2	6	12	21	32	47	85	124	153	169	180	168	145	120	96	75	60	51	44	39	35	30	26	20	6
.20	0	0	0	0	0	0	0	2	4	10	17	27	41	75	114	146	165	175	170	149	124	99	76	62	52	45	39	35	30	27	21	6
.30	0	0	0	0	0	0	0	0	1	3	7	14	23	49	86	122	151	170	174	160	136	107	82	66	54	47	41	37	31	27	21	8
.40	0	0	0	0	0	0	0	0	1	2	6	11	19	43	77	113	144	165	173	163	140	111	85	67	55	47	41	37	31	27	21	8
.50	0	0	0	0	0	0	0	0	1	2	4	9	16	37	68	104	136	160	171	165	144	114	87	69	56	48	42	37	31	27	21	9
.75	0	0	0	0	0	0	0	0	0	0	1	2	5	15	34	62	96	127	152	167	160	132	100	77	62	52	45	40	32	28	22	11
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	24	48	79	111	150	166	153	118	90	71	58	49	43	34	29	23	14
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	24	45	88	130	161	148	115	88	70	57	48	37	31	24	17
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	32	68	122	157	143	113	87	68	56	42	34	26	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	16	51	114	153	144	116	89	70	49	38	27	19
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	15	59	118	150	140	113	88	57	42	29	19
IA/P = 0.50														* * * TC =2.0 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	1	4	8	13	20	28	51	73	92	104	111	112	106	97	86	75	66	60	54	49	46	41	37	30	7
.10	0	0	0	0	0	0	0	1	3	6	11	17	24	45	68	87	101	109	112	107	98	88	76	67	60	55	50	46	41	37	30	8
.20	0	0	0	0	0	0	0	1	2	5	9	14	21	40	62	82	98	107	111	108	100	89	77	68	61	55	50	47	41	37	30	8
.30	0	0	0	0	0	0	0	0	0	2	4	7	12	26	46	67	86	100	108	111	104	93	80	70	63	57	52	48	42	38	30	10
.40	0	0	0	0	0	0	0	0	0	1	3	6	10	22	41	62	81	96	106	110	105	94	81	71	63	57	52	48	42	38	30	11
.50	0	0	0	0	0	0	0	0	0	0	1	2	4	13	27	46	67	85	99	110	108	98	85	74	66	59	54	49	43	39	31	13
.75	0	0	0	0	0	0	0	0	0	0	0	1	2	7	18	33	52	71	88	104	108	102	89	77	68	61	55	50	44	39	31	15
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	13	25	43	62	87	103	108	97	84	73	65	59	53	45	41	32	20
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	12	24	48	74	99	106	95	83	72	64	58	48	43	34	25
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	17	37	69	99	104	94	82	72	64	52	45	36	27
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	27	65	95	102	95	83	73	58	49	38	28
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	32	68	95	101	93	82	64	52	40	28

RAINFALL TYPE = II * * * TC = 2.0 HR * * * SHEET 10 OF 10

Exhibit 5-III: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =0.1 HR * * *																		IA/P = 0.10
C.0	29	38	57	172	241	425	662	531	345	265	191	130	101	83	68	62	58	54	50	44	41	37	32	27	23	21	19	16	14	13	11	0
.10	26	32	47	98	147	210	353	559	540	410	313	231	164	101	80	67	61	57	53	47	43	39	34	28	24	22	19	17	14	13	11	0
.20	25	31	44	86	127	182	296	471	517	446	357	273	200	117	86	70	63	58	54	48	44	39	34	29	24	22	20	17	14	13	11	0
.30	22	28	37	57	76	110	158	250	398	477	457	390	312	178	111	83	69	62	57	51	45	41	36	31	25	23	20	18	15	13	11	0
.40	21	27	35	53	68	96	137	213	336	430	448	410	345	210	128	90	72	64	58	52	46	41	36	31	26	23	20	18	15	13	11	0
.50	19	24	30	43	49	62	85	120	182	284	382	426	415	305	188	120	86	71	63	55	49	43	38	33	27	24	21	19	15	14	11	0
.75	17	22	27	37	41	49	62	84	120	181	258	327	375	353	264	177	120	88	72	59	52	45	39	34	29	25	22	20	15	14	11	0
1.0	13	17	22	27	30	33	37	43	52	66	91	131	190	315	358	307	220	149	104	72	60	50	43	37	32	27	23	21	16	14	12	0
1.5	9	11	14	18	19	21	23	25	27	29	33	37	44	70	134	229	304	318	269	172	106	68	52	44	38	33	28	24	19	15	12	2
2.0	6	8	10	13	14	15	16	17	19	20	22	24	26	32	45	73	130	207	271	292	216	121	68	51	43	37	32	27	21	16	13	6
2.5	3	4	6	8	9	10	10	11	12	13	14	16	17	20	23	29	38	57	97	189	271	244	136	75	53	44	38	33	24	19	14	9
3.0	1	2	4	5	6	6	7	8	8	9	10	11	12	14	16	19	23	28	38	74	146	256	226	131	74	53	44	37	27	21	14	10
IA/P = 0.30														* * * TC =0.1 HR * * *																		IA/P = 0.30
C.0	0	0	0	48	106	296	597	496	368	300	221	155	125	106	89	83	79	74	69	62	59	54	47	40	35	32	28	25	22	20	17	0
.10	0	0	0	35	82	225	473	488	408	336	260	190	147	113	94	85	80	75	70	63	59	54	48	40	35	32	29	25	22	20	17	0
.20	0	0	0	7	26	64	171	372	449	422	365	295	225	142	109	92	84	79	74	66	61	56	50	43	36	33	30	26	22	20	17	0
.30	0	0	0	5	19	49	130	291	397	414	381	323	258	161	118	96	86	80	75	68	62	57	50	43	37	33	30	27	22	20	17	0
.40	0	0	0	0	3	14	37	99	227	340	389	384	343	229	152	113	94	85	79	71	65	59	52	46	38	34	31	28	23	21	17	0
.50	0	0	0	0	2	10	28	75	177	286	355	374	354	256	170	123	99	87	80	73	66	60	53	46	39	35	31	28	23	21	18	0
.75	0	0	0	0	0	1	4	13	35	86	161	238	296	325	266	194	141	110	93	80	71	63	56	50	43	37	33	30	24	21	18	0
1.0	0	0	0	0	0	0	0	2	6	19	48	99	165	282	311	264	197	144	112	88	77	67	59	52	45	39	34	31	24	22	18	0
1.5	0	0	0	0	0	0	0	0	0	0	0	1	4	29	99	197	265	277	236	162	113	84	69	60	53	46	39	35	28	23	19	2
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	35	94	172	233	253	196	124	83	68	59	52	45	39	31	25	20	8
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	37	88	184	235	201	122	83	67	59	52	45	34	27	21	13
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	38	110	222	202	131	88	69	60	52	39	31	22	15
IA/P = 0.50														* * * TC =0.1 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	107	226	282	258	209	155	130	123	107	97	95	91	87	82	78	74	69	61	52	47	43	39	35	32	29	25	0
.10	0	0	0	0	0	71	174	246	254	224	178	146	130	112	100	96	92	88	83	78	75	70	62	53	48	44	40	35	32	29	25	0
.20	0	0	0	0	0	0	48	132	208	239	229	195	162	127	109	99	95	91	87	80	77	72	65	56	49	45	41	36	32	30	25	0
.30	0	0	0	0	0	0	32	99	172	216	225	205	176	136	113	101	96	92	88	81	77	72	65	57	50	45	41	37	32	30	26	0
.40	0	0	0	0	0	0	0	21	73	139	191	213	208	164	131	111	100	95	91	85	79	74	68	60	51	47	43	38	33	30	26	0
.50	0	0	0	0	0	0	0	14	53	110	164	197	204	174	139	116	103	97	92	86	80	75	68	60	52	47	43	39	33	30	26	0
.75	0	0	0	0	0	0	0	5	22	54	96	137	166	180	159	134	115	103	96	89	83	77	70	63	54	48	44	40	33	31	26	0
1.0	0	0	0	0	0	0	0	0	0	2	10	29	60	132	175	169	146	124	109	97	89	81	74	67	59	52	47	43	34	31	27	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	2	17	58	112	150	159	148	122	104	91	81	74	67	59	51	46	38	32	28	1
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	20	54	98	133	149	133	108	90	80	73	66	58	51	42	34	29	7
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	35	87	131	141	111	92	81	74	66	59	46	38	30	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	22	63	120	136	110	91	81	73	66	51	42	31	22

RAINFALL TYPE = III * * * TC = 0.1 HR * * * SHEET 1 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 (* * * TC =0.2 HR * * *)																																
0.0	27	34	50	119	176	258	448	565	483	358	270	194	137	93	75	65	60	56	52	46	42	38	33	28	24	21	19	17	14	13	11	0
.10	24	30	42	70	103	151	222	372	501	489	402	314	234	128	91	73	64	59	55	49	44	40	35	30	25	22	20	17	15	13	11	0
.20	23	29	39	64	90	131	192	312	438	472	425	351	273	153	101	78	66	61	56	50	45	40	35	30	25	22	20	18	15	13	11	0
.30	21	26	33	48	59	79	114	166	263	380	441	431	378	238	141	96	75	65	60	53	47	42	37	32	26	23	21	18	15	13	11	0
.40	20	25	32	45	54	71	99	144	224	328	404	422	392	271	165	108	81	68	61	54	48	43	37	32	27	23	21	19	15	14	11	0
.50	18	22	28	38	43	51	64	88	125	191	282	363	402	356	241	151	102	78	66	57	51	44	39	34	28	24	22	19	15	14	11	0
.75	15	18	23	30	33	37	42	50	64	87	125	184	253	359	341	260	177	121	89	67	57	48	42	36	31	26	23	21	16	14	12	0
1.0	12	16	20	25	28	30	33	37	43	53	68	94	135	251	345	330	260	181	125	81	63	52	44	38	33	28	24	21	17	14	12	0
1.5	8	10	13	17	18	19	21	23	25	27	30	33	38	55	99	179	266	308	289	201	124	74	54	45	39	34	29	24	19	15	12	2
2.0	5	7	9	12	13	14	15	16	17	19	20	22	24	29	38	57	99	166	238	284	239	141	75	54	44	38	33	28	21	17	13	6
2.5	2	4	5	7	8	9	10	10	11	12	13	14	16	18	22	26	33	46	75	155	240	264	154	83	56	46	39	34	25	19	14	9
3.0	1	2	3	5	5	6	6	7	8	8	9	10	11	13	15	18	21	25	33	59	118	220	250	147	82	56	45	39	28	22	14	10
IA/P = 0.30 (* * * TC =0.2 HR * * *)																																
0.0	0	0	0	17	49	115	297	489	462	379	307	230	167	119	98	86	81	76	72	64	60	55	48	41	36	32	29	26	22	20	17	0
.10	0	0	0	12	37	89	228	402	442	400	338	266	200	131	104	89	82	78	73	65	61	56	49	42	36	33	29	26	22	20	17	0
.20	0	0	0	1	8	27	69	175	326	403	401	359	297	182	126	100	88	81	76	69	63	58	51	44	37	34	30	27	23	21	17	0
.30	0	0	0	1	6	20	52	134	262	356	386	368	321	208	140	107	91	83	78	70	64	58	52	45	38	34	31	27	23	21	17	0
.40	0	0	0	1	4	15	40	103	209	307	360	365	336	234	157	116	95	85	79	72	65	59	53	46	39	34	31	28	23	21	17	0
.50	0	0	0	0	0	3	11	30	78	165	260	327	352	305	213	147	111	93	84	75	68	61	55	48	41	35	32	29	23	21	18	0
.75	0	0	0	0	0	1	5	14	37	83	150	220	276	311	264	196	144	112	94	80	72	64	56	50	43	37	33	30	24	21	18	0
1.0	0	0	0	0	0	0	0	0	2	7	20	48	94	215	299	286	230	171	128	95	81	69	61	54	47	40	35	32	25	22	18	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	2	13	56	139	224	266	253	186	128	89	71	61	54	48	41	36	29	23	19	3
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	17	58	126	196	245	214	140	89	71	61	54	47	40	32	25	20	9
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	21	57	145	228	213	136	89	70	60	53	46	35	28	21	13
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	23	78	180	215	145	94	72	61	54	41	32	22	15
IA/P = 0.50 (* * * TC =0.2 HR * * *)																																
0.0	0	0	0	0	0	10	110	206	245	245	208	162	137	117	102	96	93	90	85	79	76	71	63	54	48	44	40	36	32	29	25	0
.10	0	0	0	0	0	7	76	163	217	235	217	181	152	122	106	98	94	90	86	80	76	71	64	55	49	45	41	36	32	29	25	0
.20	0	0	0	0	0	0	5	52	126	187	219	218	193	145	119	104	97	93	89	83	78	73	66	58	50	46	42	37	32	30	26	0
.30	0	0	0	0	0	0	3	36	96	156	198	211	199	155	125	108	99	94	90	84	79	74	67	59	51	46	42	38	32	30	26	0
.40	0	0	0	0	0	0	0	2	24	72	128	175	199	184	147	121	106	98	93	87	81	76	69	61	53	48	44	39	33	30	26	0
.50	0	0	0	0	0	0	0	1	17	54	103	151	183	194	156	127	109	100	95	88	82	76	70	62	54	48	44	40	33	30	26	0
.75	0	0	0	0	0	0	0	0	6	23	52	90	127	174	168	146	124	109	100	92	85	78	72	65	56	49	45	41	34	31	26	0
1.0	0	0	0	0	0	0	0	0	0	0	2	11	29	91	149	169	157	135	117	100	92	83	76	69	61	53	48	43	35	32	27	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7	33	81	128	155	155	130	109	94	83	75	68	60	53	47	39	33	28	2
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	34	72	112	145	139	114	93	82	74	67	60	52	43	35	29	9
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12	33	83	126	139	112	92	81	74	67	59	47	38	30	18
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	21	60	116	133	110	92	81	73	66	51	42	31	22

RAINFALL TYPE = III (* * * TC = 0.2 HR * * *) SHEET 2 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
	HYDROGRAPH TIME (HOURS)																															
IA/P = 0.10	* * * TC =0.3 HR * * *																															
0.0	25	31	44	84	124	181	287	441	498	451	358	276	204	118	87	70	63	58	54	48	44	39	34	29	24	22	20	17	14	13	11	0
.10	22	28	37	56	74	108	156	244	375	457	453	389	314	180	113	83	69	62	57	51	46	41	36	31	26	23	20	18	15	13	11	0
.20	21	27	35	53	67	94	136	208	319	411	439	406	345	212	130	91	73	64	59	52	46	42	36	31	26	23	21	18	15	13	11	0
.30	19	24	30	42	49	61	83	118	178	272	365	414	409	305	190	121	87	71	63	55	49	43	38	33	27	24	21	19	15	14	11	0
.40	18	23	29	40	46	56	74	103	153	232	321	383	400	329	217	138	96	75	65	57	50	44	38	33	28	24	21	19	15	14	11	0
.50	16	21	26	34	38	43	52	67	91	132	199	280	349	383	297	196	128	91	73	60	53	46	40	35	30	25	22	20	16	14	11	0
.75	14	18	23	30	33	37	43	52	66	91	131	187	251	347	331	260	182	126	92	68	57	49	42	36	31	26	23	21	16	14	12	0
1.0	11	15	18	23	25	28	30	33	38	44	54	71	98	192	296	334	294	221	154	94	69	55	45	40	34	29	25	22	17	15	12	0
1.5	7	9	12	15	17	18	19	21	23	25	27	30	33	45	75	137	222	287	300	233	149	84	57	47	40	35	30	25	20	16	13	3
2.0	4	6	8	11	12	13	14	15	16	17	19	20	22	26	33	46	76	131	201	278	258	165	85	57	46	40	34	29	22	17	13	7
2.5	2	3	5	7	7	8	9	10	10	11	12	13	14	17	20	24	29	39	60	125	213	260	177	94	60	47	40	35	25	20	14	9
3.0	1	2	3	4	5	5	6	6	7	8	8	9	10	12	14	16	19	23	29	48	95	195	247	167	93	60	47	40	29	22	15	10
IA/P = 0.30	* * * TC =0.3 HR * * *																															
0.0	0	0	0	6	22	58	146	308	424	422	367	303	234	145	111	92	84	79	74	67	62	57	50	43	36	33	30	26	22	20	17	0
.10	0	0	0	4	16	44	112	243	364	402	379	328	266	166	120	97	86	80	75	68	62	57	51	44	37	33	30	27	22	21	17	0
.20	0	0	0	3	12	33	86	190	306	370	376	344	292	189	132	103	89	82	77	69	63	58	51	44	37	34	30	27	23	21	17	0
.30	0	0	0	0	2	8	25	65	149	254	331	361	350	261	175	126	100	88	81	73	66	60	53	46	39	35	31	28	23	21	18	0
.40	0	0	0	0	1	6	19	50	116	208	290	338	346	282	195	138	107	91	83	74	67	60	54	47	40	35	32	28	23	21	18	0
.50	0	0	0	0	0	1	4	14	38	90	168	250	308	333	256	180	131	103	89	78	71	63	56	49	42	36	33	29	23	21	18	0
.75	0	0	0	0	0	0	2	6	17	43	89	150	213	299	286	229	171	129	104	85	75	65	58	51	44	38	34	30	24	22	18	0
1.0	0	0	0	0	0	0	0	0	1	3	9	24	53	153	253	288	257	200	150	105	85	72	62	55	48	41	36	32	26	22	19	0
1.5	0	0	0	0	0	0	0	0	0	0	0	1	2	15	59	138	217	258	248	187	130	91	71	62	55	48	41	36	29	23	19	3
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	36	90	159	239	227	158	97	74	63	55	48	42	32	26	20	10
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	37	113	194	224	151	96	73	62	55	48	36	29	21	14
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	24	78	176	211	145	95	73	62	54	41	32	22	15
IA/P = 0.50	* * * TC =0.3 HR * * *																															
0.0	0	0	0	0	0	2	33	116	193	221	221	200	165	129	110	99	95	92	87	81	77	72	65	56	49	45	41	37	32	30	25	0
.10	0	0	0	0	0	1	23	85	157	200	214	205	178	138	115	102	96	92	88	82	77	73	66	57	50	46	42	37	32	30	26	0
.20	0	0	0	0	0	1	15	62	125	175	201	203	187	147	121	105	98	94	89	83	78	73	66	58	50	46	42	38	32	30	26	0
.30	0	0	0	0	0	0	0	10	45	99	149	184	197	174	140	117	104	97	93	86	80	75	69	61	52	47	43	39	33	30	26	0
.40	0	0	0	0	0	0	0	7	32	76	125	164	189	179	148	123	107	99	94	87	81	76	69	62	53	48	44	39	33	30	26	0
.50	0	0	0	0	0	0	0	0	5	23	59	103	144	183	169	141	119	105	98	90	84	78	71	64	55	49	45	41	33	31	26	0
.75	0	0	0	0	0	0	0	0	2	9	27	55	89	148	168	156	135	117	105	94	87	80	73	66	58	51	46	42	34	31	27	0
1.0	0	0	0	0	0	0	0	0	0	0	1	4	14	59	119	157	163	145	126	105	95	85	77	71	63	55	49	44	36	32	27	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	3	19	56	103	139	151	138	116	97	85	77	70	62	54	48	40	33	28	3
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	21	52	91	135	143	120	96	84	76	69	61	54	44	35	29	11
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	22	65	112	136	117	96	83	75	68	60	48	39	30	19
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	45	102	131	114	95	83	75	67	53	43	31	22
RAINFALL TYPE = III	* * * TC = 0.3 HR * * *																															

SHEET 3 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =0.4 HR * * *																		IA/P = 0.10
0.0	23	29	39	65	91	132	198	308	422	449	417	345	274	162	108	82	68	61	57	50	45	41	35	30	25	22	20	18	15	13	11	0
.10	20	26	33	48	60	80	114	170	262	368	422	418	370	242	149	102	79	67	60	53	47	42	37	32	27	23	21	18	15	13	11	0
.20	20	25	32	45	55	72	100	147	224	320	388	408	383	272	171	114	85	70	62	54	48	43	37	32	27	23	21	19	15	14	11	0
.30	17	22	28	38	43	51	65	88	127	191	277	351	389	349	244	157	108	81	68	58	51	45	39	34	29	24	22	19	15	14	11	0
.40	17	21	27	36	41	47	59	79	111	165	240	314	378	359	268	178	120	88	72	60	52	45	40	34	29	25	22	20	15	14	11	0
.50	15	19	24	31	34	38	44	54	71	98	142	207	278	364	332	243	163	113	84	65	56	48	41	36	31	26	23	20	16	14	12	0
.75	12	16	20	25	27	30	33	38	44	54	70	97	138	249	333	320	257	185	131	85	65	53	44	39	33	28	24	22	17	14	12	0
1.0	11	13	17	22	23	25	28	30	34	38	46	57	75	145	245	322	311	255	188	114	77	58	47	41	35	30	26	23	18	15	12	1
1.5	6	9	11	14	15	17	18	19	21	23	25	27	30	39	59	105	180	255	292	257	176	98	61	48	41	36	31	26	20	16	13	4
2.0	4	6	8	10	11	12	13	14	15	16	17	19	20	24	30	39	61	103	166	253	272	189	98	61	48	41	35	30	23	18	13	8
2.5	2	3	4	6	7	7	8	9	10	10	11	12	13	16	18	22	26	34	49	100	183	255	198	108	66	50	42	36	26	20	14	9
3.0	1	1	2	4	4	5	5	6	6	7	8	8	9	11	13	15	18	21	26	40	77	169	243	185	106	65	49	41	30	23	15	10
IA/P = 0.30														* * * TC =0.4 HR * * *																		IA/P = 0.30
0.0	0	0	0	2	10	30	78	177	306	379	379	347	293	187	133	105	90	82	77	69	63	58	51	44	38	34	30	27	23	21	17	0
.10	0	0	0	2	7	22	59	138	250	336	365	353	313	212	146	112	94	84	78	71	64	59	52	45	38	34	31	27	23	21	17	0
.20	0	0	0	1	5	17	45	107	202	292	341	349	325	235	162	121	98	87	80	72	65	59	53	46	39	34	31	28	23	21	17	0
.30	0	0	0	0	1	4	12	34	83	162	249	310	336	298	215	152	116	96	85	76	68	61	55	48	41	36	32	29	23	21	18	0
.40	0	0	0	0	0	3	9	26	64	130	209	276	324	307	234	168	125	101	88	77	70	62	55	49	41	36	32	29	23	21	18	0
.50	0	0	0	0	0	0	2	7	19	49	103	173	242	313	285	216	157	119	98	82	73	65	57	51	44	37	33	30	24	22	18	0
.75	0	0	0	0	0	0	1	3	9	23	52	97	153	253	285	253	199	151	118	91	78	68	59	53	46	39	35	31	25	22	18	0
1.0	0	0	0	0	0	0	0	0	0	1	4	13	30	104	204	276	276	226	175	120	92	75	64	57	50	43	37	33	26	22	19	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	1	8	36	98	177	236	250	207	148	99	75	63	56	49	42	37	29	24	19	4
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	22	62	124	210	232	176	107	78	65	57	50	43	33	27	20	11
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	24	85	167	219	167	106	77	64	56	49	37	29	21	14
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	15	58	152	207	159	104	76	64	55	42	33	22	15
IA/P = 0.50														* * * TC =0.4 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	10	54	121	182	204	204	191	146	121	106	98	94	90	83	78	73	66	58	50	46	42	38	32	30	26	0
.10	0	0	0	0	0	0	7	38	94	153	187	198	193	155	128	110	100	95	91	84	79	74	67	59	51	46	42	38	32	30	26	0
.20	0	0	0	0	0	0	5	27	71	126	166	187	191	164	134	114	103	96	92	85	80	75	68	60	52	47	43	38	33	30	26	0
.30	0	0	0	0	0	0	0	3	19	54	102	145	173	185	155	129	111	101	95	88	82	76	70	62	54	48	44	40	33	31	26	0
.40	0	0	0	0	0	0	0	2	13	40	81	124	157	180	161	135	116	104	97	90	83	77	71	63	55	49	44	40	33	31	26	0
.50	0	0	0	0	0	0	0	0	1	9	30	64	104	163	174	154	130	113	102	93	86	79	73	66	57	50	46	42	34	31	27	0
.75	0	0	0	0	0	0	0	0	0	3	13	32	59	120	157	162	145	126	111	98	90	82	75	68	60	52	47	43	35	31	27	0
1.0	0	0	0	0	0	0	0	0	0	0	0	2	6	36	90	138	158	152	135	112	98	88	79	72	65	56	50	45	37	32	27	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	37	80	121	148	143	123	102	87	78	71	64	56	49	41	34	28	4
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	36	71	121	140	126	101	86	78	70	63	55	44	36	29	13
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	14	49	97	135	122	100	86	77	70	62	49	40	30	20
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	33	88	130	119	98	85	76	69	54	44	32	22

RAINFALL TYPE = III * * * TC = 0.4 HR * * * SHEET 4 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

TRVL TIME (HR) — HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =0.5 HR * * *																		IA/P = 0.10
0.0	21	27	35	54	70	97	144	217	316	397	411	388	330	214	139	99	78	67	60	52	47	42	36	31	26	23	21	18	15	13	11	0
.10	19	24	30	43	50	64	86	125	186	273	355	392	390	296	194	129	94	75	65	56	49	43	38	33	28	24	21	19	15	14	11	0
.20	18	23	29	40	47	58	77	109	161	235	315	367	382	318	218	145	103	80	68	57	50	44	39	33	28	24	22	19	15	14	11	0
.30	16	21	26	34	38	44	53	69	95	139	203	278	337	367	289	199	135	98	77	62	54	46	40	35	30	25	22	20	16	14	11	0
.40	16	20	25	33	36	41	49	62	84	121	176	244	306	358	306	220	151	107	83	64	55	47	41	35	30	25	23	20	16	14	12	0
.50	14	18	22	28	31	35	39	46	57	75	106	152	213	323	346	282	202	140	102	73	59	50	42	37	32	27	23	21	16	14	12	0
.75	12	16	20	25	28	30	34	38	45	56	75	104	145	246	319	308	252	187	135	89	67	53	44	39	33	28	24	22	17	14	12	0
1.0	10	12	16	20	22	23	25	28	31	34	39	47	60	110	197	280	309	279	220	138	90	63	49	42	37	31	26	23	18	15	12	1
1.5	6	8	10	13	14	15	17	18	19	21	23	25	27	34	49	82	143	218	283	271	203	116	68	51	43	37	32	27	21	16	13	4
2.0	3	5	7	9	10	11	12	13	14	15	16	17	19	22	27	34	50	82	135	226	265	211	114	67	50	42	37	31	23	18	13	8
2.5	2	3	4	6	7	7	8	9	10	10	11	12	13	16	18	22	26	34	50	102	182	249	197	111	67	50	42	36	26	20	14	9
3.0	1	1	2	3	4	4	5	5	6	6	7	8	8	10	12	14	16	19	23	34	63	144	238	201	121	72	52	43	31	23	15	10
IA/P = 0.30														* * * TC =0.5 HR * * *																		IA/P = 0.30
0.0	0	0	0	1	4	15	40	101	198	295	345	345	325	232	161	122	100	88	80	72	65	59	53	46	39	34	31	28	23	21	18	0
.10	0	0	0	1	3	11	30	77	158	249	313	335	329	253	178	132	106	91	82	73	66	60	53	47	40	35	31	28	23	21	18	0
.20	0	0	0	0	2	8	23	59	125	208	278	316	324	271	196	144	112	95	85	75	67	61	54	47	40	35	32	28	23	21	18	0
.30	0	0	0	0	0	2	6	17	45	98	171	242	291	313	249	182	136	108	92	80	71	63	56	49	42	36	33	29	24	21	18	0
.40	0	0	0	0	0	1	4	13	34	77	140	208	264	304	263	198	148	115	97	81	72	64	57	50	43	37	33	30	24	21	18	0
.50	0	0	0	0	0	0	1	3	10	26	60	113	177	276	295	244	185	140	111	88	77	67	59	52	45	39	34	31	24	22	18	0
.75	0	0	0	0	0	0	0	1	4	12	29	60	104	204	271	263	222	174	136	101	83	70	61	54	47	40	35	32	25	22	18	0
1.0	0	0	0	0	0	0	0	0	0	1	2	6	16	67	155	235	263	242	198	138	102	80	66	58	51	44	38	34	27	23	19	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	22	67	138	205	241	221	167	110	79	66	58	51	44	38	30	24	20	5
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	42	93	182	225	191	119	83	67	58	51	44	34	27	21	12
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	15	62	139	213	180	117	82	67	58	51	38	30	22	15
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	41	127	203	171	114	81	66	57	43	33	23	16
IA/P = 0.50														* * * TC =0.5 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	3	24	68	124	174	190	190	162	133	114	103	97	92	85	80	75	68	60	52	47	43	39	33	30	26	0
.10	0	0	0	0	0	0	2	17	51	100	149	177	186	169	14C	119	106	99	93	86	81	75	69	61	52	47	43	39	33	30	26	0
.20	0	0	0	0	0	0	1	12	38	79	126	160	181	173	147	124	109	101	95	88	81	76	69	62	53	48	44	39	33	30	26	0
.30	0	0	0	0	0	0	0	1	8	28	62	105	141	176	165	141	120	107	99	91	84	78	71	64	56	49	45	41	33	31	26	0
.40	0	0	0	0	0	0	0	1	6	20	48	86	123	172	172	146	125	111	101	92	85	79	72	65	56	50	45	41	34	31	26	0
.50	0	0	0	0	0	0	0	0	4	15	37	70	105	157	167	151	130	114	104	94	87	79	73	66	57	50	46	42	34	31	27	0
.75	0	0	0	0	0	0	0	0	0	1	6	17	37	91	139	157	150	134	119	103	93	84	76	69	62	54	48	44	35	32	27	0
1.0	0	0	0	0	0	0	0	0	0	0	1	3	9	40	91	135	153	149	135	113	99	88	79	72	65	57	50	45	37	32	27	1
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	24	59	101	132	144	130	107	90	80	73	65	57	51	41	34	29	6
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	25	55	106	138	130	105	89	79	72	65	57	45	37	30	15
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	36	81	133	133	104	88	79	71	64	50	41	31	21
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	24	74	128	122	103	88	78	70	55	45	32	23

RAINFALL TYPE = III — * * * TC = 0.5 HR * * * — SHEET 5 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

IRVL TIME (HR) — HYDROGRAPH TIME (HOURS)

IA/P = 0.10 — * * * TC =0.75 HR * * *

IRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	17	22	28	39	45	56	73	104	151	215	281	328	343	310	228	163	121	94	77	63	53	45	39	34	29	25	22	20	15	14	11	0
.10	17	21	27	37	42	51	66	91	131	187	250	302	336	319	247	179	131	101	82	65	55	46	40	35	29	25	22	20	16	14	11	0
.20	15	19	24	31	35	40	48	60	81	114	163	221	275	328	298	229	167	124	96	73	60	49	42	36	31	26	23	20	16	14	12	0
.30	14	18	23	30	33	38	44	55	72	100	142	194	248	320	305	245	182	135	103	76	62	50	42	37	31	27	23	21	16	14	12	0
.40	13	16	21	26	29	32	36	41	50	65	88	124	171	268	313	288	228	170	127	88	68	54	44	38	33	28	24	21	17	14	12	0
.50	12	16	20	25	28	30	34	39	46	59	78	109	150	244	306	294	242	184	138	94	71	56	45	39	34	28	24	22	17	14	12	0
.75	10	13	16	21	23	25	27	30	33	38	46	58	77	140	221	277	287	248	197	133	92	66	50	42	36	31	26	23	18	15	12	1
1.0	8	10	13	16	18	19	21	23	25	27	30	34	39	61	109	181	249	280	265	198	134	85	58	46	40	34	29	25	20	16	12	2
1.5	5	7	9	12	13	14	15	16	17	19	20	22	24	30	40	63	106	167	225	261	226	147	84	58	46	39	34	29	22	17	13	5
2.0	2	4	5	7	8	9	9	10	11	12	13	14	16	18	22	26	34	50	80	155	226	246	158	91	61	47	40	34	25	20	14	9
2.5	1	2	3	5	5	6	6	7	8	8	9	10	11	13	15	18	21	26	34	62	120	209	234	151	90	60	47	39	29	22	15	10
3.0	0	1	2	3	3	3	4	4	5	5	6	7	7	9	10	12	15	17	21	29	50	113	209	224	144	88	59	46	33	25	16	10

IA/P = 0.30 — * * * TC =0.75 HR * * *

IRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	1	3	8	24	58	113	182	243	283	287	233	178	139	114	98	83	73	64	56	50	43	37	33	30	24	21	18	0
.10	0	0	0	0	0	2	6	18	45	91	151	212	259	284	245	191	149	120	102	85	75	65	57	50	43	37	33	30	24	21	18	0
.20	0	0	0	0	0	0	1	5	14	35	72	125	183	263	277	230	180	142	116	93	80	68	59	52	45	39	34	31	25	22	18	0
.30	0	0	0	0	0	0	1	3	10	26	57	102	156	245	270	240	192	151	122	96	82	69	60	53	46	39	35	31	25	22	18	0
.40	0	0	0	0	0	0	0	1	2	8	20	45	83	182	252	264	226	181	144	108	89	73	62	55	48	41	36	32	26	22	19	0
.50	0	0	0	0	0	0	0	0	2	6	15	35	67	158	235	259	235	192	153	113	92	75	63	56	49	42	36	33	26	22	19	1
.75	0	0	0	0	0	0	0	0	0	0	1	2	7	35	100	178	232	242	217	163	121	90	71	61	54	47	40	35	28	23	19	2
1.0	0	0	0	0	0	0	0	0	0	0	0	1	4	21	68	140	205	236	229	181	135	97	74	63	55	48	41	36	29	24	19	3
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	13	42	94	155	221	212	158	103	77	64	56	49	42	33	26	20	10
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	15	42	113	184	209	151	101	76	63	55	48	36	29	21	14
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	27	80	168	199	146	100	75	63	55	41	32	22	15
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	56	154	191	151	105	78	64	48	37	24	16

IA/P = 0.50 — * * * TC =0.75 HR * * *

IRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
0.0	0	0	0	0	0	0	0	3	13	37	71	108	140	167	156	136	120	108	101	92	85	78	72	64	56	50	45	41	34	31	26	0
.10	0	0	0	0	0	0	0	2	10	28	57	91	124	163	158	140	124	111	103	94	86	79	72	65	57	50	46	41	34	31	27	0
.20	0	0	0	0	0	0	0	0	1	7	21	45	76	135	159	153	136	120	109	98	90	82	74	67	59	52	47	43	35	31	27	0
.30	0	0	0	0	0	0	0	0	1	5	15	35	62	121	157	157	140	124	112	100	91	83	75	68	60	52	47	43	35	31	27	0
.40	0	0	0	0	0	0	0	0	1	3	11	27	50	107	146	154	143	128	115	102	93	84	76	69	61	53	48	43	35	32	27	0
.50	0	0	0	0	0	0	0	0	0	0	2	8	21	66	118	148	152	139	125	108	97	87	78	71	63	55	49	45	36	32	27	1
.75	0	0	0	0	0	0	0	0	0	0	1	4	10	38	82	122	142	144	133	116	103	91	80	73	66	58	51	46	37	32	28	1
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	24	60	102	132	142	133	116	99	86	77	70	62	55	49	40	33	28	3
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	25	55	91	128	136	119	98	85	77	69	62	54	44	36	29	11
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	25	66	109	131	116	97	85	76	69	61	48	39	30	18
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	47	100	127	114	96	84	75	68	53	43	31	22
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	44	102	124	112	95	83	75	59	47	33	23

RAINFALL TYPE = III — * * * TC = 0.75 HR * * *

SHEET 6 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 * * * TC =1.0 HR * * * IA/P = 0.10																																
0.0	15	19	24	32	37	44	54	71	98	136	181	227	264	297	270	215	164	128	103	78	64	52	43	36	31	26	23	21	16	14	12	0
.10	13	17	22	28	31	35	41	49	64	87	120	161	205	273	289	254	201	155	122	90	71	56	45	38	33	28	24	21	17	14	12	0
.20	13	16	21	27	29	33	38	46	58	77	105	142	184	257	285	263	214	167	130	95	74	57	46	39	33	28	24	22	17	14	12	0
.30	12	16	20	26	28	31	36	42	53	69	93	126	165	240	279	268	225	178	139	100	77	59	47	39	34	29	25	22	17	15	12	1
.40	11	14	18	23	25	27	30	34	40	48	62	83	112	185	251	276	256	213	163	118	87	65	50	41	35	30	26	23	18	15	12	1
.50	11	13	17	22	24	26	29	32	37	45	56	74	99	167	235	270	261	223	179	126	92	67	51	42	36	31	26	23	18	15	12	1
.75	8	10	13	17	18	19	21	23	25	28	31	36	44	72	122	186	239	258	243	189	136	90	62	48	40	34	29	25	20	16	12	2
1.0	6	9	11	14	15	17	18	20	21	23	25	28	32	46	75	124	185	234	253	226	170	110	71	53	43	37	31	27	21	16	13	4
1.5	4	6	8	10	11	12	13	14	15	16	17	19	21	25	32	46	74	118	170	230	239	179	108	70	52	43	36	31	23	18	13	7
2.0	2	3	4	6	7	7	8	9	10	10	11	12	13	16	18	22	28	38	58	111	179	228	185	116	75	54	44	37	27	21	14	9
2.5	1	1	2	4	4	5	5	6	6	7	8	8	9	11	13	15	18	22	28	46	87	167	219	176	113	73	54	43	31	23	15	10
3.0	0	0	1	2	2	2	3	3	3	4	4	5	5	7	8	10	12	14	16	21	32	68	156	210	179	120	78	56	37	27	16	11
IA/P = 0.30 * * * TC =1.0 HR * * * IA/P = 0.30																																
0.0	0	0	0	0	0	1	5	13	30	57	95	141	186	243	249	213	174	142	119	97	83	70	60	53	46	39	35	31	25	22	18	0
.10	0	0	0	0	0	1	3	10	23	46	79	120	164	230	245	221	183	150	125	101	85	72	61	53	46	40	35	31	25	22	18	0
.20	0	0	0	0	0	0	1	3	7	18	36	65	102	183	233	241	210	174	144	112	92	76	64	56	48	42	36	33	26	22	19	1
.30	0	0	0	0	0	0	1	2	6	14	29	53	86	163	221	237	217	183	151	117	95	78	65	56	49	42	37	33	26	22	19	1
.40	0	0	0	0	0	0	0	0	1	4	11	23	43	107	180	225	233	207	175	133	105	84	68	59	51	44	38	34	27	23	19	1
.50	0	0	0	0	0	0	0	0	1	3	8	18	34	91	162	214	230	213	183	139	109	86	70	60	52	45	39	34	27	23	19	1
.75	0	0	0	0	0	0	0	0	0	0	1	4	9	33	82	145	196	218	211	174	135	101	77	64	56	48	42	37	29	24	19	3
1.0	0	0	0	0	0	0	0	0	0	0	0	1	2	11	37	85	144	192	214	199	160	116	85	69	59	51	44	38	30	25	20	5
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	23	56	104	174	203	177	123	89	71	60	52	45	35	27	21	11
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	24	73	139	194	169	120	87	70	59	51	39	30	22	14
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	15	51	127	186	162	117	86	69	59	44	34	23	16
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	35	117	180	164	122	90	71	51	39	25	16
IA/P = 0.50 * * * TC =1.0 HR * * * IA/P = 0.50																																
0.0	0	0	0	0	0	0	0	2	6	17	34	57	83	127	151	142	130	118	109	99	91	83	75	68	59	52	47	43	35	31	27	1
.10	0	0	0	0	0	0	0	1	5	13	27	47	71	117	146	144	133	121	112	101	92	84	76	68	60	53	48	43	35	32	27	1
.20	0	0	0	0	0	0	0	1	3	10	21	38	60	106	138	143	135	124	114	102	94	85	76	69	61	54	48	44	35	32	27	1
.30	0	0	0	0	0	0	0	0	0	2	7	16	31	73	114	139	142	132	121	108	98	88	79	71	64	56	50	45	36	32	27	1
.40	0	0	0	0	0	0	0	0	0	2	5	13	25	62	104	133	140	134	124	110	99	89	80	72	64	56	50	45	37	32	27	1
.50	0	0	0	0	0	0	0	0	0	0	1	4	10	35	74	112	134	138	131	117	104	93	82	74	67	59	52	47	38	33	28	2
.75	0	0	0	0	0	0	0	0	0	0	0	2	5	19	48	[illegible]	115	131	134	123	110	97	85	77	69	61	54	48	39	33	28	3
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	21	49	84	113	129	132	119	103	89	80	72	64	56	50	41	34	28	5
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	21	46	75	113	128	120	102	88	79	71	63	56	45	37	29	12
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	14	42	82	119	124	104	90	80	72	64	50	41	31	20
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	29	75	117	121	102	89	79	71	56	45	32	23
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	28	80	113	118	101	88	79	63	49	34	24

RAINFALL TYPE = III * * * TC = 1.0 HR * * * SHEET 7 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =1.25 HR * * *																		IA/P = 0.10
0.0	13	17	22	28	32	37	44	56	75	100	133	170	206	255	264	236	194	155	125	95	75	59	47	39	33	28	24	22	17	14	12	1
.10	13	16	21	27	30	34	41	51	67	89	118	152	188	243	261	243	204	164	133	100	79	61	48	40	34	29	25	22	17	15	12	1
.20	11	15	18	24	26	29	33	38	47	60	79	105	137	203	248	256	232	193	156	115	88	67	51	42	35	30	26	23	18	15	12	1
.30	11	14	18	23	25	27	31	36	43	54	71	94	122	187	237	254	238	203	165	121	92	69	53	43	36	30	26	23	18	15	12	1
.40	10	12	16	20	22	24	26	29	34	40	49	64	84	140	201	242	250	228	193	142	106	77	57	46	38	32	27	24	19	15	12	1
.50	9	12	15	19	21	23	25	28	32	37	45	58	75	126	186	232	248	233	201	150	111	80	58	47	39	33	28	24	19	15	12	2
.75	8	11	14	17	19	20	22	24	27	31	36	44	56	93	144	196	230	237	220	174	131	91	64	50	41	34	29	25	20	16	12	2
1.0	6	8	11	14	15	16	17	19	20	22	25	28	32	46	74	119	170	213	234	218	174	120	79	58	46	38	32	27	21	17	13	4
1.5	3	5	7	9	9	10	11	12	13	14	16	17	18	22	27	38	58	91	134	197	223	194	128	83	60	47	39	33	24	19	14	7
2.0	2	3	4	6	6	7	8	8	9	10	11	12	13	15	18	22	27	38	57	106	166	214	184	124	82	59	47	39	28	21	14	9
2.5	1	1	2	3	3	4	4	5	5	6	7	7	8	10	11	13	16	19	24	38	68	137	206	186	130	87	62	48	33	24	15	10
3.0	0	0	1	2	2	2	2	3	3	4	4	5	5	6	8	9	11	13	16	21	31	66	145	200	178	126	85	61	39	28	17	11
IA/P = 0.30														* * * TC =1.25 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	1	2	7	18	35	61	94	130	192	222	218	191	161	136	110	93	77	65	56	48	41	36	32	26	22	19	1
.10	0	0	0	0	0	1	2	5	14	28	50	79	113	177	214	219	197	168	142	115	96	79	66	57	49	42	37	33	26	22	19	1
.20	0	0	0	0	0	0	1	4	10	22	41	66	97	162	205	217	202	175	149	119	99	81	67	58	50	43	37	33	26	23	19	1
.30	0	0	0	0	0	0	0	1	3	8	17	33	55	115	174	208	214	195	168	133	108	87	70	60	52	45	39	34	27	23	19	2
.40	0	0	0	0	0	0	0	1	2	6	14	26	45	100	159	200	212	199	174	138	112	89	72	61	53	45	39	35	28	23	19	2
.50	0	0	0	0	0	0	0	0	1	2	5	11	21	60	116	170	203	209	192	156	124	97	76	64	55	47	41	36	29	24	19	3
.75	0	0	0	0	0	0	0	0	0	1	2	5	11	35	79	131	175	201	201	172	140	107	82	67	58	50	43	37	30	24	20	4
1.0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	23	57	105	153	186	198	172	131	95	75	63	54	47	41	32	25	20	7
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	24	54	96	157	189	174	127	94	74	63	54	46	35	28	21	12
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	24	69	127	182	167	124	93	74	62	53	40	31	22	15
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	35	99	176	167	129	96	76	63	46	35	23	16
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	34	107	171	161	125	94	75	53	40	25	17
IA/P = 0.50														* * * TC =1.25 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	1	4	10	21	36	55	95	123	138	131	122	114	104	95	86	78	70	62	55	49	44	36	32	27	1
.10	0	0	0	0	0	0	0	0	1	3	8	16	30	66	102	125	134	128	120	108	99	89	80	73	65	57	51	46	37	32	28	2
.20	0	0	0	0	0	0	0	0	0	2	6	13	24	57	94	120	132	130	122	110	101	91	81	73	66	58	51	46	37	33	28	2
.30	0	0	0	0	0	0	0	0	0	1	4	10	19	49	85	113	131	131	124	112	102	92	82	74	66	58	52	47	38	33	28	2
.40	0	0	0	0	0	0	0	0	0	1	3	8	16	42	76	106	126	130	125	114	104	93	83	75	67	59	52	47	38	33	28	3
.50	0	0	0	0	0	0	0	0	0	0	1	2	6	22	51	84	112	127	129	120	109	97	86	77	70	61	54	49	40	33	28	4
.75	0	0	0	0	0	0	0	0	0	0	0	1	3	12	32	61	91	113	125	123	114	101	89	80	72	64	56	50	41	34	28	5
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	22	47	76	102	122	124	111	96	85	76	69	61	54	43	36	29	9
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	22	43	82	111	121	109	95	84	76	68	60	48	39	30	16
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	9	30	63	104	118	107	94	83	75	67	53	43	31	21
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	20	58	104	116	106	93	83	74	59	47	33	23
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	19	64	104	114	104	92	82	65	52	35	24

RAINFALL TYPE = III * * * TC = 1.25 HR * * * SHEET 8 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10 * * * TC =1.5 HR * * * IA/P = 0.10																																
0.0	12	15	19	25	27	31	37	45	57	75	97	122	151	203	231	238	213	182	150	115	91	70	54	44	37	30	26	23	18	15	12	1
.10	10	13	17	21	23	26	29	34	41	52	67	87	111	165	210	233	227	205	173	131	102	77	58	46	39	32	27	24	19	15	12	1
.20	10	13	16	21	23	25	28	32	38	47	61	78	100	152	199	228	231	210	181	138	107	80	59	47	39	33	28	24	19	15	12	2
.30	9	12	15	20	22	24	27	30	36	44	55	70	90	139	188	221	228	215	188	145	112	83	61	48	40	33	28	24	19	15	12	2
.40	8	11	14	18	19	21	23	25	29	33	40	50	64	103	152	196	223	226	208	166	127	92	66	52	42	35	30	25	20	16	13	2
.50	8	10	13	17	18	20	22	24	27	31	37	46	58	93	140	186	216	224	212	173	133	96	69	53	43	36	30	26	20	16	13	3
.75	6	8	11	14	15	16	18	19	21	23	26	31	36	55	87	130	173	205	217	202	165	119	81	60	48	39	33	28	21	17	13	4
1.0	5	6	8	11	12	13	14	15	16	18	19	21	24	31	46	71	109	151	189	214	200	153	102	72	55	44	37	31	23	18	13	6
1.5	3	4	5	7	8	9	10	11	11	12	14	15	16	19	24	31	45	69	103	159	207	207	147	99	71	54	44	36	26	20	14	8
2.0	1	2	3	5	5	6	6	7	8	9	9	10	11	13	16	19	23	31	45	81	132	189	199	142	97	69	53	43	30	22	15	10
2.5	0	1	1	2	3	3	4	4	4	5	6	6	7	8	10	12	14	17	20	31	53	107	179	194	147	102	73	55	36	26	16	10
3.0	0	0	1	1	1	2	2	2	3	3	3	4	4	5	7	8	10	11	13	18	26	51	116	178	188	142	100	71	43	30	18	11
IA/P = 0.30 * * * TC =1.5 HR * * * IA/P = 0.30																																
0.0	0	0	0	0	0	1	2	5	11	22	38	59	84	138	180	200	195	176	154	125	105	86	71	60	52	44	39	34	27	23	19	2
.10	0	0	0	0	0	0	0	1	4	9	18	31	50	99	149	184	198	190	170	139	115	93	75	63	55	47	40	35	28	23	19	3
.20	0	0	0	0	0	0	0	1	3	7	14	25	41	86	137	176	195	192	175	144	119	95	76	64	55	47	41	36	28	24	19	3
.30	0	0	0	0	0	0	0	0	1	2	5	11	21	53	100	147	181	194	187	159	130	103	81	68	58	50	43	37	29	24	19	4
.40	0	0	0	0	0	0	0	0	0	2	4	9	17	45	88	136	172	192	189	164	135	106	83	69	59	51	43	38	30	24	20	4
.50	0	0	0	0	0	0	0	0	0	0	1	3	7	23	56	101	145	177	190	177	149	116	89	73	62	53	45	39	31	25	20	6
.75	0	0	0	0	0	0	0	0	0	0	0	1	3	13	35	71	113	151	176	184	162	128	97	77	65	55	48	41	32	26	20	7
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	24	53	92	132	174	182	153	114	88	72	61	52	45	34	27	21	10
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	24	50	103	152	175	148	112	87	71	60	51	38	30	22	14
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	24	62	127	170	151	116	89	73	61	45	34	23	16
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	16	58	131	165	146	113	88	72	52	39	25	16
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16	67	134	161	142	111	87	60	44	27	17
IA/P = 0.50 * * * TC =1.5 HR * * * IA/P = 0.50																																
0.0	0	0	0	0	0	0	0	1	2	6	13	22	34	65	94	114	129	122	117	108	100	91	81	74	66	58	52	46	38	33	28	2
.10	0	0	0	0	0	0	0	0	0	2	5	10	18	42	73	99	116	126	121	112	104	94	84	76	68	60	53	48	39	33	28	3
.20	0	0	0	0	0	0	0	0	0	1	4	8	15	36	65	93	112	123	122	113	105	95	85	77	69	61	54	48	39	34	28	4
.30	0	0	0	0	0	0	0	0	0	0	1	3	6	20	44	72	97	114	122	118	109	99	88	79	71	63	56	50	41	34	28	5
.40	0	0	0	0	0	0	0	0	0	0	1	2	5	16	38	65	91	110	121	119	110	100	89	80	72	64	57	51	41	34	29	5
.50	0	0	0	0	0	0	0	0	0	0	0	1	4	13	33	59	85	105	118	120	112	101	90	81	73	65	57	51	41	35	29	6
.75	0	0	0	0	0	0	0	0	0	0	0	1	2	7	20	41	66	89	107	118	115	105	93	83	75	67	60	53	43	35	29	8
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	14	31	53	78	106	117	113	100	89	80	72	64	57	46	37	30	12
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	14	29	60	91	115	111	99	88	79	71	63	50	41	31	18
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	20	45	85	113	109	98	87	78	70	56	45	32	22
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	42	87	111	107	97	86	78	62	49	34	24
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	39	82	109	109	98	87	70	56	37	25

RAINFALL TYPE = III * * * TC = 1.5 HR * * * SHEET 9 OF 10

Exhibit 5-III, continued: Tabular hydrograph unit discharges (csm/in) for type III rainfall distribution

HYDROGRAPH TIME (HOURS)

TRVL TIME (HR)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
IA/P = 0.10														* * * TC =2.0 HR * * *																		IA/P = 0.10
0.0	9	11	15	19	21	23	27	31	39	48	60	75	91	129	164	187	200	191	178	147	119	92	69	55	45	37	31	26	20	16	13	3
.10	8	10	13	17	18	20	22	25	29	36	44	55	68	101	139	170	189	197	188	163	132	101	75	59	47	39	33	28	21	17	13	3
.20	7	10	13	16	18	19	21	24	28	33	40	50	62	93	129	162	185	195	190	168	137	104	77	60	48	40	33	28	21	17	13	4
.30	7	9	12	15	17	18	20	23	26	31	37	46	56	85	120	154	179	193	191	172	142	108	80	62	49	41	34	29	21	17	13	4
.40	6	8	11	14	15	16	18	19	22	25	29	34	42	64	94	129	161	183	192	183	157	120	87	66	53	43	36	30	22	17	13	5
.50	6	8	10	13	14	16	17	19	21	23	27	32	38	58	87	121	153	177	191	185	162	124	90	68	54	44	36	31	22	18	13	5
.75	5	6	8	11	12	13	14	15	16	18	20	23	26	37	55	81	113	144	169	186	179	147	106	78	61	49	40	33	24	19	14	6
1.0	4	5	7	9	10	11	12	13	14	15	17	18	20	27	38	56	82	113	143	176	185	164	121	88	67	53	43	36	26	20	14	7
1.5	2	3	4	5	6	7	7	8	9	10	10	11	12	15	18	23	31	45	65	106	148	180	166	126	92	69	55	44	31	23	15	9
2.0	1	1	2	3	4	4	5	5	6	6	7	8	8	10	12	14	18	23	31	52	87	139	176	160	122	90	68	54	36	26	16	10
2.5	0	0	1	2	2	2	2	3	3	4	4	5	5	6	7	9	11	13	16	22	36	71	132	172	161	126	94	71	45	31	18	11
3.0	0	0	0	1	1	1	1	1	2	2	2	3	3	4	5	6	7	9	10	14	19	35	78	136	168	156	123	92	54	36	20	11
IA/P = 0.30														* * * TC =2.0 HR * * *																		IA/P = 0.30
0.0	0	0	0	0	0	0	1	2	6	11	18	29	41	75	111	140	159	170	163	145	124	103	84	70	60	51	44	39	30	25	20	4
.10	0	0	0	0	0	0	0	1	2	4	9	15	24	50	84	118	145	160	167	155	134	110	89	74	63	54	46	40	31	25	20	5
.20	0	0	0	0	0	0	0	0	1	3	7	12	20	43	76	110	138	157	165	157	138	113	91	75	64	55	47	41	32	26	20	5
.30	0	0	0	0	0	0	0	0	1	3	5	10	17	38	68	101	131	152	164	159	141	116	93	77	65	56	48	41	32	26	20	6
.40	0	0	0	0	0	0	0	0	0	1	2	4	8	22	45	76	109	137	155	163	151	125	99	81	68	58	50	43	33	26	20	7
.50	0	0	0	0	0	0	0	0	0	1	1	3	7	18	39	69	101	130	151	162	153	128	101	83	69	59	51	44	34	27	20	7
.75	0	0	0	0	0	0	0	0	0	0	0	1	2	6	17	36	63	93	122	151	158	143	114	92	76	64	55	47	36	28	21	9
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	18	37	63	93	132	157	153	125	100	82	68	58	50	38	29	21	11
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	12	26	59	100	142	154	128	102	83	70	59	44	34	23	15
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	18	43	93	142	150	125	101	82	69	50	38	24	16
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	12	41	98	141	147	122	99	81	58	43	26	17
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	38	92	135	144	124	102	69	50	30	18
IA/P = 0.50														* * * TC =2.0 HR * * *																		IA/P = 0.50
0.0	0	0	0	0	0	0	0	0	1	3	6	11	16	33	54	75	91	102	114	114	103	96	87	79	72	64	57	51	41	35	29	6
.10	0	0	0	0	0	0	0	0	1	2	5	9	14	29	49	70	87	99	106	113	104	97	88	80	72	65	58	52	42	35	29	6
.20	0	0	0	0	0	0	0	0	0	1	2	4	7	18	34	54	74	90	101	112	107	99	90	82	75	67	60	53	43	36	29	8
.30	0	0	0	0	0	0	0	0	0	0	1	3	6	15	30	49	69	86	98	111	108	100	91	83	75	68	60	54	43	36	29	8
.40	0	0	0	0	0	0	0	0	0	0	0	1	2	8	19	35	55	73	89	105	110	103	94	86	78	70	62	56	45	37	30	10
.50	0	0	0	0	0	0	0	0	0	0	0	1	2	6	16	31	50	69	85	102	109	104	95	86	78	71	63	56	45	37	30	11
.75	0	0	0	0	0	0	0	0	0	0	0	0	1	4	10	21	37	55	73	93	107	107	97	89	81	73	65	58	47	38	30	13
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	15	29	46	72	93	107	103	94	86	78	70	62	50	40	31	16
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	7	15	34	59	89	105	101	93	85	77	69	55	44	32	21
2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	25	55	90	104	100	92	84	76	61	49	34	23
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	24	59	91	103	99	91	83	68	54	36	25
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	28	62	91	101	98	90	75	60	39	26

RAINFALL TYPE = III * * * TC = 2.0 HR * * * SHEET 10 OF 10

Chapter 6: Storage volume for detention basins

As rural areas become urbanized, the resulting increases in peak discharges can adversely affect downstream flood plains. Increasingly, planners, developers, and the public want these downstream areas to be protected. Many local governments are adopting ordinances to control the type of development and its allowable impacts on the watershed. One of the most common controls requires that postdevelopment discharges do not exceed present-condition discharges for one or more storm frequencies at specified points along a channel.

This chapter discusses ways to manage peak discharges by delaying runoff. It also presents a procedure for estimating the storage capacity required to maintain the peaks within a specified level.

Efforts to reduce the effects of increased runoff from urban areas have been innovative and diverse. Many methods have been used effectively, such as infiltration trenches, porous pavement, rooftop storage, and cisterns. But these solutions can be expensive or require site conditions that cannot be provided.

The detention basin is the most widely used measure for controlling peak discharge. It is generally the least expensive and most reliable of the measures that have been considered. It can be designed to fit a wide variety of sites and can accommodate multiple-outlet spillways to meet requirements for multifrequency control of outflow. Measures other than a detention basin may be preferred in some locations; their omission here is not intended to discourage their use. Any device selected, however, should be assessed as to its function, maintenance needs, and impact.

Estimating the effect of storage

When a detention basin is installed, hydraulic routing procedures can be used to estimate the effect on hydrographs. Both the TR-20 (SCS 1983) and DAMS2 (SCS 1982) computer programs provide accurate methods of analysis. Programmable calculator and computer programs are available for routing hydrographs through dams.

This chapter contains a manual method for quick estimates of the effects of temporary detention on peak discharges. The method is based on average storage and routing effects for many structures.

Figure 6-1 relates two ratios: peak outflow to peak inflow discharge (q_o/q_i) and storage volume to runoff volume (V_s/V_r) for all four rainfall distributions.

The relationships in figure 6-1 were determined on the basis of single stage outflow devices. Some were controlled by pipe flow, others by weir flow. Verification runs were made using multiple stage outflow devices, and the variance was similar to that in the base data. The method can therefore be used for both single- and multiple-stage outflow devices. The only constraints are that (1) each stage requires a design storm and a computation of the storage required for it and (2) the discharge of the upper stage(s) includes the discharge of the lower stage(s).

The brevity of the procedure allows the planner to examine many combinations of detention basins. When combined with the Tabular Hydrograph method, the procedure's usefulness is increased. Its principal use is to develop preliminary indications of storage adequacy and to allocate control to a group of detention basins. It is also adequate, however, for final design of small detention basins.

Input requirements and procedures

Use figure 6-1 to estimate storage volume (V_s) required or peak outflow discharge (q_o). The most frequent application is to estimate V_s, for which the required inputs are runoff volume (V_r), q_o, and peak inflow discharge (q_i). To estimate q_o, the required inputs are V_r, V_s, and q_i.

Estimating V_s

Use worksheet 6a to estimate V_s, storage volume required, by the following procedure.

1. Determine q_o. Many factors may dictate the selection of peak outflow discharge. The most common is to limit downstream discharges to a desired level, such as predevelopment discharge. Another factor may be that the outflow device has already been selected.
2. Estimate q_i by procedures in chapters 4 or 5. Do not use peak discharges developed by any other procedure. When using the Tabular Hydrograph method to estimate q_i for a subarea, only use

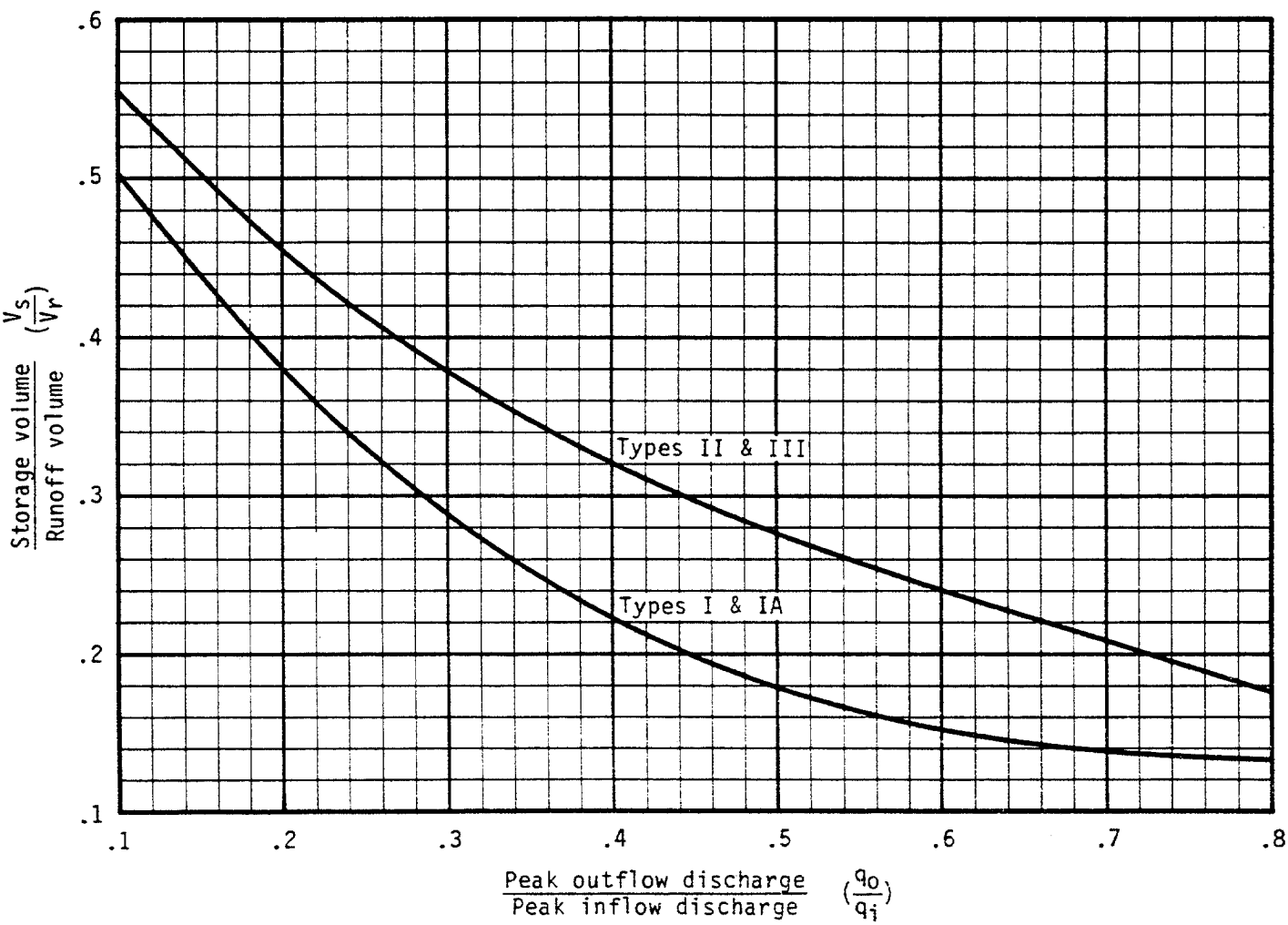


Figure 6-1.—Approximate detention basin routing for rainfall types I, IA, II, and III.

peak discharge associated with $T_t = 0$.

3. Compute q_o/q_i and determine V_s/V_r from figure 6-1.
4. Q (in inches) was determined when computing q_i in step 2, but now it must be converted to the units in which V_s is to be expressed—most likely, acre-feet or cubic feet. The most common conversion of Q to V_r is expressed in acre-feet:

$$V_r = 53.33Q(A_m) \qquad \text{[Eq. 6-1]}$$

where

V_r = runoff volume (acre-ft),
Q = runoff (in),
A_m = drainage area (mi_2), and
53.33 = conversion factor from in-mi² to acre-ft.

5. Use the results of steps 3 and 4 to compute V_s:

$$V_s = V_r\left(\frac{V_s}{V_r}\right) \qquad \text{[Eq. 6-2]}$$

where V_s = storage volume required (acre-ft).

6. The stage in the detention basin corresponding to V_s must be equal to the stage used to generate q_o. In most situations a minor modification of the outflow device can be made. If the outflow device has been preselected, repeat the calculations with a modified q_o value.

Estimating q_o

Use worksheet 6b to estimate q_o, required peak outflow discharge, by the following procedure.

1. Determine V_s. If the maximum stage in the detention basin is constrained, set V_s by the maximum permissible stage.
2. Compute Q (in inches) by the procedures in chapter 2, and convert it to the same units as V_s (see step 4 in "Estimating V_s").
3. Compute V_s/V_r and determine q_o/q_i from figure 6-1.
4. Estimate q_i by the procedures in chapters 4 or 5. Do not use peak discharges developed by any other method. When using the Tabular method to estimate q_i for a subarea, use only the peak discharge associated with $T_t = 0$.
5. From steps 3 and 4, compute q_o:

$$q_o = q_i\left(\frac{q_o}{q_i}\right) \qquad \text{[Eq. 6-3]}$$

6. Proportion the outflow device so that the stage at q_o is equal to the stage corresponding to V_s. If q_o cannot be calibrated except in discrete steps (i.e., pipe sizes), repeat the procedure until the stages for q_o and V_s are approximately equal.

Limitations

- This routing method is less accurate as the q_o/q_i ratio approaches the limits shown in figure 6-1. The curves in figure 6-1 depend on the relationship between available storage, outflow device, inflow volume, and shape of the inflow hydrograph. When storage volume (V_s) required is small, the shape of the outflow hydrograph is sensitive to the rate of rise of the inflow hydrograph. Conversely, when V_s is large, the inflow hydrograph shape has little effect on the outflow hydrograph. In such instances, the outflow hydrograph is controlled by the hydraulics of the outflow device and the procedure therefore yields consistent results. When the peak outflow discharge (q_o) approaches the peak inflow discharge (q_i), parameters that affect the rate of rise of a hydrograph, such as rainfall volume, curve number, and time of concentration, become especially significant.

- The procedure should not be used to perform final design if an error in storage of 25 percent cannot be tolerated. Figure 6-1 is biased to prevent undersizing of outflow devices, but it may significantly overestimate the required storage capacity. More detailed hydrograph development and routing will often pay for itself through reduced construction costs.

Examples

Four examples illustrate the use of figure 6-1. Examples 6-1 through 6-4, respectively, show estimation of V_s, use of a two-stage structure, estimation of q_o, and use with the Tabular Hydrograph method.

Example 6-1: Estimating V_s, single-stage structure

A development is being planned in a 75-acre (0.117-mi^2) watershed that outlets into an existing concrete-lined channel designed for present conditions. If the channel capacity is exceeded, damages will be substantial. The watershed is in the type II storm distribution region. The present channel capacity, 180 cfs, was established by computing discharge for the 25-year-frequency storm by the Graphical Peak Discharge method (chapter 4).

The developed-condition peak discharge (q_i) computed by the same method is 360 cfs, and runoff (Q) is 3.4 inches. Since outflow must be held to 180 cfs, a detention basin having that maximum outflow discharge (q_o) will be built at the watershed outlet.

How much storage (V_s) will be required to meet the maximum outflow discharge (q_o) of 180 cfs, and what will be the approximate dimensions of a rectangular weir outflow structure? Figure 6-2 shows how worksheet 6a is used to estimate required storage (V_s = 5.9 acre-ft) and maximum stage (E_{max} = 105.7 ft).

The rectangular weir was chosen for its simplicity; however, several types of outlets can meet the outflow device proportion requirement. Most hydraulic references, along with considerable research data that are available, provide more guidance on variations of outlet devices than can be summarized here.

An outlet device should be proportioned to meet specific objectives. A single-stage device was specified in this example because only one storm was considered. A weir is suitable here because of the low head. The weir crest elevation is 100.0 ft.

Using V_s = 5.9 acre-ft (figure 6-2, step 9) and the elevation-storage curve, the maximum stage (E_{max}) is 105.7 ft.

The rectangular weir equation is

$$q_o = 3.2\ L_w H_w^{1.5} \qquad \text{[Eq. 6-4]}$$

where

q_o = peak outflow discharge (cfs),
L_w = weir crest length (ft), and
H_w = head over weir crest (ft).

H_w and q_o are computed as follows:

$$H_w = E_{max} - \text{weir crest elevation}$$
$$= 105.7 - 100.0 = 5.7 \text{ ft.}$$

Since q_o is known to be 180 cfs, solving equation 6-4 for L_w yields

$$L_w = \frac{q_o}{3.2\ H_w^{1.5}} \qquad \text{[Eq. 6-5]}$$

$$= \frac{180}{3.2\ (5.7)^{1.5}} = 4.1 \text{ ft.}$$

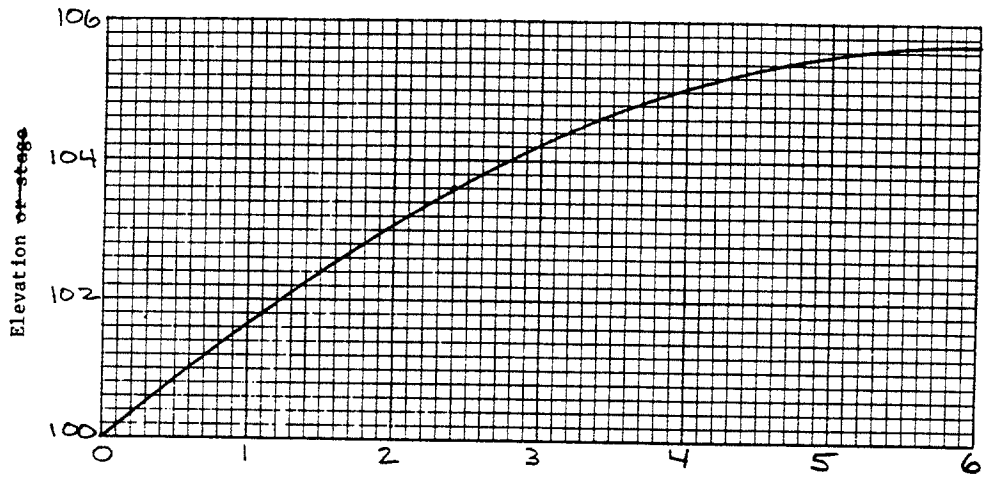
In summary, the outlet structure is a rectangular weir with crest length of 4.1 ft, H_w = 5.7 ft, and q_o = 180 cfs corresponding to a V_s = 5.9 acre-ft.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Robbinsville By SWR Date 11/5/85

Location Dyer County, Tennessee Checked RGC Date 11/8/85

Circle one: Present (Developed) Single-stage-structure



1. Data:
   Drainage area ..... A_m = 0.117 mi^2
   Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ..... yr	25	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	360	
4. Peak outflow discharge, q_o .... cfs 1/	180	
5. Compute $\frac{q_o}{q_i}$	0.50	
6. $\frac{V_s}{V_r}$ ..... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.28	
7. Runoff, Q ..... in (From worksheet 2)	3.4	
8. Runoff volume, V_r ..... ac-ft ($V_r = QA_m 53.33$)	21.2	
9. Storage volume, V_s ..... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	5.9	
10. Maximum stage, E_{max} (From plot)	105.7	

1/ 2nd stage q_o includes 1st stage q_o.

Figure 6-2.—Worksheet 6a for example 6-1.

Example 6-2: Estimating V_s, two-stage structure

In addition to the requirements for a 25-year peak outflow discharge of 180 cfs stated in example 6-1, a decision was made to limit the 2-year outflow discharge to 50 cfs because of potential damages to agricultural property below the lined channel. By the method in chapter 4, the estimated 2-year peak discharge for developed conditions will be 91 cfs and runoff (Q) will be 1.5 inches.

Again, a rectangular concrete weir outflow device was selected; the device could have been another type, but it is important to remember that the flows through the first stage are part of the total discharge of the higher stage.

Figure 6-3 shows how worksheet 6a is used to compute the V_s of 2.4 acre-ft and E_{max} of 103.6 for the first stage. E_{max} of 103.6 is the weir crest elevation for the second stage.

Equation 6-5 is again used to compute L_w for the first stage. The weir crest elevation for the first stage is 100.00 ft and q_o = 50 cfs. The first-stage computations for H_w and L_w are

$$H_w = E_{max} - \text{weir crest elevation}$$
$$= 103.6 - 100.0 = 3.6 \text{ ft;}$$

and, from equation 6-5,

$$L_w = \frac{50}{3.2(3.6)^{1.5}} = 2.3 \text{ ft.}$$

The second stage is then proportioned to discharge the correct amount at 105.7 ft (figure 6-2, step 10). Compute the discharge through the first stage for elevation 105.7 ft using

$$L_w = 2.3 \text{ ft (first stage)}$$

and

$$H_w = 105.7 - 100.0 = 5.7 \text{ ft.}$$

By substituting these values in equation 6-4, discharge (q_o) through the first stage at 105.7 ft is calculated:

$$q_o = 3.2(2.3)(5.7)^{1.5} = 100 \text{ cfs.}$$

Now compute the required weir crest length (L_w) for the second stage, using equation 6-5. Since the second stage crest elevation is 103.6 ft,

$$H_w = 105.7 - 103.6 = 2.1 \text{ ft;}$$

and, since q_o for the second stage equals the total discharge from example 6-1 minus discharge through the first stage,

$$q_o = 180 - 100 = 80 \text{ cfs.}$$

Finally, substituting these H_w and q_o values in equation 6-5 results in

$$L_w = \frac{80}{3.2(2.1)^{1.5}} = 8.2 \text{ ft.}$$

In summary, the outlet structure is a 2-stage rectangular weir with first stage crest length of 2.3 ft at elevation 100.0, and second stage crest length of 8.2 ft at elevation 103.6 ft.

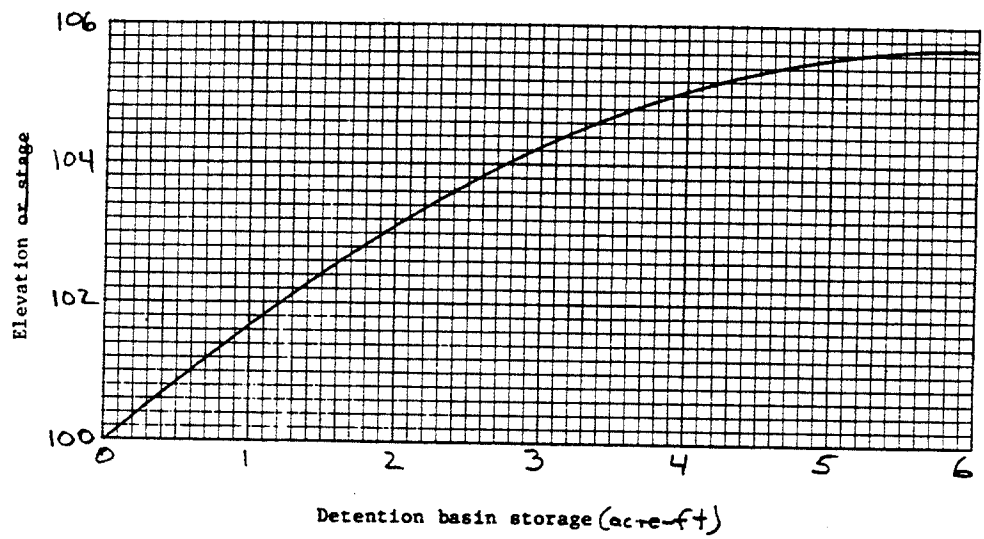
The weir equation used is probably less accurate for the two-stage example than for the single-stage example. The actual second-stage discharge will be slightly more than the one computed, but a discussion of hydraulics of outflow devices is outside the scope of this technical release. Example 6-2 is presented only to illustrate the interrelationship of outflow discharges and storage volume and to show how to develop preliminary estimates of storage requirements for two-stage outlet structures.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Robbinsville By SWR Date 11/6/85

Location Dyer County, Tennessee Checked RGC Date 11/9/85

Circle one: Present (Developed) 2- stage structure



1. Data:
   Drainage area ..... A_m = 0.117 mi^2
   Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ..... yr	2	25
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	91	360
4. Peak outflow discharge, q_o .... cfs 1/	50	180
5. Compute $\frac{q_o}{q_i}$	0.55	0.50
6. $\frac{V_s}{V_r}$ ..... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.26	0.28
7. Runoff, Q ..... in (From worksheet 2)	1.5	3.4
8. Runoff volume, V_r ..... ac-ft ($V_r = QA_m 53.33$)	9.4	21.2
9. Storage volume, V_s ..... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	2.4	5.9
10. Maximum stage, E_{max} (From plot)	103.6	105.7

1/ 2nd stage q_o includes 1st stage q_o.

Figure 6-3.—Worksheet 6a for example 6-2.

Example 6-3: Estimating q_o

A development is being planned for a 10-acre watershed (0.0156 mi^2). A county ordinance requires that the developed-condition outflow from the watershed for a 24-hr, 100-year frequency storm does not exceed the outflow for present conditions. The peak discharge from the watershed for present conditions, 35 cfs, is calculated from procedures in chapter 4. For developed conditions, runoff (Q) is 5.4 inches, peak discharge from the watershed is 42 cfs from procedures in chapter 4, and rainfall distribution is type II.

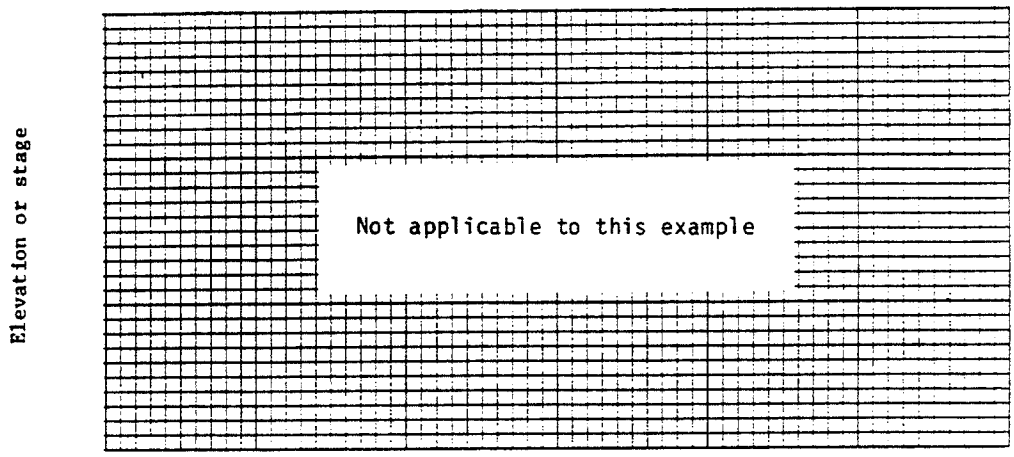
What will be the peak outflow discharge (q_o) from a detention basin that is located at the outlet and has maximum allowable storage volume (V_s) of 35,000 ft^3 and peak inflow discharge (q_i) of 42 cfs? Figure 6-4 shows how worksheet 6b is used to estimate q_o as 33 cfs, which is within the 35-cfs limit. An outflow device will be selected to discharge 33 cfs at a stage corresponding to a V_s of 35,000 ft^3.

Worksheet 6b: Detention basin peak outflow, storage volume (V_s) known

Project Woods Acres By SWR Date 11/8/85

Location Dyer County, Tennessee Checked RGC Date 11/11/85

Circle one: Present (Developed)



Detention basin storage

1. Data:
   Drainage area ..... A_m = 0.0156 mi^2
   Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ..... yr	100	
3. Storage volume, V_s ..... ac ft	0.8	
4. Runoff, Q ..... in (From worksheet 2)	5.4	
5. Runoff volume, V_r ..... ac-ft ($V_r = QA_m 53.33$)	4.5	
6. Compute $\frac{V_s}{V_r}$	0.18	
7. $\frac{q_o}{q_i}$ ..... in (Use $\frac{V_s}{V_r}$ and figure 6-1)	0.78	
8. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	42	
9. Peak outflow discharge, q_o .... cfs ($q_o = q_i(\frac{q_o}{q_i})$) 1/	33	
10. Maximum stage, E_{max} (From plot)	N/A	

1/ 2nd stage q_o includes 1st stage q_o.

Figure 6-4.—Worksheet 6b for example 6-3.

Example 6-4: Estimating V_s, Tabular Hydrograph method

This example builds on examples 5-1 and 5-2 (pages 5-4 to 5-8). If peak outflow discharge from subarea 7 must not exceed the discharge for present conditions, what will be the storage volume (V_s) required in a detention basin at the outlet of subarea 6?

First, compute the outflow hydrograph without subarea 6 as shown in the table below, which presents developed-condition discharges for example 5-2. (The information in the table is from figure 5-4.)

	Discharge (cfs) at time (hr)—								
Subarea	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0
	cfs								
1	7	9	11	16	24	40	78	122	155
2	7	9	12	20	33	55	96	132	132
3	14	29	58	89	106	102	74	46	25
4	19	32	63	114	169	207	193	143	83
5	117	167	205	214	202	175	132	99	70
6 omitted	—	—	—	—	—	—	—	—	—
7	244	167	119	90	72	59	48	40	34
Total without subarea 6	408	413	468	543	606	638	621	582	499

After computing the outflow hydrograph, determine the maximum permissible outflow discharge from subarea 6. The present condition peak discharge at the outlet of subarea 7 is 720 cfs at 14.3 hr (figure 5-2), and the developed condition peak discharge at the outlet of subarea 7 minus subarea 6 is 638 cfs (table above). The difference between these two discharges, 82 cfs, is the maximum outflow discharge (q_o) for the detention basin.

Next, determine the peak discharge for subarea 6 for developed conditions by substituting values in equation 5-1:

$$q = q_t A_m Q. \qquad \text{[Eq. 5-1]}$$

From exhibit 5-II, the largest q_t value is 357 csm/in (exhibit 5-II, sheet 7: T_c = 1.0 hr, T_t = 0, and I_a/P = 0.10 at 12.8 hr). From figure 5-4, A_mQ for subarea 6 is 1.31. Therefore,

$$q = (357)(1.31) = 468 \text{ cfs.}$$

This q value is, of course, the same as the peak inflow discharge (q_i) into the detention basin.

Finally, use worksheet 6a (figure 6-5) to compute V_s as 33.2 acre-ft.

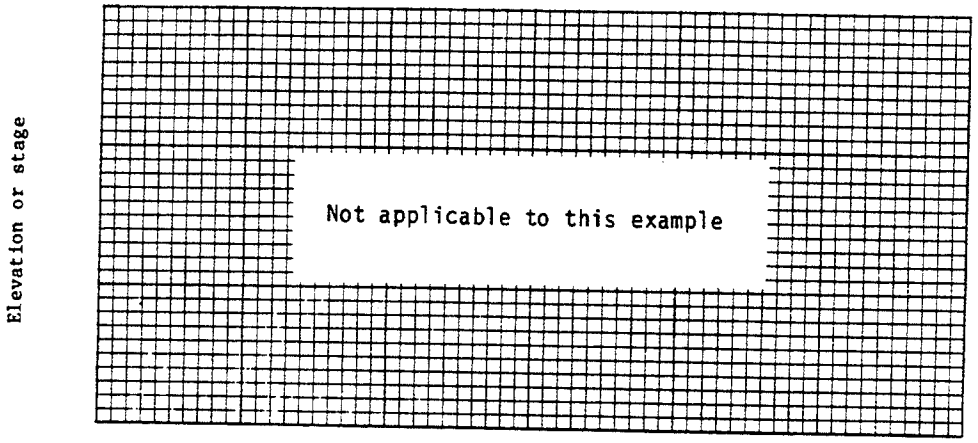
The required storage volume of 33.2 acre-ft is the basis for determining the required stage in the detention basin. This stage is a guide in proportioning a spillway that will discharge 82 cfs or less at that storage. The timing or routing effect is not considered because the outflow hydrograph will discharge at near q_o for a significant period.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Fallswood By SNR Date 10/8/85

Location Dyer County, Tennessee Checked RGC Date 10/10/85

Circle one: Present Developed



Detention basin storage

1. Data:
   Drainage area ..... A_m = 0.40 mi^2
   Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ..... yr	25	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	468	
4. Peak outflow discharge, q_o .... cfs 1/	82	
5. Compute $\frac{q_o}{q_i}$	0.175	
6. $\frac{V_s}{V_r}$ ..... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.475	
7. Runoff, Q ..... in (From worksheet 2)	3.28	
8. Runoff volume, V_r ..... ac-ft ($V_r = QA_m 53.33$)	69.9	
9. Storage volume, V_s ..... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	33.2	
10. Maximum stage, E_{max} (From plot)	N/A	

1/ 2nd stage q_o includes 1st stage q_o.

Figure 6-5.—Worksheet 6a for example 6-4.

Appendix A: Hydrologic soil groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983):

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

Exhibit A-1:

HYDROLOGIC SOIL GROUPS FOR ALABAMA

Alaga A
Albany C
Albertville C
Aloca B
Allen B
Alpin A
Altavista C
Americus A
Amite B
Amy D
Angie C
Annemaine C
Anniston B
Apison B
Appling B
Ardilla C
Armour B
Atkins D
Atmore B/D
Augusta C
Aycock B
Bama B
Barbourville B
Barfield D
Barth C
Basin C
Bassfield B
Baxter B
Banterville B
Bayboro D
Beason D
Benndale B
Bewleyville B
Bibb C
Bigbee A
Binnsville D
Bladen D
Blaney B
Blanton A
Bodine B
Bomar C
Boswell D
Bowie B
Bradley B
Brantley C
Bremo C
Brewton C
Brilliant B
Bruno A
Buncombe A
Butusha C
Byars D
Cahaba B
Camp B
Cane C
Canton Bend C
Capshaw C
Captina C
Carnegie C
Cartecay C
Catalpa C
Cecil B
Cedarbluff C
Chandler B
Chastain D
Chattahoochee B
Cheaha D
Chenneby C
Chesterfield B
Chewacla C
Chipley C
Christian C
Choccolocco B
Clarkesville B
Cloudland C
Colbert D
Colfax C
Conasauga C
Congaree B
Cowarts C
Coxville D
Craven C
Crevassee A
Crossville B
Cumberland B
Cuthbert C
Davidson B
Decatur B
DeKalb C
Dellrose B
Demopolis C
Dewey B
Dickson C
Dierks B
Doravan D
Dothan B
Dowellton D
Ducker B
Dulac C
Dunbar D
Dunning D
Duplin C
Durham B
Edgemont B
Egam C
Ellisville B
Emory B
Enders C
Ennis B
Escambia C
Esto B
Etowah B
Eunola C
Eustis A
Eutaw D
Exum C
Faceville B
Fairhope C
Falaya D
Fannin B
Firestone C
Flint C
Flomaton A
Forestdale D
Freemanville B
Fruithurst C
Fullerton B
Fuquay B
Garner D
Gaylesville D
Geiger D
Georgeville B
Gilead C
Goldsboro B
Gorgas D
Grady D
Grasmere B
Greendale B
Greenville B
Grover B

B/D = Drained-Undrained Condition.

Exhibit A-1, Continued

Guin A
Gunter B
Guthrie D
Gwinnett B
Hamblen C
Hanceville B
Harleston C
Hartsells B
Hayesville B
Hector D
Heidel B
Helena C
Henderson B
Herndon B
Hiwassee B
Hoffman C
Hokesbluff B
Hollywood D
Holston B
Houlka D
Houston D
Hulett B
Humphreys B
Huntington B
Huxford C
Hyde B/D
Iredell C/D
Irvington C
Iuka C
Izagora C
Jefferson B
Johns C
Johnsburg D
Johnston D
Jones B
Kalmia B
Kaufman D
Kenansville A
Kershaw A
Ketona D
Kipling D
Kirvin D
Klej B
Lakeland A
Lakewood A
Latonia B
Lauderdale D
Lawrence B/D
Leadvale C
Leaf D
Lee D
Leefield C
Leesburg B
Leeper D
Lehew C
Lenoir D
Leon B/D
Lindside C
Linker B
Litz C
Lloyd B
Lobelville C
Locust C
Louisa B
Louisburg B
Lucedale B
Lucy A
Luverne C
Lynchburg C
Macon B
Madison B
Magnolia B
Malbis B
Mallory C
Mantachie C
Marietta C
Marlboro B
Masada C
Mashulaville B/D
Maury B
Maxton B
Mayhew D
NcLaurin B
McQueen C
Mecklenburg C
Melvin D
Mimosa C
Minter D
Minvale B
Molena A
Monongahela C
Montevallo D
Mora Bay D
Mooresville C
Mountainburg D
Muse B
Musella B
Muskingum C
Myatt D
Nauvoo B
Nectar C
Nella B
Newark C
Nolichucky B
Norfolk B
Notcher B
Ochlockonee B
Ocilla C
Okenee D
Oktibbeha D
Ora C
Orangeburg B
Osier A/D
Pace B
Pacolet B
Palmerdale B
Pansey D
Paraloma C
Pearman C
Pelham B/D
Pheba C
Philco C
Pikeville B
Pine Flat B
Pinson B
Pirum B
Plummer B/D
Poarch B
Ponzer D
Pope B
Portsmouth B/D
Pottsville D
Prader D
Prentiss C
Purdy D
Quitman C
Rains B/D
Ramsey D
Rarden C
Red Bay B
Remlap C
Riverview B
Roanoke D
Robertsdale C
Robertsville D
Rumford B
Ruston B
Rutlege B/D
Sacul C
Saffell B
Sango C
Saucier C

A/D - B/D = Drained - Undrained Condition

Exhibit A-1, Continued

Savannah C
Sawyer C
Scranton A/D
Seneca B
Sequatchie B
Sequoia C
Shadygrove C
Sharkey D
Shubuta C
Shuster C
Smithdale B
Smithton D
Spadra B
Starr B
Staser B
State B
Stemley C
Stendell C
St. Johns B/D
St. Lucie A
Stough C
Sumter C
Sun Shine C
Sunsweet C
Susquehanna D
Swain C
Sylacauga D
Tadlock B
Taft C
Talbott C
Talladega C
Tallapoosa C
Tarklin C
Tate B
Tatum B
Tellico B
Tifton B
Tilden C
Tilsit C
Toccoa B
Tombigbee A
Townley C
Trinity D
Troup A
Tupelo D
Tuscumbia D
Tuskegee C
Tyler D
Una D
Urbo D
Vaiden D
Vance C
Varina C
Vaucluse C
Wagram A
Wahee D
Warner C/D
Watauga B
Watsonia D
Waugh C
Waynesboro B
Wedowee D
Wehadkee D
Weston D
West Point D
Wickham B
Wicksburg B
Wilcox D
Wilkes C
Wolftever C
Worsham D
Wynnville C
York C

A/D - B/D - C/D = Drained-Undrained Condition

Appendix B: Synthetic rainfall distributions and rainfall data sources

The highest peak discharges from small watersheds in the United States are usually caused by intense, brief rainfalls that may occur as distinct events or as part of a longer storm. These intense rainstorms do not usually extend over a large area and intensities vary greatly. One common practice in rainfall-runoff analysis is to develop a synthetic rainfall distribution to use in lieu of actual storm events. This distribution includes maximum rainfall intensities for the selected design frequency arranged in a sequence that is critical for producing peak runoff.

Synthetic rainfall distributions

The length of the most intense rainfall period contributing to the peak runoff rate is related to the time of concentration (T_c) for the watershed. In a hydrograph created with SCS procedures, the duration of rainfall that directly contributes to the peak is about 170 percent of the T_c. For example, the most intense 8.5-minute rainfall period would contribute to the peak discharge for a watershed with a T_c of 5 minutes; the most intense 8.5-hour period would contribute to the peak for a watershed with a 5-hour T_c.

Different rainfall distributions can be developed for each of these watersheds to emphasize the critical rainfall duration for the peak discharges. However, to avoid the use of a different set of rainfall intensities for each drainage area size, a set of synthetic rainfall distributions having "nested" rainfall intensities was developed. The set "maximizes" the rainfall intensities by incorporating selected short duration intensities within those needed for longer durations at the same probability level.

For the size of the drainage areas for which SCS usually provides assistance, a storm period of 24 hours was chosen for the synthetic rainfall distributions. The 24-hour storm, while longer than that needed to determine peaks for these drainage areas, is appropriate for determining runoff volumes. Therefore, a single storm duration and associated synthetic rainfall distribution can be used to represent not only the peak discharges but also the runoff volumes for a range of drainage area sizes.

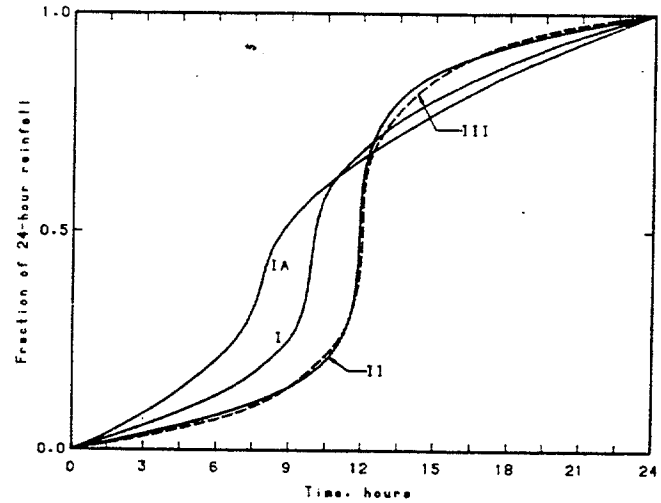


Figure B-1.—SCS 24-hour rainfall distributions.

The intensity of rainfall varies considerably during a storm as well as over geographic regions. To represent various regions of the United States, SCS developed four synthetic 24-hour rainfall distributions (I, IA, II, and III) from available National Weather Service (NWS) duration-frequency data (Hershfield 1961; Frederick et al., 1977) or local storm data. Type IA is the least intense and type II the most intense short duration rainfall. The four distributions are shown in figure B-1, and figure B-2 shows their approximate geographic boundaries.

Types I and IA represent the Pacific maritime climate with wet winters and dry summers. Type III represents Gulf of Mexico and Atlantic coastal areas where tropical storms bring large 24-hour rainfall amounts. Type II represents the rest of the country. For more precise distribution boundaries in a state having more than one type, contact the SCS State Conservation Engineer.

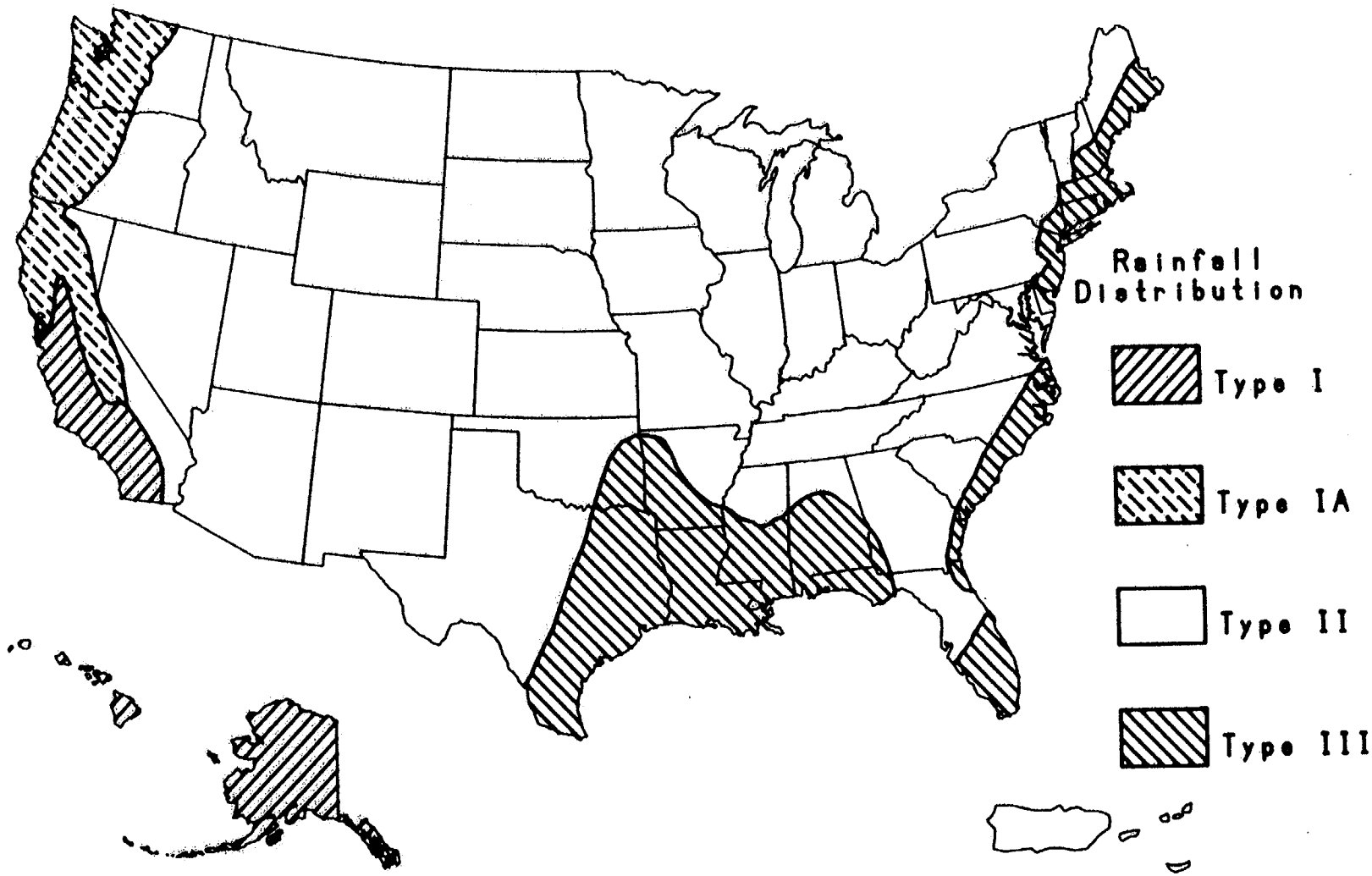


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Oceanic and Atmospheric Administration.

East of 105th meridian

Hershfield, D. M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 115 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I, Montana; Vol. II, Wyoming; Vol. III, Colorado; Vol. IV, New Mexico; Vol. V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dep. Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 p.

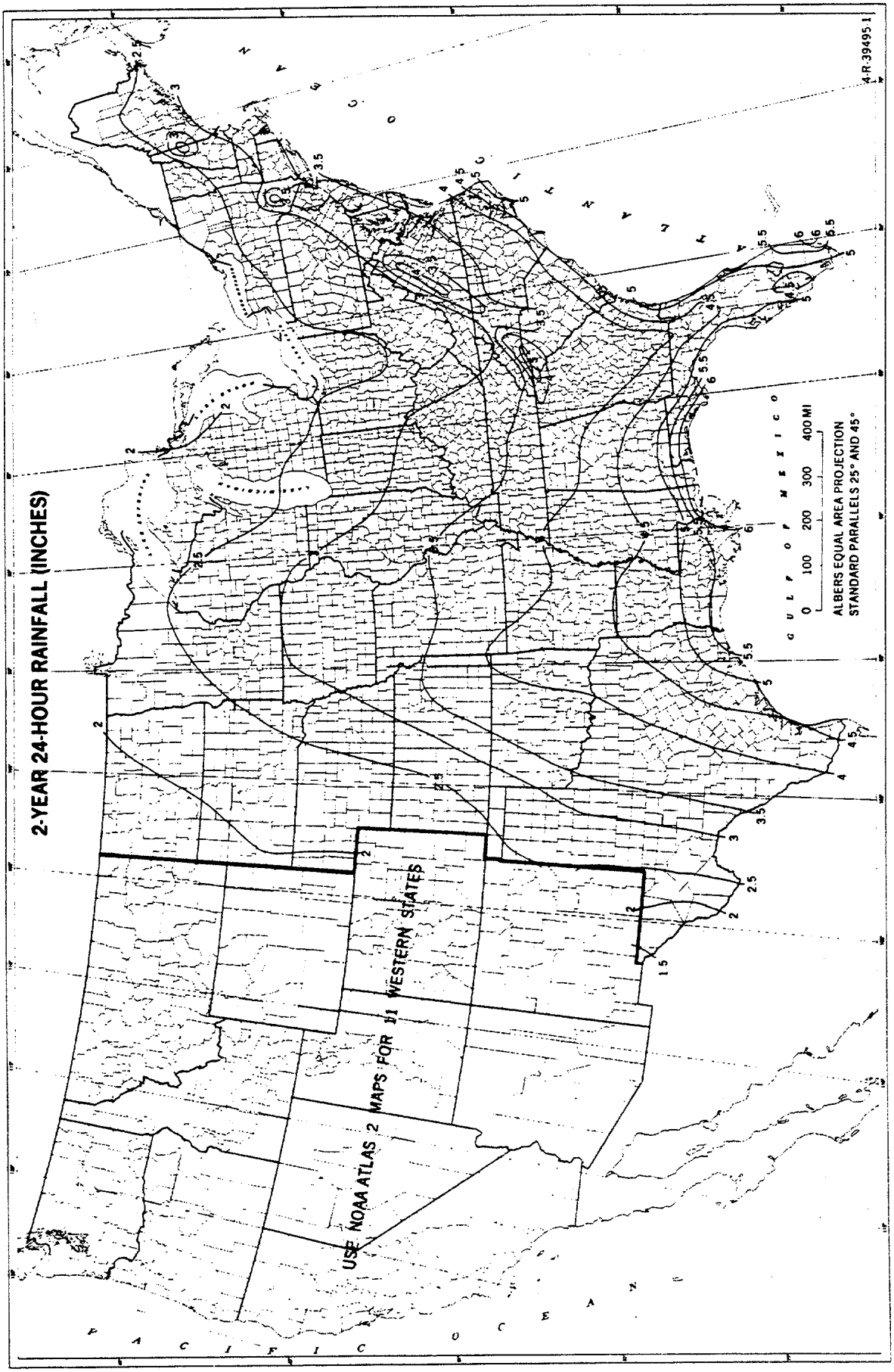


Figure B-3.—Two-year, 24-hour rainfall.

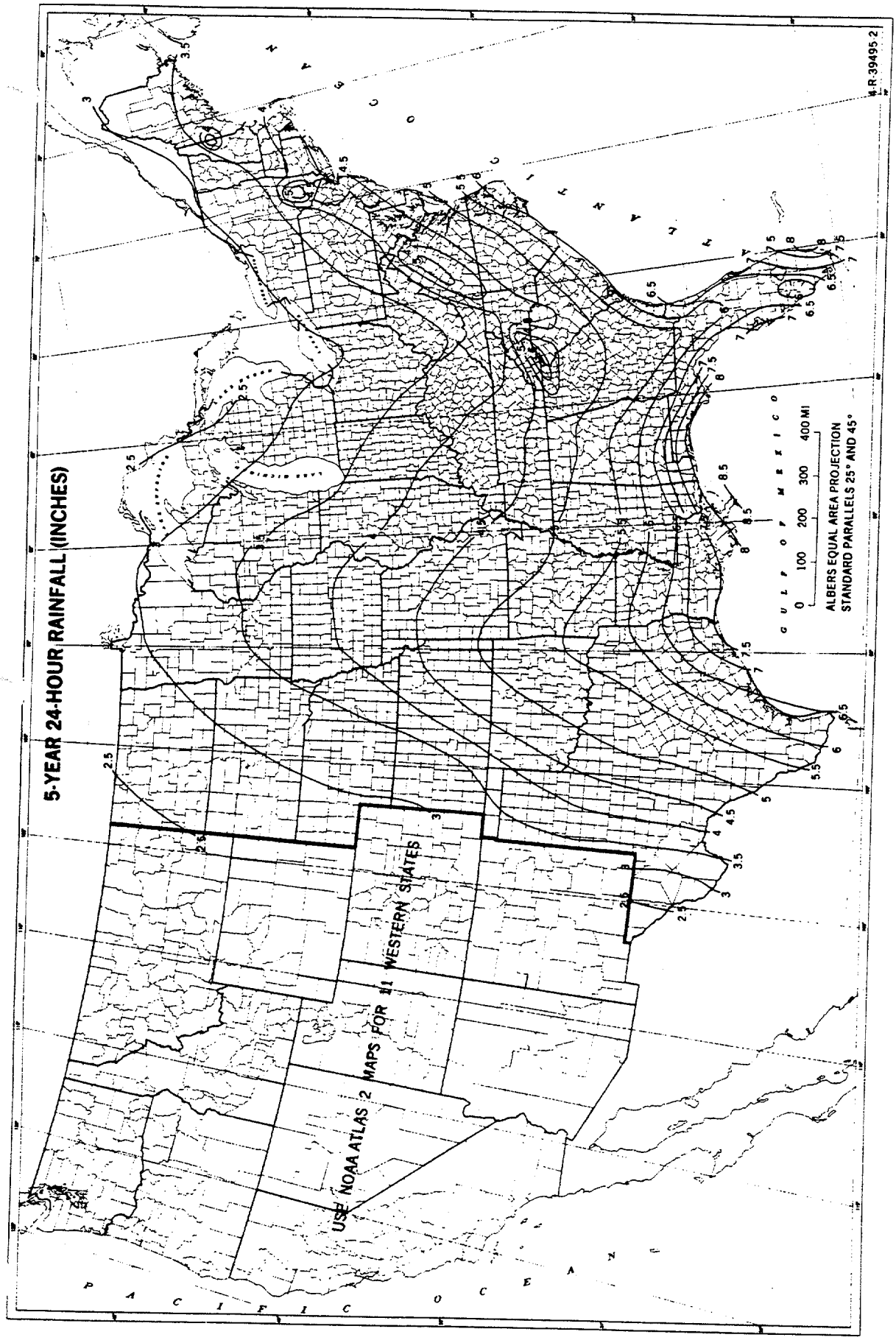


Figure B-4.—Five-year, 24-hour rainfall.

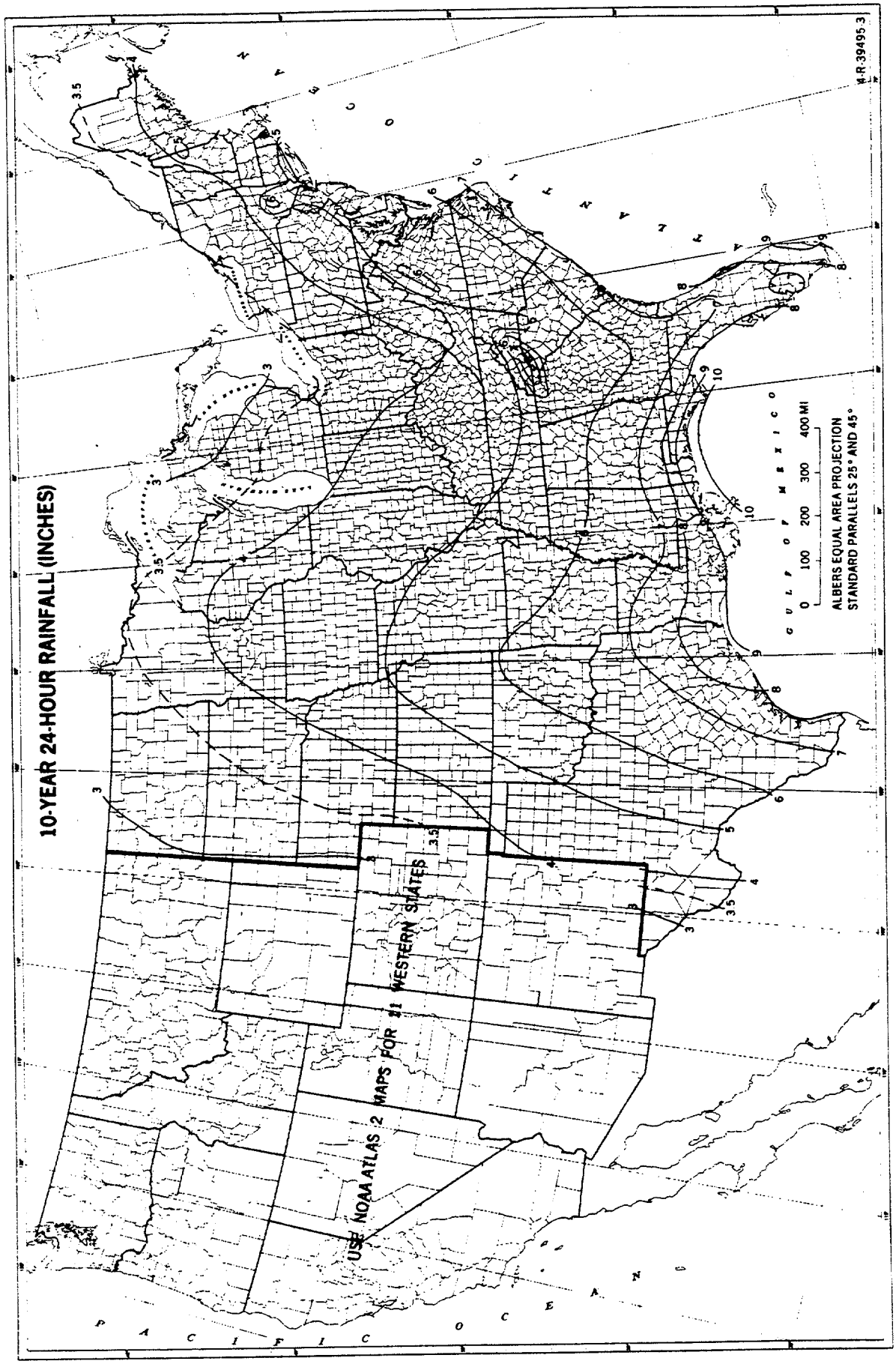


Figure B-5.—Ten-year, 24-hour rainfall.

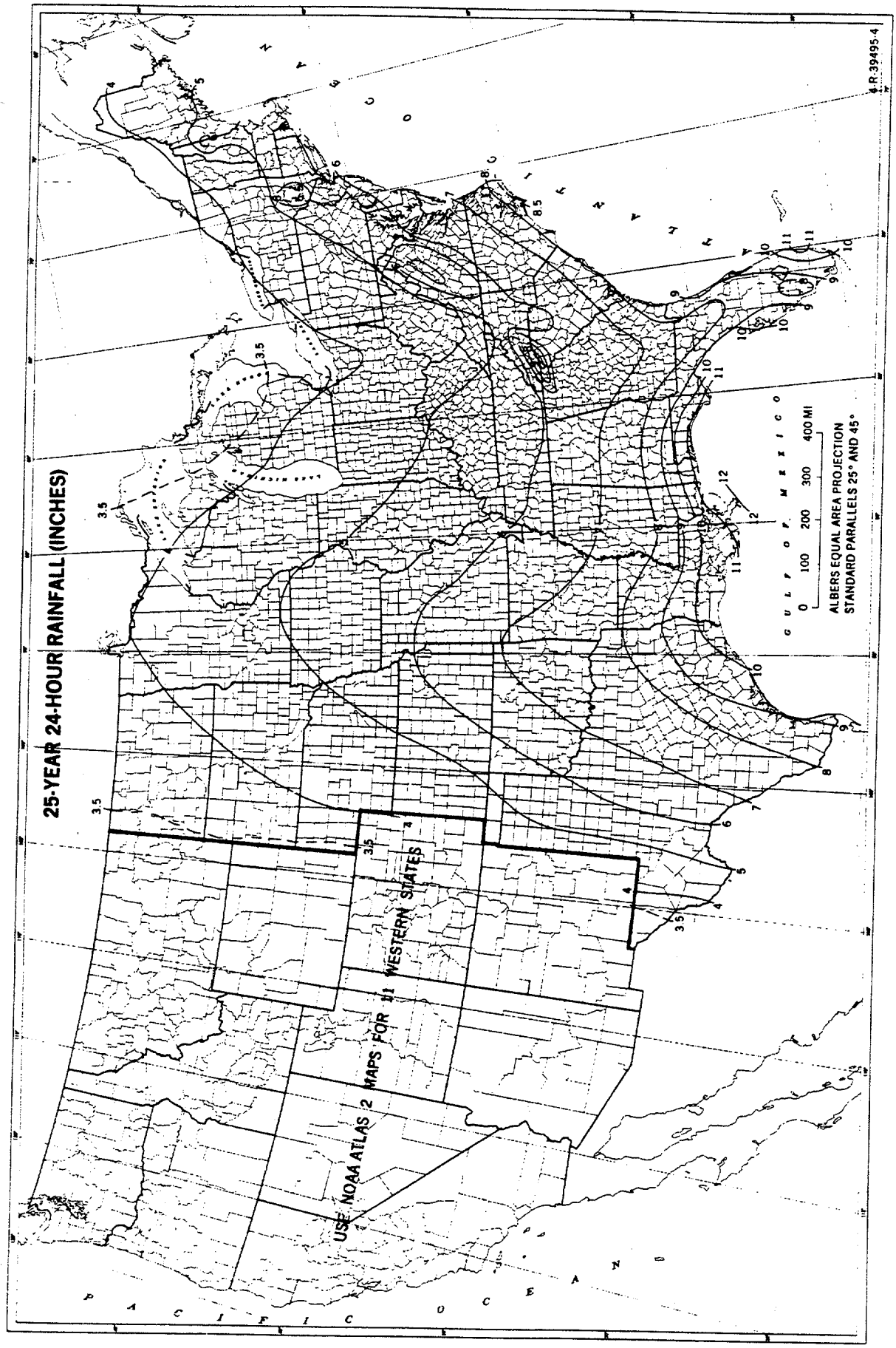


Figure B-6.—Twenty-five-year, 24-hour rainfall.

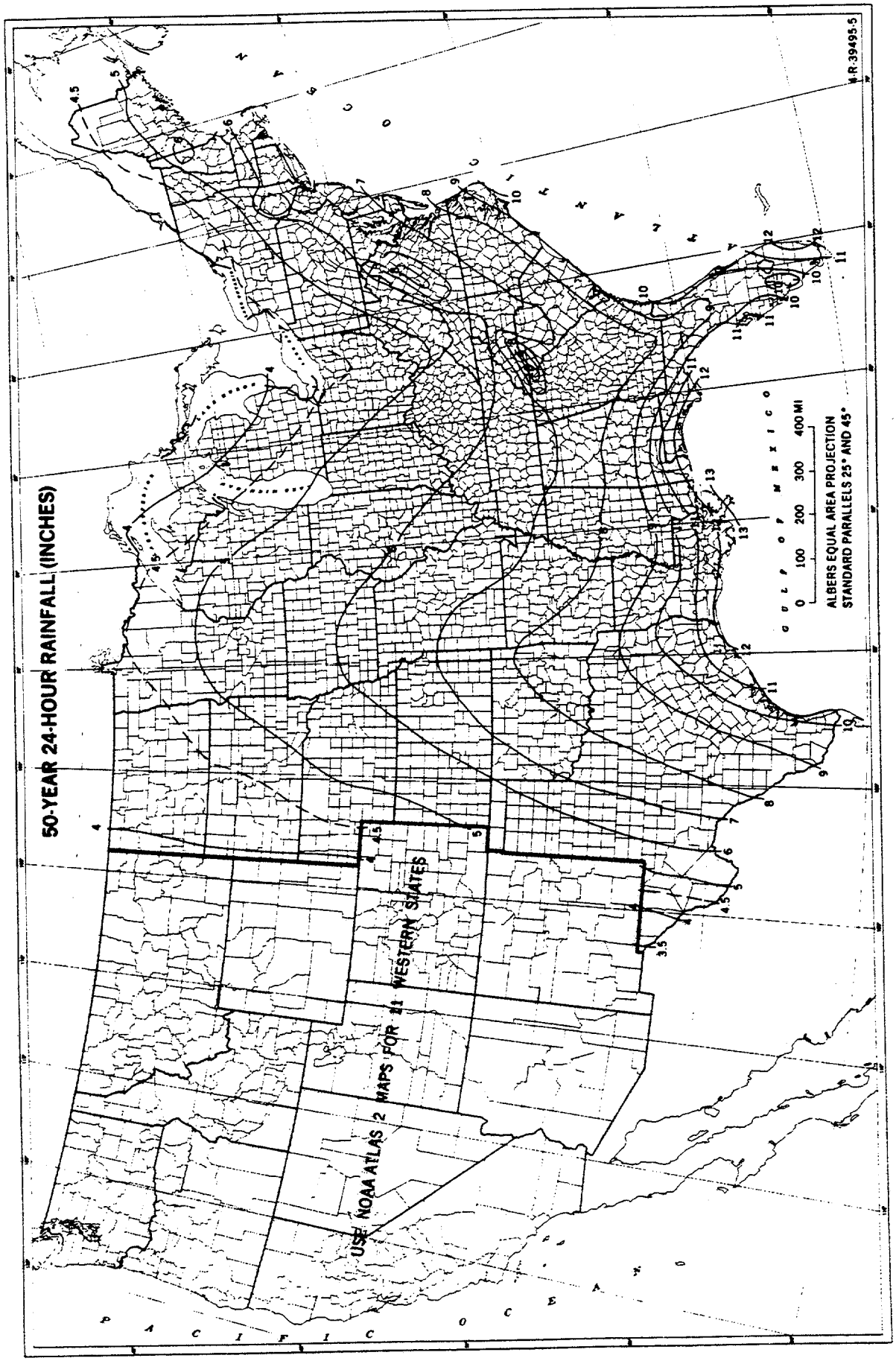


Figure B-7.—Fifty-year, 24-hour rainfall.

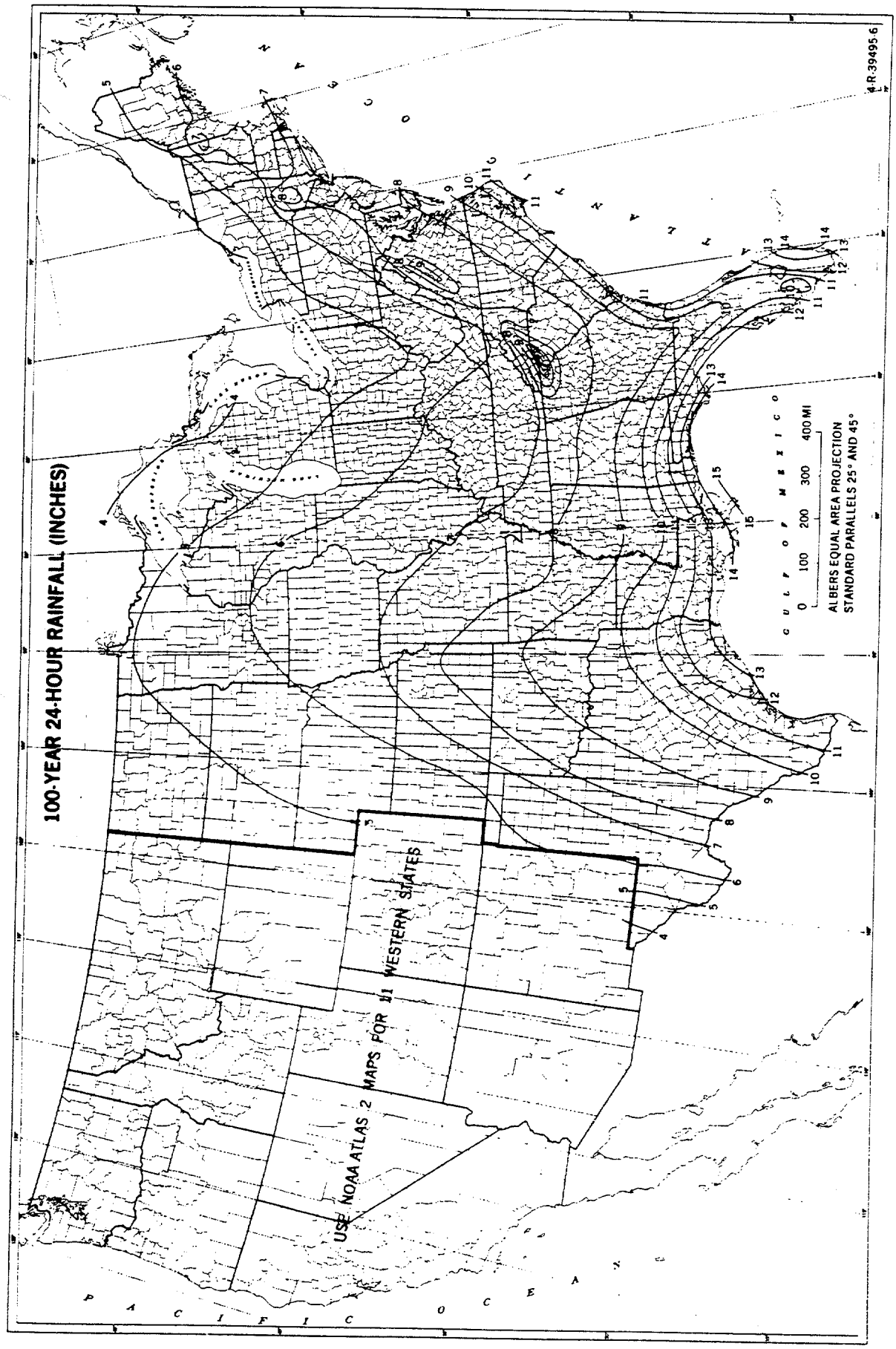


Figure B-8.—One-hundred-year, 24-hour rainfall.

Appendix C: Computer program

The TR-55 procedures have been incorporated in a computer program. The program, written in BASIC, requires less than 256K memory to operate and was developed for an MS-DOS operating system. Users of the program, however, still need to be familiar with the procedures in this TR. Features of the program include the following:

- The full screen (24 lines, 80 columns) is used to enter data. Flexibility of coding allows movement about the screen for quick data modifications.

- Function keys provide menu power to move to different modules (TR-55 chapters) within the program. Some keys are permanently defined while others vary by module.

- "Help" screens provide pertinent information to the user depending on location in the program. Two types of information are included: (1) define system operation and (2) describe input parameters.

- User files provide for optional entry of local data, such as rainfall-frequency, graphic peak discharge equation coefficients, and tabular hydrographs for other rainfall distributions.

Copies of the program can be obtained from—

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Telephone (703) 487-4650

Appendix D: Worksheets

This appendix contains seven worksheets that can be reproduced for use with chapters 2 through 6. There is no worksheet for chapter 1.

Chapter	*Worksheet*
2	2
3	3
4	4
5	5a, 5b
6	6a, 6b

Worksheet 2: Runoff curve number and runoff

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area ☐ acres ☐ mi^2 ☐ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
					Totals =	

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = _____ = _____; Use CN = ☐

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency ..... yr			
Rainfall, P (24-hour) .... in			
Runoff, Q ..... in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)			

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t through subarea _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID		
1. Surface description (table 3-1)			
2. Manning's roughness coeff., n (table 3-1) ..			
3. Flow length, L (total L $\leq$ 300 ft) ..... ft			
4. Two-yr 24-hr rainfall, P_2 ..... in			
5. Land slope, s ..... ft/ft			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t ..... hr		+	=

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L ..... ft			
9. Watercourse slope, s ..... ft/ft			
10. Average velocity, V (figure 3-1) ..... ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t ..... hr		+	=

Channel flow	Segment ID		
12. Cross sectional flow area, a ..... ft^2			
13. Wetted perimeter, p_w ..... ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ..... ft			
15. Channel slope, s ..... ft/ft			
16. Manning's roughness coeff., n			
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V ..... ft/s			
18. Flow length, L ..... ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t ..... hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) ..... hr _____

Worksheet 4: Graphical Peak Discharge method

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____

1. Data:

Drainage area ..... A_m = _____ mi^2 (acres/640)

Runoff curve number .... CN = _____ (From worksheet 2)

Time of concentration .. T_c = _____ hr (From worksheet 3)

Rainfall distribution type = _____ (I, IA, II, III)

Pond and swamp areas spread throughout watershed ..... = _____ percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr			
3. Rainfall, P (24-hour)	in			
4. Initial abstraction, I_a ..... (Use CN with table 4-1.)	in			
5. Compute I_a/P				
6. Unit peak discharge, q_u ..... (Use T_c and I_a/P with exhibit 4-____)	csm/in			
7. Runoff, Q ..... (From worksheet 2).	in			
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)				
9. Peak discharge, q_p ..... (Where $q_p = q_u A_m Q F_p$)	cfs			

Worksheet 5a: Basic watershed data

Project _____ Location _____ By _____ Date _____

Circle one: Present Developed _____ Frequency (yr) _____ Checked _____ Date _____

Subarea name	Drainage area A_m (mi^2)	Time of concentration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet ΣT_t (hr)	24-hr Rainfall P (in)	Runoff curve number CN	Runoff Q (in)	$A_m Q$ (mi^2-in)	Initial abstraction I_a (in)	I_a/P

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ From worksheet 3

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ From worksheet 2

↑ ↑ ↑ ↑ From table 5-1

Worksheet 5b: Tabular hydrograph discharge summary

Project ______________ Location ______________ By ______ Date ______

Circle one: Present Developed ______________ Frequency (yr) ______ Checked ______ Date ______

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours from exhibit 5- 2/											
	Sub-area T_c (hr)	ΣT_t to outlet (hr)	I_a/P	A_mQ (mi^2-in)												
					Discharges at selected hydrograph times 3/ ———— (cfs) ————											
Composite hydrograph at outlet																

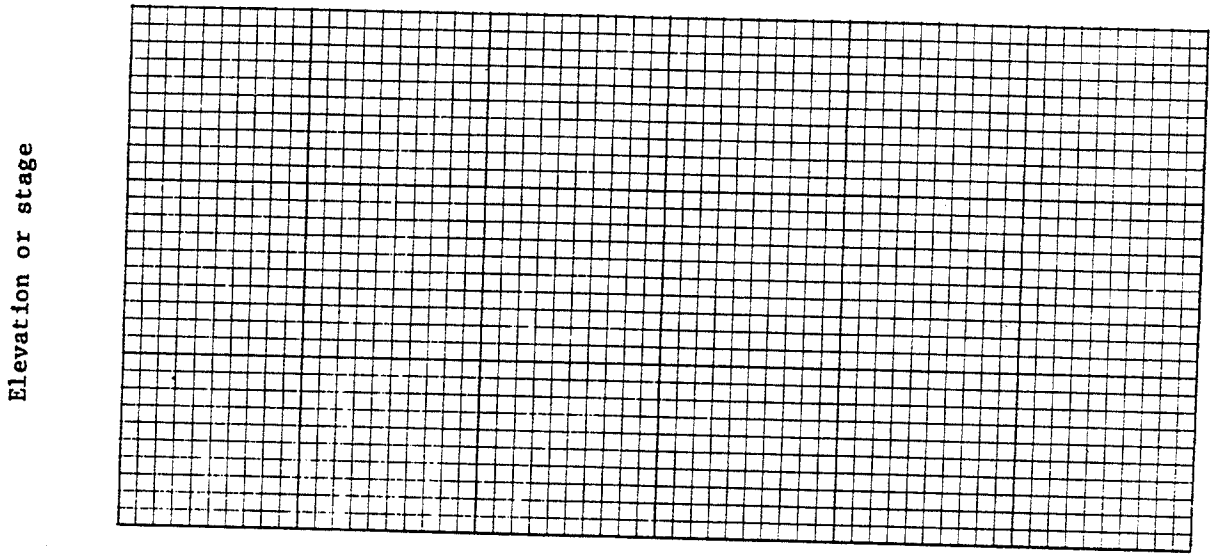
1/ Worksheet 5a. Rounded as needed for use with exhibit 5.
2/ Enter rainfall distribution type used.
3/ Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____



Detention basin storage

1. Data:
   Drainage area ..... A_m = _____ mi^2
   Rainfall distribution type (I, IA, II, III) = _____

	1st stage	2nd stage
2. Frequency ..... yr		
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)		
4. Peak outflow discharge, q_o .... cfs 1/		
5. Compute $\frac{q_o}{q_i}$		
6. $\frac{V_s}{V_r}$ ..... (Use $\frac{q_o}{q_i}$ with figure 6-1)		
7. Runoff, Q ..... in (From worksheet 2)		
8. Runoff volume, V_r ..... ac-ft ($V_r = QA_m 53.33$)		
9. Storage volume, V_s ..... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)		
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

Worksheet 6b: Detention basin peak outflow, storage volume (V_s) known

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____

Elevation or stage

Detention basin storage

1. Data:
   Drainage area ..... A_m = _____ mi^2
   Rainfall distribution type (I, IA, II, III) = _____

	1st stage	2nd stage
2. Frequency ..... yr		
3. Storage volume, V_s ..... ac ft		
4. Runoff, Q ..... in (From worksheet 2)		
5. Runoff volume, V_r ..... ac-ft ($V_r = QA_m 53.33$)		
6. Compute $\frac{V_s}{V_r}$		
7. $\frac{q_o}{q_i}$ ..... in (Use $\frac{V_s}{V_r}$ and figure 6-1)		
8. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)		
9. Peak outflow discharge, q_o .... cfs ($q_o = q_i(\frac{q_o}{q_i})$)		1/
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

Appendix F: Equations for figures and exhibits

This appendix presents the equations used in procedure applications to generate figures and exhibits in TR-55.

Figure 2-1 (runoff equation):

$$Q = \frac{\left[P - 0.2\left(\frac{1000}{CN} - 10\right)\right]^2}{P + 0.8\left(\frac{1000}{CN} - 10\right)}$$

where

Q = runoff (in),
P = rainfall (in), and
CN = runoff curve number.

Figure 2-3 (composite CN with connected impervious area):

$$CN_c = CN_p + (P_{imp}/100)(98 - CN_p)$$

where

CN_c = composite runoff curve number,
CN_p = pervious runoff curve number, and
P_{imp} = percent imperviousness.

Figure 2-4 (composite CN with unconnected impervious areas and total impervious area less than 30%):

$$CN_c = CN_p + (P_{imp}/100)(98 - CN_p)(1 - 0.5R)$$

where R = ratio of unconnected impervious area to total impervious area.

Figure 3-1 (average velocities for estimating travel time for shallow concentrated flow):

Unpaved $V = 16.1345\ (s)^{0.5}$
Paved $V = 20.3282\ (s)^{0.5}$

where

V = average velocity (ft/s), and
s = slope of hydraulic grade line (watercourse slope, ft/ft).

These two equations are based on the solution of Manning's equation (Eq. 3-4) with different assumptions for n (Manning's roughness coefficient) and r (hydraulic radius, ft). For unpaved areas, n is 0.05 and r is 0.4; for paved areas, n is 0.025 and r is 0.2.

Exhibit 4 (unit peak discharges for SCS type I, IA, II, and III distributions):

$$\log(q_u) = C_0 + C_1 \log(T_c) + C_2 [\log(T_c)]^2$$

where

q_u = unit peak discharge (csm/in),
T_c = time of concentration (hr) (minimum, 0.1; maximum, 10.0), and
C_0, C_1, C_2 = coefficients from table F-1.

Figure 6-1 (approximate detention basin routing through single- and multiple-stage structures for 24-hour rainfalls of the indicated type):

$$V_s/V_r = C_0 + C_1 (q_o/q_i) + C_2 (q_o/q_i)^2 + C_3 (q_o/q_i)^3$$

where

V_s/V_r = ratio of storage volume (V_s) to runoff volume (V_r),
q_o/q_i = ratio of peak outflow discharge (q_o) to peak inflow discharge (q_i), and
C_0, C_1, C_2, C_3 = coefficients from table F-2.

Table F-1.—Coefficients for the equation used to generate exhibits 4-I through 4-III

Rainfall type	I_a/P	C_0	C_1	C_2
I	0.10	2.30550	-0.51429	-0.11750
	0.20	2.23537	-0.50387	-0.08929
	0.25	2.18219	-0.48488	-0.06589
	0.30	2.10624	-0.45695	-0.02835
	0.35	2.00303	-0.40769	0.01983
	0.40	1.87733	-0.32274	0.05754
	0.45	1.76312	-0.15644	0.00453
	0.50	1.67889	-0.06930	0.0
IA	0.10	2.03250	-0.31583	-0.13748
	0.20	1.91978	-0.28215	-0.07020
	0.25	1.83842	-0.25543	-0.02597
	0.30	1.72657	-0.19826	0.02633
	0.50	1.63417	-0.09100	0.0
II	0.10	2.55323	-0.61512	-0.16403
	0.30	2.46532	-0.62257	-0.11657
	0.35	2.41896	-0.61594	-0.08820
	0.40	2.36409	-0.59857	-0.05621
	0.45	2.29238	-0.57005	-0.02281
	0.50	2.20282	-0.51599	-0.01259
III	0.10	2.47317	-0.51848	-0.17083
	0.30	2.39628	-0.51202	-0.13245
	0.35	2.35477	-0.49735	-0.11985
	0.40	2.30726	-0.46541	-0.11094
	0.45	2.24876	-0.41314	-0.11508
	0.50	2.17772	-0.36803	-0.09525

Table F-2.—Coefficients for the equation used to generate figure 6-1

Rainfall distribution (appendix B)	C_0	C_1	C_2	C_3
I, IA	0.660	-1.76	1.96	-0.730
II, III	0.682	-1.43	1.64	-0.804

☆U.S. GOVERNMENT PRINTING OFFICE:1986-624-060/661

Appendix E: References

Brakensiek, D.L. and W.J. Rawls. 1983. Green-Ampt infiltration model parameters for hydrologic classification of soils. *In* John Borrelli, Victor R. Hasfurther, and Robert D. Burman (ed.) Advances in Irrigation and Drainage Surviving External Pressures. Proceedings of Am. Soc. Civ. Eng. specialty conference. NewYork, NY. p. 226-233.

Chow, V.T. 1959. Open channel hydraulics. McGraw-Hill Book Company, Inc. New York, NY. p. 109-113.

Comer, G.H., F.D. Theurer, and H.H Richardson. 1981. The Modified Attenuation-Kinematic (Att-Kin) routing model. *In* V.P. Singh (ed.) Rainfall-Runoff Relationships: Proceedings, International Symposium on Rainfall-Runoff Modeling. Mississippi State University. p.553-564.

Engman, E.T. 1986. Roughness coefficients for routing surface runoff. Journal of Irrigation and Drainage Engineering 112 (1): 39-53.

Frederick, R.H., V.A. Myers, and E.P. Auciello. 1977. Five to 60 minute precipitation frequency for the Eastern and Central United States. U.S. Dep. Commerce, National Weather Service, National Oceanic and Atmospheric Administration Tech. Memo NWS HYDRO 35. Silver Spring, MD. 36 p.

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dep. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 115 p.

Linsley, R.K., M.A. Kohler, and J.L.H. Paulhus. 1982. Hydrology for engineers. Third Edition. McGraw-Hill Book Company, Inc. New York, NY. p. 484.

Musgrave, G.W. 1955. How much of the rain enters the soil? *In* Water. The Yearbook of Agriculture 1955. U.S. Dep. Agric. U.S. Gov. Print. Off. Washington, DC. p. 151-159.

Overton, D.E. and M.E. Meadows. 1976. Storm water modeling. Academic Press. New York, NY. p. 58-88.

Rallison, R.E. and N. Miller. 1981. Past, present, and future SCS runoff procedure. *In* V.P. Singh (ed.) Rainfall-Runoff Relationships: Proceedings, International Symposium on Rainfall-Runoff Modeling. Mississippi State University. p. 353-364.

Rawls, W.J., A. Shalaby, and R.H. McCuen. 1981. Evaluation of methods for determining urban runoff curve numbers. Transactions of the American Society of Agricultural Engineers 24 (6):1562-1566.

Soil Conservation Service. 1982 [Draft]. Structure site analysis computer program DAMS2 (interim version). SCS Technical Release 48. Washington, DC.

__. 1983 [Draft]. Computer program for project formulation—hydrology. SCS Technical Release 20. Washington, DC.

__. 1985. National engineering handbook. Section 4—Hydrology. Washington, DC.

DIVERSION DESIGN

Table A6-DV-1 through A6-DV-14 may be used to facilitate the design of grass-lined diversions with parabolic cross-sections. These tables are based on a retardance of "D" (vegetation newly cut) to determine V_1 for stability considerations. To determine channel capacity, chose a retardance of "C" when proper maintenance is expected; otherwise, design channel capacity based on retardance "B". Refer to Table DV-2 for maximum permissible velocities. The permissible velocities guide the selection of V_1 and should not be exceeded. It is good practice to use a value for V_1 that is significantly less than the maximum allowable when choosing a design cross-section. When velocities approach the maximum allowable, flatter grades should be evaluated or a more erosion resistant liner such as riprap should be considered. After the diversion dimensions are selected in the design tables, the top width should be increased by 4 ft. and the depth by 0.3 ft. for freeboard.

<u>Example Problem</u>

Given:

Q: 30 cfs
Grade: 1%
Soil: Sandy clay loam
Condition of vegetation expected: fair
Maintenance: low; will be cut only twice a year.
Site will allow a top width of 26 ft.

Find:

Diversion top width and depth that will be stable and fit site conditions.

Solution:

From Table DV-2 use maximum permissible velocity of 3.0 ft./sec.
Since Maintenance will be low use "B" retardance for capacity.
From Table A6-DV-2 use retardance "D" and "B"; grade 1%
Top width = 21.0 ft. + 4 ft. = 25.0 ft.
Depth = 1.6 ft. + 0.3 ft. = 1.9 ft.
V_2 = 1.3 ft./sec.
Note: V_1 < 3.0 ft./sec.; Top width < 26 ft., design O.K.

Note: It is good practice to select a cross-section that will give a velocity, V_1, well below the maximum allowable whenever site conditions permit. Wide, shallow cross-sections are more stable and require less maintenance. It is

always prudent to evaluate flatter design grades in order to best fit diversions to the site and keep velocities well below maximum allowable.

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 0.50 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10																											
15	10.0	2.2	1.0																								
20	13.7	2.1	1.0	8.4	2.7	1.3																					
25	17.4	2.1	1.0	11.3	2.4	1.4																					
30	21.0	2.0	1.0	13.9	2.3	1.4																					
35	24.6	2.0	1.1	16.4	2.3	1.4	10.7	2.8	1.8																		
40	28.5	2.0	1.0	18.9	2.3	1.4	12.6	2.7	1.8																		
45	31.9	2.0	1.1	21.4	2.3	1.4	14.4	2.6	1.8																		
50	35.5	2.0	1.1	23.9	2.2	1.4	16.2	2.5	1.8	9.9	3.4	2.2															
55	39.0	2.0	1.1	26.3	2.2	1.4	17.9	2.5	1.8	11.9	3.1	2.3															
60	42.5	2.0	1.1	28.8	2.2	1.4	19.7	2.5	1.8	13.2	3.0	2.3															
65	46.1	2.0	1.1	31.6	2.2	1.4	21.4	2.5	1.8	14.5	2.9	2.3															
70	49.6	2.0	1.1	34.0	2.2	1.4	23.1	2.5	1.8	15.8	2.9	2.3	11.0	3.6	2.6												
75	53.1	2.0	1.1	36.4	2.2	1.4	24.9	2.5	1.8	17.1	2.8	2.3	12.7	3.4	2.7												
80	56.6	2.0	1.1	38.8	2.2	1.4	26.6	2.5	1.8	18.4	2.8	2.3	13.7	3.3	2.7												
85	60.2	2.0	1.1	41.2	2.2	1.4	28.3	2.5	1.8	19.7	2.8	2.3	14.8	3.2	2.7												
90	63.7	2.0	1.1	43.6	2.2	1.4	30.0	2.4	1.8	20.9	2.8	2.3	15.9	3.2	2.7												
95	67.2	2.0	1.1	46.1	2.2	1.4	31.7	2.4	1.8	22.1	2.8	2.3	16.9	3.1	2.7												
100	70.8	2.0	1.1	48.5	2.2	1.4	33.7	2.4	1.8	23.4	2.8	2.3	17.9	3.1	2.7	12.3	3.9	3.1									
105	74.3	2.0	1.1	50.9	2.2	1.4	35.4	2.4	1.8	24.5	2.7	2.4	18.9	3.1	2.7	13.7	3.7	3.1									
110	77.8	2.0	1.1	53.3	2.2	1.4	37.1	2.4	1.8	25.8	2.7	2.4	19.9	3.1	2.7	14.6	3.6	3.1									
115	81.4	2.0	1.1	55.7	2.2	1.4	38.7	2.4	1.8	27.0	2.7	2.4	20.8	3.0	2.7	15.4	3.6	3.1									
120	84.9	2.0	1.1	58.1	2.2	1.4	40.4	2.4	1.9	28.2	2.7	2.4	21.8	3.0	2.7	16.3	3.5	3.1									
125	88.4	2.0	1.1	60.6	2.2	1.4	42.1	2.4	1.9	29.4	2.7	2.4	22.8	3.0	2.7	17.1	3.5	3.1									
130	92.0	2.0	1.1	63.0	2.2	1.4	43.8	2.4	1.9	30.6	2.7	2.4	23.8	3.0	2.7	17.9	3.5	3.1									
135	95.5	2.0	1.1	65.4	2.2	1.4	45.4	2.4	1.9	31.8	2.7	2.4	24.8	3.0	2.7	18.7	3.4	3.2									
140	99.0	2.0	1.1	67.8	2.2	1.4	47.1	2.4	1.9	33.1	2.7	2.4	25.7	3.0	2.8	19.4	3.4	3.2									
145	102.6	2.0	1.1	70.2	2.2	1.4	48.8	2.4	1.9	34.3	2.7	2.4	26.7	3.0	2.8	20.2	3.4	3.2	13.5	4.4	3.6						
150	106.1	2.0	1.1	72.6	2.2	1.4	50.5	2.4	1.9	35.5	2.7	2.4	27.7	3.0	2.8	21.0	3.4	3.2	14.4	4.3	3.6						

Table A6-DV-1. Parabolic Diversion Design Chart (Retardance "D" and "B", Grade 0.50%)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 1.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10	9.7	1.6	1.0	6.2	2.0	1.2																					
15	14.8	1.5	1.0	10.2	1.7	1.3	6.5	2.2	1.5																		
20	20.2	1.5	1.0	13.8	1.7	1.3	9.6	1.9	1.6																		
25	25.1	1.5	1.0	17.4	1.7	1.3	12.2	1.9	1.6	8.5	2.2	2.0															
30	30.1	1.5	1.0	21.0	1.6	1.3	14.9	1.8	1.7	10.6	2.1	2.1															
35	35.1	1.5	1.0	24.7	1.6	1.3	17.5	1.8	1.7	12.6	2.0	2.1	8.9	2.4	2.5												
40	40.1	1.5	1.0	28.2	1.6	1.3	20.0	1.8	1.7	14.5	2.0	2.1	10.5	2.3	2.5												
45	45.1	1.5	1.0	31.7	1.6	1.3	22.5	1.8	1.7	16.4	2.0	2.1	12.1	2.2	2.5	9.2	2.8	2.9									
50	50.2	1.5	1.0	35.2	1.6	1.3	25.4	1.8	1.7	18.3	2.0	2.1	13.6	2.2	2.5	10.0	2.6	2.9									
55	55.2	1.5	1.0	38.8	1.6	1.3	27.9	1.8	1.7	20.3	1.9	2.1	15.1	2.2	2.5	11.2	2.5	3.0									
60	60.2	1.5	1.0	42.3	1.6	1.3	30.4	1.8	1.7	22.2	1.9	2.1	16.6	2.1	2.5	12.4	2.4	3.0									
65	65.2	1.5	1.0	45.8	1.6	1.3	32.9	1.8	1.7	24.0	1.9	2.1	18.0	2.1	2.5	13.6	2.4	3.0	8.9	3.1	3.5						
70	70.2	1.5	1.0	49.3	1.6	1.3	35.5	1.8	1.7	25.9	1.9	2.1	19.5	2.1	2.6	14.8	2.4	3.0	10.6	2.8	3.5						
75	75.2	1.5	1.0	52.8	1.6	1.3	38.0	1.8	1.7	28.2	1.9	2.1	20.9	2.1	2.6	16.0	2.3	3.0	11.5	2.8	3.5						
80	80.2	1.5	1.0	56.3	1.6	1.3	40.5	1.8	1.7	30.0	1.9	2.1	22.3	2.1	2.6	17.1	2.3	3.0	12.5	2.7	3.5						
85	85.2	1.5	1.0	59.8	1.6	1.3	43.0	1.8	1.7	31.9	1.9	2.1	23.7	2.1	2.6	18.3	2.3	3.0	13.5	2.7	3.6	9.8	3.3	3.9			
90	90.2	1.5	1.0	63.3	1.6	1.3	45.6	1.8	1.7	33.6	1.9	2.1	25.2	2.1	2.6	19.4	2.3	3.1	14.4	2.6	3.6	10.9	3.1	3.9			
95	95.2	1.5	1.0	66.9	1.6	1.3	48.1	1.8	1.7	35.5	1.9	2.1	26.6	2.1	2.6	20.5	2.3	3.1	15.3	2.6	3.6	12.0	3.0	3.9			
100	100.2	1.5	1.0	70.4	1.6	1.3	50.6	1.8	1.7	37.4	1.9	2.1	28.0	2.1	2.6	21.6	2.3	3.1	16.2	2.6	3.6	12.9	2.9	4.0			
105	105.3	1.5	1.0	73.9	1.6	1.3	53.1	1.8	1.7	39.2	1.9	2.1	29.8	2.1	2.6	22.8	2.3	3.1	17.1	2.6	3.6	13.7	2.9	4.0	10.8	3.4	4.3
110	110.3	1.5	1.0	77.4	1.6	1.3	55.7	1.8	1.7	41.1	1.9	2.1	31.3	2.1	2.6	23.9	2.3	3.1	18.0	2.6	3.6	14.4	2.9	4.0	12.0	3.2	4.3
115	115.3	1.5	1.0	80.9	1.6	1.3	58.2	1.8	1.7	42.9	1.9	2.1	32.7	2.1	2.6	25.0	2.3	3.1	18.9	2.5	3.6	15.2	2.8	4.0	12.7	3.2	4.3
120	120.3	1.5	1.0	84.4	1.6	1.3	60.7	1.8	1.7	44.8	1.9	2.1	34.1	2.1	2.6	26.1	2.2	3.1	19.7	2.5	3.6	16.0	2.8	4.0	13.4	3.1	4.3
125	125.3	1.5	1.0	88.0	1.6	1.3	63.2	1.8	1.7	46.7	1.9	2.1	35.5	2.1	2.6	27.2	2.2	3.1	20.6	2.5	3.6	16.8	2.8	4.0	14.1	3.1	4.3
130	130.3	1.5	1.0	91.5	1.6	1.3	65.8	1.8	1.7	48.5	1.9	2.1	36.9	2.1	2.6	28.4	2.2	3.1	21.5	2.5	3.6	17.4	2.8	4.0	14.8	3.1	4.3
135	135.3	1.5	1.0	95.0	1.6	1.3	68.3	1.8	1.7	50.4	1.9	2.1	38.3	2.1	2.6	29.5	2.2	3.1	22.4	2.5	3.6	18.2	2.8	4.0	15.5	3.0	4.3
140	140.3	1.5	1.0	98.5	1.6	1.3	70.8	1.8	1.7	52.2	1.9	2.1	39.7	2.0	2.6	30.6	2.2	3.1	23.2	2.5	3.6	18.9	2.7	4.0	16.1	3.0	4.4
145	145.3	1.5	1.0	102.0	1.6	1.3	73.3	1.8	1.7	54.1	1.9	2.1	41.1	2.0	2.6	32.1	2.2	3.0	24.1	2.5	3.6	19.7	2.7	4.0	16.8	3.0	4.4
150	150.3	1.5	1.0	105.5	1.6	1.3	75.9	1.8	1.7	56.0	1.9	2.1	42.5	2.0	2.6	33.2	2.2	3.0	25.0	2.5	3.6	20.4	2.7	4.1	17.5	2.9	4.4

Table A6-DV-2. Parabolic Diversion Design Chart (Retardance "D" and "B", Grade 1.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 2.00 PERCENT

Q	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
CFS	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	7.1	1.2	0.9																								
10	14.7	1.2	0.9	9.5	1.3	1.2	7.0	1.4	1.5																		
15	22.0	1.2	0.9	14.5	1.3	1.2	10.8	1.4	1.5	8.0	1.5	1.9	5.5	1.9	2.1												
20	29.3	1.2	0.9	19.6	1.2	1.2	14.6	1.3	1.5	10.9	1.5	1.9	8.1	1.6	2.3	5.5	2.1	2.6									
25	36.6	1.2	0.9	24.4	1.2	1.2	18.5	1.3	1.5	13.8	1.4	1.9	10.4	1.6	2.3	7.9	1.8	2.7									
30	43.9	1.2	0.9	29.3	1.2	1.2	22.2	1.3	1.6	16.6	1.4	1.9	12.7	1.5	2.3	9.7	1.7	2.7	7.3	2.0	3.1						
35	51.2	1.2	0.9	34.2	1.2	1.2	25.8	1.3	1.6	19.6	1.4	1.9	14.9	1.5	2.3	11.5	1.7	2.7	8.9	1.9	3.2						
40	58.5	1.2	0.9	39.0	1.2	1.2	29.5	1.3	1.6	22.4	1.4	1.9	17.1	1.5	2.3	13.3	1.6	2.8	10.4	1.8	3.2	8.0	2.1	3.6			
45	65.8	1.2	0.9	43.9	1.2	1.2	33.2	1.3	1.6	25.2	1.4	1.9	19.3	1.5	2.3	15.0	1.6	2.8	11.8	1.8	3.2	9.2	2.0	3.7			
50	73.1	1.2	0.9	48.8	1.2	1.2	36.8	1.3	1.6	28.0	1.4	1.9	21.7	1.5	2.3	16.7	1.6	2.8	13.2	1.8	3.2	10.5	1.9	3.7	7.9	2.3	4.1
55	80.4	1.2	0.9	53.6	1.2	1.2	40.5	1.3	1.6	30.7	1.4	1.9	23.9	1.5	2.3	18.5	1.6	2.8	14.6	1.7	3.2	11.7	1.9	3.7	9.2	2.2	4.1
60	87.7	1.2	0.9	58.5	1.2	1.2	44.2	1.3	1.6	33.5	1.4	1.9	26.0	1.5	2.3	20.2	1.6	2.8	16.0	1.7	3.2	12.8	1.9	3.7	10.2	2.1	4.1
65	95.0	1.2	0.9	63.4	1.2	1.2	47.9	1.3	1.6	36.3	1.4	1.9	28.2	1.5	2.3	22.1	1.6	2.8	17.4	1.7	3.3	14.0	1.9	3.7	11.3	2.1	4.2
70	102.3	1.2	0.9	68.2	1.2	1.2	51.6	1.3	1.6	39.1	1.4	1.9	30.3	1.5	2.3	23.8	1.6	2.8	18.8	1.7	3.3	15.2	1.9	3.7	12.3	2.1	4.2
75	109.6	1.2	0.9	73.1	1.2	1.2	55.2	1.3	1.6	41.9	1.4	1.9	32.5	1.5	2.3	25.5	1.6	2.8	20.1	1.7	3.3	16.2	1.8	3.7	13.2	2.0	4.2
80	116.9	1.2	0.9	78.0	1.2	1.2	58.9	1.3	1.6	44.7	1.4	1.9	34.6	1.5	2.3	27.2	1.6	2.8	21.5	1.7	3.3	17.4	1.8	3.8	14.2	2.0	4.2
85	124.2	1.2	0.9	82.9	1.2	1.2	62.6	1.3	1.6	47.4	1.4	1.9	36.8	1.5	2.3	28.9	1.6	2.8	22.9	1.7	3.3	18.5	1.8	3.8	15.1	2.0	4.2
90	131.5	1.2	0.9	87.7	1.2	1.2	66.3	1.3	1.6	50.2	1.4	1.9	39.0	1.5	2.3	30.6	1.6	2.8	24.6	1.7	3.2	19.6	1.8	3.8	16.1	2.0	4.2
95	138.8	1.2	0.9	92.6	1.2	1.2	69.9	1.3	1.6	53.0	1.4	1.9	41.1	1.5	2.3	32.3	1.6	2.8	25.9	1.7	3.3	20.8	1.8	3.8	17.0	2.0	4.2
100	146.1	1.2	0.9	97.5	1.2	1.2	73.6	1.3	1.6	55.8	1.4	1.9	43.3	1.5	2.3	34.0	1.6	2.8	27.3	1.7	3.3	21.9	1.8	3.8	18.0	2.0	4.2
105	153.4	1.2	0.9	102.3	1.2	1.2	77.3	1.3	1.6	58.6	1.4	1.9	45.4	1.5	2.3	35.7	1.6	2.8	28.6	1.7	3.3	23.0	1.8	3.8	18.9	2.0	4.2
110	160.7	1.2	0.9	107.2	1.2	1.2	81.0	1.3	1.6	61.4	1.4	1.9	47.6	1.5	2.3	37.3	1.6	2.8	30.0	1.7	3.3	24.1	1.8	3.8	19.8	2.0	4.2
115	168.0	1.2	0.9	112.1	1.2	1.2	84.7	1.3	1.6	64.2	1.4	1.9	49.8	1.5	2.3	39.0	1.6	2.8	31.3	1.7	3.3	25.3	1.8	3.8	20.8	2.0	4.2
120	175.3	1.2	0.9	117.0	1.2	1.2	88.3	1.3	1.6	67.0	1.4	1.9	51.9	1.5	2.3	40.7	1.6	2.8	32.7	1.7	3.3	26.7	1.8	3.7	21.7	2.0	4.2
125	182.6	1.2	0.9	121.8	1.2	1.2	92.0	1.3	1.6	69.7	1.4	1.9	54.1	1.5	2.3	42.4	1.6	2.8	34.1	1.7	3.3	27.8	1.8	3.7	22.6	1.9	4.3
130	189.9	1.2	0.9	126.7	1.2	1.2	95.7	1.3	1.6	72.5	1.4	1.9	56.2	1.5	2.3	44.1	1.6	2.8	35.4	1.7	3.3	28.9	1.8	3.7	23.6	1.9	4.3
135	197.3	1.2	0.9	131.6	1.2	1.2	99.4	1.3	1.6	75.3	1.4	1.9	58.4	1.5	2.3	45.8	1.6	2.8	36.8	1.7	3.3	30.0	1.8	3.7	24.5	1.9	4.3
140	204.6	1.2	0.9	136.5	1.2	1.2	103.1	1.3	1.6	78.1	1.4	1.9	60.6	1.5	2.3	47.5	1.6	2.8	38.1	1.7	3.3	31.1	1.8	3.7	25.4	1.9	4.3
145	211.9	1.2	0.9	141.3	1.2	1.2	106.7	1.3	1.6	80.9	1.4	1.9	62.7	1.5	2.3	49.2	1.6	2.8	39.5	1.7	3.3	32.3	1.8	3.7	26.4	1.9	4.3
150	219.2	1.2	0.9	146.2	1.2	1.2	110.4	1.3	1.6	83.7	1.4	1.9	64.9	1.5	2.3	50.9	1.6	2.8	40.8	1.7	3.3	33.4	1.8	3.7	27.3	1.9	4.3

Table A6-DV-3. Parabolic Diversion Design Chart (Retardance "D" and "B", Grade 2.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 4.00 PERCENT

Q	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
CFS	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	10.1	0.9	0.8	7.0	1.0	1.1	4.9	1.1	1.4																		
10	20.5	0.9	0.8	14.4	0.9	1.1	10.3	1.0	1.4	7.9	1.1	1.8	6.1	1.2	2.1	4.5	1.4	2.4									
15	30.7	0.9	0.8	21.5	0.9	1.1	15.7	1.0	1.4	12.0	1.1	1.8	9.4	1.1	2.1	7.4	1.2	2.5	5.8	1.4	2.8						
20	40.9	0.9	0.8	28.6	0.9	1.1	20.9	1.0	1.4	16.3	1.0	1.8	12.6	1.1	2.1	10.1	1.2	2.5	8.0	1.3	2.9	6.3	1.4	3.3			
25	51.1	0.9	0.8	35.8	0.9	1.1	26.1	1.0	1.4	20.3	1.0	1.8	16.0	1.1	2.1	12.7	1.2	2.5	10.2	1.3	2.9	8.2	1.4	3.4	6.5	1.5	3.8
30	61.3	0.9	0.8	42.9	0.9	1.1	31.4	1.0	1.4	24.4	1.0	1.8	19.2	1.1	2.1	15.2	1.2	2.5	12.3	1.3	2.9	10.0	1.3	3.4	8.1	1.5	3.8
35	71.5	0.9	0.8	50.1	0.9	1.1	36.6	1.0	1.4	28.3	1.0	1.8	22.4	1.1	2.1	18.0	1.2	2.5	14.4	1.2	2.9	11.7	1.3	3.4	9.6	1.4	3.8
40	81.8	0.9	0.8	57.2	0.9	1.1	41.8	1.0	1.5	32.4	1.0	1.8	25.6	1.1	2.1	20.6	1.2	2.5	16.5	1.2	2.9	13.5	1.3	3.4	11.1	1.4	3.8
45	92.0	0.9	0.8	64.4	0.9	1.1	47.0	1.0	1.5	36.4	1.0	1.8	28.8	1.1	2.1	23.1	1.2	2.5	18.8	1.2	2.9	15.2	1.3	3.4	12.6	1.4	3.9
50	102.2	0.9	0.8	71.5	0.9	1.1	52.2	1.0	1.5	40.5	1.0	1.8	32.0	1.1	2.1	25.7	1.2	2.5	20.9	1.2	2.9	17.0	1.3	3.4	14.0	1.4	3.9
55	112.4	0.9	0.8	78.7	0.9	1.1	57.5	1.0	1.5	44.5	1.0	1.8	35.2	1.1	2.1	28.2	1.2	2.5	23.0	1.2	2.9	18.9	1.3	3.4	15.4	1.4	3.9
60	122.6	0.9	0.8	85.8	0.9	1.1	62.7	1.0	1.5	48.5	1.0	1.8	38.4	1.1	2.2	30.8	1.2	2.5	25.1	1.2	2.9	20.6	1.3	3.4	16.9	1.4	3.9
65	132.8	0.9	0.8	93.0	0.9	1.1	67.9	1.0	1.5	52.6	1.0	1.8	41.5	1.1	2.2	33.4	1.2	2.5	27.2	1.2	2.9	22.3	1.3	3.4	18.3	1.4	3.9
70	143.1	0.9	0.8	100.1	0.9	1.1	73.1	1.0	1.5	56.6	1.0	1.8	44.7	1.1	2.2	35.9	1.2	2.5	29.2	1.2	2.9	24.0	1.3	3.4	20.0	1.4	3.9
75	153.3	0.9	0.8	107.3	0.9	1.1	78.3	1.0	1.5	60.7	1.0	1.8	47.9	1.1	2.2	38.5	1.2	2.5	31.3	1.2	2.9	25.7	1.3	3.4	21.4	1.4	3.9
80	163.5	0.9	0.8	114.4	0.9	1.1	83.6	1.0	1.5	64.7	1.0	1.8	51.1	1.1	2.2	41.0	1.2	2.5	33.4	1.2	2.9	27.4	1.3	3.4	22.8	1.4	3.9
85	173.7	0.9	0.8	121.6	0.9	1.1	88.8	1.0	1.5	68.8	1.0	1.8	54.3	1.1	2.2	43.6	1.2	2.5	35.5	1.2	2.9	29.1	1.3	3.4	24.2	1.4	3.9
90	183.9	0.9	0.8	128.7	0.9	1.1	94.0	1.0	1.5	72.8	1.0	1.8	57.5	1.1	2.2	46.2	1.2	2.5	37.6	1.2	2.9	30.8	1.3	3.4	25.7	1.4	3.9
95	194.1	0.9	0.8	135.9	0.9	1.1	99.2	1.0	1.5	76.8	1.0	1.8	60.7	1.1	2.2	48.7	1.2	2.5	39.7	1.2	2.9	32.5	1.3	3.4	27.1	1.4	3.9
100	204.4	0.9	0.8	143.0	0.9	1.1	104.4	1.0	1.5	80.9	1.0	1.8	63.9	1.1	2.2	51.3	1.2	2.5	41.7	1.2	2.9	34.2	1.3	3.4	28.5	1.3	3.9
105	214.6	0.9	0.8	150.2	0.9	1.1	109.7	1.0	1.5	84.9	1.0	1.8	67.1	1.1	2.2	53.9	1.2	2.5	43.8	1.2	2.9	35.9	1.3	3.4	29.9	1.3	3.9
110	224.8	0.9	0.8	157.4	0.9	1.1	114.9	1.0	1.5	89.0	1.0	1.8	70.3	1.1	2.2	56.4	1.2	2.5	45.9	1.2	2.9	37.6	1.3	3.4	31.3	1.3	3.9
115	235.0	0.9	0.8	164.5	0.9	1.1	120.1	1.0	1.5	93.0	1.0	1.8	73.5	1.1	2.2	59.0	1.2	2.5	48.0	1.2	2.9	39.3	1.3	3.4	32.7	1.3	3.9
120	245.2	0.9	0.8	171.7	0.9	1.1	125.3	1.0	1.5	97.1	1.0	1.8	76.7	1.1	2.2	61.5	1.2	2.5	49.9	1.2	3.0	41.0	1.3	3.4	34.2	1.3	3.9
125	255.5	0.9	0.8	178.8	0.9	1.1	130.5	1.0	1.5	101.1	1.0	1.8	79.9	1.1	2.2	64.1	1.2	2.5	52.0	1.2	3.0	42.7	1.3	3.4	35.6	1.3	3.9
130	265.7	0.9	0.8	186.0	0.9	1.1	135.8	1.0	1.5	105.1	1.0	1.8	83.0	1.1	2.2	66.7	1.2	2.5	54.1	1.2	3.0	44.4	1.3	3.4	37.0	1.3	3.9
135	275.9	0.9	0.8	193.1	0.9	1.1	141.0	1.0	1.5	109.2	1.0	1.8	86.2	1.1	2.2	69.2	1.2	2.5	56.1	1.2	3.0	46.1	1.3	3.4	38.4	1.3	3.9
140	286.1	0.9	0.8	200.3	0.9	1.1	146.2	1.0	1.5	113.2	1.0	1.8	89.4	1.1	2.2	71.8	1.2	2.5	58.2	1.2	3.0	47.8	1.3	3.4	39.9	1.3	3.9
145	296.3	0.9	0.8	207.4	0.9	1.1	151.4	1.0	1.5	117.3	1.0	1.8	92.6	1.1	2.2	74.4	1.2	2.5	60.3	1.2	3.0	49.6	1.3	3.4	41.3	1.3	3.9
150	306.5	0.9	0.8	214.6	0.9	1.1	156.7	1.0	1.5	121.3	1.0	1.8	95.8	1.1	2.2	76.9	1.2	2.5	62.4	1.2	3.0	51.3	1.3	3.4	42.7	1.3	3.9

Table A6-DV-4. Parabolic Diversion Design Chart (Retardance "D" and "B", Grade 4.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 6.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	12.4	0.7	0.8	8.7	0.8	1.0	6.2	0.9	1.4	4.7	1.0	1.6	3.5	1.2	1.9												
10	24.7	0.7	0.8	17.6	0.8	1.0	12.8	0.9	1.4	9.8	0.9	1.7	7.8	1.0	2.0	6.2	1.0	2.3	4.9	1.1	2.7						
15	37.1	0.7	0.8	26.4	0.8	1.1	19.2	0.8	1.4	15.0	0.9	1.7	11.8	0.9	2.0	9.5	1.0	2.4	7.7	1.1	2.7	6.2	1.2	3.1	5.0	1.3	3.5
20	49.4	0.7	0.8	35.1	0.8	1.1	25.6	0.8	1.4	19.9	0.9	1.7	16.0	0.9	2.0	12.9	1.0	2.4	10.4	1.0	2.8	8.5	1.1	3.2	7.0	1.2	3.6
25	61.8	0.7	0.8	43.9	0.8	1.1	32.0	0.8	1.4	24.9	0.9	1.7	19.9	0.9	2.0	16.1	1.0	2.4	13.1	1.0	2.8	10.8	1.1	3.2	8.9	1.2	3.6
30	74.1	0.7	0.8	52.7	0.8	1.1	38.4	0.8	1.4	29.9	0.9	1.7	23.8	0.9	2.1	19.3	1.0	2.4	15.9	1.0	2.8	13.0	1.1	3.2	10.8	1.1	3.6
35	86.5	0.7	0.8	61.5	0.8	1.1	44.8	0.8	1.4	34.8	0.9	1.7	27.8	0.9	2.1	22.5	1.0	2.4	18.5	1.0	2.8	15.4	1.1	3.2	12.7	1.1	3.6
40	98.9	0.7	0.8	70.2	0.8	1.1	51.2	0.8	1.4	39.8	0.9	1.7	31.8	0.9	2.1	25.7	1.0	2.4	21.2	1.0	2.8	17.6	1.1	3.2	14.5	1.1	3.6
45	111.2	0.7	0.8	79.0	0.8	1.1	57.6	0.8	1.4	44.8	0.9	1.7	35.7	0.9	2.1	29.0	1.0	2.4	23.8	1.0	2.8	19.8	1.1	3.2	16.6	1.1	3.6
50	123.6	0.7	0.8	87.8	0.8	1.1	64.0	0.8	1.4	49.7	0.9	1.7	39.7	0.9	2.1	32.2	1.0	2.4	26.4	1.0	2.8	22.0	1.1	3.2	18.4	1.1	3.6
55	135.9	0.7	0.8	96.6	0.8	1.1	70.4	0.8	1.4	54.7	0.9	1.7	43.6	0.9	2.1	35.4	1.0	2.4	29.1	1.0	2.8	24.2	1.1	3.2	20.2	1.1	3.7
60	148.3	0.7	0.8	105.3	0.8	1.1	76.8	0.8	1.4	59.7	0.9	1.7	47.6	0.9	2.1	38.6	1.0	2.4	31.7	1.0	2.8	26.3	1.1	3.2	22.0	1.1	3.7
65	160.6	0.7	0.8	114.1	0.8	1.1	83.2	0.8	1.4	64.7	0.9	1.7	51.6	0.9	2.1	41.8	1.0	2.4	34.3	1.0	2.8	28.5	1.1	3.2	23.8	1.1	3.7
70	173.0	0.7	0.8	122.9	0.8	1.1	89.6	0.8	1.4	69.6	0.9	1.7	55.5	0.9	2.1	45.0	1.0	2.4	37.0	1.0	2.8	30.7	1.1	3.2	25.6	1.1	3.7
75	185.4	0.7	0.8	131.7	0.8	1.1	96.0	0.8	1.4	74.6	0.9	1.7	59.5	0.9	2.1	48.2	1.0	2.4	39.6	1.0	2.8	32.9	1.1	3.2	27.4	1.1	3.7
80	197.7	0.7	0.8	140.4	0.8	1.1	102.3	0.8	1.4	79.6	0.9	1.7	63.5	0.9	2.1	51.4	1.0	2.4	42.2	1.0	2.8	35.1	1.1	3.2	29.3	1.1	3.7
85	210.1	0.7	0.8	149.2	0.8	1.1	108.7	0.8	1.4	84.5	0.9	1.7	67.4	0.9	2.1	54.7	1.0	2.4	44.9	1.0	2.8	37.3	1.1	3.2	31.1	1.1	3.7
90	222.4	0.7	0.8	158.0	0.8	1.1	115.1	0.8	1.4	89.5	0.9	1.7	71.4	0.9	2.1	57.9	1.0	2.4	47.5	1.0	2.8	39.5	1.1	3.2	32.9	1.1	3.7
95	234.8	0.7	0.8	166.8	0.8	1.1	121.5	0.8	1.4	94.5	0.9	1.7	75.4	0.9	2.1	61.1	1.0	2.4	50.2	1.0	2.8	41.7	1.1	3.2	34.7	1.1	3.7
100	247.1	0.7	0.8	175.5	0.8	1.1	127.9	0.8	1.4	99.5	0.9	1.7	79.3	0.9	2.1	64.3	1.0	2.4	52.8	1.0	2.8	43.9	1.1	3.2	36.6	1.1	3.7
105	259.5	0.7	0.8	184.3	0.8	1.1	134.3	0.8	1.4	104.4	0.9	1.7	83.3	0.9	2.1	67.5	1.0	2.4	55.4	1.0	2.8	46.1	1.1	3.2	38.4	1.1	3.7
110	271.8	0.7	0.8	193.1	0.8	1.1	140.7	0.8	1.4	109.4	0.9	1.7	87.3	0.9	2.1	70.7	1.0	2.4	58.1	1.0	2.8	48.2	1.1	3.2	40.2	1.1	3.7
115	284.2	0.7	0.8	201.9	0.8	1.1	147.1	0.8	1.4	114.4	0.9	1.7	91.2	0.9	2.1	73.9	1.0	2.4	60.7	1.0	2.8	50.4	1.1	3.2	42.0	1.1	3.7
120	296.6	0.7	0.8	210.7	0.8	1.1	153.5	0.8	1.4	119.3	0.9	1.7	95.2	0.9	2.1	77.2	1.0	2.4	63.3	1.0	2.8	52.6	1.1	3.2	43.9	1.1	3.7
125	308.9	0.7	0.8	219.4	0.8	1.1	159.9	0.8	1.4	124.3	0.9	1.7	99.2	0.9	2.1	80.4	1.0	2.4	66.0	1.0	2.8	54.8	1.1	3.2	45.7	1.1	3.7
130	321.3	0.7	0.8	228.2	0.8	1.1	166.3	0.8	1.4	129.3	0.9	1.7	103.1	0.9	2.1	83.6	1.0	2.4	68.6	1.0	2.8	57.0	1.1	3.2	47.5	1.1	3.7
135	333.6	0.7	0.8	237.0	0.8	1.1	172.7	0.8	1.4	134.3	0.9	1.7	107.1	0.9	2.1	86.8	1.0	2.4	71.3	1.0	2.8	59.2	1.1	3.2	49.3	1.1	3.7
140	346.0	0.7	0.8	245.8	0.8	1.1	179.1	0.8	1.4	139.2	0.9	1.7	111.0	0.9	2.1	90.0	1.0	2.4	73.9	1.0	2.8	61.4	1.1	3.2	51.2	1.1	3.7
145	358.3	0.7	0.8	254.5	0.8	1.1	185.5	0.8	1.4	144.2	0.9	1.7	115.0	0.9	2.1	93.2	1.0	2.4	76.5	1.0	2.8	63.6	1.1	3.2	53.0	1.1	3.7
150	370.7	0.7	0.8	263.3	0.8	1.1	191.9	0.8	1.4	149.2	0.9	1.7	119.0	0.9	2.1	96.4	1.0	2.4	79.2	1.0	2.8	65.8	1.1	3.2	54.8	1.1	3.7

Table A6-DV-5. Parabolic Diversion Design Chart (Retardance "D" and "B", Grade 6.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 8.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	14.0	0.7	0.8	10.1	0.7	1.0	7.4	0.8	1.3	5.5	0.8	1.6	4.4	0.9	1.9	3.4	1.0	2.1									
10	28.0	0.7	0.8	20.1	0.7	1.0	15.0	0.8	1.3	11.3	0.8	1.7	9.1	0.8	2.0	7.4	0.9	2.3	6.0	0.9	2.6	4.9	1.0	3.0	3.8	1.2	3.3
15	41.9	0.7	0.8	30.1	0.7	1.0	22.4	0.8	1.3	17.0	0.8	1.7	13.9	0.8	2.0	11.4	0.9	2.3	9.2	0.9	2.7	7.6	1.0	3.0	6.3	1.0	3.4
20	55.9	0.7	0.8	40.1	0.7	1.0	29.9	0.8	1.3	22.6	0.8	1.7	18.5	0.8	2.0	15.1	0.9	2.3	12.5	0.9	2.7	10.2	1.0	3.1	8.5	1.0	3.5
25	69.9	0.7	0.8	50.1	0.7	1.0	37.3	0.8	1.3	28.2	0.8	1.7	23.1	0.8	2.0	18.8	0.9	2.3	15.6	0.9	2.7	13.0	0.9	3.1	10.8	1.0	3.5
30	83.9	0.7	0.8	60.1	0.7	1.0	44.8	0.8	1.3	33.9	0.8	1.7	27.7	0.8	2.0	22.6	0.9	2.3	18.6	0.9	2.7	15.6	0.9	3.1	13.0	1.0	3.5
35	97.9	0.7	0.8	70.1	0.7	1.0	52.3	0.8	1.3	39.5	0.8	1.7	32.3	0.8	2.0	26.3	0.9	2.3	21.7	0.9	2.7	18.2	0.9	3.1	15.3	1.0	3.5
40	111.8	0.7	0.8	80.2	0.7	1.0	59.7	0.8	1.3	45.1	0.8	1.7	36.9	0.8	2.0	30.1	0.9	2.3	24.8	0.9	2.7	20.8	0.9	3.1	17.5	1.0	3.5
45	125.8	0.7	0.8	90.2	0.7	1.0	67.2	0.8	1.3	50.8	0.8	1.7	41.5	0.8	2.0	33.8	0.9	2.3	27.9	0.9	2.7	23.3	0.9	3.1	19.7	1.0	3.5
50	139.8	0.7	0.8	100.2	0.7	1.0	74.7	0.8	1.3	56.4	0.8	1.7	46.1	0.8	2.0	37.6	0.9	2.3	31.0	0.9	2.7	25.9	0.9	3.1	21.9	1.0	3.5
55	153.8	0.7	0.8	110.2	0.7	1.0	82.1	0.8	1.3	62.1	0.8	1.7	50.7	0.8	2.0	41.3	0.9	2.3	34.1	0.9	2.7	28.5	0.9	3.1	24.0	1.0	3.5
60	167.8	0.7	0.8	120.2	0.7	1.0	89.6	0.8	1.3	67.7	0.8	1.7	55.3	0.8	2.0	45.1	0.9	2.3	37.2	0.9	2.7	31.1	0.9	3.1	26.2	1.0	3.5
65	181.7	0.7	0.8	130.3	0.7	1.0	97.0	0.8	1.3	73.3	0.8	1.7	60.0	0.8	2.0	48.8	0.9	2.3	40.3	0.9	2.7	33.7	0.9	3.1	28.4	1.0	3.5
70	195.7	0.7	0.8	140.3	0.7	1.0	104.5	0.8	1.3	79.0	0.8	1.7	64.6	0.8	2.0	52.6	0.9	2.3	43.4	0.9	2.7	36.3	0.9	3.1	30.6	1.0	3.5
75	209.7	0.7	0.8	150.3	0.7	1.0	112.0	0.8	1.3	84.6	0.8	1.7	69.2	0.8	2.0	56.3	0.9	2.3	46.5	0.9	2.7	38.9	0.9	3.1	32.8	1.0	3.5
80	223.7	0.7	0.8	160.3	0.7	1.0	119.4	0.8	1.3	90.3	0.8	1.7	73.8	0.8	2.0	60.1	0.9	2.3	49.6	0.9	2.7	41.4	0.9	3.1	35.0	1.0	3.5
85	237.7	0.7	0.8	170.3	0.7	1.0	126.9	0.8	1.3	95.9	0.8	1.7	78.4	0.8	2.0	63.8	0.9	2.3	52.7	0.9	2.7	44.0	0.9	3.1	37.1	1.0	3.5
90	251.6	0.7	0.8	180.3	0.7	1.0	134.4	0.8	1.3	101.6	0.8	1.7	83.0	0.8	2.0	67.6	0.9	2.3	55.8	0.9	2.7	46.6	0.9	3.1	37.3	1.0	3.5
95	265.6	0.7	0.8	190.4	0.7	1.0	141.8	0.8	1.3	107.2	0.8	1.7	87.6	0.8	2.0	71.3	0.9	2.3	58.9	0.9	2.7	49.2	0.9	3.1	41.5	1.0	3.5
100	279.6	0.7	0.8	200.4	0.7	1.0	149.3	0.8	1.3	112.8	0.8	1.7	92.2	0.8	2.0	75.1	0.9	2.3	62.0	0.9	2.7	51.8	0.9	3.1	43.7	1.0	3.5
105	293.6	0.7	0.8	210.4	0.7	1.0	156.8	0.8	1.3	118.5	0.8	1.7	96.8	0.8	2.0	78.9	0.9	2.3	65.1	0.9	2.7	54.4	0.9	3.1	45.9	1.0	3.5
110	307.6	0.7	0.8	220.4	0.7	1.0	164.2	0.8	1.3	124.1	0.8	1.7	101.4	0.8	2.0	82.6	0.9	2.3	68.2	0.9	2.7	57.0	0.9	3.1	48.0	1.0	3.5
115	321.5	0.7	0.8	230.4	0.7	1.0	171.7	0.8	1.3	129.8	0.8	1.7	106.1	0.8	2.0	86.4	0.9	2.3	71.3	0.9	2.7	59.6	0.9	3.1	50.2	1.0	3.5
120	335.5	0.7	0.8	240.5	0.7	1.0	179.1	0.8	1.3	135.4	0.8	1.7	110.7	0.8	2.0	90.1	0.9	2.3	74.4	0.9	2.7	62.2	0.9	3.1	52.4	1.0	3.5
125	349.5	0.7	0.8	250.5	0.7	1.0	186.6	0.8	1.3	141.0	0.8	1.7	115.3	0.8	2.0	93.9	0.9	2.3	77.5	0.9	2.7	64.7	0.9	3.1	54.6	1.0	3.5
130	363.5	0.7	0.8	260.5	0.7	1.0	194.1	0.8	1.3	146.7	0.8	1.7	119.9	0.8	2.0	97.6	0.9	2.3	80.6	0.9	2.7	67.3	0.9	3.1	56.8	1.0	3.5
135	377.5	0.7	0.8	270.5	0.7	1.0	201.5	0.8	1.3	152.3	0.8	1.7	124.5	0.8	2.0	101.4	0.9	2.3	83.7	0.9	2.7	69.9	0.9	3.1	59.0	1.0	3.5
140	391.5	0.7	0.8	280.5	0.7	1.0	209.0	0.8	1.3	158.0	0.8	1.7	129.1	0.8	2.0	105.1	0.9	2.3	86.8	0.9	2.7	72.5	0.9	3.1	61.1	1.0	3.5
145	405.4	0.7	0.8	290.6	0.7	1.0	216.5	0.8	1.3	163.6	0.8	1.7	133.7	0.8	2.0	108.9	0.9	2.3	89.9	0.9	2.7	75.1	0.9	3.1	63.3	1.0	3.5
150	419.4	0.7	0.8	300.6	0.7	1.0	223.9	0.8	1.3	169.3	0.8	1.7	138.3	0.8	2.0	112.6	0.9	2.3	93.0	0.9	2.7	77.7	0.9	3.1	65.5	1.0	3.5

Table A6-DV-6. Parabolic Diversion Design Chart (Retardance "D" and "B", Grade 8.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 10.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	15.3	0.6	0.8	11.1	0.7	1.0	8.1	0.7	1.3	6.3	0.7	1.6	4.8	0.8	1.9	4.0	0.9	2.2	3.1	1.0	2.4						
10	30.6	0.6	0.8	22.1	0.7	1.0	16.5	0.7	1.3	12.8	0.7	1.6	10.0	0.8	2.0	8.4	0.8	2.2	6.9	0.8	2.6	5.7	0.9	2.9	4.7	1.0	3.3
15	45.9	0.6	0.8	33.2	0.7	1.0	24.7	0.7	1.3	19.2	0.7	1.6	15.0	0.8	2.0	12.7	0.8	2.2	10.5	0.8	2.6	8.7	0.9	3.0	7.3	0.9	3.3
20	61.2	0.6	0.8	44.2	0.7	1.0	32.9	0.7	1.3	25.6	0.7	1.6	20.0	0.8	2.0	17.0	0.8	2.2	14.1	0.8	2.6	11.8	0.9	3.0	9.8	0.9	3.4
25	76.5	0.6	0.8	55.3	0.7	1.0	41.1	0.7	1.3	32.0	0.7	1.6	25.0	0.8	2.0	21.2	0.8	2.3	17.6	0.8	2.6	14.7	0.9	3.0	12.5	0.9	3.4
30	91.8	0.6	0.8	66.3	0.7	1.0	49.3	0.7	1.3	38.3	0.7	1.6	29.9	0.8	2.0	25.4	0.8	2.3	21.1	0.8	2.6	17.7	0.8	3.0	15.0	0.9	3.3
35	107.1	0.6	0.8	77.4	0.7	1.0	57.5	0.7	1.3	44.7	0.7	1.6	34.9	0.8	2.0	29.7	0.8	2.3	24.6	0.8	2.6	20.6	0.8	3.0	17.5	0.9	3.4
40	122.4	0.6	0.8	88.4	0.7	1.0	65.7	0.7	1.3	51.1	0.7	1.6	39.9	0.8	2.0	33.9	0.8	2.3	28.1	0.8	2.6	23.5	0.8	3.0	20.0	0.9	3.4
45	137.8	0.6	0.8	99.5	0.7	1.0	73.9	0.7	1.3	57.5	0.7	1.6	44.9	0.8	2.0	38.0	0.8	2.3	31.6	0.8	2.6	26.5	0.8	3.0	22.5	0.9	3.4
50	153.1	0.6	0.8	110.6	0.7	1.0	82.1	0.7	1.3	63.9	0.7	1.6	49.9	0.8	2.0	42.2	0.8	2.3	35.1	0.8	2.6	29.4	0.8	3.0	25.0	0.9	3.4
55	168.4	0.6	0.8	121.6	0.7	1.0	90.3	0.7	1.3	70.3	0.7	1.6	54.9	0.8	2.0	46.4	0.8	2.3	38.6	0.8	2.6	32.3	0.8	3.0	27.5	0.9	3.4
60	183.7	0.6	0.8	132.7	0.7	1.0	98.5	0.7	1.3	76.7	0.7	1.6	59.9	0.8	2.0	50.7	0.8	2.3	42.1	0.8	2.6	35.3	0.8	3.0	30.0	0.9	3.4
65	199.0	0.6	0.8	143.7	0.7	1.0	106.7	0.7	1.3	83.1	0.7	1.6	64.8	0.8	2.0	54.9	0.8	2.3	45.6	0.8	2.6	38.2	0.8	3.0	32.5	0.9	3.4
70	214.3	0.6	0.8	154.8	0.7	1.0	115.0	0.7	1.3	89.4	0.7	1.6	69.8	0.8	2.0	59.1	0.8	2.3	49.1	0.8	2.6	41.2	0.8	3.0	35.0	0.9	3.4
75	229.6	0.6	0.8	165.8	0.7	1.0	123.2	0.7	1.3	95.8	0.7	1.6	74.8	0.8	2.0	63.3	0.8	2.3	52.6	0.8	2.6	44.1	0.8	3.0	37.4	0.9	3.4
80	244.9	0.6	0.8	176.9	0.7	1.0	131.4	0.7	1.3	102.2	0.7	1.6	79.8	0.8	2.0	67.6	0.8	2.3	56.1	0.8	2.6	47.0	0.8	3.0	39.8	0.9	3.4
85	260.2	0.6	0.8	187.9	0.7	1.0	139.6	0.7	1.3	108.6	0.7	1.6	84.8	0.8	2.0	71.8	0.8	2.3	59.6	0.8	2.6	50.0	0.8	3.0	42.3	0.9	3.4
90	275.5	0.6	0.8	199.0	0.7	1.0	147.8	0.7	1.3	115.0	0.7	1.6	89.8	0.8	2.0	76.0	0.8	2.3	63.1	0.8	2.6	52.9	0.8	3.0	44.8	0.9	3.4
95	290.8	0.6	0.8	210.0	0.7	1.0	156.0	0.7	1.3	121.4	0.7	1.6	94.8	0.8	2.0	80.2	0.8	2.3	66.6	0.8	2.6	55.8	0.8	3.0	47.3	0.9	3.4
100	306.1	0.6	0.8	221.1	0.7	1.0	164.2	0.7	1.3	127.8	0.7	1.6	99.8	0.8	2.0	84.4	0.8	2.3	70.1	0.8	2.6	58.8	0.8	3.0	49.7	0.9	3.4
105	321.4	0.6	0.8	232.2	0.7	1.0	172.4	0.7	1.3	134.2	0.7	1.6	104.7	0.8	2.0	88.7	0.8	2.3	73.6	0.8	2.6	61.7	0.8	3.0	52.2	0.9	3.4
110	336.7	0.6	0.8	243.2	0.7	1.0	180.6	0.7	1.3	140.5	0.7	1.6	109.7	0.8	2.0	92.9	0.8	2.3	77.1	0.8	2.6	64.7	0.8	3.0	54.7	0.9	3.4
115	352.0	0.6	0.8	254.3	0.7	1.0	188.8	0.7	1.3	146.9	0.7	1.6	114.7	0.8	2.0	97.1	0.8	2.3	80.6	0.8	2.6	67.6	0.8	3.0	57.2	0.9	3.4
120	367.3	0.6	0.8	265.3	0.7	1.0	197.1	0.7	1.3	153.3	0.7	1.6	119.7	0.8	2.0	101.3	0.8	2.3	84.1	0.8	2.6	70.5	0.8	3.0	59.7	0.9	3.4
125	382.6	0.6	0.8	276.4	0.7	1.0	205.3	0.7	1.3	159.7	0.7	1.6	124.7	0.8	2.0	105.5	0.8	2.3	87.6	0.8	2.6	73.5	0.8	3.0	62.2	0.9	3.4
130	397.9	0.6	0.8	287.4	0.7	1.0	213.5	0.7	1.3	166.1	0.7	1.6	129.7	0.8	2.0	109.8	0.8	2.3	91.1	0.8	2.6	76.4	0.8	3.0	64.7	0.9	3.4
135	413.2	0.6	0.8	298.5	0.7	1.0	221.7	0.7	1.3	172.5	0.7	1.6	134.7	0.8	2.0	114.0	0.8	2.3	94.6	0.8	2.6	79.3	0.8	3.0	67.2	0.9	3.4
140	428.6	0.6	0.8	309.3	0.7	1.0	229.9	0.7	1.3	178.9	0.7	1.6	139.7	0.8	2.0	118.2	0.8	2.3	98.1	0.8	2.6	82.3	0.8	3.0	69.6	0.9	3.4
145	443.9	0.6	0.8	320.6	0.7	1.0	238.1	0.7	1.3	185.3	0.7	1.6	144.6	0.8	2.0	122.4	0.8	2.3	101.7	0.8	2.6	85.2	0.8	3.0	72.1	0.9	3.4
150	459.2	0.6	0.8	331.7	0.7	1.0	246.3	0.7	1.3	191.6	0.7	1.6	149.6	0.8	2.0	126.7	0.8	2.3	105.2	0.8	2.6	88.2	0.8	3.0	74.6	0.9	3.4

Table A6-DV-7. Parabolic Diversion Design Chart (Retardance "D" and "B", Grade 10.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 0.50 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10																											
15	8.4	1.6	1.7																								
20	11.7	1.5	1.7	7.1	2.0	2.2																					
25	14.9	1.5	1.7	9.7	1.8	2.2																					
30	18.0	1.5	1.7	12.0	1.7	2.2																					
35	21.0	1.5	1.7	14.2	1.7	2.2	9.3	2.1	2.7																		
40	24.4	1.5	1.7	16.3	1.7	2.2	10.9	2.0	2.7																		
45	27.4	1.5	1.7	18.5	1.7	2.2	12.5	2.0	2.7																		
50	30.5	1.5	1.7	20.6	1.7	2.2	14.1	1.9	2.7	8.7	2.6	3.3															
55	33.5	1.5	1.7	22.7	1.7	2.2	15.7	1.9	2.7	10.4	2.4	3.3															
60	36.6	1.5	1.7	24.8	1.7	2.2	17.2	1.9	2.7	11.7	2.3	3.3															
65	39.6	1.5	1.7	27.3	1.7	2.2	18.8	1.9	2.7	12.9	2.3	3.3															
70	42.6	1.5	1.7	29.4	1.7	2.2	20.3	1.9	2.7	14.0	2.2	3.3	9.8	2.8	3.8												
75	45.7	1.5	1.7	31.4	1.7	2.2	21.8	1.9	2.7	15.2	2.2	3.3	11.3	2.7	3.8												
80	48.7	1.5	1.7	33.5	1.7	2.2	23.3	1.9	2.7	16.3	2.2	3.3	12.2	2.6	3.8												
85	51.7	1.5	1.7	35.6	1.6	2.2	24.8	1.9	2.7	17.4	2.2	3.3	13.2	2.5	3.8												
90	54.8	1.5	1.7	37.7	1.6	2.2	26.3	1.9	2.7	18.5	2.2	3.3	14.2	2.5	3.8												
95	57.8	1.5	1.7	39.8	1.6	2.2	27.8	1.9	2.7	19.6	2.2	3.3	15.1	2.5	3.8												
100	60.9	1.5	1.7	41.9	1.6	2.2	29.7	1.9	2.7	20.7	2.2	3.3	16.0	2.5	3.8	11.0	3.2	4.3									
105	63.9	1.5	1.7	44.0	1.6	2.2	31.2	1.9	2.7	21.8	2.2	3.3	16.9	2.5	3.8	12.3	3.0	4.3									
110	66.9	1.5	1.7	46.1	1.6	2.2	32.6	1.9	2.7	22.9	2.2	3.3	17.8	2.4	3.8	13.1	2.9	4.3									
115	70.0	1.5	1.7	48.1	1.6	2.2	34.1	1.9	2.7	24.0	2.1	3.3	18.7	2.4	3.8	13.9	2.9	4.3									
120	73.0	1.5	1.7	50.2	1.6	2.2	35.6	1.9	2.7	25.1	2.1	3.3	19.6	2.4	3.8	14.6	2.9	4.3									
125	76.1	1.5	1.7	52.3	1.6	2.2	37.1	1.9	2.7	26.2	2.1	3.3	20.5	2.4	3.8	15.4	2.8	4.3									
130	79.1	1.5	1.7	54.4	1.6	2.2	38.5	1.9	2.7	27.3	2.1	3.3	21.3	2.4	3.8	16.1	2.8	4.3									
135	82.1	1.5	1.7	56.5	1.6	2.2	40.0	1.9	2.7	28.4	2.1	3.3	22.2	2.4	3.8	16.9	2.8	4.3									
140	85.2	1.5	1.7	58.6	1.6	2.2	41.5	1.9	2.7	29.4	2.1	3.3	23.1	2.4	3.8	17.6	2.8	4.3									
145	88.2	1.5	1.7	60.7	1.6	2.2	43.0	1.9	2.7	30.5	2.1	3.3	24.0	2.4	3.8	18.3	2.8	4.3	12.3	3.7	4.9						
150	91.3	1.5	1.7	62.8	1.6	2.2	44.5	1.9	2.7	31.6	2.1	3.3	24.8	2.4	3.8	19.0	2.7	4.3	13.1	3.5	4.9						

Table A6-DV-8. Parabolic Diversion Design Chart (Retardance "D" and "C", Grade 0.50%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 1.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10	8.2	1.2	1.6	5.2	1.4	2.0																					
15	12.6	1.1	1.6	8.7	1.3	2.1	5.5	1.6	2.6																		
20	17.1	1.1	1.6	11.8	1.2	2.1	8.2	1.4	2.6																		
25	21.4	1.1	1.6	14.9	1.2	2.1	10.5	1.4	2.6	7.3	1.6	3.1															
30	25.7	1.1	1.6	18.0	1.2	2.1	12.8	1.4	2.6	9.1	1.6	3.2															
35	29.9	1.1	1.6	21.2	1.2	2.1	15.0	1.3	2.6	10.9	1.5	3.1	7.8	1.8	3.7												
40	34.2	1.1	1.6	24.3	1.2	2.1	17.3	1.3	2.6	12.6	1.5	3.1	9.2	1.7	3.7												
45	38.5	1.1	1.6	27.3	1.2	2.1	19.5	1.3	2.6	14.3	1.5	3.1	10.6	1.7	3.7	7.2	2.2	4.3									
50	42.7	1.1	1.6	30.3	1.2	2.1	21.9	1.3	2.6	16.0	1.5	3.2	11.9	1.7	3.7	8.8	2.0	4.3									
55	47.0	1.1	1.6	33.3	1.2	2.1	24.1	1.3	2.6	17.7	1.5	3.2	13.3	1.7	3.7	9.9	1.9	4.3									
60	51.3	1.1	1.6	36.3	1.2	2.1	26.3	1.3	2.6	19.3	1.5	3.2	14.6	1.7	3.7	11.0	1.9	4.3									
65	55.5	1.1	1.6	39.4	1.2	2.1	28.5	1.3	2.6	21.0	1.5	3.2	15.9	1.6	3.7	12.1	1.9	4.3	8.0	2.5	4.9						
70	59.8	1.1	1.6	42.4	1.2	2.1	30.7	1.3	2.6	22.7	1.5	3.2	17.1	1.6	3.7	13.2	1.9	4.3	9.5	2.3	4.8						
75	64.1	1.1	1.6	45.4	1.2	2.1	32.9	1.3	2.6	24.6	1.5	3.1	18.5	1.6	3.7	14.2	1.8	4.3	10.4	2.2	4.9						
80	68.3	1.1	1.6	48.4	1.2	2.1	35.0	1.3	2.6	26.2	1.5	3.1	19.8	1.6	3.7	15.2	1.8	4.3	11.3	2.2	4.9						
85	72.6	1.1	1.6	51.5	1.2	2.1	37.2	1.3	2.6	27.9	1.5	3.1	21.0	1.6	3.7	16.3	1.8	4.3	12.1	2.2	4.9	8.8	2.7	5.4			
90	76.9	1.1	1.6	54.5	1.2	2.1	39.4	1.3	2.6	29.5	1.5	3.1	22.3	1.6	3.7	17.3	1.8	4.3	13.0	2.1	4.9	9.8	2.6	5.4			
95	81.1	1.1	1.6	57.5	1.2	2.1	41.6	1.3	2.6	31.1	1.5	3.1	23.6	1.6	3.7	18.3	1.8	4.3	13.8	2.1	4.9	10.9	2.5	5.3			
100	85.4	1.1	1.6	60.5	1.2	2.1	43.8	1.3	2.6	32.7	1.5	3.1	24.9	1.6	3.7	19.3	1.8	4.3	14.6	2.1	4.9	11.6	2.4	5.4			
105	89.7	1.1	1.6	63.6	1.2	2.1	46.0	1.3	2.6	34.4	1.5	3.1	26.5	1.6	3.7	20.3	1.8	4.3	15.4	2.1	4.9	12.4	2.4	5.4	9.7	2.8	5.8
110	94.0	1.1	1.6	66.6	1.2	2.1	48.2	1.3	2.6	36.0	1.5	3.1	27.7	1.6	3.7	21.3	1.8	4.3	16.2	2.1	4.9	13.1	2.4	5.4	10.8	2.6	5.8
115	98.2	1.1	1.6	69.6	1.2	2.1	50.4	1.3	2.6	37.6	1.5	3.1	29.0	1.6	3.7	22.3	1.8	4.3	17.0	2.1	4.9	13.8	2.3	5.4	11.5	2.6	5.8
120	102.5	1.1	1.6	72.6	1.2	2.1	52.5	1.3	2.6	39.3	1.5	3.1	30.2	1.6	3.7	23.3	1.8	4.3	17.9	2.1	4.9	14.5	2.3	5.4	12.2	2.6	5.8
125	106.8	1.1	1.6	75.7	1.2	2.1	54.7	1.3	2.6	40.9	1.5	3.1	31.5	1.6	3.7	24.3	1.8	4.3	18.7	2.1	4.9	15.2	2.3	5.4	12.8	2.5	5.8
130	111.0	1.1	1.6	78.7	1.2	2.1	56.9	1.3	2.6	42.5	1.5	3.1	32.7	1.6	3.7	25.3	1.8	4.3	19.4	2.1	4.9	15.9	2.3	5.4	13.4	2.5	5.8
135	115.3	1.1	1.6	81.7	1.2	2.1	59.1	1.3	2.6	44.2	1.5	3.1	34.0	1.6	3.7	26.3	1.8	4.3	20.2	2.0	4.9	16.6	2.3	5.4	14.1	2.5	5.8
140	119.6	1.1	1.6	84.7	1.2	2.1	61.3	1.3	2.6	45.8	1.5	3.1	35.2	1.6	3.7	27.3	1.8	4.3	21.0	2.0	4.9	17.2	2.3	5.4	14.7	2.5	5.8
145	123.8	1.1	1.6	87.8	1.2	2.1	63.5	1.3	2.6	47.5	1.5	3.1	36.5	1.6	3.7	28.7	1.8	4.3	21.8	2.0	4.9	17.9	2.3	5.4	15.3	2.5	5.8
150	128.1	1.1	1.6	90.8	1.2	2.1	65.7	1.3	2.6	49.1	1.5	3.1	37.8	1.6	3.7	29.7	1.8	4.3	22.6	2.0	4.9	18.6	2.3	5.4	15.9	2.4	5.8

Table A6-DV-9. Parabolic Diversion Design Chart (Retardance "D" and "C", Grade 1.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 2.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	5.9	0.9	1.5																								
10	12.4	0.8	1.5	8.1	0.9	2.0	5.9	1.0	2.5																		
15	18.5	0.8	1.5	12.3	0.9	2.0	9.3	1.0	2.5	6.8	1.1	3.0	4.7	1.4	3.5												
20	24.7	0.8	1.5	16.7	0.9	2.0	12.5	1.0	2.5	9.4	1.1	3.0	7.0	1.2	3.6	4.7	1.5	4.1									
25	30.8	0.8	1.5	20.8	0.9	2.0	15.9	1.0	2.4	11.8	1.1	3.0	9.0	1.2	3.5	6.8	1.3	4.1									
30	37.0	0.8	1.5	25.0	0.9	2.0	19.0	1.0	2.5	14.3	1.1	3.0	11.0	1.2	3.5	8.5	1.3	4.1	6.4	1.5	4.7						
35	43.2	0.8	1.5	29.1	0.9	2.0	22.2	1.0	2.5	16.9	1.0	3.0	12.9	1.1	3.5	10.1	1.3	4.1	7.8	1.4	4.7						
40	49.3	0.8	1.5	33.3	0.9	2.0	25.3	1.0	2.5	19.3	1.0	3.0	14.8	1.1	3.5	11.6	1.3	4.1	9.1	1.4	4.7	7.1	1.6	5.2			
45	55.5	0.8	1.5	37.4	0.9	2.0	28.5	1.0	2.5	21.7	1.0	3.0	16.7	1.1	3.5	13.1	1.3	4.1	10.4	1.4	4.7	8.2	1.6	5.2			
50	61.7	0.8	1.5	41.6	0.9	2.0	31.7	1.0	2.5	24.1	1.0	3.0	18.8	1.1	3.5	14.7	1.2	4.1	11.7	1.4	4.7	9.3	1.5	5.3	7.1	1.8	5.8
55	67.8	0.8	1.5	45.7	0.9	2.0	34.8	1.0	2.5	26.5	1.0	3.0	20.7	1.1	3.5	16.2	1.2	4.1	12.9	1.4	4.7	10.4	1.5	5.3	8.2	1.7	5.8
60	74.0	0.8	1.5	49.9	0.9	2.0	38.0	1.0	2.5	28.9	1.0	3.0	22.6	1.1	3.5	17.7	1.2	4.1	14.1	1.4	4.7	11.4	1.5	5.3	9.2	1.7	5.8
65	80.2	0.8	1.5	54.0	0.9	2.0	41.1	1.0	2.5	31.4	1.0	3.0	24.5	1.1	3.5	19.5	1.2	4.1	15.4	1.3	4.7	12.4	1.5	5.3	10.1	1.7	5.8
70	86.3	0.8	1.5	58.2	0.9	2.0	44.3	1.0	2.5	33.8	1.0	3.0	26.3	1.1	3.5	21.0	1.2	4.1	16.6	1.3	4.7	13.5	1.5	5.3	11.0	1.6	5.8
75	92.5	0.8	1.5	62.3	0.9	2.0	47.5	1.0	2.5	36.2	1.0	3.0	28.2	1.1	3.5	22.4	1.2	4.1	17.8	1.3	4.7	14.5	1.5	5.3	11.8	1.6	5.8
80	98.7	0.8	1.5	66.5	0.9	2.0	50.6	1.0	2.5	38.6	1.0	3.0	30.1	1.1	3.5	23.9	1.2	4.1	19.0	1.3	4.7	15.5	1.5	5.3	12.7	1.6	5.8
85	104.8	0.8	1.5	70.6	0.9	2.0	53.8	1.0	2.5	41.0	1.0	3.0	32.0	1.1	3.5	25.4	1.2	4.1	20.3	1.3	4.7	16.5	1.5	5.3	13.6	1.6	5.8
90	111.0	0.8	1.5	74.8	0.9	2.0	57.0	1.0	2.5	43.4	1.0	3.0	33.8	1.1	3.5	26.9	1.2	4.1	21.8	1.3	4.6	17.5	1.5	5.3	14.4	1.6	5.8
95	117.2	0.8	1.5	78.9	0.9	2.0	60.1	1.0	2.5	45.8	1.0	3.0	35.7	1.1	3.5	28.4	1.2	4.1	23.0	1.3	4.6	18.6	1.5	5.3	15.3	1.6	5.8
100	123.3	0.8	1.5	83.1	0.9	2.0	63.3	1.0	2.5	48.2	1.0	3.0	37.6	1.1	3.5	29.9	1.2	4.1	24.2	1.3	4.6	19.6	1.5	5.3	16.2	1.6	5.8
105	129.5	0.8	1.5	87.3	0.9	2.0	66.4	1.0	2.5	50.6	1.0	3.0	39.5	1.1	3.5	31.4	1.2	4.1	25.4	1.3	4.6	20.6	1.5	5.3	17.0	1.6	5.8
110	135.7	0.8	1.5	91.4	0.9	2.0	69.6	1.0	2.5	53.0	1.0	3.0	41.3	1.1	3.5	32.9	1.2	4.1	26.6	1.3	4.7	21.6	1.4	5.3	17.9	1.6	5.8
115	141.8	0.8	1.5	95.6	0.9	2.0	72.8	1.0	2.5	55.4	1.0	3.0	43.2	1.1	3.5	34.4	1.2	4.1	27.9	1.3	4.7	22.6	1.4	5.3	18.7	1.6	5.8
120	148.0	0.8	1.5	99.7	0.9	2.0	75.9	1.0	2.5	57.9	1.0	3.0	45.1	1.1	3.5	35.9	1.2	4.1	29.1	1.3	4.7	23.9	1.4	5.2	19.5	1.6	5.8
125	154.1	0.8	1.5	103.9	0.9	2.0	79.1	1.0	2.5	60.3	1.0	3.0	47.0	1.1	3.5	37.4	1.2	4.1	30.3	1.3	4.7	24.8	1.4	5.2	20.4	1.6	5.8
130	160.3	0.8	1.5	108.0	0.9	2.0	82.3	1.0	2.5	62.7	1.0	3.0	48.8	1.1	3.5	38.9	1.2	4.1	31.5	1.3	4.7	25.8	1.4	5.3	21.2	1.6	5.8
135	166.5	0.8	1.5	112.2	0.9	2.0	85.4	1.0	2.5	65.1	1.0	3.0	50.7	1.1	3.5	40.3	1.2	4.1	32.7	1.3	4.7	26.8	1.4	5.3	22.1	1.6	5.8
140	172.6	0.8	1.5	116.3	0.9	2.0	88.6	1.0	2.5	67.5	1.0	3.0	52.6	1.1	3.5	41.8	1.2	4.1	33.9	1.3	4.7	27.8	1.4	5.3	22.9	1.6	5.8
145	178.8	0.8	1.5	120.5	0.9	2.0	91.8	1.0	2.5	69.9	1.0	3.0	54.5	1.1	3.5	43.3	1.2	4.1	35.1	1.3	4.7	28.8	1.4	5.3	23.7	1.6	5.8
150	185.0	0.8	1.5	124.6	0.9	2.0	94.9	1.0	2.5	72.3	1.0	3.0	56.4	1.1	3.5	44.8	1.2	4.1	36.3	1.3	4.7	29.8	1.4	5.3	24.6	1.6	5.8

Table A6-DV-10. Parabolic Diversion Design Chart (Retardance "D" and "C", Grade 2.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 4.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	8.5	0.6	1.4	5.9	0.7	1.8	4.1	0.8	2.3																		
10	17.2	0.6	1.4	12.1	0.7	1.8	8.8	0.7	2.3	6.7	0.8	2.8	5.2	0.9	3.3	3.8	1.0	3.9									
15	25.8	0.6	1.4	18.1	0.7	1.8	13.4	0.7	2.3	10.3	0.8	2.8	8.1	0.8	3.4	6.4	0.9	3.9	4.9	1.0	4.5						
20	34.4	0.6	1.4	24.2	0.7	1.8	17.8	0.7	2.3	13.9	0.8	2.8	10.9	0.8	3.4	9.7	0.9	3.9	6.9	1.0	4.5	5.5	1.1	5.0			
25	43.0	0.6	1.4	30.2	0.7	1.9	22.3	0.7	2.3	17.4	0.8	2.8	13.8	0.8	3.3	10.9	0.9	3.9	8.8	1.0	4.5	7.1	1.0	5.1	5.7	1.2	5.6
30	51.6	0.6	1.4	36.3	0.7	1.9	26.7	0.7	2.3	20.8	0.8	2.8	16.5	0.8	3.3	13.2	0.9	3.9	10.7	0.9	4.5	8.7	1.0	5.1	7.1	1.1	5.6
35	60.2	0.6	1.4	42.3	0.7	1.9	31.1	0.7	2.3	24.3	0.8	2.8	19.3	0.8	3.4	15.6	0.9	3.9	12.5	0.9	4.5	10.3	1.0	5.0	8.4	1.1	5.6
40	68.8	0.6	1.4	48.3	0.7	1.9	35.6	0.7	2.3	27.8	0.8	2.8	22.0	0.8	3.4	17.8	0.9	3.9	14.4	0.9	4.5	11.8	1.0	5.0	9.8	1.1	5.7
45	77.4	0.6	1.4	54.4	0.7	1.9	40.0	0.7	2.4	31.2	0.8	2.8	24.8	0.8	3.4	20.0	0.9	3.9	16.4	0.9	4.4	13.3	1.0	5.0	11.1	1.1	5.7
50	86.0	0.6	1.4	60.4	0.7	1.9	44.5	0.7	2.4	34.7	0.8	2.8	27.5	0.8	3.4	22.2	0.9	3.9	18.2	0.9	4.4	14.9	1.0	5.0	12.3	1.1	5.7
55	94.6	0.6	1.4	66.5	0.7	1.9	48.9	0.7	2.4	38.2	0.8	2.8	30.3	0.8	3.4	24.4	0.9	3.9	20.0	0.9	4.4	16.6	1.0	5.0	13.6	1.1	5.7
60	103.2	0.6	1.4	72.5	0.7	1.9	53.4	0.7	2.4	41.7	0.8	2.8	33.0	0.8	3.4	26.6	0.9	3.9	21.8	0.9	4.5	18.1	1.0	5.0	14.9	1.1	5.7
65	111.8	0.6	1.4	78.5	0.7	1.9	57.8	0.7	2.4	45.1	0.8	2.8	35.8	0.8	3.4	28.9	0.9	3.9	23.6	0.9	4.5	19.6	1.0	5.0	16.2	1.1	5.7
70	120.4	0.6	1.4	84.6	0.7	1.9	62.3	0.7	2.4	48.6	0.8	2.8	38.6	0.8	3.4	31.1	0.9	3.9	25.4	0.9	4.5	21.1	1.0	5.0	17.7	1.1	5.6
75	129.0	0.6	1.4	90.6	0.7	1.9	66.7	0.7	2.4	52.1	0.8	2.8	41.3	0.8	3.4	33.3	0.9	3.9	27.2	0.9	4.5	22.6	1.0	5.0	19.0	1.1	5.6
80	137.6	0.6	1.4	96.7	0.7	1.9	71.2	0.7	2.4	55.5	0.8	2.8	44.1	0.8	3.4	35.5	0.9	3.9	29.1	0.9	4.5	24.1	1.0	5.0	20.2	1.1	5.6
85	146.2	0.6	1.4	102.7	0.7	1.9	75.6	0.7	2.4	59.0	0.8	2.8	46.8	0.8	3.4	37.7	0.9	3.9	30.9	0.9	4.5	25.6	1.0	5.0	21.5	1.1	5.6
90	154.8	0.6	1.4	108.7	0.7	1.9	80.0	0.7	2.4	62.5	0.8	2.8	49.6	0.8	3.4	39.9	0.9	3.9	32.7	0.9	4.5	27.1	1.0	5.0	22.8	1.1	5.6
95	163.4	0.6	1.4	114.8	0.7	1.9	84.5	0.7	2.4	65.9	0.8	2.8	52.3	0.8	3.4	42.2	0.9	3.9	34.5	0.9	4.5	28.6	1.0	5.0	24.0	1.1	5.6
100	172.0	0.6	1.4	120.8	0.7	1.9	88.9	0.7	2.4	69.4	0.8	2.8	55.1	0.8	3.4	44.4	0.9	3.9	36.3	0.9	4.5	30.1	1.0	5.0	25.3	1.1	5.6
105	180.6	0.6	1.4	126.9	0.7	1.9	93.4	0.7	2.4	72.9	0.8	2.8	57.8	0.8	3.4	46.6	0.9	3.9	38.1	0.9	4.5	31.6	1.0	5.0	26.5	1.1	5.6
110	189.2	0.6	1.4	132.9	0.7	1.9	97.8	0.7	2.4	76.3	0.8	2.8	60.6	0.8	3.4	48.8	0.9	3.9	39.9	0.9	4.5	33.1	1.0	5.0	27.8	1.1	5.6
115	197.8	0.6	1.4	138.9	0.7	1.9	102.3	0.7	2.4	79.8	0.8	2.8	63.3	0.8	3.4	51.0	0.9	3.9	41.7	0.9	4.5	34.6	1.0	5.0	29.0	1.1	5.6
120	206.4	0.6	1.4	145.0	0.7	1.9	106.7	0.7	2.4	83.3	0.8	2.8	66.1	0.8	3.4	53.3	0.9	3.9	43.6	0.9	4.5	36.1	1.0	5.0	30.2	1.1	5.7
125	215.0	0.6	1.4	151.0	0.7	1.9	111.2	0.7	2.4	86.8	0.8	2.8	68.8	0.8	3.4	55.5	0.9	3.9	45.4	0.9	4.5	37.6	1.0	5.0	31.5	1.1	5.7
130	223.7	0.6	1.4	157.1	0.7	1.9	115.6	0.7	2.4	90.2	0.8	2.8	71.6	0.8	3.4	57.7	0.9	3.9	47.2	0.9	4.5	39.1	1.0	5.0	32.7	1.1	5.7
135	232.3	0.6	1.4	163.1	0.7	1.9	120.1	0.7	2.4	93.7	0.8	2.8	74.3	0.8	3.4	59.9	0.9	3.9	49.0	0.9	4.5	40.6	1.0	5.0	34.0	1.1	5.7
140	240.9	0.6	1.4	169.1	0.7	1.9	124.5	0.7	2.4	97.2	0.8	2.8	77.1	0.8	3.4	62.1	0.9	3.9	50.8	0.9	4.5	42.1	1.0	5.0	35.2	1.1	5.7
145	249.5	0.6	1.4	175.2	0.7	1.9	129.0	0.7	2.4	100.6	0.8	2.8	79.8	0.8	3.4	64.3	0.9	3.9	52.6	0.9	4.5	43.6	1.0	5.0	36.5	1.1	5.7
150	258.1	0.6	1.4	181.2	0.7	1.9	133.4	0.7	2.4	104.1	0.8	2.8	82.6	0.8	3.4	66.6	0.9	3.9	54.4	0.9	4.5	45.1	1.0	5.0	37.8	1.1	5.7

Table A6-DV-11. Parabolic Diversion Design Chart (Retardance "D" and "C", Grade 4.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 6.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	10.6	0.5	1.3	7.3	0.6	1.8	5.3	0.6	2.3	4.0	0.7	2.8	2.9	0.8	3.2												
10	21.1	0.5	1.3	14.7	0.6	1.8	10.9	0.6	2.3	8.4	0.7	2.8	6.6	0.7	3.2	5.3	0.8	3.8	4.2	0.8	4.3						
15	31.6	0.5	1.3	22.1	0.6	1.8	16.3	0.6	2.3	12.7	0.6	2.7	10.1	0.7	3.3	8.2	0.7	3.8	6.6	0.8	4.3	5.4	0.9	4.9	4.3	1.0	5.5
20	42.1	0.5	1.3	29.5	0.6	1.8	21.7	0.6	2.3	17.0	0.6	2.7	13.6	0.7	3.2	1..1	0.7	3.7	9.0	0.8	4.3	7.4	0.8	4.9	6.1	0.9	5.5
25	52.7	0.5	1.3	36.8	0.6	1.8	27.1	0.6	2.3	21.2	0.6	2.8	17.0	0.7	3.2	13.9	0.7	3.8	11.3	0.8	4.3	9.3	0.8	4.9	7.8	0.9	5.5
30	63.2	0.5	1.3	44.2	0.6	1.8	32.5	0.6	2.3	25.4	0.6	2.8	20.4	0.7	3.2	16.6	0.7	3.8	13.7	0.8	4.3	11.3	0.8	4.9	9.4	0.9	5.5
35	73.7	0.5	1.3	51.6	0.6	1.8	38.0	0.6	2.3	29.7	0.6	2.8	23.8	0.7	3.2	19.4	0.7	3.8	16.0	0.8	4.3	13.4	0.8	4.9	11.1	0.9	5.5
40	84.2	0.5	1.3	58.9	0.6	1.8	43.4	0.6	2.3	33.9	0.6	2.8	27.2	0.7	3.3	22.2	0.7	3.8	18.3	0.8	4.3	15.3	0.8	4.9	12.7	0.9	5.5
45	94.8	0.5	1.3	66.3	0.6	1.8	48.8	0.6	2.3	38.2	0.6	2.8	30.7	0.7	3.3	24.9	0.7	3.8	20.6	0.8	4.3	17.2	0.8	4.9	14.5	0.9	5.4
50	105.3	0.5	1.3	73.6	0.6	1.8	54.2	0.6	2.3	42.4	0.6	2.8	34.1	0.7	3.3	27.7	0.7	3.8	22.8	0.8	4.3	19.1	0.8	4.9	16.1	0.9	5.4
55	115.8	0.5	1.3	81.0	0.6	1.8	59.7	0.6	2.3	46.6	0.6	2.8	37.5	0.7	3.3	30.5	0.7	3.8	25.1	0.8	4.3	21.0	0.8	4.9	17.7	0.9	5.4
60	126.4	0.5	1.3	88.4	0.6	1.8	65.1	0.6	2.3	50.9	0.6	2.8	40.9	0.7	3.3	33.3	0.7	3.8	27.4	0.8	4.3	22.9	0.8	4.9	19.3	0.9	5.4
65	136.9	0.5	1.3	95.7	0.6	1.8	70.5	0.6	2.3	55.1	0.6	2.8	44.3	0.7	3.3	36.0	0.7	3.8	29.7	0.8	4.3	24.8	0.8	4.9	2C.9	0.9	5.4
70	147.4	0.5	1.3	103.1	0.6	1.8	75.9	0.6	2.3	59.3	0.6	2.8	47.7	0.7	3.3	38.8	0.7	3.8	32.0	0.8	4.3	26.7	0.8	4.9	22.5	0.9	5.4
75	158.0	0.5	1.3	110.5	0.6	1.8	81.3	0.6	2.3	63.6	0.6	2.8	51.1	0.7	3.3	41.6	0.7	3.8	34.3	0.8	4.3	28.6	0.8	4.9	24.1	0.9	5.4
80	168.5	0.5	1.3	117.8	0.6	1.8	86.8	0.6	2.3	67.8	0.6	2.8	54.5	0.7	3.3	44.3	0.7	3.8	36.5	0.8	4.3	30.5	0.8	4.9	25.7	0.9	5.5
85	179.0	0.5	1.3	125.2	0.6	1.8	92.2	0.6	2.3	72.0	0.6	2.8	57.9	0.7	3.3	47.1	0.7	3.8	38.8	0.8	4.3	32.4	0.8	4.9	27.3	0.9	5.5
90	189.6	0.5	1.3	132.6	0.6	1.8	97.6	0.6	2.3	76.3	0.6	2.8	61.3	0.7	3.3	49.9	0.7	3.8	41.1	0.8	4.3	34.3	0.8	4.9	28.9	0.9	5.5
95	200.1	0.5	1.3	139.9	0.6	1.8	103.0	0.6	2.3	80.5	0.6	2.8	64.7	0.7	3.3	52.6	0.7	3.8	43.4	0.8	4.3	36.2	0.8	4.9	30.5	0.9	5.5
100	210.6	0.5	1.3	147.3	0.6	1.8	108.5	0.6	2.3	84.8	0.6	2.8	68.1	0.7	3.3	55.4	0.7	3.8	45.7	0.8	4.3	38.1	0.8	4.9	32.1	0.9	5.5
105	221.1	0.5	1.3	154.6	0.6	1.8	113.9	0.6	2.3	89.0	0.6	2.8	71.5	0.7	3.3	58.2	0.7	3.8	47.9	0.8	4.3	40.0	0.8	4.9	33.7	0.9	5.5
110	231.7	0.5	1.3	162.0	0.6	1.8	119.3	0.6	2.3	93.2	0.6	2.8	74.9	0.7	3.3	60.9	0.7	3.8	50.2	0.8	4.3	41.9	0.8	4.9	35.3	0.9	5.5
115	242.2	0.5	1.3	169.4	0.6	1.8	124.7	0.6	2.3	97.5	0.6	2.8	78.3	0.7	3.3	63.7	0.7	3.8	52.5	0.8	4.3	43.8	0.8	4.9	36.9	0.9	5.5
120	252.7	0.5	1.3	176.7	0.6	1.8	130.2	0.6	2.3	101.7	0.6	2.8	81.7	0.7	3.3	66.5	0.7	3.8	54.8	0.8	4.3	45.7	0.8	4.9	38.5	0.9	5.5
125	263.3	0.5	1.3	184.1	0.6	1.8	135.6	0.6	2.3	106.0	0.6	2.8	85.1	0.7	3.3	69.3	0.7	3.8	57.1	0.8	4.3	47.6	0.8	4.9	40.1	0.9	5.5
130	273.8	0.5	1.3	191.5	0.6	1.8	141.0	0.6	2.3	110.2	0.6	2.8	88.5	0.7	3.3	72.0	0.7	3.8	59.4	0.8	4.3	49.5	0.8	4.9	41.7	0.9	5.5
135	284.3	0.5	1.3	198.8	0.6	1.8	146.4	0.6	2.3	114.4	0.6	2.8	91.9	0.7	3.3	74.8	0.7	3.8	61.6	0.8	4.3	51.4	0.8	4.9	43.3	0.9	5.5
140	294.9	0.5	1.3	206.2	0.6	1.8	151.8	0.6	2.3	118.7	0.6	2.8	95.3	0.7	3.3	77.6	0.7	3.8	63.9	0.8	4.3	53.3	0.8	4.9	44.9	0.9	5.5
145	305.4	0.5	1.3	213.6	0.6	1.8	157.3	0.6	2.3	122.9	0.6	2.8	98.7	0.7	3.3	80.3	0.7	3.8	66.2	0.8	4.3	55.2	0.8	4.9	46.5	0.9	5.5
150	315.9	0.5	1.3	220.9	0,6	1.8	162.7	0.6	2.3	127.1	0.6	2.8	102.1	0.7	3.3	83.1	0.7	3.8	68.5	0.8	4.3	57.1	0.8	4.9	48.1	0.9	5.5

Table A6-DV-12. Parabolic Diversion Design Chart (Retardance "D" and "C", Grade 6.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 8.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	12.0	0.5	1.3	8.5	0.5	1.7	6.2	0.5	2.2	4.6	0.6	2.7	3.7	0.6	3.2	2.9	0.7	3.6									
10	24.1	0.5	1.3	16.9	0.5	1.7	12.6	0.5	2.2	9.6	0.6	2.7	7.8	0.6	3.2	6.3	0.6	3.7	5.1	0.7	4.2	4.2	0.8	4.8	3.2	0.9	5.3
15	36.1	0.5	1.3	25.3	0.5	1.7	18.9	0.5	2.2	14.4	0.6	2.7	11.8	0.6	3.2	9.7	0.6	3.7	7.9	0.7	4.2	6.5	0.7	4.8	5.4	0.8	5.3
20	48.1	0.5	1.3	33.8	0.5	1.7	25.2	0.5	2.2	19.2	0.6	2.7	15.8	0.6	3.2	12.9	0.6	3.7	10.7	0.7	4.2	8.8	0.7	4.8	7.4	0.8	5.3
25	60.1	0.5	1.3	42.2	0.5	1.7	31.5	0.5	2.2	24.0	0.6	2.7	19.7	0.6	3.2	16.2	0.6	3.7	13.4	0.7	4.2	11.2	0.7	4.7	9.3	0.8	5.3
30	72.1	0.5	1.3	50.6	0.5	1.7	37.8	0.5	2.2	28.8	0.6	2.7	23.6	0.6	3.2	19.4	0.6	3.7	16.1	0.7	4.2	13.5	0.7	4.8	11.3	0.7	5.3
35	84.1	0.5	1.3	59.1	0.5	1.7	44.1	0.5	2.2	33.6	0.6	2.7	27.6	0.6	3.2	22.6	0.6	3.7	18.7	0.7	4.2	15.7	0.7	4.8	13.3	0.7	5.3
40	96.2	0.5	1.3	67.5	0.5	1.7	50.4	0.5	2.2	38.4	0.6	2.7	31.5	0.6	3.2	25.8	0.6	3.7	21.4	0.7	4.2	17.9	0.7	4.8	15.2	0.7	5.3
45	108.2	0.5	1.3	76.0	0.5	1.7	56.7	0.5	2.2	43.2	0.6	2.7	35.4	0.6	3.2	29.0	0.6	3.7	24.1	0.7	4.2	20.2	0.7	4.8	17.1	0.7	5.3
50	120.2	0.5	1.3	84.4	0.5	1.7	63.0	0.5	2.2	48.0	0.6	2.7	39.4	0.6	3.2	32.3	0.6	3.7	26.8	0.7	4.2	22.4	0.7	4.8	19.0	0.7	5.3
55	132.2	0.5	1.3	92.8	0.5	1.7	69.3	0.5	2.2	52.8	0.6	2.7	43.3	0.6	3.2	35.5	0.6	3.7	29.4	0.7	4.2	24.7	0.7	4.8	20.9	0.7	5.3
60	144.2	0.5	1.3	101.3	0.5	1.7	75.6	0.5	2.2	57.6	0.6	2.7	47.2	0.6	3.2	38.7	0.6	3.7	32.1	0.7	4.2	26.9	0.7	4.8	22.8	0.7	5.3
65	156.3	0.5	1.3	109.7	0.5	1.7	81.8	0.5	2.2	62.4	0.6	2.7	51.2	0.6	3.2	41.9	0.6	3.7	34.8	0.7	4.2	29.1	0.7	4.8	24.7	0.7	5.3
70	168.3	0.5	1.3	118.2	0.5	1.7	88.1	0.5	2.2	67.2	0.6	2.7	55.1	0.6	3.2	45.2	0.6	3.7	37.5	0.7	4.2	31.4	0.7	4.8	26.6	0.7	5.3
75	180.3	0.5	1.3	126.6	0.5	1.7	94.4	0.5	2.2	72.0	0.6	2.7	59.0	0.6	3.2	48.4	0.6	3.7	40.1	0.7	4.2	33.6	0.7	4.8	28.5	0.7	5.3
80	192.3	0.5	1.3	135.0	0.5	1.7	100.7	0.5	2.2	76.8	0.6	2.7	63.0	0.6	3.2	51.6	0.6	3.7	42.8	0.7	4.2	35.9	0.7	4.8	30.3	0.7	5.3
85	204.3	0.5	1.3	143.5	0.5	1.7	107.0	0.5	2.2	81.6	0.6	2.7	66.9	0.6	3.2	54.9	0.6	3.7	45.5	0.7	4.2	38.1	0.7	4.8	32.2	0.7	5.3
90	216.4	0.5	1.3	151.9	0.5	1.7	113.3	0.5	2.2	86.4	0.6	2.7	70.8	0.6	3.2	58.1	0.6	3.7	48.1	0.7	4.2	40.3	0.7	4.8	34.1	0.7	5.3
95	228.4	0.5	1.3	160.3	0.5	1.7	119.6	0.5	2.2	91.2	0.6	2.7	74.8	0.6	3.2	61.3	0.6	3.7	50.8	0.7	4.2	42.6	0.7	4.8	36.0	0.7	5.3
100	240.4	0.5	1.3	168.8	0.5	1.7	125.9	0.5	2.2	96.0	0.6	2.7	78.7	0.6	3.2	64.5	0.6	3.7	53.5	0.7	4.2	44.8	0.7	4.8	37.9	0.7	5.3
105	252.4	0.5	1.3	177.2	0.5	1.7	132.2	0.5	2.2	100.8	0.6	2.7	82.6	0.6	3.2	67.8	0.6	3.7	56.2	0.7	4.2	47.1	0.7	4.8	39.8	0.7	5.3
110	264.4	0.5	1.3	185.7	0.5	1.7	138.5	0.5	2.2	105.6	0.6	2.7	86.6	0.6	3.2	71.0	0.6	3.7	58.8	0.7	4.2	49.3	0.7	4.8	41.7	0.7	5.3
115	276.5	0.5	1.3	194.1	0.5	1.7	144.8	0.5	2.2	110.4	0.6	2.7	90.5	0.6	3.2	74.2	0.6	3.7	61.5	0.7	4.2	51.5	0.7	4.8	43.6	0.7	5.3
120	288.5	0.5	1.3	202.5	0.5	1.7	151.1	0.5	2.2	115.2	0.6	2.7	94.4	0.6	3.2	77.4	0.6	3.7	64.2	0.7	4.2	53.8	0.7	4.8	45.5	0.7	5.3
125	300.5	0.5	1.3	211.0	0.5	1.7	157.4	0.5	2.2	120.0	0.6	2.7	98.4	0.6	3.2	80.7	0.6	3.7	66.9	0.7	4.2	56.0	0.7	4.8	47.4	0.7	5.3
130	312.5	0.5	1.3	219.4	0.5	1.7	163.7	0.5	2.2	124.8	0.6	2.7	102.3	0.6	3.2	83.9	0.6	3.7	69.5	0.7	4.2	58.3	0.7	4.8	49.3	0.7	5.3
135	324.5	0.5	1.3	227.9	0.5	1.7	170.0	0.5	2.2	129.6	0.6	2.7	106.2	0.6	3.2	87.1	0.6	3.7	72.2	0.7	4.2	60.5	0.7	4.8	51.2	0.7	5.3
140	336.6	0.5	1.3	236.3	0.5	1.7	176.3	0.5	2.2	134.4	0.6	2.7	110.2	0.6	3.2	90.3	0.6	3.7	74.9	0.7	4.2	62.7	0.7	4.8	53.1	0.7	5.3
145	348.6	0.5	1.3	244.7	0.5	1.7	182.6	0.5	2.2	139.2	0.6	2.7	114.1	0.6	3.2	93.6	0.6	3.7	77.6	0.7	4.2	65.0	0.7	4.8	55.0	0.7	5.3
150	360.6	0.5	1.3	253.2	0.5	1.7	188.9	0.5	2.2	144.0	0.6	2.7	118.0	0.6	3.2	96.8	0.6	3.7	80.2	0.7	4.2	67.2	0.7	4.8	56.9	0.7	5.3

Table A6-DV-13. Parabolic Diversion Design Chart (Retardance "D" and "C", Grade 8.00%)

V1 FOR RETARDANCE "D". TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 10.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	13.3	0.4	1.3	9.4	0.5	1.7	6.8	0.5	2.2	5.3	0.5	2.6	4.1	0.6	3.2	3.4	0.6	3.6	2.6	0.7	4.1						
10	26.6	0.4	1.3	18.7	0.5	1.7	13.8	0.5	2.2	10.9	0.5	2.6	8.5	0.6	3.2	7.1	0.6	3.6	5.9	0.6	4.1	4.9	0.7	4.7	4.0	0.7	5.3
15	39.9	0.4	1.3	28.0	0.5	1.7	20.7	0.5	2.2	16.3	0.5	2.6	12.8	0.6	3.2	10.9	0.6	3.6	9.0	0.6	4.1	7.5	0.6	4.7	6.3	0.7	5.2
20	53.2	0.4	1.3	37.4	0.5	1.7	27.6	0.5	2.2	21.7	0.5	2.7	17.0	0.6	3.2	14.5	0.6	3.6	12.1	0.6	4.1	10.2	0.6	4.6	8.5	0.7	5.2
25	66.5	0.4	1.3	46.7	0.5	1.7	34.5	0.5	2.2	27.1	0.5	2.7	21.3	0.6	3.2	18.1	0.6	3.6	15.1	0.6	4.1	12.7	0.6	4.7	10.8	0.7	5.2
30	79.8	0.4	1.3	56.1	0.5	1.7	41.4	0.5	2.2	32.5	0.5	2.7	25.5	0.6	3.2	21.7	0.6	3.6	18.1	0.6	4.1	15.2	0.6	4.7	12.9	0.7	5.2
35	93.1	0.4	1.3	65.4	0.5	1.7	48.3	0.5	2.2	37.9	0.5	2.7	29.8	0.6	3.2	25.3	0.6	3.6	21.1	0.6	4.1	17.8	0.6	4.7	15.1	0.7	5.2
40	106.4	0.4	1.3	74.7	0.5	1.7	55.2	0.5	2.2	43.3	0.5	2.7	34.0	0.6	3.2	29.0	0.6	3.6	24.1	0.6	4.1	20.3	0.6	4.7	17.2	0.7	5.2
45	119.7	0.4	1.3	84.1	0.5	1.7	62.1	0.5	2.2	48.8	0.5	2.7	38.3	0.6	3.2	32.6	0.6	3.6	27.2	0.6	4.1	22.8	0.6	4.7	19.4	0.7	5.2
50	133.0	0.4	1.3	93.4	0.5	1.7	69.0	0.5	2.2	54.2	0.5	2.7	42.5	0.6	3.2	36.2	0.6	3.6	30.2	0.6	4.1	25.4	0.6	4.7	21.5	0.7	5.2
55	146.3	0.4	1.3	102.8	0.5	1.7	75.9	0.5	2.2	59.6	0.5	2.7	46.8	0.6	3.2	39.8	0.6	3.6	33.2	0.6	4.1	27.9	0.6	4.7	23.7	0.7	5.3
60	159.6	0.4	1.3	112.1	0.5	1.7	82.8	0.5	2.2	65.0	0.5	2.7	51.0	0.6	3.2	43.4	0.6	3.6	36.2	0.6	4.1	30.5	0.6	4.7	25.9	0.7	5.2
65	172.9	0.4	1.3	121.4	0.5	1.7	89.7	0.5	2.2	70.4	0.5	2.7	55.3	0.6	3.2	47.1	0.6	3.6	39.2	0.6	4.1	33.0	0.6	4.7	28.0	0.7	5.2
70	186.2	0.4	1.3	130.8	0.5	1.7	96.6	0.5	2.2	75.8	0.5	2.7	59.5	0.6	3.2	50.7	0.6	3.6	42.2	0.6	4.1	35.5	0.6	4.7	30.2	0.7	5.2
75	199.5	0.4	1.3	140.1	0.5	1.7	103.5	0.5	2.2	81.2	0.5	2.7	63.8	0.6	3.2	54.3	0.6	3.6	45.2	0.6	4.1	38.1	0.6	4.7	32.3	0.7	5.2
80	212.8	0.4	1.3	149.5	0.5	1.7	110.5	0.5	2.2	86.7	0.5	2.7	68.0	0.6	3.2	57.9	0.6	3.6	48.3	0.6	4.1	40.6	0.6	4.7	34.5	0.7	5.2
85	226.1	0.4	1.3	158.8	0.5	1.7	117.4	0.5	2.2	92.1	0.5	2.7	72.3	0.6	3.2	61.5	0.6	3.6	51.3	0.6	4.1	43.1	0.6	4.7	36.6	0.7	5.2
90	239.4	0.4	1.3	168.1	0.5	1.7	124.3	0.5	2.2	97.5	0.5	2.7	76.5	0.6	3.2	65.2	0.6	3.6	54.3	0.6	4.1	45.7	0.6	4.7	38.8	0.7	5.2
95	252.7	0.4	1.3	177.5	0.5	1.7	131.2	0.5	2.2	102.9	0.5	2.7	80.8	0.6	3.2	68.8	0.6	3.6	57.3	0.6	4.1	48.2	0.6	4.7	40.9	0.7	5.2
100	266.0	0.4	1.3	186.8	0.5	1.7	138.1	0.5	2.2	108.3	0.5	2.7	85.0	0.6	3.2	72.4	0.6	3.6	60.3	0.6	4.1	50.7	0.6	4.7	43.1	0.7	5.2
105	279.3	0.4	1.3	196.2	0.5	1.7	145.0	0.5	2.2	113.7	0.5	2.7	89.3	0.6	3.2	76.0	0.6	3.6	63.3	0.6	4.1	53.3	0.6	4.7	45.2	0.7	5.2
110	292.6	0.4	1.3	205.5	0.5	1.7	151.9	0.5	2.2	119.2	0.5	2.7	93.5	0.6	3.2	79.6	0.6	3.6	66.4	0.6	4.1	55.8	0.6	4.7	47.4	0.7	5.2
115	305.9	0.4	1.3	214.9	0.5	1.7	158.8	0.5	2.2	124.6	0.5	2.7	97.8	0.6	3.2	83.3	0.6	3.6	69.4	0.6	4.1	58.3	0.6	4.7	49.5	0.7	5.3
120	319.2	0.4	1.3	224.2	0.5	1.7	165.7	0.5	2.2	130.0	0.5	2.7	102.0	0.6	3.2	86.9	0.6	3.6	72.4	0.6	4.1	60.9	0.6	4.7	51.7	0.7	5.3
125	332.5	0.4	1.3	233.5	0.5	1.7	172.6	0.5	2.2	135.4	0.5	2.7	106.3	0.6	3.2	90.5	0.6	3.6	75.4	0.6	4.1	63.4	0.6	4.7	53.8	0.7	5.3
130	345.8	0.4	1.3	242.9	0.5	1.7	179.5	0.5	2.2	140.8	0.5	2.7	110.5	0.6	3.2	94.1	0.6	3.6	78.4	0.6	4.1	66.0	0.6	4.7	56.0	0.7	5.3
135	359.1	0.4	1.3	252.2	0.5	1.7	186.4	0.5	2.2	146.2	0.5	2.7	114.8	0.6	3.2	97.7	0.6	3.6	81.4	0.6	4.1	68.5	0.6	4.7	58.1	0.7	5.3
140	372.4	0.4	1.3	261.6	0.5	1.7	193.3	0.5	2.2	151.7	0.5	2.7	119.0	0.6	3.2	101.3	0.6	3.6	84.4	0.6	4.1	71.0	0.6	4.7	60.3	0.7	5.3
145	385.7	0.4	1.3	270.9	0.5	1.7	200.2	0.5	2.2	157.1	0.5	2.7	123.3	0.6	3.2	105.0	0.6	3.6	87.5	0.6	4.1	73.6	0.6	4.7	62.5	0.7	5.3
150	399.0	0.4	1.3	280.2	0.5	1.7	207.1	0.5	2.2	162.5	0.5	2.7	127.5	0.6	3.2	108.6	0.6	3.6	90.5	0.6	4.1	76.1	0.6	4.7	64.6	0.7	5.3

Table A6-DV-14. Parabolic Diversion Design Chart (Retardance "D" and "C", Grade 10.00%)

OUTLET PROTECTION DESIGN

Example 1:

Given: An 18-inch pipe discharges 24 cu. ft./sec. at design capacity onto a grassy slope (no defined channel).

Find: The required length, width and median stone size (d_{50}) for a riprap-lined apron.

Solution:

1. Since the pipe discharges onto a grassy slope with no defined channel, a Minimum Tailwater Condition may be assumed.

2. From Figure OP-2, an apron length (La) of 20 feet and a median stone size (d_{50}) of 0.8 ft. is determined.

3. The upstream apron width equals three times the pipe diameter; 3 x 1.5 ft. = 4.5 ft.

4. The downstream apron width equals the apron length plus the pipe diameter; 20 ft. + 1.5 ft. = 21.5 ft.

Example 2:

Given: The pipe in example No. 1 discharges into a channel with a triangular cross section, 2 feet deep and 2:1 side slopes. The channel has a 2% slope and an "n" coefficient of 0.045.

Find: The required length, width and the median stone size (d_{50}) for a riprap lining.

Solution:

1. Determine the tailwater depth using Manning's Equation and the Continuity Equation.

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

$$24 = \frac{1.49}{.045}\left(\frac{2d}{4.47}\right)^{2/3} (.02)^{1/2} (2d^2)$$

where,

d = depth of tailwater
d = 1.74 ft.*

* Since d is greater than half the pipe diameter, a <u>Maximum Tailwater Condition</u> exists.

2. From Figure OP-3, a median stone size (d_{50}) of 0.5 ft. and an apron length (La) of 41 ft. is determined.

3. The entire channel cross section should be lined, since the maximum tailwater depth is within one foot of the top of the channel.

RIPRAP DESIGN IN CHANNELS

The design method described below is adapted from Hydraulic Engineering Circular No. 15 of the Federal Highway Administration. It is applicable to both straight and curved sections of channel where the flow is tangent to the bank of the channel.

Tangent Flow - Federal Highway Administration Method

This design method determines a stable rock size for straight and curved sections of channels. It is assumed that the shape, depth of flow, and slope of the channel are known. A stone size is chosen for the maximum depth of flow. If the sides of the channel are steeper than 3:1, the stone size must be modified accordingly. The final design size will be stable on both the sides of the channel and the bottom.

1. Enter Figure A6-RR-1 with the maximum depth of flow (feet) and channel slope (feet/foot). Where the two lines intersect, choose the d_{50} size of stone. (Select the d_{50} for the diagonal line above the point of intersection).

2. If channel side slopes are steeper than 3:1, continue with step 3; if not, the procedure is complete.

3. Enter Figure A6-RR-2 with the side slope and the base width to maximum depth ratio (B/d). Where the two lines intersect, move horizontally left to read K_1.

4. Determine from Figure A6-RR-3 the angle of repose for the d_{50} size of stone and the side slope of the channel. (Use 42° for d_{50} greater than 1.0'±. Do not use riprap on slopes steeper than the angle of repose for the size of stone).

5. Enter Figure A6-RR-4 with the side slope of the channel and the angle of repose for the d_{50} size of stone. Where the two lines intersect, move vertically down to read K_2.

6. Compute $d_{50} \times K_1/K_2 = d'_{50}$ to determine the correct size stone for the bottom and side slopes of straight sections of channel.

For Curved Sections of Channel

1. Compute the radius of the curve (Ro), measured at the outside edge of the bottom.

2. Compute the ratio of the top width of the water surface (Bs) to the radius of the curve (Ro), Bs/Ro.

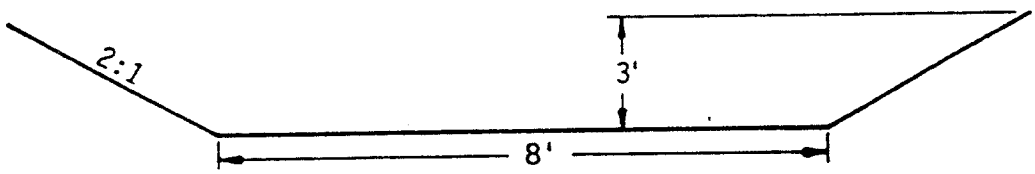
3. Enter Figure A6-RR-5 with the ratio Bs/Ro. Move vertically until the curve is intersected. Move horizontally left to read K_3.

4. Compute $d'_{50} \times K_3 = d_{50c}$ to determine the correct size stone for bottom and side slopes of curved sections of channel.

Example Problems

Given:

A trapezoidal channel 3 feet deep, 8 feet bottom, 2:1 side slopes, and a 2% slope.



Calculate:

A stable riprap size for the bottom and side slopes of the channel.

Solution:

1. From Figure A6-RR-1, for a 3-foot-deep channel on a 2% grade, d_{50} = 0.75 feet or 9 inches.

2. Since the side slopes are steeper than 3:1, continue with step 3.

3. From Figure A6-RR-2, $B/d = 8/3 = 2.67$, $Z = 2$, $K_1 = 0.82$.

4. From Figure A6-RR-3, for $d_{50} = 9$ inches, Angle of Repose = 41°.

5. From Figure A6-RR-4, for $Z = 2$ and Angle of Repose = 41°, $K_2 = 0.73$.

6. $d_{50} \times K_1/K_2 = d'_{50} = 0.75 \times 0.82/0.73 = 0.84$ feet.

   $0.84 \text{ feet} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 10.08$. Use $d'_{50} = 10$ inches.

Given:

The preceding channel has a curved section with a radius of 50 feet.

Calculate:

A stable riprap size for the bottom and side slopes of the curved section of channel.

Solution:

1. Ro = 50 feet

2. Bs/Ro = 20/50 = 0.40

3. From Figure A6-RR-5, for Bs/Ro = 0.40, $K_3 = 1.1$

4. $d'_{50} \times K_3 = d_{50c} = 0.84 \times 1.1 = 0.92$ feet

   $0.92 \text{ feet} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 11.0$ inches

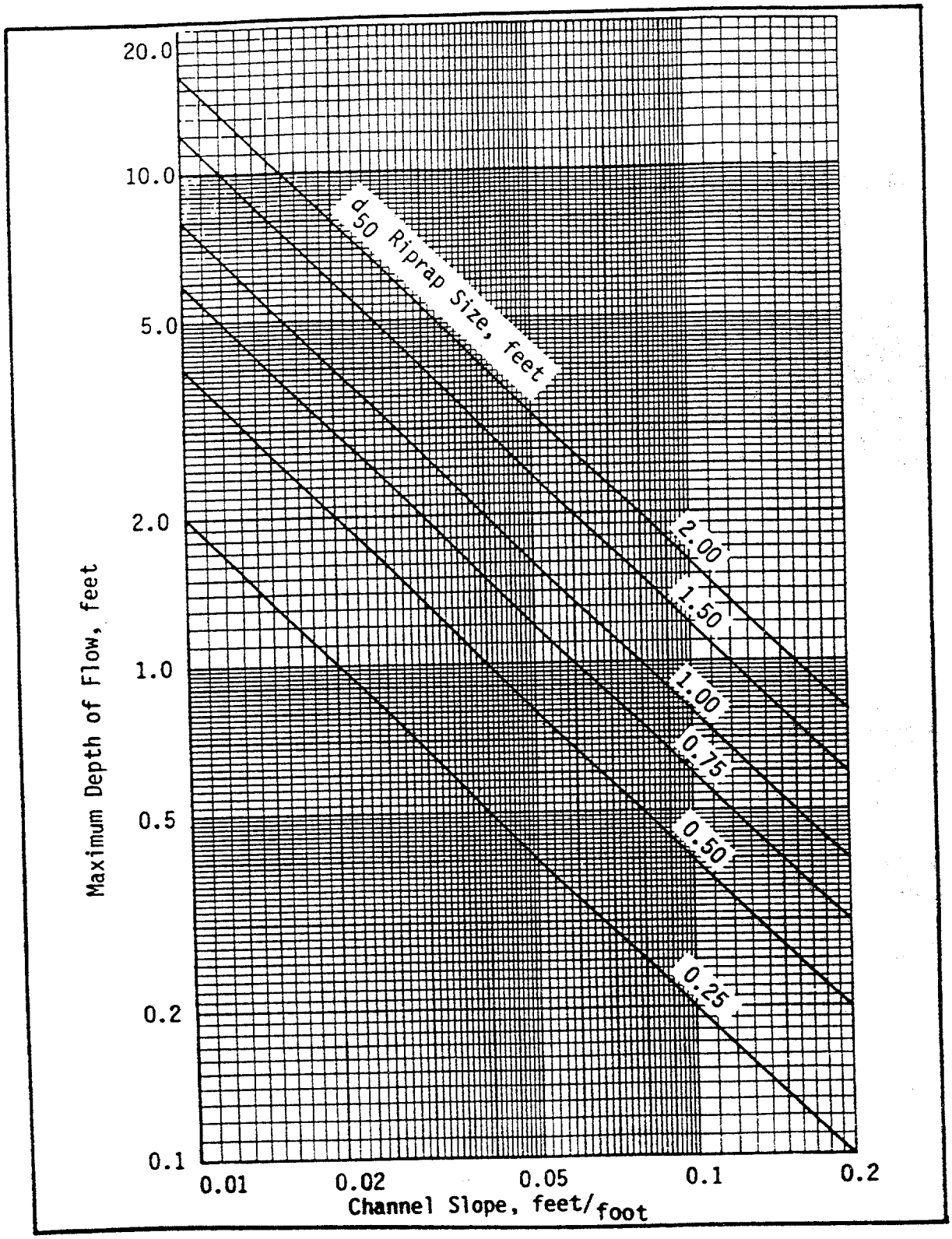


Figure A6-RR-1. Maximum Depth of Flow for Riprap Lined Channels.

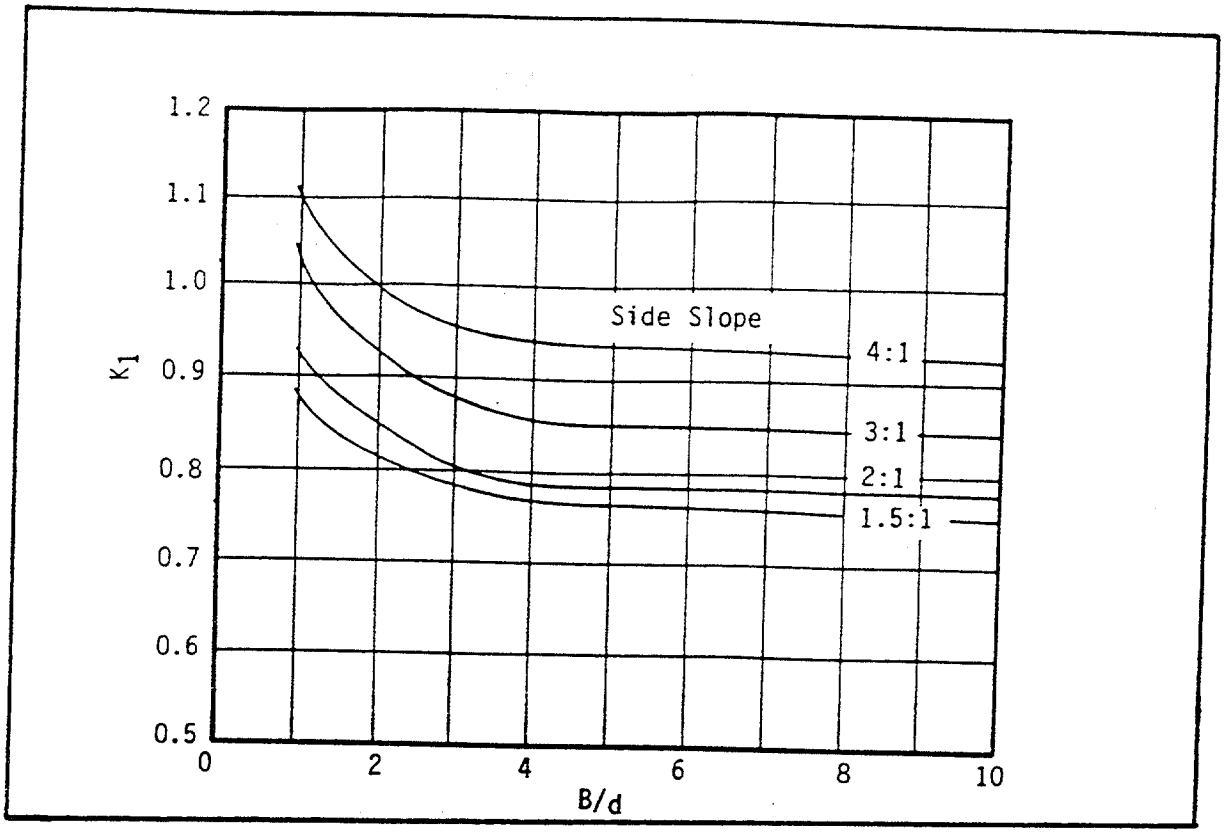


Figure A6-RR-2. Distribution of Boundary Shear Around Wetted Perimeter of Trapezoidal Channel.

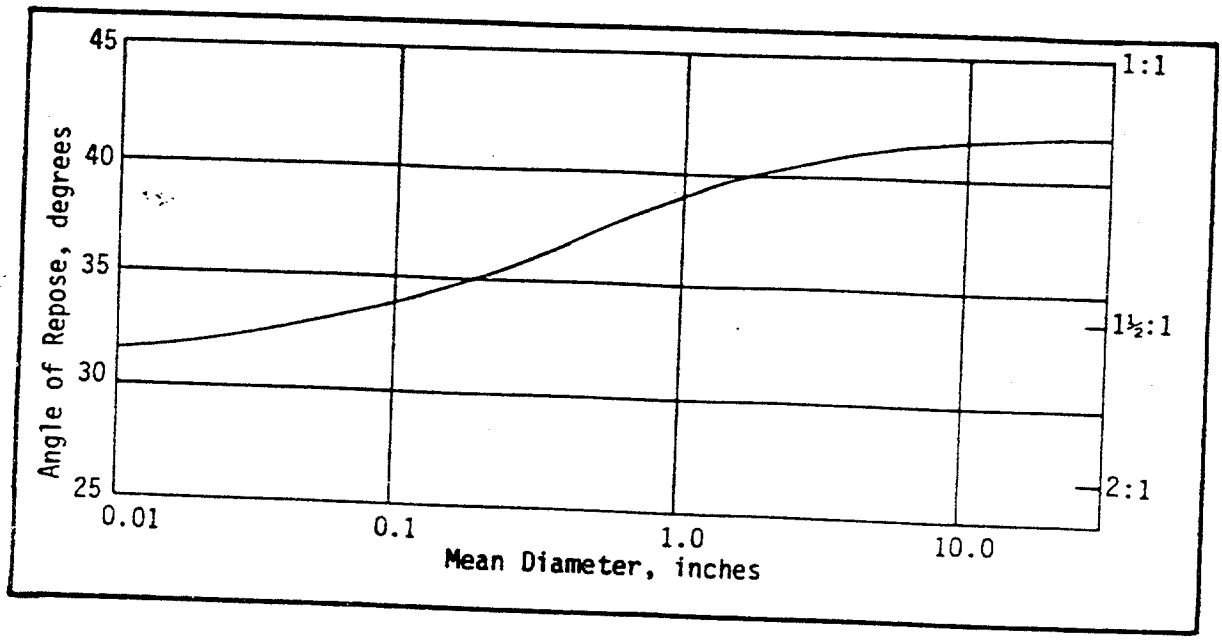


Figure A6-RR-3. Angle of Repose for Riprap Stones.

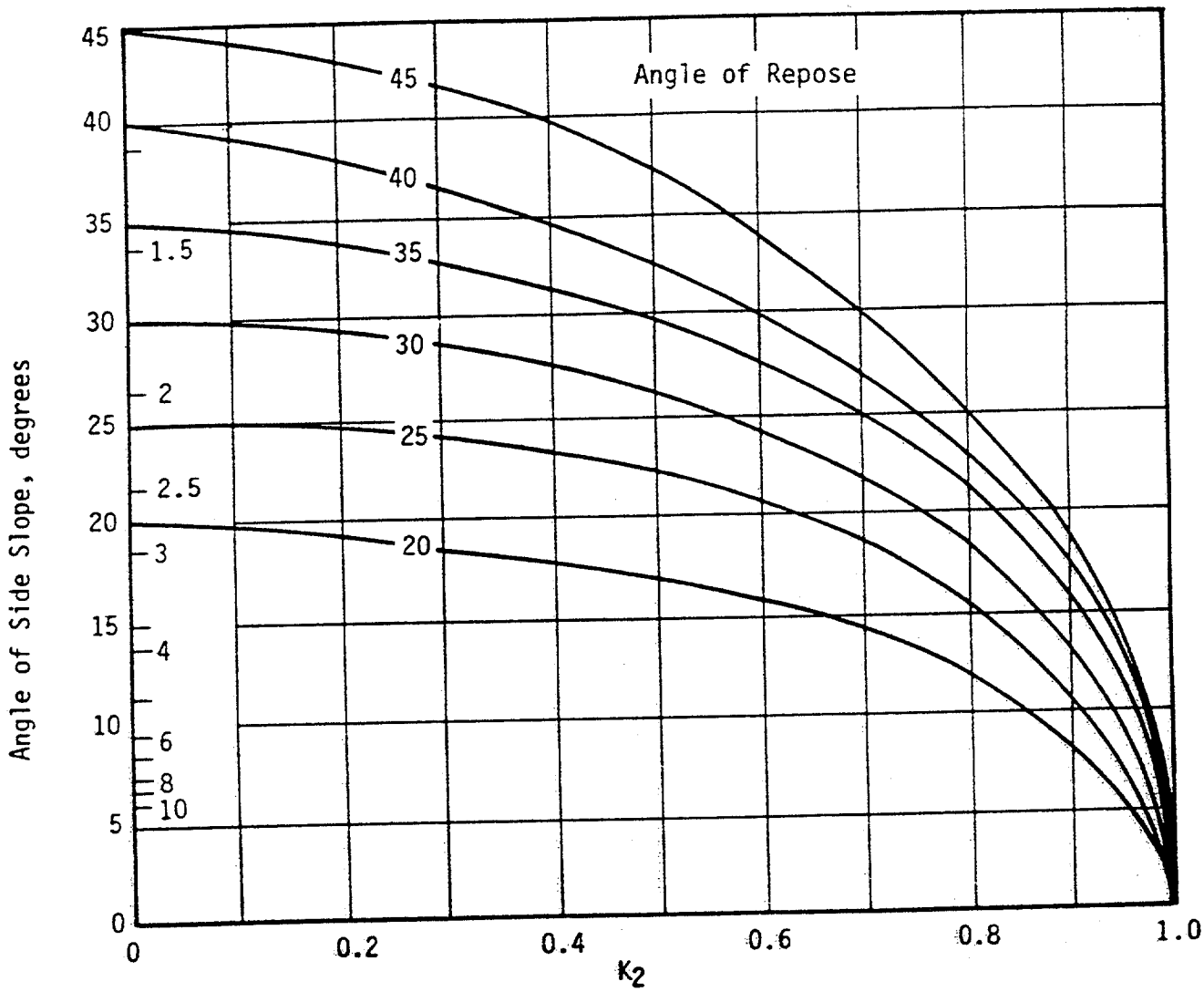


Figure A6-RR-4. Ratio of Critical Shear on Sides to Critical Shear on Bottoms.

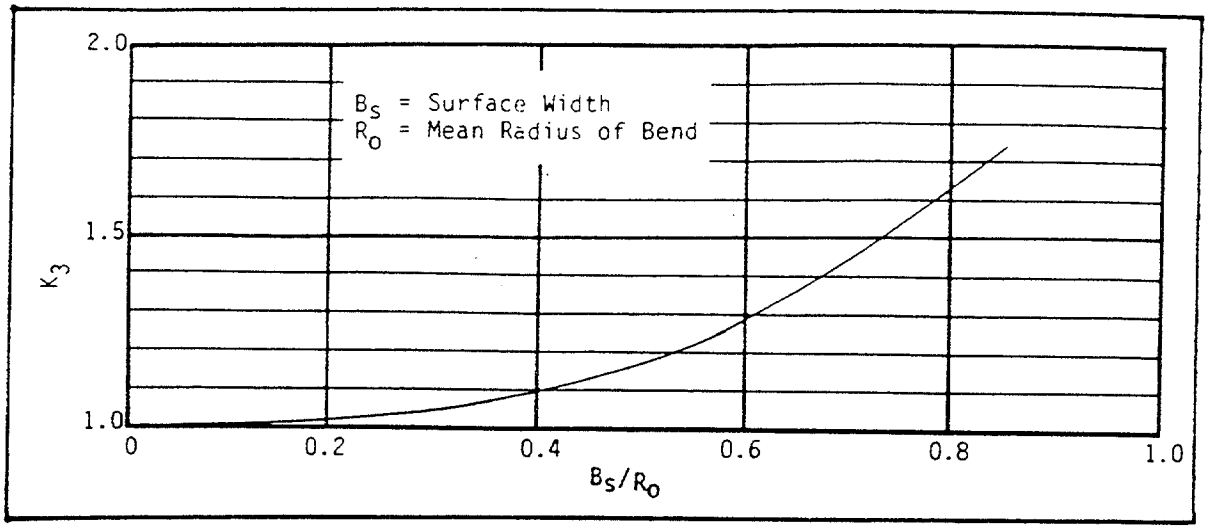


Figure A6-RR-5. Ratio of Maximum Boundary Shear in Bends to Maximum Bottom Shear in Straight Reaches.

SEDIMENT BASIN DESIGN

Temporary Sediment Basin Design Data Sheet

Computed by_____Date_____
Checked by_____Date_____

Project_____
Basin #_____

Total area draining to basin, _____ acres.

Basin Volume Design

1. Volume of basin below riser = 67 cu. yds. x ac. drainage = _____cu.yds.
2. Excavate _____ cu. yds. to obtain required capacity.
3. Vol. at dewatering and cleanout elev. = 67 cu. yds. x 0.5 x_____acres = _____ cu. yds.
4. Elevation corresponding to top of riser _____ft.
5. Elevation corresponding to dewater and cleanout basin _____ft.
6. Distance below top of riser_____ft.

Design of Spillways

Runoff

7. Q10pd =_____cfs (Pre-development peak discharge from 10-yr/24-hour storm event, assuming meadow land use. Attach runoff computation sheet).
8. Q10d = _____cfs (Disturbed condition peak discharge from 10-year/24-hour storm event. Attach runoff computation sheet).
9. Vr = _____inches
10. Q25d =_____cfs (Disturbed condition peak discharge from 25-year/24-hour storm event. Attach runoff computation sheet).

Principal Spillway (Qps)

11. Maximum principal spillway cap., Q10pd = _____ cfs.
12. H =_____ft. Barrel length =_____ft..
13. Volume of storage above riser (minimum 1 ft.) expressed in inches over drainage area, Vs = _____inches
14. Table A or B (circle one) using Vs and Vr.
15. Calculated principal spillway flow, Qps = _____cfs < Q10pd

16. Inside Barrel Diam._____in.
17. Riser Diam._____ in.; Length_____ft.;h =_____ ft.
18. Trashrack Diam._____in;
19. Pipe Slope = _____ % ; % Drained in 3 Days = _____ % ;

Emergency Spillway (Qes)

20. Emergency spillway cap., Qes = Q25d - Q10d = _____cfs.
21. Width_____ft.; Hp_____ft.; Side Slopes _____(3:1 min.)
22. Entrance channel slope_____%
23. Exit channel slope_____%

Anti-Seep Collar Design (If Required)

24. y =_____ft.; z =_____ft.; Ls: _____ ft.
25. Use_____ collars, _____ - _____" square;
projection =_____ft.

Design Elevations

26. Riser Crest = _____ Design High Water_____
27. Em. Spwy. Crest = _____ Top of Dam_____

Temporary Sediment Basin Design Data Sheet
Instructions for use of Form

1. The minimum required volume of storage at the top of the riser is 67 cubic yards per acre from each acre of drainage area although only part may be disturbed.

2. The volume of a naturally shaped basin (no excavation) may be approximated by the formula V=0.4 Axd, where V is in cubic feet, A is the surface area of the basin in square ft. and d is the maximum depth of the basin in feet. Volume may be computed from contour information or other suitable methods. If the volume of the basin is not adequate for required storage, excavate to obtain the required volume.

3. The volume of the basin for dewatering and cleanout is 50% of the required sediment storage.

4. Determine the design elevation for the minimum required storage volume of the basin. This is the elevation at the top of the riser.

5. Determine the design elevation of the dewatering and cleanout level.

6. Determine the distance of the dewatering and cleanout level below the riser crest.

7. The pre-development peak discharge rate (Q10pd) is computed assuming a meadow land use for a 10-year/24-hour storm event using approved SCS methods (see Chapter 2, Alabama Engineering Field Design Manual in Appendix A6 for runoff calculations). The runoff curve number shall be for appropriate soil types for a pre-development meadow condition.

8. The peak discharge rate is computed for a disturbed land use condition of a 10-year/24-hour storm event (Q10d).

9. Determine the volume of runoff in inches for the Q10d storm event (see page A-VI-SB-8).

10. The peak discharge rate is computed for a disturbed land use condition for a 25-year/24-hour storm event (Q25d).

11. The maximum principal spillway discharge capacity shall be the 10-year pre-development peak discharge rate (Q10pd).

12. Determine the value of "H" from field conditions. "H" is the elevation difference between the centerline of the outlet pipe and the emergency spillway crest. Determine the barrel length.

13. Determine the volume of storage (Vs) between the top of the riser and the emergency spillway crest (minimum difference in elevation of 1 ft.) expressed in inches of storage over the entire drainage area.

14. Determine whether to use Table A or B (see page A-VI-SB-9).

15. Calculate principal spillway flow using Table A or B (see pages A-VI-SB-10 & 11). Make sure this flow is less than the Q10pd. If not, adjust the Vs by raising the emergency spillway crest elevation and recalculate.

16. Determine the barrel diameter needed to pass the calculated principal spillway flow (Qps) from design charts (see page A-VI-SB-12).

17. Determine the riser diameter (see page A-VI-SB-13), length, and "h" feet (1 foot minimum) below the emergency spillway.

18. Determine the trash rack and anti-vortex device size (see page A-VI-SB-15).

19. Determine the slope of the barrel pipe. Determine the percent of the 10-year/24-hour runoff that is removed in 3 days.

20. Compute the emergency spillway capacity (Qes) by subtracting the Q10d from Q25d.

21. Use the appropriate tables to obtain values of Hp and bottom width for the vegetated emergency spillway with a velocity of less than 6 fps (see pages A-VI-SB-16 & 17).

22. Determine the entrance channel slope.

23. Determine the exit channel slope.

24. Determine the anti-seep collar design if required (see pages A-VI-SB-18, 19 & 20).

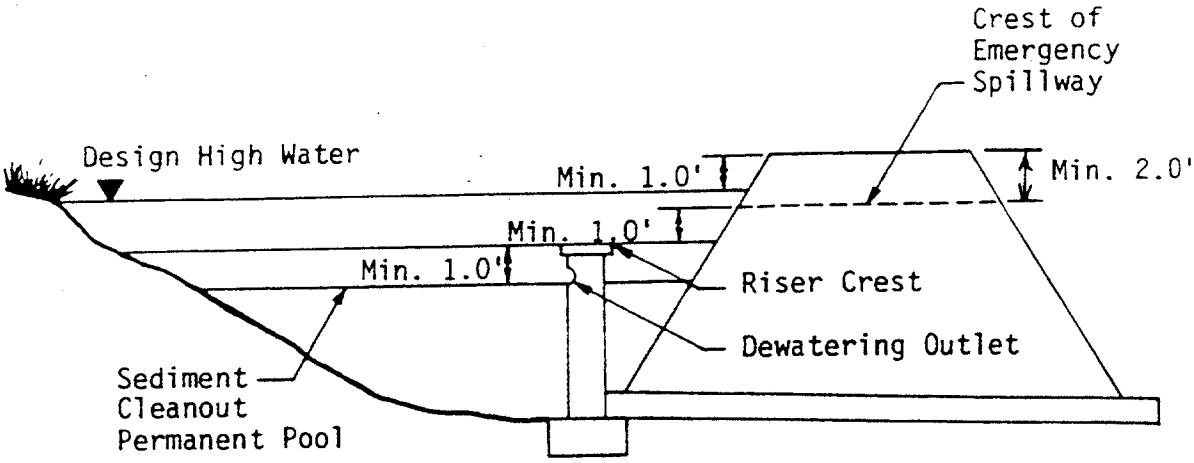
25. Determine the number of anti-seep collars to use.

26. Determine the design elevation of the riser crest and design high water for the emergency spillway flowing full.

27. Determine the design elevation of the emergency spillway. The emergency spillway crest must be set no closer to the riser crest than 1 foot and high enough to cause the pipe spillway to prime and carry the maximum required Qps.

    Therefore, the elevation difference between spillways shall be equal to the value of h, or one foot, whichever is greater. Design high water is the elevation of the emergency spillway crest plus the value of Hp. The minimum top of dam elevation requires 1.0 ft. of freeboard above design high water.

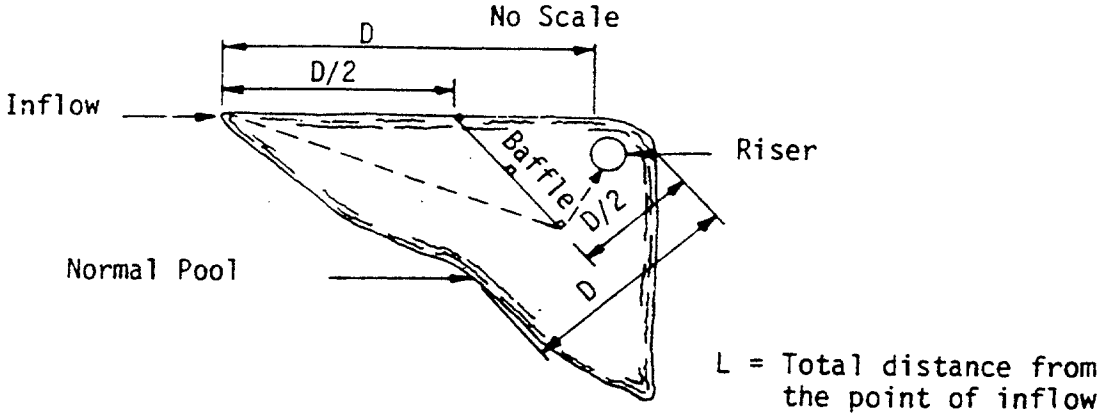
SEDIMENT BASIN SCHEMATIC ELEVATIONS



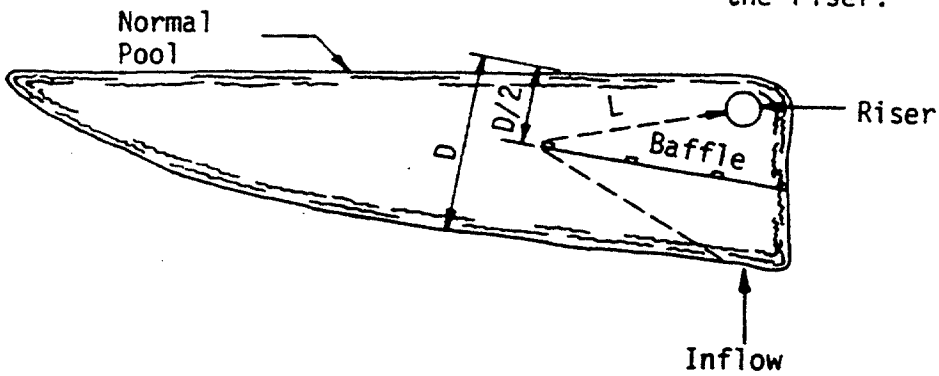
Design Elevations With Emergency Spillway

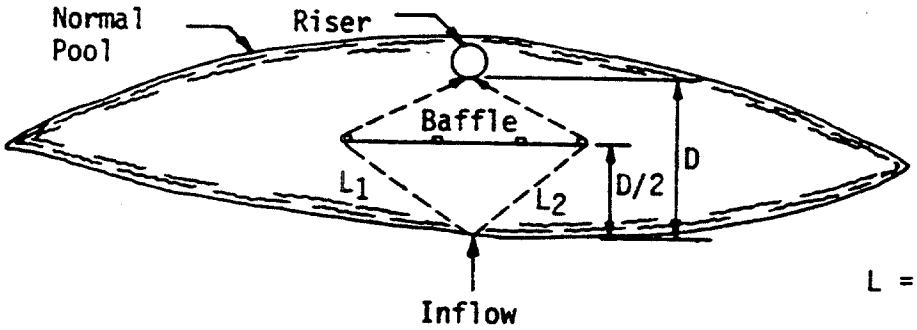
EXAMPLE PLAN VIEWS OF BAFFLE LOCATIONS IN SEDIMENT BASINS

No Scale

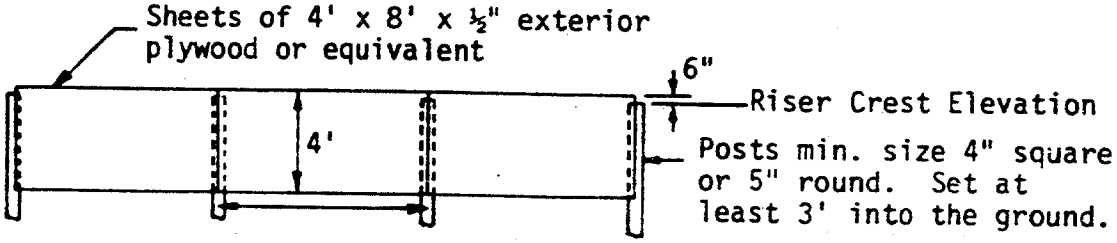


L = Total distance from the point of inflow around the baffle to the riser.





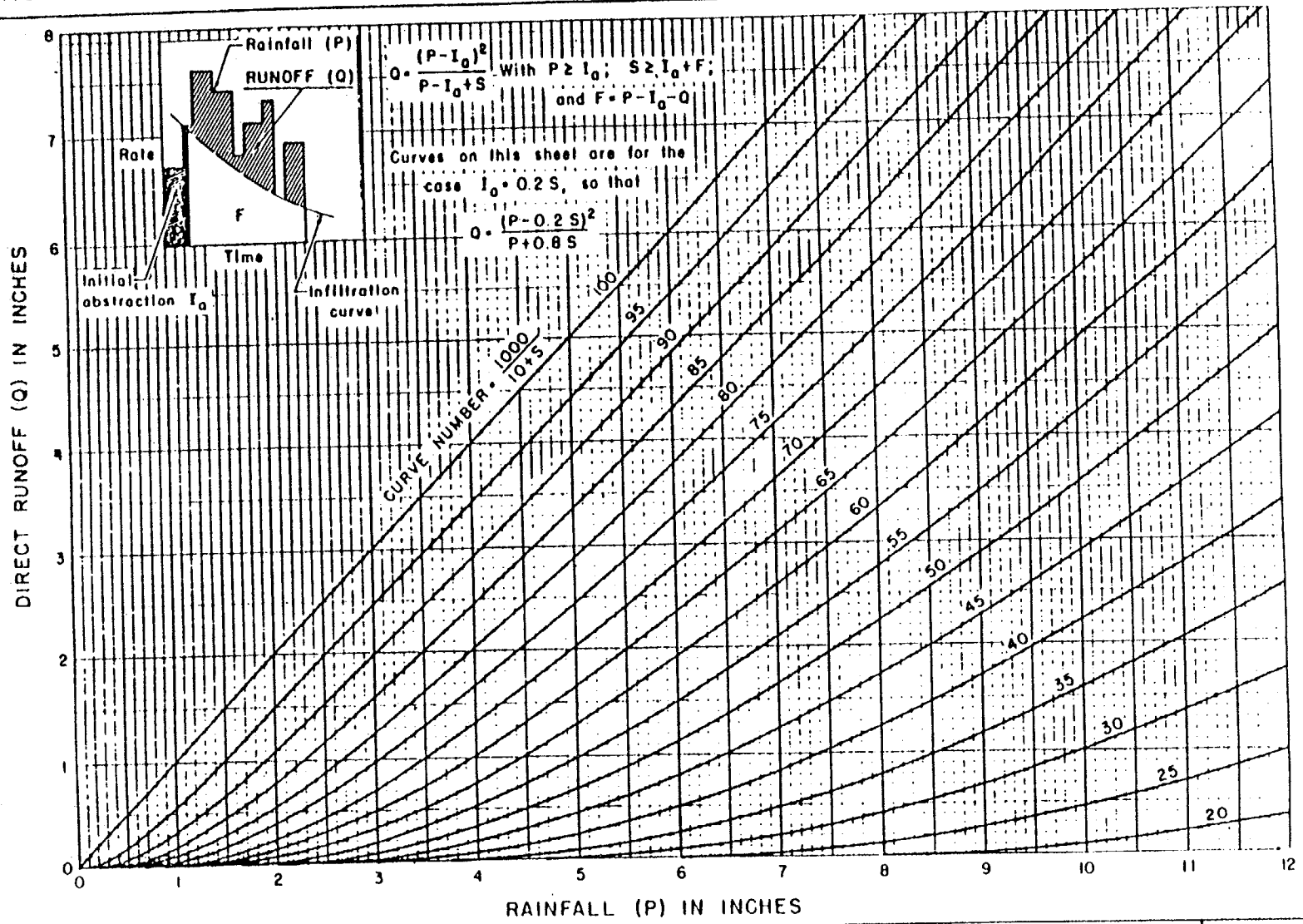
$L = L_1 + L_2$



Source: USDA-SCS

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches



REFERENCE
Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION — HYDROLOGY BRANCH

STANDARD DWG. NO
ES 1001
SHEET 1 OF 2
DATE 6 29 56
REVISED 10 1 64

USDA SCS FORT WORTH TEX 1968

4-68 4-1-18280-1 of 2

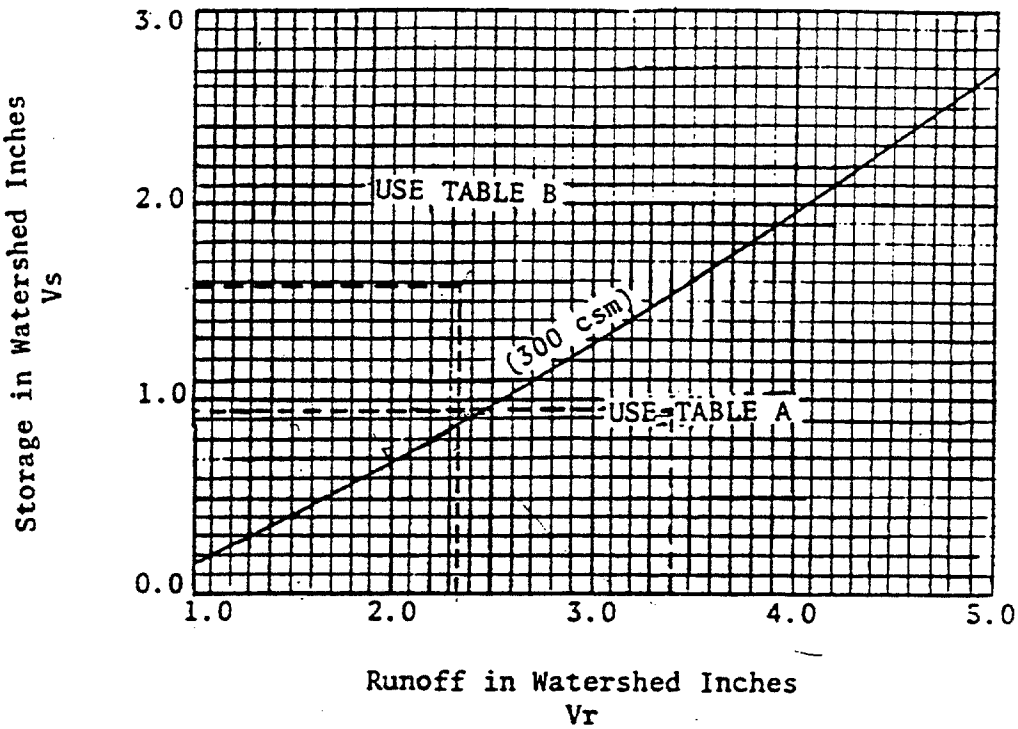


Figure 1 and Tables A and B can be used to determine the capacity of principal spillways considering temporary storage. Figure 1 is a plot of Vs versus Vr to determine which Table to use. Table A is for pipe flow structures with a discharge over 0.47 $ft^3/s/acre$ (300 csm) and Table B is for pipe flow structures with a discharge under 0.47 $ft^3/s/acre$.

Description of Terms:

Vs = Volume of temporary storage, acre-feet or in.
Vr = Volume of runoff, acre-feet or in.
Qo = Required principal spillway discharge, ft^3/s (Table A) and $ft^3/s/acre$ (Table B)
Qi = Peak flow from design storm, ft^3/s

Table A

$\frac{Vs}{Vr}$ tenth	Hundredth 0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	1.00	.99	.98	.96	.95	.94	.92	.91	.90	.88
0.1	.87	.85	.84	.82	.81	.79	.78	.76	.75	.74
0.2	.70	.67	.64	.61	.58	.56	.54	.52	.50	.48
0.3	.47	.45	.44	.42	.41	.40	.39	.38	.37	.36
0.4	.35	.32	.30	.28	.26	.24	.23	.21	.20	.19
0.5	.18	.17	.16	.15	.14	.13	.12	.12	.11	.11
0.6	.10	.10	.09	.09	.08	.08	.07	.07	.07	.07
0.7	.06	.06	.06	.06	.05	.05	.05	.05	.04	.04
0.8	.04	.04	.04	.04	.04	.03	.03	.03	.03	.03

Table A: Values of Qo/Qi for pipe flow structures with a discharge over 0.47 $ft^3/s/acre$ (300 csm).

Example #1:

Given: Vs = 1.84 in.
Vr = 4.0 in.
Qi = 175 ft^3/s
D.A. = 60 acres

Find: Qo

Solution: Find the point for Vs of 1.84 in. and Vr of 4.0 in. in figure 1. Since the point is below the line, use Table A.

$$\frac{Vs}{Vr} = \frac{1.84}{4.0} = 0.46$$ (Vs and Vr must be in same units)

$$\frac{Qo}{Qi} = 0.23$$ (From Table A)

$$Qo = 0.23 \times Qi = 0.23 \times 175 \ ft^3/s = 40 \ ft^3/s$$

Table B

VALUES OF Qo IN $ft^3/s/acre$

STORAGE IN WATERSHED INCHES

Vr \ Vs	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4
1.0	.89	.39	.19	.10	.06	.044	.031	.024	.018													
1.2		.62	33	.20	.12	.08	.05	.04	.030	.022												
1.4			.57	.31	.21	.14	.09	.07	.05	.038	.026											
1.6				.57	.33	.23	.16	.11	.08	.06	.039	.028										
1.8					.59	.37	.25	.19	.13	.09	.06	.041	.031									
2.0						.64	.42	.27	.21	.14	.09	.06	.040									
2.2							.62	.45	.32	.23	.13	.08	.05	.020								
2.4								.65	.49	.34	.20	.12	.08	.05								
2.6									-	.49	.28	.17	.11	.08	.05							
2.8										.69	.41	.25	.16	.11	.08	.05						
3.0											.55	.34	.22	.15	.11	.08	.05					
3.2												.49	.31	.20	.14	.10	.08	.05				
3.4												.66	.44	.28	.19	.14	.10	.08	.05			
3.6													.56	.39	.26	.19	.14	.10	.08	.05		
3.8														.49	.34	.23	.16	.13	.10	.08	.05	
4.0														.65	.45	.31	.22	.17	.13	.09	.07	.05
4.2															.55	.41	.28	.20	.16	.12	.09	.07
4.4																.49	.36	.25	.21	.14	.12	.09
4.6																.62	.45	.33	.27	.19	.15	.12
4.8																	.55	.43	.33	.23	.19	.14
5.0																		.49	.39	.31	.23	.18

RUNOFF IN WATERSHED INCHES

DISCHARGE VALUES TO THE LEFT OF LINE ARE TO BE USED FOR INTERPOLATION ONLY.

HOWEVER, INTERPOLATED VALUES SHOULD NOT EXCEED .47 $ft^3/s/acre$

Table B is for pipe flow structures with a discharge under 0.47 $ft^3/s/acre$ (300 csm).

Example #2:

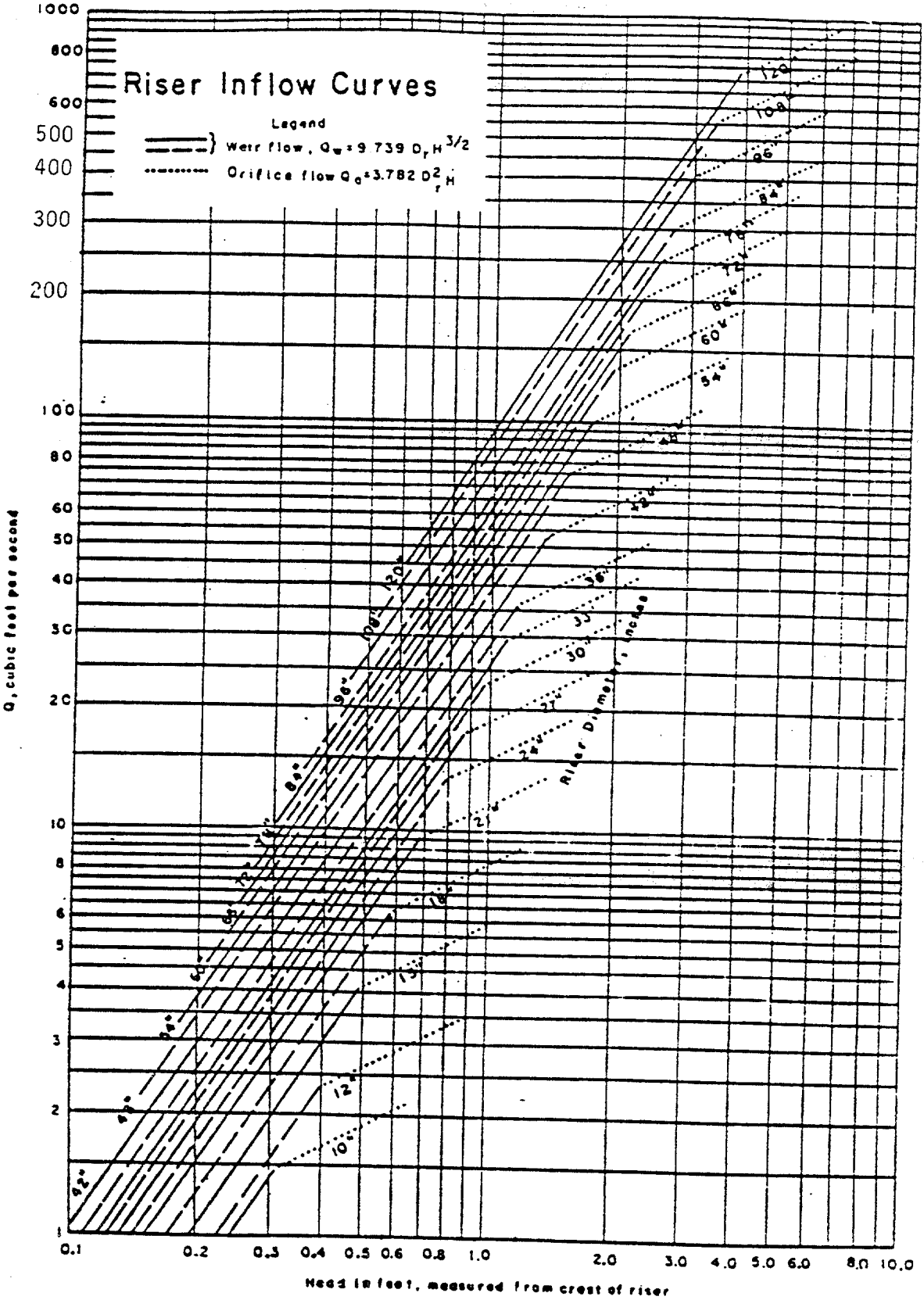
Given: Vs = 0.9 in.
Vr = 2.2 in.
Qi = 130 ft^3/s
D.A. = 125 acres (drainage area)

Find: Qo

Solution: Use Table B (determined from Figure 1)
Qo = 0.32 $ft^3/s/acre$ (from Table B)
= 0.32 $ft^3/s/acre$ X 125 acres = 40 ft^3/s

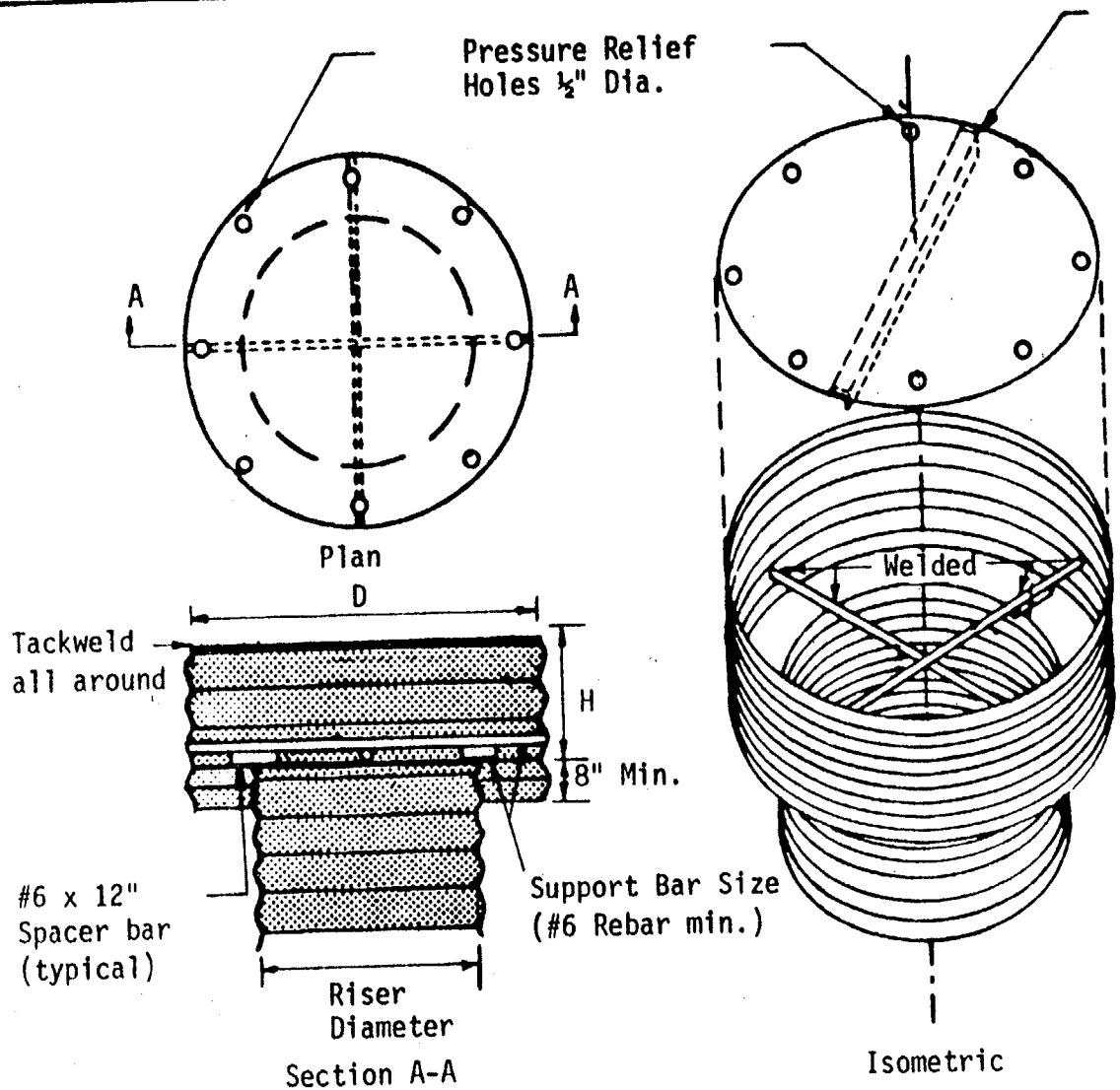
	SMOOTH PIPE									CORRUGATED PIPE							
Barrel Diam.	4"	6"	8"	10"	12"	15"	18"	24"	30"	6"	8"	10"	12"	15"	18"	24"	30"
Riser Diam.	USE RISER INFLOW CURVES																
Head In Feet																	
6	0.8	1.8	3.4	5.7	8.3	14.1	24.6	40.7	65.0	1.0	2.1	3.7	5.7	10.2	15.7	31.4	53.0
7	0.8	1.8	3.6	5.9	8.6	14.9	24.9	42.8	69.1	1.0	2.1	3.8	5.8	10.5	16.3	32.6	55.2
8	0.9	1.8	3.7	6.1	8.9	15.3	25.3	45.0	73.2	1.1	2.2	3.9	5.9	10.7	16.9	33.8	57.5
9	0.9	1.8	3.8	6.4	9.2	15.8	25.7	46.9	76.5	1.1	2.2	4.0	6.1	11.0	17.3	34.8	59.3
10	1.0	1.9	3.9	6.6	9.6	16.4	26.1	48.7	79.7	1.1	2.3	4.1	6.2	11.3	17.7	35.8	61.1
11	1.0	1.9	4.0	6.8	9.9	17.0	26.6	50.3	82.6	1.1	2.3	4.1	6.4	11.6	18.1	36.7	62.7
12	1.1	2.0	4.1	7.0	10.2	17.6	27.0	52.0	85.1	1.1	2.4	4.2	6.5	11.8	18.5	37.5	64.2
13	1.1	2.0	4.2	7.2	10.5	18.1	27.2	53.3	87.4	1.2	2.4	4.3	6.6	12.0	18.7	38.1	65.4
14	1.2	2.1	4.3	7.5	10.8	18.7	27.5	54.6	89.7	1.2	2.5	4.4	6.8	12.3	19.0	38.7	66.5
15	1.2	2.1	4.4	7.7	11.2	19.3	27.6	57.0	93.8	1.2	2.5	4.5	6.9	12.6	19.7	40.1	69.2
16	1.3	2.2	4.5	7.9	11.5	19.9	27.8	59.4	97.9	1.2	2.6	4.6	7.0	12.9	20.4	41.6	71.9
17	1.3	2.2	4.7	8.1	11.8	20.5	28.1	60.9	100.4	1.3	2.6	4.7	7.1	13.2	20.6	42.3	73.2
18	1.4	2.3	4.8	8.3	12.1	21.0	28.4	62.4	103.0	1.3	2.7	4.8	7.3	13.4	20.9	43.0	74.5
19	1.4	2.3	4.9	8.6	12.4	21.6	28.7	63.6	105.1	1.3	2.7	4.9	7.5	13.7	21.1	43.6	75.0
20	1.5	2.4	5.0	8.8	12.7	22.2	29.0	64.8	107.1	1.4	2.8	4.9	7.6	13.9	21.4	44.2	75.6

Discharge in cubic feet per second (CFS) for pipe conduits with different heads



A-VI-SB-13

July 1, 1993



Top stiffener (if required) is ____x____x____ angle welded to top and oriented perpendicular to corrugations.

Top is ____ gage corrugated metal or 1/8" steel plate. Pressure relief holes may be omitted, if ends of corrugations are left fully open when the top is attached.

Cylinder is ____gage corrugated metal pipe or fabricated from 1/8" steel plate.

Notes:
1. The cylinder must be firmly fastened to the top of the riser.
2. Support bars are welded to the top of the riser or attached by straps bolted to top of riser

ANTI - VORTEX DEVICE DESIGN

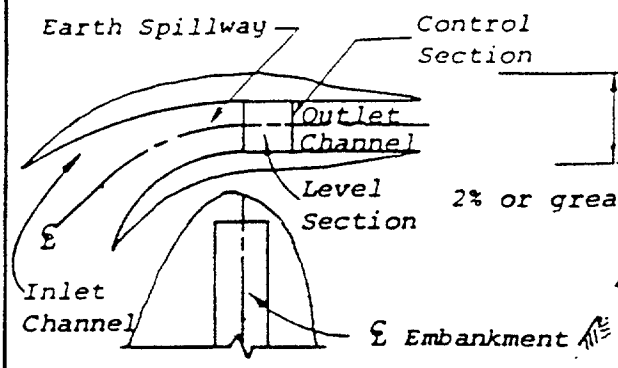
Source: USDA-SCS

CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE DESIGN TABLE

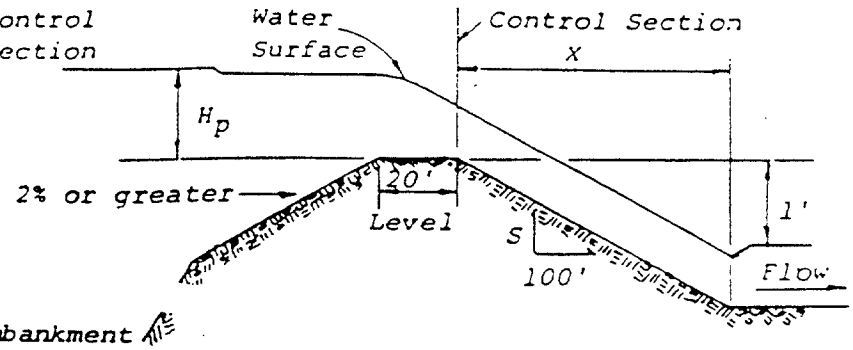
Riser Diam., in.	Cylinder Diam. in.	Cylinder Thick., gage	H, in.	Minimum Size Support Bar	Minimum Top Thickness	Minimum Top Stiffener
12	18	16	6	#6 Rebar	16 ga.	-
15	21	16	7	"	"	-
18	27	16	8	"	"	-
21	30	16	11	"	"	-
24	36	16	13	"	14 ga.	-
27	42	16	15	"	"	-
36	54	14	17	#8 Rebar	12 ga.	-
42	60	14	19	"	"	-
48	72	12	21	1-1/4" pipe or 1-1/4x1-1/4x1/4 angle	10 ga.	-
54	78	12	25	"	"	-
60	90	12	29	1-1/2" pipe or 1-1/2x1-1/2x1/4 angle	8 ga.	-
66	96	10	33	2" pipe or 2x2x3/16 angle	8 ga., w/stiffener	2x2x1/4 angle
72	102	10	36	"	"	2-1/2x2-1/2x 1/4 angle
78	114	10	39	2-1/2" pipe or 2x2x1/4 angle	"	"
84	120	10	42	2-1/2" pipe or 2-1/2x2-1/2x1/4 angle	"	2-1/2x2-1/2x 5/16 angle

Note: The criterion for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.

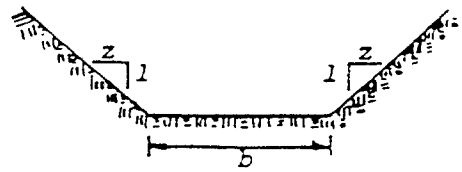
Source: USDA-SCS



PLAN OF EARTH SPILLWAY



PROFILE ALONG ℄ OF EARTH SPILLWAY



CROSS SECTION OF EARTH SPILLWAY AT CONTROL SECTION

LEGEND

n = Manning's Coefficient of Roughness.
H_p = Difference in Elevation between Crest of Earth Spillway at the Control Section and Water Surface in Reservoir, in feet.
b = Bottom Width of Earth Spillway at the Control Section, in feet.
Q = Total Discharge, in cfs.
V = Velocity, in feet per second, that will exist in Channel below Control Section, at Design Q, if constructed to slope (S) that is shown.
S = Flattest Slope (S), in %, allowable for Channel below Control Section.
X = Minimum Length of Channel below Control Section, in feet.
z = Side Slope Ratio.

NOTES:

1) For a given H_p a decrease in the exit slope from S as given in the table decreases spillway discharge but increasing the exit slope from S does not increase discharge. If an exit slope (S_e) steeper than S is used, then velocity (V_e) in the exit channel will increase according to the following relationship:

$$V_e = V\left(\frac{S_e}{S}\right)^{0.3}$$

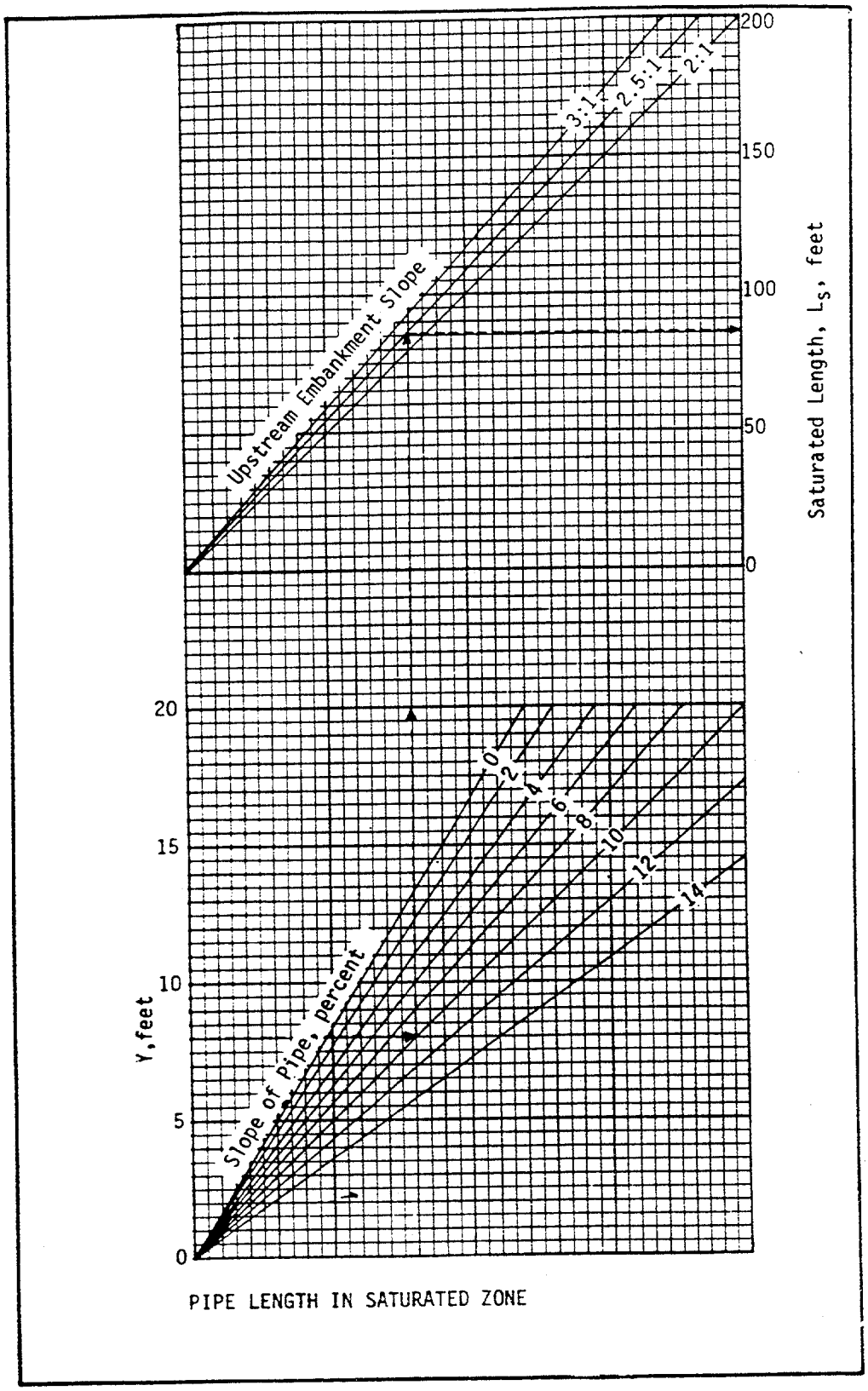
2) Data to right of heavy vertical lines on drawings should be used with caution, as the resulting sections will be either poorly proportioned or have velocities in excess of 6 ft/sec.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE College Park, Md.	DESIGN DATA FOR EARTH SPILLWAYS	Ref: Engineering Field Manual

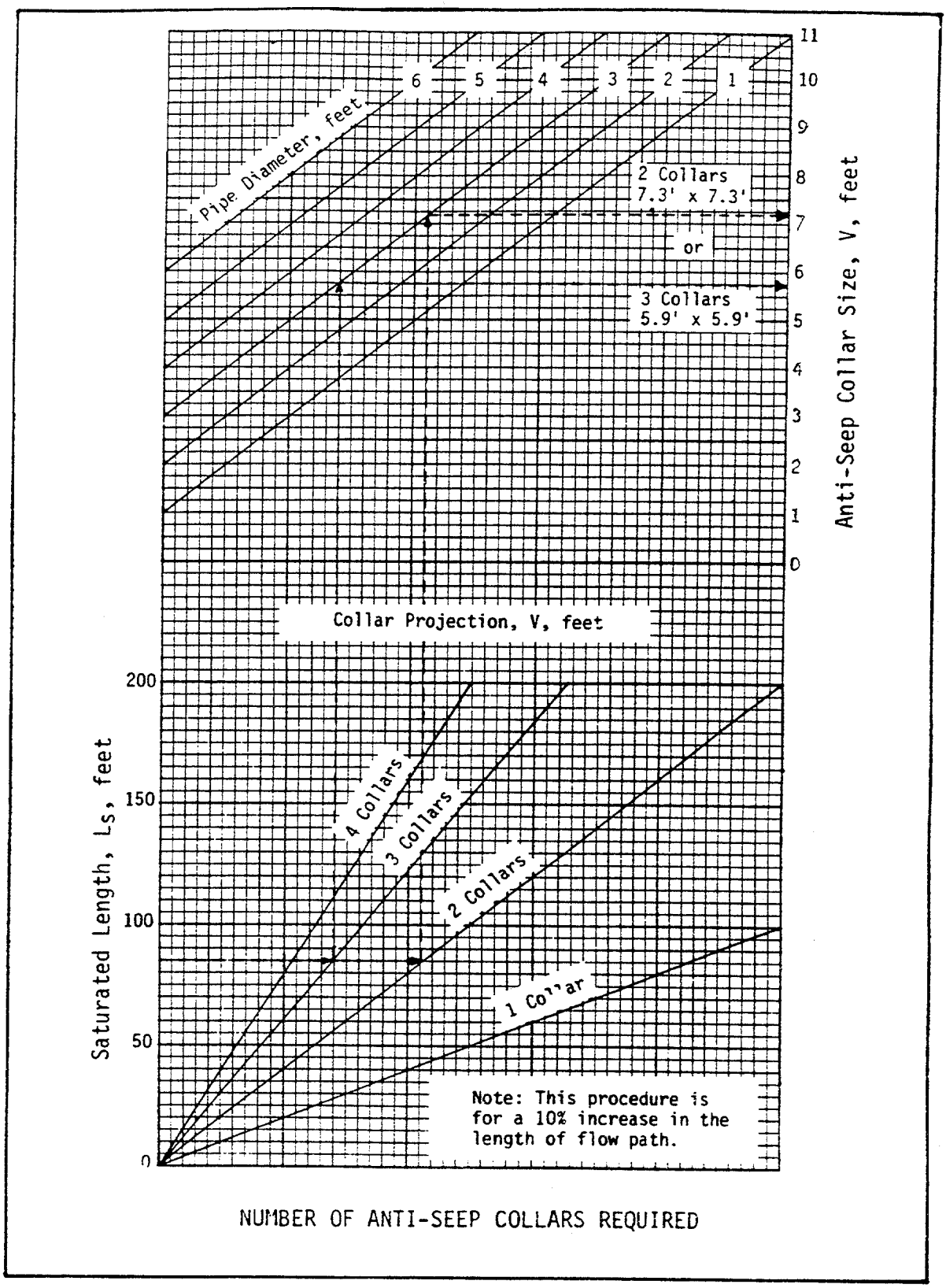
DESIGN DATA FOR EARTH SPILLWAYS

STAGE (Hp) IN FEET	SPILLWAY VARIABLES	BOTTOM WIDTH (b) IN FEET																
		8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
0.5	Q	6	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
	V	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	X	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
0.6	Q	8	10	12	14	16	18	20	22	24	26	28	30	32	34	35	37	39
	V	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.6	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	X	36	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37
0.7	Q	11	13	16	18	20	23	25	28	30	33	35	38	41	43	44	46	48
	V	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	X	39	40	40	40	41	41	41	41	41	41	41	41	41	41	41	41	41
0.8	Q	13	16	19	22	26	29	32	35	38	42	45	46	48	51	54	57	60
	V	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	S	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	X	44	44	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45
0.9	Q	17	20	24	28	32	35	39	43	47	51	53	57	60	64	68	71	75
	V	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.2	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	X	47	47	48	48	48	48	48	48	48	48	49	49	49	49	49	49	49
1.0	Q	20	24	29	33	38	42	47	51	56	61	63	68	72	77	81	86	90
	V	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	X	51	51	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52
1.1	Q	23	28	34	39	44	49	54	60	65	70	74	79	84	89	95	100	105
	V	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	S	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	55	55	55	55	55	55	55	56	56	56	56	56	56	56	56	56	56
1.2	Q	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	S	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	58	58	59	59	59	59	59	59	60	60	60	60	60	60	60	60	60
1.3	Q	32	38	46	53	58	65	73	80	86	91	99	106	112	119	125	133	140
	V	4.5	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	X	62	62	62	63	63	63	63	63	63	63	63	64	64	64	64	64	64
1.4	Q	37	44	51	59	66	74	82	90	96	103	111	119	127	134	142	150	158
	V	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
	S	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	X	65	66	66	66	66	67	67	67	67	67	67	68	68	68	68	68	69
1.5	Q	41	50	58	66	75	85	92	101	108	116	125	133	142	150	160	169	178
	V	4.8	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.1	5.1
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5
	X	69	69	70	70	71	71	71	71	71	71	71	72	72	72	72	72	72
1.6	Q	46	56	65	75	84	94	104	112	122	132	142	149	158	168	178	187	197
	V	5.0	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	72	74	74	75	75	76	76	76	76	76	76	76	76	76	76	76	76
1.7	Q	52	62	72	83	94	105	115	126	135	145	156	167	175	187	196	206	217
	V	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	S	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	76	78	79	80	80	80	80	80	80	80	80	80	80	80	80	80	80
1.8	Q	58	69	81	93	104	116	127	138	150	160	171	182	194	204	214	226	233
	V	5.3	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.6	5.6	5.6
	S	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	80	82	83	84	84	84	84	84	84	84	84	84	84	84	84	84	84
1.9	Q	64	76	88	102	114	127	140	152	164	175	188	201	213	225	235	248	260
	V	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	S	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	84	85	86	87	88	88	88	88	88	88	88	88	88	88	88	88	88
2.0	Q	71	83	97	111	125	138	153	164	178	193	204	218	232	245	256	269	283
	V	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	88	90	91	91	91	91	92	92	92	92	92	92	92	92	92	92	92
2.1	Q	77	91	107	122	135	149	162	177	192	207	220	234	250	267	276	291	305
	V	5.7	5.8	5.9	5.9	5.9	5.9	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	S	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	92	93	95	95	95	95	95	95	95	96	96	96	96	96	96	96	96
2.2	Q	84	100	116	131	146	163	177	194	210	224	238	253	269	288	301	314	330
	V	5.9	5.9	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2
	S	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	96	98	99	99	99	99	99	100	100	100	100	100	100	100	100	100	100
2.3	Q	90	108	124	140	158	175	193	208	226	243	258	275	292	306	323	341	354
	V	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	S	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	100	102	102	103	103	103	104	104	104	105	105	105	105	105	105	105	105
2.4	Q	99	116	136	152	170	189	206	224	241	260	275	294	312	327	346	364	378
	V	6.1	6.2	6.2	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
	S	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	105	105	106	107	107	108	108	108	108	109	109	109	109	109	109	109	109

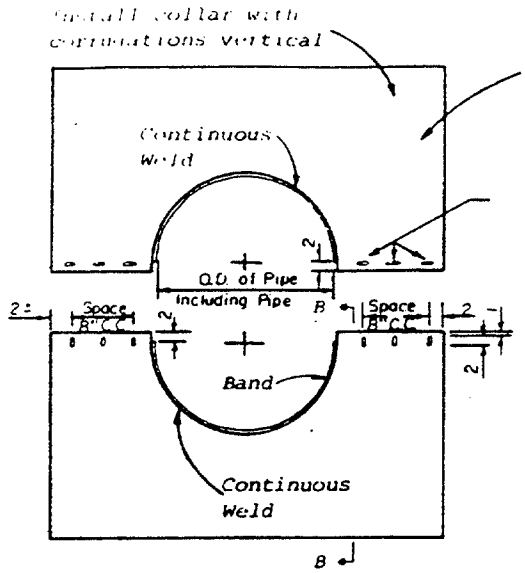
Source: USDA-SCS



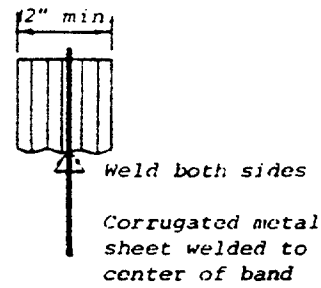
Source: USDA-SCS



Source: USDA-SCS



ELEVATION OF UNASSEMBLED COLLAR



SECTION B-B

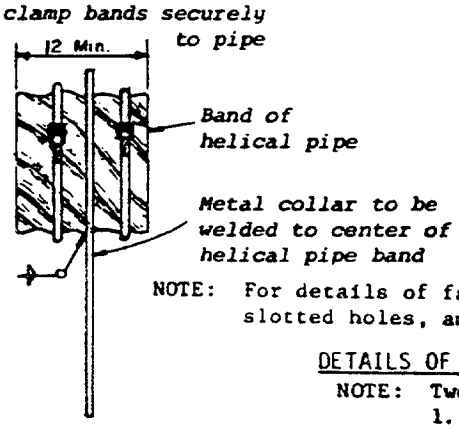
NOTES FOR COLLARS:

1. All materials to be in accordance with construction and construction material specifications.
2. When specified on the plans, coating of collars shall be in accordance with construction and construction material specifications.
3. Unassembled collars shall be marked by painting or tagging to identify matching pairs.
4. The lap between the two half sections and between the pipe and connecting band shall be caulked with asphalt mastic at time of installation.
5. Each collar shall be furnished with two 1/2" diameter rods with standard tank lugs for connecting collars to pipe.

DETAILS OF CORRUGATED METAL ANTI-SEEP COLLAR

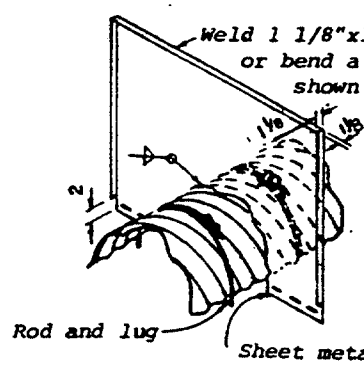
Size and spacing of slotted openings shall be the same as shown for CM collar

Use rods and lugs to clamp bands securely to pipe



PARTIAL ELEVATION

Ref: Engr. Field Manual



NOTE FOR BANDS AND COLLARS: Modifications of the details shown may be used providing equal watertightness is maintained and detailed drawings are submitted and approved by the Engineer prior to delivery.

Sheet metal collar shall be cut to fit corrugations of helical band, and welded with a continuous weld.

ISOMETRIC VIEW

NOTE: For details of fabrication dimensions, minimum gages, slotted holes, and notes, see detail above.

DETAILS OF HELICAL PIPE ANTI-SEEP COLLAR

NOTE: Two other types of anti-seep collars are:

1. Corrugated metal, similar to upper detail, except shop welded to a short (4 ft.) section of the pipe and connected with connecting bands to the pipe.
2. Concrete, six inches thick formed around the pipe with #3 rebar spaced 15" horizontally and vertically.

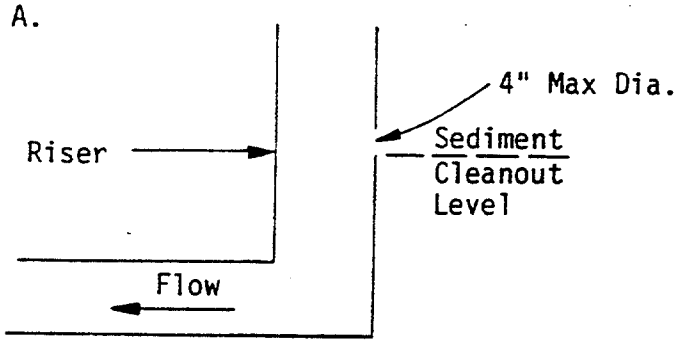
Source: USDA-SCS

METHODS OF DEWATERING SEDIMENT BASIN
DETENTION POOLS

Methods

Comments

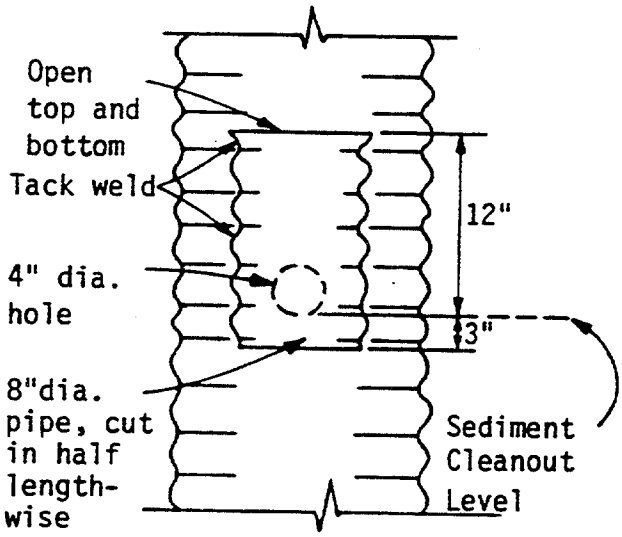
A.



Cross-Section

Easy to construct
May clog with trash
Non-skimming
Capable of draining down to sediment clean-out level
Passes base flow without storage of water

B. Same as "A" except for skimming device, detailed below:

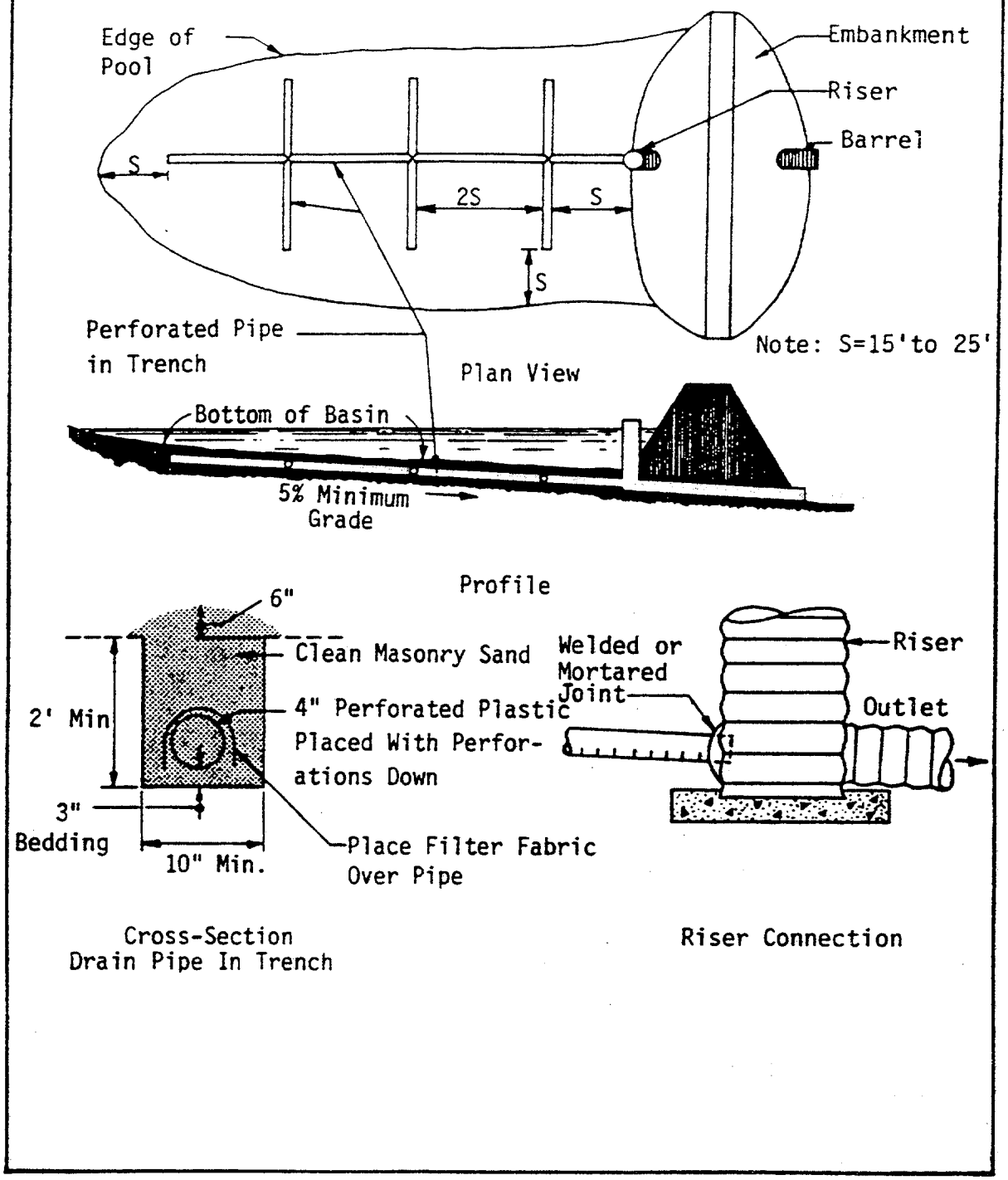


Elevation

Efficient skimmer
Non-clogging
Fairly easy to construct
Capable of draining down to sediment clean-out level
Passes base flow without storage of water

Source: USDA-SCS

DEWATERING SEDIMENT BASIN WITH SUBSURFACE DRAIN



Source: USDA-SCS

DESIGN PROCEDURES
FOR
VEGETATED WATERWAY OR STORMWATER CONVEYANCE CHANNEL

Manning's equation shall be used to determine velocities and capacities in waterways and channels. Manning's equation is available in most hydraulics or fluid mechanics books. Numerous handbooks, charts or tables and computer programs are available for making computations using Manning's formula.

To calculate the flow in an open channel, it must be assumed that the quantity of flow in the channel does not change with time and that the cross-sectional area and slope of the channel remain constant. While in reality these conditions are seldom met, the channel can be divided into reaches which have similar cross-sections and slope, and the flow can be considered at one point in time, such as the peak flow, when the quantity of flow will be more or less constant.

Two equations are used to calculate the flow in open channels. They are:

<u>Manning's Equation</u>,

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

Where,

V = the average velocity in the channel (ft./sec.)
n = Manning's roughness coefficient, based upon the lining of the channel
R = the hydraulic radius (feet)
S = the slope of the channel (feet/foot)

<u>and The Continuity Equation</u>,

$$Q = AV$$

Where,

Q = flow in the channel (ft.^{3}/sec.)
A = cross-sectional area of the channel (ft.^{2})
V = average velocity in the channel (ft./sec.)

Manning's Equation and the Continuity Equation are used simultaneously to determine flow capacity and velocity in

the channel. A nomograph for solving Manning's Equation is given on Figure A6-WW-1.

Vegetated Waterways.

The design of a vegetated waterway is more complicated than for a bare or lined channel since the value for "n" varies where grass linings are used. Vegetation tends to bend or oscillate under the influence of velocity and depth of flow. The retardance to flow varies as these factors change.

Five general retardance curves, designated as A, B, C, D & E have been developed for various cover conditions. The vegetated conditions under which the various retardance values apply are shown in Table A6-WW-1. These cover classifications are based on tests in experimental channels when the covers were green and generally uniform.

Tables have been developed which take into account the retardance of the vegetation protecting the waterway. Retardance "D" should be used to check velocity of the new waterway. Velocities shall be limited to those shown in Table A6-WW-1.

Most vegetated waterways are constructed with a parabolic cross-section. Waterways that are constructed to a trapezoidal cross-section usually go to a parabolic shape during the topsoiling and vegetation establishment. The velocity determined by the "D" retardance is the "as-built" velocity (V1) in the design exhibit.

Retardance "C" should be used to determine the velocity to calculate the capacity of the waterway. The velocity determined by the "C" retardance is the "aged" velocity (V2) in the design exhibit.

The following steps are used in the design of the vegetated waterway.

1. Determine Peak Discharge. Use the methods described in the second paragraph of Design Criteria of this standard.

2. Determine the Grade of the Waterway. Use engineer survey information or site topography map or other suitable methods to calculate the slope of the planned waterway in percent.

3. Determine Retardance. The retardance for design of vegetated waterways should be "D" and "C" to produce a safe velocity and an adequate capacity.

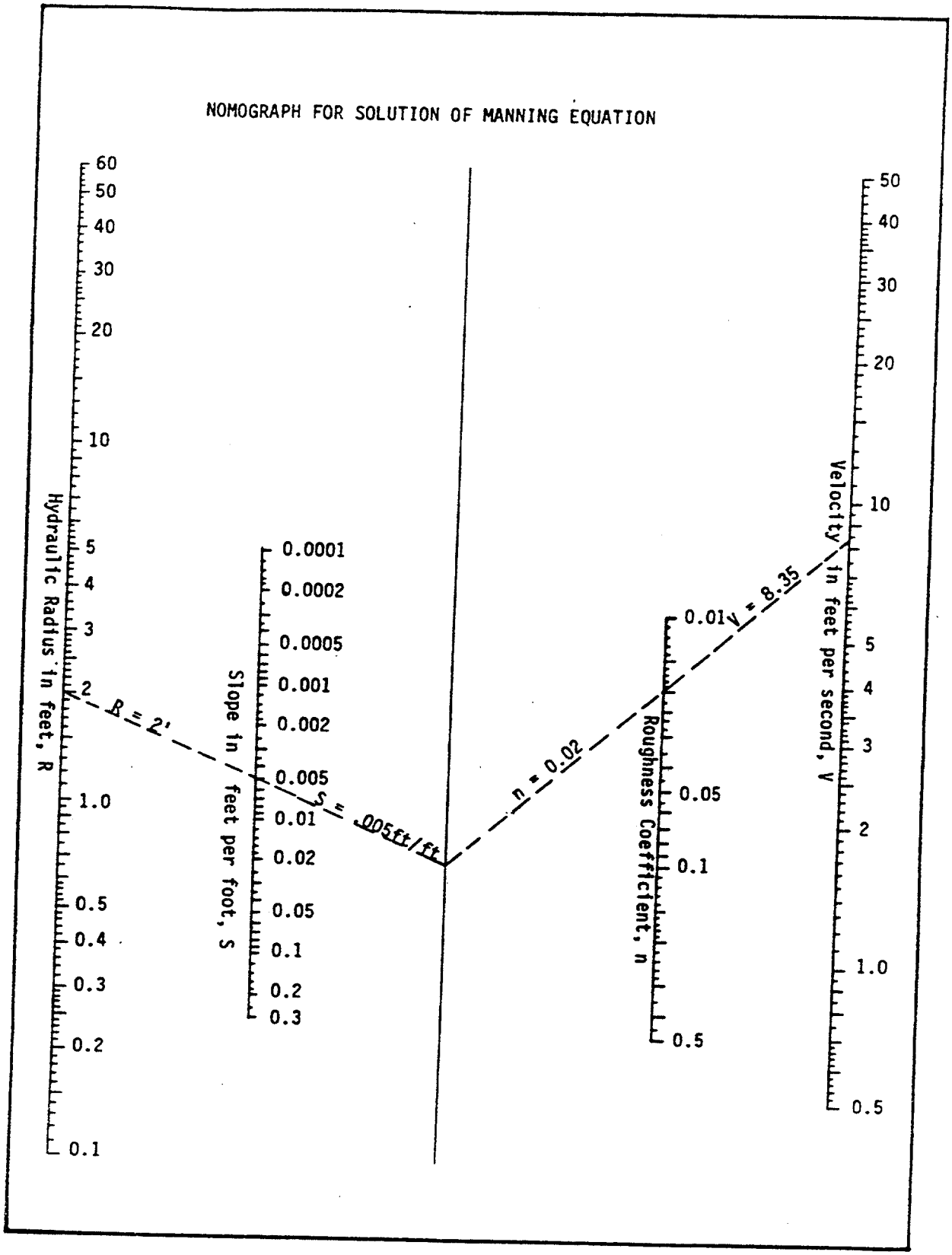


Figure A6-WW-1. Nomograph for Solution of Manning's Equation.

Table A6-WW-1. Classification of Vegetative Cover as to Degree of Retardance.

Retar-dance	Cover	Condition
A	Reed canarygrass	Excellent stand, tall (average 36 inches)
	Yellow bluestem Ischaemum	Excellent stand, tall (average 36 inches)
B	Smooth bromegrass	Good stand, mowed (average 12 to 15 inches)
	Bermudagrass	Good stand, tall (average 12 inches)
	Native grass mixture (little bluestem, blue grama, and other long and short midwest grasses)	Good stand, unmowed
	Tall fescue	Good stand, unmowed (average 18 inches)
	Lespedeza sericea	Good stand, not woody, tall (average 19 inches)
	Grass-legume mixture--Timothy, smooth bromegrass, or orchard grass	Good stand, uncut (average 20 inches)
	Reed canarygrass	Good stand, mowed (average 12 to 15 inches)
	Tall fescue, with bird's foot trefoil or lodino ..	Good stand, uncut (average 18 inches)
	Blue grama	Good stand, uncut (average 13 inches)
C	Bahia	Good stand, uncut (6 to 8 inches)
	Bermudagrass	Good stand, mowed (average 6 inches)
	Redtop	Good stand, headed (15 to 20 inches)
	Grass-legume mixture--summer (Orchard grass, redtop, Italian ryegrass, and common lespedeza) ...	Good stand, uncut (6 to 8 inches)
	Centipedegrass	Very dense cover (average 6 inches)
	Kentucky bluegrass	Good stand, headed (6 to 12 inches)
D	Bermudagrass	Good stand, cut to 2.5-inch height
	Red fescue	Good stand, headed (12 to 18 inches)
	Buffalograss	Good stand, uncut (3 to 6 inches)
	Grass-legume mixture--fall, spring (Orchard grass, redtop, Italian ryegrass, and common lespedeza).	Good stand, uncut (4 to 5 inches)
	Lespedeza sericea	After cutting to 2-inch height. Very good stand before cutting
E	Bermudagrass	Good stand, cut to 1.5-inch height.
	Bermudagrass	Burned stubble.

4. Determine the Maximum Permissible Velocity (V_1) in the waterway.

   A. Classify the soil as either erosion resistant or easily eroded.

   B. Determine the kind of vegetative cover to be established in the waterway.

   C. Enter Table WW-1, permissible velocities for channels lined with vegetation, using cover type, slope and soil erodibility to determine permissible velocity. A maximum of 4 feet per second is recommended on clayey soils (erosion resistant) and 3 feet per second on sandy soils (easily eroded) under normal conditions where vegetation is to be established by seeding.

5. Determine Parabolic Waterway Dimensions. Under Exhibit A6-WW-1, Parabolic Waterway Design, with "Q" (peak discharge), grade in percent, permissible velocity - V_1 and retardance to determine the parabolic waterway dimensions.

Example: Vegetated Waterway

Problem: Determine the permissible velocity and dimensions for stability and capacity for a waterway with parabolic cross section.

Given: Peak Rate of Runoff, Q = 55 cfs
Vegetative Cover = Tall Fescue
Soil = Easily Erodible
Grade = 3%

Solution: Enter Table WW-1 at tall fescue, <5% grade and easily erodible soils and find maximum permissible velocity to be 5 fps. This is the velocity that would be safe if the vegetative cover is a near perfect stand and well-established and maintenance is proper. However, 3 feet per second is recommended when vegetation is established by seeding.

Enter Exhibit A6-WW-1, Parabolic Waterway Design on sheet 9 of 14. At Q = 55 cfs move horizontally to V_1 = 3.0 feet per second to find the proper dimensions of the waterway. The top width (T) = 42.6 feet and the depth would be 0.8 feet. The aged velocity would be 2.4 feet per second.

Adding freeboard and additional width for freeboard would require a top width of 42.6 feet + 4 feet = 46.7 feet, use 47 feet. The depth would be 0.8 feet plus 0.25 feet freeboard equals 1.05 feet. Use 1.1 feet for the constructed depth.

Stone Center Waterway. Stone center waterways will be designed with riprap type stone over the middle third to two thirds of the waterway. The stone should be sized using Exhibit A6-WW-2. An example calculation is shown on the exhibit.

Riprap lined Channels. Channels sized by the use of Manning's formula are calculated by trial and error until a satisfactory channel is determined. A channel size, depth shape and "n" value is assumed and then checked for adequacy.

Example: Riprap Lined Channel

Problem: Determine the proper dimensions of a riprap channel with a trapezoidal cross section.

Given: Peak rate of runoff, Q = 155 cfs; median size of riprap, d_{50} = 6"; Slope of Channel = 6.5%

Solution: Assume a bottom width of 8 feet and 2:1 (horizontal to vertical) side slopes. Use Figure WW-2 to determine the "n" value. Assume a depth (d) and use Manning's and Continuity Equation to determine the velocity of flow and volume of flow.

Given and Assumed: d_{50} = 6"; S = 6.5%; B = 8'

Trial	d	"n"	A	r	v	q
1	1.6	0.0434	17.92	1.18	9.75	174.7
2	1.4	0.0447	15.12	1.06	8.81	133.3
3	1.5	0.044	16.50	1.12	9.28	153.2
4	1.51	0.044	16.64	1.13	9.33	155.3

Check to see that "v" is not exceeded in Figure WW-3. Tables, nomographs and computer programs are available to assist in solving for the required depth of flow. Riprap cannot be constructed to 0.01'. Therefore, the depth of flow should be 1.5'.

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 0.25 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																					
10																					
15																					
20																					
25	9.3	2.3	1.7																		
30	11.7	2.2	1.8																		
35	14.1	2.1	1.7																		
40	16.3	2.1	1.8																		
45	18.5	2.1	1.8	10.4	2.8	2.3															
50	20.7	2.1	1.8	12.3	2.6	2.3															
55	22.9	2.1	1.8	13.8	2.6	2.3															
60	25.0	2.0	1.8	15.3	2.5	2.3															
65	27.2	2.0	1.8	16.8	2.5	2.3	10.4	3.4	2.8												
70	29.3	2.0	1.8	18.2	2.5	2.3	12.1	3.1	2.8												
75	31.9	2.0	1.7	19.7	2.4	2.3	13.5	3.0	2.8												
80	34.0	2.0	1.7	21.1	2.4	2.3	14.7	2.9	2.8												
85	36.1	2.0	1.7	22.5	2.4	2.3	15.8	2.9	2.8												
90	38.2	2.0	1.7	23.9	2.4	2.3	16.9	2.8	2.8												
95	40.3	2.0	1.7	25.3	2.4	2.3	18.0	2.8	2.8												
100	42.4	2.0	1.7	26.7	2.4	2.3	19.1	2.8	2.8												
105	44.6	2.0	1.7	28.1	2.4	2.3	20.2	2.8	2.8												
110	46.7	2.0	1.7	29.5	2.4	2.3	21.3	2.8	2.8	12.9	3.8	3.4									
115	48.8	2.0	1.7	30.8	2.4	2.3	22.3	2.8	2.8	14.0	3.7	3.4									
120	50.9	2.0	1.7	32.2	2.4	2.3	23.4	2.8	2.8	15.3	3.5	3.4									
125	53.0	2.0	1.8	33.6	2.4	2.3	24.4	2.8	2.8	16.1	3.5	3.4									
130	55.1	2.0	1.8	35.0	2.4	2.3	25.5	2.8	2.8	16.9	3.4	3.4									
135	57.3	2.0	1.8	36.4	2.4	2.3	26.5	2.7	2.8	17.7	3.4	3.4									
140	59.4	2.0	1.8	38.3	2.4	2.3	27.6	2.7	2.8	18.5	3.4	3.4									
145	61.5	2.0	1.8	39.7	2.4	2.3	28.6	2.7	2.8	19.3	3.3	3.4									
150	63.6	2.0	1.8	41.1	2.4	2.3	29.6	2.7	2.8	20.1	3.3	3.4									

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C") Sheet 1 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 0.50 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																					
10																					
15	8.4	1.6	1.7																		
20	11.7	1.5	1.7	7.1	2.0	2.2															
25	14.9	1.5	1.7	9.7	1.8	2.2															
30	18.0	1.5	1.7	12.0	1.7	2.2															
35	21.0	1.5	1.7	14.2	1.7	2.2	9.3	2.1	2.7												
40	24.4	1.5	1.7	16.3	1.7	2.2	10.9	2.0	2.7												
45	27.4	1.5	1.7	18.5	1.7	2.2	12.5	2.0	2.7												
50	30.5	1.5	1.7	20.6	1.7	2.2	14.1	1.9	2.7	8.7	2.6	3.3									
55	33.5	1.5	1.7	22.7	1.7	2.2	15.7	1.9	2.7	10.4	2.4	3.3									
60	36.6	1.5	1.7	24.8	1.7	2.2	17.2	1.9	2.7	11.7	2.3	3.3									
65	39.6	1.5	1.7	27.3	1.7	2.2	18.8	1.9	2.7	12.9	2.3	3.3									
70	42.6	1.5	1.7	29.4	1.7	2.2	20.3	1.9	2.7	14.0	2.2	3.3	9.8	2.8	3.8						
75	45.7	1.5	1.7	31.4	1.7	2.2	21.8	1.9	2.7	15.2	2.2	3.3	11.3	2.7	3.8						
80	48.7	1.5	1.7	33.5	1.7	2.2	23.3	1.9	2.7	16.3	2.2	3.3	12.2	2.6	3.8						
85	51.7	1.5	1.7	35.6	1.6	2.2	24.8	1.9	2.7	17.4	2.2	3.3	13.2	2.5	3.8						
90	54.8	1.5	1.7	37.7	1.6	2.2	26.3	1.9	2.7	18.5	2.2	3.3	14.2	2.5	3.8						
95	57.8	1.5	1.7	39.8	1.6	2.2	27.8	1.9	2.7	19.6	2.2	3.3	15.1	2.5	3.8						
100	60.9	1.5	1.7	41.9	1.6	2.2	29.7	1.9	2.7	20.7	2.2	3.3	16.0	2.5	3.8	11.0	3.2	4.3			
105	63.9	1.5	1.7	44.0	1.6	2.2	31.2	1.9	2.7	21.8	2.2	3.3	16.9	2.5	3.8	12.3	3.0	4.3			
110	66.9	1.5	1.7	46.1	1.6	2.2	32.6	1.9	2.7	22.9	2.2	3.3	17.8	2.4	3.8	13.1	2.9	4.3			
115	70.0	1.5	1.7	48.1	1.6	2.2	34.1	1.9	2.7	24.0	2.1	3.3	18.7	2.4	3.8	13.9	2.9	4.3			
120	73.0	1.5	1.7	50.2	1.6	2.2	35.6	1.9	2.7	25.1	2.1	3.3	19.6	2.4	3.8	14.6	2.9	4.3			
125	76.1	1.5	1.7	52.3	1.6	2.2	37.1	1.9	2.7	26.2	2.1	3.3	20.5	2.4	3.8	15.4	2.8	4.3			
130	79.1	1.5	1.7	54.4	1.6	2.2	38.5	1.9	2.7	27.3	2.1	3.3	21.3	2.4	3.8	16.1	2.8	4.3			
135	82.1	1.5	1.7	56.5	1.6	2.2	40.0	1.9	2.7	28.4	2.1	3.3	22.2	2.4	3.8	16.9	2.8	4.3			
140	85.2	1.5	1.7	58.6	1.6	2.2	41.5	1.9	2.7	29.4	2.1	3.3	23.1	2.4	3.8	17.6	2.8	4.3			
145	88.2	1.5	1.7	60.7	1.6	2.2	43.0	1.9	2.7	30.5	2.1	3.3	24.0	2.4	3.8	18.3	2.8	4.3	12.3	3.7	4.9
150	91.3	1.5	1.7	62.8	1.6	2.2	44.5	1.9	2.7	31.6	2.1	3.3	24.8	2.4	3.8	19.0	2.7	4.3	13.1	3.5	4.9

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C") Sheet 2 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 0.75 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																					
10	7.0	1.3	1.6																		
15	11.0	1.3	1.6	7.1	1.5	2.1															
20	14.9	1.3	1.6	9.9	1.4	2.1	6.1	1.9	2.6												
25	18.9	1.2	1.6	12.7	1.4	2.1	8.6	1.6	2.7												
30	22.7	1.2	1.6	15.3	1.4	2.1	10.6	1.6	2.6	6.7	2.1	3.2									
35	26.5	1.2	1.6	18.0	1.4	2.1	12.6	1.6	2.7	8.7	1.9	3.2									
40	30.2	1.2	1.6	20.6	1.4	2.1	14.5	1.6	2.7	10.3	1.8	3.2									
45	34.0	1.2	1.6	23.5	1.4	2.1	16.4	1.5	2.7	11.8	1.8	3.2	7.8	2.3	3.8						
50	37.8	1.2	1.6	26.1	1.4	2.1	18.3	1.5	2.7	13.2	1.8	3.2	9.5	2.1	3.8						
55	41.5	1.2	1.6	28.7	1.4	2.1	20.2	1.5	2.7	14.7	1.7	3.2	10.7	2.0	3.8						
60	45.3	1.2	1.6	31.3	1.4	2.1	22.1	1.5	2.7	16.1	1.7	3.2	11.8	2.0	3.8						
65	49.1	1.2	1.6	33.9	1.4	2.1	24.3	1.5	2.6	17.6	1.7	3.2	13.0	2.0	3.8	8.5	2.6	4.4			
70	52.9	1.2	1.6	36.5	1.4	2.1	26.2	1.5	2.6	19.0	1.7	3.2	14.1	2.0	3.8	10.0	2.4	4.3			
75	56.6	1.2	1.6	39.1	1.4	2.1	28.0	1.5	2.6	20.4	1.7	3.2	15.2	2.0	3.8	11.0	2.4	4.4			
80	60.4	1.2	1.6	41.7	1.4	2.1	29.9	1.5	2.6	21.8	1.7	3.2	16.3	1.9	3.8	11.9	2.3	4.4			
85	64.2	1.2	1.6	44.3	1.4	2.1	31.8	1.5	2.6	23.2	1.7	3.2	17.4	1.9	3.8	12.8	2.3	4.4	9.1	2.9	4.8
90	67.9	1.2	1.6	46.9	1.4	2.1	33.6	1.5	2.6	24.6	1.7	3.2	18.5	1.9	3.8	13.7	2.3	4.4	10.3	2.7	4.8
95	71.7	1.2	1.6	49.5	1.4	2.1	35.5	1.5	2.6	26.0	1.7	3.2	19.6	1.9	3.8	14.6	2.2	4.4	11.4	2.6	4.8
100	75.5	1.2	1.6	52.1	1.4	2.1	37.3	1.5	2.6	27.8	1.7	3.2	20.7	1.9	3.8	15.4	2.2	4.4	12.2	2.6	4.8
105	79.3	1.2	1.6	54.7	1.4	2.1	39.2	1.5	2.6	29.1	1.7	3.2	21.8	1.9	3.8	16.3	2.2	4.4	12.9	2.5	4.8
110	83.0	1.2	1.6	57.3	1.4	2.1	41.1	1.5	2.6	30.5	1.7	3.2	22.8	1.9	3.8	17.2	2.2	4.4	13.7	2.5	4.8
115	86.8	1.2	1.6	59.9	1.4	2.1	42.9	1.5	2.6	31.9	1.7	3.2	23.9	1.9	3.8	18.0	2.2	4.4	14.4	2.5	4.8
120	90.6	1.2	1.6	62.5	1.4	2.1	44.8	1.5	2.7	33.3	1.7	3.2	25.0	1.9	3.8	18.9	2.2	4.4	15.2	2.5	4.8
125	94.3	1.2	1.6	65.1	1.4	2.1	46.7	1.5	2.7	34.7	1.7	3.2	26.0	1.9	3.8	19.7	2.2	4.4	15.9	2.4	4.8
130	98.1	1.2	1.6	67.7	1.4	2.1	48.5	1.5	2.7	36.0	1.7	3.2	27.1	1.9	3.8	20.5	2.2	4.4	16.6	2.4	4.8
135	101.9	1.2	1.6	70.3	1.4	2.1	50.4	1.5	2.7	37.4	1.7	3.2	28.2	1.9	3.8	21.4	2.2	4.4	17.3	2.4	4.8
140	105.7	1.2	1.6	72.9	1.4	2.1	52.2	1.5	2.7	38.8	1.7	3.2	29.3	1.9	3.8	22.2	2.2	4.4	18.0	2.4	4.9
145	109.4	1.2	1.6	75.5	1.4	2.1	54.1	1.5	2.7	40.2	1.7	3.2	30.8	1.9	3.7	23.1	2.2	4.4	18.7	2.4	4.9
150	113.2	1.2	1.6	78.1	1.4	2.1	56.0	1.5	2.7	41.6	1.7	3.2	31.9	1.9	3.7	23.9	2.1	4.4	19.4	2.4	4.9

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 3 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 1.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																					
10	8.2	1.2	1.6	5.2	1.4	2.0															
15	12.6	1.1	1.6	8.7	1.3	2.1	5.5	1.6	2.6												
20	17.1	1.1	1.6	11.8	1.2	2.1	8.2	1.4	2.6												
25	21.4	1.1	1.6	14.9	1.2	2.1	10.5	1.4	2.6	7.3	1.6	3.1									
30	25.7	1.1	1.6	18.0	1.2	2.1	12.8	1.4	2.6	9.1	1.6	3.2									
35	29.9	1.1	1.6	21.2	1.2	2.1	15.0	1.3	2.6	10.9	1.5	3.1	7.8	1.8	3.7						
40	34.2	1.1	1.6	24.3	1.2	2.1	17.3	1.3	2.6	12.6	1.5	3.1	9.2	1.7	3.7						
45	38.5	1.1	1.6	27.3	1.2	2.1	19.5	1.3	2.6	14.3	1.5	3.1	10.6	1.7	3.7	7.2	2.2	4.3			
50	42.7	1.1	1.6	30.3	1.2	2.1	21.9	1.3	2.6	16.0	1.5	3.2	11.9	1.7	3.7	8.8	2.0	4.3			
55	47.0	1.1	1.6	33.3	1.2	2.1	24.1	1.3	2.6	17.7	1.5	3.2	13.3	1.7	3.7	9.9	1.9	4.3			
60	51.3	1.1	1.6	36.3	1.2	2.1	26.3	1.3	2.6	19.3	1.5	3.2	14.6	1.7	3.7	11.0	1.9	4.3			
65	55.5	1.1	1.6	39.4	1.2	2.1	28.5	1.3	2.6	21.0	1.5	3.2	15.9	1.6	3.7	12.1	1.9	4.3	8.0	2.5	4.9
70	59.8	1.1	1.6	42.4	1.2	2.1	30.7	1.3	2.6	22.7	1.5	3.2	17.1	1.6	3.7	13.2	1.9	4.3	9.5	2.3	4.8
75	64.1	1.1	1.6	45.4	1.2	2.1	32.9	1.3	2.6	24.6	1.5	3.1	18.5	1.6	3.7	14.2	1.8	4.3	10.4	2.2	4.9
80	68.3	1.1	1.6	48.4	1.2	2.1	35.0	1.3	2.6	26.2	1.5	3.1	19.8	1.6	3.7	15.2	1.8	4.3	11.3	2.2	4.9
85	72.6	1.1	1.6	51.5	1.2	2.1	37.2	1.3	2.6	27.9	1.5	3.1	21.0	1.6	3.7	16.3	1.8	4.3	12.1	2.2	4.9
90	76.9	1.1	1.6	54.5	1.2	2.1	39.4	1.3	2.6	29.5	1.5	3.1	22.3	1.6	3.7	17.3	1.8	4.3	13.0	2.1	4.9
95	81.1	1.1	1.6	57.5	1.2	2.1	41.6	1.3	2.6	31.1	1.5	3.1	23.6	1.6	3.7	18.3	1.8	4.3	13.8	2.1	4.9
100	85.4	1.1	1.6	60.5	1.2	2.1	43.8	1.3	2.6	32.7	1.5	3.1	24.9	1.6	3.7	19.3	1.8	4.3	14.6	2.1	4.9
105	89.7	1.1	1.6	63.6	1.2	2.1	46.0	1.3	2.6	34.4	1.5	3.1	26.5	1.6	3.7	20.3	1.8	4.3	15.4	2.1	4.9
110	94.0	1.1	1.6	66.6	1.2	2.1	48.2	1.3	2.6	36.0	1.5	3.1	27.7	1.6	3.7	21.3	1.8	4.3	16.2	2.1	4.9
115	98.2	1.1	1.6	69.6	1.2	2.1	50.4	1.3	2.6	37.6	1.5	3.1	29.0	1.6	3.7	22.3	1.8	4.3	17.0	2.1	4.9
120	102.5	1.1	1.6	72.6	1.2	2.1	52.5	1.3	2.6	39.3	1.5	3.1	30.2	1.6	3.7	23.3	1.8	4.3	17.9	2.1	4.9
125	106.8	1.1	1.6	75.7	1.2	2.1	54.7	1.3	2.6	40.9	1.5	3.1	31.5	1.6	3.7	24.3	1.8	4.3	18.7	2.1	4.9
130	111.0	1.1	1.6	78.7	1.2	2.1	56.9	1.3	2.6	42.5	1.5	3.1	32.7	1.6	3.7	25.3	1.8	4.3	19.4	2.1	4.9
135	115.3	1.1	1.6	81.7	1.2	2.1	59.1	1.3	2.6	44.2	1.5	3.1	34.0	1.6	3.7	26.3	1.8	4.3	20.2	2.0	4.9
140	119.6	1.1	1.6	84.7	1.2	2.1	61.3	1.3	2.6	45.8	1.5	3.1	35.2	1.6	3.7	27.3	1.8	4.3	21.0	2.0	4.9
145	123.8	1.1	1.6	87.8	1.2	2.1	63.5	1.3	2.6	47.5	1.5	3.1	36.5	1.6	3.7	28.7	1.8	4.3	21.8	2.0	4.9
150	128.1	1.1	1.6	90.8	1.2	2.1	65.7	1.3	2.6	49.1	1.5	3.1	37.8	1.6	3.7	29.7	1.8	4.3	22.6	2.0	4.9

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 4 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 1.25 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	4.1	1.2	1.5																		
10	9.4	1.0	1.5	6.3	1.2	2.0															
15	14.3	1.0	1.6	9.9	1.1	2.0	6.8	1.3	2.6												
20	19.4	1.0	1.5	13.4	1.1	2.0	9.5	1.2	2.6	6.7	1.4	3.1									
25	24.2	1.0	1.5	17.0	1.1	2.0	12.1	1.2	2.6	8.8	1.4	3.1	5.9	1.7	3.6						
30	29.0	1.0	1.6	20.4	1.1	2.0	14.6	1.2	2.6	10.7	1.4	3.1	7.8	1.6	3.7						
35	33.8	1.0	1.6	23.8	1.1	2.0	17.1	1.2	2.6	12.7	1.3	3.1	9.4	1.5	3.7	6.5	1.9	4.2			
40	38.6	1.0	1.6	27.1	1.1	2.0	19.8	1.2	2.5	14.6	1.3	3.1	10.9	1.5	3.7	8.1	1.7	4.2			
45	43.5	1.0	1.6	30.5	1.1	2.0	22.3	1.2	2.5	16.5	1.3	3.1	12.5	1.5	3.7	9.4	1.7	4.2			
50	48.3	1.0	1.6	33.9	1.1	2.0	24.8	1.2	2.5	18.3	1.3	3.1	13.9	1.5	3.7	10.6	1.7	4.2	7.7	2.0	4.8
55	53.1	1.0	1.6	37.3	1.1	2.0	27.2	1.2	2.6	20.5	1.3	3.1	15.4	1.5	3.7	11.8	1.6	4.3	9.0	1.9	4.8
60	57.9	1.0	1.6	40.7	1.1	2.0	29.7	1.2	2.6	22.3	1.3	3.1	16.9	1.5	3.7	13.0	1.6	4.3	10.1	1.9	4.8
65	62.8	1.0	1.6	44.1	1.1	2.0	32.2	1.2	2.6	24.2	1.3	3.1	18.3	1.5	3.7	14.2	1.6	4.3	11.1	1.8	4.8
70	67.6	1.0	1.6	47.5	1.1	2.0	34.6	1.2	2.6	26.0	1.3	3.1	19.8	1.4	3.7	15.4	1.6	4.3	12.0	1.8	4.8
75	72.4	1.0	1.6	50.8	1.1	2.0	37.1	1.2	2.6	27.9	1.3	3.1	21.2	1.4	3.7	16.5	1.6	4.3	13.0	1.8	4.8
80	77.2	1.0	1.6	54.2	1.1	2.0	39.6	1.2	2.6	29.7	1.3	3.1	23.0	1.4	3.6	17.7	1.6	4.3	14.0	1.8	4.8
85	82.1	1.0	1.6	57.6	1.1	2.0	42.0	1.2	2.6	31.6	1.3	3.1	24.4	1.4	3.6	18.8	1.6	4.3	14.9	1.8	4.8
90	86.9	1.0	1.6	61.0	1.1	2.0	44.5	1.2	2.6	33.5	1.3	3.1	25.8	1.4	3.6	20.0	1.6	4.3	15.9	1.8	4.8
95	91.7	1.0	1.6	64.4	1.1	2.0	47.0	1.2	2.6	35.3	1.3	3.1	27.3	1.4	3.6	21.1	1.6	4.3	16.8	1.8	4.8
100	96.6	1.0	1.6	67.8	1.1	2.0	49.4	1.2	2.6	37.2	1.3	3.1	28.7	1.4	3.6	22.3	1.6	4.3	17.7	1.8	4.8
105	101.4	1.0	1.6	71.2	1.1	2.0	51.9	1.2	2.6	39.0	1.3	3.1	30.1	1.4	3.6	23.4	1.6	4.3	18.7	1.8	4.8
110	106.2	1.0	1.6	74.6	1.1	2.0	54.4	1.2	2.6	40.9	1.3	3.1	31.6	1.4	3.6	24.6	1.6	4.3	19.6	1.7	4.8
115	111.0	1.0	1.6	78.0	1.1	2.0	56.8	1.2	2.6	42.7	1.3	3.1	33.0	1.4	3.6	26.1	1.6	4.2	20.5	1.7	4.8
120	115.9	1.0	1.6	81.3	1.1	2.0	59.3	1.2	2.6	44.6	1.3	3.1	34.4	1.4	3.6	27.2	1.6	4.2	21.5	1.7	4.8
125	120.7	1.0	1.6	84.7	1.1	2.0	61.8	1.2	2.6	46.4	1.3	3.1	35.9	1.4	3.6	28.3	1.6	4.2	22.4	1.7	4.8
130	125.5	1.0	1.6	88.1	1.1	2.0	64.3	1.2	2.6	48.3	1.3	3.1	37.3	1.4	3.7	29.5	1.6	4.2	23.3	1.7	4.8
135	130.3	1.0	1.6	91.5	1.1	2.0	66.7	1.2	2.6	50.2	1.3	3.1	38.7	1.4	3.7	30.6	1.6	4.2	24.2	1.7	4.8
140	135.2	1.0	1.6	94.9	1.1	2.0	69.2	1.2	2.6	52.0	1.3	3.1	40.2	1.4	3.7	31.7	1.6	4.2	25.1	1.7	4.8
145	140.0	1.0	1.6	98.3	1.1	2.0	71.7	1.2	2.6	53.9	1.3	3.1	41.6	1.4	3.7	32.9	1.6	4.2	26.1	1.7	4.8
150	144.8	1.0	1.6	101.7	1.1	2.0	74.1	1.2	2.6	55.7	1.3	3.1	43.0	1.4	3.7	34.0	1.6	4.2	27.0	1.7	4.8

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 5 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 1.50 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	4.9	1.0	1.5																		
10	10.5	0.9	1.5	7.1	1.1	2.0	4.6	1.3	2.5												
15	16.0	0.9	1.5	10.9	1.0	2.0	7.8	1.1	2.5	5.3	1.4	3.1									
20	21.3	0.9	1.5	14.7	1.0	2.0	10.6	1.1	2.5	7.7	1.3	3.1	5.1	1.6	3.6						
25	26.6	0.9	1.5	18.6	1.0	2.0	13.4	1.1	2.5	9.9	1.2	3.1	7.3	1.4	3.6						
30	31.9	0.9	1.5	22.3	1.0	2.0	16.2	1.1	2.5	12.0	1.2	3.1	9.0	1.4	3.6	6.6	1.6	4.2			
35	37.3	0.9	1.5	26.0	1.0	2.0	19.1	1.1	2.5	14.1	1.2	3.1	10.7	1.4	3.6	8.1	1.5	4.2			
40	42.6	0.9	1.5	29.7	1.0	2.0	21.8	1.1	2.5	16.2	1.2	3.1	12.4	1.3	3.6	9.5	1.5	4.2	6.9	1.8	4.7
45	47.9	0.9	1.5	33.4	1.0	2.0	24.5	1.1	2.5	18.3	1.2	3.1	14.0	1.3	3.6	10.8	1.5	4.2	8.3	1.7	4.7
50	53.2	0.9	1.5	37.1	1.0	2.0	27.3	1.1	2.5	20.6	1.2	3.0	15.7	1.3	3.6	12.1	1.5	4.2	9.4	1.7	4.8
55	58.5	0.9	1.5	40.8	1.0	2.0	30.0	1.1	2.5	22.7	1.2	3.0	17.3	1.3	3.6	13.4	1.5	4.2	10.5	1.6	4.8
60	63.8	0.9	1.5	44.5	1.0	2.0	32.7	1.1	2.5	24.7	1.2	3.0	18.9	1.3	3.6	14.7	1.4	4.2	11.6	1.6	4.8
65	69.2	0.9	1.5	48.2	1.0	2.0	35.4	1.1	2.5	26.8	1.2	3.1	20.8	1.3	3.6	16.0	1.4	4.2	12.7	1.6	4.8
70	74.5	0.9	1.5	51.9	1.0	2.0	38.2	1.1	2.5	28.8	1.2	3.1	22.4	1.3	3.6	17.3	1.4	4.2	13.7	1.6	4.8
75	79.8	0.9	1.5	55.6	1.0	2.0	40.9	1.1	2.5	30.9	1.2	3.1	23.9	1.3	3.6	18.6	1.4	4.2	14.8	1.6	4.8
80	85.1	0.9	1.5	59.4	1.0	2.0	43.6	1.1	2.5	32.9	1.2	3.1	25.5	1.3	3.6	19.9	1.4	4.2	15.8	1.6	4.8
85	90.4	0.9	1.5	63.1	1.0	2.0	46.3	1.1	2.5	35.0	1.2	3.1	27.1	1.3	3.6	21.2	1.4	4.2	16.9	1.6	4.8
90	95.8	0.9	1.5	66.8	1.0	2.0	49.0	1.1	2.5	37.1	1.2	3.1	28.7	1.3	3.6	22.8	1.4	4.1	17.9	1.6	4.8
95	101.1	0.9	1.5	70.5	1.0	2.0	51.8	1.1	2.5	39.1	1.2	3.1	30.3	1.3	3.6	24.0	1.4	4.2	18.9	1.6	4.8
100	106.4	0.9	1.5	74.2	1.0	2.0	54.5	1.1	2.5	41.2	1.2	3.1	31.9	1.3	3.6	25.3	1.4	4.2	20.0	1.6	4.8
105	111.7	0.9	1.5	77.9	1.0	2.0	57.2	1.1	2.5	43.2	1.2	3.1	33.5	1.3	3.6	26.5	1.4	4.2	21.0	1.6	4.8
110	117.0	0.9	1.5	81.6	1.0	2.0	59.9	1.1	2.5	45.3	1.2	3.1	35.1	1.3	3.6	27.8	1.4	4.2	22.0	1.6	4.8
115	122.4	0.9	1.5	85.3	1.0	2.0	62.6	1.1	2.5	47.3	1.2	3.1	36.7	1.3	3.6	29.1	1.4	4.2	23.1	1.6	4.8
120	127.7	0.9	1.5	89.0	1.0	2.0	65.4	1.1	2.5	49.4	1.2	3.1	38.3	1.3	3.6	30.3	1.4	4.2	24.1	1.6	4.8
125	133.0	0.9	1.5	92.7	1.0	2.0	68.1	1.1	2.5	51.4	1.2	3.1	39.9	1.3	3.6	31.6	1.4	4.2	25.4	1.6	4.8
130	138.3	0.9	1.5	96.4	1.0	2.0	70.8	1.1	2.5	53.5	1.2	3.1	41.4	1.3	3.6	32.8	1.4	4.2	26.4	1.6	4.8
135	143.6	0.9	1.5	100.1	1.0	2.0	73.5	1.1	2.5	55.6	1.2	3.1	43.0	1.3	3.6	34.1	1.4	4.2	27.4	1.6	4.8
140	149.0	0.9	1.5	103.9	1.0	2.0	76.3	1.1	2.5	57.6	1.2	3.1	44.6	1.3	3.6	35.3	1.4	4.2	28.5	1.6	4.8
145	154.3	0.9	1.5	107.6	1.0	2.0	79.0	1.1	2.5	59.7	1.2	3.1	46.2	1.3	3.6	36.6	1.4	4.2	29.5	1.6	4.8
150	159.6	0.9	1.5	111.3	1.0	2.0	81.7	1.1	2.5	61.7	1.2	3.1	47.8	1.3	3.6	37.9	1.4	4.2	30.5	1.6	4.8

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C") Sheet 6 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 1.75 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	5.4	0.9	1.5																		
10	11.4	0.9	1.5	7.7	1.0	2.0	5.4	1.1	2.5												
15	17.3	0.9	1.5	11.8	1.0	2.0	8.6	1.1	2.5	6.2	1.2	3.0									
20	23.1	0.9	1.5	16.0	0.9	2.0	11.6	1.0	2.5	8.6	1.2	3.0	6.3	1.3	3.6						
25	28.8	0.9	1.5	20.0	0.9	2.0	14.6	1.0	2.5	10.9	1.1	3.0	8.2	1.3	3.6	5.9	1.5	4.1			
30	34.6	0.9	1.5	24.0	0.9	2.0	17.8	1.0	2.5	13.2	1.1	3.0	10.1	1.2	3.6	7.6	1.4	4.2			
35	40.3	0.9	1.5	28.0	0.9	2.0	20.7	1.0	2.5	15.5	1.1	3.0	11.9	1.2	3.6	9.1	1.4	4.2	6.9	1.6	4.7
40	46.1	0.9	1.5	32.0	0.9	2.0	23.7	1.0	2.5	18.0	1.1	3.0	13.7	1.2	3.6	10.6	1.4	4.2	8.2	1.6	4.7
45	51.9	0.9	1.5	36.0	0.9	2.0	26.6	1.0	2.5	20.2	1.1	3.0	15.4	1.2	3.6	12.0	1.3	4.2	9.4	1.5	4.7
50	57.6	0.9	1.5	40.0	0.9	2.0	29.6	1.0	2.5	22.4	1.1	3.0	17.2	1.2	3.6	13.5	1.3	4.1	10.6	1.5	4.7
55	63.4	0.9	1.5	44.0	0.9	2.0	32.5	1.0	2.5	24.7	1.1	3.0	19.2	1.2	3.6	14.9	1.3	4.1	11.8	1.5	4.7
60	69.1	0.9	1.5	48.0	0.9	2.0	35.5	1.0	2.5	26.9	1.1	3.0	20.9	1.2	3.6	16.3	1.3	4.1	12.9	1.5	4.7
65	74.9	0.9	1.5	52.0	0.9	2.0	38.4	1.0	2.5	29.2	1.1	3.0	22.7	1.2	3.6	17.7	1.3	4.1	14.1	1.5	4.7
70	80.7	0.9	1.5	56.0	0.9	2.0	41.4	1.0	2.5	31.4	1.1	3.0	24.4	1.2	3.6	19.1	1.3	4.1	15.2	1.5	4.7
75	86.4	0.9	1.5	60.0	0.9	2.0	44.3	1.0	2.5	33.6	1.1	3.0	26.1	1.2	3.6	20.5	1.3	4.1	16.4	1.4	4.7
80	92.2	0.9	1.5	63.9	0.9	2.0	47.3	1.0	2.5	35.9	1.1	3.0	27.9	1.2	3.6	22.2	1.3	4.1	17.5	1.4	4.7
85	97.9	0.9	1.5	67.9	0.9	2.0	50.2	1.0	2.5	38.1	1.1	3.0	29.6	1.2	3.6	23.5	1.3	4.1	18.6	1.4	4.7
90	103.7	0.9	1.5	71.9	0.9	2.0	53.2	1.0	2.5	40.3	1.1	3.0	31.4	1.2	3.6	24.9	1.3	4.1	19.8	1.4	4.7
95	109.5	0.9	1.5	75.9	0.9	2.0	56.1	1.0	2.5	42.6	1.1	3.0	33.1	1.2	3.6	26.3	1.3	4.1	20.9	1.4	4.7
100	115.2	0.9	1.5	79.9	0.9	2.0	59.1	1.0	2.5	44.8	1.1	3.0	34.8	1.2	3.6	27.7	1.3	4.1	22.0	1.4	4.7
105	121.0	0.9	1.5	83.9	0.9	2.0	62.0	1.0	2.5	47.1	1.1	3.0	36.6	1.2	3.6	29.0	1.3	4.1	23.4	1.4	4.7
110	126.8	0.9	1.5	87.9	0.9	2.0	65.0	1.0	2.5	49.3	1.1	3.0	38.3	1.2	3.6	30.4	1.3	4.1	24.5	1.4	4.7
115	132.5	0.9	1.5	91.9	0.9	2.0	67.9	1.0	2.5	51.5	1.1	3.0	40.1	1.2	3.6	31.8	1.3	4.1	25.6	1.4	4.7
120	138.3	0.9	1.5	95.9	0.9	2.0	70.9	1.0	2.5	53.8	1.1	3.0	41.8	1.2	3.6	33.2	1.3	4.1	26.8	1.4	4.7
125	144.0	0.9	1.5	99.9	0.9	2.0	73.8	1.0	2.5	56.0	1.1	3.0	43.5	1.2	3.6	34.6	1.3	4.1	27.9	1.4	4.7
130	149.8	0.9	1.5	103.9	0.9	2.0	76.8	1.0	2.5	58.3	1.1	3.0	45.3	1.2	3.6	35.9	1.3	4.1	29.0	1.4	4.7
135	155.6	0.9	1.5	107.9	0.9	2.0	79.7	1.0	2.5	60.5	1.1	3.0	47.0	1.2	3.6	37.3	1.3	4.1	30.1	1.4	4.7
140	161.3	0.9	1.5	111.9	0.9	2.0	82.7	1.0	2.5	62.7	1.1	3.0	48.8	1.2	3.6	38.7	1.3	4.1	31.2	1.4	4.7
145	167.1	0.9	1.5	115.9	0.9	2.0	85.6	1.0	2.5	65.0	1.1	3.0	50.5	1.2	3.6	40.1	1.3	4.1	32.3	1.4	4.7
150	172.8	0.9	1.5	119.9	0.9	2.0	88.6	1.0	2.5	67.2	1.1	3.0	52.2	1.2	3.6	41.5	1.3	4.1	33.4	1.4	4.7

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 7 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 2.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	5.9	0.9	1.5																		
10	12.4	0.8	1.5	8.1	0.9	2.0	5.9	1.0	2.5												
15	18.5	0.8	1.5	12.3	0.9	2.0	9.3	1.0	2.5	6.8	1.1	3.0	4.7	1.4	3.5						
20	24.7	0.8	1.5	16.7	0.9	2.0	12.5	1.0	2.5	9.4	1.1	3.0	7.0	1.2	3.6	4.7	1.5	4.1			
25	30.8	0.8	1.5	20.8	0.9	2.0	15.9	1.0	2.4	11.8	1.1	3.0	9.0	1.2	3.5	6.8	1.3	4.1			
30	37.0	0.8	1.5	25.0	0.9	2.0	19.0	1.0	2.5	14.3	1.1	3.0	11.0	1.2	3.5	8.5	1.3	4.1	6.4	1.5	4.7
35	43.2	0.8	1.5	29.1	0.9	2.0	22.2	1.0	2.5	16.9	1.0	3.0	12.9	1.1	3.5	10.1	1.3	4.1	7.8	1.4	4.7
40	49.3	0.8	1.5	33.3	0.9	2.0	25.3	1.0	2.5	19.3	1.0	3.0	14.8	1.1	3.5	11.6	1.3	4.1	9.1	1.4	4.7
45	55.5	0.8	1.5	37.4	0.9	2.0	28.5	1.0	2.5	21.7	1.0	3.0	16.7	1.1	3.5	13.1	1.3	4.1	10.4	1.4	4.7
50	61.7	0.8	1.5	41.6	0.9	2.0	31.7	1.0	2.5	24.1	1.0	3.0	18.8	1.1	3.5	14.7	1.2	4.1	11.7	1.4	4.7
55	67.8	0.8	1.5	45.7	0.9	2.0	34.8	1.0	2.5	26.5	1.0	3.0	20.7	1.1	3.5	16.2	1.2	4.1	12.9	1.4	4.7
60	74.0	0.8	1.5	49.9	0.9	2.0	38.0	1.0	2.5	28.9	1.0	3.0	22.6	1.1	3.5	17.7	1.2	4.1	14.1	1.4	4.7
65	80.2	0.8	1.5	54.0	0.9	2.0	41.1	1.0	2.5	31.4	1.0	3.0	24.5	1.1	3.5	19.5	1.2	4.1	15.4	1.3	4.7
70	86.3	0.8	1.5	58.2	0.9	2.0	44.3	1.0	2.5	33.8	1.0	3.0	26.3	1.1	3.5	21.0	1.2	4.1	16.6	1.3	4.7
75	92.5	0.8	1.5	62.3	0.9	2.0	47.5	1.0	2.5	36.2	1.0	3.0	28.2	1.1	3.5	22.4	1.2	4.1	17.8	1.3	4.7
80	98.7	0.8	1.5	66.5	0.9	2.0	50.6	1.0	2.5	38.6	1.0	3.0	30.1	1.1	3.5	23.9	1.2	4.1	19.0	1.3	4.7
85	104.8	0.8	1.5	70.6	0.9	2.0	53.8	1.0	2.5	41.0	1.0	3.0	32.0	1.1	3.5	25.4	1.2	4.1	20.3	1.3	4.7
90	111.0	0.8	1.5	74.8	0.9	2.0	57.0	1.0	2.5	43.4	1.0	3.0	33.8	1.1	3.5	26.9	1.2	4.1	21.8	1.3	4.6
95	117.2	0.8	1.5	78.9	0.9	2.0	60.1	1.0	2.5	45.8	1.0	3.0	35.7	1.1	3.5	28.4	1.2	4.1	23.0	1.3	4.6
100	123.3	0.8	1.5	83.1	0.9	2.0	63.3	1.0	2.5	48.2	1.0	3.0	37.6	1.1	3.5	29.9	1.2	4.1	24.2	1.3	4.6
105	129.5	0.8	1.5	87.3	0.9	2.0	66.4	1.0	2.5	50.6	1.0	3.0	39.5	1.1	3.5	31.4	1.2	4.1	25.4	1.3	4.6
110	135.7	0.8	1.5	91.4	0.9	2.0	69.6	1.0	2.5	53.0	1.0	3.0	41.3	1.1	3.5	32.9	1.2	4.1	26.6	1.3	4.7
115	141.8	0.8	1.5	95.6	0.9	2.0	72.8	1.0	2.5	55.4	1.0	3.0	43.2	1.1	3.5	34.4	1.2	4.1	27.9	1.3	4.7
120	148.0	0.8	1.5	99.7	0.9	2.0	75.9	1.0	2.5	57.9	1.0	3.0	45.1	1.1	3.5	35.9	1.2	4.1	29.1	1.3	4.7
125	154.1	0.8	1.5	103.9	0.9	2.0	79.1	1.0	2.5	60.3	1.0	3.0	47.0	1.1	3.5	37.4	1.2	4.1	30.3	1.3	4.7
130	160.3	0.8	1.5	108.0	0.9	2.0	82.3	1.0	2.5	62.7	1.0	3.0	48.8	1.1	3.5	38.9	1.2	4.1	31.5	1.3	4.7
135	166.5	0.8	1.5	112.2	0.9	2.0	85.4	1.0	2.5	65.1	1.0	3.0	50.7	1.1	3.5	40.3	1.2	4.1	32.7	1.3	4.7
140	172.6	0.8	1.5	116.3	0.9	2.0	88.6	1.0	2.5	67.5	1.0	3.0	52.6	1.1	3.5	41.8	1.2	4.1	33.9	1.3	4.7
145	178.8	0.8	1.5	120.5	0.9	2.0	91.8	1.0	2.5	69.9	1.0	3.0	54.5	1.1	3.5	43.3	1.2	4.1	35.1	1.3	4.7
150	185.0	0.8	1.5	124.6	0.9	2.0	94.9	1.0	2.5	72.3	1.0	3.0	56.4	1.1	3.5	44.8	1.2	4.1	36.3	1.3	4.7

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 8 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 3.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	7.4	0.7	1.4	4.9	0.8	1.9	3.2	1.0	2.3												
10	15.1	0.7	1.4	10.2	0.8	1.9	7.6	0.8	2.4	5.7	0.9	2.9	4.0	1.1	3.4						
15	22.6	0.7	1.4	15.6	0.8	1.9	11.5	0.8	2.4	8.8	0.9	2.9	6.7	1.0	3.4	5.1	1.1	4.0			
20	30.1	0.7	1.4	20.7	0.8	1.9	15.5	0.8	2.4	11.8	0.9	2.9	9.2	0.9	3.4	7.2	1.0	4.0	5.5	1.2	4.6
25	37.6	0.7	1.4	25.9	0.8	1.9	19.4	0.8	2.4	15.0	0.9	2.9	11.6	0.9	3.4	9.2	1.0	4.0	7.2	1.1	4.6
30	45.1	0.7	1.4	31.1	0.8	1.9	23.3	0.8	2.4	18.0	0.9	2.9	14.0	0.9	3.4	11.1	1.0	4.0	8.9	1.1	4.6
35	52.7	0.7	1.4	36.2	0.8	1.9	27.1	0.8	2.4	21.0	0.9	2.9	16.5	0.9	3.4	13.0	1.0	4.0	10.5	1.1	4.6
40	60.2	0.7	1.4	41.4	0.8	1.9	31.0	0.8	2.4	24.0	0.9	2.9	18.9	0.9	3.4	14.9	1.0	4.0	12.0	1.1	4.6
45	67.7	0.7	1.4	46.6	0.8	1.9	34.9	0.8	2.4	27.0	0.9	2.9	21.2	0.9	3.4	17.0	1.0	4.0	13.6	1.1	4.6
50	75.2	0.7	1.4	51.8	0.8	1.9	38.8	0.8	2.4	29.9	0.9	2.9	23.6	0.9	3.4	18.9	1.0	4.0	15.2	1.1	4.6
55	82.8	0.7	1.4	56.9	0.8	1.9	42.6	0.8	2.4	32.9	0.9	2.9	25.9	0.9	3.4	20.8	1.0	4.0	16.7	1.1	4.6
60	90.3	0.7	1.4	62.1	0.8	1.9	46.5	0.8	2.4	35.9	0.9	2.9	28.3	0.9	3.4	22.7	1.0	4.0	18.5	1.1	4.5
65	97.8	0.7	1.4	67.3	0.8	1.9	50.4	0.8	2.4	38.9	0.9	2.9	30.6	0.9	3.4	25.6	1.0	4.0	20.0	1.1	4.5
70	105.3	0.7	1.4	72.4	0.8	1.9	54.3	0.8	2.4	41.9	0.9	2.9	33.0	0.9	3.4	26.4	1.0	4.0	21.5	1.1	4.5
75	112.8	0.7	1.4	77.6	0.8	1.9	58.1	0.8	2.4	44.9	0.9	2.9	35.3	0.9	3.4	28.3	1.0	4.0	23.1	1.1	4.5
80	120.4	0.7	1.4	82.8	0.8	1.9	62.0	0.8	2.4	47.9	0.9	2.9	37.7	0.9	3.4	30.2	1.0	4.0	24.6	1.1	4.5
85	127.9	0.7	1.4	88.0	0.8	1.9	65.9	0.8	2.4	50.9	0.9	2.9	40.1	0.9	3.4	32.1	1.0	4.0	26.1	1.1	4.5
90	135.4	0.7	1.4	93.1	0.8	1.9	69.8	0.8	2.4	53.9	0.9	2.9	42.4	0.9	3.4	34.0	1.0	4.0	27.7	1.1	4.5
95	142.9	0.7	1.4	98.3	0.8	1.9	73.6	0.8	2.4	56.9	0.9	2.9	44.8	0.9	3.4	35.9	1.0	4.0	29.2	1.1	4.5
100	150.5	0.7	1.4	103.5	0.8	1.9	77.5	0.8	2.4	59.9	0.9	2.9	47.1	0.9	3.4	37.8	1.0	4.0	30.7	1.1	4.5
105	158.0	0.7	1.4	108.7	0.8	1.9	81.4	0.8	2.4	62.8	0.9	2.9	49.5	0.9	3.4	39.6	1.0	4.0	32.3	1.1	4.5
110	165.5	0.7	1.4	113.8	0.8	1.9	85.3	0.8	2.4	65.8	0.9	2.9	51.8	0.9	3.4	41.5	1.0	4.0	33.8	1.1	4.6
115	173.0	0.7	1.4	119.0	0.8	1.9	89.1	0.8	2.4	68.8	0.9	2.9	54.2	0.9	3.4	43.4	1.0	4.0	35.4	1.1	4.6
120	180.5	0.7	1.4	124.2	0.8	1.9	93.0	0.8	2.4	71.8	0.9	2.9	56.5	0.9	3.4	45.3	1.0	4.0	36.9	1.1	4.6
125	188.1	0.7	1.4	129.4	0.8	1.9	96.9	0.8	2.4	74.8	0.9	2.9	58.9	0.9	3.4	47.2	1.0	4.0	38.4	1.1	4.6
130	195.6	0.7	1.4	134.5	0.8	1.9	100.8	0.8	2.4	77.8	0.9	2.9	61.2	0.9	3.4	49.1	1.0	4.0	40.0	1.1	4.6
135	203.1	0.7	1.4	139.7	0.8	1.9	104.6	0.8	2.4	80.8	0.9	2.9	63.6	0.9	3.4	51.0	1.0	4.0	41.5	1.1	4.6
140	210.6	0.7	1.4	144.9	0.8	1.9	108.5	0.8	2.4	83.8	0.9	2.9	66.0	0.9	3.4	52.8	1.0	4.0	43.0	1.1	4.6
145	218.2	0.7	1.4	150.1	0.8	1.9	112.4	0.8	2.4	86.8	0.9	2.9	68.3	0.9	3.4	54.7	1.0	4.0	44.6	1.1	4.6
150	225.7	0.7	1.4	155.2	0.8	1.9	116.3	0.8	2.4	89.8	0.9	2.9	70.7	0.9	3.4	56.6	1.0	4.0	46.1	1.1	4.6

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 9 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 4.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	8.5	0.6	1.4	5.9	0.7	1.8	4.1	0.8	2.3												
10	17.2	0.6	1.4	12.1	0.7	1.8	8.8	0.7	2.3	6.7	0.8	2.8	5.2	0.9	3.3	3.8	1.0	3.9			
15	25.8	0.6	1.4	18.1	0.7	1.8	13.4	0.7	2.3	10.3	0.8	2.8	8.1	0.8	3.4	6.4	0.9	3.9	4.9	1.0	4.5
20	34.4	0.6	1.4	24.2	0.7	1.8	17.8	0.7	2.3	13.9	0.8	2.8	10.9	0.8	3.4	8.7	0.9	3.9	6.9	1.0	4.5
25	43.0	0.6	1.4	30.2	0.7	1.9	22.3	0.7	2.3	17.4	0.8	2.8	13.8	0.8	3.3	10.9	0.9	3.9	8.8	1.0	4.5
30	51.6	0.6	1.4	36.3	0.7	1.9	26.7	0.7	2.3	20.8	0.8	2.8	16.5	0.8	3.3	13.2	0.9	3.9	10.7	0.9	4.5
35	60.2	0.6	1.4	42.3	0.7	1.9	31.1	0.7	2.3	24.3	0.8	2.8	19.3	0.8	3.4	15.6	0.9	3.9	12.5	0.9	4.5
40	68.8	0.6	1.4	48.3	0.7	1.9	35.6	0.7	2.3	27.8	0.8	2.8	22.0	0.8	3.4	17.8	0.9	3.9	14.4	0.9	4.5
45	77.4	0.6	1.4	54.4	0.7	1.9	40.0	0.7	2.4	31.2	0.8	2.8	24.8	0.8	3.4	20.0	0.9	3.9	16.4	0.9	4.4
50	86.0	0.6	1.4	60.4	0.7	1.9	44.5	0.7	2.4	34.7	0.8	2.8	27.5	0.8	3.4	22.2	0.9	3.9	18.2	0.9	4.4
55	94.6	0.6	1.4	66.5	0.7	1.9	48.9	0.7	2.4	38.2	0.8	2.8	30.3	0.8	3.4	24.4	0.9	3.9	20.0	0.9	4.4
60	103.2	0.6	1.4	72.5	0.7	1.9	53.4	0.7	2.4	41.7	0.8	2.8	33.0	0.8	3.4	26.6	0.9	3.9	21.8	0.9	4.5
65	111.8	0.6	1.4	78.5	0.7	1.9	57.8	0.7	2.4	45.1	0.8	2.8	35.8	0.8	3.4	28.9	0.9	3.9	23.6	0.9	4.5
70	120.4	0.6	1.4	84.6	0.7	1.9	62.3	0.7	2.4	48.6	0.8	2.8	38.6	0.8	3.4	31.1	0.9	3.9	25.4	0.9	4.5
75	129.0	0.6	1.4	90.6	0.7	1.9	66.7	0.7	2.4	52.1	0.8	2.8	41.3	0.8	3.4	33.3	0.9	3.9	27.2	0.9	4.5
80	137.6	0.6	1.4	96.7	0.7	1.9	71.2	0.7	2.4	55.5	0.8	2.8	44.1	0.8	3.4	35.5	0.9	3.9	29.1	0.9	4.5
85	146.2	0.6	1.4	102.7	0.7	1.9	75.6	0.7	2.4	59.0	0.8	2.8	46.8	0.8	3.4	37.7	0.9	3.9	30.9	0.9	4.5
90	154.8	0.6	1.4	108.7	0.7	1.9	80.0	0.7	2.4	62.5	0.8	2.8	49.6	0.8	3.4	39.9	0.9	3.9	32.7	0.9	4.5
95	163.4	0.6	1.4	114.8	0.7	1.9	84.5	0.7	2.4	65.9	0.8	2.8	52.3	0.8	3.4	42.2	0.9	3.9	34.5	0.9	4.5
100	172.0	0.6	1.4	120.8	0.7	1.9	88.9	0.7	2.4	69.4	0.8	2.8	55.1	0.8	3.4	44.4	0.9	3.9	36.3	0.9	4.5
105	180.6	0.6	1.4	126.9	0.7	1.9	93.4	0.7	2.4	72.9	0.8	2.8	57.8	0.8	3.4	46.6	0.9	3.9	38.1	0.9	4.5
110	189.2	0.6	1.4	132.9	0.7	1.9	97.8	0.7	2.4	76.3	0.8	2.8	60.6	0.8	3.4	48.8	0.9	3.9	39.9	0.9	4.5
115	197.8	0.6	1.4	138.9	0.7	1.9	102.3	0.7	2.4	79.8	0.8	2.8	63.3	0.8	3.4	51.0	0.9	3.9	41.7	0.9	4.5
120	206.4	0.6	1.4	145.0	0.7	1.9	106.7	0.7	2.4	83.3	0.8	2.8	66.1	0.8	3.4	53.3	0.9	3.9	43.6	0.9	4.5
125	215.0	0.6	1.4	151.0	0.7	1.9	111.2	0.7	2.4	86.8	0.8	2.8	68.8	0.8	3.4	55.5	0.9	3.9	45.4	0.9	4.5
130	223.7	0.6	1.4	157.1	0.7	1.9	115.6	0.7	2.4	90.2	0.8	2.8	71.6	0.8	3.4	57.7	0.9	3.9	47.2	0.9	4.5
135	232.3	0.6	1.4	163.1	0.7	1.9	120.1	0.7	2.4	93.7	0.8	2.8	74.3	0.8	3.4	59.9	0.9	3.9	49.0	0.9	4.5
140	240.9	0.6	1.4	169.1	0.7	1.9	124.5	0.7	2.4	97.2	0.8	2.8	77.1	0.8	3.4	62.1	0.9	3.9	50.8	0.9	4.5
145	249.5	0.6	1.4	175.2	0.7	1.9	129.0	0.7	2.4	100.6	0.8	2.8	79.8	0.8	3.4	64.3	0.9	3.9	52.6	0.9	4.5
150	258.1	0.6	1.4	181.2	0.7	1.9	133.4	0.7	2.4	104.1	0.8	2.8	82.6	0.8	3.4	66.6	0.9	3.9	54.4	0.9	4.5

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 10 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 5.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	9.5	0.6	1.4	6.7	0.6	1.8	4.7	0.7	2.3	3.5	0.8	2.8									
10	19.0	0.6	1.4	13.7	0.6	1.8	9.7	0.7	2.3	7.6	0.7	2.8	6.0	0.8	3.3	4.7	0.8	3.8	3.4	1.0	4.4
15	28.5	0.6	1.4	20.5	0.6	1.8	14.8	0.7	2.3	11.7	0.7	2.8	9.2	0.7	3.3	7.3	0.8	3.8	5.9	0.9	4.4
20	38.0	0.6	1.4	27.3	0.6	1.8	19.7	0.7	2.3	15.5	0.7	2.8	12.4	0.7	3.3	9.9	0.8	3.8	8.0	0.9	4.4
25	47.5	0.6	1.4	34.1	0.6	1.8	24.6	0.7	2.3	19.4	0.7	2.8	15.5	0.7	3.3	12.6	0.8	3.8	10.1	0.8	4.4
30	57.0	0.6	1.4	40.9	0.6	1.8	29.5	0.7	2.3	23.3	0.7	2.8	18.6	0.7	3.3	15.1	0.8	3.8	12.2	0.8	4.4
35	66.5	0.6	1.4	47.7	0.6	1.8	34.4	0.7	2.3	27.2	0.7	2.8	21.7	0.7	3.3	17.6	0.8	3.8	14.5	0.8	4.4
40	76.0	0.6	1.4	54.6	0.6	1.8	39.4	0.7	2.3	31.0	0.7	2.8	24.8	0.7	3.3	20.1	0.8	3.8	16.5	0.8	4.4
45	85.5	0.6	1.4	61.4	0.6	1.8	44.3	0.7	2.3	34.9	0.7	2.8	27.9	0.7	3.3	22.6	0.8	3.8	18.6	0.8	4.4
50	95.0	0.6	1.4	68.2	0.6	1.8	49.2	0.7	2.3	38.8	0.7	2.8	31.0	0.7	3.3	25.1	0.8	3.8	20.6	0.8	4.4
55	104.6	0.6	1.4	75.0	0.6	1.8	54.1	0.7	2.3	42.7	0.7	2.8	34.1	0.7	3.3	27.6	0.8	3.8	22.7	0.8	4.4
60	114.1	0.6	1.4	81.8	0.6	1.8	59.0	0.7	2.3	46.6	0.7	2.8	37.2	0.7	3.3	30.1	0.8	3.8	24.7	0.8	4.4
65	123.6	0.6	1.4	88.6	0.6	1.8	63.9	0.7	2.3	50.4	0.7	2.8	40.3	0.7	3.3	32.6	0.8	3.8	26.8	0.8	4.4
70	133.1	0.6	1.4	95.5	0.6	1.8	68.9	0.7	2.3	54.3	0.7	2.8	43.4	0.7	3.3	35.1	0.8	3.8	28.9	0.8	4.4
75	142.6	0.6	1.4	102.3	0.6	1.8	73.8	0.7	2.3	58.2	0.7	2.8	46.5	0.7	3.3	37.7	0.8	3.8	30.9	0.8	4.4
80	152.1	0.6	1.4	109.1	0.6	1.8	78.7	0.7	2.3	62.1	0.7	2.8	49.6	0.7	3.3	40.2	0.8	3.8	33.0	0.8	4.4
85	161.6	0.6	1.4	115.9	0.6	1.8	83.6	0.7	2.3	65.9	0.7	2.8	52.7	0.7	3.3	42.7	0.8	3.8	35.0	0.8	4.4
90	171.1	0.6	1.4	122.7	0.6	1.8	88.5	0.7	2.3	69.8	0.7	2.8	55.8	0.7	3.3	45.2	0.8	3.8	37.1	0.8	4.4
95	180.6	0.6	1.4	129.6	0.6	1.8	93.4	0.7	2.3	73.7	0.7	2.8	58.9	0.7	3.3	47.7	0.8	3.8	39.2	0.8	4.4
100	190.1	0.6	1.4	136.4	0.6	1.8	98.4	0.7	2.3	77.6	0.7	2.8	62.0	0.7	3.3	50.2	0.8	3.8	41.2	0.8	4.4
105	199.6	0.6	1.4	143.2	0.6	1.8	103.3	0.7	2.3	81.5	0.7	2.8	65.1	0.7	3.3	52.7	0.8	3.8	43.3	0.8	4.4
110	209.1	0.6	1.4	150.0	0.6	1.8	108.2	0.7	2.3	85.3	0.7	2.8	68.2	0.7	3.3	55.2	0.8	3.8	45.3	0.8	4.4
115	218.6	0.6	1.4	156.8	0.6	1.8	113.1	0.7	2.3	89.2	0.7	2.8	71.3	0.7	3.3	57.7	0.8	3.8	47.4	0.8	4.4
120	228.1	0.6	1.4	163.6	0.6	1.8	118.0	0.7	2.3	93.1	0.7	2.8	74.3	0.7	3.3	60.2	0.8	3.8	49.5	0.8	4.4
125	237.6	0.6	1.4	170.5	0.6	1.8	123.0	0.7	2.3	97.0	0.7	2.8	77.4	0.7	3.3	62.7	0.8	3.8	51.5	0.8	4.4
130	247.1	0.6	1.4	177.3	0.6	1.8	127.9	0.7	2.3	100.8	0.7	2.8	80.5	0.7	3.3	65.2	0.8	3.8	53.6	0.8	4.4
135	256.6	0.6	1.4	184.1	0.6	1.8	132.8	0.7	2.3	104.7	0.7	2.8	83.6	0.7	3.3	67.8	0.8	3.8	55.6	0.8	4.4
140	266.1	0.6	1.4	190.9	0.6	1.8	137.7	0.7	2.3	108.6	0.7	2.8	86.7	0.7	3.3	70.3	0.8	3.8	57.7	0.8	4.4
145	275.6	0.6	1.4	197.7	0.6	1.8	142.6	0.7	2.3	112.5	0.7	2.8	89.8	0.7	3.3	72.8	0.8	3.8	59.8	0.8	4.4
150	285.1	0.6	1.4	204.6	0.6	1.8	147.5	0.7	2.3	116.4	0.7	2.8	92.9	0.7	3.3	75.3	0.8	3.8	61.8	0.8	4.4

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 11 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 6.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	10.6	0.5	1.3	7.3	0.6	1.8	5.3	0.6	2.3	4.0	0.7	2.8	2.9	0.8	3.2						
10	21.1	0.5	1.3	14.7	0.6	1.8	10.9	0.6	2.3	8.4	0.7	2.8	6.6	0.7	3.2	5.3	0.8	3.8	4.2	0.8	4.3
15	31.6	0.5	1.3	22.1	0.6	1.8	16.3	0.6	2.3	12.7	0.6	2.7	10.1	0.7	3.3	8.2	0.7	3.8	6.6	0.8	4.3
20	42.1	0.5	1.3	29.5	0.6	1.8	21.7	0.6	2.3	17.0	0.6	2.7	13.6	0.7	3.2	1.1	0.7	3.7	9.0	0.8	4.3
25	52.7	0.5	1.3	36.8	0.6	1.8	27.1	0.6	2.3	21.2	0.6	2.8	17.0	0.7	3.2	13.9	0.7	3.8	11.3	0.8	4.3
30	63.2	0.5	1.3	44.2	0.6	1.8	32.5	0.6	2.3	25.4	0.6	2.8	20.4	0.7	3.2	16.6	0.7	3.8	13.7	0.8	4.3
35	73.7	0.5	1.3	51.6	0.6	1.8	38.0	0.6	2.3	29.7	0.6	2.8	23.8	0.7	3.2	19.4	0.7	3.8	16.0	0.8	4.3
40	84.2	0.5	1.3	58.9	0.6	1.8	43.4	0.6	2.3	33.9	0.6	2.8	27.2	0.7	3.3	22.2	0.7	3.8	18.3	0.8	4.3
45	94.8	0.5	1.3	66.3	0.6	1.8	48.8	0.6	2.3	38.2	0.6	2.8	30.7	0.7	3.3	24.9	0.7	3.8	20.6	0.8	4.3
50	105.3	0.5	1.3	73.6	0.6	1.8	54.2	0.6	2.3	42.4	0.6	2.8	34.1	0.7	3.3	27.7	0.7	3.8	22.8	0.8	4.3
55	115.8	0.5	1.3	81.0	0.6	1.8	59.7	0.6	2.3	46.6	0.6	2.8	37.5	0.7	3.3	30.5	0.7	3.8	25.1	0.8	4.3
60	126.4	0.5	1.3	88.4	0.6	1.8	65.1	0.6	2.3	50.9	0.6	2.8	40.9	0.7	3.3	33.3	0.7	3.8	27.4	0.8	4.3
65	136.9	0.5	1.3	95.7	0.6	1.8	70.5	0.6	2.3	55.1	0.6	2.8	44.3	0.7	3.3	36.0	0.7	3.8	29.7	0.8	4.3
70	147.4	0.5	1.3	103.1	0.6	1.8	75.9	0.6	2.3	59.3	0.6	2.8	47.7	0.7	3.3	38.8	0.7	3.8	32.0	0.8	4.3
75	158.0	0.5	1.3	110.5	0.6	1.8	81.3	0.6	2.3	63.6	0.6	2.8	51.1	0.7	3.3	41.6	0.7	3.8	34.3	0.8	4.3
80	168.5	0.5	1.3	117.8	0.6	1.8	86.8	0.6	2.3	67.8	0.6	2.8	54.5	0.7	3.3	44.3	0.7	3.8	36.5	0.8	4.3
85	179.0	0.5	1.3	125.2	0.6	1.8	92.2	0.6	2.3	72.0	0.6	2.8	57.9	0.7	3.3	47.1	0.7	3.8	38.8	0.8	4.3
90	189.6	0.5	1.3	132.6	0.6	1.8	97.6	0.6	2.3	76.3	0.6	2.8	61.3	0.7	3.3	49.9	0.7	3.8	41.1	0.8	4.3
95	200.1	0.5	1.3	139.9	0.6	1.8	103.0	0.6	2.3	80.5	0.6	2.8	64.7	0.7	3.3	52.6	0.7	3.8	43.4	0.8	4.3
100	210.6	0.5	1.3	147.3	0.6	1.8	108.5	0.6	2.3	84.8	0.6	2.8	68.1	0.7	3.3	55.4	0.7	3.8	45.7	0.8	4.3
105	221.1	0.5	1.3	154.6	0.6	1.8	113.9	0.6	2.3	89.0	0.6	2.8	71.5	0.7	3.3	58.2	0.7	3.8	47.9	0.8	4.3
110	231.7	0.5	1.3	162.0	0.6	1.8	119.3	0.6	2.3	93.2	0.6	2.8	74.9	0.7	3.3	60.9	0.7	3.8	50.2	0.8	4.3
115	242.2	0.5	1.3	169.4	0.6	1.8	124.7	0.6	2.3	97.5	0.6	2.8	78.3	0.7	3.3	63.7	0.7	3.8	52.5	0.8	4.3
120	252.7	0.5	1.3	176.7	0.6	1.8	130.2	0.6	2.3	101.7	0.6	2.8	81.7	0.7	3.3	66.5	0.7	3.8	54.8	0.8	4.3
125	263.3	0.5	1.3	184.1	0.6	1.8	135.6	0.6	2.3	106.0	0.6	2.8	85.1	0.7	3.3	69.3	0.7	3.8	57.1	0.8	4.3
130	273.8	0.5	1.3	191.5	0.6	1.8	141.0	0.6	2.3	110.2	0.6	2.8	88.5	0.7	3.3	72.0	0.7	3.8	59.4	0.8	4.3
135	284.3	0.5	1.3	198.8	0.6	1.8	146.4	0.6	2.3	114.4	0.6	2.8	91.9	0.7	3.3	74.8	0.7	3.8	61.6	0.8	4.3
140	294.9	0.5	1.3	206.2	0.6	1.8	151.8	0.6	2.3	118.7	0.6	2.8	95.3	0.7	3.3	77.6	0.7	3.8	63.9	0.8	4.3
145	305.4	0.5	1.3	213.6	0.6	1.8	157.3	0.6	2.3	122.9	0.6	2.8	98.7	0.7	3.3	80.3	0.7	3.8	66.2	0.8	4.3
150	315.9	0.5	1.3	220.9	0.6	1.8	162.7	0.6	2.3	127.1	0.6	2.8	102.1	0.7	3.3	83.1	0.7	3.8	68.5	0.8	4.3

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 12 of 14

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 8.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	12.0	0.5	1.3	8.5	0.5	1.7	6.2	0.5	2.2	4.6	0.6	2.7	3.7	0.6	3.2	2.9	0.7	3.6			
10	24.1	0.5	1.3	16.9	0.5	1.7	12.6	0.5	2.2	9.6	0.6	2.7	7.8	0.6	3.2	6.3	0.6	3.7	5.1	0.7	4.2
15	36.1	0.5	1.3	25.3	0.5	1.7	18.9	0.5	2.2	14.4	0.6	2.7	11.8	0.6	3.2	9.7	0.6	3.7	7.9	0.7	4.2
20	48.1	0.5	1.3	33.8	0.5	1.7	25.2	0.5	2.2	19.2	0.6	2.7	15.8	0.6	3.2	12.9	0.6	3.7	10.7	0.7	4.2
25	60.1	0.5	1.3	42.2	0.5	1.7	31.5	0.5	2.2	24.0	0.6	2.7	19.7	0.6	3.2	16.2	0.6	3.7	13.4	0.7	4.2
30	72.1	0.5	1.3	50.6	0.5	1.7	37.8	0.5	2.2	28.8	0.6	2.7	23.6	0.6	3.2	19.4	0.6	3.7	16.1	0.7	4.2
35	84.1	0.5	1.3	59.1	0.5	1.7	44.1	0.5	2.2	33.6	0.6	2.7	27.6	0.6	3.2	22.6	0.6	3.7	18.7	0.7	4.2
40	96.2	0.5	1.3	67.5	0.5	1.7	50.4	0.5	2.2	38.4	0.6	2.7	31.5	0.6	3.2	25.8	0.6	3.7	21.4	0.7	4.2
45	108.2	0.5	1.3	76.0	0.5	1.7	56.7	0.5	2.2	43.2	0.6	2.7	35.4	0.6	3.2	29.0	0.6	3.7	24.1	0.7	4.2
50	120.2	0.5	1.3	84.4	0.5	1.7	63.0	0.5	2.2	48.0	0.6	2.7	39.4	0.6	3.2	32.3	0.6	3.7	26.8	0.7	4.2
55	132.2	0.5	1.3	92.8	0.5	1.7	69.3	0.5	2.2	52.8	0.6	2.7	43.3	0.6	3.2	35.5	0.6	3.7	29.4	0.7	4.2
60	144.2	0.5	1.3	101.3	0.5	1.7	75.6	0.5	2.2	57.6	0.6	2.7	47.2	0.6	3.2	38.7	0.6	3.7	32.1	0.7	4.2
65	156.3	0.5	1.3	109.7	0.5	1.7	81.8	0.5	2.2	62.4	0.6	2.7	51.2	0.6	3.2	41.9	0.6	3.7	34.8	0.7	4.2
70	168.3	0.5	1.3	118.2	0.5	1.7	88.1	0.5	2.2	67.2	0.6	2.7	55.1	0.6	3.2	45.2	0.6	3.7	37.5	0.7	4.2
75	180.3	0.5	1.3	126.6	0.5	1.7	94.4	0.5	2.2	72.0	0.6	2.7	59.0	0.6	3.2	48.4	0.6	3.7	40.1	0.7	4.2
80	192.3	0.5	1.3	135.0	0.5	1.7	100.7	0.5	2.2	76.8	0.6	2.7	63.0	0.6	3.2	51.6	0.6	3.7	42.8	0.7	4.2
85	204.3	0.5	1.3	143.5	0.5	1.7	107.0	0.5	2.2	81.6	0.6	2.7	66.9	0.6	3.2	54.9	0.6	3.7	45.5	0.7	4.2
90	216.4	0.5	1.3	151.9	0.5	1.7	113.3	0.5	2.2	86.4	0.6	2.7	70.8	0.6	3.2	58.1	0.6	3.7	48.1	0.7	4.2
95	228.4	0.5	1.3	160.3	0.5	1.7	119.6	0.5	2.2	91.2	0.6	2.7	74.8	0.6	3.2	61.3	0.6	3.7	50.8	0.7	4.2
100	240.4	0.5	1.3	168.8	0.5	1.7	125.9	0.5	2.2	96.0	0.6	2.7	78.7	0.6	3.2	64.5	0.6	3.7	53.5	0.7	4.2
105	252.4	0.5	1.3	177.2	0.5	1.7	132.2	0.5	2.2	100.8	0.6	2.7	82.6	0.6	3.2	67.8	0.6	3.7	56.2	0.7	4.2
110	264.4	0.5	1.3	185.7	0.5	1.7	138.5	0.5	2.2	105.6	0.6	2.7	86.6	0.6	3.2	71.0	0.6	3.7	58.8	0.7	4.2
115	276.5	0.5	1.3	194.1	0.5	1.7	144.8	0.5	2.2	110.4	0.6	2.7	90.5	0.6	3.2	74.2	0.6	3.7	61.5	0.7	4.2
120	288.5	0.5	1.3	202.5	0.5	1.7	151.1	0.5	2.2	115.2	0.6	2.7	94.4	0.6	3.2	77.4	0.6	3.7	64.2	0.7	4.2
125	300.5	0.5	1.3	211.0	0.5	1.7	157.4	0.5	2.2	120.0	0.6	2.7	98.4	0.6	3.2	80.7	0.6	3.7	66.9	0.7	4.2
130	312.5	0.5	1.3	219.4	0.5	1.7	163.7	0.5	2.2	124.8	0.6	2.7	102.3	0.6	3.2	83.9	0.6	3.7	69.5	0.7	4.2
135	324.5	0.5	1.3	227.9	0.5	1.7	170.0	0.5	2.2	129.6	0.6	2.7	106.2	0.6	3.2	87.1	0.6	3.7	72.2	0.7	4.2
140	336.6	0.5	1.3	236.3	0.5	1.7	176.3	0.5	2.2	134.4	0.6	2.7	110.2	0.6	3.2	90.3	0.6	3.7	74.9	0.7	4.2
145	348.6	0.5	1.3	244.7	0.5	1.7	182.6	0.5	2.2	139.2	0.6	2.7	114.1	0.6	3.2	93.6	0.6	3.7	77.6	0.7	4.2
150	360.6	0.5	1.3	253.2	0.5	1.7	188.9	0.5	2.2	144.0	0.6	2.7	118.0	0.6	3.2	96.8	0.6	3.7	80.2	0.7	4.2

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 13 of 14

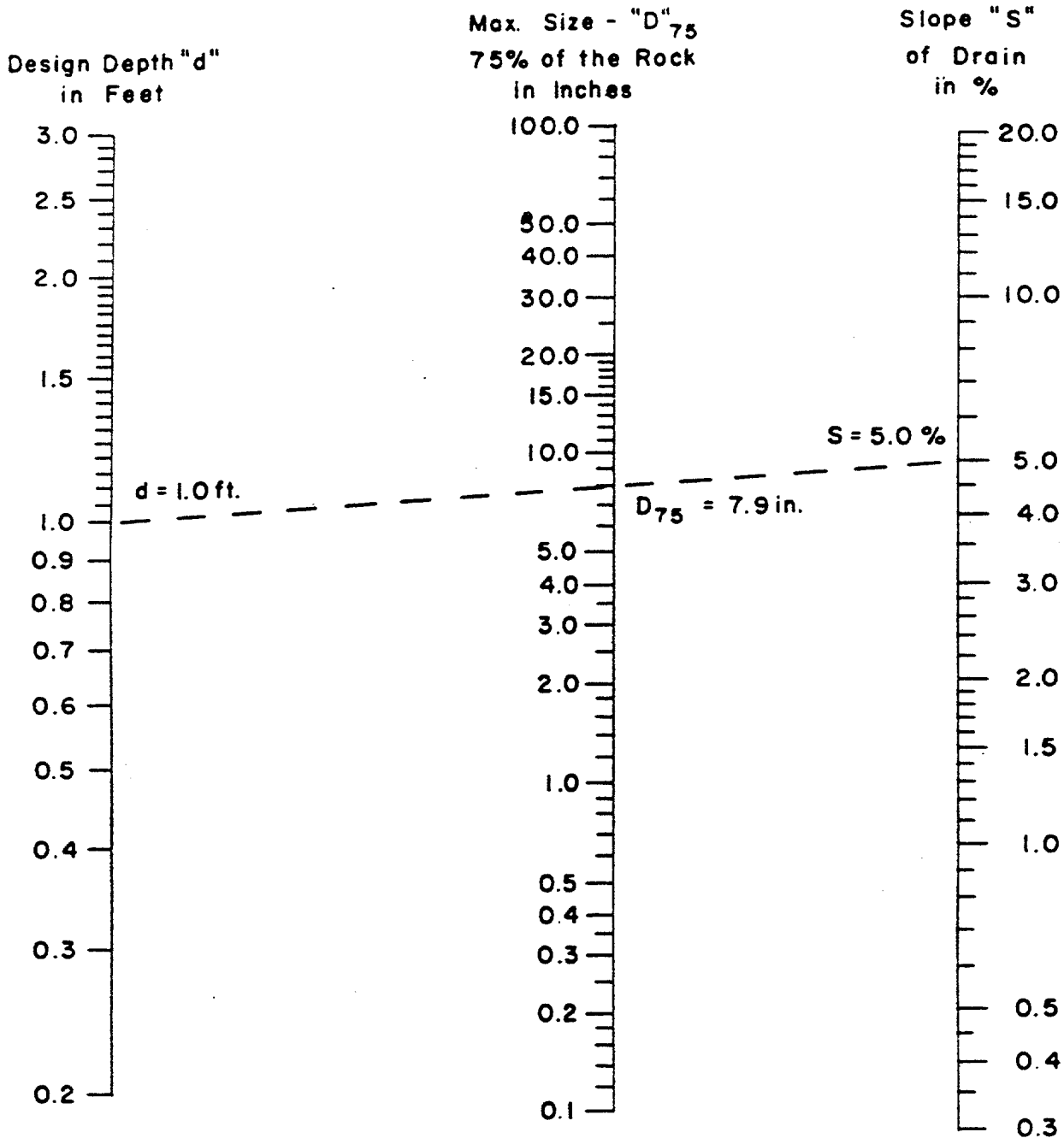
V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 10.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	13.3	0.4	1.3	9.4	0.5	1.7	6.8	0.5	2.2	5.3	0.5	2.6	4.1	0.6	3.2	3.4	0.6	3.6	2.6	0.7	4.1
10	26.6	0.4	1.3	18.7	0.5	1.7	13.8	0.5	2.2	10.9	0.5	2.6	8.5	0.6	3.2	7.1	0.6	3.6	5.9	0.6	4.1
15	39.9	0.4	1.3	28.0	0.5	1.7	20.7	0.5	2.2	16.3	0.5	2.6	12.8	0.6	3.2	10.9	0.6	3.6	9.0	0.6	4.1
20	53.2	0.4	1.3	37.4	0.5	1.7	27.6	0.5	2.2	21.7	0.5	2.7	17.0	0.6	3.2	14.5	0.6	3.6	12.1	0.6	4.1
25	66.5	0.4	1.3	46.7	0.5	1.7	34.5	0.5	2.2	27.1	0.5	2.7	21.3	0.6	3.2	18.1	0.6	3.6	15.1	0.6	4.1
30	79.8	0.4	1.3	56.1	0.5	1.7	41.4	0.5	2.2	32.5	0.5	2.7	25.5	0.6	3.2	21.7	0.6	3.6	18.1	0.6	4.1
35	93.1	0.4	1.3	65.4	0.5	1.7	48.3	0.5	2.2	37.9	0.5	2.7	29.8	0.6	3.2	25.3	0.6	3.6	21.1	0.6	4.1
40	106.4	0.4	1.3	74.7	0.5	1.7	55.2	0.5	2.2	43.3	0.5	2.7	34.0	0.6	3.2	29.0	0.6	3.6	24.1	0.6	4.1
45	119.7	0.4	1.3	84.1	0.5	1.7	62.1	0.5	2.2	48.8	0.5	2.7	38.3	0.6	3.2	32.6	0.6	3.6	27.2	0.6	4.1
50	133.0	0.4	1.3	93.4	0.5	1.7	69.0	0.5	2.2	54.2	0.5	2.7	42.5	0.6	3.2	36.2	0.6	3.6	30.2	0.6	4.1
55	146.3	0.4	1.3	102.8	0.5	1.7	75.9	0.5	2.2	59.6	0.5	2.7	46.8	0.6	3.2	39.8	0.6	3.6	33.2	0.6	4.1
60	159.6	0.4	1.3	112.1	0.5	1.7	82.8	0.5	2.2	65.0	0.5	2.7	51.0	0.6	3.2	43.4	0.6	3.6	36.2	0.6	4.1
65	172.9	0.4	1.3	121.4	0.5	1.7	89.7	0.5	2.2	70.4	0.5	2.7	55.3	0.6	3.2	47.1	0.6	3.6	39.2	0.6	4.1
70	186.2	0.4	1.3	130.8	0.5	1.7	96.6	0.5	2.2	75.8	0.5	2.7	59.5	0.6	3.2	50.7	0.6	3.6	42.2	0.6	4.1
75	199.5	0.4	1.3	140.1	0.5	1.7	103.5	0.5	2.2	81.2	0.5	2.7	63.8	0.6	3.2	54.3	0.6	3.6	45.2	0.6	4.1
80	212.8	0.4	1.3	149.5	0.5	1.7	110.5	0.5	2.2	86.7	0.5	2.7	68.0	0.6	3.2	57.9	0.6	3.6	48.3	0.6	4.1
85	226.1	0.4	1.3	158.8	0.5	1.7	117.4	0.5	2.2	92.1	0.5	2.7	72.3	0.6	3.2	61.5	0.6	3.6	51.3	0.6	4.1
90	239.4	0.4	1.3	168.1	0.5	1.7	124.3	0.5	2.2	97.5	0.5	2.7	76.5	0.6	3.2	65.2	0.6	3.6	54.3	0.6	4.1
95	252.7	0.4	1.3	177.5	0.5	1.7	131.2	0.5	2.2	102.9	0.5	2.7	80.8	0.6	3.2	68.8	0.6	3.6	57.3	0.6	4.1
100	266.0	0.4	1.3	186.8	0.5	1.7	138.1	0.5	2.2	108.3	0.5	2.7	85.0	0.6	3.2	72.4	0.6	3.6	60.3	0.6	4.1
105	279.3	0.4	1.3	196.2	0.5	1.7	145.0	0.5	2.2	113.7	0.5	2.7	89.3	0.6	3.2	76.0	0.6	3.6	63.3	0.6	4.1
110	292.6	0.4	1.3	205.5	0.5	1.7	151.9	0.5	2.2	119.2	0.5	2.7	93.5	0.6	3.2	79.6	0.6	3.6	66.4	0.6	4.1
115	305.9	0.4	1.3	214.9	0.5	1.7	158.8	0.5	2.2	124.6	0.5	2.7	97.8	0.6	3.2	83.3	0.6	3.6	69.4	0.6	4.1
120	319.2	0.4	1.3	224.2	0.5	1.7	165.7	0.5	2.2	130.0	0.5	2.7	102.0	0.6	3.2	86.9	0.6	3.6	72.4	0.6	4.1
125	332.5	0.4	1.3	233.5	0.5	1.7	172.6	0.5	2.2	135.4	0.5	2.7	106.3	0.6	3.2	90.5	0.6	3.6	75.4	0.6	4.1
130	345.8	0.4	1.3	242.9	0.5	1.7	179.5	0.5	2.2	140.8	0.5	2.7	110.5	0.6	3.2	94.1	0.6	3.6	78.4	0.6	4.1
135	359.1	0.4	1.3	252.2	0.5	1.7	186.4	0.5	2.2	146.2	0.5	2.7	114.8	0.6	3.2	97.7	0.6	3.6	81.4	0.6	4.1
140	372.4	0.4	1.3	261.6	0.5	1.7	193.3	0.5	2.2	151.7	0.5	2.7	119.0	0.6	3.2	101.3	0.6	3.6	84.4	0.6	4.1
145	385.7	0.4	1.3	270.9	0.5	1.7	200.2	0.5	2.2	157.1	0.5	2.7	123.3	0.6	3.2	105.0	0.6	3.6	87.5	0.6	4.1
150	399.0	0.4	1.3	280.2	0.5	1.7	207.1	0.5	2.2	162.5	0.5	2.7	127.5	0.6	3.2	108.6	0.6	3.6	90.5	0.6	4.1

Exhibit A6-WW-1. Parabolic Waterway Design.
(Retardance "D" and "C")

Sheet 14 of 14



EXAMPLE: "d" = 1.0 Feet "S" = 5 %

Place straight edge at "d" value in Design Depth column and at "S" value in Slope column. Read rock size in middle column 7.9 inches. Say 8 inches.

FOR DESIGN:

25 % of the rock by volume should be in sizes of 8 inches or slightly larger. The remaining 75 % or less should be of well graded material, smaller than 8 inches, including sufficient sands and gravels to fill the voids between the larger rock.

Exhibit A6-WW-2. Determination of Rock Size for Stone Center Waterway.

Appendix A7 – Examples of Landscape Architecture Plans

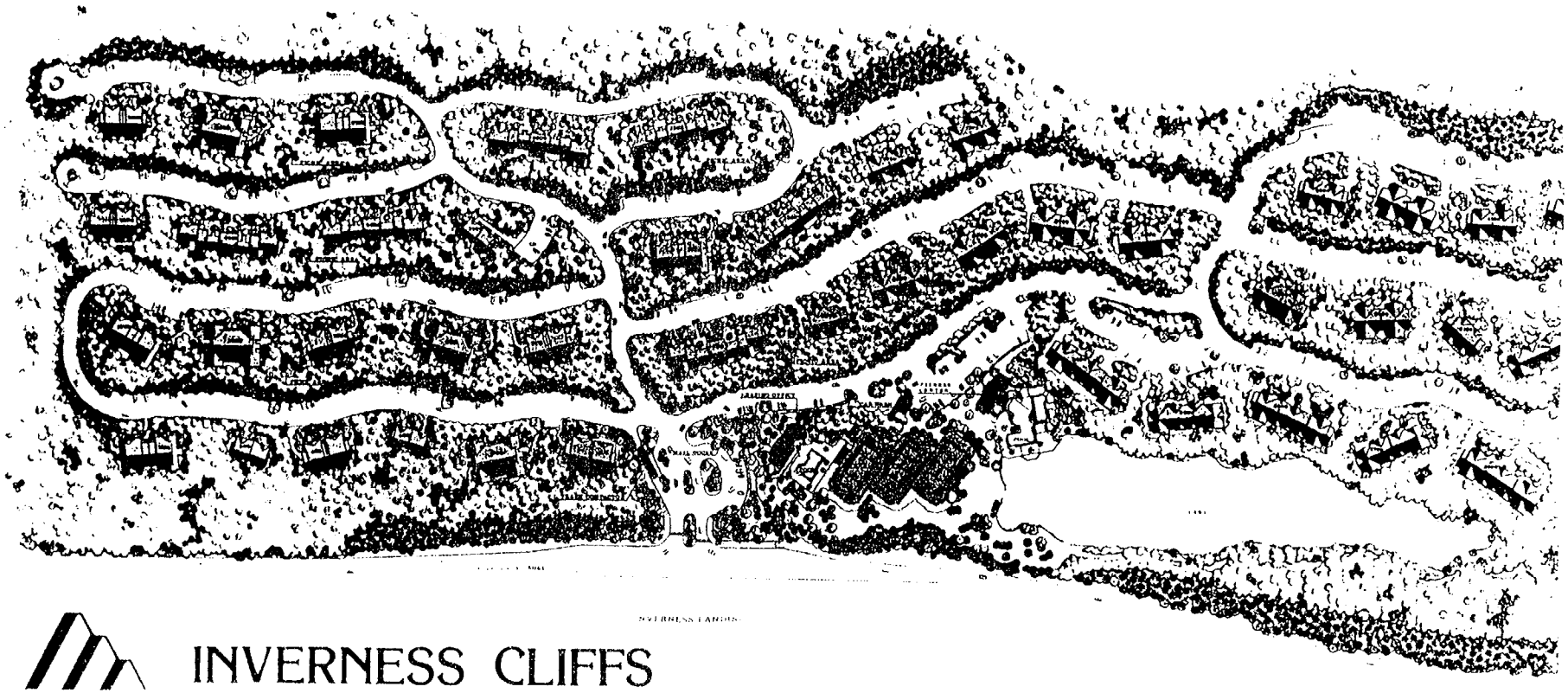
Appendix A7

EXAMPLES OF LANDSCAPE ARCHITECTURE PLAN

CONTENTS

	Page
INVERNESS CLIFFS - Plan View	A-VII-1
Reserved for additional plans	

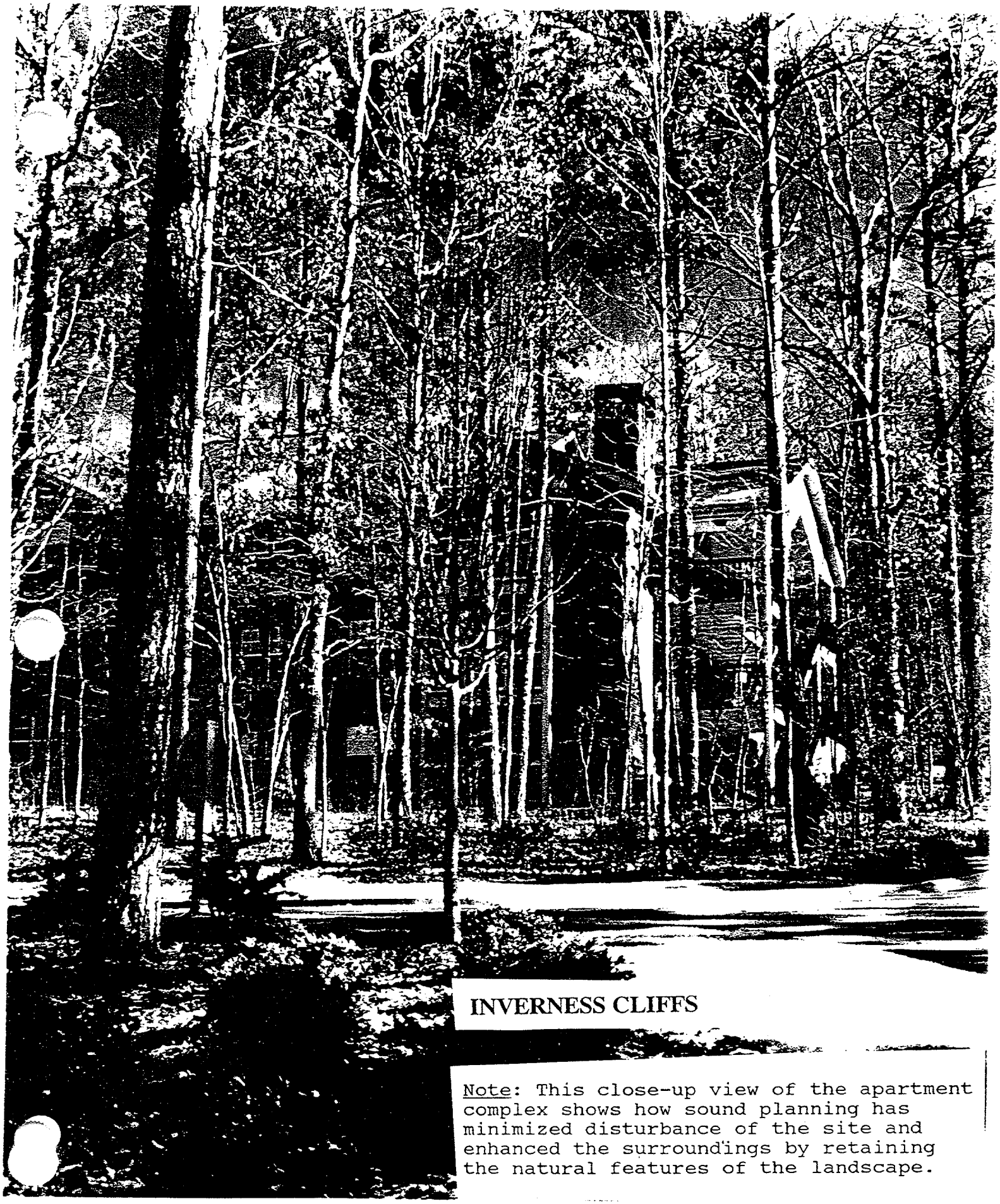
July 1, 1993



INVERNESS CLIFFS

PLAN VIEW

Note: This landscape plan illustrates a 400-unit apartment complex planned on fifty wooded acres. The plan includes the apartment units, a two acre lake, two pools, three tennis courts, a fitness center and a nature trail. The landscape architecture firm was involved in the project in preliminary layout, final site and grading plans, amenity area design and detailing, planting design and entrance design and details. Courtesy Taylor & Mathis, Developer.)



INVERNESS CLIFFS

Note: This close-up view of the apartment complex shows how sound planning has minimized disturbance of the site and enhanced the surroundings by retaining the natural features of the landscape.

Appendix A8 – Model Ordinances

Appendix A8

MODEL ORDINANCES

CONTENTS

	Page
Erosion and Sediment Control	A-VIII-1
Reserved for additional ordinances	

July 1, 1993

SOIL EROSION AND SEDIMENT CONTROL ORDINANCE

NOW THEREFORE, BE IT ORDAINED, BY THE _____ OF _____.

SECTION I TITLE

This ordinance will be known as "_____ Soil Erosion and Sedimentation Control Ordinance."

SECTION II DEFINITIONS

The following definitions shall apply in the interpretation and enforcement of this ordinance, unless otherwise specifically stated:

1. Buffer: An area along the course of any State waters to be maintained in an undisturbed and natural condition.
2. Conservation Commission: The State Soil & Water Conservation Commission.
3. Cut: A portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface. Also know as excavation.
4. Department: The Department of Natural Resources.
5. Director: The Director of the Environmental Protection Division.
6. District: The (Local SWCD Name) Soil and Water Conservation District.
7. Division: The Environmental Protection Division.
8. Drainage Structure: Any roadway drainage structure as defined below, and any piping or ditching for stormwater management purposes.
9. Erosion: The process by which land surface is worn away by the action of wind, water, ice or gravity.

10. Erosion and Sediment Control Plan: A plan for the control of soil erosion and sediment resulting from land-disturbing activity. Also known as the "plan".

11. Existing Grade: The vertical location of the existing ground surface prior to cutting or filling.

12. Filling: The placement of any soil or other solid material either organic or inorganic on a natural ground surface or excavation.

13. Finished Grade: The final elevation and contour of the ground after cutting or filling and conforming to the proposed design.

14. Grading: Altering ground surfaces to specified elevations, dimensions, and/or slopes; this includes stripping, cutting, filling, stockpiling and shaping or any combination thereof and shall include the land in its cut or filled condition.

15. Issuing Authority: The governing authority of county or municipality which has been certified by the Director of the Environmental Protection Division of the Department of Natural Resources as an issuing authority, pursuant to the Erosion and Sedimentation Act of 1975, as amended.

16. Land-Disturbing Activity: Any activity which may result in soil erosion from water or wind and the movement of sediments into state waters or onto lands within the state, including, but not limited to, clearing, dredging, grading, excavating, transporting, and filling of land but not including agricultural practices as described in Section III, Paragraph 5.

17. Metropolitan River Protection Act (MRPA): A state law referenced as O.C.G.A. 12-5-440 et seq., which addresses environmental and developmental matters in certain metropolitan

river corridors and their drainage basins.

18. Natural Ground Surface: The ground surface in its original state before any grading, excavation or filling.

19. Nephelometric Turbidity Units (NTU): Numerical units of measure based upon photometric analytical techniques for measuring the light scattered by finely divided particles of a substance in suspension. This technique is used to estimate the extent of turbidity in water in which colloidally dispersed particles are present.

20. One Hundred Year Flood Plain: Land in the flood plain subject to a one percent or greater statistical occurrence probability of flooding in any given year.

21. Permit: The authorization necessary to conduct a land-disturbing activity under the provisions of this ordinance.

22. Person: Any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, state agency, municipality or other political subdivision of this State, any interstate body or any other legal entity.

23. Project: The entire proposed development project regardless of the size of the area of land to be disturbed.

24. Roadway Drainage Structure: Bridges, culverts and ditches associated with roadway construction, which allow stream flows to move freely under a stream crossing or to convey storm-water run-off from a roadway to a stream.

25. Sediment: Solid material, both organic and inorganic, that is in suspension, is being transported, or has been moved from its

site of origin by air, water, ice, or gravity as a product of erosion.

26. Sedimentation: The action or process of forming or depositing sediment.

27. Stabilization: The process of establishing an enduring soil cover of vegetation and/or mulch or other ground cover and/or in combination with installing temporary or permanent structures for the purpose of reducing to a minimum the erosion process and the resultant transport of sediment by wind, water, ice or gravity.

28. State Waters: Any and all rivers, streams, creeks, branches, lakes, reservoirs, ponds, drainage systems, springs, wells, and other bodies of surface or subsurface water, natural and artificial, lying within or forming a part of the boundaries of the State which are not entirely confined and retained completely upon the property of a single individual, partnership, or corporation.

29. Structural Erosion and Sediment Control Practices: Measures for the stabilization of erosive or sediment-producing areas by utilizing the mechanical properties of matter for the purpose of either changing the surface of the land or storing, regulating or disposing of runoff to prevent excessive sediment loss. Examples of structural erosion and sediment control practices are riprap, sediment basins, dikes, level spreaders, waterways or outlets, diversions, grade stabilization structures, sediment traps, land grading, etc.

30. Trout Streams: All streams or portions of streams within the watershed as designated by the Game and Fish Division of the Georgia Department of Natural Resources under the provisions of

the Georgia Water Quality Control Act, O.C.G.A. 12-5-20 et seq. Streams designated as primary trout waters are defined as water supporting a self-sustaining population of rainbow, brown or brook trout. Streams designated as secondary trout waters are those in which there is no evidence of natural trout reproduction, but are capable of supporting trout throughout the year.

31. Vegetative Erosion and Sediment Control Practices: Measures for the stabilization of erosive or sediment-producing areas by covering the soil with:

    i. Permanent seeding, sprigging or planting, producing long-term vegetative cover; or

    ii. Temporary seeding, producing short-term vegetative cover; or

    iii. Sodding, covering areas with a turf of perennial sod-forming grass.

32. Watercourse: Any natural or artificial watercourse, stream, river, creek, channel, ditch, canal, conduit, culvert, drain, waterway, gully, ravine, or wash in which water flows either continuously or intermittently and which has a definite channel, bed and banks, and including any area adjacent thereto subject to inundation by reason of overflow or floodwater.

SECTION III EXEMPTIONS

This ordinance shall apply to any land-disturbing activity undertaken by any person on any land except for the following:

1. Surface mining, as the same is defined in O.C.G.A. 12-4-72;
2. Granite quarrying and land clearing for such quarrying;
3. Such minor land-disturbing activities as home gardens and individual home landscaping, repairs, maintenance work, and

other related activities which result in minor soil erosion;

4. (A) The construction of single-family residences when such ar constructed by or under contract with the owner for his own occupancy; or

   (B) The construction of single-family residences not a part of a larger project and not exempted under subparagraph (A) of this paragraph; provided, however, that construction of any such residence not otherwise exempt must conform to the minimum standards as set forth in Section IV and that such standards may be enforced by the issuing authority;

5. Agricultural practices involving the establishment, cultivation, or harvesting of products of the field or orchard; the preparation and planting of pasture land; forestry land management practices, including harvesting; farm ponds; dairy operations; livestock and poultry management practices; and th construction of farm buildings;

6. Any project carried out under the technical supervision of the Soil Conservation Service of the United States Department of Agriculture;

7. Any project involving one and one-tenth acres or less; provided, however, that this exemption shall not apply to any land-disturbing activity within 200 feet of the bank of any State waters, and for purposes of this paragraph, "State Waters" excludes channels and drainageways which have water in them only during and immediately after rainfall events and intermittent streams which do not have water in them year-round; provided, however, that any person responsible for a project which involves one and one-tenth acres or less, which involves land-disturbing activity, and which is within

200 feet of any such excluded channel or drainageway, must prevent sediment from moving beyond the boundaries of the property on which such project is located and provided, further, that nothing contained herein shall prevent the issuing authority from regulating any such project which is not specifically exempted by sub-paragraph (B) of paragraph (4) or by paragraphs (1), (2), (3), (5), (6), (8), (9), or (10) of this section;

8. Construction or maintenance projects, or both, undertaken or financed in whole or in part, or both, by the Department of Transportation, the Georgia Highway Authority, or the Georgia Tollway Authority; or any road construction or maintenance project, or both, undertaken by any county or municipality; or construction and maintenance, or either, by any water or sewerage authority established by the General Assembly of this state; provided, however, that:

   (A) If such projects are constructed within 200 feet of the banks of any channels or drainageways which have water in them only during and immediately after rainfall events, or intermittent streams which do not have water in them year-round, then such projects shall conform to the specifications used by the Department of Transportation for control of soil erosion and sedimentation on its highway construction projects;

   (B) If such projects are constructed within 200 feet of the banks of any state waters which do have water in them year-round and in which the drainage area of the watershed upstream from such projects is less than three square miles, then such projects shall conform to the

specifications used by the Department of Transportation for control of soil erosion and sedimentation on its highway construction projects.

(C) If such projects are constructed within 200 feet of the banks of any state waters which do have water in them year-round and in which the drainage area of the watershed upstream from such projects is equal to or more than three square miles, then such projects shall conform to the minimum standards set forth in Section IV and;

(D) If such projects are constructed within 100 feet (horizontal) of the banks of any state waters classified as "trout streams" pursuant to the "Georgia Water Quality Control Act", regardless of the size of the watershed area, then such projects shall conform to the minimum standards as set forth in Section IV.

9. Any land-disturbing activities conducted by any airport authority, provided that any such land-disturbing activity shall conform to the minimum standards set forth in Section IV, or;

10. Any land-disturbing activities conducted by any electric membership corporation or municipal electrical system or any public utility under the regulatory jurisdiction of the Public Service Commission, provided that any such land-disturbing activity shall conform to the minimum requirements set forth in Section IV.

SECTION IV <u>MINIMUM REQUIREMENTS FOR EROSION AND SEDIMENTATION CONTROL</u>

A. General Provisions

Excessive soil erosion and resulting sedimentation can take place during land-disturbing activities. Therefore, plans for

those land-disturbing activities which are not excluded by this ordinance shall contain provisions for application of soil erosion and sediment control measures. The provisions shall be incorporated into the erosion and sediment control plans. Soil erosion and sediment control measures shall conform to the requirements of this ordinance. The application of measures shall apply to all features of the site, including street and utility installations, drainage facilities and other temporary and permanent improvements. Measures shall be installed to prevent or control erosion and sediment pollution during all stages of any land-disturbing activity.

B. Requirements

The permittee shall follow sound conservation and engineering practices to prevent and minimize erosion and resulting sedimentation consistent with the following requirements:

1. Stripping of vegetation, regrading and other development activities shall be conducted in a manner so as to minimize erosion.
2. Cut-fill operations must be kept to a minimum.
3. Development plans must conform to topography and soil type so as to create the lowest practical erosion potential.
4. Whenever feasible, natural vegetation shall be retained, protected and supplemented.
5. The disturbed area and the duration of exposure to erosive elements shall be kept to a practicable minimum.
6. Disturbed soil shall be stabilized as quickly as practicable.

7. Temporary vegetation or mulching shall be employed to protect exposed critical areas during development.
8. Permanent vegetation and structural erosion control measures shall be installed as soon as practicable.
9. To the extent necessary, sediment in run-off water must be trapped by the use of debris basins, sediment basins, silt traps, or similar measures until the disturbed area is stabilized.
10. Adequate provisions must be provided to minimize damage from surface water to the cut face of excavations or the sloping surface of fills.
11. Cuts and fills may not endanger adjoining property.
12. Fills may not encroach upon natural watercourses or constructed channels in a manner so as to adversely affect other property owners.
13. Grading equipment must cross flowing streams by means of bridges or culverts except when such methods are not feasible and provided, in any such case, that such crossings are kept to a minimum.
14. Land-disturbing activity plans for erosion and sedimentation control shall include provisions for control or treatment of any source of sediments and adequate sedimentation control facilities to retain sediments onsite or preclude sedimentation of adjacent streams beyond the levels specified in paragraph (18) of this section;
15. Land-disturbing activities shall not be conducted within the 100-year flood plain unless compliance with any applicable local flood plain management ordinance

is demonstrated or such construction is in compliance with the Federal Emergency Management Agency regulations or flood storage compensation for flood waters is provided;

16. An undisturbed natural vegetative buffer of 25 feet measured from the stream banks shall normally be retained adjacent to any state waters except where otherwise required by the "Metropolitan River Protection Act", O.C.G.A. 12-5-440 et seq., or by the department pursuant to O.C.G.A. 12-2-8, or when the economic use and the contour of the land require a different buffer subject to the division's approval, or where a drainage structure must be constructed, provided that adequate erosion control measures are incorporated in the project plans and specifications and are implemented;

17. Land-disturbing activities shall not be conducted within 100 feet (horizontal) of the banks of any state waters classified as "trout streams" pursuant to the "Georgia Water Quality Control Act", O.C.G.A. 12-5-20 et seq., unless a variance for such activity is granted by the director except where a roadway drainage structure must be constructed, provided that adequate erosion control measures are incorporated in the project plans and specifications and are implemented; and

18. Discharges of stormwater runoff from disturbed areas shall be controlled to the extent that turbidity of the stormwater runoff shall not exceed 50

nephelometric turbidity units higher than the turbidity level of the receiving stream immediately upstream from the stormwater runoff discharge at the time of such discharge except where a roadway drainage structure must be constructed, the turbidity of the receiving stream downstream of the construction site shall not exceed 60 nephelometric turbidity units higher than the turbidity level of the receiving stream immediately upstream from the construction site. Downstream turbidity measurements shall be taken at points where the entering discharge is fully mixed with the receiving stream flow. Should the division determine that other turbidity limits may be applicable, the issuing authority may accept same.

SECTION V APPLICATION/PERMIT PROCESS

A. GENERAL

The landowner, developer and designated planners and engineer shall review the general development plans and detailed plans of the issuing authority that affect the tract to be developed and the area surrounding it. They shall review the zoning ordinance, subdivision ordinance, this ordinance, and other ordinances which regulate the development of land within the boundaries of the issuing authority.

B. APPLICATION REQUIREMENTS

1. No person shall conduct any land-disturbing activity within the confines of the City or County Name without first obtaining a permit from the Issuing Authority of City or County Name to perform such activity.
2. The application for a permit shall be submitted to the

Issuing Authority and must include the applicant's erosion and sedimentation control plan with supporting data, as necessary. Said plans shall include, as a minimum, the data specified in Section V, C of this ordinance. Soil erosion and sedimentation control plans shall conform to the provisions of Section IV of this ordinance. Applications for a permit will not be accepted unless accompanied by ____ copies of the applicant's soil erosion and sedimentation control plans.

3. A fee, in the amount of $_____, shall be charged for each application.

4. Immediately upon receipt of an application and plan for a permit, the Issuing Authority shall refer the application and plan to the Local Soil and Water Conservation District for its review and approval or disapproval concerning the adequacy of the erosion and sediment control plan. The results of the District review shall be forwarded to the Issuing Authority. No permit will be issued unless the plan has been appproved by the District, and any variances required by Section IV B (16 & 17) and bonding, if required as per Section V B (5), have been obtained. Such review will not be required if the Issuing Authority and the District have entered into an agreement which allows the Issuing Authority to conduct such review and approval of the plan without referring the application and plan to the District.

5. When reviewing any application for a land-disturbing activity permit, the Issuing Authority shall consider the past record of the permit applicant in complying with

previous land-disturbing activity permits and this ordinance. If the applicant has had two or more violatic of previous permits or this ordinance within three years prior to the date of the filing of the application under consideration, the Issuing Authority may require the applicant to post a bond up to, but not exceeding, $3,000 per acre of the proposed land-disturbing activity prior to issuing the permit. If the applicant does not comply with this ordinance or with the conditions of the permit after issuance, the Issuing Authority may call the bond or any part thereof to be forfeited and may use the proceeds to hire a contractor to stabilize the site of the land-disturbing activity and bring it into compliance.

C. PLAN REQUIREMENTS

1. Plans must be prepared to meet the miniumum requirements contained in Section IV of this ordinance.

   Conformance with the minimum requirements may be attained through the use of design criteria in the Manual For Erosion And Sediment Control In Georgia, revised in 1989, published by the State Soil and Water Conservation Commission as a guide; or through the use of alternate design criteria which conform to sound conservation and engineering practices. The Manual for Erosion and Sediment Control in Georgia is hereby incorporated by reference into this ordinance.

   The Plan for the land-disturbing activity shall consider the interrelationship of the soil types, geological and hydrological characteristics, topography, watershed, vegetation, proposed permanent structures including

roadways, constructed waterways, sediment control and storm water management facilities, local ordinances and State laws.

2. Data Required For Site Plan:

(A) Narrative or notes, and other information: Notes or narrative to be located on the site plan in general notes or in erosion and sediment control notes.

(B) Description of existing land use at project site and description of proposed project.

(C) Name, address, and phone number of developer/owner.

(D) Name and phone number of 24-hour local contact who is responsible for erosion and sediment controls.

(E) Size of project, or phase under construction, in acres.

(F) Activity schedule - show anticipated starting and completion dates for project. Include the statement in <u>bold</u> <u>letters</u>, that "the installation of erosion control measures and practices shall occur prior to or concurrent with land disturbing activities."

(G) Stormwater and sediment management systems-storage capacity, hydrologic study, and calculations, including off-site drainage area.

(H) Vegetative plan - for all temporary and permanent vegetative practices, including species, planting dates, and seeding, fertilizer, lime, and mulching rates. Vegetative plan should show options for year-round seeding.

(I) Detail drawings - for all structural practices. Specifications may follow guidelines set forth in the

Manual for Erosion and Sediment Control in Georgia.

(J) Maintenance statement - "Erosion control measures will be maintained at all times. Additional erosion and sediment control measures will be installed if deemed necessary by onsite inspection."

3. Maps, drawings, and supportive computations shall bear the signature/seal of a registered or certified professional in engineering, architecture, landscape architecture, land surveying, or erosion and sedimentation control.

(A) Graphic scale and north point or arrow indicating magnetic north.

(B) Vicinity maps showing location of project and existing streets.

(C) Boundary line survey.

(D) Delineation of disturbed areas within project boundary.

(E) Existing and planned contours, with contour lines drawn with an interval of not more than five (5) feet. (The procedure or method used in arriving at the contour intervals shall be indicated.)

(F) Adjacent areas and features areas such as streams, lakes, residential areas, etc. which might be affected should be indicated on the plan.

(G) Proposed structures or additions to existing structures and paved areas.

(H) Delineate 100-year flood plain. (Reference data used in determination.)

(I) Delineate the 25-foot undisturbed vegetative buffer adjacent to state waters.

(J) Delineate the 100-foot management zone along designated trout streams where applicable.

(K) Location of erosion and sediment control practices, preferably using uniform coding symbols from the Manual for Erosion and Sediment Control in Georgia, Chapter 6. Practices may include, but are not limited to:

(1) Construction exit

(2) Sediment barrier

(3) Sediment basin

(4) Grassed waterway (open swale)

(5) Storm drain outlet protection

4. Maintenance of all soil erosion and sedimentation control practices, whether temporary or permanent, shall be at all times the responsibility of the owner.

D. PERMITS

1. Permits shall be issued or denied as soon as practicable but in any event not later than forty-five (45) days after receipt by the issuing authority of a completed application, providing variances and bonding are obtained, where necessary.

2. No permit shall be issued by the Issuing Authority unless the erosion and sedimentation control plan has been approved by the District and the Issuing Authority has affirmatively determined that the plan is in compliance with this ordinance, any variances required by Sec. IV B (16 & 17) are obtained, bonding requirements, if necessary, as per Sec. V B. 5 are met and all ordinances and rules and regulations in effect within the City or County name

are met.

If the permit is denied, the reason for denial shall be furnished the applicant.

3. If the tract is to be developed in phases, then a separate permit shall be required for each phase.

4. The permit may be suspended, revoked, or modified by the Issuing Authority, as to all or any portion of the land affected by the plan, upon finding that the holder or his successor in the title is not in compliance with the approved erosion and sediment control plan or that the holder or his successor in title is in violation of this ordinance. A holder of a permit shall notify any successor in title to him as to all or any portion of the land affected by the approved plan of the conditions contained in the permit.

SECTION VI INSPECTION AND ENFORCEMENT

A. The _____ will periodically inspect the sites of land-disturbing activities for which permits have been issued to determine if the activities are being conducted in accordance with the plan and if the measures required in the plan are effective in controlling erosion and sedimentation. If, through inspection, it is deemed that a person engaged in land-disturbing activities as defined herein has failed to comply with the approved plan, with permit conditions, or with the provisions of this ordinance, a written notice to comply shall be served upon that person. The notice shall set forth the measures necessary to achieve compliance and shall state the time within which such measures must be completed. If the person engaged in the land-disturbing activity fails to comply

within the time specified, he shall be deemed in violation of this ordinance.

B. The _____ shall have the power to conduct such investigations as it may reasonably deem necessary to carry out duties as prescribed in this ordinance, and for this purpose to enter at reasonable times upon any property, public or private, for the purpose of investigation and inspecting the sites of land-disturbing activities.

C. No person shall refuse entry or access to any authorized representative or agent of the Issuing Authority, the Conservation Commission, the District, or Division who requests entry for the purposes of inspection, and who presents appropriate credentials, nor shall any person obstruct, hamper or interfere with any such representative while in the process of carrying out his official duties.

SECTION VII PENALTIES AND INCENTIVES

A. Failure to Obtain a Permit for Land-Disturbing Activity:

If any person commences any land-disturbing activity requiring a land-disturbing permit as prescribed in this ordinance without first obtaining said permit, the person shall be subject to revocation of his business license, work permit or other authorization for the conduct of a business and associated work activities within the jurisdictional boundaries of the Issuing Authority.

B. Stop-Work Orders:

Upon notice from the Issuing Authority or its agent, work on any project that is being done contrary to the provisions of this ordinance or in a dangerous or unsafe manner, shall be immediately stopped. Such notice shall be in writing and shall

be given to the owner of the property, his authorized agent or the person or persons in charge of the activity on the property, and shall state the conditions under which work may be resumed. Where an emergency exists, no written notice shall be required.

C. Bond Forfeiture:

If, through inspection, it is determined that a person engaged in land-disturbing activities has failed to comply with the approved plan, a written notice to comply shall be served upon that person. The notice shall set forth the measures necessary to achieve compliance with the plan and shall state the time within which such measures must be completed. If the person engaged in the land-disturbing activity fails to comply within the time specified, he shall be deemed in violation of this ordinance and, in addition to other penalties, shall be deemed to have forfeited his performance bond, if required to post one under the provisions of Section V, B. 5. The Issuing Authority may call the bond or any part thereof to be forfeited and may use the proceeds to hire a contractor to stabilize the site of the land-disturbing activity and bring it into compliance.

D. Civil Penalties:

Any person violating any provisions of this ordinance, permitting conditions, or stop-work order shall be liable for a civil penalty of not less than $500 per day, by a sentence of imprisonment not exceeding 60 days in jail or both fine and jail or work alternative. Each day the violation continues shall constitute a separate offense.

SECTION VIII ADMINISTRATIVE APPEAL, JUDICIAL REVIEW

Appendix A8

MODEL ORDINANCES

CONTENTS

	Page
Erosion and Sediment Control	A-VIII-1
Reserved for additional ordinances	

July 1, 1993

SOIL EROSION AND SEDIMENT CONTROL ORDINANCE

NOW THEREFORE, BE IT ORDAINED, BY THE _____ OF _____.

SECTION I TITLE

This ordinance will be known as "_____ Soil Erosion and Sedimentation Control Ordinance."

SECTION II DEFINITIONS

The following definitions shall apply in the interpretation and enforcement of this ordinance, unless otherwise specifically stated:

1. Buffer: An area along the course of any State waters to be maintained in an undisturbed and natural condition.
2. Conservation Commission: The State Soil & Water Conservation Commission.
3. Cut: A portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface. Also know as excavation.
4. Department: The Department of Natural Resources.
5. Director: The Director of the Environmental Protection Division.
6. District: The (Local SWCD Name) Soil and Water Conservation District.
7. Division: The Environmental Protection Division.
8. Drainage Structure: Any roadway drainage structure as defined below, and any piping or ditching for stormwater management purposes.
9. Erosion: The process by which land surface is worn away by the action of wind, water, ice or gravity.

10. Erosion and Sediment Control Plan: A plan for the control of soil erosion and sediment resulting from land-disturbing activity. Also known as the "plan".

11. Existing Grade: The vertical location of the existing ground surface prior to cutting or filling.

12. Filling: The placement of any soil or other solid material either organic or inorganic on a natural ground surface or excavation.

13. Finished Grade: The final elevation and contour of the ground after cutting or filling and conforming to the proposed design.

14. Grading: Altering ground surfaces to specified elevations, dimensions, and/or slopes; this includes stripping, cutting, filling, stockpiling and shaping or any combination thereof and shall include the land in its cut or filled condition.

15. Issuing Authority: The governing authority of county or municipality which has been certified by the Director of the Environmental Protection Division of the Department of Natural Resources as an issuing authority, pursuant to the Erosion and Sedimentation Act of 1975, as amended.

16. Land-Disturbing Activity: Any activity which may result in soil erosion from water or wind and the movement of sediments into state waters or onto lands within the state, including, but not limited to, clearing, dredging, grading, excavating, transporting, and filling of land but not including agricultural practices as described in Section III, Paragraph 5.

17. Metropolitan River Protection Act (MRPA): A state law referenced as O.C.G.A. 12-5-440 et seq., which addresses environmental and developmental matters in certain metropolitan

river corridors and their drainage basins.

18. Natural Ground Surface: The ground surface in its original state before any grading, excavation or filling.

19. Nephelometric Turbidity Units (NTU): Numerical units of measure based upon photometric analytical techniques for measuring the light scattered by finely divided particles of a substance in suspension. This technique is used to estimate the extent of turbidity in water in which colloidally dispersed particles are present.

20. One Hundred Year Flood Plain: Land in the flood plain subject to a one percent or greater statistical occurrence probability of flooding in any given year.

21. Permit: The authorization necessary to conduct a land-disturbing activity under the provisions of this ordinance.

22. Person: Any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, state agency, municipality or other political subdivision of this State, any interstate body or any other legal entity.

23. Project: The entire proposed development project regardless of the size of the area of land to be disturbed.

24. Roadway Drainage Structure: Bridges, culverts and ditches associated with roadway construction, which allow stream flows to move freely under a stream crossing or to convey storm-water run-off from a roadway to a stream.

25. Sediment: Solid material, both organic and inorganic, that is in suspension, is being transported, or has been moved from its

site of origin by air, water, ice, or gravity as a product of erosion.

26. Sedimentation: The action or process of forming or depositing sediment.

27. Stabilization: The process of establishing an enduring soil cover of vegetation and/or mulch or other ground cover and/or in combination with installing temporary or permanent structures for the purpose of reducing to a minimum the erosion process and the resultant transport of sediment by wind, water, ice or gravity.

28. State Waters: Any and all rivers, streams, creeks, branches, lakes, reservoirs, ponds, drainage systems, springs, wells, and other bodies of surface or subsurface water, natural and artificial, lying within or forming a part of the boundaries of the State which are not entirely confined and retained completely upon the property of a single individual, partnership, or corporation.

29. Structural Erosion and Sediment Control Practices: Measures for the stabilization of erosive or sediment-producing areas by utilizing the mechanical properties of matter for the purpose of either changing the surface of the land or storing, regulating or disposing of runoff to prevent excessive sediment loss. Examples of structural erosion and sediment control practices are riprap, sediment basins, dikes, level spreaders, waterways or outlets, diversions, grade stabilization structures, sediment traps, land grading, etc.

30. Trout Streams: All streams or portions of streams within the watershed as designated by the Game and Fish Division of the Georgia Department of Natural Resources under the provisions of

the Georgia Water Quality Control Act, O.C.G.A. 12-5-20 et seq. Streams designated as primary trout waters are defined as water supporting a self-sustaining population of rainbow, brown or brook trout. Streams designated as secondary trout waters are those in which there is no evidence of natural trout reproduction, but are capable of supporting trout throughout the year.

31. Vegetative Erosion and Sediment Control Practices: Measures for the stabilization of erosive or sediment-producing areas by covering the soil with:

    i. Permanent seeding, sprigging or planting, producing long-term vegetative cover; or

    ii. Temporary seeding, producing short-term vegetative cover; or

    iii. Sodding, covering areas with a turf of perennial sod-forming grass.

32. Watercourse: Any natural or artificial watercourse, stream, river, creek, channel, ditch, canal, conduit, culvert, drain, waterway, gully, ravine, or wash in which water flows either continuously or intermittently and which has a definite channel, bed and banks, and including any area adjacent thereto subject to inundation by reason of overflow or floodwater.

SECTION III EXEMPTIONS

This ordinance shall apply to any land-disturbing activity undertaken by any person on any land except for the following:

1. Surface mining, as the same is defined in O.C.G.A. 12-4-72;
2. Granite quarrying and land clearing for such quarrying;
3. Such minor land-disturbing activities as home gardens and individual home landscaping, repairs, maintenance work, and

other related activities which result in minor soil erosion;

4. (A) The construction of single-family residences when such ar constructed by or under contract with the owner for his own occupancy; or

   (B) The construction of single-family residences not a part of a larger project and not exempted under subparagraph (A) of this paragraph; provided, however, that construction of any such residence not otherwise exempt must conform to the minimum standards as set forth in Section IV and that such standards may be enforced by the issuing authority;

5. Agricultural practices involving the establishment, cultivation, or harvesting of products of the field or orchard; the preparation and planting of pasture land; forestry land management practices, including harvesting; farm ponds; dairy operations; livestock and poultry management practices; and th construction of farm buildings;

6. Any project carried out under the technical supervision of the Soil Conservation Service of the United States Department of Agriculture;

7. Any project involving one and one-tenth acres or less; provided, however, that this exemption shall not apply to any land-disturbing activity within 200 feet of the bank of any State waters, and for purposes of this paragraph, "State Waters" excludes channels and drainageways which have water in them only during and immediately after rainfall events and intermittent streams which do not have water in them year-round; provided, however, that any person responsible for a project which involves one and one-tenth acres or less, which involves land-disturbing activity, and which is within

200 feet of any such excluded channel or drainageway, must prevent sediment from moving beyond the boundaries of the property on which such project is located and provided, further, that nothing contained herein shall prevent the issuing authority from regulating any such project which is not specifically exempted by sub-paragraph (B) of paragraph (4) or by paragraphs (1), (2), (3), (5), (6), (8), (9), or (10) of this section;

8. Construction or maintenance projects, or both, undertaken or financed in whole or in part, or both, by the Department of Transportation, the Georgia Highway Authority, or the Georgia Tollway Authority; or any road construction or maintenance project, or both, undertaken by any county or municipality; or construction and maintenance, or either, by any water or sewerage authority established by the General Assembly of this state; provided, however, that:

   (A) If such projects are constructed within 200 feet of the banks of any channels or drainageways which have water in them only during and immediately after rainfall events, or intermittent streams which do not have water in them year-round, then such projects shall conform to the specifications used by the Department of Transportation for control of soil erosion and sedimentation on its highway construction projects;

   (B) If such projects are constructed within 200 feet of the banks of any state waters which do have water in them year-round and in which the drainage area of the watershed upstream from such projects is less than three square miles, then such projects shall conform to the

specifications used by the Department of Transportation for control of soil erosion and sedimentation on its highway construction projects.

(C) If such projects are constructed within 200 feet of the banks of any state waters which do have water in them year-round and in which the drainage area of the watershed upstream from such projects is equal to or more than three square miles, then such projects shall conform to the minimum standards set forth in Section IV and;

(D) If such projects are constructed within 100 feet (horizontal) of the banks of any state waters classified as "trout streams" pursuant to the "Georgia Water Quality Control Act", regardless of the size of the watershed area, then such projects shall conform to the minimum standards as set forth in Section IV.

9. Any land-disturbing activities conducted by any airport authority, provided that any such land-disturbing activity shall conform to the minimum standards set forth in Section IV, or;

10. Any land-disturbing activities conducted by any electric membership corporation or municipal electrical system or any public utility under the regulatory jurisdiction of the Public Service Commission, provided that any such land-disturbing activity shall conform to the minimum requirements set forth in Section IV.

SECTION IV <u>MINIMUM REQUIREMENTS FOR EROSION AND SEDIMENTATION CONTROL</u>

A. General Provisions

Excessive soil erosion and resulting sedimentation can take place during land-disturbing activities. Therefore, plans for

those land-disturbing activities which are not excluded by this ordinance shall contain provisions for application of soil erosion and sediment control measures. The provisions shall be incorporated into the erosion and sediment control plans. Soil erosion and sediment control measures shall conform to the requirements of this ordinance. The application of measures shall apply to all features of the site, including street and utility installations, drainage facilities and other temporary and permanent improvements. Measures shall be installed to prevent or control erosion and sediment pollution during all stages of any land-disturbing activity.

B. Requirements

The permittee shall follow sound conservation and engineering practices to prevent and minimize erosion and resulting sedimentation consistent with the following requirements:

1. Stripping of vegetation, regrading and other development activities shall be conducted in a manner so as to minimize erosion.
2. Cut-fill operations must be kept to a minimum.
3. Development plans must conform to topography and soil type so as to create the lowest practical erosion potential.
4. Whenever feasible, natural vegetation shall be retained, protected and supplemented.
5. The disturbed area and the duration of exposure to erosive elements shall be kept to a practicable minimum.
6. Disturbed soil shall be stabilized as quickly as practicable.

7. Temporary vegetation or mulching shall be employed to protect exposed critical areas during development.

8. Permanent vegetation and structural erosion control measures shall be installed as soon as practicable.

9. To the extent necessary, sediment in run-off water must be trapped by the use of debris basins, sediment basins, silt traps, or similar measures until the disturbed area is stabilized.

10. Adequate provisions must be provided to minimize damage from surface water to the cut face of excavations or the sloping surface of fills.

11. Cuts and fills may not endanger adjoining property.

12. Fills may not encroach upon natural watercourses or constructed channels in a manner so as to adversely affect other property owners.

13. Grading equipment must cross flowing streams by means of bridges or culverts except when such methods are not feasible and provided, in any such case, that such crossings are kept to a minimum.

14. Land-disturbing activity plans for erosion and sedimentation control shall include provisions for control or treatment of any source of sediments and adequate sedimentation control facilities to retain sediments onsite or preclude sedimentation of adjacent streams beyond the levels specified in paragraph (18) of this section;

15. Land-disturbing activities shall not be conducted within the 100-year flood plain unless compliance with any applicable local flood plain management ordinance

is demonstrated or such construction is in compliance with the Federal Emergency Management Agency regulations or flood storage compensation for flood waters is provided;

16. An undisturbed natural vegetative buffer of 25 feet measured from the stream banks shall normally be retained adjacent to any state waters except where otherwise required by the "Metropolitan River Protection Act", O.C.G.A. 12-5-440 et seq., or by the department pursuant to O.C.G.A. 12-2-8, or when the economic use and the contour of the land require a different buffer subject to the division's approval, or where a drainage structure must be constructed, provided that adequate erosion control measures are incorporated in the project plans and specifications and are implemented;

17. Land-disturbing activities shall not be conducted within 100 feet (horizontal) of the banks of any state waters classified as "trout streams" pursuant to the "Georgia Water Quality Control Act", O.C.G.A. 12-5-20 et seq., unless a variance for such activity is granted by the director except where a roadway drainage structure must be constructed, provided that adequate erosion control measures are incorporated in the project plans and specifications and are implemented; and

18. Discharges of stormwater runoff from disturbed areas shall be controlled to the extent that turbidity of the stormwater runoff shall not exceed 50

nephelometric turbidity units higher than the turbidity level of the receiving stream immediately upstream from the stormwater runoff discharge at the time of such discharge except where a roadway drainage structure must be constructed, the turbidity of the receiving stream downstream of the construction site shall not exceed 60 nephelometric turbidity units higher than the turbidity level of the receiving stream immediately upstream from the construction site. Downstream turbidity measurements shall be taken at points where the entering discharge is fully mixed with the receiving stream flow. Should the division determine that other turbidity limits may be applicable, the issuing authority may accept same.

SECTION V APPLICATION/PERMIT PROCESS

A. GENERAL

The landowner, developer and designated planners and engineer shall review the general development plans and detailed plans of the issuing authority that affect the tract to be developed and the area surrounding it. They shall review the zoning ordinance, subdivision ordinance, this ordinance, and other ordinances which regulate the development of land within the boundaries of the issuing authority.

B. APPLICATION REQUIREMENTS

1. No person shall conduct any land-disturbing activity within the confines of the City or County Name without first obtaining a permit from the Issuing Authority of City or County Name to perform such activity.
2. The application for a permit shall be submitted to the

Issuing Authority and must include the applicant's erosion and sedimentation control plan with supporting data, as necessary. Said plans shall include, as a minimum, the data specified in Section V, C of this ordinance. Soil erosion and sedimentation control plans shall conform to the provisions of Section IV of this ordinance. Applications for a permit will not be accepted unless accompanied by ____ copies of the applicant's soil erosion and sedimentation control plans.

3. A fee, in the amount of $_____, shall be charged for each application.

4. Immediately upon receipt of an application and plan for a permit, the Issuing Authority shall refer the application and plan to the Local Soil and Water Conservation District for its review and approval or disapproval concerning the adequacy of the erosion and sediment control plan. The results of the District review shall be forwarded to the Issuing Authority. No permit will be issued unless the plan has been appproved by the District, and any variances required by Section IV B (16 & 17) and bonding, if required as per Section V B (5), have been obtained. Such review will not be required if the Issuing Authority and the District have entered into an agreement which allows the Issuing Authority to conduct such review and approval of the plan without referring the application and plan to the District.

5. When reviewing any application for a land-disturbing activity permit, the Issuing Authority shall consider the past record of the permit applicant in complying with

previous land-disturbing activity permits and this ordinance. If the applicant has had two or more violatic of previous permits or this ordinance within three years prior to the date of the filing of the application under consideration, the Issuing Authority may require the applicant to post a bond up to, but not exceeding, $3,000 per acre of the proposed land-disturbing activity prior to issuing the permit. If the applicant does not comply with this ordinance or with the conditions of the permit after issuance, the Issuing Authority may call the bond or any part thereof to be forfeited and may use the proceeds to hire a contractor to stabilize the site of the land-disturbing activity and bring it into compliance.

C. PLAN REQUIREMENTS

1. Plans must be prepared to meet the miniumum requirements contained in Section IV of this ordinance.

   Conformance with the minimum requirements may be attained through the use of design criteria in the Manual For Erosion And Sediment Control In Georgia, revised in 1989, published by the State Soil and Water Conservation Commission as a guide; or through the use of alternate design criteria which conform to sound conservation and engineering practices. The Manual for Erosion and Sediment Control in Georgia is hereby incorporated by reference into this ordinance.

   The Plan for the land-disturbing activity shall consider the interrelationship of the soil types, geological and hydrological characteristics, topography, watershed, vegetation, proposed permanent structures including

roadways, constructed waterways, sediment control and storm water management facilities, local ordinances and State laws.

2. Data Required For Site Plan:

(A) Narrative or notes, and other information: Notes or narrative to be located on the site plan in general notes or in erosion and sediment control notes.

(B) Description of existing land use at project site and description of proposed project.

(C) Name, address, and phone number of developer/owner.

(D) Name and phone number of 24-hour local contact who is responsible for erosion and sediment controls.

(E) Size of project, or phase under construction, in acres.

(F) Activity schedule - show anticipated starting and completion dates for project. Include the statement in <u>bold</u> <u>letters</u>, that "the installation of erosion control measures and practices shall occur prior to or concurrent with land disturbing activities."

(G) Stormwater and sediment management systems-storage capacity, hydrologic study, and calculations, including off-site drainage area.

(H) Vegetative plan - for all temporary and permanent vegetative practices, including species, planting dates, and seeding, fertilizer, lime, and mulching rates. Vegetative plan should show options for year-round seeding.

(I) Detail drawings - for all structural practices. Specifications may follow guidelines set forth in the

Manual for Erosion and Sediment Control in Georgia.

(J) Maintenance statement - "Erosion control measures w: be maintained at all times. Additional erosion and sediment control measures will be installed if deemed necessary by onsite inspection."

3. Maps, drawings, and supportive computations shall bear the signature/seal of a registered or certified professional in engineering, architecture, landscape architecture, land surveying, or erosion and sedimentation control.

(A) Graphic scale and north point or arrow indicating magnetic north.

(B) Vicinity maps showing location of project and existing streets.

(C) Boundary line survey.

(D) Delineation of disturbed areas within project boundary.

(E) Existing and planned contours, with contour lines drawn with an interval of not more than five (5) feet. (The procedure or method used in arriving at the contour intervals shall be indicated.)

(F) Adjacent areas and features areas such as streams, lakes, residential areas, etc. which might be affected should be indicated on the plan.

(G) Proposed structures or additions to existing structures and paved areas.

(H) Delineate 100-year flood plain. (Reference data used in determination.)

(I) Delineate the 25-foot undisturbed vegetative buffer adjacent to state waters.

(J) Delineate the 100-foot management zone along designated trout streams where applicable.

(K) Location of erosion and sediment control practices, preferably using uniform coding symbols from the Manual for Erosion and Sediment Control in Georgia, Chapter 6. Practices may include, but are not limited to:

(1) Construction exit

(2) Sediment barrier

(3) Sediment basin

(4) Grassed waterway (open swale)

(5) Storm drain outlet protection

4. Maintenance of all soil erosion and sedimentation control practices, whether temporary or permanent, shall be at all times the responsibility of the owner.

D. PERMITS

1. Permits shall be issued or denied as soon as practicable but in any event not later than forty-five (45) days after receipt by the issuing authority of a completed application, providing variances and bonding are obtained, where necessary.

2. No permit shall be issued by the Issuing Authority unless the erosion and sedimentation control plan has been approved by the District and the Issuing Authority has affirmatively determined that the plan is in compliance with this ordinance, any variances required by Sec. IV B (16 & 17) are obtained, bonding requirements, if necessary, as per Sec. V B. 5 are met and all ordinances and rules and regulations in effect within the City or County name

are met.

If the permit is denied, the reason for denial shall be furnished the applicant.

3. If the tract is to be developed in phases, then a separate permit shall be required for each phase.

4. The permit may be suspended, revoked, or modified by the Issuing Authority, as to all or any portion of the land affected by the plan, upon finding that the holder or his successor in the title is not in compliance with the approved erosion and sediment control plan or that the holder or his successor in title is in violation of this ordinance. A holder of a permit shall notify any successor in title to him as to all or any portion of the land affected by the approved plan of the conditions contained in the permit.

SECTION VI INSPECTION AND ENFORCEMENT

A. The _____ will periodically inspect the sites of land-disturbing activities for which permits have been issued to determine if the activities are being conducted in accordance with the plan and if the measures required in the plan are effective in controlling erosion and sedimentation. If, through inspection, it is deemed that a person engaged in land-disturbing activities as defined herein has failed to comply with the approved plan, with permit conditions, or with the provisions of this ordinance, a written notice to comply shall be served upon that person. The notice shall set forth the measures necessary to achieve compliance and shall state the time within which such measures must be completed. If the person engaged in the land-disturbing activity fails to comply

within the time specified, he shall be deemed in violation of this ordinance.

B. The _____ shall have the power to conduct such investigations as it may reasonably deem necessary to carry out duties as prescribed in this ordinance, and for this purpose to enter at reasonable times upon any property, public or private, for the purpose of investigation and inspecting the sites of land-disturbing activities.

C. No person shall refuse entry or access to any authorized representative or agent of the Issuing Authority, the Conservation Commission, the District, or Division who requests entry for the purposes of inspection, and who presents appropriate credentials, nor shall any person obstruct, hamper or interfere with any such representative while in the process of carrying out his official duties.

SECTION VII PENALTIES AND INCENTIVES

A. Failure to Obtain a Permit for Land-Disturbing Activity:

If any person commences any land-disturbing activity requiring a land-disturbing permit as prescribed in this ordinance without first obtaining said permit, the person shall be subject to revocation of his business license, work permit or other authorization for the conduct of a business and associated work activities within the jurisdictional boundaries of the Issuing Authority.

B. Stop-Work Orders:

Upon notice from the Issuing Authority or its agent, work on any project that is being done contrary to the provisions of this ordinance or in a dangerous or unsafe manner, shall be immediately stopped. Such notice shall be in writing and shall

be given to the owner of the property, his authorized agent or the person or persons in charge of the activity on the property, and shall state the conditions under which work may be resumed. Where an emergency exists, no written notice shall be required.

C. Bond Forfeiture:

If, through inspection, it is determined that a person engaged in land-disturbing activities has failed to comply with the approved plan, a written notice to comply shall be served upon that person. The notice shall set forth the measures necessary to achieve compliance with the plan and shall state the time within which such measures must be completed. If the person engaged in the land-disturbing activity fails to comply within the time specified, he shall be deemed in violation of this ordinance and, in addition to other penalties, shall be deemed to have forfeited his performance bond, if required to post one under the provisions of Section V, B. 5. The Issuing Authority may call the bond or any part thereof to be forfeited and may use the proceeds to hire a contractor to stabilize the site of the land-disturbing activity and bring it into compliance.

D. Civil Penalties:

Any person violating any provisions of this ordinance, permitting conditions, or stop-work order shall be liable for a civil penalty of not less than $500 per day, by a sentence of imprisonment not exceeding 60 days in jail or both fine and jail or work alternative. Each day the violation continues shall constitute a separate offense.

SECTION VIII ADMINISTRATIVE APPEAL, JUDICIAL REVIEW

A. Administrative Remedies:

The suspension, revocation, modification or grant with condition of a permit by the Issuing Authority upon finding that the holder is not in compliance with the approved erosion and sediment control plan; or that the holder is in violation of permit conditions; or that the holder is in violation of any ordinance; shall entitle the person submitting the plan or holding the permit to a hearing before the _____ within _____ days after receipt by the Issuing Authority of written notice of appeal.

B. Judicial Review:

Any person, aggrieved by a decision or order of the Issuing Authority, after exhausting his administrative remedies, shall have the right to appeal de novo to the Superior Court of _____.

SECTION IX EFFECTIVITY, VALIDITY AND LIABILITY

A. EFFECTIVITY

This ordinance shall become effective on the ___ day of _____, 19___.

B. VALIDITY

If any section, paragraph, clause, phrase, or provision of this ordinance shall be adjudged invalid or held unconstitutional, such decisions shall not affect the remaining portions of this ordinance.

C. LIABILITY

Neither the approval of a plan under the provisions of this ordinance, nor the compliance with provisions of this ordinance shall relieve any person from the responsibility for damage to any person or property otherwise imposed by law nor impose any

liability upon the (Municipality/County) or (District) for damage to any person or property.

ATTEST:

Signature

Signature