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MEMORANDUM

TO: Recipients of the *Manual for Erosion and Sediment Control of Georgia*, 5th Edition

FROM: F. Graham Liles, Jr., Executive Director

DATE: April 28, 2000

RE: *Manual for Erosion and Sediment Control in Georgia*, 5th Edition

Thank you for your request for the *Manual for Erosion and Sediment Control in Georgia*, 5th Edition. Unfortunately, due to cost constraints, we are unable to provide complete manuals or manual amendments to all individual requests. To satisfy the high demand for this publication, we are forced to limit each firm/organization to only one copy. A copy of the amendments is included if our records indicate that your firm/organization currently has a copy of the 4th edition. A complete copy is included if our records do not indicate a full manual has been issued in the past.

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If you should have any additional questions concerning this matter, please contact Dana M. Heil at 706-542-3065.

MANUAL FOR EROSION AND SEDIMENT CONTROL IN GEORGIA

Fifth Edition
2000

includes any
changes through
January 1, 2000

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PREFACE TO THE FIFTH EDITION

The fourth edition of the "Manual for Erosion and Sediment Control in Georgia" has been revised with a focus on erosion control. Implementation of newly researched products has been incorporated to expand on the traditional erosion and sediment control practices included in the fourth edition. These new products have been proven to aid in controlling erosion and subsequent sedimentation in a cost-effective manner.

It is important that this publication is used as a guideline and that "creativity" must be utilized when necessary to fully protect a site from erosion and subsequent sedimentation. The fifth edition has been modified to include detailed guidance on what is required on erosion and sediment control plans.

Several important additions and changes have been incorporated into the fifth edition. The definition of "stabilized" and "final stabilization" as well as time-lines for the application for vegetation have been included. Eight new practices have been added. These are Construction Road Stabilization, Stream Diversion Channel, Filter Ring, Disturbed Area Stabilization (With Sodding), Erosion Control Matting and Blankets, Polyacrylamide (PAM), Streambank Stabilization, and Tackifiers and Binders.

Every effort has been made to incorporate pertinent aspects of the Georgia Department of Transportation's erosion and sediment control specifications. Additional information on "linear" projects has been included as well.

It is hoped that users of this manual will realize the significant changes and recognize that technology changes rapidly in the erosion and sediment control arena. The Commission is dedicated to providing the State of Georgia with the latest "proven" erosion and sediment control practices.

The Commission is appreciative of all of the help and guidance received during the revision of the manual. Many thanks go to the Georgia Department of Transportation, Natural Resources Conservation Service, DNR Environmental Protection Division, DNR Wildlife and Fisheries, University of Georgia, UGA Institute of Ecology, Gwinnett County Planning and Development, the Upper Chattahoochee Riverkeeper, and Jim Spotts Ph.D., CPESC.

FOREWORD

Perhaps the most harmful damage to Georgia's land and water resources is incurred through unchecked and uncorrected erosion and sediment deposition. Years of work have done much to remedy the situation. There has also been created an awareness that efforts must continue to further reduce the volume of the sediment pollution in all the state's waters.

While ongoing work in soil and water conservation has been of considerable success, it was recognized that some state regulation of land-disturbing activities could add a needed dimension to the overall control effort. The General Assembly responded to this need, and in 1975, the Erosion and Sedimentation Act (O.C.G.A. 12-7-1 et seq.) was passed. The Act has been amended several times since then.

The Act requires counties and municipalities to have erosion and sediment control ordinances or be covered under state regulations. While the Soil and Water Conservation Districts provide assistance in this at the local level, the State Soil and Water Conservation Commission provides expert, step-by-step guidance for activities under such ordinances through a comprehensive publication of reference information. Thus the ``Manual for Erosion and Sediment Control in Georgia" can serve as a technical guide in formulating plans for land-disturbing activities. In preparing the manual, the State Conservation Commission is indebted to the many hundreds of researchers, engineers, farmers, conservationists and others who, over the years, made possible the accumulation of information on modern conservation.

The criteria, standards and specifications contained in Chapter 6 must be incorporated into all local erosion and sediment control programs. The remaining chapters and sections of this Manual contain guidelines and support materials to assist users in the implementation of best management practices in accordance with the provisions of the Erosion and Sedimentation Act.

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CHAPTER 1

The Erosion and
Sedimentation Act of 1975

CHAPTER 1

THE EROSION AND SEDIMENTATION ACT OF 1975

On April 24, 1975, the Honorable George Busbee, Governor of the State of Georgia, signed into law Act 599, the Erosion and Sedimentation Act of 1975 (O.C.G.A. 12-7-1 et. seq.) This landmark legislation is the result of over five years of exhausting work, debate and legislative compromise.

With the passage of the Act, Georgia joined the few far-sighted states adopting legislation specifically designed to protect soil and water resources. But, of all the various state laws, Georgia's shows the greatest concern for *local* implementation and *local* enforcement. There now exists in Georgia a mechanism whereby local decision makers can do something about the abuses of soil and water resources which have troubled them so long.

The Erosion and Sedimentation Act of 1975 states: "It is found that soil erosion and sediment deposition onto lands and into waters within the watersheds of this State are occuring as a result of widespread failure to apply proper soil erosion and sedimentation control practices in land clearing, soil movement and construction activities, and that such erosion and sediment deposition result in pollution of State waters and damage to domestic, agricultural, recreational, fish and wildlife, and other resource uses. It is, therefore, declared to be the policy of this State and the intent of this Act to strengthen and extend the present erosion and sediment control program to conserve and protect land, water, air and other resources of this State."

Numerous studies have been made which indicate the vast amounts of sediment eroding from our lands. It has been estimated, for example, that approximately 4 billion tons of sediment are eroded in the United States each year (13).

Sediment in Georgia comes from many sources including farm land, roadside construction sites and even city streets. Studies show sediment yields from agricultural areas can average about seven tons per acre per year (17). Lands undergoing development for roadways and urban and suburban development are experiencing losses at a much higher rate. A research project at Cartersville, Georgia, indicated that total area erosion from roadbanks without proper vegetative cover can exceed over 350 tons per acre per year (9).

Figure 1-1. – Erosion on this construction site was the result of poor planning.

Figure 1-2. – Advanced gully erosion on an abandoned construction site.

Historically, farm land has been the greatest source of sediment. The trend was reversed around the midpoint of the century with much idle land or land in row crops planted to perennial grasses or trees. Records from various waterworks in Georgia tell the effects of this movement. Water analysis at the Atlanta waterworks, for instance, showed that the average turbidity of water taken from the Chattahoochee River dropped from 400 parts per million in the 1930's to less than 40 ppm in the 1950's. It is now reported to be about 25 ppm (17). Similar data was recorded in Newnan, Columbus, Macon and other cities.

Erosion damage is costly to repair, often requiring regrading or replacement of eroded soil and replacement of damaged pavements and structures. Sediment damages are not only unnecessary but extremely costly. A report shows that on five harbor projects in Michigan, a total of over one million cubic yards of man-induced sediment was removed at a cost of $2.50-$4.00 per cubic yard. Yet the establishment of control measures to hold this soil in place would have cost only 10-15 cents per cubic yard (29)!

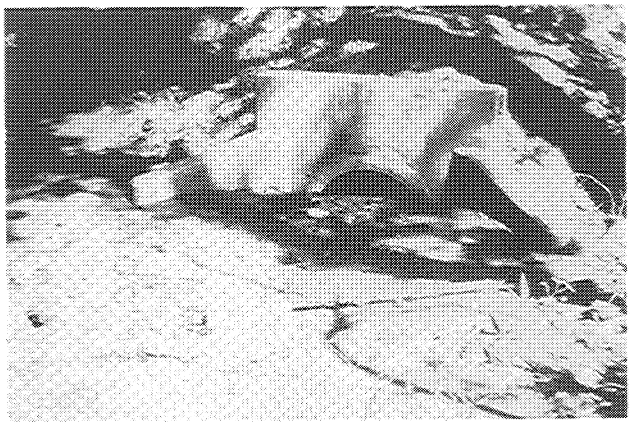


Figure 1-3. – Sediment from upstream erosion has severely reduced the capacity of this culvert

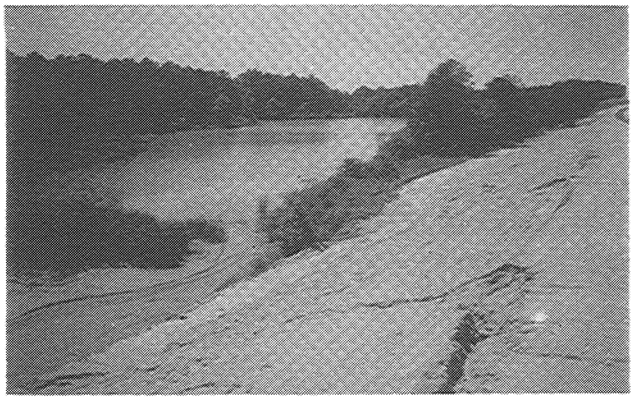


Figure 1-5. – If unchecked, sediment would gradually fill this lake.

Georgia's soil and water conservation districts have been charged with performing a vital role in the implementation of Act 599. Since their formation beginning in 1937, the districts have worked toward treating each acre of land in accordance with its capabilities. This has been done on two-thirds of Georgia's 37 million acres with most of the work on agricultural lands. The Erosion And Sedimentation Act, however, will deal primarily with land-disturbing activities in urban and urbanizing areas. It should be remembered that the same methodolgy and expertise is required in planning for the conservation of soil and water on any lands.

It is believed that Act 599 will effectively reduce the major source of water pollution in Georgia. And because two-thirds of the population is located in urban areas covering less than seven percent of the land, this reduction in erosion damage to natural resources will occur in locations most critical to the general health and wellbeing of the people.

Figure 1-4. – Removing sediment from this tennis court was a costly and time consuming operation.

PROVISIONS UNDER ACT 599

Act 599 requires that governing authorities of Georgia's 159 counties and 537 incorporated municipalities adopt comprehensive ordinances governing land-disturbing activities within their boundaries. The ordinances must contain technical principles as provided in the law and procedures for issuance of permits.

There are minimum standards included in the law. Local ordinances may, however, be more stringent than the minimum requirements of the law. Municipalities may specify in their ordinances that the responsibilities of permit issuance, inspection, and enforcement be delegated to the local Planning and Zoning Commission.

Municipalities and counties failing to have in effect a comprehensive erosion and sediment control program will be subject to rules and regulations developed by the Environmental Protection Division of the Georgia Department of Natural Resources. This division of state government would then issue permits, perform inspections and become the enforcer for all land-disturbing activities within their boundaries until such time as the local authorities adopt an ordinance.

LAND-DISTURBING ACTIVITY:

"Any activity which may result in soil erosion from water or wind and the movement of sediments into state water or onto lands within the state, including, but not limited to:

1. clearing
2. dredging
3. grading
4. excavating
5. transporting
6. filling"

The law could have a significant impact on any area's natural resource base because it requires detailed planning *before* land-disturbing activities are undertaken. The law requires that erosion and sediment control plans for each non-exempt activity be prepared and submitted with application to the local unit of government for a permit. The plans will then be forwarded to the appropriate Soil and Water Conservation District. This agreement, in effect, would bypass District approval if the local unit demonstrates that it possesses the capability and expertise to conduct erosion and sediment control plan review.

After a thorough analysis of the plans, they will be returned to the issuing authority with the District's recommendations upon which the issuing authority will issue or deny permits. Should a permit be denied because of a discrepancy in the plans, such discrepancies *must* be made apparent to the applicant. The law requires that a permit be issued or denied within a period not to exceed 45 days after the plan and applications are submitted. If a permit is denied there are appeal procedures provided for in the Act.

The law deals basically with processes. That is, permit processing, plan processing, etc. However, technical guidelines are included as minimum requirements which may be strengthened by local units of government. The technical requirements, if skillfully utilized in planning for land-disturbing activities, will result in orderly development but with the ultimate result of conserving and protecting soil resources.

There are several exclusions or exemptions written into the Act. Home gardens and individual home landscaping require no permit nor does the construction of single-family residences for individuals owners. Surface mining and granite quarrying are covered by other laws and are exempt, as are all agricultural and forestry practices. Projects carried out under the technical supervision of the USDA Natural Resources Conservation Service are exempt.

Public utilities regulated by the Public Service Commission are exempt but required to meet State minimum erosion and sedimentation control standards. Also exempted are land-disturbing projects financed in any way by the Department of Transportation or the Georgia Highway and Tollway Authority, as well as any road construction or maintenance project undertaken by any county or municipality, provided they meet State minimum requirements.

Key exemptions to the permit provisions of the Act are found in the requirements that any land change to 1.1 acres or less will require a permit if they are within 200 feet of state waters.

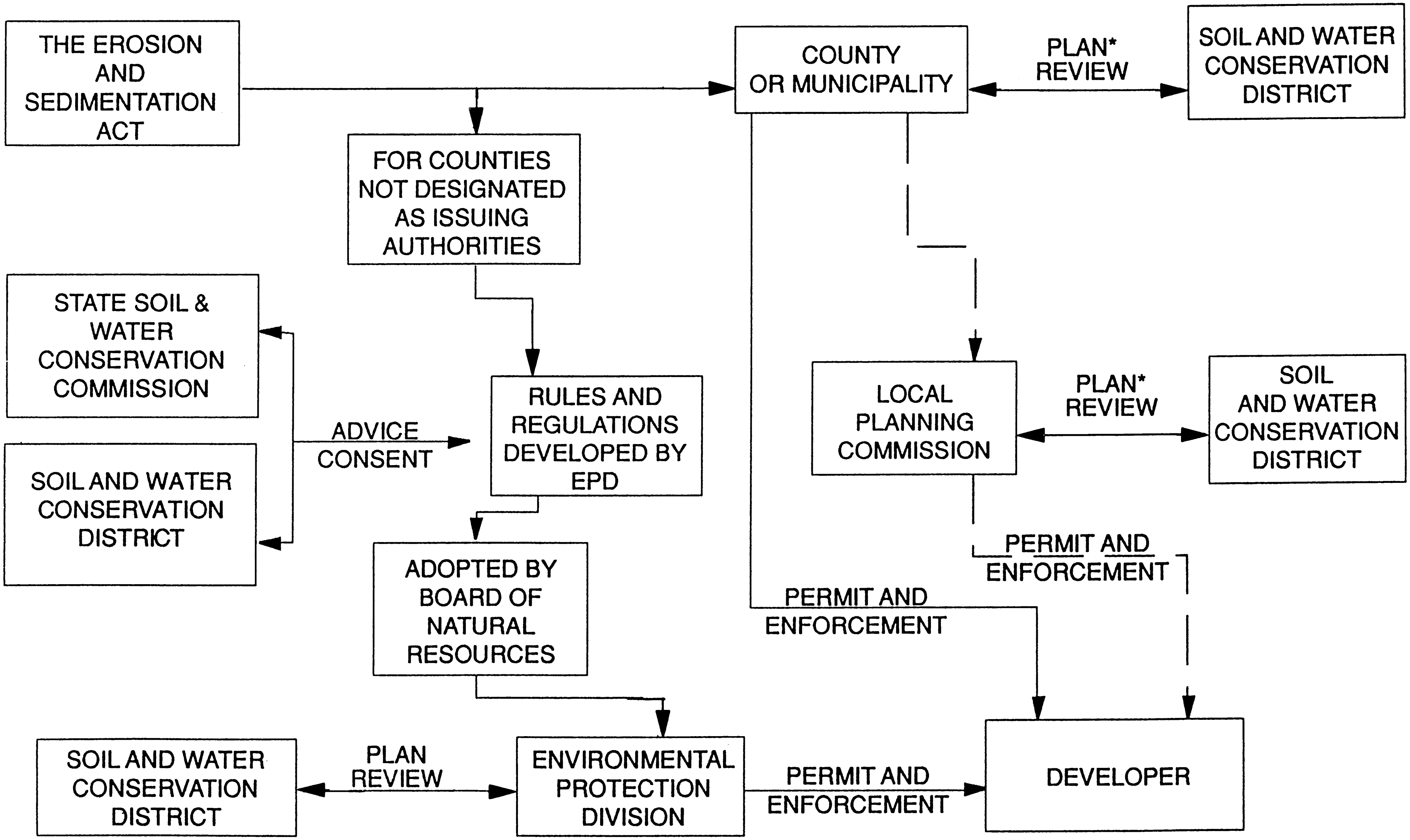
At this point it should be repeated that Act 599 provides *minimum* requirements to be adopted by local units of government. Said units are permitted to strengthen ordinances by elimination of certain exclusions.

LAND DISTURBING ACTIVITY DOES NOT INCLUDE:

1. Suface mining
2. Granite quarrying
3. Minor land-disturbing activities
4. a. Construction of single-family residences under contract to the owner
   b. Construction of single-family residences not part of a larger project; provided the activity meets State minimum requirements.
5. Agricultural and forestry practices
6. Any project under the technical supervision of the Natural Resources Conservation Service
7. Projects involving 1.1 acres or less (if not within 200 feet of state waters)
8. Construction or maintenance by the Department of Transportation, Georgia Highway Authority, Georgia Tollway Authority; road construction or maintenance project undertaken by counties or muncipalities; provided the activity meets State minimum requirements.
9. Projects undertaken by EMCs or municipal electrical systems, or any public utility under the Public Service Commission, provided the activity meets State minimum requirements.

Figure 1-6

AGENCIES AND AUTHORITIES EROSION AND SEDIMENTATION ACT OF 1975



* This step may be bypassed if the local unit of government: (1) Has been certified by the Department of Natural Resources as meeting or exceeding the standards, requirements, and provisions of the Act and
(2) Enters into a Memorandum of Agreement with the local District.

THE MANUAL

This manual has been assembled to provide guidance in the implementation of Act 599. It was written for four specific audiences.

1. The **land disturbers:** landowners, developers and their consultants, architects, engineers, land surveyors, planners, etc.
2. The **enforcers:** officials and employees of local units of government charged with responsibility of administering and enforcing the law on a local level and the Environmental Protection Division when it is the issuing authority.
3. The **plan reviewers:** the Soil and Water Conservation Districts and local issuing authorities.
4. The **plan preparers.**

CHAPTER 2

Sediment and Erosion Control Processes, Principles and Practices

CHAPTER 2

SEDIMENT AND EROSION CONTROL PROCESSES, PRINCIPLES AND PRACTICES

Erosion is the process by which the land surface is worn away by the action of wind, water, ice or gravity. Water-generated erosion is unquestionably the most damaging and is thus the problem to which this manual is primarily addressed.

Natural, or geologic, erosion has been occurring at a relatively slow rate since the earth was formed and is a tremendous factor in creating the earth as we know it today. The picturesque mountains of the north, the fertile farmlands of the Piedmont and the productive estuaries of the coastal zone are all products of geologic erosion and sedimentation in Georgia. Excepting some cases of shore and stream channel erosion, natural erosion occurs at a very slow and uniform rate and remains a vital factor in maintaining environmental balance.

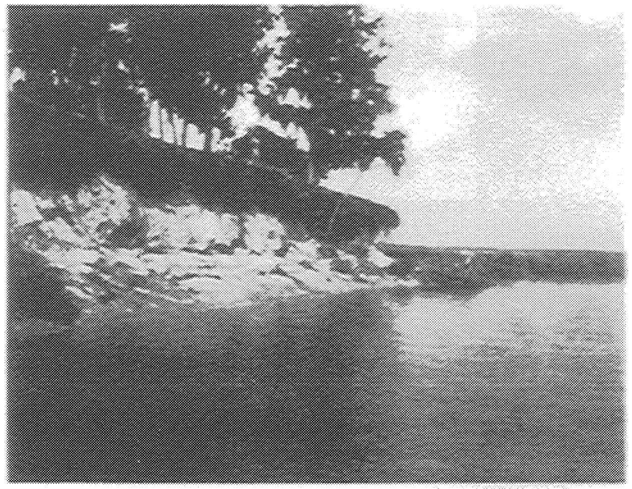


Figure 2-1. - Erosion of this coastal shore is an example of geologic erosion.

Human alteration of the earth's surface can lead to "accelerated erosion." This is a classic example of environmental abuse and is normally the result of poor planning and unorganized construction.

Erosion by water is a process of breaking loose and transporting soil particles. The energy of raindrops falling on denuded or exposed soils is the key element. The annual impact energy of raindrops, for instance, has been estimated to average approximately 30 billion foot-pounds or the equivalent of 10 thousand tons of T.N.T. per square mile (19). Water flowing over exposed soil picks up detached soil particles. As the velocity of flowing water increased, 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. As the volume and velocity of runoff increases in unprotected streams and channels, additional erosion occurs on stream banks and bottoms.

Figure 2.2. - Energy of falling raindrops has detached and transported soil particles from unprotected areas.

Sedimentation is the process where soil particles settle out of suspension as the velocity of water decreases. The heavier particles, gravel and sand, settle out more rapidly than fine silt and clay particles. The characteristic reddish color of Georgia's streams in the Piedmont results from suspended microscopic clay particles. Unfortunately, these 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 and temperature extremes are principle factors influencing the volume of runoff from a given area. As the volume and intensity of rainfall increases, the ability of water to detach and transport soil particle 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, soils with high moisture content are subject to "spew," or uplift by freezing action, and are usually very easily eroded upon thawing.

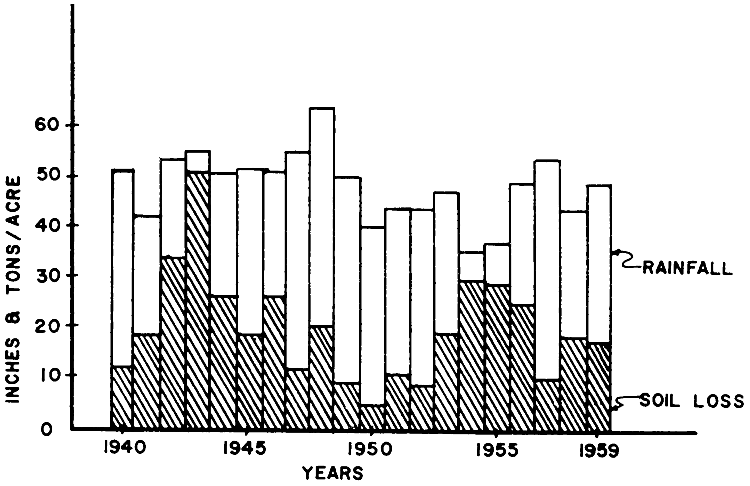
Topography. The size, shape and slope characteristics of a watershed influence the amount and duration of runoff. The greater the slope length and gradient, the greater the potential for both runoff and erosion. Velocities of water will increase as the distance from the top of the slope or the grade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

Soils. The soil type will determine its vulnerability to erosion. Properties determining the erodibility of a soil are texture, structure, organic matter content and permeability. Soil containing high percentages of fine sands and silt are normally the most erodible. As the clay and organic matter content of these soils increases, 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 gravels are usually the least erodible soils. The high infiltration rates and permeabilities either prevent or delay runoff.

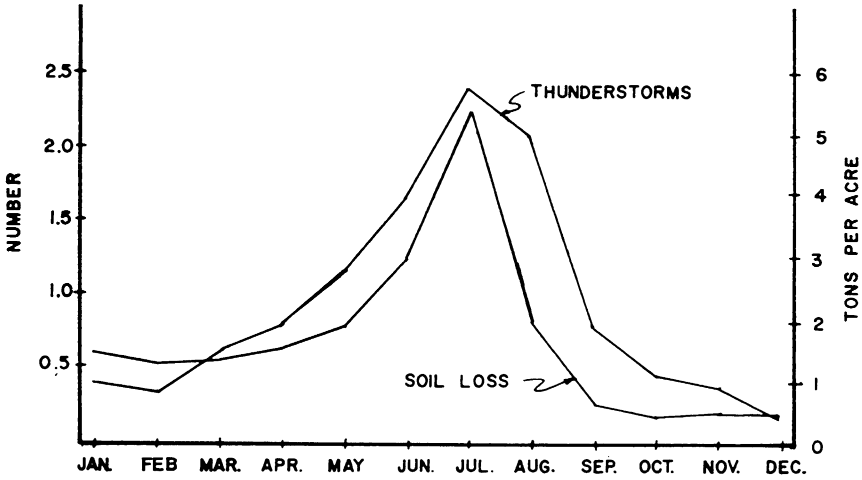
Vegetative Cover. Vegetative cover is an extremely important factor in reducing erosion from a site. It will:

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.



*** Soil Loss Varies Annually**



*** Soil Loss Varies Seasonally**

*Information taken from: Barnett, A. P. and B. H. Hendrickson, *"Erosion on Piedmont Soils," Soil Conservation Magazine, USDA, Soil Conservation Service, Volume XXVI, No. 2 Sept. 1960.*

Figure 2-3.

GENERAL DESIGN PRINCIPLES

For an erosion and sedimentation control program to be effective, it is imperative that provisions for sediment control measures be made in the planning stage. These planned measures, when conscientiously and expeditiously applied during construction, will result in orderly development without adverse environmental degradation.

From the previous discussion on erosion and sediment control processes and factors affecting erosion, basic technical principles can be formulated to assist the project planner or designer in providing for effective sediment control. It is felt that these certain key principles *must* be utilized to the maximum extent possible on all projects.

Fit the Activity to the Topography and Soils. Detailed planning should be employed to assure that roadways, buildings and other permanent features of the activity conform to the natural characteristics of the site. Large graded areas should be located on the most level portion of the site. Areas subject to flooding should be avoided. Areas of steep slopes, erodible soils with severe limitations for the intended uses should not be utilized without overcoming the limitations through sound engineering practices. Erosion control, development and maintenance costs can be minimized if a site is selected for a specific activity rather than attempting to modify the site to conform to the proposed activity.

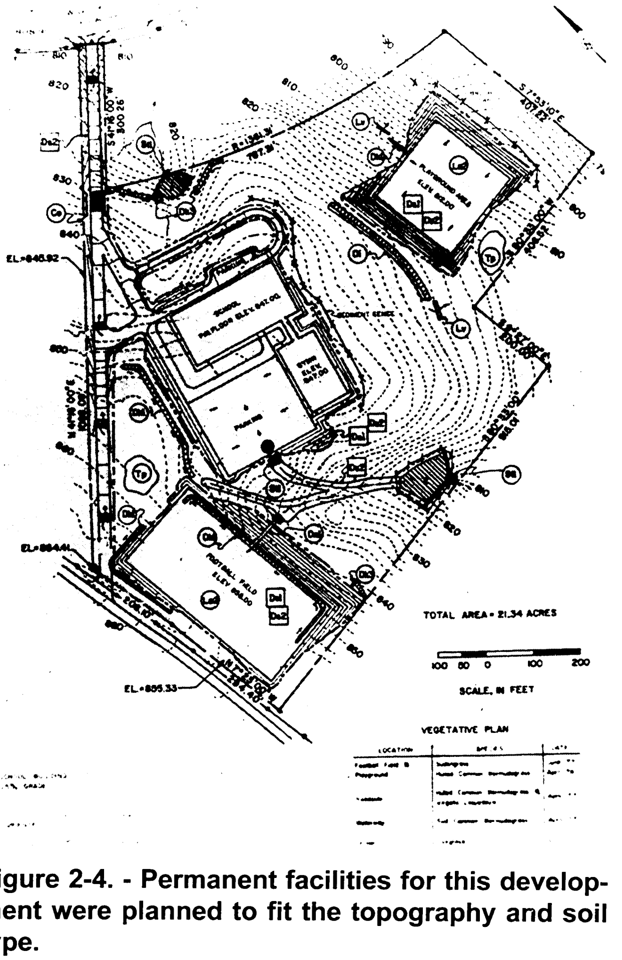


Figure 2-4. - Permanent facilities for this development were planned to fit the topography and soil type.

Figure 2-5. - Unstable soil conditions, as on this roadbank, should be avoided.

The Disturbed Area and the Duration of Exposure to Erosion Elements Should be Minimized. Clearing of natural vegetation should be limited to only those areas of the site to be developed at a given time. Natural vegetation should be retained, protected and *supplemented* with construction scheduling employed to limit the duration of soil exposure. Major land clearing and grading operations should be scheduled during seasons of low potential runoff.

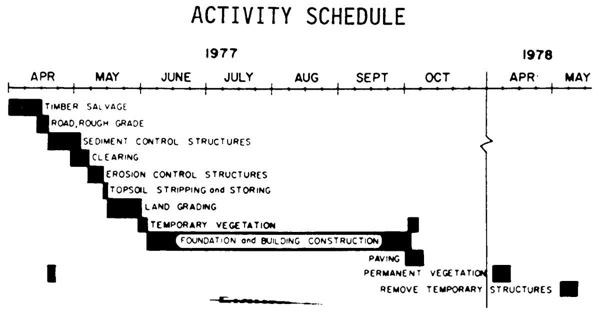


Figure 2-6.

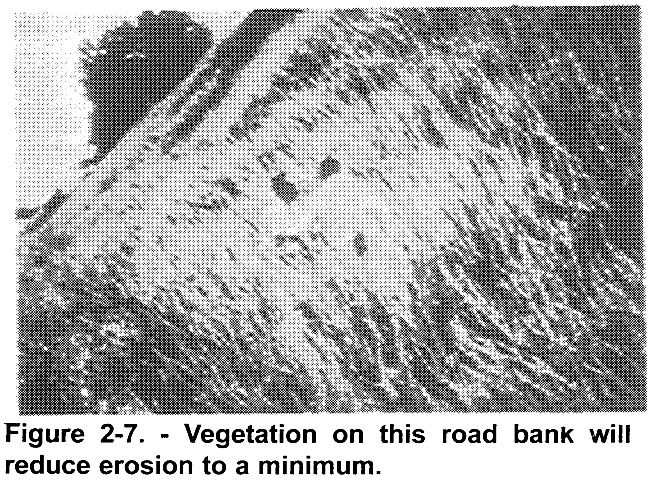


Figure 2-7. - Vegetation on this road bank will reduce erosion to a minimum.

Stabilize Disturbed Areas Immediately. Permanent structures, temporary or permanent vegetation, and mulch, or a combination of these measures, should be employed as quickly as possible after the land is disturbed. Temporary vegetation and mulches can be most effective on areas where it is not practical to establish permanent vegetation. These temporary measures should be employed immediately after rough grading is completed if a delay is anticipated in obtaining finished grade. The finished slope of a cut or fill should be stable and ease of maintenance considered in the design. Stabilize all roadways, parking areas, and paved areas with a gravel subbase, temporary vegetation or mulch.

Figure 2-8. - Hydroseeding equipment can efficiently and quickly establish disturbed areas.

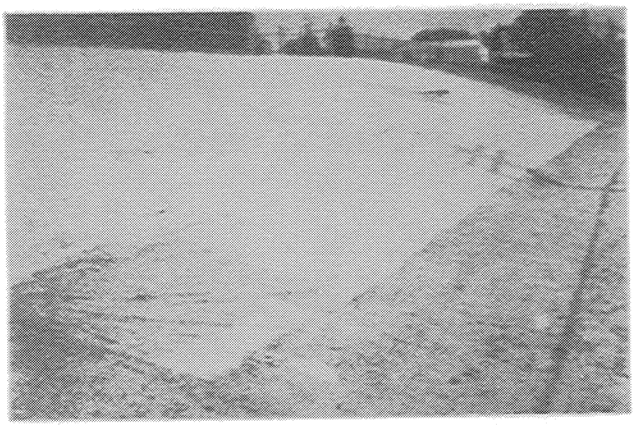


Figure 2-9. - Jute matting can assist in rapid establishment of vegetation.

Retain or Accommodate Runoff. Runoff from the development should be safely conveyed to a stable outlet using storm drains, diversions, stable waterways or similar measures. Consideration should also be given to the installation of storm water detention structures to prevent flooding and damage to downstream facilities resulting from increased runoff from the site. Temporary or permanent facilities for conveyance of storm water should be designed to withstand the velocities of projected peak discharges. These facilities should be operational as soon as possible after the start of construction.

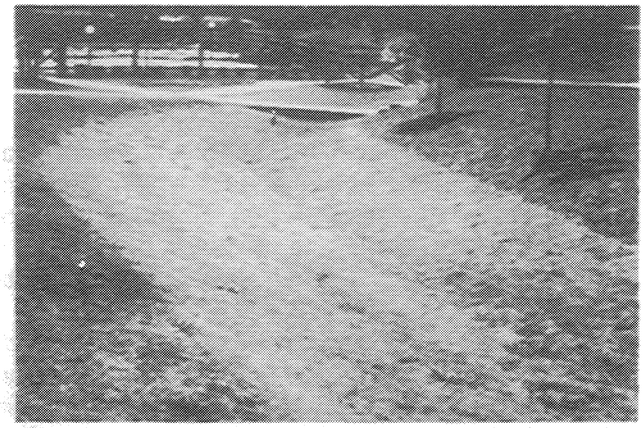


Figure 2-10. - This vegetated waterway will safely convey storm water away from this swimming pool.

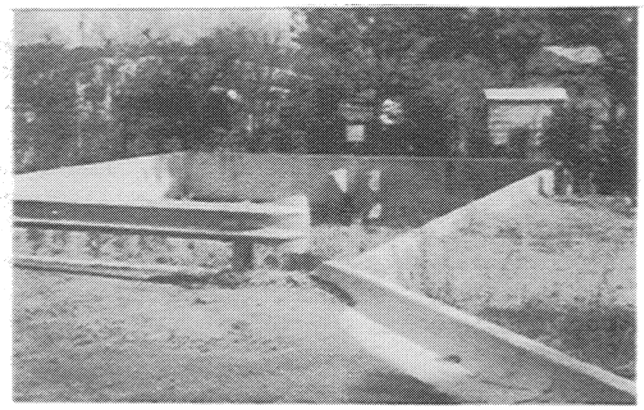


Figure 2-11. - Storm water detention structures will reduce storm water runoff from developed areas.

Retain Sediment. Sediment basins, sediment barriers and related structures should be installed to filter or trap sediment *on the site to be disturbed*. The most effective method of controlling sediment, however is to control erosion at its *source*. Sediment retention structures should be planned to retain sediment when erosion control methods are not practical, are insufficient, in the process of being installed, or have failed due to some unforeseen factor.

Figure 2-12. - This temporary sediment basin effectively trapped sediment from upstream erosion.

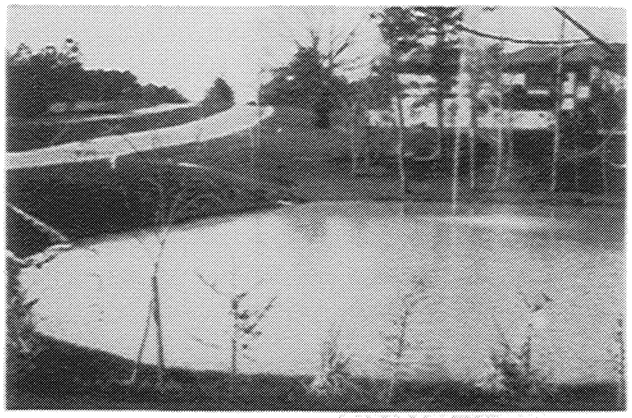


Figure 2-13. - A temporary sediment basin converted to a permanent pond enhances landscape.

Do Not Encroach Upon Watercourses. Permanent buildings should not be subjected to flooding, sediment damages or erosion hazards. Earth fills should not be constructed in flood-prone areas so as to adversely obstruct water flows or increase downstream velocity of water flows. When necessary to span a flood-prone area or watercourse, bridge and culvert openings should be sized to permit passage of peak discharges without causing undue restrictions in water flows or without creating excessive downstream velocities. Uses of flood-prone areas should be limited to activities which would not suffer excessive damages from flooding, scour and sediment. Temporary bridges or culverts should be employed when construction equipment is required to cross natural or constructed channels.

Figure 2-14. - An undersized culvert in this roadway has created an obstruction to floodwaters.

Figure 2-15. - The result when residences are constructed in flood prone areas.

EROSION AND SEDIMENTATION CONTROL PRACTICES

Severe erosion on lands undergoing land-disturbing activities can be reduced if proper control measures are implemented. The timely application of erosion and sediment control measures will minimize the time that the soils are exposed, control runoff, shield the soil from erosive forces, and bind the soils.

A most effective tool in controlling erosion is good site planning which includes planning and installation of erosion sediment control practices. In Chapter 6 of this manual are standards and specifications for such practices which can be utilized on areas undergoing land-disturbing activities. These standards were developed to establish statewide uniformity in selection, design, review, approval, installation and maintenance of conservation practices. They establish minimum requirements for planning, designing and installing the practices on disturbed areas.

For effective erosion control, a combination of these measures must be employed. Alternates may be approved for individual erosion and sediment control plans. In general, they fall into the rather broad categories of structural practices and vegetative measures.

VEGETATIVE CONSERVATION MEASURES

Vegetative practices may be applied singularly or in combination with other conservation measures. They may be either short lived or of a permanent nature. Sub-soils, mixtures of soils and soils with varying organic matter content will be encountered when soil surfaces are disturbed. Unfavorable growth conditions such as acidity, low fertility, compaction and adverse moisture contents are often prevalent. These conditions are difficult to overcome but must be eliminated if adequate plant growth is to be obtained. Steep gradients and long slopes are often present on areas to be vegetated. These areas are subject to erosive forces from rainfall impact and flowing water and will require special techniques and grasses which will resist erosion. Establishing vegetation is possible with techniques and plants developed over the years.

Temporary Vegetation. In many instances, grading of areas is completed at a time when it is not practical to try to establish permanent vegetation. These areas can be stabilized by planting instead a variety of temporary annual grasses such as rye grass, rye, small grains and similar species. These temporary grasses will provide a rapid cover that can later be worked into the soil to provide organic matter when permanent vegetation is established. Every effort should be made to select temporary plants that will be compatible with the final permanent vegetation.

Permanent Vegetation. A wide selection of various grasses, legumes, ground cover, trees and shrubs can be used for permanent vegetation. If a high level of management is possible, an even wider range of plants can be used.

It is imperative that the final selection of plants be based on the adaptability of those plants to the topography and climate. Ease of establishment, life expectancy, maintenance requirements, aesthetics and any other special qualities should be considered. It is desirable to select plants requiring little maintenance. Many plants can be used to improve the aesthetics of a site and still be effective soil stabilizers. Special attention should be given to steep cut and fill slopes where plants requiring little maintenance must be utilized.

Mulching. Due to time constraints, it may be impractical to stabilize an area with vegetation. Excellent temporary soil stabilization can be otherwise achieved using wood chips, straw, hay, asphalt emulsion, jute matting and synthetic fibers. Areas where final grade has been reached can be stabilized with mulch and over seeded at the proper time for permanent grasses. Mulches allow for greater infiltration of water into soil; reduce the amount of runoff; retain seeds, fertilizer and lime in place; and improve soil moisture and temperature conditions. Mulch is essential in establishing good stands of grasses and legumes on disturbed areas. In order to prevent movement by wind or water, it is important that it be anchored to the soil.

Following are examples of vegetative practices suitable for utilization on disturbed land. A map code has been assigned to teach practice and appears at the beginning of the title of each practice.

Bf - BUFFER ZONE

A strip of undisturbed original vegetation, enhanced or restored existing vegetation, or the re-establishment of vegetation surrounding an area of disturbance or bordering streams, ponds, wetlands, lakes, and coastal waters.

Cs - COASTAL DUNE STABILIZATION (WITH VEGETATION)

Planting vegetation on dunes that are denuded, artificially constructed, or re-nourished.

Ds1 - DISTURBED AREA STABILIZATION (WITH MULCHING ONLY)

Using plant residues or other suitable materials on the soil surface to reduce runoff and erosion, conserve moisture, prevent soil compaction and crusting, control undesirable vegetation, modify soil temperature and to increase biological activity in the soil. This practice is applicable where stabilizing disturbed or denuded areas is not practical utilizing seeding or plantings.

Ds2 - DISTURBED AREA STABILIZATION (WITH TEMPORARY SEEDING)

A temporary vegetative cover with fast growing seedings for disturbed or denuded areas. This practice is applicable for up to six months or until permanent vegetative cover can be installed. It should be coordinated with permanent measures to assure economical and effective stabilization. Techniques for establishing temporary cover utilizing both conventional and hydraulic seeding equipment are included.

Ds3 - DISTURBED AREA STABILIZATION (WITH PERMANENT VEGETATION)

A permanent vegetative cover such as trees, shrubs, vines, grasses and legume on disturbed or denuded areas. It will apply on cut and fill slopes, earth spillways, borrow areas, spoil areas and severely eroded or gullied lands. Techniques utilizing both conventional and hydraulic seeding equipment are discussed.

Ds4 - DISTURBED AREA STABILIZATION (WITH SODDING)

A permanent vegetative cover using sods on high-

ly erodible or critically eroded lands. Sods provide immediate ground cover and help filter sediments and nutrients.

Du - DUST CONTROL ON DISTURBED AREAS

Controlling the surface and air movements of dust on construction sites, roadways and similar sites. Methods and materials which can be used include mulches, vegetative cover, spray-on adhesives, mechanical manipulation of existing soils surfaces, irrigation, barriers, chemicals, and stone surface covers.

Mb - EROSION CONTROL MATTING AND BLANKETS

A protective covering (blanket) or soil stabilization mat used to establish permanent vegetation on steep slopes, channels, or shorelines. Blanket and mats provide an excellent microclimate, which protects young vegetation and promotes establishment.

Pm - POLYACRYLAMIDE (PAM)

The land application of product containing anionic polyacrylamide (PAM) as temporary soil binding agents to reduce soil erosion. PAM reduces erosion from wind and water on construction sites.

Sb - STREAMBANK STABILIZATION (USING PERMANENT VEGETATION)

The use of readily available native plant materials to maintain and enhance streambanks, or to prevent, or restore and repair small streambank erosion problems.

Tb - TACKIFIERS AND BINDERS

Substances used to anchor straw or hay mulch by causing the organic material to bind together. Tackifiers and binders reduce runoff and erosion as well as conserve moisture and prevent surface compaction.

EFFECTIVENESS OF GROUND COVER ON EROSION AND SEDIMENT CONTROL ON CONSTRUCTION SITES

Kinds of Ground Cover	Soil Reductions Related to Bare Surfaces
Seedings[1]	
Permanent grasses	99
Ryegrass (perennials)	95
Ryegrass (annuals)	90
Small grain	95
Millet or sudangrass	95
Grass sod	99
Hay (2 tons/acre)	98
Small grain straw (2 tons/acre)	98
Corn stalks (4 tons/acre)	98
Woodchips (6 tons/acre)[2]	94
Wood cellulose fiber (1 3/4 tons/acre)[2]	90
Fiberglass (1000 lbs/acre)[2]	95
Asphalt emulsion (1250 gal/acre)	98

Other kinds of mulches that may be used are gravel, stones, fiber matting and excelsior.

[1] Values of seeded vegetation are based upon a fully established stand.

[2] Based on research in progress.

Reference: USDA, Agricultural Research Service.

STRUCTURAL CONSERVATION PRACTICES

In some instances, vegetative cover and mulches alone will not provide sufficient protection from the erosive forces of water. In such cases, alternate structural practices can be used to curb erosion and sedimentation during land-disturbing activities. These practices should be planned and employed in a practicable combination with vegetative and mulching measures.

Structural practices must be adequately designed and properly installed to accomplish the desired objective. Design should be based on the appropriate storm discharge and velocities. Consideration should be given to the damage potential, safety hazards, planned life and required maintenance of each individual structural practice.

Following is an overview of standards and specifications for structural practices contained in Chapter 6 of this Manual.

Cd – CHECKDAM

A small temporary barrier or dam constructed across a swale or drainage ditch. This is applicable for use in small channels which drain five (5) acres or less (not to be used in a live stream) in order to reduce erosion by slowing the velocity of concentrated storm water flows.

Ch – CHANNEL STABILIZATION

Improving, constructing or stabilizing a natural or artificial channel for conveying water flows. In certain instances on selected development, it will be found that existing channels will not be adequate to convey desired discharges. New channels may be required to eliminate flooding. In many cases existing channels cannot be considered stable. Therefore, this practice may be employed to assist in stabilizing these channels

Co - CONSTRUCTION EXIT

A stone-stabilized pad located at any point where vehicular traffic will be leaving a site onto a public right-of-way, street, roadway, or parking area. Its purpose is to reduce or eliminate transportation of soil (by motor vehicles) from the construction area onto public rights-of-way.

Cr - CONSTRUCTION ROAD STABILIZATION

Roads, parking areas, and other transportation routes that are stabilized with coarse aggregate between the time of initial grading and final stabilization. This travelway provides a fixed route for travel for construction traffic, reduces erosion, and subsequent regrading of permanent roadbeds, and provides a stable base for paving.

Dc - STREAM DIVERSION CHANNEL

A temporary channel that diverts a stream around a construction site to protect the streambed from erosion and allow work "in the dry". This diversion is used when in-stream work is unavoidable, as with linear projects such as utilities or roads that frequently cross and impact live streams and create a potential for excessive sediment loss by both the disturbance of the approach areas and by the work within the streambed and banks.

Di - DIVERSION

An earth channel with a compacted supporting ridge on the lower side, constructed above, across, or below a slope. The purpose of this practice is to reduce slope lengths, break-up concentrations of runoff and move water to stable outlets at non-erosive velocities. Diversions should be designed to discharge water into established disposal areas.

Dn1 - TEMPORARY DOWNDRAIN STRUCTURE

A flexible conduit of heavy-duty plastic or other material used as a temporary structure to convey concentrations of stormwater down the face of a cut or fill slope. Flexible downdrains are used on slopes where concentrations of stormwater would cause substantial erosion. They are removed once the permanent water disposal system is installed.

Dn2 - PERMANENT DOWNDRAIN STRUCTURE

A paved chute, pipe or a sectional conduit of prefabricated material designed to safely conduct surface runoff from the top to the bottom of a slope. Downdrain structures are to be used where concentrated water will cause excessive erosion of cut and fill slopes.

Fr - FILTER RING

A temporary stone barrier used in conjunction with other sediment control measures and constructed to reduce flow velocities and filter sediment. A filter ring can be installed at or a around devices such as inlet sediment traps, temporary downdrain inlets, and detention pond retrofits to provide additional sediment filtering capacity.

Ga - GABION

Large, rock-filled baskets wired together to form flexible monolithic building blocks. They are used in channels, retaining walls, abutments, check dams, etc., to prevent erosion and sediment damage to a specific structure.

Gr - GRADE STABILIZATION STRUCTURE

Structures of concrete, rock masonry, steel, aluminum, treated wood, etc. They are installed to stabilize the grade in natural or artificial channels and to prevent the formation or advance of gullies and to reduce erosion and sediment pollution.

Lv - LEVEL SPREADER

A temporary structure constructed with a flat grade across a slope where concentrated runoff may be intercepted and diverted onto a stabilized outlet. Concentrated flow of stormwater is converted to sheet flow at the level spreader.

Rd - ROCK FILTER DAM

A permanent or temporary stone filter dam installed across small streams and drainageways with a drainage area of 50 acres or less. This structure is installed to serve as a sediment-filtering device and to reduce storm water flow velocities.

Re - RETAINING WALL

A constructed wall of concrete, masonry, reinforced concrete, cribbing, treated timbers, gabions, stone dry wall, riprap or other durable material. They are installed to stabilize cut or fill slopes where maximum permissible slopes of earth are not obtainable. Each situation will require a specific design by a design engineer.

Rt - RETROFITTING

The physical modification of a storm water management outlet structure, using a half round corrugated metal pipe or similar device, to trap sediment contained in runoff water.

Sd1 - SEDIMENT BARRIER

A temporary structure constructed of silt fences, straw or hay bales, brush, logs and poles, gravel or other filtering materials. They are installed to prevent sediment from leaving the site or from entering natural drainageways or storm drainage systems. They are not to be used on high-risk areas or where there will be a possibility of failure. Formal design is normally not required for sediment barriers.

Sd2 - INLET SEDIMENT TRAP

Small temporary basins excavated around a storm drain inlet. They are employed to trap sediment in runoff water from small, disturbed areas. Cleanout of these facilities is normally required after each heavy rainfall.

Sd3 - TEMPORARY SEDIMENT BASIN

A basin created by an embankment or dam containing a principal spillway pipe and an emergency spillway. These structures are normally situated within natural drainageways and at the lowest point on a construction site and are used to trap sediment contained in runoff water. Excavated basins may be employed where sites for embankment do not exist. Sediment basins serve only during the construction phase and are removed from the site when the disturbed area has been permanently stabilized.

Structure size will vary depending on the size of the drainage area, volume of sediments to be trapped, rainfall, structure location, etc. These structures can be regarded as being hazardous if constructed in areas of dense population. In these cases, it is advisable to protect them from trespassing.

Permanent sediment basins are designed to fit into the overall plan of the completed development. They may be converted to storm water retention facilities to reduce storm water discharges.

This specification does not apply to the design of permanent sediment basins.

Sr - TEMPORARY STREAM CROSSING

A temporary structure installed across a flowing stream or watercourse for use by construction equipment. The structure may consist of a pipe, bridge, or other suitable device permitting vehicular traffic without damaging stream banks and beds.

St - STORM DRAIN OUTLET PROTECTION

A paved or short section of riprap channel placed at the outlet of a storm drain system. The purpose is to reduce the velocity of water flows below storm drain outlets, and to prevent erosion from concentrated flow.

Su - SURFACE ROUGHENING

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. This aids in the establishment of vegetation, reduction of runoff, and reduction of sediment.

Tp - TOPSOILING

Topsoiling areas to be vegetated by utilizing a suitable quality soil. The purpose is to provide a suitable soil medium for vegetative growth on areas where desired stands of vegetation are difficult to establish and maintain.

Wt - VEGETATED WATERWAY OR STORMWATER CONVEYANCE CHANNEL

Outlets for diversions, terraces, berms, or other structures. They may be natural or constructed, shaped to required dimensions and paved or vegetated for disposal of storm water runoff. They may be of two general cross sections: parabolic or trapezoidal. Parabolic waterways are the most commonly used. For waterways to be successful, it is essential that a protective cover of vegetation or other erosion protective measures be implemented. Flow velocities must be selected that will produce non-erosive flows within the waterway during peak discharges.

CONSTRUCTION TECHNIQUES

Other construction techniques may be employed by field personnel to assist in implementing an effective erosion control program. A few of these are discussed below.

a. **Leave Exposed Soil Surfaces Rough.** Smooth soil surfaces will erode more readily than rough ones. Therefore, cut or fill slopes should not be "dressed" or smoothed until time to establish vegetation. Cut or fill slopes may be scarified or serrated using conventional earth moving equipment to provide this roughening effect. The cleated tracks of bulldozers are effective in compacting as well as roughening cut or fill slopes.

b. **Selective Fill Placement.** Fills over culverts and conduits can be left in a condition to drain rain water to the upstream side of the culvert. This operation can be performed at the end of each construction day and will assist in retaining sediment on the site.

c. **Selective Clearing.** Clearing operations should be confined to the removal of timber and heavy brush only. Ground covers consisting of small plants, weeds and organic matter should be retained until the start of the grading operation.

d. **Retain Natural Sediment Traps.** Small depressions in the land surface, natural creek berms and other natural sediment traps may be preserved in a natural state until such time as building sequences will require their alteration.

e. **Retention of Natural Vegetation.** Natural Vegetation on disturbed area perimeters and adjacent to stream channels should be retained.

UNIFORM CODING SYSTEM

The following coding system chart has been developed to provide statewide uniformity for erosion and sediment control plans. A code has been assigned to each practice. This code should appear at the desired location on the plan. In some instances, more than one code will appear. For example, an area planted in temporary vegetation will eventually be established to permanent seeding. Therefore, both codes should appear on the plans at the appropriate location. A symbol also has been assigned to most practices. For certain practices it will be necessary to place both the symbol and code letter on the plans.

To assist the user, a small detail drawing and a brief description of the major characteristics of the practice have been included on the coding system chart.

CHAPTER 3

PLANNING AND PLANS

SECTION I – PLANNING

Planning is the critical process by which land-disturbing activities are formulated. The planning process for activities governed by Act 599 can be broken down into the following four progressive stages:

1. preliminary site investigations
2. preliminary design
3. subsurface investigation
4. final design

For many small land-disturbing activities, steps one and two are sometimes combined but planning for major developments normally follows these three steps. The Erosion and Sedimentation Act of 1975 does not change this planning process. It merely states that erosion and sediment control planning should be included as one of the major considerations.

To be successful, a plan must include measures for efficient scheduling and coordination of construction activities and provisions for the maintenance of conservation practices. Stormwater management facilities should be included to reduce the impact of stormwater runoff to on-site facilities both during and after construction is completed. It is *desirable* to include stormwater retention structures. Land-disturbing activities normally will result in an increase in runoff from the site. Stormwater management structures will reduce the impact of damages on downstream facilities resulting from an increase in runoff.

PLANNING STAGES

Preliminary Site Investigation Stage. The first consideration in the preliminary site investigation stage should be the assimilation of all available resource information. This information will assist the planners in identifying critical physical features of the site which would have significant impact on erosion and sediment control. Delineation of flood-prone areas and areas which would have a high aesthetic value if protected can be identified. Sources of resource information are included in Chapter 5 of this handbook.

A conservation planning base map should be prepared utilizing all information available. The final step would be a detailed *on-site inspection.* At this time, base maps should be thoroughly checked for accuracy.

Preliminary Design Stage. In the preliminary design stage, a thorough analysis of the information assembled during the preliminary site investigation stage should be accomplished. The objective of the analysis is to determine how the proposed site can be best utilized as intended without causing undue harm to the environment. Areas particularly vulnerable to erosion and sedimentation because of existing topography, soils, vegetation or drainage should be identified. The planner is encouraged to use available soils information in his site analysis. A discussion of the use of soils information in site planning follows in this chapter.

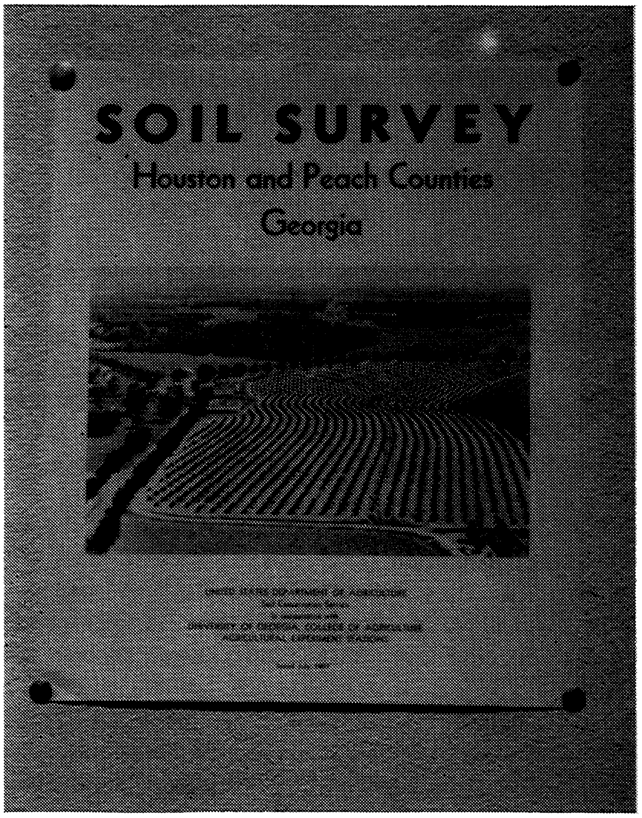
Subsurface Investigation Stage. A subsurface investigation should be accomplished to determine the geological features and the nature and properties of the soils present on the site. A detailed on-site soils investigation will be necessary for the design of complex buildings, roadways, and other engineering structures. Facilities which will be serviced by septic tank will require on-site testing. The stability of slopes should be determined based on soils analysis. Groundwater problems should be identified at this time. Soils subject to water flows should be analyzed for permissible velocities. Soils to be established in vegetation should be examined for pH, nutrient levels and ease of establishing vegetation. Methods of overcoming soils limitations should be explored.

Final Design Stage. Final designs should be based on detailed engineering surveys, subsurface investigations and sound conservation and engineering principles. Permanent buildings, roadways and engineering structures should be fitted to the topography and soil types. Efficient, durable and easily maintained erosion control measures should be employed. Sediment basins, barriers and traps should be designed to trap sediment which would be transported from the site. All stormwater facilities should be of adequate capacity and have the ability to withstand peak velocities. Filling or development within flood-prone areas should be avoided except those activities necessary to promote public health and welfare. If, for example, roadway crossings are made, openings must be sized to eliminate undue restriction in water flows and excessive downstream velocities. Natural vegetation and open space should be provided. Finally, rigid construction scheduling should be employed.

SOILS INFORMATION AND SITE PLANNING

An invaluable tool in planning for land disturbing activities is soils information available through Georgia Soil and Water Conservation Districts. The USDA Natural Resources Conservation Service soil scientists study, evaluate, classify and map soils in counties throughout

Georgia and publish soil surveys with maps and descriptions. This soils information can be related to local plat maps to identify kinds of soils in a specific area. The map on page 3-5 shows the status of soil survey publications in Georgia. If unpublished, arrangements can possibly be made through local Soil and Water Conservation Districts to examine available soils maps and to obtain additional soil information for the proposed land-disturbing activity.



SOIL SURVEY
Houston and Peach Counties
Georgia

Figure 3-1. – Soils information is a valuable tool in planning for land-disturbing activities.

Soil maps and supporting data provide information about important soil properties, including the following:

Flood Hazards — Soil surveys show areas that are subject to flooding. Although this information is not a substitute for hydrologic surveys, which determine the limits of flooding on the basis of the severest flood expected once in 10, 25, 50 or 100 years, it does provide a good first approximation of the flood-prone areas.

Wetness — Soil surveys show if the soil is well drained, poorly drained, or seasonally waterlogged, and if the water table is seasonally high. The rating of the permeability of soils is also included.

Bearing Capacity — Soil surveys provide test data and estimates of the physical properties of soils that enable engineers to make sound judgments about bearing capacities for shallow foundations. Major soil layers to a depth of about 5 feet are classified in both the United and the AASHTO systems. Data is also given on grain-size distribution and expansiveness for each soil layer.

Depth to Rock — Soil surveys show locations where bedrock is at depths of less than 5 or 6 feet and describe the geologic material that underlies the soil.

Shrink-swell and Slippage — Soil properties that result in high swelling pressures, mainly the kind and amount of clay, are given in soil surveys. Soil surveys also indicate soil properties that make soils unstable and susceptible to slippage.

THE UNIVERSAL SOIL LOSS EQUATION

The properties that affect the erodibility of the soil are of particular interest in planning for the reduction of soil erosion and sedimentation. The erodibility of Georgia soils has been calculated.

The soil erodibility factor (k factor) is one of the variables in the Universal Soil Loss Equation. It will yield an estimate of the annual soil loss for a site in tons per acre. The equation is:

$$\text{Soil Loss} = RKLSCP$$

Where R = rainfall factor
K = soil erodibility factor
LS = slope length and steepness
C = vegetative cover
P = support practice factor

A detailed discussion of the equation is contained in Appendix B-2 of this Manual.

To assist the user in the interpretation of soils for land-disturbing activities, a table of estimated soil properties for Georgia soils has been completed and is contained in Appendix B-1. Estimated soil properties are included for permeability, soil reaction (pH), shrink-swell potential, corrosivity, depth to water table and bedrock, flood frequencies, and hydrologic soil groupings. Soil limitation ratings for septic tank absorption fields, sewage lagoon areas, shallow excavations, dwellings and small commercial building, and local roads and streets have also been included. Planners are encouraged to use this material in evaluating the suitability of tracts of land for specific developments.

Additional soils information for site planning can be obtained during the subsurface investigation phase of planning. For example, the K values of the soils in Appendix B-1 of this manual are estimates for the surface layer of the soil. Because this value will differ at varying depths of the soil profile, planners of land-disturbing activities should specify that the estimated erodibility of subsurface soil be obtained during site borings.

SECTION II – PLANS

Following are examples illustrating methods used in the preparation of erosion and sediment control plans. The set of drawings is intended to demonstrate a methodology for the preparation of an erosion and sediment control plan for a land-disturbing activity.

It should be emphasized that the methodology utilized in this example is only one of many available to the designer or planner. Many other practical combinations of erosion control measures could have been employed to effectively reduce erosion on this site.

LAND DISTURBING ACTIVITY PLAN

The set of drawings for the proposed land disturbing activity are intended to illustrate a method for the preparation of plans for a *phased development.* Hypothetically, the owner has requested that the consulting engineering firm prepare a plan for a 105-acre development that will be constructed in two phases. The first phase will consist of a parcel of land to be developed into a public school facility. Phase two will consist of a single family residential development. Initially, the engineering firm is to select approximately 21 acres from the total tract of land. This first phase is then to be planned for the public school facility. The remaining acreage will be developed at a later date.

The first step that the engineering firm has undertaken is to prepare a detailed boundary line sketch for the total tract of land (See Drawing 1). On this sketch, all major roadways, watercourses, soils and vegetative information have been imposed.

Information on the soils, slope and drainage patterns was obtained from a soils map of the county. Vegetative information was obtained from a field reconnaissance survey of the site. A soils information chart was added to the drawing using soils information from Appendix B-1 of this manual. Each soil series was then shaded on the drawing to effectively illustrate the soils limitations of the site. A zoning sketch obtained from county zoning maps and a site location sketch obtained from the soil survey map were added to the drawing.

An analysis of the combined soils, vegetation and drainage drawing indicated that the portion of the total development which can best support a development requiring extensive grading is located in the northwest portion of the overall tract, on soils with the symbol GeB2, Gwinnett Clay Loam. This portion of the tract would permit an intensive development with a minimum of clearing, grading and potential erosion. After analysis, conclusions were obtained from Drawing Number 1 and a detailed boundary line survey and a topographic map was then completed for the phase one development (See Drawing 2).

All fixed improvements including the school buildings, gymnasium, football field, playground area, and roadways were then located on the topographic map in a manner which would reduce disturbed areas and avoid the steeper, more erodible slopes. Volumes of earth work were reduced as much as possible by balancing the cut from the school and parking area with the fill required for the football field. Cuts and fills for the playground area and roadway were carefully balanced. As much vegetation as practical was preserved and protected as planned.

After determining the location of proposed fixed improvements, the next step was to plan for the installation of stormwater management and erosion control measures (See Drawing 3). The final erosion and sediment control plan contains combinations of vegetative measures and structural erosion and sediment control practices which should conform to the requirements of the law, and effectively reduce erosion from the land-disturbing activity site. Sediment retention structures have been added to reduce the probability of sediment leaving the site. A timing schedule was developed and has been included on the drawing.

It should be emphasized again that there are numerous methodologies, techniques, and combinations of erosion and sediment control practices which could have been employed in this example.

U.S. Department of Agriculture

Natural Resources Conservation Service

Legend

■ Modern Published Soil Survey (1966 or newer)

░ Old Published Soil Survey (1965 or older)

▒ Modern Soil Survey with field mapping complete, to be published

□ Modern Soil Survey being conducted, with completion date set

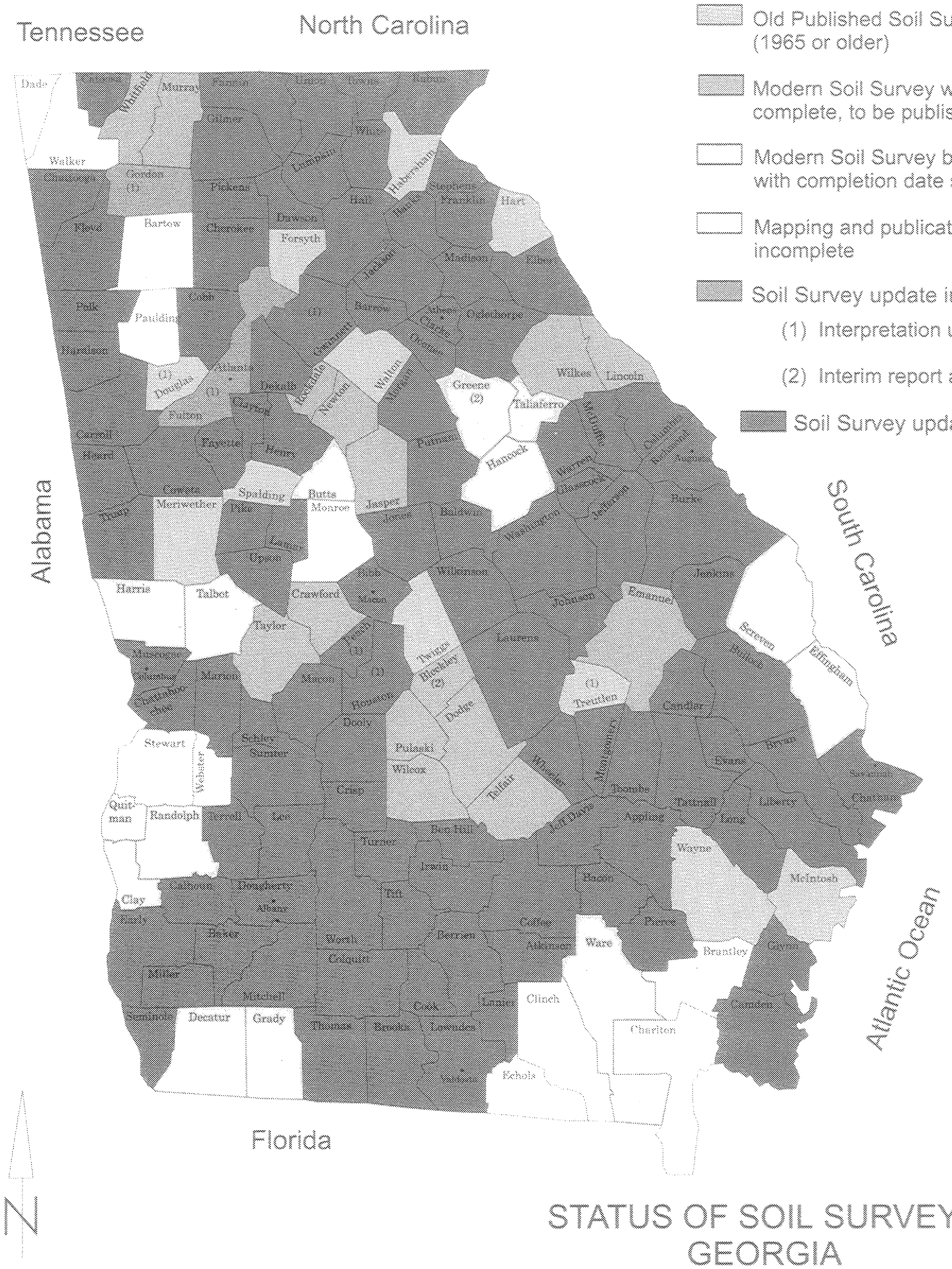
□ Mapping and publication plans incomplete

▒ Soil Survey update in progress

(1) Interpretation update available

(2) Interim report available

■ Soil Survey update completed

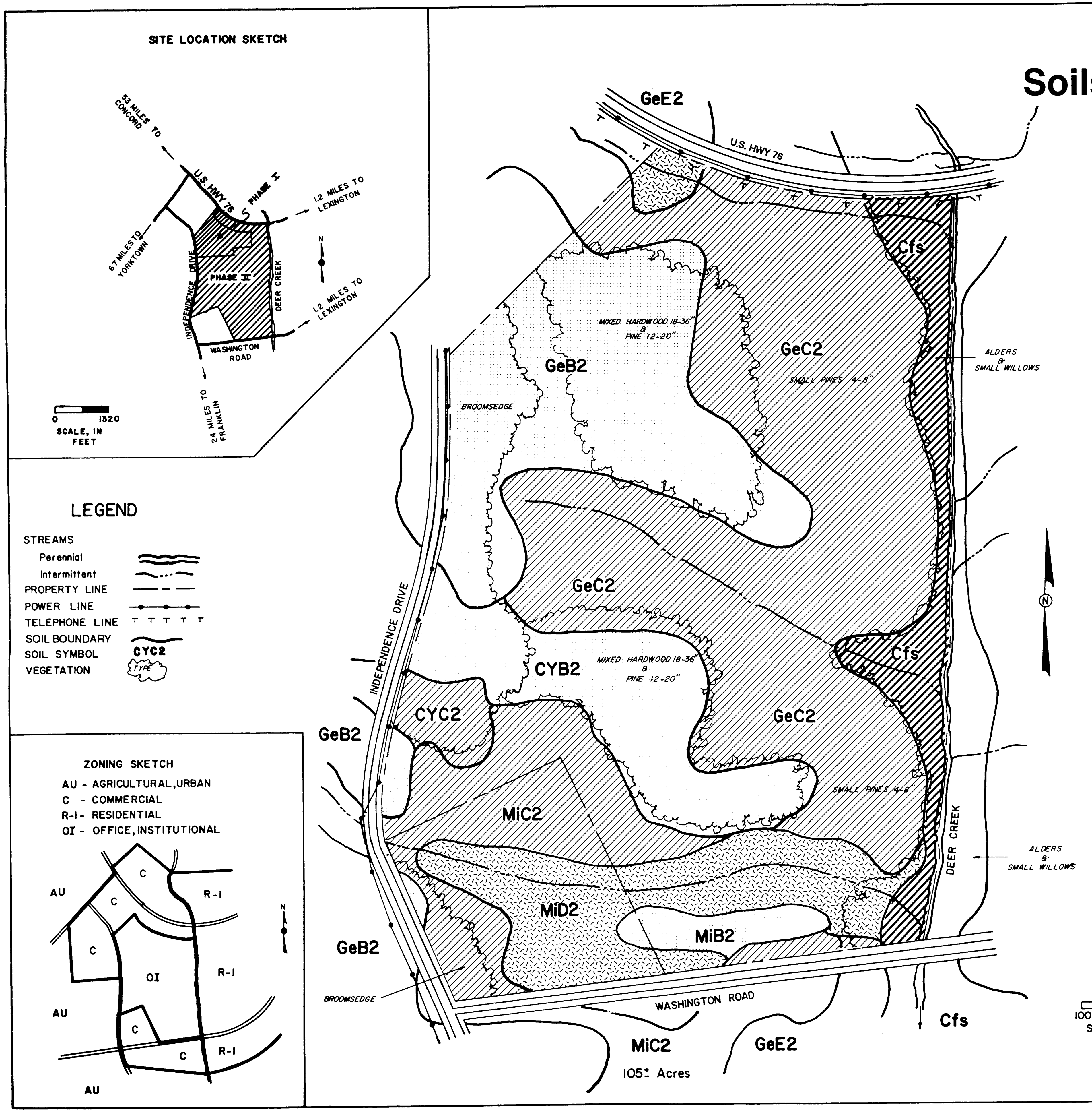


STATUS OF SOIL SURVEYS
GEORGIA
December 1997

Source:
Information provided by NRCS field personnel.
Natural Resources Conservation Service, Athens, GA 1997.

Scale is approximate

Drawing 1
Soils, Vegetation, and Drainage



SOILS INFORMATION

SOIL SYMBOL	NAME	SLOPE %	K	LIMITATION	SYMBOL	REASONS FOR LIMITATIONS
Cfs	Chewacla	0-2	.32	Severe	▨	Very frequent flooding High seasonal water table
CYB2	Cecil Sandy Loam	2-6	.32	Slight	░	
GeB2	Gwinnett Clay Loam	2-6	.28	Slight	░	
GeC2	Gwinnett Clay Loam	6-10	.28	Moderate	▨	Slopes
GeE2	Gwinnett Clay Loam	10-25	.28	Severe	▒	Slopes
MiC2	Madison Sandy Clay Loam	6-10	.32	Moderate	▨	Slopes; moderate shrink-swell potential
MiD2	Madison Sandy Clay Loam	10-15	.32	Severe	▒	Slopes

Seal

Certification

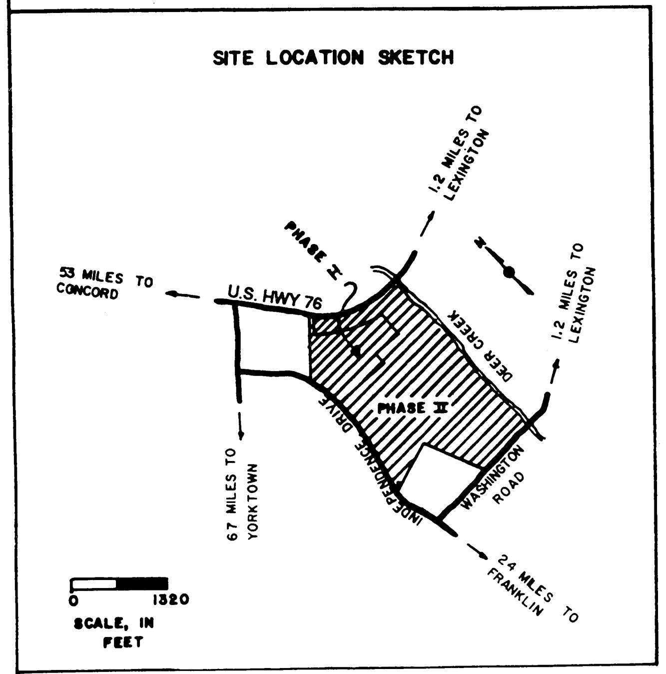
100 0 100 200 300
SCALE, IN FEET

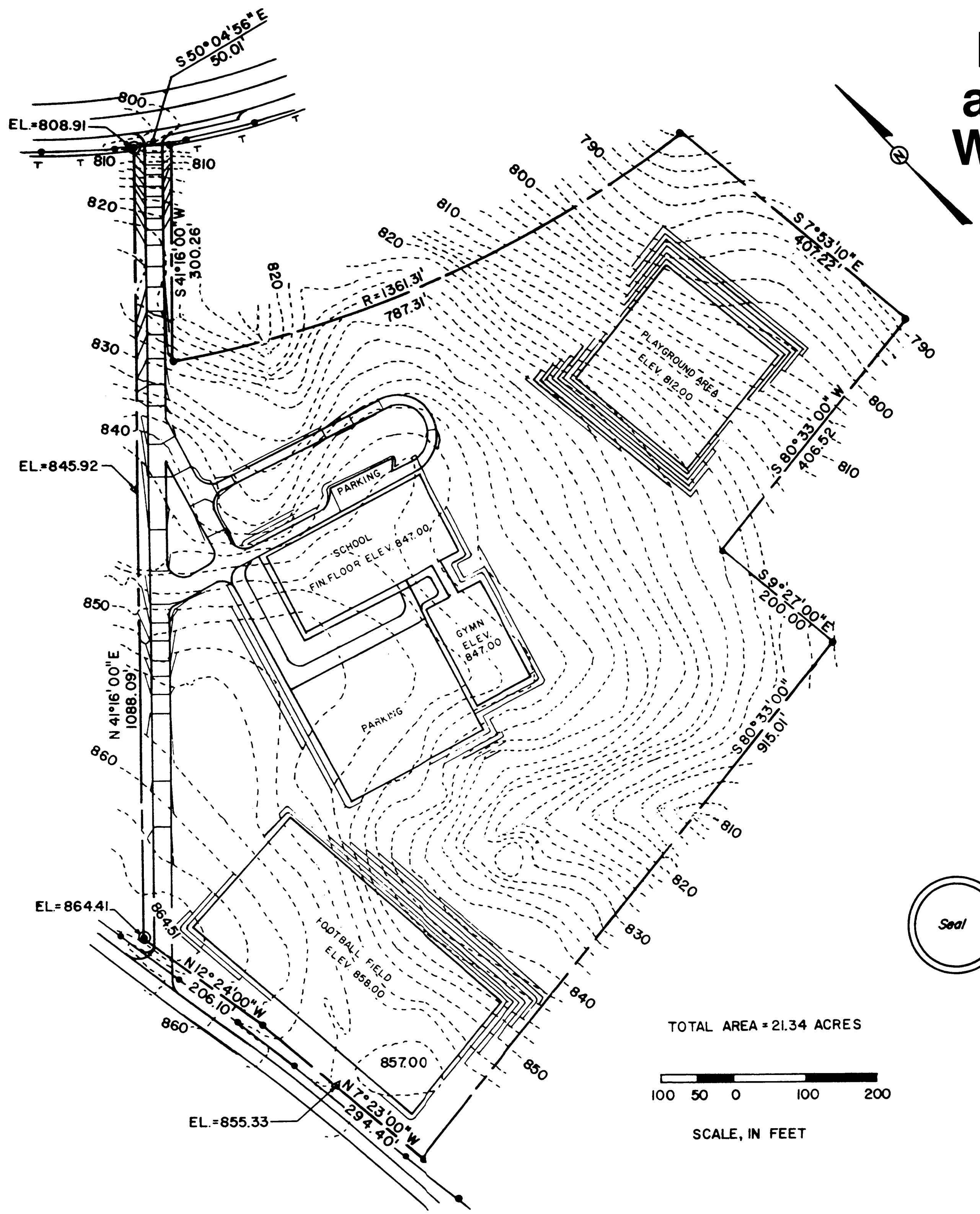
INDEPENDENCE DEVELOPMENT

BILL PENN
CONSULTING PLANNERS AND ENGINEERS

OWNER G. WASHINGTON	COUNTY, STATE GWINNETT, GEORGIA
DRAWN BY TOM JEFFERSON	LAND LOT 200
DATE JULY 4, 1990	LAND DISTRICT 26th.

Drawing 2
Detailed Boundary Line and Topographic Survey With Fixed Improvements





LEGEND

IRON PIN FOUND	◎
PROPERTY LINE	•— — —•
TEMPORARY BENCH MARK	Δ
POWER LINE	—•—•—
TELEPHONE LINE	T T T T
CONTOUR LINE, EXISTING	- - - -
CONTOUR LINE, FINISH	———

NOTE: SLOPE PARKING LOT AREA TO DRAIN AWAY FROM MAIN SCHOOL BUILDING ON 1.0% GRADE AND TOWARD CENTERLINE OF LOT ON 0.5% GRADE

CROWN FOOTBALL FIELD 1.5 FEET AT CENTER

SLOPE PLAYGROUND AREA TO DRAIN TOWARD CENTERLINE ORIENTED NORTH-SOUTH

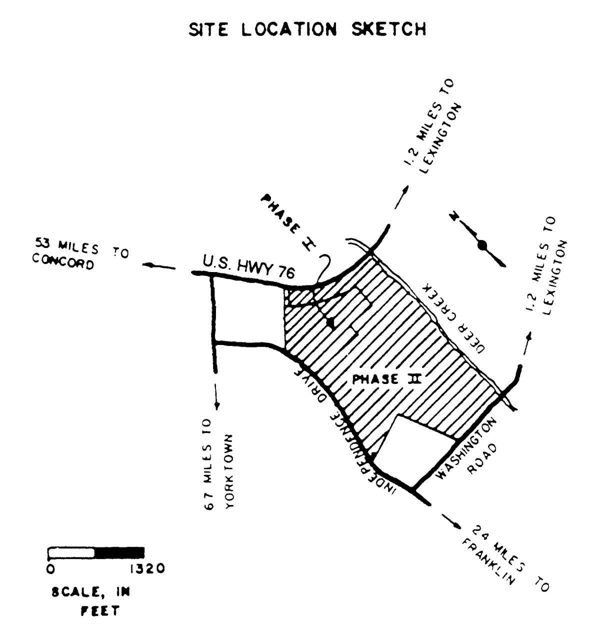
INDEPENDENCE SCHOOL

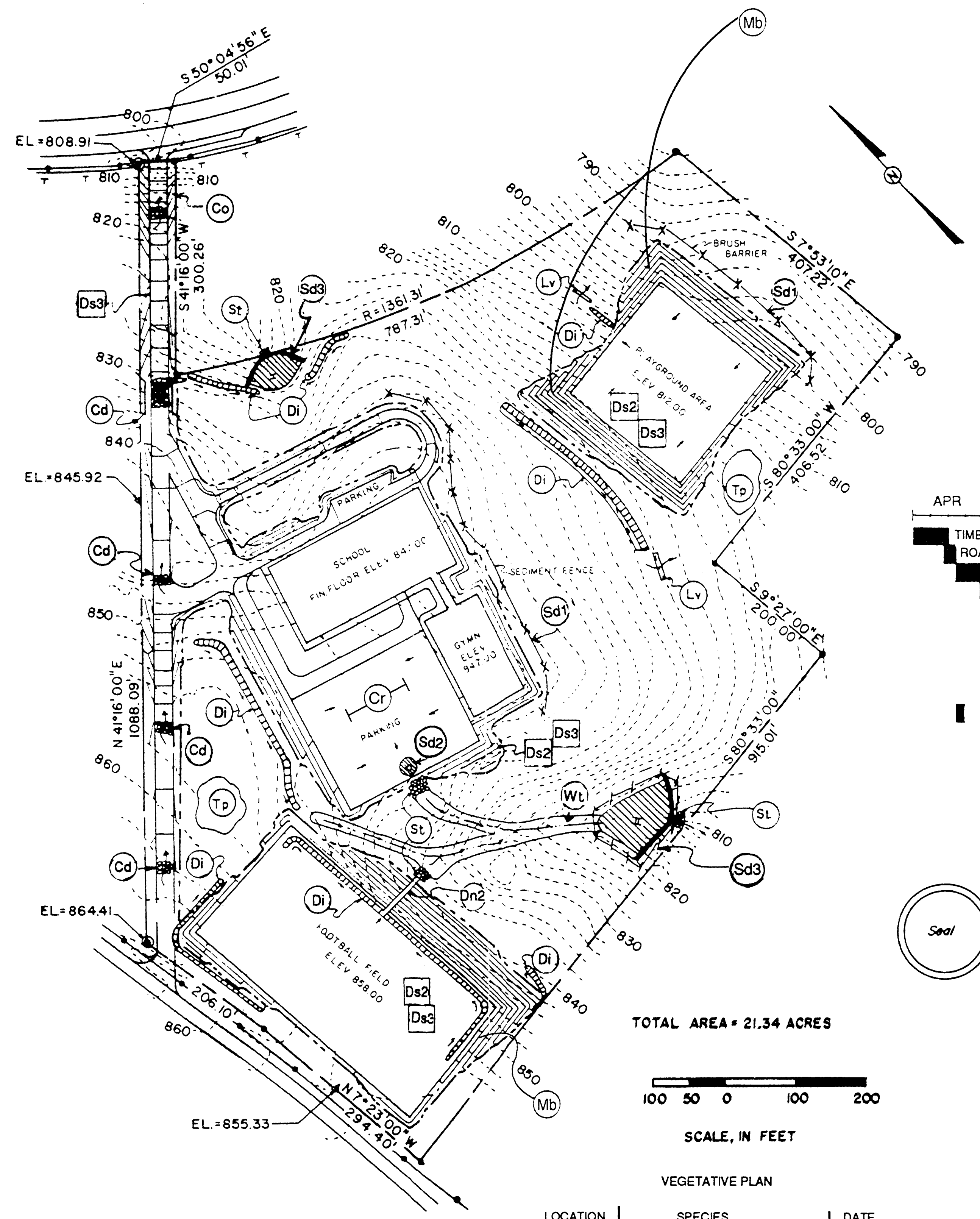
BILL PENN
CONSULTING PLANNERS AND ENGINEERS

OWNER G. WASHINGTON	COUNTY, STATE GWINNETT, GEORGIA
DRAWN BY TOM JEFFERSON	LAND LOT 200
DATE JULY 4, 1990	LAND DISTRICT 26th.

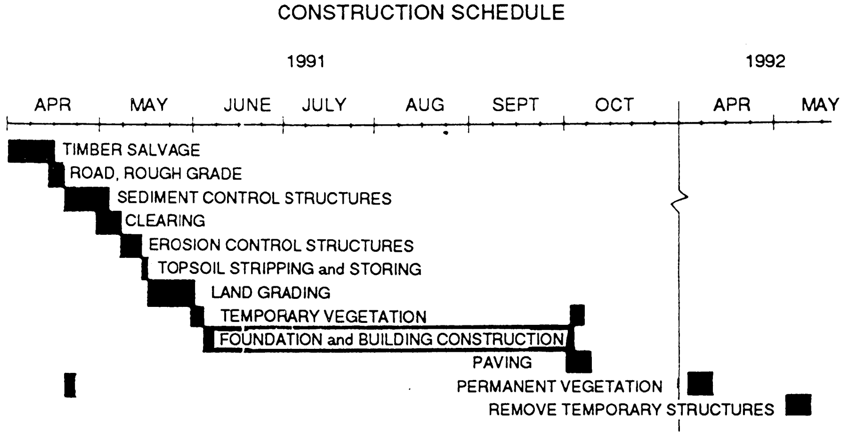
Drawing 3
Erosion and Sediment Control Plan

SITE LOCATION SKETCH





CONSTRUCTION SCHEDULE



Seal

Certification

LEGEND

IRON PIN FOUND	⊙
PROPERTY LINE	●— — —●
TEMPORARY BENCH MARK	Δ
POWER LINE	●——●——●
TELEPHONE LINE	T T T T
CONTOUR LINE, EXISTING	- - - -
CONTOUR LINE, FINISH	——
CLEARING LIMIT LINE	—·—·—

NOTE: SLOPE PARKING LOT AREA TO DRAIN AWAY FROM MAIN SCHOOL BUILDING ON 10% GRADE AND TOWARD CENTERLINE OF LOT ON 0.5% GRADE

CROWN FOOTBALL FIELD 1.5 FEET AT CENTER

SLOPE PLAYGROUND AREA TO DRAIN TOWARD CENTERLINE ORIENTED NORTH-SOUTH

VEGETATIVE PLAN

LOCATION	SPECIES	DATE
Football Field & Playground	Hulled Common Bermudagrass	April '92
Roadside	Hulled Common Bermudagrass & Virgata Lespedeza	April '91
Waterway	Sod Common Bermudagrass	April '91
School	Ryegrass	Oct. '91

INDEPENDENCE SCHOOL

BILL PENN
CONSULTING PLANNERS AND ENGINEERS

OWNER G. WASHINGTON	COUNTY, STATE GWINNETT, GEORGIA
DRAWN BY TOM JEFFERSON	LAND LOT 200
DATE JULY 4, 1990	LAND DISTRICT 26th

EXAMPLE NARRATIVE DESCRIPTION OF A LAND-DISTURBING ACTIVITY PLAN
(Fictional)

DESCRIPTION: Phase I of this proposed development is located on Hwy. 76, 1.2 miles west of Lexington, Georgia, and contains 21.34 acres. This area will be developed for use as a public school facility. Improvements will consist of a 28,800-square-foot school building, a 13,500-square-foot gymnasium, .88 acres of parking, a football field, a one-acre playground, and service roads. Phase II, which comprises approximately 83.7 acres, will contain single family residences and will be developed at a later date.

ZONING: The present zoning classification of Phase I is Office-Institutional (O-I). (See zoning sketch of Drawing Number 1 for zoning classifications of adjacent properties.)

DATES OF CONSTRUCTION: Initial construction is scheduled to begin April 1, 1991. Final stabilization should be accomplished before May 15, 1992.

SOILS, TOPOGRAPHIC AND DRAINAGE INFORMATION: (For soils, topographic and drainage information, see Drawing Number 1.)

VEGETATION: (For a description of existing vegetation, see Drawing Number 1.) All marketable timber will be salvaged. Top soil will be salvaged, stockpiled and spread on areas to be vegetated. Trees outside of the clearing line will be protected from damage by appropriate markings. (See Drawing Number 1 for clearing information and vegetative plan.) Supplemental vegetation will be established.

BUFFER REQUIREMENTS: An undisturbed natural vegetative buffer of 25 feet measured from the stream banks (100 feet measured horizontally, adjacent to trout streams) shall normally be retained adjacent to any state waters except where otherwise required by Part 6 of Article 5 of Chapter 5 of this title, the "Metropolitan River Protection Act," or by the department pursuant to Code Section 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 are implemented.

EROSION CONTROL PROGRAM: Clearing will be kept to an absolute minimum. Vegetation and mulch will be applied to applicable areas immediately after grading is completed. Gravel will be applied to parking areas and roadways as soon as grading is completed. Land-disturbing will be scheduled to limit exposure of bare soils to erosive elements. Storm water management structures will be employed to prevent erosion in areas of concentrated water flows. Erosion at the exits of all stormwater structures will be prevented by the installation of storm drain outlet protection devices.

SEDIMENT CONTROL PROGRAM: Sediment control will be accomplished by the installation of two sediment basins, approximately 550 linear feet of sediment fences and 375 feet of temporary brush barriers. Diversions will be installed to divert sediment laden runoff into the sediment basins and to protect cut and fill slopes from erosive water flow. A temporary construction exit will be employed to prevent the transport of sediment from the site by vehicular traffic.

STANDARDS AND SPECIFICATIONS: All designs will conform to and all work will be performed in accordance with the Standards and Specifications of the publication entitled, *Manual for Erosion and Sediment Control in Georgia.* (See attached calculations).

SAFETY PROTECTION: Construction activities will be performed in compliance with all applicable laws, rules and regulations. Sediment basin number II, which will be converted to a storm water detention structure, will be posted and fenced to exclude children.

MAINTENANCE PROGRAM: Sediment and erosion control measures will be inspected daily. Any damages observed will be repaired by the end of that day. Cleanout of sediment control structures will be accomplished in accordance with the specifications and sediment disposal accomplished by spreading on the site. Sediment basins and barriers will remain in place until sediment contributing areas are stabilized. The sediment basin, sediment fences, and the barriers will then be removed and the areas occupied by these structures vegetated. Sediment from the detention basin will be removed and this basin converted to a storm water detention structure. Guidelines for the maintenance of established vegetation will be provided to the owner when all disturbed areas are stabilized.

24-HOUR CONTACT PERSON: The telephone number of a person responsible for the project's erosion and sediment control program must be provided.

CHAPTER 4

LOCAL PROGRAMS: PRINCIPLES AND PROCESSES

The Erosion and Sedimentation Act of 1975 states that the governing authority of each county and municipality shall adopt a comprehensive ordinance establishing procedures governing land-disturbing activities conducted within their respective boundaries.

If counties and municipalities have failed to have in effect an ordinance conforming to the provisions of the law, then the State Board of Natural Resources will adopt appropriate rules and regulations governing activities within those areas.

The emphasis of the law is truly on implementation of *local* erosion and sediment control programs. It has been said that, "Unquestionably, local officials have the constitutional authority to make decisions concerning the use and allocation of local land and water resources. Also an erosion and sediment control program constitutes a segment of soil and water resources management which ought to be the responsibility of elected officials at the local level."(21)

PRINCIPLES

For any erosion and sediment control *program* to become effective, there are certain principles which should be applied for maximum effectiveness.

1. Erosion and sediment control should become a stated policy of all concerned, including public and private agencies operating in or having jurisdiction within the boundaries of the unit of government. It is imperative that developers, owners of land to be developed, their designated consultants, planners and engineers become aware of the necessity for sound erosion and sediment control programs.
2. A well-planned public information and education program on erosion and sediment control is essential for public and private support.
3. Competent technical personnel knowledgeable in local soil and climatic conditions, workable procedures, and inspections are necessary for successful erosion and sediment control.
4. To be effective, provision for erosion and sediment control must be made in the planning stage. Practical combinations of the basic design principles contained in Chapter 2 should be skillfully planned and applied in a timely manner.
5. Research observations and evaluations should be conducted to provide needed information for improvement of the erosion and sediment control program. A comprehensive review and evaluation of the overall sediment and erosion control program should be conducted at least every few years.

PROCESSES

An erosion and sediment control program may be subdivided into four basic processes:

a. ordinance development and implementation
b. plan preparation and review
c. inspection and enforcement
d. information, education and training

ORDINANCE DEVELOPMENT AND IMPLEMENTATION

Local officials have a working knowledge of local conditions and problems. It is they who can best implement ordinances which take local needs into account.

In the past, the cost of correcting expensive sediment damages has often been the responsibility of local units of government. Therefore, it is advisable that local governments have direct control over the enforcement of laws pertaining to erosion.

Although the direct responsibility for drafting ordinances falls on local officials, citizen participation should be encouraged to insure that the final product will reflect their needs and wishes.

A model ordinance has been developed by the State Soil and Water Conservation Commission for use by officials in municipalities and counties. The model is intended primarily to provide guidelines for control of *urban* soil erosion and sediment pollution. It is designed to meet state requirements for establishing programs as required in Act 599. A copy of the model is contained in Appendix D of this manual.

Preceeding the body of the model ordinance is a brief explanation of the contents. This explanation is intended to clarify certain sections or phrases contained in the model. Opinions expressed therein are not necessarily requirements to be fulfilled. Local authorities may wish to develop individual ordinances from the wealth of comprehensive material available for this, or they may utilize another of the models available. Regardless of the method used, the contents of the model ordinance should be tailored to fulfill specific needs of the local governing authority. A review of the final draft by the county or city attorney should be mandatory.

The adoption of an ordinance should be considered as only the first step toward a sound soil erosion and sedimentation control program. It is essential that sufficient lead time be provided for education of the public and technical training of persons directly involved in its full implementation.

PLAN PREPARATION AND REVIEW PROCESS

All parties involved in the plan development and review process must realize without exception that there is more *than one approach* to minimizing erosion and sedimentation damages. Flexibility without compromising the primary objective must be encouraged to arrive at a common solution to erosion and sediment control problems on any given site. All available resources should be explored. Local officials should plan to provide assistance to the developer and his consulting planners and engineers prior to plan submission before plan processing can be effective. Assistance from federal and state agencies having expertise in the field of soil and water conservation should be provided to the developer and his consultant. Developers may benefit by entering into an agreement for assistance through their Soil and Water Conservation District. Technical expertise can then be provided by federal and state agencies.

The erosion and sediment control plan should be submitted as early in the planning stage as possible. The plan itself should embrace all aspects of the requirements of the basic design priciples as specified in Chapter 2 of this manual. In addition, practical combinations of vegetative and structural conservation practices should be designed in accordance with the minimum requirements of the Standards and Specifications contained in Chapter 6.

It is recommended that the plan review process be broken down into the preliminary planning phase and the final design phase to reduce costly engineering fees. Such fees are normally considerably higher than preliminary planning fees. Costs for changes to engineering drawings and specifications can be prohibitive. An early, or first phase, submission of erosion and sediment control plans will promote general agreement and cooperation and provide for changes with minimum delay to the development process.

The responsibility for plan reviews has been delegated by Act 599 to the Soil and Water Conservation Districts. This does not relieve the county or municipality, however, from a responsibility to assure that plans conform to other local regulations and ordinances.

PLAN PROCESSING

Following is a recommended procedure for preparation and processing of an erosion and sediment control plan:

1. The owner, developer, or the authorized agent for either the owner or the developer, prepares the erosion and sediment control plan. The plan is prepared in accordance with the minimum requirements and recommendations contained in the Manual for Erosion and Sediment Control. (The manual should be incorporated by reference in the local erosion and sediment control ordinance.) Plans should be prepared only after consultation with the local governing authority, the Soil and Water Conservation District, and other agencies or individuals having expertise in the field of soil and water conservation.

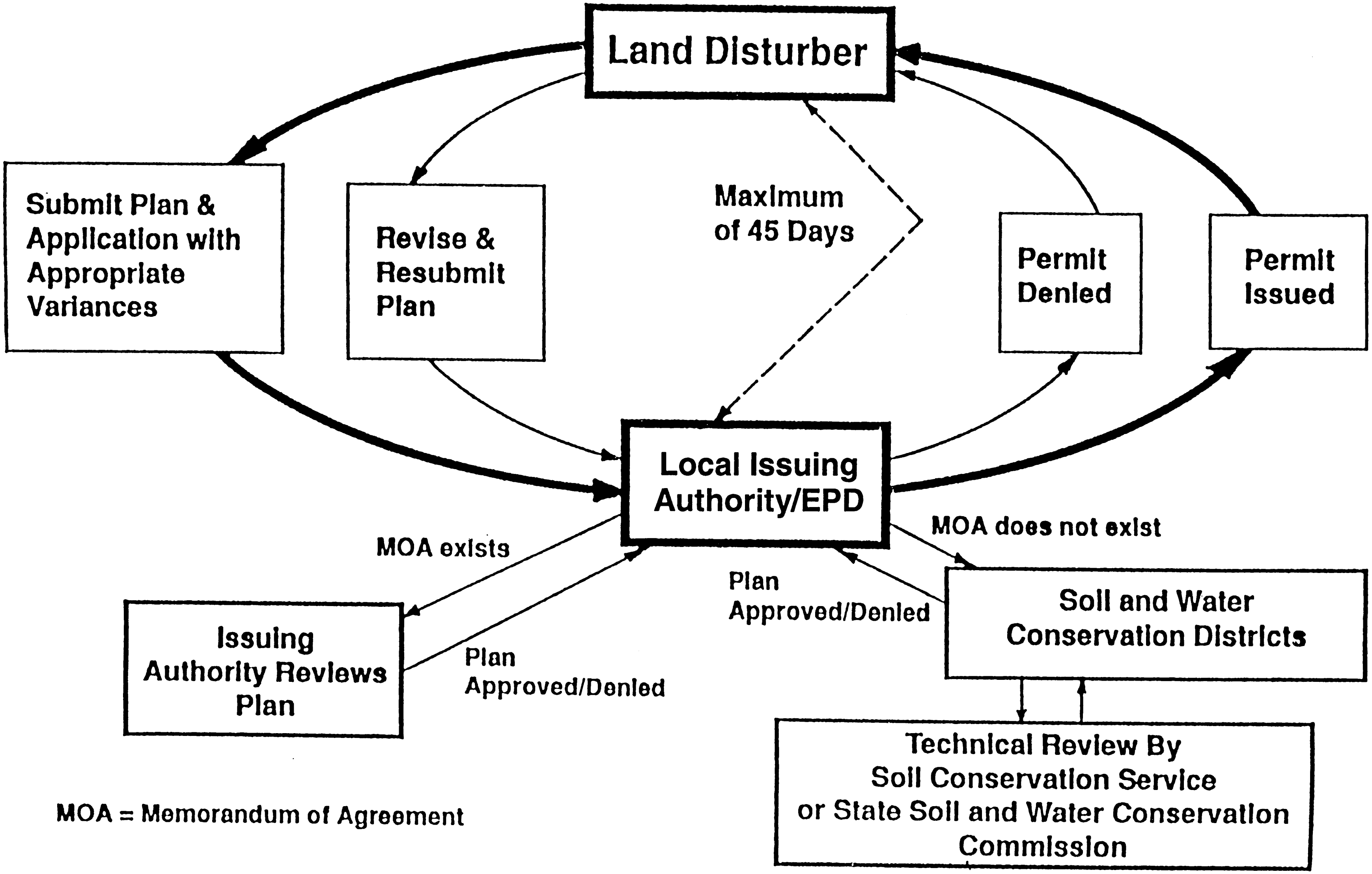
2. The owner, developer, or the authorized agent for the owner or developer, submits the plans to the local permit-issuing authority after completing an application for a permit. (Local officials should determine the number of copies of plans and applications to be submitted by the owner, etc. It is suggested that a minimum of three copies of the plan be submitted.) If an application form has not been developed by the local unit of government, a letter of transmittal containing the following information should accompany the plans.
   a. The name, address and phone number of the applicant.
   b. The name, address and phone number of the land owner of record.
   c. The name, address and phone number of the person responsible for carrying out the plan.
   d. The name, address and phone number of the person preparing the plan.
   e. The location of the activity including land lot and tax map page numbers.
   f. Any other information as determined by the local unit of government.

The local unit of government may require that a preliminary erosion and sediment control plan be submitted along with a preliminary site plan. The preliminary erosion control plan should not be cluttered with detailed erosion and sediment measures but should include the following information:

a. soil boundaries of all major soil series.
b. approximate limits of grading.
c. tentative measures for sediment and erosion control.
d. phasing of development to minimize area and duration of exposure of soils to erosive elements.

It is suggested that the governing authority of the county or municipality delegate the authority for receiving applications and processing permits to the county engineer, director of public works or other qualified individuals knowledgeable in the processing of site development plans. If in the ordinance the responsibilities of the governing authority are delegated to the constitutional or statutory local planning and zoning commission, then it is suggested that the plans and applications be processed by the director of the planning and zoning commission.

Land Disturbing Activity Application
and
Permit Procedure



3. Two copies of the erosion and sediment control plan shall be forwarded as soon as possible to the local Soil and Water Conservation District, or its delegated authority, for review. In determining the adequacy of the plan, the district officials (supervisors) will be guided by the requirements and recommendations contained in the local manual. District supervisors may request the assistance from the erosion and sediment control specialist with the State Soil and Water Conservation Commission, specialists from the district or technical personnel of the Natural Resources Conservation Service. The district supervisor, after consultation with the district board, will forward the plans and recommendations to the permit-issuing authority of the municipality or county. These recommendations should include measures necessary to meet requirements and recommendations outlined in the manual. A copy of the recommendations of the district's technical advisor may be forwarded to the permit-issuing authority.

4. The permit-issuing authority of the local unit of government, after consultation with the governing board and after a thorough review of the plan for compliance with other resolutions or ordinances rules and regulations, should then issue or deny a permit. If a plan is not approved, the modifications necessary to permit approval of the plan should be specified in writing. Time is of essence in erosion and sediment control plan processing. Act 599 states that permits shall be issued or denied as soon as practicable after the application is filed with the issuing authority—but in any event not later than 45 days of receipt of the plan and completed application.

Plan Revisions

An approved plan may be revised if inspections reveal that the erosion and sediment control plan is inadequate in accomplishing the objectives of the law. If so, modifications to correct the deficiencies must have the concurrence of the plan-reviewing authority.

Revision may also be required when the person responsible for carrying out the approved plan finds that, because of changed conditions or other reasons, the approved plan cannot be effectively carried out. Again, the plan reviewing authority must give concurrence on proposed plan changes.

Checklist of Plan Preparation and Review

A complete plan review checklist is presented on page 6-10. Some of the issues which the plan preparers and plan reviewers need to consider are:

1. Does the proposed plan contain information reflecting actual existing site conditions?
2. Will the roadways, buildings and other permanent features conform to the natural topography of the site?
3. Will the limitations of soils and steep slopes be overcome by sound engineering practices?
4. Will clearing be limited to only those areas of the site to be developed?
5. Will natural vegetation be retained and provisions made for protection of existing vegetation and for supplemental planting?
6. Will major land clearing and grading operations be scheduled during seasons of low potential sediment runoff?
7. Will the time of exposure of land clearing and grading be kept to a minimum?
8. Will permanent structures, temporary or permanent vegetation or mulch be scheduled for installation as quickly as possible after the land is disturbed?
9. Will all storm water management facilities, temporary or permanent, be designed to safely convey water to a stable outlet?
10. Will sediment basins, sediment barriers, and related devices be planned to filter or trap sediment on the site? Can these structures be easily maintained?
11. Will proposed vegetation be suitable for the intended use?
12. Do potential pollution hazards, including off-site sediment, noise and dust exist?
13. Are proposed permanent facilities subjected to flood or sediment damages?
14. Do subsurface conditions exist which could lead to pollution of ground water or aquifer recharge areas?
15. Is the construction schedule adequate?
16. Will erosion and sediment control measures be in place before extensive grading and clearing begins?
17. Have areas been designated for storage of salvaged topsoil?
18. Can *all* soil erosion and sediment control measures be adequately maintained?

INSPECTION AND ENFORCEMENT PROCESS

With regard to the inspection and enforcement process, it should be noted that it is not the purpose of this manual to support or promulgate specific courses of action by local authorities in these areas. Except as provided by Act 599, the local authorities are expected to exercise autonomy in determining the extent of any enforcement and inspection processes. The information provided here, as elsewhere in the manual, is only in keeping with the responsibility of a publication such as this to offer, for informational purposes, the alternatives available and in no way represents official opinion or recommendation.

These responsibilities begin after the issuance of a permit for a land-disturbing activity. A crucial element in any sediment and erosion control program is adequate field inspection for evaluating compliance to the approved erosion and sediment control plan. These inspections *might* be effectively incorporated in other existing local inspection programs.

Although Act 599 specifies that the actual responsibility for inspection is that of the governing authority, on-site inspection may be assigned to a building inspector or another person employed by the local unit of government. The inspector, whether a soils engineer, civil engineer, soil conservationist, or technician, should have some knowledge in the field of soil and water conservation.

To assure that the enforcing agency and the permit applicant are in agreement about the control procedures to be followed, a pre-construction conference would be desirable. This conference should be held prior to beginning the land disturbing activity. All facets of the proposed work should be discussed at this meeting and anticipated problems reviewed. The need for installing temporary sediment control measures prior to actual clearing and grading operations should be emphasized. The individual responsible for carrying out the plan should also be informed of local inspection policies and schedules.

The institution of both scheduled and random inspections would be appropriate. The former would be a routine inspection related directly to construction operations and carried out on a rigid schedule. Random or impromptu site inspections would assure continuing compliance and the proper maintenance of erosion and sediment control measures.

The implementation of a record system would insure coordination of the inspection process with other departments and local agencies. The record system should contain a detailed filing system for all land-disturbing activities. This file should contain a record including the date of each inspection, the date land-disturbing activities commenced, and pertinent comments concerning compliance or noncompliance with the erosion and sediment control plan. In cases of noncompliance, the report should contain statements of the conservation measures needed for compliance and the recommended time in which such measures should be installed. Inspection reports should be immediately forwarded to the local governing authority.

In the event that inspections indicate a violation exists, some type of system for notifying the violator would probably be necessary. An effective system often utilized by authorities involves a written "Notice to Comply." Such a notice would describe the violation and give a detailed description of conservation measures necessary to assure compliance with the approved erosion and sediment control plan. If proper action is not taken within a reasonable time, the local governing authority could then prepare a letter of intent to utilize a performance bond, cash bond, escrow monies or other legal arrangement insuring installation of the approved measure.

The county engineer, building inspector, etc., would represent the issuing authority in handling complaints about missing or ineffective erosion control measures. When it is determined that ineffective erosion control measures are being followed but those measures comply with the approved erosion control plan, the city engineer, building inspector, etc., should notify the local Soil and Water Conservation District.

Checklist of Site Inspection

The process of inspecting construction operations requires knowledge of the basic principles and control measures in Chapter 2. A thorough understanding of the erosion and sediment control plan is absolutely essential. The following checklist is supplied to assist the inspector in fulfilling his responsibilities.

1. Are all erosion and sediment control measures in place, adequate and properly constructed?
2. Have clearing operations been confined within the limits as shown on the plan?
3. Is vegetation outside of the clearing area protected? Supplemented?
4. Is sediment being transported from the site onto public right-of-way by vehicular traffic?
5. Are erosion problems present in the vicinity of temporary or permanent storm water management facilities?
6. Are sediment basins, sediment barriers and related devices effective in retaining sediment on the site?
7. Is appropriate vegetation being established as needed on the specified area?
8. Is work progressing in accordance with the proposed schedule?
9. Is the contractor following the plan and construction sequence?
10. Have temporary stream channel crossings been installed and maintained?
11. Are embankment slopes and permanent structures installed in areas subject to flood or sediment damage?
12. Has topsoil been salvaged and stored in the area designated by the plans?
13. Do severe fire hazards exist which would result in brush or grass fires?
14. Are all erosion and sediment control measures properly maintained?
15. Is excessive sediment leaving the site for any reason?
16. Have all buffers adjacent to "state waters" been honored?

Enforcement, Penalties, and Incentives

For each proposed land-disturbing activity, a decision should be made on precautions insuring that conservation measures are installed. These precautions may include a cash bond, cash escrow, letter of credit, or any combination thereof. The purpose is to insure that the planned conservation measures are installed at the applicant's expense if he fails to do it within the specified time. If a cash incentive is used, it should be required prior to commencing the land disturbing activity.

In the event that the requirements of the erosion and sediment control plans are not being fulfilled, one alternative the local units of government may consider is withholding future permits such as additional grading, building, etc., involving the particular land-disturbing site.

Local authorities may consider assessing fees for erosion and sediment control plan processing. The cost of inspection services could be recouped, if desired, by levying permit fees.

INFORMATION, EDUCATION AND TRAINING PROCESS

One of the most important processes in *any* erosion and sediment control program is an effective information and education effort. A local program *must* have the acceptance and the support of those persons most affected . . . the developers, engineers, planners, and architects, as well as the general public. Without their support, effective sediment and erosion control *will not* take place. It is very important that the "conservation pays" ethic be adopted by these groups.

Each municipality and county must formulate plans for an information/education program. Consideration should be given to:

1. Informing the developer and others affected by the requirements of the local program and of the assistance which will be made available to them.
2. Training seminars, conferences and educational material for the developer, his consultants, contractors and other support personnel of the developers.
3. Training seminars for the local government personnel authorized to perform the functions of inspections and enforcement and administrative duties within the local erosion and sediment control program.

An initial training program for new employees, or personnel such as building inspectors who will have an added duty of inspection for erosion control, is mandatory. Annual refresher courses or training programs should be planned.

Assistance in planning and conducting local training programs may be obtained through the Soil and Water Conservation Districts.

CHAPTER 5

SOURCES OF ASSISTANCE AND RESOURCE INFORMATION

ASSISTANCE

Act 599 emphasizes *local* erosion and sedimentation control programs. Policies governing permit issuance, inspection and enforcement may therefore vary between each municipality or county. The individual contemplating a land-disturbing activity should contact the governing authority of the county or municipality having jurisdiction over the proposed land change. Contacts should be made during the earliest phases of planning to avoid costly changes or delays.

FOR ADMINISTRATIVE ASSISTANCE IN ______
______________________________ COUNTY,
CONTACT: ______________________________
____
____
____

Act 599 specifies that the plan review process will be accomplished by the *local* Soil and Water Conservation District or its delegated authority. To insure that the erosion and sediment control plan will conform to local requirements, the developers should contact a District Supervisor in the county in which the land-disturbing activity will take place *early* in the planning stage.

FOR TECHNICAL ASSISTANCE IN PREPARING AN EROSION AND SEDIMENT CONTROL PLAN
IN ______________________________
COUNTY, CONTACT:

District Supervisor	or	District Conservationist
SWCD		NRCS Field Office
		Address
Address		Phone

RESOURCE INFORMATION

A wealth of resource data exists in various agencies which will assist in planning for land-disturbing activities and in the preparation of erosion and sediment control plans. If a specific address is not noted for the agency you need to contact, please refer to pages 5-3 to 5-10 to identify the agency's office nearest you.

Soils Information:

USDA Natural Resources Conservation Service

Georgia Soil and Water Conservation Commission

Local Soil and Water Conservation District

Topographic and Geologic Information:

Georgia Department of Natural Resources
Environmental Protection Division
Geologic Survey Branch
Room 400
19 Martin Luther King, Jr. Drive
Atlanta, GA 30334

Non-Point Source Pollution Control:

Georgia Department of Natural Resources
Environmental Protection Division
Water Protection Branch
Non-Point Source Pollution Control Program
4220 International Parkway, Suite 101
Atlanta, GA 30354
(404) 675-6240

Fisheries Management:

Georgia Department of Natural Resources
Wildlife Resources Division
Fisheries Management Section

Stream Flow Information:

United States Department of the Interior
Geological Survey Water Resources Division
1459 Peachtree Street, N.E.
Atlanta, GA 30304

Flood Hazard, Wetlands and 404 Permit Information:

U. S. Army Corps of Engineers (COE)

Georgia Department of Natural Resources
Environmental Protection Division
Water Resources Branch
Water Resources Management Program
Floodplain Unit
7 Martin Luther King, Jr. Drive, Suite 440
Atlanta, GA 30334
(404) 656-6382

USDA Natural Resources Conservation Service

Agriculture Information:

Georgia Soil and Water Conservation Commission

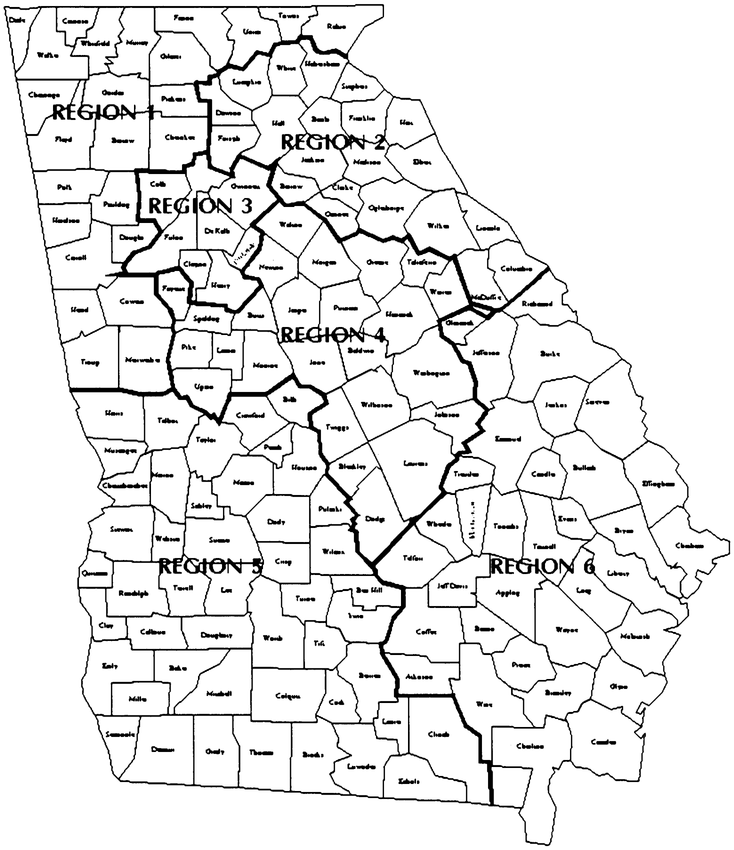
USDA Natural Resources Conservation Service

Forestry Information:

Georgia Forestry Commission

GEORGIA SOIL AND WATER CONSERVATION COMMISSION

REGIONAL OFFICES



Region 1
700 East 2nd Avenue, Suite J
Rome, Georgia 30161-3359
Phone: 706-295-6131

Region 2
P.O. Box 8024
Athens, Georgia 30603
Phone: 706-542-9233

Region 3
1500 Klondike Road
Suite A109
Conyers, Georgia 30094
Phone: 770-761-3020

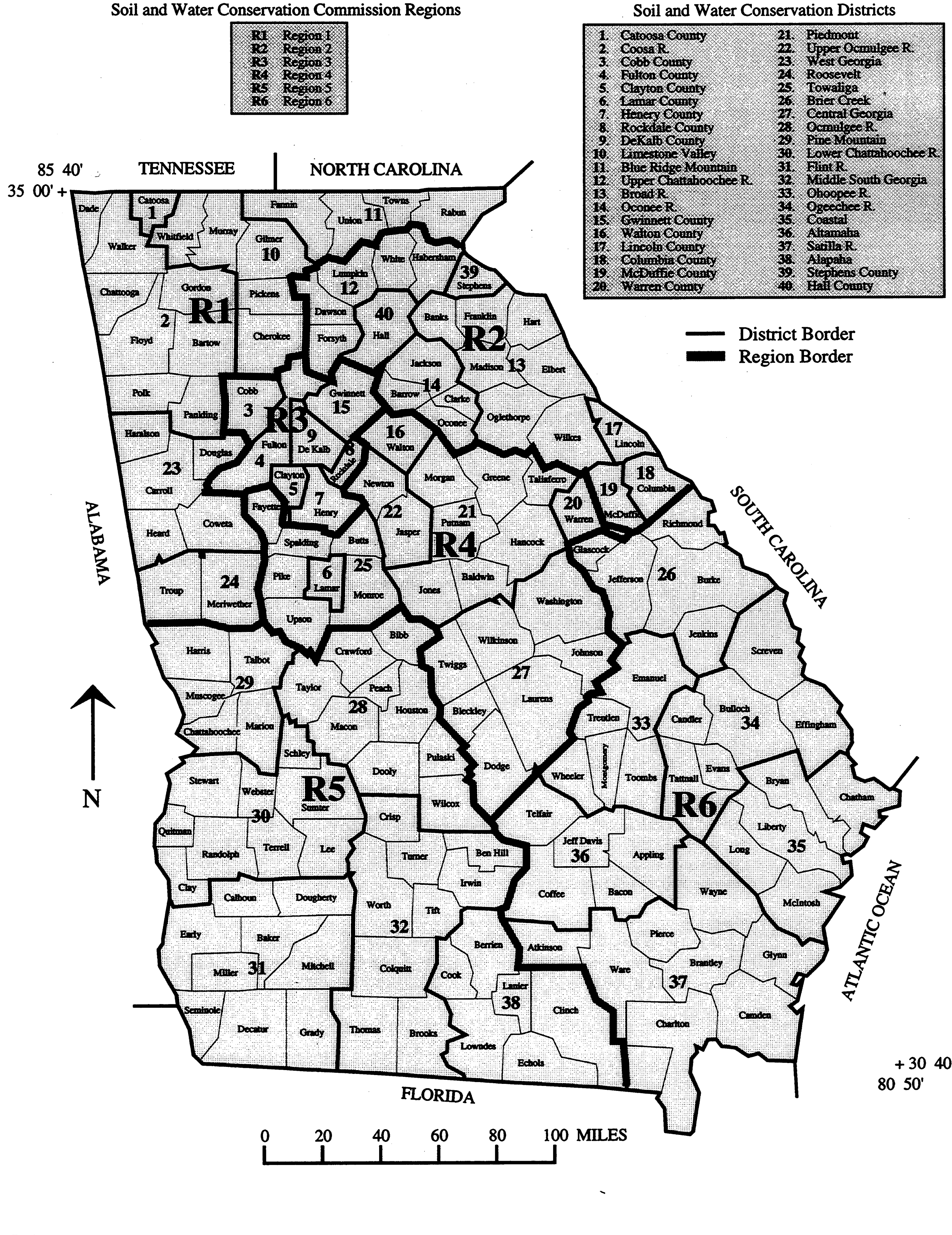
Region 4
3014 Heritage Road, Suite 1
Milledgeville, Georgia 31061
Phone: 912-445-5766

Region 5
2700 Palmyra Road
Albany, Georgia 31707-1845
Phone: 912-430-4408

Region 6
117 Savannah Avenue
Statesboro, Georgia 30458
Phone: 912-681-5241

Website
www.ganet.org/gswcc

GEORGIA
SOIL AND WATER CONSERVATION DISTRICT ORGANIZATION



Soil and Water Conservation Commission Regions

R1	Region 1
R2	Region 2
R3	Region 3
R4	Region 4
R5	Region 5
R6	Region 6

Soil and Water Conservation Districts

1.	Catoosa County	21.	Piedmont
2.	Coosa R.	22.	Upper Ocmulgee R.
3.	Cobb County	23.	West Georgia
4.	Fulton County	24.	Roosevelt
5.	Clayton County	25.	Towaliga
6.	Lamar County	26.	Brier Creek
7.	Henery County	27.	Central Georgia
8.	Rockdale County	28.	Ocmulgee R.
9.	DeKalb County	29.	Pine Mountain
10.	Limestone Valley	30.	Lower Chattahoochee R.
11.	Blue Ridge Mountain	31.	Flint R.
12.	Upper Chattahoochee R.	32.	Middle South Georgia
13.	Broad R.	33.	Ohoopee R.
14.	Oconee R.	34.	Ogeechee R.
15.	Gwinnett County	35.	Coastal
16.	Walton County	36.	Altamaha
17.	Lincoln County	37.	Satilla R.
18.	Columbia County	38.	Alapaha
19.	McDuffie County	39.	Stephens County
20.	Warren County	40.	Hall County

GEORGIA DEPARTMENT OF NATURAL RESOURCES ENVIRONMENTAL PROTECTION DIVISION

Northwest Georgia Region
Tradeport Office Park, Suite 114
4244 International Parkway
Atlanta, Georgia 30354
Phone: 404-362-2671

Northeast Georgia Region
745 Gaines School Road
Athens, Georgia 30605
Phone: 706-369-6398

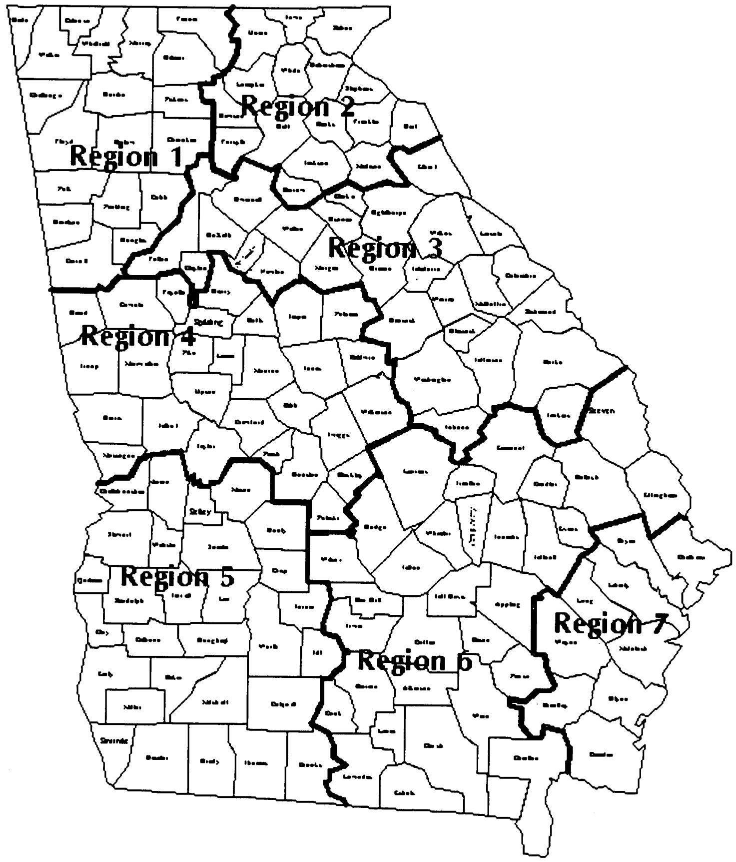
Middle Georgia Region
P.O. Box 233
Macon, Georgia 31211
Phone: 912-751-6612

Coastal Georgia Region
One Conservation Way
Brunswick, Georgia 31523
Phone: 912-264-7284

Southwest Georgia Region
2024 Newton Road
Albany, Georgia 31708
Phone: 912-430-4144

Website
www.dnr.state.ga.us/epd

GEORGIA DEPARTMENT OF NATURAL RESOURCES
WILDLIFE RESOURCES DIVISION
FISHERIES MANAGEMENT SECTION



Region 1 – Northwestern
P.O. Box 519
Calhoun, Georgia 30703
Phone: 706-629-1259

Region 2 – Northeastern
2150 Dawsonville Highway
Gainesville, Georgia 30501
Phone: 770-535-5498

Region 3 – East Central
2123 U.S. Highway 278, S.E.
Social Circle, Georgia 30279
Phone: 770-918-6418

Region 4 – West Central
Route 3, Box 75
Fort Valley, Georgia 31030
Phone: 912-825-6151

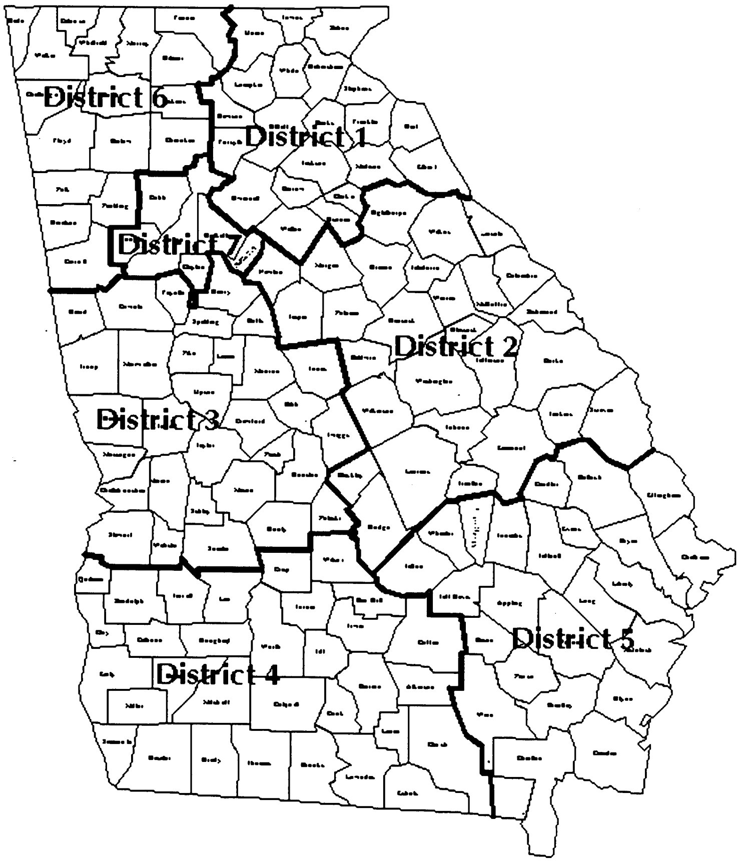
Region 5 – Southwestern
2024 Newton Road
Albany, Georgia 31701
Phone: 912-430-4256

Region 6 – South Central
P.O. Box 2089
Waycross, Georgia 31502
Phone: 912-285-6094

Region 7 – Coastal
22814 Highway 144
Richmond Hill, Georgia 31324
Phone: 912-727-2112

Website
www.state.ga.us/dnr/wild

GEORGIA DEPARTMENT OF TRANSPORTATION
DISTRICT OFFICES



District 1 – Gainesville, GA
P.O. Box 1057
Gainesville, Georgia 30503
Phone: 770-532-5526

District 2 – Tennille, GA
801 Fourth Street
P.O. Box 8
Tennille, Georgia 31089
Phone: 912-552-4600

District 3 – Thomaston, GA
715 Andrews Drive
Thomaston, Georgia 30286
Phone: 706-647-1000

District 4 – Tifton, GA
710 West Second Street
P.O. Box 7510
Tifton, Georgia 31793-7510
Phone: 912-386-3280

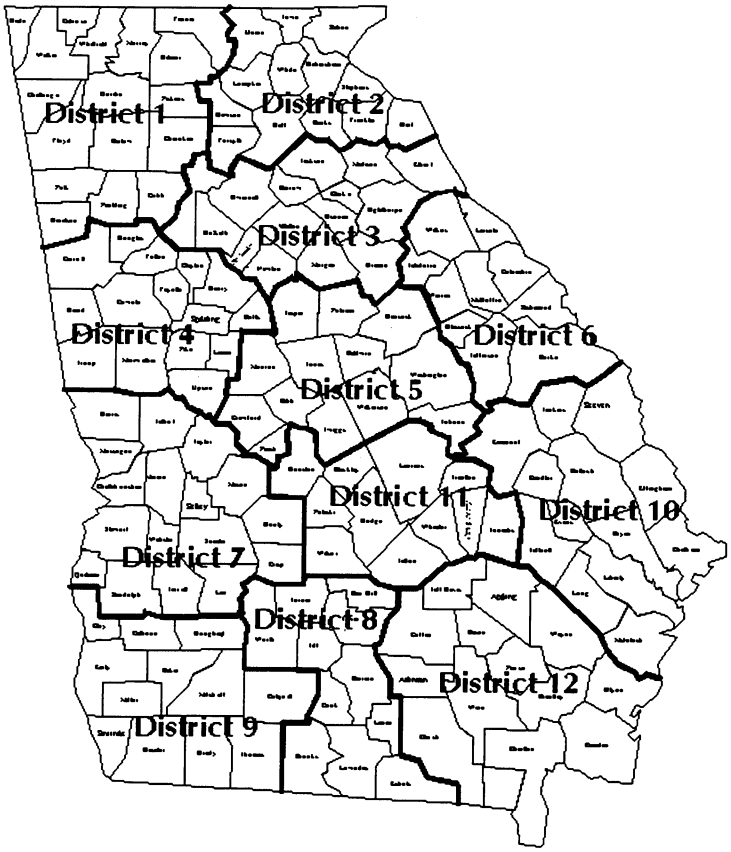
District 5 – Jesup, GA
Pine Street Extension
P.O. Box 608
Jesup, Georgia 31545
Phone: 912-427-5711

District 6 – Cartersville, GA
500 Joe Frank Harris Pkwy., S.E.
P.O. Box 10
Cartersville, Georgia 30120
Phone: 770-387-3602

District 7 – Chamblee, GA
5025 New Peachtree Road, N.E.
Chamblee, Georgia 30341
Phone: 770-986-1001

Website
www.dot.state.ga.us

GEORGIA FORESTRY COMMISSION
WATER QUALITY DISTRICTS



District 1 – Rome, GA
Phone: 706-295-6021

District 2 – Gainesville, GA
Phone: 770-531-6043

District 3 – Athens, GA
Phone: 706-542-6880

District 4 – Newnan, GA
Phone: 770-254-7218

District 5 – Milledgeville, GA
Phone: 912-445-5164

District 6 – Washington, GA
Phone: 706-678-2015

District 7 – Americus, GA
Phone: 912-931-2436

District 8 – Tifton, GA
Phone: 912-386-3617

District 9 – Camilla, GA
Phone: 912-336-5341

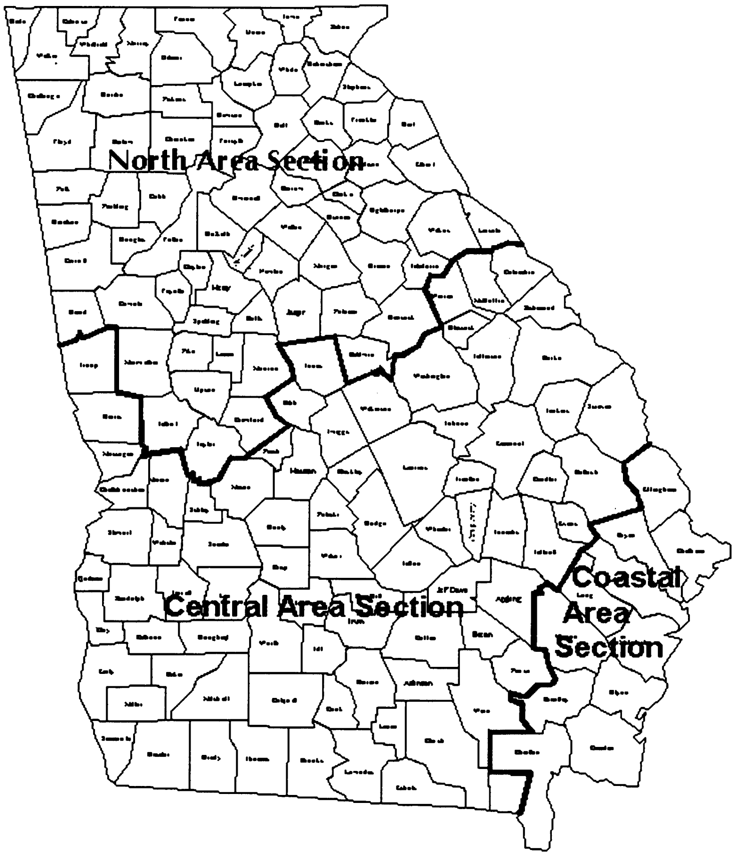
District 10 – Statesboro. GA
Phone: 912-681-5347

District 11 – McRae, GA
Phone: 912-868-5649

District 12 – Waycross, GA
Phone: 912-287-4917

Website
www.gfc.state.ga.us

UNITED STATES
ARMY CORPS OF ENGINEERS
GEORGIA AREA SECTIONS

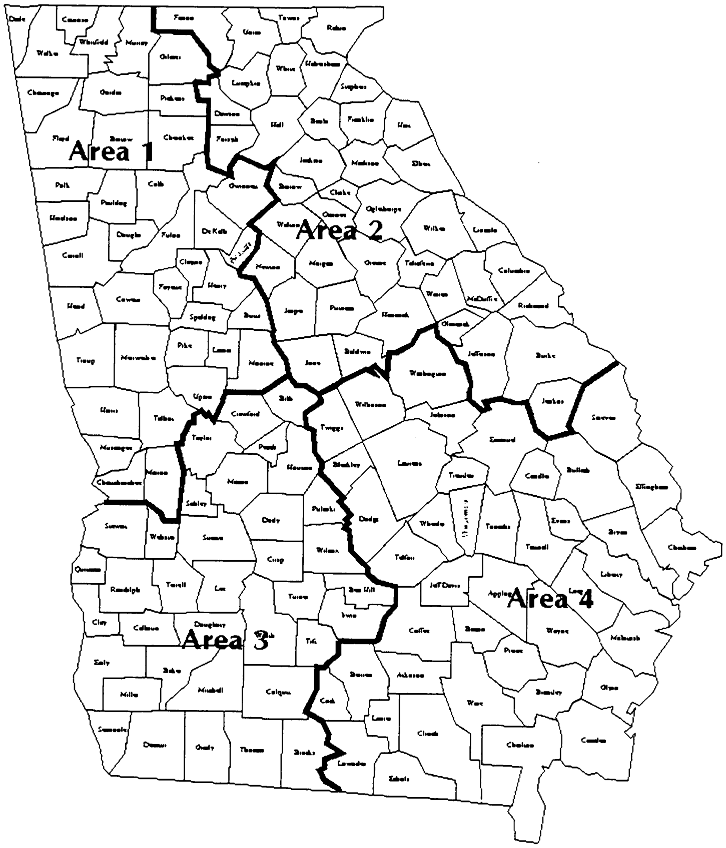


Central and Coastal Area Sections
U.S. Army Corps of Engineers
Attention: Regulatory Branch
P.O. Box 889
Savannah, Georgia 31402-0889
Phone: 912-652-5347
1-800-448-2402

North Area Section
U.S. Army Corps of Engineers
Attention: Regulatory Branch
3485 North Desert Drive
Building 2, Suite 102
Atlanta, Georgia 30344
Phone: 404-763-7933

Website
www.usace.army.mil

GEORGIA NATURAL RESOURCES CONSERVATION SERVICE AREA OFFICES



Area 1
Federal Building, Room G-27
201 West Solomon Street
Griffin, Georgia 30224-3037
Phone: 770-227-1026

Area 2
Federal Building
355 East Hancock Ave.
Athens, GA 30601
Phone: 706-546-2272

Area 3
Plant Materials Center
295 Morris Drive
Americus, GA 31709-9999
Phone: 912-924-7003

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CHAPTER 6

BMP Standards and Specifications for General Land-Disturbing Activities

CHAPTER 6

BMP STANDARDS AND SPECIFICATIONS FOR GENERAL LAND-DISTURBING ACTIVITIES

This chapter contains Standards and Specifications for planning, design and installation of erosion and sediment control measures. They are intended to provide minimum criteria for use at the local level. The many variations in climate, soils, topography, physical features and planned land use may require modifications at the local level. Local officials will assure that standards and specifications are implemented in harmony with existing ordinances, rules and regulations.

Variations of these standards have been in use since late 1930's, when Soil and Water Conservation Districts were first established. Continuing progress through experience and research will require periodic updating. The construction specifications contained herein are not intended to be complete. Detailed construction specifications should be prepared for each land-disturbing activity.

Information has been included on geotextiles based on the American Association of State Highway Transportation Officials (AASHTO). Infomation on Forestry Best Management Practices can be found in the Georgia Forestry Commission's publication entitled *Georgia's Best Managment Practices for Forestry.*

Erosion control is of primary importance during land-disturbing activities, but sediment storage must be available on the site. Temporary sediment basins and retrofitted detention ponds most commonly achieve the required 67 cubic yards per acre of disturbed area of storage. Some situations may call for the use of practices other than those mentioned above. Appropriate sediment storage must be available on the site PRIOR to any land-disturbing activities. It is imperative that creative engineering practices are used to ensure that erosion and sediment control BMP's are appropriate for the situation and activity. Linear projects pose special treatment concerning erosion and sediment control. Guidelines for dealing with linear projects has been included.

Shall or Will, Should, and **May** are used in these specifications with the following definitions:

Shall or Will - A mandatory condition. When certain requirements are described with the "shall" or "will" stipulations, it is mandatory that the requirements be met.

Should - An advisory condition. Considered to be recommended but not mandatory.

May - A permissive condition. No requirement is intended.

Section I contains standards providing general instructions for the preparation of erosion and sediment control plans for land-disturbing activities.

Section II contains standards and specifications for vegetative type measures for general land-disturbing activities.

Section III contains standards for structural practices and provides instructions for the preparation of erosion and sediment control plans for land-disturbing activities.

Section IV contains tables for design of vegetated diversion, waterway or stormwater conveyance practices.

Waters of the United States and Erosion and Sediment Control

Wetlands are defined as areas that are inundated by surface or ground water for a long enough period of time that the area supports the growth of vegetation that can perpetuate in saturated soil. Wetlands are a valuable resource, and it is imperative that these areas are protected from damage caused by adjacent erosion and subsequent sedimentation. While state law does not necessarily require buffers adjacent to wetlands, these areas are still considered valuable, and all efforts must be made to protect these areas during land disturbing activities. Obviously, the best and most effective method for protecting wetlands is maintaining a buffer between and land-disturbing activity and the wetland. If this is not possible, standard erosion and sediment control devices can be utilized to protect these areas. As always, it is imperative that these devices be designed, installed, and properly maintained.

The Georgia Erosion and Sediment Control (E&SC) Act requires that land-disturbing activities in Georgia are protected from erosion and subsequent sedimentation up to and including a 25-year storm. Few realize that activities that impact Waters of the United States can mean stricter Federal requirements for erosion and sediment control. Waters of the United States are navigable waters as well as adjacent wetlands and tributaries to navigable waters. Discharge of dredged of fill material into Waters of the United States is regulated by the United States Army Corps of Engineers under Section 404 of the Clean Water Act (33 U.S.C. 1344)

While State Law requires E&SC protection for a 25-year storm, Federal Law requires that adequate erosion and sediment control must be implemented during land-disturbing activities where a section 404 permit (usually known as a wetland permit) is required. Few realize that minor activities of filling and dredging, while not requiring U.S. Army Corps of Engineers notification, still must meet the Federal requirement of "adequate erosion and sediment control" as if a permit had been issued. According to Federal Law, "adequate equates to "no failures tolerated." In short, when filling or dredging activity impacts any Waters of the United States, adequate erosion control must occur at the site. Therefore, during land-disturbing activities regulated by the state, erosion and sediment control regulations fall under stricter Federal guidelines as well as the standard State guidelines if Waters of the United States are impacted.

To get more information concerning discharge of dredged or fill material into Waters of the United States, permitting for these activities, and stipulations for permitting please contact the United States Army Corps of Engineers, Savannah District, Regulatory Branch, at 1-800-652-5065.

STANDARDS AND SPECIFICATIONS

Page

SECTION I: LAND-DISTURBING ACTIVITY PLAN

SECTION II: VEGETATIVE MEASURES

SECTION III: STRUCTURAL PRACTICES

SECTION IV: TABLES FOR DESIGN OF VEGETATED DIVERSION, WATERWAY OR STORMWATER CONVEYENCE PRACTICES

SECTION I: LAND-DISTURBING ACTIVITY PLAN

Land-Disturbing Activity Plan

DEFINITION

A plan for the control of soil erosion and sedimentation resulting from a land-disturbing activity.

PURPOSE

The purpose of this standard is to provide instructions for the preparation of detailed plans for a proposed land-disturbing activity in order to accomplish one or more of the following:

1. provide suitable sites for buildings, roadways, facilities and other land uses.
2. improve surface drainage.
3. control soil erosion and sediment deposition.

CONDITION

This standard is applicable where land-disturbing activities are undertaken for any of the purposes set forth above.

PLANNING CRITERIA

This land-disturbing activity plan shall be based upon adequate surveys, resource data and investigations. Erosion and sediment control measures shall be designed in accordance with the applicable standard applied herein. Practical combinations of the following principles shall be utilized, as a minimum, in planning for any land-disturbing activity.

1. **Fit the Activity to the Topography and Soils.**
Detailed planning should be employed to assure that roadways, buildings and other permanent features of the activity conform to the natural characteristics of the site. Large graded areas should be located on the most level portion of this site. Areas subject to flooding should be avoided. Areas of steep slopes, erodible soils and soils with severe limitations for the intended uses should not be utilized without overcoming the limitations through sound engineering practices. *Erosion control, development and maintenance costs can be minimized if a site is selected for a specific activity.*

2. **The Disturbed Area and the Duration of Exposure to Erosion Elements Should Be Minimized.**
Clearing of natural vegetation should be limited to only those areas of the site to be developed at a given time. Natural vegetation should be retained, protected and supplemented with construction scheduling employed to limit the duration of soil exposure. Major land clearing and grading operations should be scheduled during seasons of low potential runoff.

3. **Stabilize Disturbed Areas Immediately.**
Permanent structures, temporary or permanent vegetation, and mulch, or a combination of these measures, should be employed as quickly as possible after the land is disturbed. Temporary vegetation and mulches can be most effective on areas where it is not practical to establish permanent vegetation. These temporary measures should be employed immediately after rough grading is completed if a delay is anticipated in obtaining finished grade. The finished slope of a cut or fill should be stable and ease of maintenance considered in the design. Stabilize all roadways, parking areas, and paved areas with the gravel subbase, temporary vegetation or mulch. *Mulch, temporary vegetation, or permanent vegetation shall be completed on all exposed areas within 14 days after disturbance.* Mulch and/or temporary grassing may be used up to six months; permanent vegetation shall be planted if the area is to be left undisturbed for greater than six months.

4. **Retain or Accommodate Runoff.**
Runoff from the development should be safely conveyed to a stable outlet using storm drains, diversions, stable waterways or similar conservation measures. Consideration should also be given to the installation of storm water retention structures to prevent flooding and damage to downstream facilities resulting from increased runoff from the site. Temporary or permanent facilities for conveyance of storm water should be designed to withstand the velocities of projected peak discharges. These facilities should be operational as soon as possible after the start of construction, and if possible before the disturbance of the surrounding areas.

5. **Retain Sediment.**
Sediment basins, sediment barriers and related structures should be installed to filter or trap sediment on the site to be disturbed. The most effective method of controlling sediment, however, is to control erosion at its source. Sediment retention structures should be planned to retain sediment when erosion control methods are not practical, or insufficient, or in the process of being installed, or have failed due to some unforeseen factor. If possible, the structures should be installed before the disturbance of surrounding areas.

6. **Do Not Encroach Upon Watercourses.**

Permanent buildings should not be subjected to flooding, sediment damages or erosion hazards. Earth fills should not be constructed in flood-prone areas so as to adversely obstruct water flows or increase downstream velocity of water flows. When necessary to span a flood prone area or watercourse, bridge or culvert openings should be sized to permit passage of peak discharges without causing undue restrictions in water flows or without creating excessive downstream velocities. Uses of flood prone areas should be limited to activities which would not suffer excessive damages from flooding, scour, and sediment damages. Temporary bridges or culverts should be employed when construction equipment is required to cross natural or constructed channels.

PLAN REQUIREMENTS

The land-disturbing activity plan should contain a narrative description of the project, maps, drawings, computations and supportive data in accordance with the following guidelines.

Narrative Description

A brief description of the overall project containing:

1. Location, nature, size, and zoning classification of the overall project.
2. Location, nature and size of each phase of development.
3. Size, type of structural units, paved areas and green-belt area.
4. Starting dates of initial land-disturbing activities and date expected final stabilization will be completed.
5. Existing and proposed erosion and sediment control problems for the proposed site.
6. Purpose, nature and extent of proposed sediment control program.
7. Proposed storm water management program for the development and the effect of the development on downstream facilities.
8. Major topographic features, streams, existing soil types and vegetation located on the project site.
9. Maintenance programs for the sediment control facilities including inspection frequencies, vegetative programs, repair procedures, frequency of removal and disposition of solid waste and disposition of temporary sediment structural measures.

Maps

Detailed maps, drawings and sketches showing:

1. A location sketch of the project relative to roadways, municipalities, major streams and other identifiable landmarks.
2. A boundary line survey or detailed boundary sketch of the proposed project.
3. Contours, existing and proposed, for that portion of the activity being developed.
4. Soils boundaries including name, texture, slope, depth, drainage and structure.
5. Streams and drainage areas, lakes or ponds, flood prone areas, vegetation and existing structures.
6. The proposed alteration of the area including limits of clearing and grading, roads, buildings and structures.
7. Location and extent of temporary and permanent erosion and sediment control measures including both vegetative and structural practices.
8. Location and extent of storm water management facilities.
9. Other significant features including legend, map scales, north arrow, title blocks, seals and signatures.

Activity Schedules

For each phase or stage of land-disturbing activity, an activity schedule will be included. The activity schedule will show the anticipated starting and completion date for all land development activities including:

1. Timber salvage operations
2. Installation of construction exit, sediment barriers, and other perimeter controls
3. Clearing and grubbing of areas necessary for the installation of sediment retention basins and related structures
4. Installation of sediment retention basins and related structures
5. Clearing and grubbing of remaining areas
6. Rough grading
7. Installation of stormwater management system
8. Permanent stabilization of areas at final grade and temporary stabilization of remaining areas
9. Installation of curb and gutter
10. Installation of gravel subbase for roads and parking areas (construction road stabilization)
11. Building construction
12. Final grading
13. Permanent stabilization/landscaping
14. Removal of erosion and sediment control measures.

Supportive Data

Supportive data shall include reference to the applicable standards and specifications, calculations, charts, graphs, maps and any other data used in the design and layout of the measures installed.

CONSTRUCTION SPECIFICATIONS

All timber having a marketable value shall be salvaged. Timber logs, brush, rubbish, and vegetable matter which will interfere with the grading operations or affect the planned stability of fill areas shall be removed and disposed of according to the plan and in accordance with all local and state laws.

Topsoil is to be stripped and stockpiled in amounts necessary or available on site to complete final grading of all exposed areas.

Fill material is to be free of brush, rubbish, rocks, logs, and stumps in amounts that are detrimental to constructing stable fills.

Cut slopes which are to be top soiled will be scarified to a minimum depth of 3 inches prior to placement of topsoil.

Compaction of fills will be as required to reduce slipping, erosions or excess saturation.

Frozen mixtures of soft, mucky or easily compressible materials are not to be incorporated in fills intended to support buildings, parking lots, road, structures, sewers, or conduits.

Maximum thickness of layers to be compacted by sheeps foot rollers are not to exceed 9 inches.

All disturbed areas shall be left with a neat and finished appearance and stabilized with the appropriate permanent protective cover.

EROSION AND SEDIMENT CONTROL PLAN REVIEW CHECKLIST FOR LINEAR PROJECTS

Project Name ______________________________ Address ______________________________

City/County ______________________________ Date on Plans ______________________________

Site Plan:

1) Show graphic scale and north arrow.
2) Provide vicinity map showing site's relation to surrounding area.
3) Provide both existing and planned contours in accordance with the following:
    - Existing contours: USGS 1" : 2000' topographical sheets
    - Proposed contours: 1" : 400' centerline profile
4) Delineate on-site drainage and off-site watersheds using USGS 1" : 2000' topographical sheets.
5) Delineate all state waters located on or within 200 feet of the project site – refer to 1" : 2000' USGS topographical sheets, published soil surveys, GIS information, etc.
6) Show location of erosion and sediment practices using uniform coding symbols from the Manual for Erosion and Sediment Control in Georgia, Chapter 6, with legend.
7) Delineate 25-foot undisturbed buffers of state waters and 100-foot management zones along designated trout streams. Clearly note areas of impact.
8) Delineate all wetlands and provide regulatory documentation permitting any proposed impacts.
9) Include soil series and their delineation.
10) Describe adjacent areas – neighboring areas such as streams, lakes, residential areas, etc., which might be affected.

Narrative Notes and Other Information: (Notes or narrative should be located on the site plan under general notes or under erosion and sediment control notes.)

1) Provide description of existing land use at project site and description of proposed project. Include land lot and district numbers for site location.
2) Provide name, address and phone number of utility/contractor.
3) Provide name and phone number of 24-hour local contact that is responsible for erosion and sediment controls.
4) Show signature and seal of qualified plan preparer.
5) Note total and disturbed acreage of the project or phase under construction.
6) Provide detailed construction activity schedule – show anticipated starting and completion dates for project events, include vegetation and mulching timeline.
7) Clearly note the statement in bold letters: **"The escape of sediment from the site shall be prevented by the installation of erosion and sediment control measures and practices prior to, or concurrent with, land-disturbing activities."**
8) Provide 67 cubic yards per acre sediment storage. Include specific design information and calculations for structural measures on site.
9) Show storm-drain pipe and weir velocities and provide appropriate outlet protection to accommodate discharges without erosion.
10) Provide vegetative plan, noting all temporary and permanent vegetative practices. Include species, planting dates and seeding, fertilizer, lime, and mulching rates. Vegetative plan shall be site specific for appropriate time of year that seeding will take place and for the appropriate geographic region of Georgia.
11) Provide detailed drawings for all structural practices. Specifications must, at a minimum, meet guidelines set forth in the Manual for Erosion and Sediment Control in Georgia.
12) Clearly note maintenance statement – "Erosion control measures will be maintained at all times. If full implementation of the approved plan does not provide for effective erosion control, additional erosion and sediment control measures shall be implemented to control or treat the sediment source."

EROSION AND SEDIMENT CONTROL PLAN REVIEW CHECKLIST

Project Name ______________________ Street Address ______________________

City/County ______________________ Date on Plans ______________________

Site Plan:

1) Show graphic scale and north arrow.
2) Provide vicinity map showing site's relation to surrounding area, including designation of specific phase, if necessary.
3) Provide both existing and planned contours with contour lines drawn at an interval in accordance with the following:

Map Scale	Ground Slope	Contour Interval, ft.
1 inch = 100 ft. or larger scale	Flat 0-2% Rolling 2-8% Steep 8% +	0.5 or 1 1 or 2 2, 5 or 10

4) Delineate contributing drainage areas both on and off site. Include hydrology study and maps of drainage basins for both the pre- and post-developed conditions.
5) Delineate all state waters located on or within 200 feet of the project site.
6) Show location of erosion and sediment practices using uniform coding symbols from the Manual for Erosion and Sediment Control in Georgia, Chapter 6, with legend.
7) Delineate 25-foot undisturbed buffers of state waters and 100-foot management zones along designated trout streams. Clearly note areas of impact.
8) Delineate all wetlands and provide regulatory documentation permitting any proposed impacts.
9) Include soil series and their delineation.
10) Describe adjacent areas – neighboring areas such as streams, lakes, residential areas, etc., which might be affected.

Narrative Notes and Other Information: (Notes or narrative should be located on the site plan under general notes or under erosion and sediment control notes.)

1) Provide statement from local tax official that all ad valorem taxes owed and due have been paid.
2) Provide description of existing land use at project site and description of proposed project. Include land lot and district numbers for site location.
3) Provide name, address and phone number of developer/owner.
4) Provide name and phone number of 24-hour local contact that is responsible for erosion and sediment controls.
5) Show signature and seal of qualified plan preparer.
6) Note total and disturbed acreage of the project or phase under construction.
7) Provide detailed construction activity schedule – show anticipated starting and completion dates for project events, include vegetation and mulching timeline.
8) Clearly note the statement in bold letters: **"The escape of sediment from the site shall be prevented by the installation of erosion and sediment control measures and practices prior to, or concurrent with, land-disturbing activities."**
9) Provide 67 cubic yards per acre sediment storage. Include specific design information and calculations for all structural measures on site, such as temporary sediment basins, retrofitted detention ponds, and channels.
10) Show storm-drain pipe and weir velocities and provide appropriate outlet protection to accommodate discharges without erosion.
11) Provide vegetative plan, noting all temporary and permanent vegetative practices. Include species, planting dates and seeding, fertilizer, lime, and mulching rates. Vegetative plan shall be site specific for appropriate time of year that seeding will take place and for the appropriate geographic region of Georgia.
12) Provide detailed drawings for all structural practices. Specifications must, at a minimum, meet guidelines set forth in the Manual for Erosion and Sediment Control in Georgia.
13) Clearly note maintenance statement – "Erosion control measures will be maintained at all times. If full implementation of the approved plan does not provide for effective erosion control, additional erosion and sediment control measures shall be implemented to control or treat the sediment source."

SECTION II: VEGETATIVE MEASURES

Vegetative Measures

Erosion control should be addressed in the planning stages of all proposed land-disturbing activities. While erosion is difficult to control completely, methods to reduce it are practical, affordable, and cost effective. Erosion control techniques shall be used on all areas exposed for a prolonged period of time, including areas that will be paved or built upon in the future. Various types of vegetative practices are used for erosion control.

The time-line for the implementation of various vegetative practices is as follows:

Mulch, temporary vegetation, or permanent (perennial) vegetation shall be completed on all exposed areas within 14 days after disturbance.

Ds1 - Disturbed Area Stabilization (With Mulching Only) Mulching can be used as a singular erosion control method on areas at rough grade. Mulch can be an option for up to six months provided that the mulch is applied at the appropriate depth (depending on type of mulch used), anchored, and has a continuous 90% cover or greater of the soil surface. Maintenance shall be required to maintain appropriate depth, anchorage, and 90% cover. If an area will remain undisturbed for greater than six months, permanent (perennial) vegetation shall be used.

Ds2 - Disturbed Area Stabilization (With Temporary Seeding) Temporary vegetation may be employed instead of mulch if the area will remain undisturbed for less than six months.

Ds3 - Disturbed Area Stabilization (With Permanent Vegetation) Permanent (perennial) vegetation or sod shall be used immediately on areas at final grade. Permanent (perennial) vegetation shall be used on rough graded areas that will be undisturbed for more than six months.

Ds4 - Disturbed Area Stabilization (With Sodding) may be used in place of Ds3.

"Stabilization" of an area is accomplished when 70 percent of the surface area is covered in a uniform, vegetative cover (permanent or temporary) or anchored mulch of the appropriate thickness with 90% coverage. **"Final stabilization"** means that all soil disturbing activities at the site have been completed, and that for unpaved areas and areas not covered by permanent structures, at least 70% of the soil surface is uniformly covered in permanent vegetation or equivalent permanent stabilization measures (such as the the use of rip rap, gabions, permanent mulches or geotextiles) have been employed.

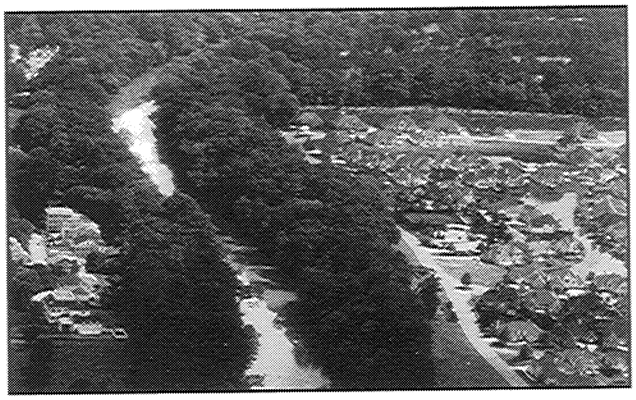
Permanent (perennial) vegetation shall consist of: planted trees, shrubs, perennial vines; a crop of perennial vegetation appropriate for the time of year and region; or a crop of annual vegetation and a seeding of target crop perennials appropriate for the region, such that within the growing season a 70% coverage by perennial vegetation shall be achieved.

For linear construction projects on land used for agricultural or silvicultural purposes, final stabilization may be accomplished by stabilizing the disturbed land for its agricultural or silvicultural use.

For the purposes of this publication, permanent vegetation is used synonymously with perennial vegetation. Perennial vegetation is plant material that lives continuously from year to year although it may have a dormant season when the leaves and possibly the stems "die back" to the ground. No vegetative planting can technically be considered permanent. Annual vegetation is plant material that lives for only one growing season. This type of vegetation is typically used for temporary establishment due to its quick germination. Some perennial vegetation can be used for temporary stabilization.

Buffer Zone

Bf



DEFINITION

A strip of undisturbed, original vegetation, enhanced or restored exisiting vegetation or the re-establishment of vegetation surrounding an area of disturbance or bordering streams, ponds, wetlands, lakes and coastal waters.

PURPOSE

To provide a buffer zone serving one or more of the following purposes:

- Reduce storm runoff velocities
- Act as screen for "visual pollution"
- Reduce construction noise
- Improve aesthetics on the disturbed land
- Filtering and infiltrating runoff
- Cooling rivers and streams by creating shade
- Provide food and cover for wildlife and aquatic organisms
- Flood protection
- Protect channel banks from scour and erosion.

CONDITIONS

A natural strip of vegetation should be preserved and, if needed, supplemented to form the buffer zone. There are two types of buffer zones.

General Buffers

A strip of undisturbed, original land surrounding the disturbed site. It can be useful not only to filter and infiltrate runoff, but also to act as a screen for "visual pollution" and reduce construction noise. General buffers may be enhanced to achieve desired goals.

Vegetated Stream Buffers

Buffers bordering streams are critical due to the invaluable protection of streams from sedimentation. Stream buffers are also useful in cooling rivers and providing food and cover for wildlife. Refer to the minimum requirements in Act 599 (O.C.G.A. 1-7-1, *et. seq.*) and Chapters 16 and 18 of the NRCS Engineering Field Handbook.

In most cases, the buffer zone will be incorporated into the permanent vegetative cover. Refer to specification **Ds3 - Disturbed Area Stabilization (With Permanent Vegetation).**

DESIGN SPECIFICATIONS

Important design factors such as slope, hydrology, width and structure shall be considered. While Georgia's Environmental Protection Division enforces minimum stream buffer requirements, expanding the stream buffer width is always encouraged. If any land-disturbing activity, including exempt and non-exempt practices, occurs within the EPD mandated stream buffers, cut and fills within the buffer shall be stabilizied with appropriate matting or blanket.

General Buffers

A width should be selected to permit the zone to serve the purpose(s) as listed above. Supplemental plantings may be used to increase the effectiveness of the buffer zone.

Vegetated Stream Buffers

The structure of vegetated stream buffers should be considered to determine if the buffer must be enhanced to achieve the necessary goals. The size of the stream as well as the topography of the area must be considered to determine the appropriate width of the vegetated stream buffer. A vegetated stream buffer of 50 feet or greater can protect waters from excess sedimentation. The buffer should be increased 2 feet in width for every 1% slope (measured along a line perpendicular to the stream bank). Surface water pollution can be reduced with a 100 foot or wider vegetative buffer.

A general multipurpose riparian buffer consists of three zones.

1. Zone 1 The first 20 feet nearest the stream should consist of trees spaced 6-10 feet apart.
2. Zone 2 The next 10 feet should consist of managed forest.

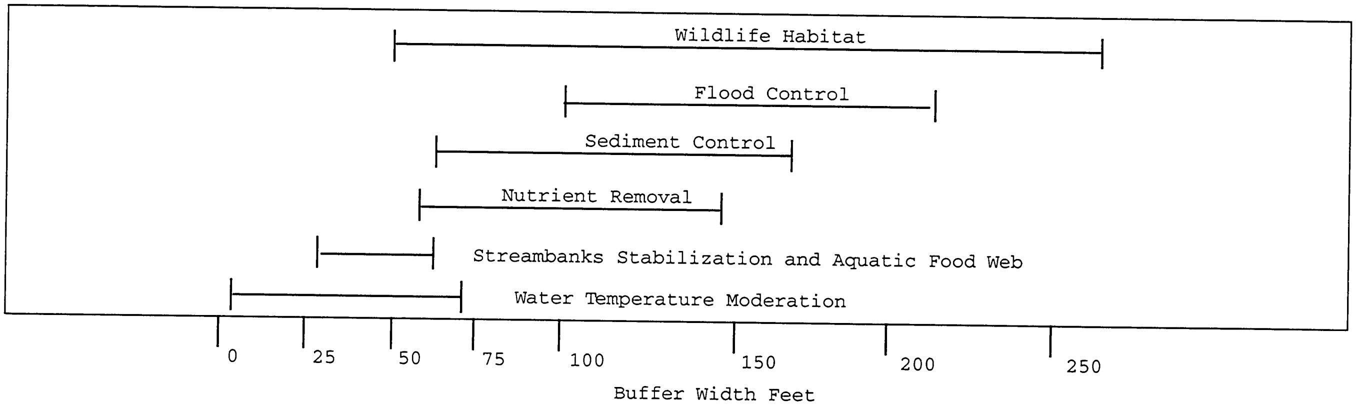


Figure 6-1.1 - Range of minimum width for meeting specific buffer objectives. (Palone and Todd,draft)

3. Zone 3 The following 20 feet should be comprised of grasses.

This general multipurpose design contains trees and shrubs that help to stabilize stream banks and grasses which spread and reduce the flow from adjacent areas as well as increase settling and infiltration. See Tables 6-1.1 and 6-1.2 for suggested plant species.

If the ideal vegetated buffer width cannot be achieved; narrower buffers can still be used to obtain the goals concerning forest structure and riparian habitat. If this is the case, several design principals should be considered:

1. **Sheet flow** should be encouraged at the edge of the vegetated stream buffer.
2. The **structure** of the buffer should consist of understory and canopy species.
3. The **width** should be proportional to the watershed area and slope.
4. **Native and non-invasive** plant species should be used.
5. **Density** must be considered to determine if the existing buffer must be enhanced to achieve the necessary goals. Vegetation must be dense enough to filter sediment and provide detrital nutrients for aquatic organism.

Streambank stabilization techniques may be required if steep slopes and hydrologic patterns deem it necessary. Refer to specification **Sb - Streambank Stabiliation (Using Permanent Vegetation).** Vegetated stream buffers on steep slopes may need to be wider to effectively filter overland flow. Corridors subject to intense flooding may require additional stream bank stabilization measures.

PLANTING TECHNIQUES

Plantings for buffer re-establishment and enhancement can consist of bare root seedlings, container-grown seedlings, container-grown plants, and balled and burlapped plants. Refer to Tables 6-1.1 and 6-2. and Wildlife Plantings in **Ds3 - Disturbed Area Stabilization (With Permanent Vegetation).** Standard permanent erosion control grasses and legumes may be used in denuded areas for quick stabilization. Refer to specification **Ds3 - Distsurbed Area Stabilization (With Permanent Vegetation).** Availability, cost, associated risk, equipment, planting procedures, and planting density must be considered when choosing planting types.

Soil preparation and maintenance are essential for the establishment of planted vegetation. Soil fertility, weed control, herbaceous cover, as well as additional associated products may be required.

OPERATIONS AND MAINTENANCE

Areas closest to the stream should be maintained with minimal impact.

Watering

During periods of drought as well as during the initial year, waterering may be necessary in all buffer areas planted for enhancement.

Weed Control

Weeds can be removed by hand or with careful spraying.

Replanting

It is imperative that the structure of the vegetated stream buffer be maintained. If the buffer has been planted, it is suggested that the area be monitored to determine if plant material must be replaced. See Tables 6-1.1 and 6-1.2 for suggested plant species. Provisions for the protection of new plantings from destruction or damage from beavers shall be incorporated into the plan.

Fertilizer

If appropriate vegetation is chosen, it is unlikely that fertilizer will be be necessary.

Local Contacts:

USDA Natural Resources Conservation
Service
Georgia Forestry Commission

PLANTS SUITABLE FOR USE AS UNROOTED (HARDWOOD) CUTTINGS

Species	Region	Tolerance To Flooding	Tolerance To Drought	Tolerance To Deposition	Tolerance To Shade
Acer negundo Boxelder	C,P,M	H	H	H	L
Baccharis halimifolia Groundsel bush	C,P (lower)	M	M	H	L
Cornus amomum Silky dogwood	P,M	L	M	L	M
Cornus sericia Ssp. stolonifera Red osier dogwood	P,M	L	M	H	M
Crataegus sp. Hawthon	C,P,M	M	H	L	L
Populus deltoids Eastern cottonwood	C,P,M	M	M	H	L
Salix sp. interior Sandbar willow	C,P,M	H	L	H	L
Salix nigra Black willow	C,P,M	H	H	H	L
Salix purpurea Streamco willow	C,P,M	H	M	H	L
Salix x cotteti Bankers willow	P,M	H	M	H	L
Sambucus canadensis American elderberry	P,M	H	M	M	M
Viburnum dentatum Arrowwood viburnum	C,P,M	M	M	M	M
Viburnum lentago Nannyberry viburnum	C,P,M	M	M	L	M

Adapted from the USDA/NRCS Engineering Field Handbook, Chapter 18

Table 6-1.1 - Unrooted hardwood cuttings.

Legend:

Tolerance to Flooding, Drought, Deposition, and Shade
H = High
M = Medium
L = Low

Region
C = Coastal
P = Piedmont
M = Mountain

Rooting of all species will be improved if nearby vegetation is pruned to increase sunlight penetration.

Whenever possible, harvest hardwood cuttings as close to the repair site as possible.

Many of the above grow naturally along streams, in adjacent wetlands, along sewer and power line easements, and where streams enter lakes and along lake shores. Willows generally grow profusely in stormwater detention ponds in urban areas.

ALWAYS OBTAIN PERMISSION FROM THE PROPERTY OWNER BEFORE HARVESTING PLANTS!

Table 6-1.1 - continued

NATIVE PLANT GUIDE FOR STREAMBANK PLANTING ROOTED STOCK

Species	Region	Stream Zone	Wildlife Value	Notes
Acer rubrum Red Maple	M,P,C	Tree	High Seeds & browse	Rapid growth.
Alnus serrulata Smooth alder	M,P,C	Shrub	Moderate, Cover	Rapid growth. Stabilizes streambanks. Sun.
Amorpha fruticosa False indigo	M,P,C	Shrub	Moderate	Sun.
Aronia arbutifolia Red chokeberry	M,P,C	Shrub	Moderate Cover & Food	Rhizomatous Colonial Shrub.
Asimina triloba Pawpaw	M,P,C	Tree	Important food for fox & possum	
Betula nigra River Burch	M,P,C	Tree	Good for cavity nester	Full sun.
Carpinus caroliniana American hornbeam	M,P,C	Tree	Low	Partial shade.
Carya cordiformis Bitternut hickory	P,C	Tree	Moderate, food	Wet bottoms.
Catalpa bignonioides Catalpa tree	P,C	Tree	Unknown	
Celtis laevigata Sugarberry	P,C	Tree	High food cover	Partial shade.
Celtis occidentalis Hackberry	P,C	Tree	High	Partial shade.
Cephalantus Occidentalis Buttonbush	M,P,C	Shrub	Moderate, ducks & Shorebirds are users. Nectar for hummingbirds.	Sun.
Chionanthus virginicus Fringe tree	P,C	Tree	Moderate	Tolerant of shade.
Clethra alnifolia Sweet pepperbush	P,C	Shrub	Moderate	Partial shade. Good landscape value.
Cornus amomum Silky dogwood	M,P	Shrub	High, songbirds, Mammals	Shade tolerant. Good bank stabilizer.

Table 6-1.2 - Native plant guide.

Species	Region	Stream Zone	Wildlife Value	Notes
Cornus stricta Swamp dogwood	M,P	Shrub	High	Good bank stabilizer in shade.
Cornus florida Flowering dogwood	M,P,C	Tree	High, birds, food	Shade tolerant.
Cyrilla racemiflora Titi	C	Tree	Low	Light shade.
Diospyros virginia Persimmon	M,P,C	Tree	Extremely high Mammals	Not shade tolerant.
Fraxinus caroliniana Carolina ash	C	Tree	Moderate	Rapid growing. Streambank grower. Sun to partial shade.
Fraxinus pennsylvanica Green ash	M,P,C	Tree	Low	Rapid grower. Full sun.
Gleditsia aquatica Water locust	P,C	Tree	Low	Sun.
Gleditsia triacanthos Honey locust	P,C	Tree	Low	Full sun, thorns.
Hibiscus aculeatus Hibiscus Comfort root	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Hibiscus militaris Hibiscus Halberd-leaved Marsh-mallow	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Hibiscus lasiocarpus Hibiscus	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Hibiscus moscheutos Hibiscus	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Ilex coriacea Sweet Gallberry	C	Shrub	Unknown	
Ilex decidua Possumhaw	P,C	Shrub	High, food, nest sites	Sun or shade.
Ilex glabra Bitter gallberry or Inkberry	C	Shrub	High	Stoloniferous. Sun to some shade.

Table 6-1.2 - continued

Species	Region	Stream Zone	Wildlife Value	Notes
Ilex opaca American holly	M,P, C	Tree	High, food, cover nests	prefers shade.
Ilex verticilata Winterberry	M,P	Shrub	High, cover & fruit for birds. Holds berries in winter.	Full sun to some shade. Seasonally flooded areas.
Ilex vomitoria Yaupon	C	Shrub	High, songbirds	Small tree, very adaptable, suckers.
Juglans nigra Black walnut	M,P	Tree	Good	Temporarily flooded wetlands along floodplains.
Juniperus virginiana Eastern red cedar	M,P,C	Tree	High, food	Tolerant to some shade in youth.
Leucothoe axillaris Leucothoe	C	Shrub	Low	Partial shade.
Lindera benzoin Common spicebush	M	Shrub	High, songbirds	Shade, acidic soils. Good understory.
Liriondendron tulipefera Tulip poplar	M,P	Tree	Low	Tolerant to partial Shade.
Liquidambar styraciflua Sweetgum	M,P,C	Tree	Low	Partial shade.
Lyonia lucida Lyonia or Fetterbush	C	Shrub	Low	Sun.
Magnolia virginia Sweetbay	P,C	Tree	Very low	Shade tolerant.
Myrica cerifera Southern wax myrtle	C	Shrub	Moderate	Light shade.
Nyssa ogeche Ogeechee lime	C	Tree	High, fruit, Cavity nesters	Wetland tree
Nyssa sylvatica Blackgum or sourgum	M,P,C	Tree	Moderate, seeds	Sun to partial shade.
Nyssa aquatica Swamp tupelo	C	Tree	High	Prefers shade.
Ostrya Virginiana Hophornbeam	M,P,C	Tree	Moderate	Tolerant of all sunlight conditions.

Table 6-1.2 - continued

Species	Region	Stream Zone	Wildlife Value	Notes
Persea borbonia Red bay	C	Tree	Good food, for quail and bluebirds.	Understory tree.
Pinus taeda Loblolly pine	P,C	Tree	Moderate	Poor sites.
Platanus occidentalis Sycamore	M,P,C	Tree	Low. Cavity Nesters	Transplants well. Rapid growth in full sun.
Populus deltoides Eastern cottonwood	M,P,C	Tree	High	Invasive roots. Rapid growth.
Quercus alba White oak	M,P,C	Tree	High, food	Prefers moist well drained soil.
Quercus laurifolia Swamp laurel oak	C	Tree	High	
Quercus lyrata Overcup oak	P,C	Tree	High	Sloughs & bottoms.
Quercus michauxii Swamp chestnut oak	M,P,C	Tree	High	Wetter sites than white oak.
Quercus nigra Water oak	M,P,C	Tree	High	
Quercus pagoda Cherrybark oak	M,P	Tree	High	
Quercus phellos Willow oak	M,P,C	Tree	High, mast	Full to partial sun.
Quercus shumardii Shumard oak	P,C	Tree	High	
Salix nigra Black willow	M,P,C	Shrub & Tree	Nesting	Rapid growth, full sun.
Rhododendron atlanticum Coast azelea	P,C	Shrub	Very low	Very fragrant, Suckers.
Rhododendron viscosum Swamp azelea	C	Shrub	Low	
Styrax american	C	Shrub	Unknown	

Table 6-1.2 - continued

Species	Region	Stream Zone	Wildlife Value	Notes
Taxodium distichum Bald cypress	C	Tree	Good perching site	Full sun.
Tsuga canadensis Eastern hemlock	M	Tree	Moderate	Tolerates all light conditions.
Viburnum nudum Swamp haw	M,P,C	Shrub	High	Shade tolerant.

Legend:

Region
M = Mountains
P = Piedmont
C = Coastal Plain

Plant List Sources:

Brown, Claude L. & Kirkman, Katherine L. 1990. Trees of Georgia and Adjacent States.

Foote, Leonard E. & Jones, Samuel B., Jr. 1989. Native Shrubs and Woody Vines of the Southeast.

Georgia Cooperative Extension Service. Native Plants for Georgia Gardens.

Hightshoe, Gary L. 1988. Native Trees, Shrubs and Vines for Urban & Rural America.

USDA Natural Resources Conservation Service. 1973. Seacoast Plants of the Carolinas.

USDA Natural Resources Conservation Service, Engineering Field Handbook, Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction.

Table 6-1.2 - continued

Coastal Dune Stabilization (With Vegetation) Cs

DEFINITION

Planting vegetation 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 allow development of dunes in areas where they have been damaged or destroyed.

CONDITIONS

On bare or sparsely vegetated dunes or areas where dune development is desired.

PLANNING CONSIDERATIONS

Coastal beaches are subject to regulation from a variety of Federal, State, and local agencies. Permits must be requested and granted by all appropriate jurisdictions before work is performed.

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.

Protection of dunes from human and vehicular traffic is essential if vegetation is to succeed. Crosswalks or crossover structures should be planned to provide beach access.

Plant species that are native to coastal areas should be used whenever possible.

An irrigation system will be required during the first growing season in order to obtain good survival.

Common Commercially Available Plants

Marshhay cordgrass (*Spartina patens*) “Flageo” variety (or native collections) is a perennial grass that occurs on dunes throughout the South Atlantic and Gulf region and in Puerto Rico. It is the dominant plant on dunes composed of broken shale and coquina rock along the northern Florida coast. The grass is especially tolerant of salt.

Stems are slender and grow two to three feet tall. Leaves are rolled inward and resemble rushes. Seed heads are composed of two to several compressed spikes attached at about 90 degrees to the culm. Plants spread by means of a network of slender rhizomes.

Plantings of vegetative material in early spring are most successful. Bare root or potted planting stock is recommended for large plantings. Stems rooted at the base can be planted at a depth of four to five inches deep. Plants that have developed rhizomes are preferred for planting stock.

Bitter panicum *(Panicum amarum)* is a perennial grass found on dunes throughout the South Atlantic and Gulf regions. It is most common in South Florida and Texas.

Plants grow to an average height of three to four feet tall. Leaves are smooth and bluish green in color. Seed heads are narrow, compressed, and generally are sparsely seeded. Plants spread from a very aggressive, scattered system of rhizomes, but stands are rather open.

Bitter panicum produces few viable seed but is easier to transplant than sea oats. They can be propagated from a stem with part of the rhizome attached or from rhizomes that are eight to twelve inches long. Plant rhizomes about four inches deep in early spring.

Plants may be propagated by removing all of the stem from robust plants and placing them in the dune at an angle of about 45 degrees. Several nodes should be buried. Spacing should be no more than six feet apart.

Coastal Panicgrass (*Panicum amarum v. amaralum*) is a somewhat dense, upright perennial bunchgrass found on coastal dunes throughout the South Atlantic and Gulf area. It is the dominant plant at many locations in West Florida, Alabama, and Texas.

The stems are coarse, straight, stiff, and up to four feet tall. Partially compressed seed heads produce moderate amounts of viable seed each fall. The crowns enlarge slowly from short, almost vertical tillers.

Plant seed one to three inches deep in the spring and mulch the area. Seedling survival depends on moisture after germination. Clumps of coastal panicgrass can be dug, divided and planted during rainy seasons or when irrigation is available.

Planting Requirements for Native Plants

Species	Stock	Date	Depth
Marshhay Cordgrass (Spartina patens)	Plants	Spring	4"-5"
Bitter Panicum (Panicum amarum)	Rhizomes	Spring	Abt 4"
Coastal Panigrass (Panicum ararum v. amaralum)	Seeds or plants	Spring	1"-3"

Sand Fence Use In Building Dunes

Sand fence may be used to build sand dunes when sand is available. Costs are usually higher but dune development is faster when compared to vegetation alone and generally less expensive than building dunes with machinery.

To form a barrier dune, construct sand fences a minimum of 100 feet from the mean high tide line. Two or more parallel fences spaced from 30 to 40 feet apart are needed. Locate fences as near as possible to a 90 degree angle with the prevailing winds, but as near parallel to the water line as possible.

Where winds are generally parallel with the water line, a single line of fence may be constructed at least 140 feet from the mean high tide. Construct short sections of fence (approximately 30 feet long) parallel to the prevailing wind and approximately perpendicular to the original fence. Place these fences opposite the water side and space these fences about 40 feet apart.

As sand collects over the fence, additional fence can be constructed over the original fence until the desired height is obtained.

Old dunes may be widened by constructing sand fence about 15 feet to the seaward side of the base of the old dune.

Vegetation must be established following development of dunes, or allowed to develop from existing stands as dunes develop.

Figure 6-2.1 - Sand fence and native plants.

SPECIFICATIONS

Sand Fence Specifications

Use standard commercial 4-foot high snow fence that consists of wooden slats wired together with spaces between the slats. Distance between slats is approximately equal to the slat width, or generally 1 1/4 inches. Slats will be made from grade A or better spruce. Slats will be woven between five two-wire cables of copper-bearing, galvanized wire. Slats will be dipped in a red oxide, weather resistant stain. The fence must be sound, free of decay, broken wire or missing or broken slats.

Fence will be supported by black locust, red cedar, or white cedar posts. Other wood of equal life or strength may be used. Posts will be a minimum of 7 feet with a minimum diameter of three inches. Posts will be spaced no farther than 10 feet apart.

Four wire ties will be used to fasten fence to posts. Weave fence between posts so that every other post will be attached on the ocean side of posts. Tie wires will be no smaller than 12-gauge galvanized wire.

Posts will be set in holes at least three feet deep.

Three or four rows of fence should be used if sufficient land area and sand are available.

MAINTENANCE

Maintaining Dunes

A strong, uniform dune line must be maintained to provide maximum protection from wind and water. Blowouts, wash pits, or other natural or man-made damage must be repaired quickly to prevent weakening of the entire system. Blow-outs in a dune system can be repaired by placing sand fence between existing dunes. One or more fences may be required. It is essential to tie the ends of the fence into the existing dune to keep the wind from slipping around the ends. Maintain fences, and erect additional fences if needed, until the eroding area is replenished to the desired height and permanently stabilized.

Foot and vehicular traffic must be controlled or prohibited on dunes to maintain vegetation and prevent excessive sand movement. Elevated walks, semi-permanent paved paths, and portable roll-up walkways are satisfactory. Walkways should be curved to reduce wind movement. Both inland and secondary dunes must be protected from traffic.

Vegetative Maintenance

Plantings are maintained with applications of fertilizer to keep desired density of plants. Annual application of about 50 pounds of nitrogen per acre should be applied. Where vegetation has been destroyed, replanting should be considered.

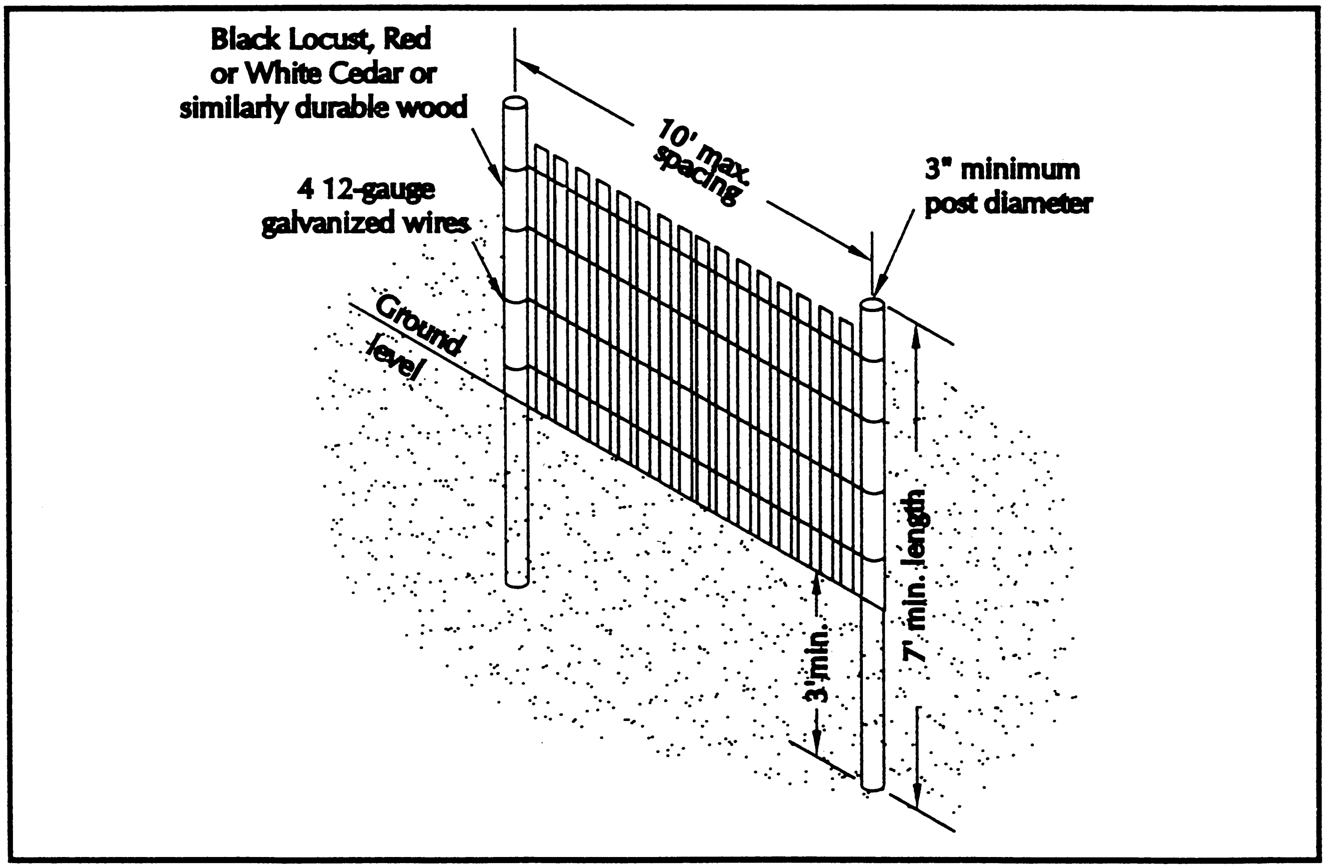


Figure 6-2.2 - Sand fence installation requirements.

Disturbed Area Stabilization (With Mulching Only) Ds1

DEFINITION

Applying plant residues or other suitable materials, produced on the site if possible, to the soil surface.

PURPOSE

- To reduce runoff and erosion
- To conserve moisture
- To prevent surface compaction or crusting
- To control undesirable vegetation
- To modify soil temperature
- To increase biological activity in the soil

REQUIREMENT FOR REGULATORY COMPLIANCE

Mulch or temporary grassing shall be applied to all exposed areas within 14 days of disturbance. Mulch can be used as a singular erosion control device for up to six months, but it shall be applied at the appropriate depth, depending on the material used, anchored, and have a continuous 90% cover or greater of the soil surface. Maintenance shall be required to maintain appropriate depth and 90% cover. Temporary vegetation may be employed instead of mulch if the area will remain undisturbed for less than six months. If an area will remain undisturbed for greater than six months, permanent vegetative techniques shall be employed. Refer to **Ds2 - Disturbed Area Stabilization (With Temporary Seeding)**, **Ds3 - Disturbed Area Stabilization (With Permanent Seeding)**, and **Ds4 - Disturbed Area Stabilization (With Sodding).**

SPECIFICATIONS

MULCHING WITHOUT SEEDING

This standard applies to grades or cleared areas where seedings may not have a suitable growing season to produce an erosion retardant cover, but can be stabilized with a mulch cover.

Site Preparation

1. Grade to permit the use of equipment for applying and anchoring mulch.
2. Install needed erosion control measures as required such as dikes, diversions, berms, terraces and sediment barriers.
3. Loosen compact soil to a minimum depth of 3 inches.

Mulching Materials

Select one of the following materials and apply at the depth indicated:

1. *Dry straw or hay* shall be applied at a depth of 2 to 4 inches providing complete soil coverage. One advantage of this material is easy application.
2. *Wood waste* (chips, sawdust or bark) shall be applied at a depth of 2 to 3 inches. Organic material from the clearing stage of development should remain on site, be chipped, and applied as mulch. This method of mulching can greatly reduce erosion control costs.
3. *Cutback asphalt* (slow curing) shall be applied at 1200 gallons per acre (or 1/4 gallon per sq. yd.).
4. *Polyethylene film* shall be secured over banks or stockpiled soil material for temporary protection. This material can be salvaged and re-used.

Applying Mulch

When mulch is used without seeding, mulch shall be applied to provide full coverage of the exposed area.

1. *Dry straw* or *hay mulch* and *wood chips* shall be applied uniformly by hand or by mechanical equipment.
2. If the area will eventually be covered with perennial vegetation, 20-30 pounds of nitrogen per acre in addition to the normal amount shall be applied to offset the uptake of nitrogen caused by the decomposition of the organic mulches.
3. Cutback asphalt shall be applied uniformly. Care should be taken in areas of pedestrian trafic due to problems of “tracking in” or damage to shoes, clothing, etc.

4. Apply polyethylene film on exposed areas.

Anchoring Mulch

1. *Straw or hay mulch* can be pressed into the soil with a disk harrow with the disk set straight or with a special "packer disk." Disks may be smooth or serrated and should be 20 inches or more in diameter and 8 to 12 inches apart. The edges of the disk should be dull enough not to cut the mulch but to press it into the soil leaving much of it in an erect position. **Straw or hay mulch shall be anchored immediately after application.**

Straw or hay mulch spread with special blower-type equipment may be anchored with emulsified asphalt (Grade AE-5 or SS-1). The asphalt emulsion shall be sprayed onto the mulch as it is ejected from the machine. Use 100 gallons of emulsified asphalt and 100 gallons of water per ton of mulch. Tackifers and binders can be substituted for emulsified asphalt. Please refer to specification **Tb - Tackifers and Binders**. Plastic mesh or netting with mesh no larger than one inch by one inch shall be installed according to manufacturer's specifications.

2. Netting of the appropriate size shall be used to anchor *wood waste*. Openings of the netting shall not be larger than the average size of the wood waste chips.

3. *Polyethylene film* shall be anchor trenched at the top as well as incrementally as necessary.

Disturbed Area Stabilization (With Temporary Seeding)

Ds2

DEFINITION

The establishment of temporary vegetative cover with fast growing seedings for seasonal protection on disturbed or denuded areas.

PURPOSE

- To reduce runoff and sediment damage of downstream resources
- To protect the soil surface from erosion
- To improve wildlife habitat
- To improve aesthetics
- To improve tilth, infiltration and aeration as well as organic matter for permanent plantings.

REQUIREMENT FOR REGULATORY COMPLIANCE

Mulch or temporary grassing shall be applied to all exposed areas within 14 days of disturbance. Temporary grassing, instead of mulch, can be applied to rough graded areas that will be exposed for less than six months. If an area is expected to be undisturbed for longer than six months, permanent perennial vegetation shall be used. If optimum planting conditions for temporary grassing is lacking, mulch can be used as a singular erosion control device for up to six months but it shall be applied at the appropriate depth, anchored, and have a continuous 90% cover or greater of the soil surface. Refer to specification **Ds1-Disturbed Area Stabilization (With Temporary Seeding).**

CONDITIONS

Temporary vegetative measures should be coordinated with permanent measures to assure economical and effective stabilization. Most types of temporary vegetation are ideal to use as companion crops until the permanent vegetation is established. Note: *Some species of temporary vegetation are not appropriate for companion crop plantings because of their potential to out-compete the desired species (e.g. annual ryegrass).* Contact NRCS or the local SWCD for more information.

SPECIFICATIONS

Grading and Shaping

Excessive water run-off shall be reduced by properly designed and installed erosion control practices such as closed drains, ditches, dikes, diversions, sediment barriers and others.

No shaping or grading is required if slopes can be stabilized by hand-seeded vegetation or if hydraulic seeding equipment is to be used.

Seedbed Preparation

When a hydraulic seeder is used, seedbed preparation is not required. When using conventional or hand-seeding, seedbed preparation is not required if the soil material is loose and not sealed by rainfall.

When soil has been sealed by rainfall or consists of smooth cut slopes, the soil shall be pitted, trenched or otherwise scarified to provide a place for seed to lodge and germinate.

Lime and Fertilizer

Agricultural lime is required unless soil tests indicate otherwise. Apply agricultural lime at a rate of one ton per acre. Graded areas require lime application. Soils can be tested to determine if fertilizer is needed. On reasonably fertile soils or soil material, fertilizer is not required. For soils with very low fertility, 500 to 700 pounds of 10-10-10 fertilizer or the equivalent per acre (12-16 lbs./1,000 sq. ft.) shall be applied. Fertilizer should be applied before land preparation and incorporated with a disk, ripper or chisel.

Seeding

Select a grass or grass-legume mixture suitable to the area and season of the year. Seed shall be applied uniformly by hand, cyclone seeder, drill, cultipacker-seeder, or hydraulic seeder (slurry including seed and fertilizer). Drill or cultipacker seeders should normally place seed one-quarter to one-half inch deep. Appropriate depth of planting is ten times the seed diameter. Soil should be "raked" lightly to cover seed with soil if seeded by hand.

Mulching

Temporary vegetation can, in most cases, be established without the use of mulch. Mulch without seeding should be considered for short term protection. Refer to **Ds1 - Disturbed Area Stabilization (With Mulching Only)**.

Irrigation

During times of drought, water shall be applied at a rate not causing runoff and erosion. The soil shall be thoroughly wetted to a depth that will insure germination of the seed. Subsequent applications should be made when needed.

Table 6-4.1

PLANTS, PLANTING RATES, AND PLANTING DATES FOR TEMPORARY COVER OR COMPANION CROPS 1/

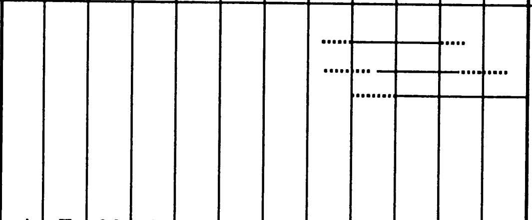
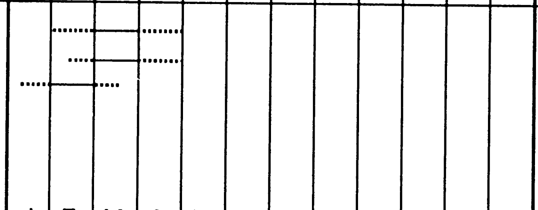
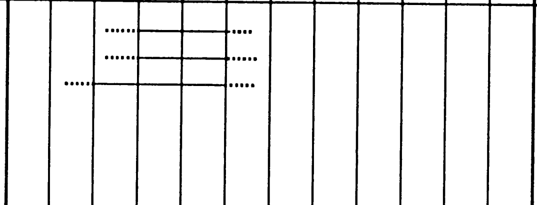
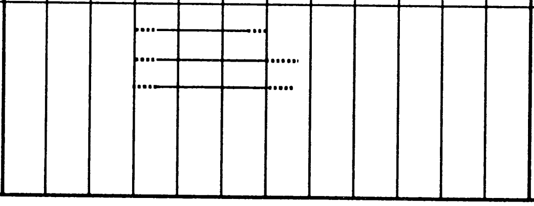
Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area 4/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.)	Remarks
				J F M A M J J A S O N D	
BARLEY (Hordeum vulgare)			M-L P C		14,000 seed per pound. Winterhardy. Use on productive soils.
alone	3 bu. (144 lbs.)	3.3 lb			
in mixtures	1/2 bu. (24 lbs.)	0.6 lb.			
				J F M A M J J A S O N D	
LESPEDEZA, ANNUAL (Lespedeza striata)			M-L P C		200,000 seed per pound. May volunteer for several years. Use inoculant EL.
alone	40 lbs.	0.9 lb.			
in mixtures	10 lbs.	0.2 lb.			
				J F M A M J J A S O N D	
LOVEGRASS, WEEPING (Eragrostis curvula)			M-L P C		1,500,000 seed per pound. May last for several years. Mix with Sericea lespedeza.
alone	4 lbs.	0.1 lb.			
in mixtures	2 lbs.	0.05 lb.			
				J F M A M J J A S O N D	
MILLET, BROWNTOP (Panicum fasciculatum)			M-L P C		137,000 seed per pound. Quick dense cover. Will provide too much competition in mixtures if seeded at high rates.
alone	40 lbs.	0.9 lb.			
in mixtures	10 lbs.	0.2 lb.			

Table 6-4.1 - continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR TEMPORARY COVER OR COMPANION CROPS 1/

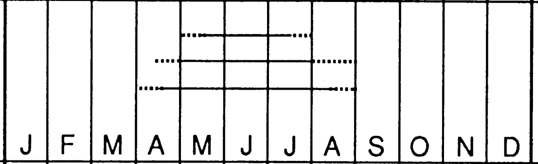
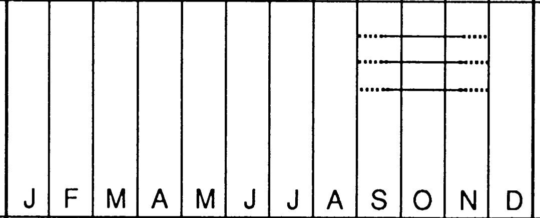
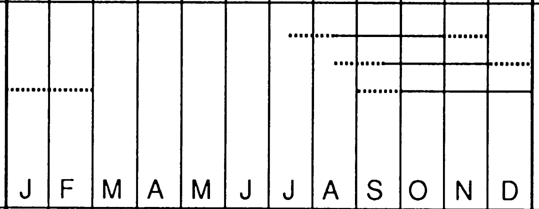
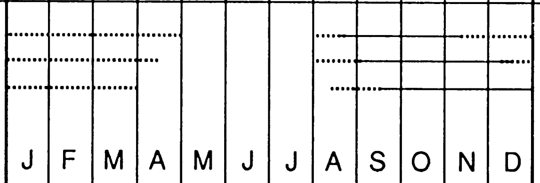
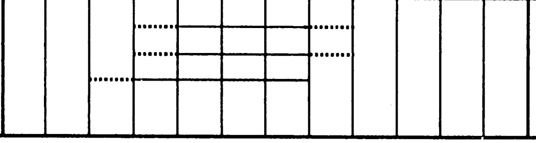
Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area 4/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
MILLET, PEARL (Pennesetum glaucum) alone	50 lbs.	1.1 lb	M-L P C		88,000 seed per pound. Quick dense cover. May reach 5 feet in height. Not recommended for mixtures.
OATS (Avena sativa) alone in mixtures	4 bu. (128 lbs.) 1 bu. (32 lbs.)	2.9 lb. 0.7 lb.	M-L P C		13,000 seed per pound. Use on productive soils. Not as winterhardy as rye or barley.
RYE (Secale cereale) alone in mixtures	3 bu. (168 lbs.) 1/2 bu. (28 lbs.)	3.9 lb. 0.6 lb.	M-L P C		18,000 seed per pound. Quick cover. Drought tolerant and winterhardy.
RYEGRASS, ANNUAL (Lolium temulentum) alone	40 lbs.	0.9 lb.	M-L P C		227,000 seed per pound. Dense cover. Very competitive and is <u>not</u> to be used in mixtures.
SUDANGRASS (Sorghum sudanese) alone	60 lbs.	1.4 lb	M-L P C		55,000 seed per pound. Good on droughty sites. <u>Not</u> recommended for mixtures.

Table 6-4.1 - continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR TEMPORARY COVER OR COMPANION CROPS 1/

Species	Broadcast Rates 2/ - PLS 3/ Per Acre	Broadcast Rates 2/ - PLS 3/ Per 1000 sq. ft.	Resource Area 4/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J	F	M	A	M	J	J	A	S	O	N	D	Remarks
TRITICALE (X-Triticosecale)			C	…								…	…—	—	—…	Use on lower part of Southern Coastal Plain and In Atlantic Coastal Flatwoods only.
alone	3 bu. (144 lbs.)	3.3 lb.														
in mixtures	1/2 bu. (24 lbs.)	0.6 lb.														
				J	F	M	A	M	J	J	A	S	O	N	D	
WHEAT (Triticum aestivum)			M-L									…—	—	—	…	15,000 seed per pound. Winterhardy.
			P									…	—	—	—…	
			C	…								…	…—	—	—	
alone	3 bu. (180 lbs.)	4.1 lb.														
in mixtures	1/2 bu. (30 lbs.)	0.7 lb.														

1/ Temporary cover crops are very competitive and will crown out perennials if seeded too heavily.
2/ Reduce seeding rates by 50% when drilled.
3/ PLS is an abbreviation for Pure Live Seed.
4/ M-L represents the Mountain; Blue Ridge; and Ridges and Valleys MLRAs
P represents the Southern Piedmont MLRA
C represents Southern Coastal Plain; Sand Hills; Black Lands; and Atlantic Coast Flatwoods MLRAs
(See Figure 6-4.1, p. 6-40).

Major Land Resource Areas (MLRA) of Georgia

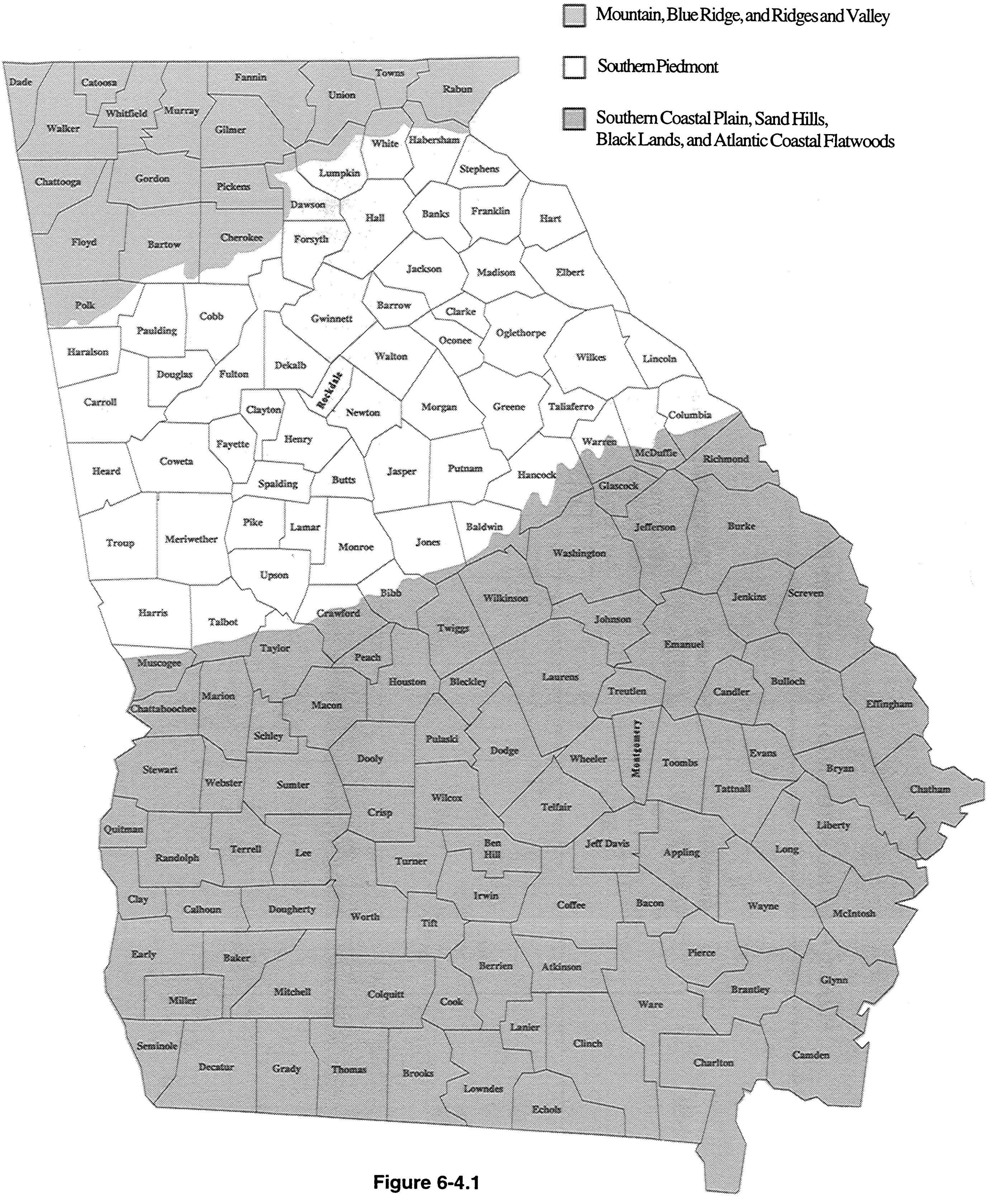
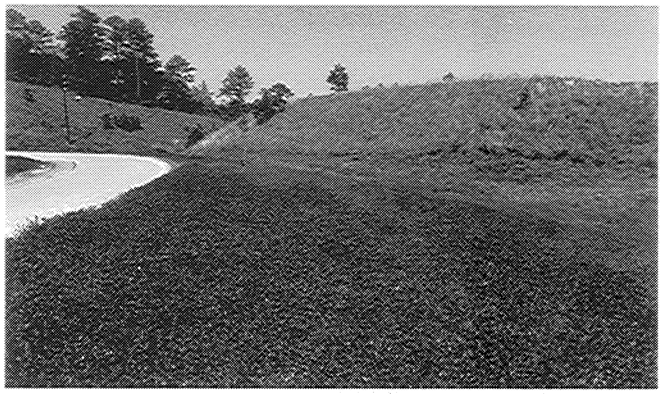


Figure 6-4.1

Disturbed Area Stabilization (With Permanent Vegetation)

Ds3



DEFINITION

The planting of perennial vegetation such as trees, shrubs, vines, grasses, or legumes on exposed areas for final permanent stabilization. Permanent perennial vegetation shall be used to achieve final stabilization.

PURPOSE

- To protect the soil surface from erosion
- To reduce damage from sediment and runoff to downstream areas
- To improve wildlife habitat and visual resources
- To improve aestetics

REQUIREMENT FOR REGULATORY COMPLIANCE

This practice shall be applied immediately to rough graded areas that will be undisturbed for longer than six months. This practice or sodding shall be applied immediately to all areas at final grade. **Final Stabilization** means that all soil disturbing activities at the site have been completed, and that for unpaved areas and areas not covered by permanment structures, at least 70% of the soil surface is uniformly covered in permanment vegetation or equivalent permanment stabilization measures (such as the use of rip rap, gabions, permanent mulches or geotextiles) have been employed. Permanent vegetation shall consist of: planted trees, shrubs, perennial vines; a crop of perennial vegetation apporpriate for the region, such that within the growing season a 70% coverage by perennial vegetation shall be achieved. Final stabilization applies to each phase of construction. For linear construction projects on land used for agricultural or silvicultural purposes, final stabilization may be accomplished by stabilizing the disturbed land for its agricultural or silvicultural use. Until this standard is satisfied and permanent control measures and facilities are operational, interim stabilization measures and temporary erosion and sedimentation control measures shall not be removed.

CONDITIONS

Permanent perennial vegetation is used to provide a protective cover for exposed areas including cuts, fills, dams, and other denuded areas.

PLANNING CONSIDERATIONS

1. Use conventional planting methods where possible.
2. When mixed plantings are done during marginal planting periods, companion crops shall be used.
3. No-till planting is effective when planting is done following a summer or winter annual cover crop. Sericea lespedeza planted no-till into stands of rye is an excellent procedure.
4. Block sod provides immediate cover. It is especially effective in controlling erosion adjacent to concrete flumes and other structures. Refer to Specification **Ds4-Disturbed Area Stabilization (With Sodding).**
5. Irrigation should be used when the soil is dry or when summer plantings are done.
6. Low maintenance plants, as well as natives, should be used to ensure long-lasting erosion control.
7. Mowing should not be performed during the quail nesting season (May to September).
8. Wildlife plantings should be included in critical area plantings.

Wildlife Plantings

Commercially available plants beneficial to wildlife species include the following:

Mast Bearing Trees

Beech, Black Cherry, Blackgum, Chestnut, Chinkapin, Hackberry, Hickory, Honey Locust, Native Oak, Persimmon, Sawtooth Oak and Sweetgum.

All trees that produce nuts or fruits are favored by many game species. Hickory provides nuts used mainly by squirrels and bear.

Shrubs and Small Trees

Bayberry, Bicolor Lespedeza, Crabapple, Dogwood, Huckleberry or Native Blueberry, Mountain Laurel, Native Holly, Red Cedar, Red Mulberry, Sumac, Wax Myrtle, Wild Plum and Blackberry.

Plant in patches without tall trees to develop stable shrub communities. All produce fruits used by many kinds of wildlife, except for lespedeza which produces seeds used by quail and songbirds.

Grasses, Legumes, Vines and Temporary Cover

Bahiagrass, Bermudagrass, Grass-Legume mixtures, Partridge Pea, Annual Lespedeza, Orchardgrass (for mountains), Browntop Millet (for temporary cover), and Native grapes.

Provides herbaceous cover in clearings for a game bird brood-rearing habitat. Appropriate legumes such as vetches, clovers, and lespedezas may be mixed with grass, but they may die out after a few years.

CONSTRUCTION SPECIFICATIONS

Grading and Shaping

Grading and shaping may not be required where hydraulic seeding and fertilizing equipment is to be used. Vertical banks shall be sloped to enable plant establishment.

When conventional seeding and fertilizing are to be done, grade and shape where feasible and practical, so that equipment can be used safely and efficiently during seedbed preparation, seeding, mulching and maintenance of the vegetation.

Concentrations of water that will cause excessive soil erosion shall be diverted to a safe outlet. Diversions and other treatment practices shall conform with the appropriate standards and specifications.

Lime and Fertilizer Rates and Analysis

Agricultural lime is required at the rate of one to two tons per acre unless soil tests indicate otherwise. Graded areas require lime application. If lime is applied within six months of planting permanent perennial vegetation, additional lime is not required. Agricultural lime shall be within the specifications of the Georgia Department of Agriculture.

Lime spread by conventional equipment shall be "ground limestone." Ground limestone is calcitic or dolomitic limestone ground so that 90 percent of the material will pass through a 10-mesh sieve, not less than 50 percent will pass through a 50-mesh sieve and not less than 25 percent will pass through a 100-mesh sieve.

Agricultural lime spread by hydraulic seeding equipment shall be "finely ground limestone." Finely ground limestone is calcitic or dolomitic limestone ground so that 98 percent of the material will pass through a 20-mesh sieve and not less than 70 percent will pass through a 100-mesh sieve.

It is desirable to use dolomitic limestone in the Sand Hills, Southern Coastal Plain and Atlantic Coast Flatwoods MLRAs. (See Figure 6-4.1)

Agricultural lime is generally not required where only trees are planted.

Initial fertilization, nitrogen, topdressing, and maintence fertilizer requirements for each species or combination of species are listed in Table 6-5.1.

Lime and Fertilizer Application

When *hydraulic seeding* equipment is used, the initial fertilizer shall be mixed with seed, innoculant (if needed), and wood cellulose or wood pulp fiber mulch and applied in a slurry. The innoculant, if needed, shall be mixed with the seed prior to being placed into the hydraulic seeder. The slurry mixture will be agitated during application to keep the ingredients thoroughly mixed. The mixture will be spread uniformly over the area within one hour after being placed in the hydroseeder.

Finely ground limestone will be mixed with water and applied immediately after mulching is completed or in combination with the top dressing.

When *conventional planting* is to be done, lime and fertilizer shall be applied uniformly in one of the following ways:

1. Apply before land preparation so that it will be mixed with the soil during seedbed preparation.
2. Mix with the soil used to fill the holes, distribute in furrows.
3. Broadcast after steep surfaces are scarified, pitted or trenched.
4. A fertilizer pellet shall be placed at root depth in the closing hole beside each pine tree seedling.

Plant Selection

Refer to Tables 6-4.1, 6-5.2, 6-5.3 and 6-5.4 for approved species. Species not listed shall be approved by the State Resource Conservationist of the Natural Resources Conservation Service before they are used.

Plants shall be selected on the basis of species characteristics, site and soil conditions, planned use and maintenance of the area; time of year of planting, method of planting; and the needs and desires of the land user.

Some perennial species are easily established and can be planted alone. Examples of these are Common Bermuda, Tall Fescue, and Weeping Lovegrass.

Other perennials, such as Bahia Grass and Sericea Lespedeza, are slow to become established and should be planted with another perennial species. The additional species will provide quick cover and ample soil protection until the target perennial species become established. For example, Common seeding combinations are 1) Weeping Lovegrass with Sericea Lespedeza (scarified) and 2) Tall Fescue with Sericea Lespedeza (unscarified).

Plant selection may also include annual companion crops. Annual companion crops should be used only when the perennial species are not planted during their optimum planting period. A common mixture is Brown Top Millet with Common Bermuda in mid-summer. Care should be taken in selecting companion crop species and seeding rates because annual crops will compete with perennial species for water, nutrients, and growing space. A high seeding rate of the companion crop may prevent the establishment of perennial species.

Ryegrass shall not be used in any seeding mixtures containing perennial species due to its ability to out-compete desired species chosen for permanent perennial cover.

Seed Quality

The term "pure live seed" is used to express the quality of seed and is not shown on the label. Pure live seed, PLS, is expressed as a percentage of the seeds that are pure and will germinate. Information on percent germination and purity can be found on seed tags. PLS is determined by multiplying the percent of pure seed with the percent of germination; i.e.,

(PLS = % germination x % purity)

EXAMPLE:

Common bermuda seed
70% germination, 80% purity

PLS = 70% germination x 80% purity

PLS = 56%

The percent of PLS helps you determine the amount of seed you need. If the seeding rate is 10 pounds PLS and the bulk seed is 56 % PLS, the bulk seeding rate is:

$$\frac{10 \text{ lbs. PLS/acre}}{56\% \text{ PLS}} = 17.9 \text{ lbs/acre}$$

You would need to plant 17.9 lbs/acre to provide 10 lbs/acre of pure live seed.

Seedbed Preparation

Seedbed preparation may not be required where hydraulic seeding and fertilizing equipment is to be used. When conventional seeding is to be used, seedbed preparation will be done as follows:

Broadcast plantings

1. Tillage at a minimum, shall adequately loosen the soil to a depth of 4 to 6 inches; alleviate compaction; incorporate lime and fertilizer; smooth and firm the soil; allow for the proper placement of seed, sprigs, or plants; and allow for the anchoring of straw or hay mulch if a disk is to be used.
2. Tillage may be done with any suitable equipment.
3. Tillage should be done on the contour where feasible.
4. On slopes too steep for the safe operation of tillage equipment, the soil surface shall be pitted or trenched across the slope with appropriate hand tools to provide two places 6 to 8 inches apart in which seed may lodge and germinate. Hydraulic seeding may also be used.

Individual Plants

1. Where individual plants are to be set, the soil shall be prepared by excavating holes, opening furrows, or dibble planting.
2. For nursery stock plants, holes shall be large enough to accommodate roots without crowding.
3. Where pine seedlings are to be planted, subsoil under the row 36 inches deep on the contour four to six months prior to planting. Subsoiling should be done when the soil is dry, preferably in August or September.

Innoculants

All legume seed shall be inoculated with appropriate nitrogen-fixing bacteria. The innoculant shall be a pure culture prepared specifically for the seed species and used within the dates on the container.

A mixing medium recommended by the manufacturer shall be used to bond the innoculant to the seed. For conventional seeding, use twice the amount of innoculant recommended by the manufacturer. For hydraulic seeding, four times the amount of innoculant recommended by the manufacturer shall be used.

All inoculated seed shall be protected from the sun and high temperatures and shall be planted the same day inoculated. No inoculated seed shall remain in the hydroseeder longer than one hour.

Planting

Hydraulic Seeding

Mix the seed (innoculated if needed), fertilizer, and wood cellulose or wood pulp fiber mulch with water and apply in a slurry uniformly over the area to be treated. Apply within one hour after the mixture is made.

Conventional Seeding

Seeding will be done on a freshly prepared and firmed seedbed. For broadcast planting, use a cultipacker-seeder, drill, rotary seeder, other mechanical seeder, or hand seeding to distribute the seed uniformly over the area to be treated. Cover the seed lightly with 1/8 to 1/4 inch of soil for small seed and 1/2 to 1 inch for large seed when using a cultipacker or other suitable equipment.

No-Till Seeding

No-till seeding is permissible into annual cover crops when planting is done following maturity of the cover crop or if the temporary cover stand is sparse enough to allow adequate growth of the permanent (perennial) species. No-till seeding shall be done with appropriate no-till seeding equipment. The seed must be uniformly distributed and planted at the proper depth.

Individual Plants

Shrubs, vines and sprigs may be planted with appropriate planters or hand tools. Pine trees shall be planted manually in the subsoil furrow. Each plant shall be set in a manner that will avoid crowding the roots.

Nursery stock plants shall be planted at the same depth or slightly deeper than they grew at the nursery. The tips of vines and sprigs must be at or slightly above the ground surface.

Where individual holes are dug, fertilizer shall be placed in the bottom of the hole, two inches of soil shall be added and the plant shall be set in the hole.

Mulching

Mulch is required for all permanent vegetation applications. Mulch applied to seeded areas shall achieve 75% soil cover. Select the mulching material from the following and apply as indicated:

1. *Dry straw* or *dry hay* of good quality and free of weed seeds can be used. Dry straw shall be applied at the rate of 2 tons per acre. Dry hay shall be applied at a rate of 2 1/2 tons per acre.
2. *Wood cellulose mulch or wood pulp fiber* shall be used with hydraulic seeding. It shall be applied at the rate of 500 pounds per acre. Dry straw or dry hay shall be applied (at the rate indicated above) after hydraulic seeding.
3. One thousand pounds of *wood cellulose or wood pulp fiber*, which includes a tackifier, shall be used with hydraulic seeding on slopes 3/4:1 or steeper .
4. *Sericea lespedeza* hay containing mature seed shall be applied at a rate of three tons per acre.
5. *Pine straw or pine bark* shall be applied at a thickness of 3 inches for bedding purposes. Other suitable materials in sufficient quantity may be used where ornamentals or other ground covers are planted. This is not appropriate for seeded areas.
6. When using temporary erosion control blankets or block sod, mulch is not required.
7. *Bituminous treated roving* may be applied on planted areas on slopes, in ditches or dry waterways to prevent erosion. Bituminous treated roving shall be applied within 24 hours after an area has been planted. Application rates and materials must meet Georgia Department of Transportation specifications.

Wood cellulose and wood pulp fibers shall not contain germination or growth inhibiting factors. They shall be evenly dispersed when agitated in water. The fibers shall contain a dye to allow visual metering and aid in uniform application during seeding.

Applying Mulch

Straw or hay mulch will be spread uniformly within 24 hours after seeding and/or planting. The mulch may be spread by blower-type spreading equipment, other spreading equipment or by hand. Mulch shall be applied to cover 75% of the soil surface.

Wood cellulose or wood fiber mulch shall be applied uniformly with hydraulic seeding equipment.

Anchoring Mulch

Anchor straw or hay mulch immediately after application by one of the following methods:

1. *Emulsified asphalt* can be (a) sprayed uniformly onto the mulch as it is ejected from the blower machine or (b) sprayed on the mulch immediately following mulch application when straw or hay is spread by methods other than special blower equipment.

The combination of asphalt emulsion and water shall consist of a homogeneous mixture satisfactory for spraying. The mixture shall consist of 100 gallons of grade SS-1h or CSS-1h emulsified asphalt and 100 gallons of water per ton of mulch.

Care shall be taken at all times to protect state waters, the public, adjacent property, pavements, curbs, sidewalks, and all other structures from asphalt discoloration.

2. *Hay and straw* mulch shall be pressed into the soil immediately after the mulch is spread. A special "packer disk"' or disk harrow with the disks set straight may be used. The disks may be smooth or serrated and should be 20 inches or more in diameter and 8 to 12 inches apart. The edges of the disks shall be dull enough to press the mulch into the ground without cutting it, leaving much of it in an erect position. Mulch shall not be plowed into the soil.
3. *Synthetic tackifiers or binders* approved by GDOT shall be applied in conjunction with or immediately after the mulch is spread. Synthetic tackifiers shall be mixed and applied according to manufacturer's specifications. Refer to **Tb - Tackifiers and Binders**.
4. *Rye or wheat* can be included with Fall and Winter plantings to stabilize the mulch. They shall be applied at a rate of one-quarter to one-half bushel per acre.
5. *Plastic mesh or netting* with mesh no larger than one inch by one inch may be needed to anchor straw or hay mulch on unstable soils and concentrated flow areas. These materials shall be installed and anchored according to manufacturer's specifications.

Bedding Material

Mulch is used as a bedding material to conserve moisture and control weeds in nurseries, ornamental beds, around shrubs, and on bare areas on lawns.

Material	Depth
Grain straw	4" to 6"
Grass Hay	4" to 6"
Pine needles	3" to 5"
Wood waste	4" to 6"

Irrigation

Irrigation will be applied at a rate that will not cause runoff.

Topdressing

Topdressing will be applied on all temporary and permanent (perennial) species planted alone or in mixtures with other species. Recommended rates of application are listed in Table 6-5.1.

Second Year and Maintenance Fertilization

Second year fertilizer rates and maintenance fertilizer rates are listed in Table 6-5.1.

Lime Maintenance Application

Apply one ton of agricultural lime every 4 to 6 years or as indicated by soil tests. Soil tests can be conducted to determine more accurate requirements if desired.

Use and Management

Mow Sericea lespedeza only after frost to ensure that the seeds are mature. Mow between November and March.

Bermudagrass, Bahiagrass and Tall Fescue may be mowed as desired. Maintain at least 6 inches of top growth under any use and management. Moderate use of top growth is beneficial after establishment.

Exclude traffic until the plants are well established. Because of the quail nesting season, mowing should not take place between May and September.

Table 6-5.1

FERTILIZER REQUIREMENTS

TYPE OF SPECIES	YEAR	ANALYSIS OR EQUIVALENT N-P-K	RATE	N TOP DRESSING RATE
1. Cool season grasses	First	6-12-12	1500 lbs./ac.	50-100 lbs./ac. 1/ 2/
	Second	6-12-12	1000 lbs./ac.	—
	Maintenance	10-10-10	400 lbs./ac.	30
2. Cool season grasses and legumes	First	6-12-12	1500 lbs./ac.	0-50 lbs./ac. 1/
	Second	0-10-10	1000 lbs./ac.	—
	Maintenance	0-10-10	400 lbs./ac.	—
3. Ground covers	First	10-10-10	1300 lbs./ac. 3/	—
	Second	10-10-10	1300 lbs./ac. 3/	—
	Maintenance	10-10-10	1100 lbs./ac.	—
4. Pine seedlings	First	20-10-5	one 21-gram pellet per seedling placed in the closing hole	—
5. Shrub Lespedeza	First	0-10-10	700 lbs./ac.	—
	Maintenance	0-10-10	700 lbs./ac. 4/	
6. Temporary cover crops seeded alone	First	10-10-10	500 lbs./ac.	30 lbs./ac. 5/
7. Warm season grasses	First	6-12-12	1500 lbs./ac.	50-100 lbs./ac. 2/ 6/
	Second	6-12-12	800 lbs./ac.	50-100 lbs./ac. 2/
	Maintenance	10-10-10	400 lbs./ac.	30 lbs./ac.
8. Warm season grasses and legumes	First	6-12-12	1500 lbs./ac.	50 lbs./ac. 6/
	Second	0-10-10	1000 lbs./ac.	
	Maintenance	0-10-10	400 lbs./ac.	

1/ Apply in spring following seeding.
2/ Apply in split applications when high rates are used.
3/ Apply in 3 split applications.
4/ Apply when plants are pruned.
5/ Apply to grass species only.
6/ Apply when plants grow to a height of 2 to 4 inches.

Table 6-5.2

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 1/ - PLS 2/ Per Acre	Broadcast Rates 1/ - PLS 2/ Per 1000 sq. ft.	Resource Area 3/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.)												Remarks
				J	F	M	A	M	J	J	A	S	O	N	D	
BAHIA, PENSACOLA (Paspalum notatum)			P	⋯	⋯	⋯	—	—	⋯	⋯	⋯	⋯	⋯	⋯	⋯	166,000 seed per pound. Low growing. Sod forming. Slow to establish. Plant with a companion crop. Will spread into bermuda pastures and lawns. Mix with Sericea lespedeza or weeping lovegrass.
			C	⋯	⋯	—	—	—	⋯	⋯	⋯	⋯	⋯	⋯	⋯	
alone or with temporary cover	60 lbs.	1.4 lb.														
with other perennials	30 lbs.	0.7 lb.		J	F	M	A	M	J	J	A	S	O	N	D	
BAHIA, WILMINGTON (Paspalum notatum)			M-L	⋯	⋯	⋯—	—	—	⋯	⋯	⋯	⋯	⋯	⋯	⋯	Same as above.
			P	⋯	⋯	—	—	—	⋯	⋯	⋯	⋯	⋯	⋯	⋯	
alone or with temporary cover	60 lbs.	1.4 lb.														
with other perennials	30 lbs.	0.7 lb.		J	F	M	A	M	J	J	A	S	O	N	D	
BERMUDA, COMMON (Cynodon dactylon) Hulled seed			P			⋯	—	—	⋯							1,787,000 seed per pound. Quick cover. Low growing and sod forming. Full sun. Good for athletic fields.
			C		⋯	⋯—	—	—	⋯							
alone	10 lbs.	0.2 lb.														
with other perennials	6 lbs.	0.1 lb.														

Table 6-25.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 1/ - PLS 2/		Resource Area 3/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.)												Remarks
	Per Acre	Per 1000 sq. ft.		J	F	M	A	M	J	J	A	S	O	N	D	
BERMUDA, COMMON (Cynodon dactylon) Unhulled seed			P	—	—								—	—	—	
			C	—										—	—	
with temporary cover	10 lbs.	0.2 lb.														Plant with winter annuals.
with other perennials	6 lbs.	0.1 lb.														**Plant with Tall fescue.**
				J	F	M	A	M	J	J	A	S	O	N	D	
BERMUDA SPRIGS (Cynodon dactylon)	40 cu. ft. or sod plugs 3' x 3'	0.9 cu. ft.	M-L			⋯	⋯—	—	—⋯	⋯						A cubic foot contains approximately 650 sprigs. A bushel contains 1.25 cubic feet or approximately 800 sprigs.
Coastal, Common, Midland, or Tift 44																
Coastal, Common, or Tift 44			P			⋯	⋯—	—	—⋯	⋯						Same as above
			C	⋯	⋯	⋯	—	—	⋯	⋯	⋯	⋯	⋯	⋯	⋯	
Tift 78			C	⋯	⋯	⋯	—	—	⋯	⋯	⋯	⋯	⋯	⋯	⋯	Southern Coastal Plain only.
CENTIPEDE (Eremochloa ophiuroides)	Block sod only		P	—	—	—	—	—						—	—	Drought tolerant. Full sun or partial shade. Effective adjacent to concrete and in concentrated flow areas. Irrigation is needed until fully established. Do not plant near pastures. Winterhardy as far north as Athens and Atlanta.
			C	—	—	—	—	—						—	—	

Table 6-5.2 - continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 1/ - PLS 2/ Per Acre	Broadcast Rates 1/ - PLS 2/ Per 1000 sq. ft.	Resource Area 3/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J	F	M	A	M	J	J	A	S	O	N	D	Remarks
CROWNVETECH (Coronilla varia) with winter annuals or cool season grasses	15 lbs.	0.3 lb.	M-L P									— —	··· ···			100,000 seed per pound. Dense growth. Drought tolerant and fire resistant. Attractive rose, pink, and white blossoms spring to late fall. Mix with 30 pounds of Tall fescue or 15 pounds of rye. Inoculate seed with M inoculant. Use from North Atlanta and Northward
FESCUE, TALL (Festuca arundinacea)				J	F	M	A	M	J	J	A	S	O	N	D	227,000 seed per pound. Use alone only on better sites. Not for droughty soils. Mix with perennial lespedezas or Crownvetch. Apply topdressing in spring following fall plantings. Not for heavy use areas or athletic fields.
alone	50 lbs.	1.1 lb.	M-L P			—	—				··· ···	— —	··· ···			
with other perennials	30 lbs.	0.7 lb.														
KUDZU (Pueraria thumbergiana) plants or crowns	3' - 7' apart		ALL	—	—	···										Rapid and vigorous growth. Excellent in gully erosion control. Will climb. Good livestock forage.

Table 6-5.2 - continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

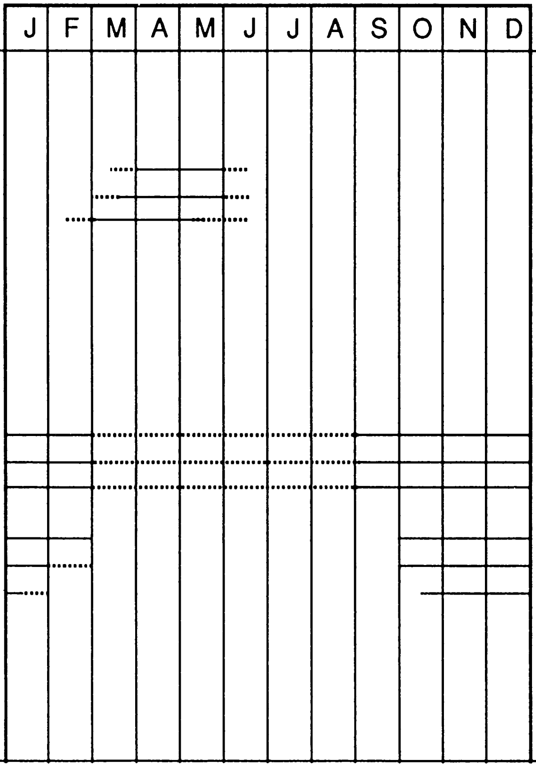
Species	Broadcast Rates 1/ - PLS 2/ Per Acre	Broadcast Rates 1/ - PLS 2/ Per 1000 sq. ft.	Resource Area 3/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
LESPEDEZA, SERICEA (Lespedeza cuneata)					
scarified	60 lbs.	1.4 lb.	M-L P C		350,000 seed per pound. Widely adapted. Low maintenance. Mix with Weeping lovegrass, Common bermuda, bahia, or tall fescue. Takes 2 to 3 years to become fully established. Excellent on roadbanks. Inoculate seed with EL inoculant.
unscarified	75 lbs.	1.7 lb.	M-L P C		Mix with Tall fescue or winter annuals.
seed-bearing hay	3 tons	138 lb.	M-L P C		Cut when seed is mature, but before it shatters. Add Tall fescue or winter annuals.

Table 6-5.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

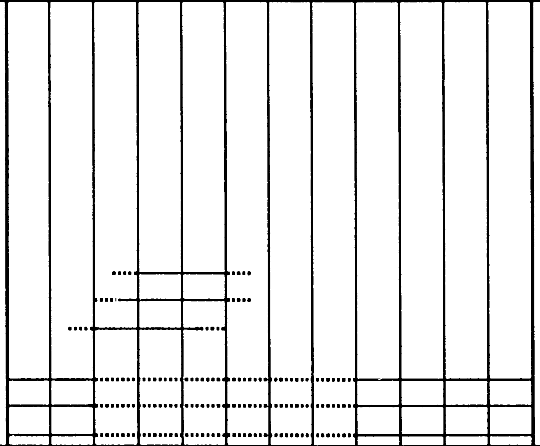
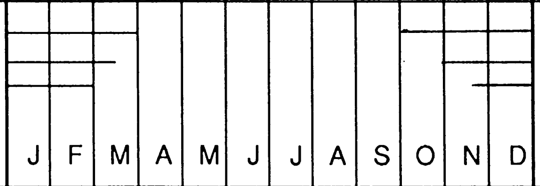
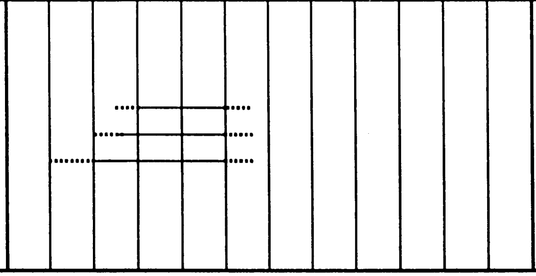
Species	Broadcast Rates 1/ - PLS 2/ Per Acre	Broadcast Rates 1/ - PLS 2/ Per 1000 sq. ft.	Resource Area 3/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J F M A M J J A S O N D	Remarks
LESPEDEZA Ambro virgata (Lespedeza virgata DC) or Appalow (Lespedeza cuneata [Dumont] G. Don)					300,000 seed per pound. Height of growth is 18 to 24 inches. Advantageous in urban areas. Spreading-type growth. New growth has bronze coloration. Mix with weeping lovegrass, common bermuda, bahia, tall fescue or winter annuals. Do not mix with Sericea lespedeza. Slow to develop solid stands. Inoculate seed with EL inoculant.
scarified	60 lbs.	1.4 lb.	M-L P C		
unscarified	75 lbs.	1.7 lb.	M-L P C		
LESPEDEZA, SHRUB (Lespedeza bicolor)) (Lespedeza thumbergii) plants	3' X 3'		M-L P C	 	Provide wildlife food and cover.
LOVEGRASS, WEEPING (Eragrostis curvula)					1,500,000 seed per pound. Quick cover. Drought tolerant. Grows well with Sericea lespedeza on roadbanks.
alone	4 lbs.	0.1 lb.	M-L P C		
with other perennials	2 lbs.	0.05 lb.			

Table 6-5.2 continued

PLANTS, PLANTING RATES, AND PLANTING DATES FOR PERMANENT COVER

Species	Broadcast Rates 1/ - PLS 2/ Per Acre	Broadcast Rates 1/ - PLS 2/ Per 1000 sq. ft.	Resource Area 3/	Planting Dates by Resource Areas Planting Dates (Solid lines indicate optimum dates, dotted lines indicate permissible but marginal dates.) J	F	M	A	M	J	J	A	S	O	N	D	Remarks
MAIDENCANE (Panicum hemitomon) sprigs	2' x 3' spacing		ALL	…	—	—	…									For very wet sites. May clog channels. Dig sprigs from local sources. Use along river banks and shorelines.
PANICGRASS, ATLANTIC COASTAL (Panicum amarum var. amarulum))	20 lbs.	0.5 lb.	P C		… …	— —	— —									Grows well on coastal sand dunes, borrow areas, and gravel pits. Provides winter cover for wildlife. Mix with Sericea lespedeza except on sand dunes.
				J	F	M	A	M	J	J	A	S	O	N	D	
REED CANARY GRASS (Phalaris arundinacea)																
alone	50 lbs.	1.1 lb.	M-L P								…— …	— —	—… —…	 …		Grows similar to Tall fescue.
with other perennials	30 lbs.	0.7 lb.														
				J	F	M	A	M	J	J	A	S	O	N	D	
SUNFLOWER, 'AZTEC' MAXIMILLIAN (Helianthus maximiliani)	10 lbs.	0.2 lb.	M-L P C				… … —	— — —								227,000 seed per pound. Mix with Weeping lovegrass or other low-growing grasses or legumes.
				J	F	M	A	M	J	J	A	S	O	N	D	

1/ Reduce seeding rates by 50% when drilled.
2/ PLS is an abbreviation for Pure Live Seed. Refer to Section V.E. of these specifications.
3/ M-L represents to Mountain; Blue Ridge; and Ridges and Valleys MLRAs.
P represents the Southern Piedmont MLRA.
C represents the Southern Coastal Plain; Sand Hills; Black Lands; and Atlantic Coast Flatwoods MLRAs.
See Figure 6-4.1.

Table 6-5.3

DURABLE SHRUBS AND GROUND COVERS FOR PERMANENT COVER

Ground covers include a wide range of low-growing plants planted together in considerable numbers to cover large areas of the landscape. Ground covers grow slower than grasses. Weeds are likely to compete, especially the first year. Maintenance is needed to insure survival. These ground covers will not be used unless proper maintenance is planned. Maintain mulch at three-inch thickness until plants provide adequate cover.

Fall planting is encouraged because the need for constant watering is reduced and plants have time to establish new roots before hot weather.

Common Name	Scientific Name	Mature Height	Plant Spacing	Comments
Albelia	Abelia grandiflora	3-4 ft.	5 ft.	Also a prostrate form 2 feet high. Sun, semi-shade. Semi-evergreen.
Carolina Yellow Jessamine	Gelsemium sempervirens	low	3 ft.	Vine. Yellow, trumpet-like flowers. Hardy, one of best vines. Evergreen. Native to Georgia.
Carpet Blue	Ajuga reptans	2-4 in.	3 ft.	Needs good drainage, partial shade. Blue or white flowers. Evergreen.
Bearberry Cotoneaster	Cotoneaster dammeri	2-4 ft.	5 ft.	White flowers, red fruit. Sun. Evergreen.
Ground Cover Cotoneaster	Cotoneaster salicifoluis 'Repens'	1-2 ft.	5 ft.	White flowers, red fruit. Sun. Evergreen.
Rock Cotoneaster	Cotoneaster horizontalis	1-2 ft.	5 ft.	Semi-evergreen. Sun.
Virginia Creeper	Parthenocissue quinquefolia	low	3 ft.	Red in fall. Vine. Deciduous. Native to Georgia.
Daylily	Hemerocallis spp.	2-3 ft.	2 ft.	Many flower colors. Full sun. Very hardy.
English Ivy	Hedera helix	low	3 ft.	Shade only. Climbs.

Table 6-5.3

DURABLE SHRUBS AND GROUND COVERS FOR PERMANENT COVER

Common Name	Scientific Name	Mature Height	Plant Spacing	Comments
Compacta Holly	Ilex crenata 'Compacta'	3-4 ft.	5 ft.	Sun, semi-shade.
Chinese Holly	Ilex cornuta 'Rotunda'	3-4 ft.	5 ft.	Very durable. Sun, semi-shade.
Dwarf Burford Holly	Ilex burfordii 'Nana'	5-8 ft.	8 ft.	
Dwarf Yaupon Holly	Ilex vomitoria 'Nana'	3-4 ft.	5 ft.	Very durable. sun, semi-shade.
Repandens Holly	Ilex crenata 'Repandens'	2-3 ft.	5 ft.	Sun, semi-shade.
Andorra Juniper	Juniperus horizontalis 'Plumosa'	2-3 ft.	5 ft.	Excellent for slopes. Sun.
Andorra Compacta Juniper	Juniperus horizontalis 'Plumosa compacta'	1-2 ft.	5 ft.	More compact than andora.
Blue Chip Juniper	Juniperus horizontalis 'Blue Chip'	8-10 in.	4 ft.	
Blue Rug Juniper	Juniperus horizontalis 'Wiltonii'	4-6 in.	3 ft.	Very low. Sun.
Parsons Juniper	Juniperus davurica 'Expansa' (Squamata Parsoni)	18-24 in.	5 ft.	One of the best, good winter cover.
Pfitzer Juniper	Juniperus chinensis 'Pfitzerana'	6-8 ft.	6 ft.	Needs room.

Table 6-5.3 continued

DURABLE SHRUBS AND GROUND COVERS FOR PERMANENT COVER

Common Name	Scientific Name	Mature Height	Plant Spacing	Comments
Prince of Wales Juniper	Juniperus horizontalis 'Prince of Wales'	8-10 in.	4 ft.	Feathery appearance.
Sargent Juniper	Juniperus chinensis 'Sargentii'	1-2 ft.	5 ft.	Full sun. Needs good drainage. Good winter color.
Shore Juniper	Juniperus conferta	2-3 ft.	5 ft.	Emerald Sea or Blue Pacific cultivars are good.
Liriope	Liriope muscari	8-10 in.	3 ft.	
Creeping Liriope	Liriope spicata	10-12 in.	1 ft.	Spreads by runners.
Big Leaf Periwinkle	Vinca major	12-15 in.	4 ft.	Lilac flowers in spring. Semi-shade.
Common Periwinkle	Vinca minor	5-6 in.	4 ft.	Lavender-blue flowers in spring. Semi-shade
Cherokee Rose	Rosa laevigata	2 ft.	5 ft.	Rampant grower. Not for restricted spaces. State flower.
Memoria Rose	Rosa weuchuriana	2 ft.	5 ft.	Rampant grower.
St. Johnswort	Hypericum calycenum	8-12 in.	3 ft.	Semi-shade.
Anthony Waterer Spirea	Spirea bumalda	3-4 ft.	5 ft.	Sun.
Thunberg Spirea	Spirea thinbergii	3-4 ft.	5 ft.	Sun.

Table 6-5.4

TREES FOR EROSION CONTROL

SITE	SOIL MATERIAL	COMMON SOILS	PLANTING TREE SPECIES 1/	SPACING	PLANTING DATES 3/
Borrow areas, graded areas, and spoil material	Sandy	Lakeland, Troup	Loblolly pine (Pinus taeda) Longleaf pine (Pinus palustris)	2/	M-L,P 12/1-3/15 C 12/1-3/1
	Loamy	Orangeburg, Tifton	Loblolly pine Slash pine	2/	M-L,P 12/1-3/15 C 12/1-3/1
	Clay	Cecil, Faceville	Loblolly pine Slash pine Virginia pine (Pinus virginiana)	2/	M-L,P 12/1-3/15 C 12/1-3/1
Streambanks			Willows 4/ (Salix species)	2 ft x 2 ft	ALL 11/15 - 3/15

1/ Other trees and shrubs listed on Table 6-25.3 may be interplanted with the pines for improved wildlife benefits.

2/

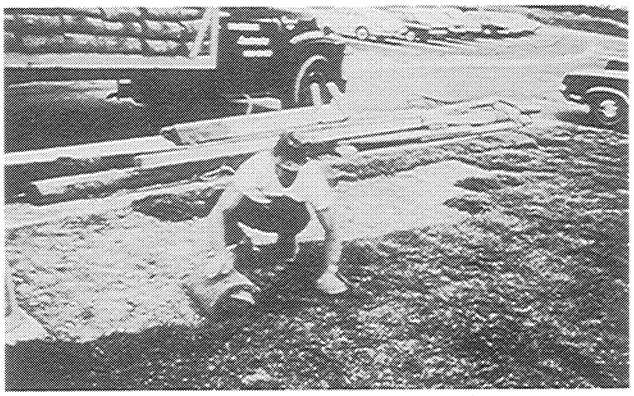
Type of Planting	Tree Spacing	No. of Trees Per Acre
Trees alone	4 ft. x 4 ft.	2722
Trees in combination with grasses and/ or other plants	6 ft. x 6 ft.	1210

3/ M-L represents the Mountains; Blue Ridge; and Ridges and Valleys MLRAs
P represents the Southern Piedmont MLRA
C represents the Southern Coastal Plain; Sand Hills; Black Lands; and Atlantic Coast Flatwoods MLRAs (See Figure 6-4.1).

4/ Fertilization of companion crop is ample for this species.

DISTURBED AREA STABILIZATION (WITH SODDING)

Ds4



DEFINITION

A permanent vegetative cover using sods on highly erodible or critically eroded lands.

PURPOSE

- Establish immediate ground cover.
- Reduce runoff and erosion.
- Improve aesthetics and land value.
- Reduce dust and sediments.
- Stabilize waterways, critical areas.
- Filter sediments, nutrients and bugs.
- Reduce downstream complaints.
- Reduce likelihood of legal action.
- Reduce likelihood of work stoppage due to legal action.
- Increase "good neighbor" benefits.

CONDITIONS

This application is appropriate for areas which require immediate vegetative covers, drop inlets, grass swales, and waterways with intermittent flow.

PLANNING CONSIDERATIONS

Sodding can initially be more costly than seeding, but the advantages justify the increased initial costs.

1. Immediate erosion control, green surface, and quick use.
2. Reduced failure as compared to seed as well as the lack of weeds.
3. Can be established nearly year-round.

Sodding is preferable to seed in waterways and swales because of the immediate protection of the channel after application. Sodding must be staked in concentrated flow areas (See Figure 6-6.1).

Consider using sod framed around drop inlets to reduce sediments and maintaining the grade.

CONSTRUCTION SPECIFICATIONS INSTALLATION

Soil Preparation

Bring soil surface to final grade. Clear surface of trash, woody debris, stones and clods larger than 1". Apply sod to soil surfaces only and not frozen surfaces, or gravel type soils.

Topsoil properly applied will help guarantee a stand. Don't use topsoil recently treated with herbicides or soil sterilants.

Mix fertilizer into soil surface. Fertilize based on soil tests or Table 6-6.1.

Table 6-6.1

Fertilizer Requirements for Soil Surface Application

Fertilizer Type	**Fertilizer Rate** (lbs./acre)	**Fertilizer Rate** (lbs./sq.ft.)	**Season**
10-10-10	1000	.025	Fall

Agricultural lime should be applied based on soil tests or at a rate of 1 to 2 tons per acre.

Installation

Lay sod with tight joints and in straight lines. Don't overlap joints. Stagger joints and do not stretch sod (See Figure 6-6.2)

On slopes steeper than 3:1, sod should be anchored with pins or other approved methods. Installed sod should be rolled or tamped to provide good contact between sod and soil.

Irrigate sod and soil to a depth of 4" immediately after installation.

Sod should not be cut or spread in extremely wet or dry weather. Irrigation should be used to supplement rainfall for a minimum of 2-3 weeks.

MATERIALS

Sod selected should be certified. Sod grown in the general area of the project is desirable.

1. Sod should be machine cut and contain 3/4" (+ or - 1/4") of soil, not including shoots or thatch.
2. Sod should be cut to the desired size within + or - 5%. Torn or uneven pads should be rejected.
3. Sod should be cut and installed within 36 hours of digging.
4. Avoid planting when subject to frost heave or hot weather if irrigation is not available.
5. The sod type should be shown on the plans or installed according to Table 6-6.2. See Figure 6-4.1 for your Resource Area.

Table 6-6.2
Sod Planting Requirements

Grass	Varieties	Resource Area	Growing Season
Bermudagrass	Common Tifway Tifgreen Tiflawn	M-L,P,C P,C P,C P,C	Warm Weather
Bahiagrass	Pensacola	P,C	Warm Weather
Centipede	–	P,C	Warm Weather
St. Augustine	Common Bitterblue Raleigh	C	Warm Weather
Zoysia	Emerald Myer	P,C	Warm Weather
Tall Fescue	Kentucky	M-L,P	Cool Weather

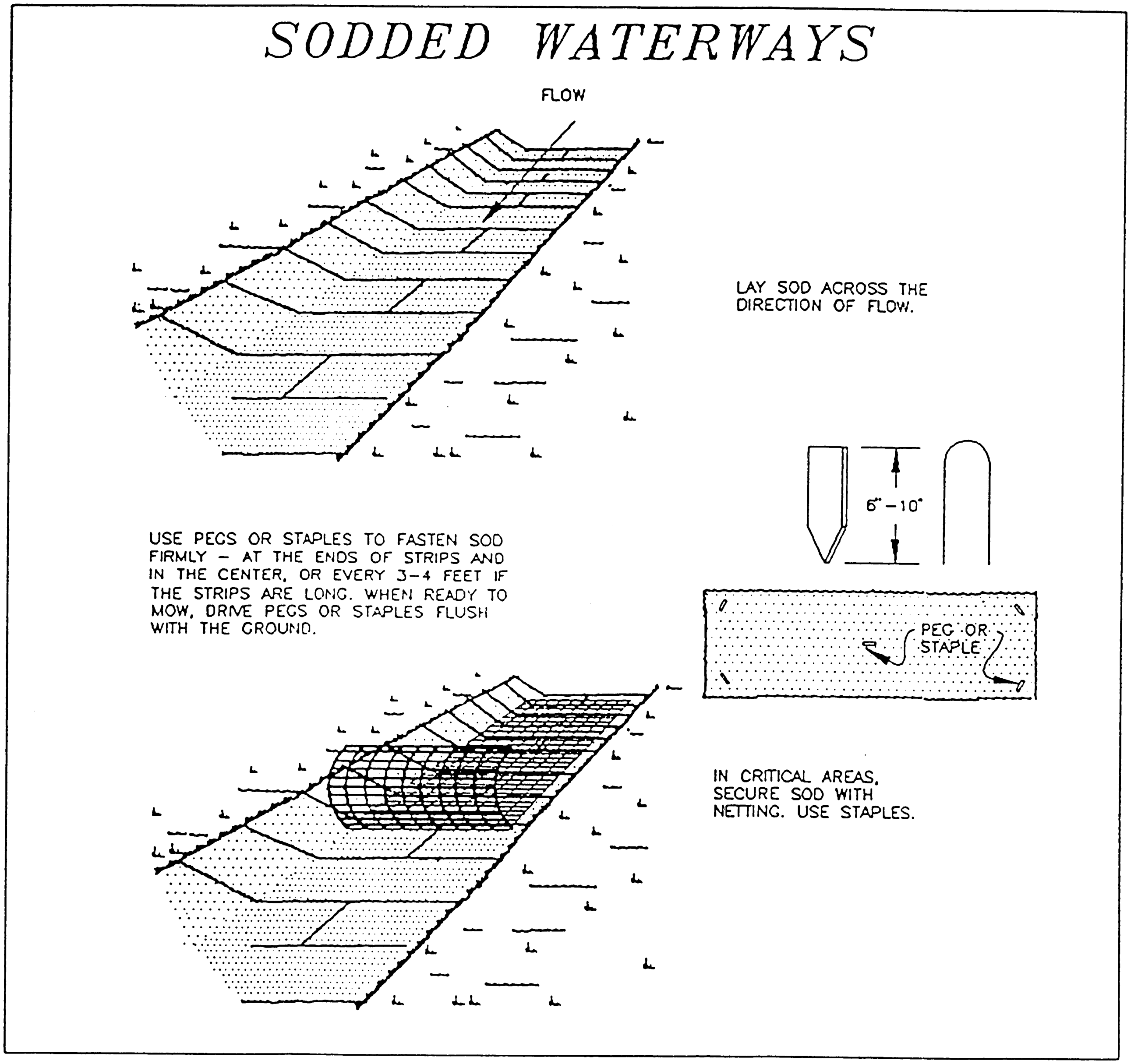
MAINTENANCE

Re-sod areas where an adequate stand of sod is not obtained. New sod should be mowed sparingly. Grass height should not be cut less than 2"-3" or as specified (See Figure 6-6.2).

Apply one ton of agricultural lime as indicated by soil test or every 4-6 years. Fertilize grasses in accordance with soil tests or Table 6-6.3.

Table 6-6.3
Fertilizer Requirements for Sod

Types of Species	Planting Year	Fertilizer (N-P-K)	Rate (lbs./acre)	Nitrogen Top Dressing Rate (lbs./acre)
Cool season grasses	First	6-12-12	1500	50-100
	Second	6-12-12	1000	-
	Maintenance	10-10-10	400	30
Warm season grasses	First	6-12-12	1500	50-100
	Second	6-12-12	800	50-100
	Maintenance	10-10-10	400	30



SODDED WATERWAYS

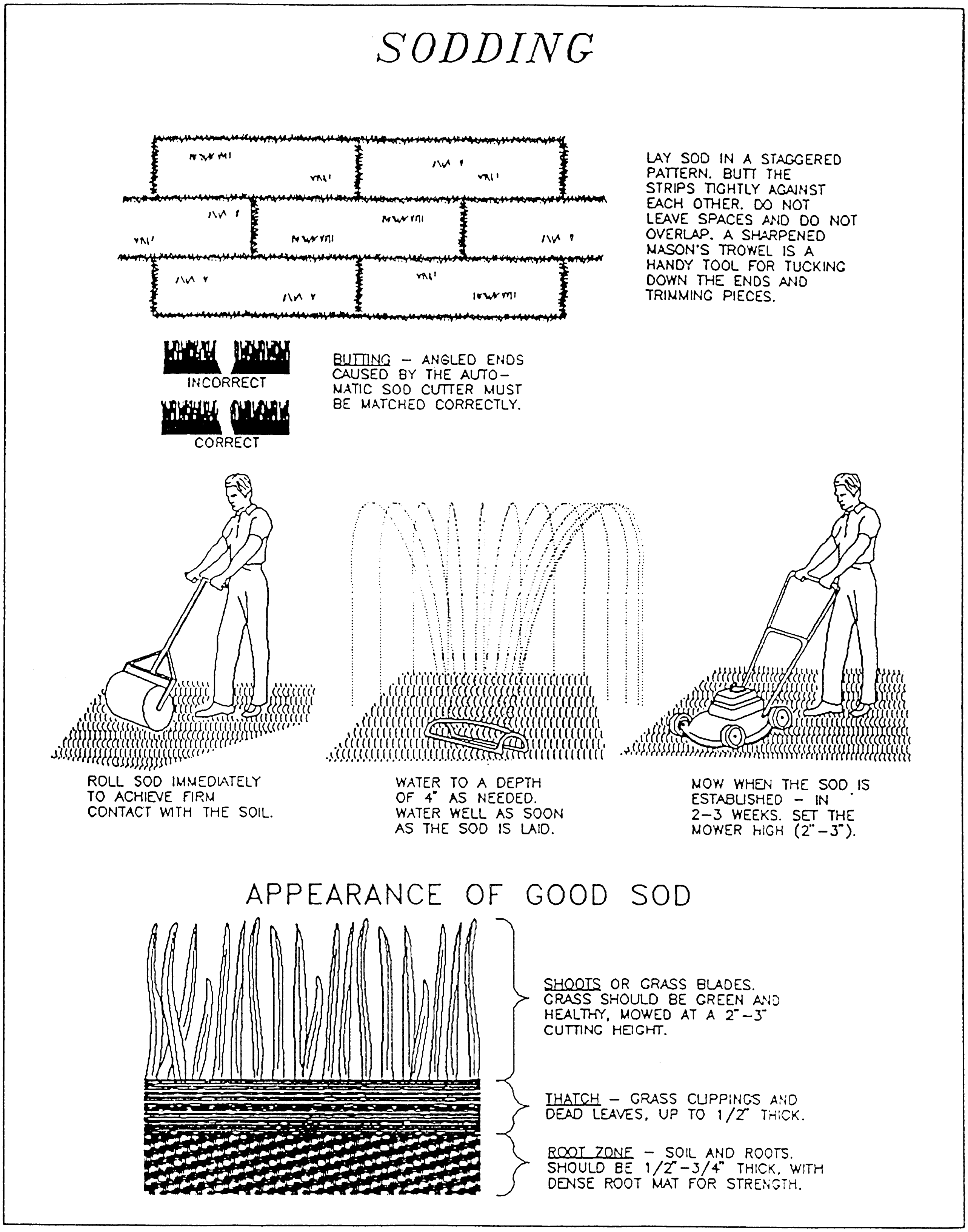
LAY SOD ACROSS THE DIRECTION OF FLOW.

USE PEGS OR STAPLES TO FASTEN SOD FIRMLY – AT THE ENDS OF STRIPS AND IN THE CENTER, OR EVERY 3–4 FEET IF THE STRIPS ARE LONG. WHEN READY TO MOW, DRIVE PEGS OR STAPLES FLUSH WITH THE GROUND.

IN CRITICAL AREAS, SECURE SOD WITH NETTING. USE STAPLES.

Source: Va. DSWC

Figure 6-6.1



SODDING

LAY SOD IN A STAGGERED PATTERN. BUTT THE STRIPS TIGHTLY AGAINST EACH OTHER. DO NOT LEAVE SPACES AND DO NOT OVERLAP. A SHARPENED MASON'S TROWEL IS A HANDY TOOL FOR TUCKING DOWN THE ENDS AND TRIMMING PIECES.

BUTTING – ANGLED ENDS CAUSED BY THE AUTOMATIC SOD CUTTER MUST BE MATCHED CORRECTLY.

ROLL SOD IMMEDIATELY TO ACHIEVE FIRM CONTACT WITH THE SOIL.

WATER TO A DEPTH OF 4" AS NEEDED. WATER WELL AS SOON AS THE SOD IS LAID.

MOW WHEN THE SOD IS ESTABLISHED – IN 2–3 WEEKS. SET THE MOWER HIGH (2"–3").

APPEARANCE OF GOOD SOD

SHOOTS OR GRASS BLADES. GRASS SHOULD BE GREEN AND HEALTHY, MOWED AT A 2"–3" CUTTING HEIGHT.

THATCH – GRASS CLIPPINGS AND DEAD LEAVES, UP TO 1/2" THICK.

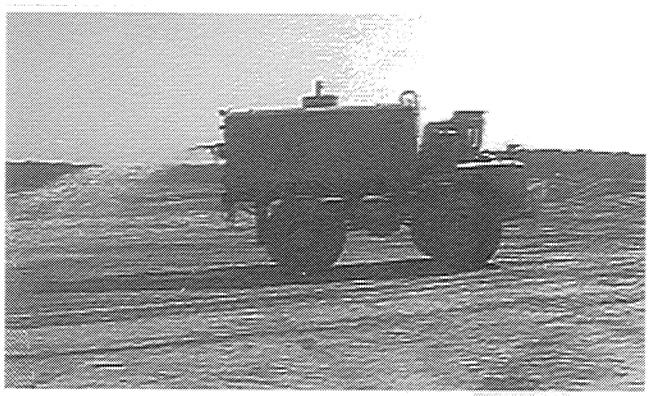
ROOT ZONE – SOIL AND ROOTS. SHOULD BE 1/2"–3/4" THICK, WITH DENSE ROOT MAT FOR STRENGTH.

Source: Va. DSWC

Figure 6-6.2

Dust Control on Disturbed Areas

Du



DEFINITION

Controlling surface and air movement of dust on construction sites, roads, and demolition sites.

PURPOSE

- To prevent surface and air movement of dust from exposed soil surfaces.
- To reduce the presence of airborne substances which may be harmful or injurious to human health, welfare, or safety, or to animals or plant life.

CONDITIONS

This practice is applicable to areas subject to surface and air movement of dust where on and off-site damage may occur without treatment.

METHOD AND MATERIALS

A. TEMPORARY METHODS

Mulches. See standard **Ds1 - Disturbed Area Stabilization (With Mulching Only).** Synthetic resins may be used instead of asphalt to bind mulch material. Refer to standard **Tb-Tackifiers and Binders.** Resins such as Curasol or Terratack should be used according to manufacturer's recommendations.

Vegetative Cover. See standard **Ds2 - Disturbed Area Stabilization (With Temporary Seeding).**

Spray-on Adhesives. These are used on mineral soils (not effective on muck soils). Keep traffic off these areas. Refer to standard **Tb-Tackifiers and Binders.**

Tillage. This practice is designed to roughen and bring clods to the surface. It is an emergency measure which should be used before wind erosion starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 inches apart, spring-toothed harrows, and similar plows are examples of equipment which may produce the desired effect.

Irrigation. This is generally done as an emergency treatment. Site is sprinkled with water until the surface is wet. Repeat as needed.

Barriers. Solid board fences, snowfences, burlap fences, crate walls, bales of hay and similar material can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of about 15 times their height are effective in controlling wind erosion.

Calcium Chloride. Apply at rate that will keep surface moist. May need retreatment.

B. PERMANENT METHODS

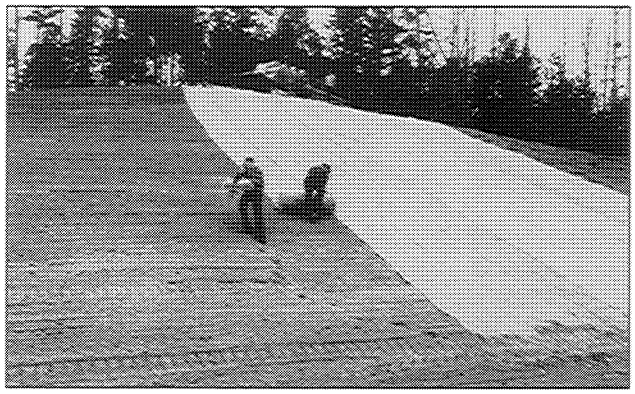
Permanent Vegetation. See standard **Ds3 - Disturbed Area Stabilization (With Permanent Vegetation)**. Existing trees and large shrubs may afford valuable protection if left in place.

Topsoiling. This entails covering the surface with less erosive soil material. See standard **Tp - Topsoiling.**

Stone. Cover surface with crushed stone or coarse gravel. See standard **Cr-Construction Road Stabilization.**

Erosion Control Matting and Blankets

Mb



DEFINITION

A protective covering (blanket) or soil stabilization mat used to establish permanent vegetation on steep slopes, channels, or shorelines.

PURPOSE

- To provide a microclimate which protects young vegetation and promotes its establishment.
- To reinforce the turf to resist forces of erosion during storm events.

CONDITIONS

Matting and blankets can be applied on steep slopes where erosion hazard is high and planting is likely to be too slow in providing adequate protective cover. **Concentrated flow areas, all slopes steeper than 2.5:1 and with a height of ten feet or greater, and cuts and fills within stream buffers, shall be stabilized with the appropriate erosion control matting or blankets.** Maintenance of final vegetative cover must be considered when choosing blankets verses matting.

On streambanks or tidal shorelines where moving water is present, matting can prevent new plantings from being washed away.

PLANNING CONSIDERATIONS

Care must be taken to choose the type of blanket or matting which is most appropriate for the specific needs of a project. Two general types of blankets and mats are discussed within this specification. Due to the abundance of erosion control matting and blanket products available, all of the advantages, disadvantages, and specifications of all manufactured products will not be discussed in this manual. Manufacturer's instructions and recommendations, as well as a site visit by designer and plan reviewer is highly recommended to determine a product's appropriateness.

Temporary Erosion Control Blankets

This includes **temporary** "combination" blankets (rolled erosion control blankets-RECB) consisting of a plastic netting which covers and is intertwined with a natural organic or manmade mulch; or, a jute mesh which is typically homogeneous in design and can act alone as a soil stabilization blanket.

Temporary blankets as a minimum shall be used to stabilize concentrated flow areas with a velocity less than 5 ft/sec and slopes 2.5:1 or steeper with a height of 10 feet or greater. Because temporary blankets will deteriorate in a short period of time, they provide no enduring reduction in erosion protection.

Benefits of using erosion control blankets include the following:

1. Protection of the seed and soil from raindrop impact and subsequent displacement.
2. Thermal consistency and moisture retention for seedbed area.
3. Stronger and faster germination of grasses and legumes.
4. Planing off excess stormwater runoff.
5. Prevention of sloughing of topsoil added to steeper slopes.

Permanent Erosion Control Matting

Consists of a **permanent** non-degradable, three-dimensional plastic structure which can be filled with soil prior to planting. These mats are also known as **permanent soil reinforcing mats** (turf reinforcement matting). Roots penetrate and become entangled in the matrix, forming a continuous anchorage for surface growth and promoting enhanced energy dissipation. Matting shall be used when a vegetative lining is desired in stormwater conveyance channels where the velocity is between five and ten feet per second.

Benefits of using erosion control matting include the following:

1. All benefits gained from using erosion control blankets.

2. Causes soil to drop out of stormwater and fill matrix with fine soils which become the growth medium for the development of roots.

3. Acts with the vegetative root system to form an erosion resistant cover which resists hydraulic lift and shear forces when embedded in the soil within stormwater channels.

Materials

All blanket and matting materials shall be on the Georgia Department of Transportation Qualified Products List (QPL # 62 for blankets, QPL # 49 for matting).

All blankets shall be nontoxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. At a minimum, the plastic netting shall be intertwined with the mulching material/fiber to maximize strength and provide for ease of handling.

Temporary Blankets

Machine produced **temporary** combination blankets shall have a consistent thickness with the organic material evenly distributed over the entire blanket area. All combination blankets shall have a minimum width of 48 inches. Machine produced combination blankets include the following:

a. **Straw blankets** are combination blankets that consist of weed-free straw from agricultural crops formed into a blanket. Blankets with a top side of photodegradable plastic mesh with a maximum mesh size of 5/16 x 5/16 inch and sewn to the straw with biodegradable thread is appropriate for slopes. The blanket shall have a minimum thickness of 3/8 inch and minimum dry weight of 0.5 pounds per square yard.

b. **Excelsior blankets** are combination blankets that consist of curled wood excelsior (80% of fibers are six inches or longer) formed into a blanket. The blanket shall have clear markings indicating the top side of the blanket and be smolder resistant. Blankets shall have photodegradable plastic mesh having a maximum mesh size of 1 1/2 x 3 inches. The blanket shall have a minimum thickness of 1/4 of an inch and a minimum dry weight of 0.8 pounds per square yard. Slopes require excelsior matting with the top side of the blanket covered in the plastic mesh, and for waterways, both sides of the blanket require plastic mesh.

c. **Coconut fiber blankets** are combination blankets that consist of 100% coconut fiber formed into a blanket. The minimum thickness of the blanket shall be 1/4 of an inch with a minimum dry weight of 0.5 pounds per square yard. Blankets shall have photodegradable plastic mesh, with a maximum mesh size of 5/8 x 5/8 inch and sewn to the fiber with a breakdown resistant synthetic yarn. Plastic mesh is required on both sides of the blanket if used in waterways. A maximum of two inches is allowable for the stitch pattern and row spacing.

d. **Wood fiber blankets** are combination blankets that consist of reprocessed wood fibers that do not possess or contain any growth or germination inhibiting factors. The blanket shall have a photodegradable plastic mesh, with a maximum mesh size of 5/8 x 3/4 inch, securely bonded to the top of the mat. The blanket shall have a minimum dry weight of 0.35 pounds per square yard. A maximum of two inches is allowable for the stitch pattern and row spacing. This practice shall be applied only to slopes.

e. **Jute Mesh** can be applied to slopes. Jute mesh with a 48 inch width shall show between 76 and 80 warpings and a one yard length shall show between 39 to 43 weftings. The woven mesh shall be at least 45 inches wide. Yarn shall have a unit weight of at least 0.9 pounds per square yard, but not more than 1.5 pounds per square yard.

Permanent Matting

Permanent matting shall consist of a lofty web of mechanically or melt bonded polymer nettings, monofilaments or fibers which are entangled to form a strong and dimensionally stable matrix. Polymer welding, thermal or polymer fusion, or the placement of fibers between two high strength, biaxially oriented nets bound securely together by parallel lock stitching with polyolefin, nylon or polyester threads are all appropriate bonding methods. Mats shall maintain their shape before, during, and after installation, under dry or water saturated conditions. Mats must be stabilized against ultraviolet degradation and shall be inert to chemicals normally encountered in a natural soil environment.

The mat shall conform to the following physical properties:

Property	**Minimum Value**
Thickness	0.5 inch
Weight	0.6 PSY
Roll Width	38 inches
Tensile Strength	
Length (50% elongation)	15 lbs./in.
Length (ultimate)	20 lbs./in.

Width (50% elongation)	5 lbs./in.
Width (ultimate)	10 lbs./in.
(ASTM D 1682 - 6" strip)	
Ultraviolet Stability	80%

(1000hrs. in an Atlas ARC Weatherometer, ASTM G 23, Type D in accordance with ASTM D 822)

Site Preparation

After the site has been shaped and graded to the approved design, prepare a friable seedbed relatively free from clods and rocks more than one inch in diameter, and any foreign material that will prevent contact of the soil stabilization mat with the soil surface. Surface must be smooth to ensure proper contact of blankets or matting to the soil surface. If necessary, redirect any runoff from the ditch or slope during installation.

Staples

The following are considered appropriate stapling and staking materials.

Temporary Blankets

This includes straw, excelsior, coconut fiber, and wood fiber blankets. Staples shall be used to anchor temporary blankets. U-shaped wire (11 gauge or greater) staples with legs at least 6 inches in length and a crown of one inch or appropriate biodegradable staples can be used. Staples shall be of sufficient thickness for soil penetration without undue distortion.

Permanent Matting

Sound wood stakes, 1 x 3 inches stock sawn in a triangular shape, shall be used. Depending on the compaction of the soil, select stakes with a length from 12 to 18 inches. U-shaped staples shall be 11 gauge steel or greater, with legs at a minimum of 8 inches length with a 2 inch crown.

Planting

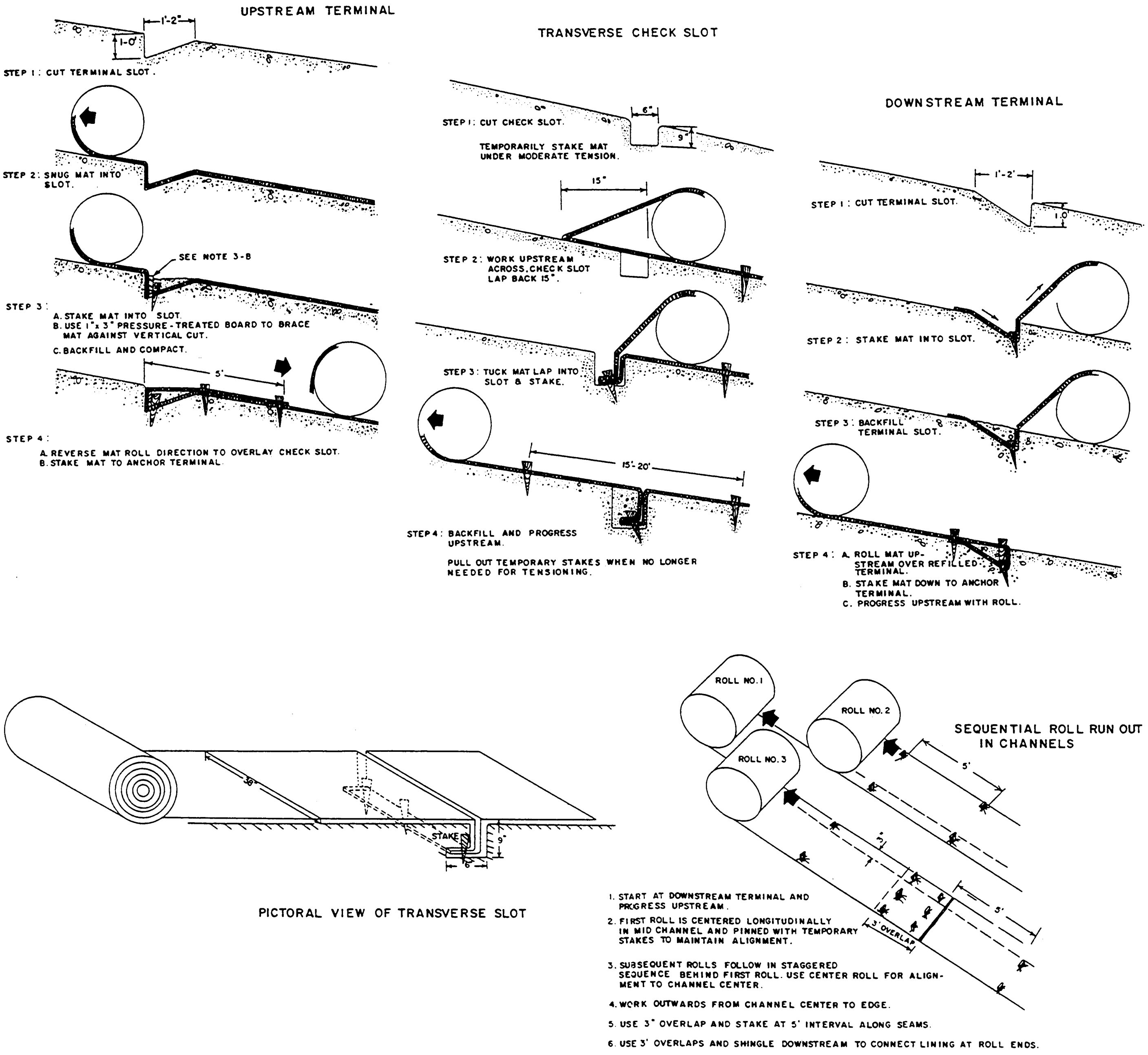
Lime, fertilizer, and seed shall be applied in accordance with seeding or other type of planting plan completed prior to installation of temporary combination blankets or jute mesh. For permanent mats, the area must be brought to final grade, plowed, limed, and fertilized. After the permanent mat has been installed and backfilled, the entire area shall be grassed. Refer to specification **Ds3 - Disturbed Area Stabilization (With Permanent Vegetation)**.

Installation

See Figure 6-7.1 for typical installation guidelines. Follow manufacturer's recommendations for laying and stapling.

Maintenance

All erosion control blankets and matting should be inspected periodically following installation, particularly after rainstorms to check for erosion and undermining. Any dislocation or failure should be repaired immediately. If washouts or breakage occurs, reinstall the material after repairing damage to the slope or ditch. Continue to monitor these areas until they become permanently stabilized.



1. START AT DOWNSTREAM TERMINAL AND PROGRESS UPSTREAM.
2. FIRST ROLL IS CENTERED LONGITUDINALLY IN MID CHANNEL AND PINNED WITH TEMPORARY STAKES TO MAINTAIN ALIGNMENT.
3. SUBSEQUENT ROLLS FOLLOW IN STAGGERED SEQUENCE BEHIND FIRST ROLL. USE CENTER ROLL FOR ALIGNMENT TO CHANNEL CENTER.
4. WORK OUTWARDS FROM CHANNEL CENTER TO EDGE.
5. USE 3" OVERLAP AND STAKE AT 5' INTERVAL ALONG SEAMS.
6. USE 3' OVERLAPS AND SHINGLE DOWNSTREAM TO CONNECT LINING AT ROLL ENDS.

Figure 6-7.1 - Typical installation guidelines for matting and blankets

Polyacrylamide (PAM) Pm

DEFINITION

The land application of product containing anionic polyacrylamide (PAM) as temporary soil binding agents to reduce soil erosion.

PURPOSE

To reduce erosion from wind and water on construction sites and agricultural lands. Other benefits may include improved water quality, infiltration, soil fertility, and visibility.

CONDITIONS

This temporary practice is intended for direct soil surface application to sites where the timely establishment of vegetation may not be feasible or where vegetative cover is absent or inadequate. Such areas may include agricultural lands, where plant residues are inadequate to protect the soil surface, and construction sites where land-disturbing activities prevent the establishment or maintenance of a vegetative cover.

This temporary practice is not intended for application to surface waters of the state. It is intended for application within construction storm water ditches and storm drainages which feed into preconstructed sediment ponds or basins.

Federal, State and Local Laws

Anionic PAM application shall comply with all federal, state, and local laws rules or regulations governing anionic PAM. The operator is responsible for securing required permits. **This standard does not contain the text of the federal, state, or local laws governing anionic PAM.**

PLANNING CONSIDERATIONS

Anionic PAM is available in emulsions, powders, and gel bars or logs. It is required that other Best Management Practices be used in combination with anionic PAM.

The use of seed and mulch for additional erosion protection beyond the life of the anionic PAM is recommended. Repeat application if disturbance occurs to target area.

Figure 6-8.1. Hydroseeded slope with and without polyacrylamide application.

The following are additional recommendations relating to design which may enhance the use of or avoid problems with the practice:

1. Use setbacks when applying anionic PAM near natural waterbodies.
2. Consider that decreased performance can occur due to ultra-violet light and time after mixing when applying anionic PAM.
3. In flow concentration channels, the effectiveness of anionic PAM for stabilization decreases.
4. Mulch to protect seed, if seed is applied with anionic PAM.
5. Never add water to PAM, add PAM slowly to water. If water is added to PAM, "globs" can form which can clog dispensers. This signifies incomplete dissolving of the PAM and therefore increases the risk of under-application.
6. NOT *ALL* POLYMERS ARE PAM.

CRITERIA

Application rates shall conform to manufacturer's guidelines for application.

1. Only the anionic form of PAM shall be used. Cationic PAM is toxic and shall NOT be used.
2. PAM and PAM mixtures shall be environmentally benign, harmless to fish, wildlife, and plants. PAM and PAM mixtures shall be non-combustible.
3. Anionic PAM, in pure form, shall have less than or equal to 0.05% acrylamide monomer by weight, as established by the Food and Drug Administration and the Environmental Protection Agency.
4. To maintain less than or equal to 0.05% of acrylamide monomer, **the maximum application rate of PAM, in pure form, shall not exceed 200 pounds/acre/year**. Do not over apply PAM.

Excessive application of PAM can lower infiltration rate or suspend solids in water, rather than promoting settling.

5. Users of anionic PAM shall obtain and follow all Material Safety Data Sheet requirements and manufacturer's recommendations.
6. Additives such as fertilizers, solubility promoters or inhibitors, etc. to PAM shall be non-toxic.
7. The manufacturer or supplier shall provide written application methods for PAM and PAM mixtures. The application method shall insure uniform coverage to the target and avoid drift to non-target areas including waters of the state. The manufacturer or supplier shall also provide written instructions to insure proper safety, storage, and mixing of the product.
8. Gel bars or logs of anionic PAM mixtures may be used in ditch systems. This application shall meet the same testing requirement as anionic PAM emulsions and powders.
9. To prevent exceeding the acrylamide monomer limit in the event of a spill, the anionic PAM in pure form shall not exceed 200 pounds/batch at 0.05% acrylamide monomer (AMD) or 400 pounds/batch at 0.025% AMD.

OPERATION AND MAINTENANCE

Maintenance will consist of reapplying anionic PAM to disturbed areas including high use traffic areas which interfere in the performance of this practice.

STREAMBANK STABILIZATION (USING PERMANENT VEGETATION)

Sb

DEFINITION

The use of readily available native plant materials to maintain and enhance streambanks, or to prevent, or restore and repair small streambank erosion problems.

PURPOSE

- Lessen the impact of rain directly on the soil.
- Trap sediment from adjacent land.
- Form a root mat to stabilize and reinforce the soil on the streambank.
- Provide wildlife habitat.
- Enhance the appearance of the stream.
- Lower summertime water temperatures for a healthy aquatic population.

NOTE: Careful thought, planning and execution is required to assure that the streambank stabilization project is done efficiently and correctly. Please refer to SSWCC's Guidelines for Streambank Restoration and Chapters 16 and 18 of the NRCS Engineering Field Handbook for more detailed information.

SELECTED MEASURES

Revegetation includes seeding and sodding of grasses, seeding in combination with erosion control fabrics, and the planting of woody vegetation (shrubs and trees). **Refer to Ds3 - Disturbed Area Stabilization (With Permanent Vegetation)**, **Ds4 - Disturbed Area Stabilization (With Sodding)**, and **Bf - Buffer Zone.**

Use jute mesh and other geotextiles to aid in soil stabilization and revegetation. Refer to **Mb - Matting and Blankets**.

Live Stake

Fresh, live woody plant cuttings are tamped into the ground as stakes, intended to root and grow into mature shrubs that will stabilize soils and restore the riparian zone habitats. Live stakes provide no immediate streambank stabilization. Willow species work best.

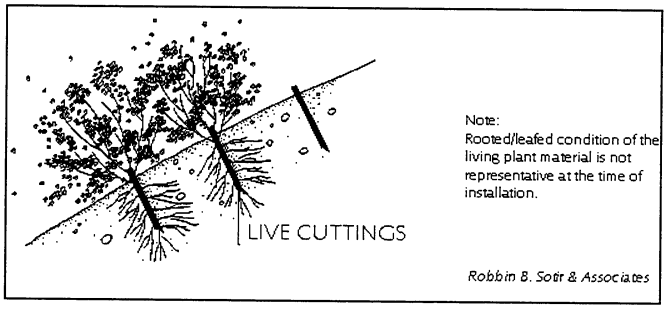


Figure 6-9.1- Illustration of a live stake.

Joint Planting

Install live willow stakes between rock previously placed along the streambank. Rock needs to be loosely dumped or hand placed and no thicker than 2 feet. Joint plantings enable a bank previously installed with conventional rip-rap to become naturalized.

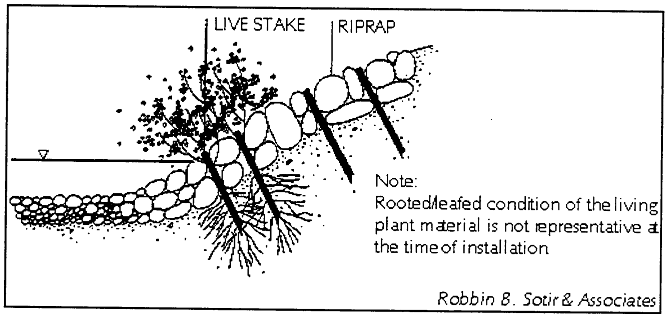


Figure 6-9.2- Illustration of joint planting.

Live Fascine

Live fascines are sausage-like bundles of live cut branches placed into trenches along the streambank. They provide immediate protection from erosion when properly used and installed. Willow species work best.

Live fascines create very little site disturbance as compared to other systems and works especially well when combined with surface covers such as jute mesh or coir fabrics.

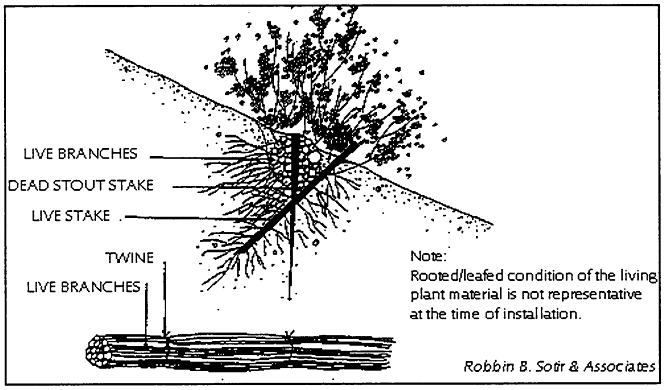


Figure 6-9.3 - Illustration of a live fascine.

Brushmattress

A combination of living units that forms an immediate protective surface cover over the streambank. Living units used include live stakes, live fascines, and a mattress branch cover (long, flexible branches placed against the bank surface).

Brushmattreses require a great deal of live material, and is complicated as well as expensive to evaluate, design, and install.

Brushmatresses capture sediment during flood conditions, produces habitat rapidly and quickly develops a healthy riparian zone.

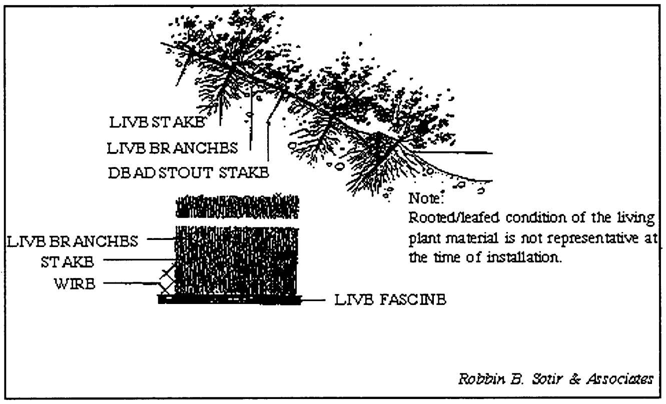


Figure 6-9.4 - Illustration of a brushmattress.

Live Cribwall

A rectangular framework of logs or timbers, rock, and woody cuttings. This requires a great deal of assessment and understanding of stream behavior.

Cribwalls can be complicated and expensive if a supply of wood and some volunteer help is not available.

Benefits include developing a natural streambank or upland slope appearance after it has begun to grow and provides excellent habitat for a variety of fish, birds, and animals. It is very useful where space is limited on small, narrow stream corridors.

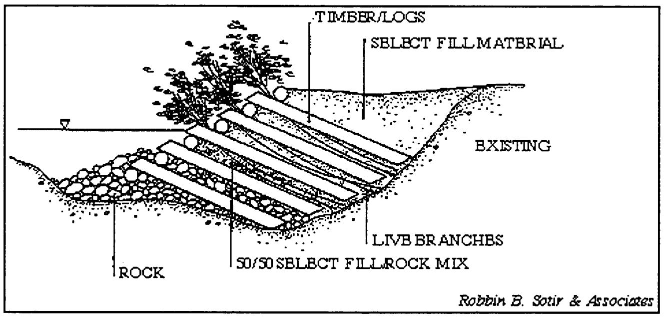


Figure 6-9.5 - Illustration of a live cribwall.

Branchpacking

Process of alternating layers of live branches and soil, incorporated into a hole, gully, or slumped-out area in a slope or streambank. There is a moderate to complex level of difficulty for construction.

Branchpacking produces an immediate filter barrier, reducing scouring conditions, repairing gully erosion, and providing habitat cover and bank reinforcement.

This is one of the most effective and inexpensive methods for repairing holes in earthen embankments along small stream sites.

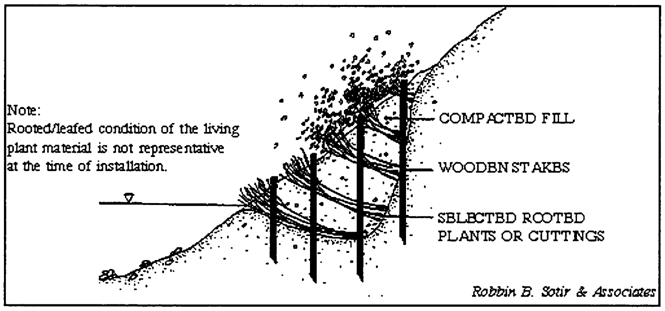


Figure 6-9.6 - Illustration of branchpacking.

Table 6-9.1

Streambank Erosion Protection Measures Relative Costs and Complexity

Measure	Relative Cost	Relative Complexity
Live Stake	Low	Simple
Joint planting	Low*	Simple*
Live Fascine	Moderate	Moderate
Bushmatress	Moderate	Moderate to Complex
Live cribwall	High	Complex
Branchpacking	Moderate	Moderate to Complex
Conventional vegetation	Low to Moderate	Simple to Moderate
Conventional bank armoring (riprap)	Moderate to High	Moderate to Complex

*Assumes rock is in place.

MAINTENANCE

Check banks after every high-water event, fixing gaps in the vegetative cover at once with structural materials or new plants, and mulching if necessary. Fresh cuttings from other plants may be used for repairs.

When fertilizer is applied on the surface, it is best to apply about one-half at planting, one-fourth when new growth is about two inches tall, and one-fourth about six weeks later.

REFERENCES

Guidelines for Streambank Restoration, Georgia Soil and Water Conservation Commission

LOCAL CONTACTS

USDA Natural Resources Conservation Service
Georgia Soil and Water Conservation Commission

Tackifiers and Binders **Tb**

DEFINITION

Substances used to anchor straw or hay mulch by causing the organic material to bind together.

PURPOSE

To prevent the movement of mulching material from the desired location. Increases performance of the mulching material, so that it can

- Increase infiltration.
- Reduce wind and water erosion.
- Conserve moisture, prevent surface compaction or crusting.
- Control undesirable vegetation.
- Modify soil temperature.
- Increase biological activity in the soil.

CONDITIONS

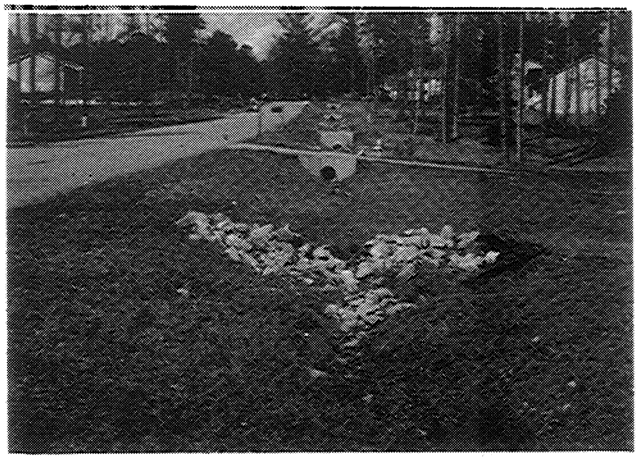
All organic mulching materials shall be anchored by tackifiers/binders or matting/netting. Tackifiers and binders are used to anchor wood cellulose, wood pulp fiber, and other mulch materials applied with hydroseeding equipment.

APPROVED TACKIFIERS AND BINDERS

Product or Trade Name	Recommended Application Rate
A500 HYDRO-STIK	40 lb./ac.
Agro Tack MP	PMR
CONWED CON-TAC	40 lb./ac.
EcoTak-OP/EcoTAk-SATII	PMR
Emulsified Asphalt	100 gal. of SS-1h or CSS-1h and 100 gal. of water per ton of mulch
Hercules Soilloc-E	PMR
HYDRO-BOND	35 lb./ac.
RMB-plus	80-120 lb./ac.
TACPAC GT	PMR
TERRA-MULCH	
TACKING AGENT III	PMR

SECTION III: STRUCTURAL PRACTICES

Check Dam (Cd)



DEFINITION

Small temporary barrier, grade control structure, or dam constructed across a swale, drainage ditch, or area of concentrated flow.

PURPOSE

To minimize the erosion rate by reducing the velocity of storm water in areas of concentrated flow.

CONDITIONS

This practice is applicable for use in small open channels and is **not to be used in a live stream**. Specific applications include:

1. Temporary or permanent swales or ditches in need of protection during establishment of grass linings.
2. Temporary or permanent swales or ditches which, due to their short length of service or other reasons, cannot receive a permanent non-erodible lining for an extended period of time.
3. Other locations where small localized erosion and resulting sedimentation problems exist.

DESIGN CRITERIA

Formal design is not required. The following standards shall be used:

Drainage Area

For stone check dams, the drainage area shall not exceed two acres. For haybales, the drainage area shall not exceed one acre.

Height

The center of the check dam must be at least 9 inches lower than outer edges. Dam height should be 2 feet maximum measured to center of check dam. (See Figure 6-10.2)

Side Slopes

Side slopes shall be 2:1 or flatter.

Spacing

Two or more check dams in series shall be used for drainage areas greater than one acre. Maximum spacing between dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam. (See Figure 6-10.1)

Geotextiles

A geotextile should be used as a separator between the graded stone and the soil base and abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. The geotextile shall be selected/specified in accordance with AASHTO M288-96 Section 7.3, *Separation Requirements*, Table 3. Geotextiles shall be "set" into the subgrade soils. The geotextile shall be placed immediately adjacent to the subgrade without any voids and extend five feet beyond the downstream toe of the dam to prevent scour.

CONSTRUCTION SPECIFICATIONS

The following types of check dams are used for this standard:

Stone Check Dams (Cd-S)

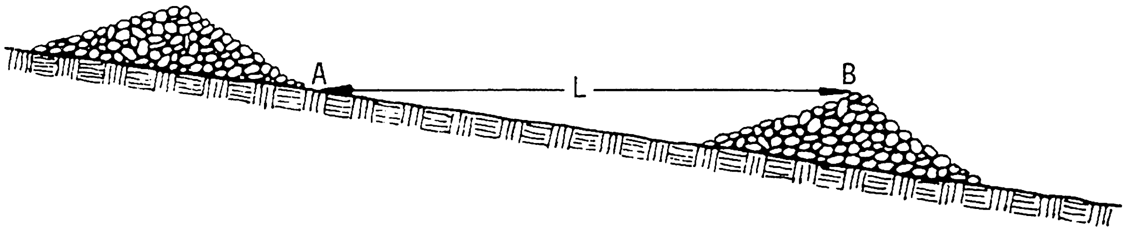
Stone check dams should be constructed of graded size 2-10 inch stone. (See Figure 6-10.2) Mechanical or hand placement shall be required to insure complete coverage of entire width of ditch or swale and that center of dam is lower than edges.

Haybale Check Dams (Cd-Hb)

Staked and embedded hay-bales may be used as temporary check dams in concentrated flow areas while vegetation is becoming established. They should not be used where the drainage area exceeds one acre. Haybales should be embedded a minimum of 4 inches. (See Figure 6-10.3)

MAINTENANCE

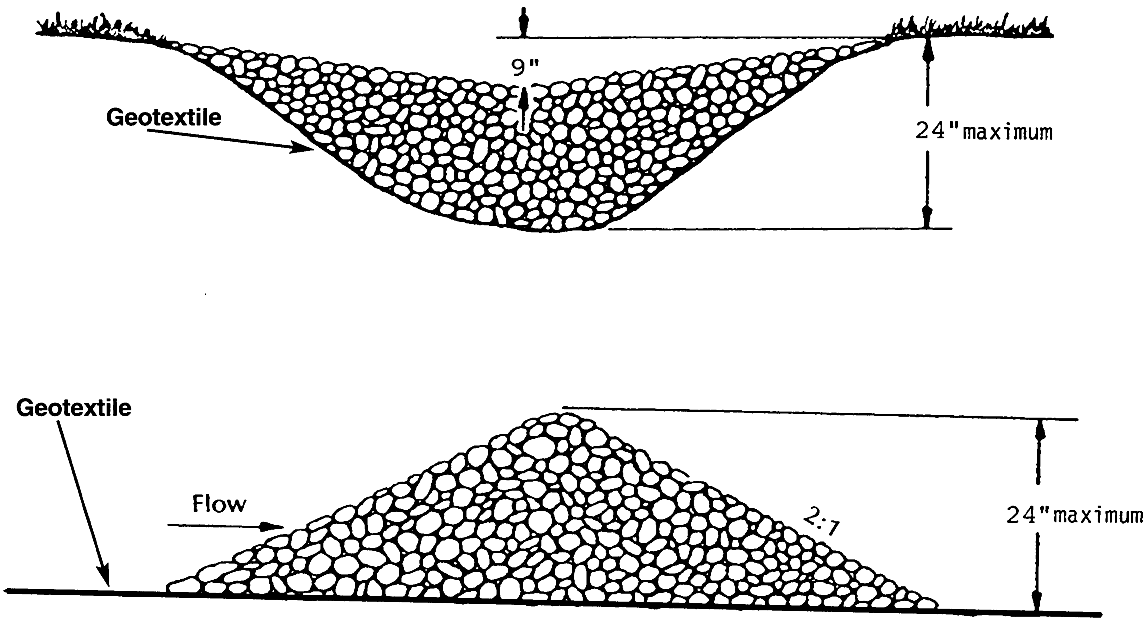
Periodic inspection and required maintenance must be provided. Sediment shall be removed when it reaches a depth of one-half the original dam height or before. If the area is to be mowed, check dams shall be removed once final stabilization has occurred. Otherwise, check dams may remain in place permanently. After removal, the area beneath the dam shall be seeded and mulched immediately.



L = The distance such that points
A and B are of equal elevation

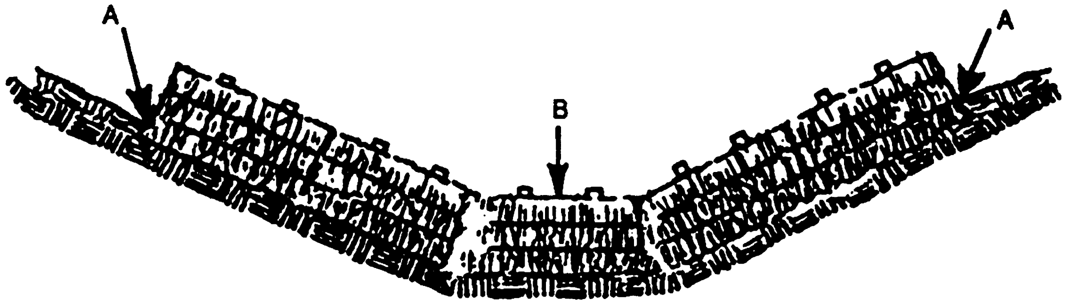
SPACING BETWEEN CHECK DAMS

Figure 6-10.1



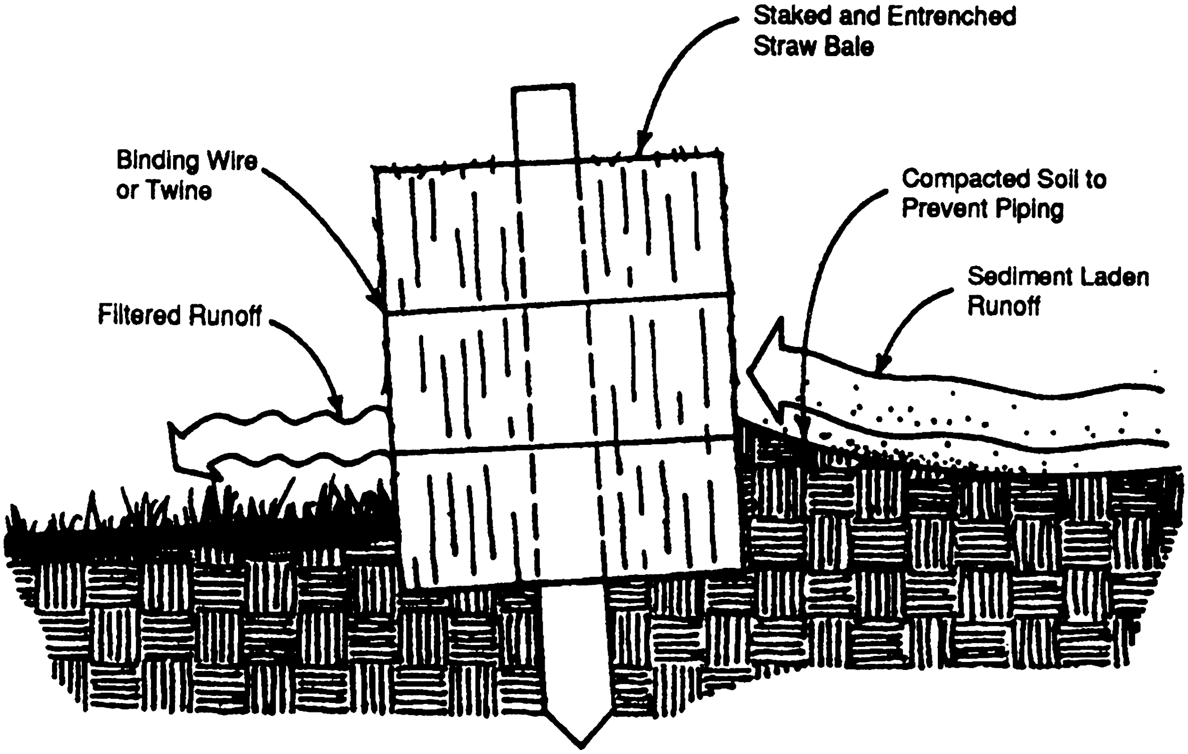
STONE CHECK DAM

Figure 6-10.2



Points A should be higher than point B

PROPER PLACEMENT OF STRAW BALE BARRIER IN DRAINAGE WAY

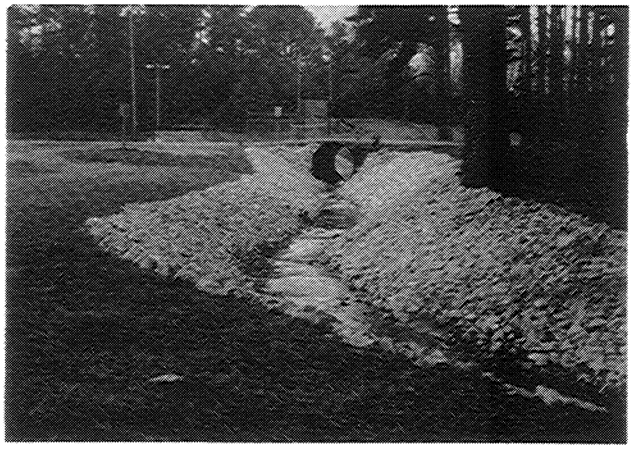


Note: Embed hay bales a minimum of 4 inches.

CROSS-SECTION OF A PROPERLY INSTALLED STRAW BALE

Figure 6-10.3

Channel Stabilization (Ch)



DEFINITION

Improving, constructing or stabilizing an open channel for water conveyance.

PURPOSE

Open channels are constructed or stabilized to be non-erosive, with no sediment deposition and to provide adequate capacity for flood water, drainage, other water management practices, or any combination thereof.

CONDITIONS

This standard applies to the improvement, construction or stabilization of open channels and existing ditches with drainage areas less than one square mile. **This standard applies only to channels conveying intermittent flow, not to channels conveying a continuous, live stream.**

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 attractive trees shall be preserved.

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 text-books.

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

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

Characteristics of a Stable Channel

1. Aggradation or degradation does not interfere with the function of the channel or affect adjacent areas.
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.
6. The determination of channel stability considers "bankfull" flow. Bankfull flow is defined as 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 should not be considered in determinations of bankfull flow.

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:

Vegetated Lining (Ch-V)

Vegetated lining shall be designed to resist erosion when the channel is flowing at the bankfull discharge or 25-year frequency discharge, whichever is the lesser. *Temporary erosion control blankets or sod shall be used on all channels and concentrated flow areas to aid in the establishment of the vegetated lining. If a vegetated lining is desired in a channel with velocities between 5-10 ft/sec, permanent soil reinforcement matting shall be used.* Refer to specifications **Ds3 - Disturbed Area Stabilization (With Permanent Vegetation)**, **Ds4 - Disturbed Area Stabilization (With Sodding)**, and **Mb - Matting and Blankets**.

Rock Riprap Lining (Ch-Rp)

Rock riprap shall be designed to resist displacement when the channel is flowing at the bankfull discharge or 25-year frequency discharge, whichever is the lesser. *Rock riprap lining should be used when channel velocities are between 5 and 10 ft/sec.*

Dumped and machine placed riprap should not be installed on slopes steeper than 1-1/2 horizontal to 1 vertical. Rock shall be dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended. Rock shall be installed according to standards specified in **Riprap, Appendix C**.

A filter blanket layer consisting of an appropriately designed graded filter sand and/or gravel or geotextile material shall be placed between the riprap and base material. The gradation of the filter blanket material shall be designed to create a graded filter between the base material and the riprap. A geotextile can be used as a substitution for a layer of sand in a graded filter or as the filter blanket. Criteria for selecting an appropriate geotextile and guidance for recommended drop heights and stone weights are found in AASHTO M288-96 Section 7.5, *Permanent Erosion Control Specifications.*

Concrete Lining (Ch-C)

If a channel has velocities high enough to require a concrete lining (when channel velocities exceed 10 ft/sec), methods should be utilized to reduce the velocity of the runoff and reduce erosion at the outlet - a common problem created by the smooth, concrete lining. Refer to specification **St - Storm Drain Outlet Protection** for information regarding energy dissipators.

If a concrete lining is chosen, it shall be designed according to currently accepted guides for structural and hydraulic adequacy. It must be designed to carry the required discharge and to withstand the loading imposed by site conditions.

A separation geotextile should be placed under concrete linings to prevent undermining in the event of stress cracks due to settlement of the base material. The separation geotextile will keep the base material soils in place and minimize the likelihood of a system failure.

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 shall be designed hydraulically to adequately carry the channel discharge and structurally to withstand loadings imposed by the site conditions. The structure shall meet requirements of **Gr - Grade Stabilization Structure**.

CONSTRUCTION SPECIFICATIONS

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.
3. Excavation shall be at the locations and grades shown on the drawings. The lining shall not compromise the capacity of the channel, *e.g.* the emergency spillway shall be over-excavated so that the lining will be flush with the slope surface.
4. The geotextile shall be placed on a smooth graded surface. The geotextile shall be placed in such a manner that it will not excessively stretch or tear upon placement of the overlying materials. Care should be taken to place the geotextile in intimate contact with

the soil such that no void spaces exist between the underlying soil and the geotextile.

5. 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.

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

7. Structures shall be installed according to lines and grades shown on the plan. The foundation for structures shall be cleared of all undesirable materials prior to the installation of the structures.

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

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

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. Refer to specification **Ds1 - Disturbed Area Stabilization (With Mulching Only)**. Seeding, fertilizing and mulching shall conform to the standard for permanent vegetative cover. Refer to specification **Ds3-Disturbed Area Stabilization (With Permanment Vegetation).**

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

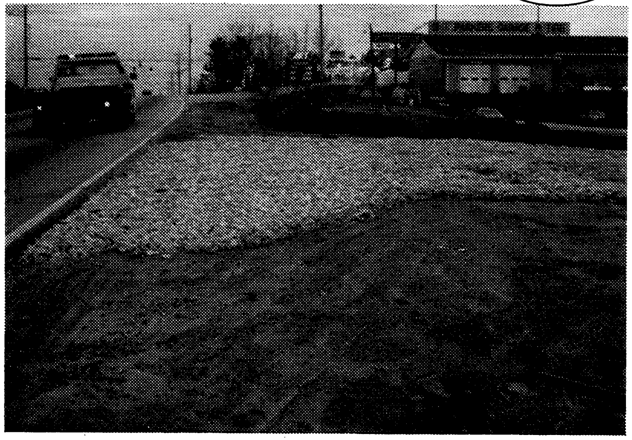
13. Trees and other fallen natural vegetation not causing a deterrent to stream flow should be left for the purpose of habitat.

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

1. **The velocity in the channel**, in ft/sec, for when the channel is flowing at the bankfull discharge or 25-year frequency discharge, whichever is the lesser.

2. **The type of lining to be used** to stabilize the channel, *i.e.* vegetation (**Ch-V**: indicate type of vegetation and matting or blanket to be used), riprap (**Ch-Rp**: indicate average stone size), or concrete (**Ch-C**).

Construction Exit (Co)



DEFINITION

A stone stabilized pad located at any point where traffic will be leaving a construction site to a public right-of-way, street, alley, sidewalk or parking area or any other area where there is a transition from bare soil to a paved area.

PURPOSE

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

CONDITIONS

This practice is applied at appropriate points of construction egress. Geotextile underliners are required to stabilize and support the pad aggregates.

DESIGN CRITERIA

Formal design is not required. The following standards shall be used:

Aggregate Size

Stone will be in accordance with National Stone Association R-2 (1.5 to 3.5 inch stone).

Pad Thickness

The gravel pad shall have a minimum thickness of 6 inches.

Pad Width

At a minimum, the width should equal full width of all points of vehicular egress, but not less than 20 feet wide.

Washing

If the action of the vehicle travelling over the gravel pad does not sufficiently remove the mud, the tires should be washed prior to entrance onto public rights-of-way. When washing is required, it shall be done on an area stabilized with crushed stone and provisions that intercept the sediment-laden runoff and direct it into an approved sediment trap or sediment basin.

Location

The exit shall be located or protected to prevent sediment from leaving the site.

CONSTRUCTION SPECIFICATIONS

It is recommended that the entrance area be excavated to a depth of 3 inches and be cleared of all vegetation and roots.

Diversion Ridge

On sites where the grade toward the paved area is greater than 2%, a diversion ridge 6 to 8 inches high with 3:1 side slopes shall be constructed across the foundation approximately 15 feet above the road.

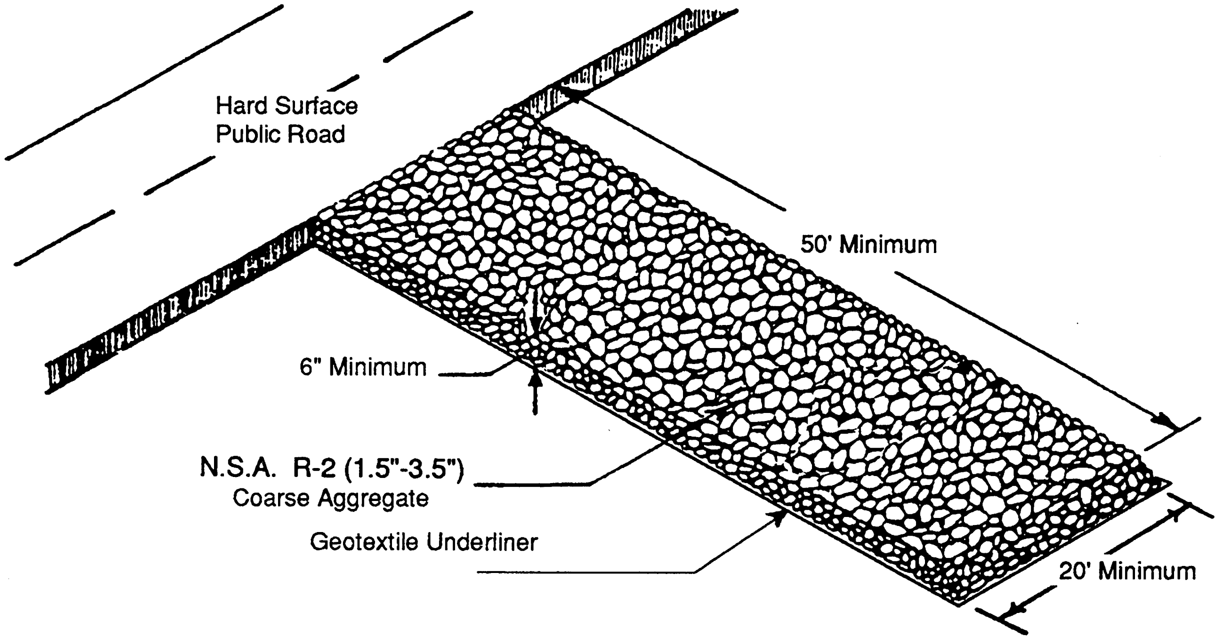
Geotextile

The geotextile underliner must be placed the full length and width of the entrance. Geotextile selection shall be based on AASHTO M288-98 specification:

1. For subgrades with a CBR greater than or equal to 3 or shear strength greater than 90 kPa, geotextile must meet requirements of section AASHTO M288-96 Section 7.3, *Separation Requirements*.
2. For subgrades with a CBR between 1 and 3 or sheer strength between 30 and 90 kPa, geotextile must meet requirements of section AASHTO M288-96 Section 7.4, *Stabilization Requirements*.

MAINTENANCE

The exit shall be maintained in a condition which will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with 1.5 -3.5 inch stone, as conditions demand, and repair and/or cleanout of any structures to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles or site onto roadways or into storm drains must be removed immediately.

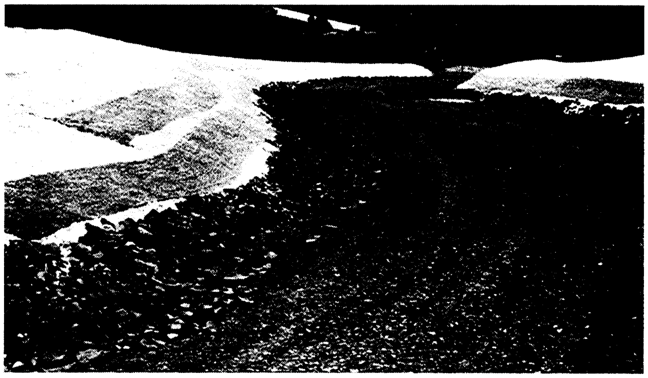


CRUSHED STONE CONSTRUCTION EXIT

Figure 6-11.1

Construction Road Stabilization

Cr



DEFINITION

A travelway constructed as part of a construction plan including access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes.

PURPOSE

To provide a fixed route for travel for construction traffic and reduce erosion and subsequent regrading of permanent roadbeds between time of initial grading and final stabilization.

CONDITIONS

This practice is applicable where travelways are needed in a planned land use area or wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

PLANNING CONSIDERATIONS

Areas graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil is continually disturbed, eliminating the possibility of stabilization with vegetation. The prolonged exposure of the roads and parking areas to surface runoff can create severe rilling and muddying of the areas, requiring regrading before paving. The soil removed during this process may enter streams and other waters of the state via stormwater management systems, compromising the water quality. Also, because the roads become so unstable during wet weather, they are virtually unusable, limiting access, and causing delays in construction.

DESIGN CRITERIA

TEMPORARY ROADS AND PARKING AREAS

The type of vehicle or equipment, speed, loads, climatic, and other conditions under which vehicles and equipment are expected to operate shall be considered.

Location

Temporary roads shall be located to serve the purpose intended, facilitate the control and disposal of water, control or reduce erosion, and make the best use of topographic features.

Temporary roads shall follow the contour of the natural terrain to minimize disturbance of drainage patterns. If a temporary road must cross a stream, the crossing must be designed, installed and maintained according to specification **Sr - Temporary Stream Crossing**.

Temporary parking areas should be located on naturally flat areas to minimize grading.

Grade and Alignment

The gradient and vertical and horizontal alignment shall be adapted to the intensity of use, mode of travel, and level of development.

Grades for temporary roads should not exceed ten percent except for very short lengths (200 feet or less), but maximum grades of 20 percent or more may be used if necessary for special uses. Frequent grade changes generally cause fewer erosion problems than long continuous gradients.

Curves and switchbacks must be of sufficient radius for trucks and other large vehicles to negotiate easily. On temporary roads, the radius should be no less than 35 feet for standard vehicles and 50 feet for tractor-trailers.

Grades for temporary parking areas should be sufficient to provide drainage but should not exceed four percent.

Width

Temporary roadbeds shall be at least 14 feet wide for one-way traffic and 20 feet wide for two-way traffic. The width for two-way traffic shall be increased approximately four feet for trailer traffic. A minimum shoulder width shall be two feet on each side. Where turnouts are used, road width shall be increased to a minimum of 20 feet for a distance of 30 feet.

Side Slopes

All cuts and fills shall have side slopes designed to be stable for the particular site conditions and soil materials involved. All cut and fills shall be 2:1 or flatter to the extent possible. When maintenance by machine mowing is planned, side slopes shall be no steeper than 3:1.

Drainage

The type of drainage structure used will depend on the type of enterprise and runoff conditions. The capacity and design shall be consistent with sound engineering principles and shall be adequate for the class of vehicle, type of road, development, or use. Structures should be designed to withstand flows from a 25-year, 24-hour frequency storm or the storm specified in Title 12-7-1 of the Official Code of Georgia Annotated. Channels shall be designed to be on stable grades or protected with structures or linings for stability.

Water breaks or bars may be used to control surface runoff on low-intensity use roads.

Stabilization

Geotextile should be applied to the roadbed for additional stability. Geotextile selection shall be based on AASHTO M288-98 specification:

1. For subgrades with a CBR greater than or equal to 3 or shear strength greater than 90 kPa, geotextile must meet requirements of section AASHTO M288-96 Section 7.3, *Separation Requirements*.
2. For subgrades with a CBR between 1 and 3 or sheer strength between 30 and 90 kPa, geotextile must meet requirements of section AASHTO M288-96 Section 7.4, *Stabilization Requirements*.

A 6-inch course of coarse aggregate shall be applied immediately after grading or the completion of utility installation within the right-of-way. In areas experiencing "heavy duty" traffic situations, stone should be placed at an 8 to 10 inch depth to avoid excessive dissipation or maintenance needs.

All roadside ditches, cuts, fills, and disturbed areas adjacent to parking areas and roads shall be stabilized with appropriate temporary or permanent vegetation according to specification in **Ds2 and Ds3 - Disturbed Area Stabilization (With Temporary Seeding) and Disturbed Area Stabilization (With Permanent Vegetation)**.

PERMANENT ROADS AND PARKING AREAS

Permanent roads and parking areas shall be designed and constructed according criteria established by the Georgia Department of Transportation or local authority. Permanent roads and parking areas shall be stabilized in accordance with this specification, applying an initial base course of gravel immediately following grading.

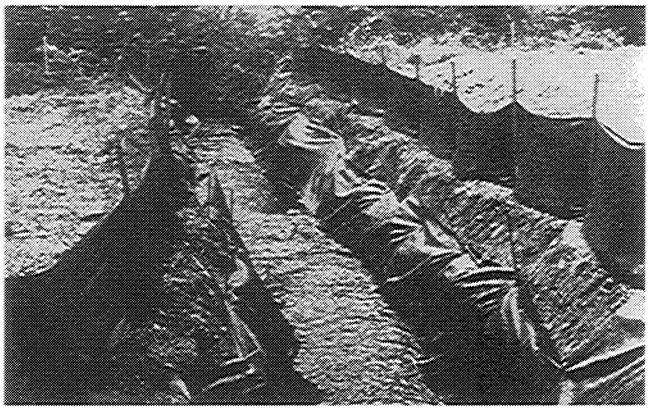
CONSTRUCTION SPECIFICATIONS

1. Trees, stumps, roots, brush, weeds, and other objectionable materials shall be removed from the work area.
2. Unsuitable material shall be removed from the roadbed and parking areas
3. Grading, subgrade preparation, and compaction shall be done as needed. Fill material shall be deposited in layers not to exceed 9 inches and compacted with the controlled movement of compacting and earth moving equipment.
4. The roadbed and parking area shall be graded to the required elevation. Subgrade preparation and placement of the surface course shall be in accordance with sound highway construction practice.
5. Structures such as culverts, pipe drops, or bridges shall be installed to the lines and grades shown on the plans or as staked in the field. Pipe conduits shall be placed on a firm foundation. Selected backfill material shall be placed around the conduit in layers not to exceed 6 inches. Each layer shall be properly compacted.
6. Roads shall be planned and laid out according to good landscape management principles.

MAINTENANCE

Roads and parking areas may require a periodic top dressing of gravel to maintain the gravel depth at 6 inches. Vegetated areas should be checked periodically to ensure a good stand of vegetation is maintained. Remove any silt or other debris causing clogging of roadside ditches or other drainage structure.

Stream Diversion Channel (Dc)



DEFINITION

A temporary channel constructed to convey flow around a construction site while a permanent structure is being constructed in the stream channel.

PURPOSE

To protect the streambed from erosion and allow work “in the dry”.

CONDITIONS

Temporary stream diversion channels shall be used only on flowing streams with a drainage area less than one square mile. Structures or methodology for crossing streams with larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

PLANNING CONSIDERATIONS

Linear projects, such as utilities or roads, frequently cross and impact live streams creating a potential for excessive sediment loss into a stream by both the disturbance of the approach areas and by the work within the streambed and banks.

In cases where in-stream work is unavoidable, the amount of encroachment and time spent working in the channel shall be minimized. If construction in the streambed will take an extended period of time, substantial in-stream controls or stream diversion channel should be considered to prevent excessive sedimentation damage. To limit land-disturbance, overland pumping of the stream should be considered in low-flow conditions. Clearing of the stream bed and banks shall be kept to a minimum.

DESIGN CRITERIA

Drainage Area

Temporary stream diversion channels shall not be used on streams with a drainage area greater than one square mile (640 acres).

Size

The bottom width of the stream diversion shall be a minimum of six feet or equal to the bottom width of the existing streambed, whichever is greater.

Side Slopes

Side slopes of the stream diversion channel shall be no steeper than 2:1.

STREAM DIVERSION CHANNEL LININGS

Lining Materials	Symbol	Acceptable Velocity Range
Geotextile, polyethylene film, or sod	Dc-A	0 - 2.5 fps
Geotextile alone	Dc-B	2.5 - 9.0 fps
Class I riprap and geotextile	Dc-C	9.0 - 13.0 fps

Table 6-12.1

Depth and Grade

Depth and grade may be variable, dependent on site conditions, but shall be sufficient to ensure continuous flow of water in the diversion.

Channel Lining

A stream diversion channel shall be lined to prevent erosion of the channel and sedimentation in the stream. The lining is selected based upon the expected velocity of bankfull flow. Table 6-12.1 shows the selection of channel linings that may be used. Refer to specification **Mb - Matting and Blankets**.

Geotextile

Geotextiles should be used as a protective cover for soil or, if the channel is to be lined with rip-rap, as a separator between graded stone and the soil base. The geotextile will prevent erosion of the channel and the migration of soil particles from the subgrade into the graded stone. The geotextile shall be specified in accordance with AASHTO M288-96 Section 7.5, *Permanent Erosion Control Recommendations*. The geotextile should be placed immediately adjacent to the subgrade without any voids.

CONSTRUCTION SPECIFICATIONS

1. The channel shall be excavated, constructing plugs at both ends. Plugs can be constructed of compacted soil, riprap, sandbags or sheet piling.
2. Silt fence or a berm shall be placed along the sides of the channel to prevent unfiltered runoff from entering the stream. The berm can be constructed using the material excavated for the stream diversion.
3. The channel surface shall be smooth (to prevent tearing of the liner) and lined with the material specified in the plans. The outer edges of the geotextile shall be secured at the top of the channel with compacted soil.
4. The plugs are removed when the liner installation is complete, removing the downstream plug first.
5. As soon as construction in the streambed is complete, the diversion shall be replugged and backfilled. The liner should be inspected for damage and salvaged if possible.
4. Upon removal of the lining, the stream shall immediately be restored and properly stabilized.

MAINTENANCE

The stream diversion channel shall be inspected at the end of each day to make sure that the construction materials are positioned securely. This will ensure that the work area stays dry and that no construction materials float downstream. All repairs shall be made immediately.

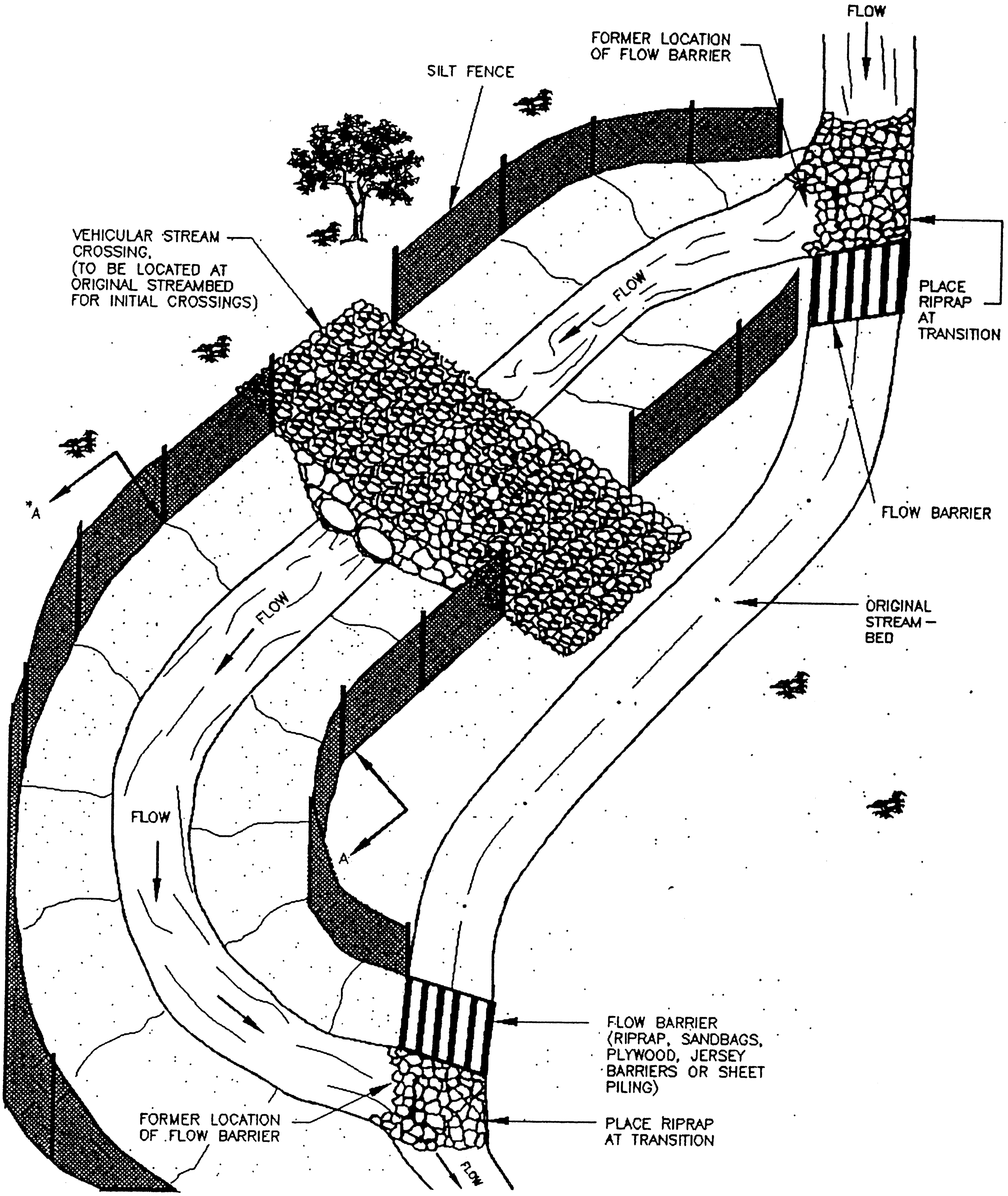
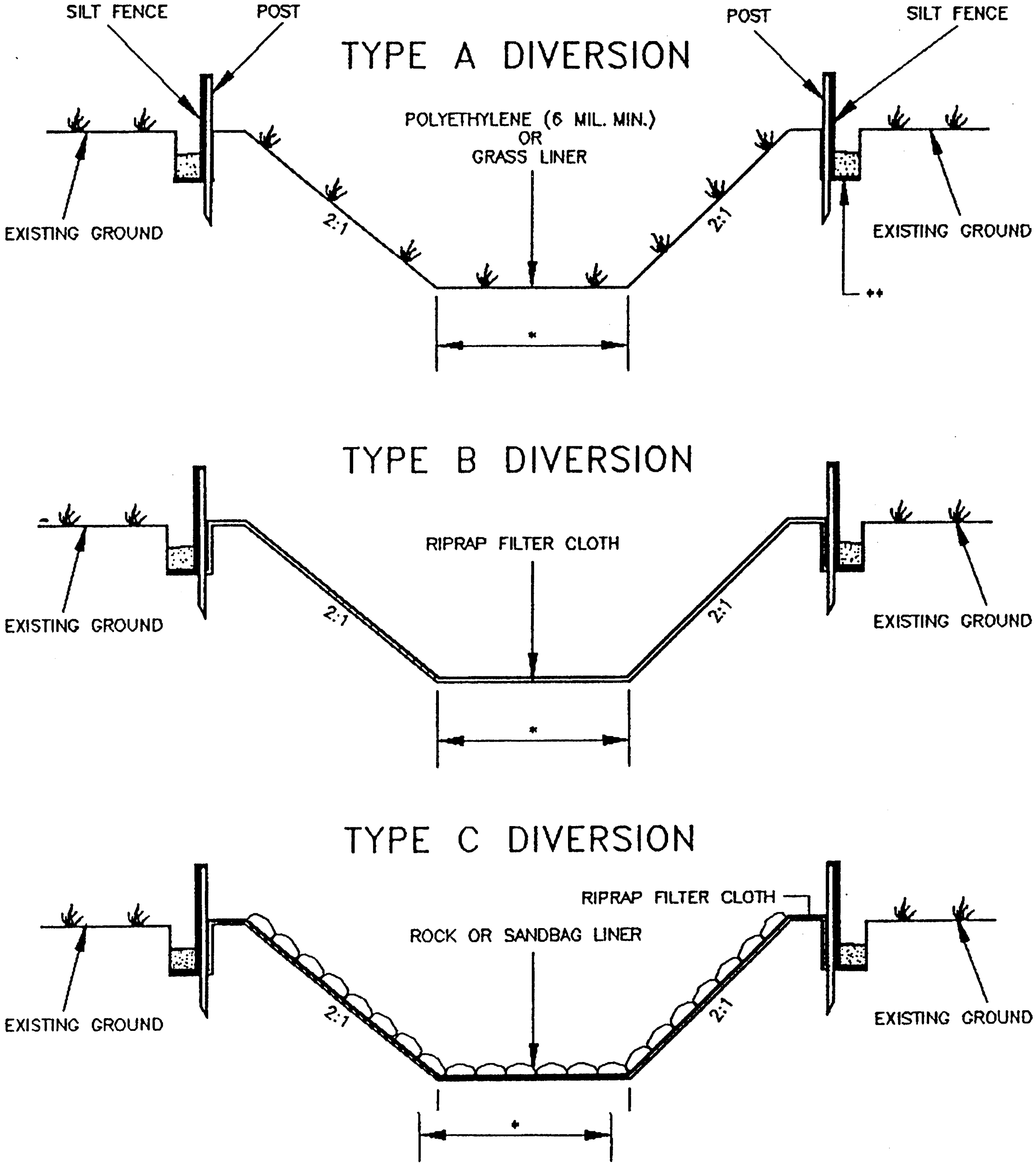


Figure 6-12.1 Stream diversion channel (perspective view).



* 6' MINIMUM OR WIDTH OF EXISTING STREAM WHICHEVER IS LESS

** ENTRENCH SILT FENCE AND FILTER CLOTH IN SAME TRENCH

Figure 6-12.2 Stream diversion channel linings.

Diversion

Di

DEFINITION

A ridge of compacted soil, constructed above, across or below a slope.

PURPOSE

To reduce the erosion of steep, or otherwise highly erodible areas by reducing slope lengths, intercepting storm runoff and diverting it to a stable outlet at a non-erosive velocity.

CONDITIONS

Diversions are applicable when:

1. Runoff from higher areas is or has potential for damaging property, causing erosion, contributing to pollution, flooding, interfering with or preventing the establishment of vegetation on lower areas.
2. Surface and/or shallow subsurface flow is damaging sloping upland.
3. The length of slope needs to be reduced so that soil loss will be reduced to a minimum.

This standard applies to temporary and permanent diversions in developments involving land-disturbing activities.

DESIGN CRITERIA

Location

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seep planes (when seepage is a problem), and the development layout. Diversions should be tailored to fit the conditions for a particular field and local soil type(s).

A diversion consists of two components that must be designed - the ridge and the channel.

Ridge Design

The ridge shall be compacted and designed to have stable side slopes, which shall not be steeper than 2:1. The ridge shall be a minimum width of four feet at the design water elevation after settlement. Its design shall allow ten percent for settlement.

Channel Design

Land slope must be taken into consideration when choosing channel dimensions. On the steeper slopes, narrow and deep channels may be required. On the more gentle slopes, broad, shallow channels usually are applicable. The wide, shallow section will be easier to maintain. Since sediment deposition is often a problem in diversions, the designed flow velocity should be kept as high as the channel lining will permit.

Table 6-13.1 indicates the storm frequency required for the design of the diversion. The required storm frequency is based on the purpose of the diversion. The storm frequency is used to determine the required channel capacity, Q (peak rate of runoff).

The channel portion of the diversion may have a parabolic or trapezoidal cross-section. Detailed information for the design of these channels is provided in the specification **Wt - Stormwater Conveyance Channel**.

Outlets

Each diversion must have an adequate outlet. The outlet may be a constructed or natural waterway, a stabilized vegetated area or a stabilized open channel. In all cases, the outlet must discharge in such a manner as to not cause an erosion problem. Protected outlets shall be constructed and stabilized prior to construction of the diversion.

Stabilization

Channels shall be stabilized in accordance with item 5 of the construction specifications on page 6-94.

DIVERSIONS FOR ROADS AND UTILITY RIGHTS-OF-WAY

A detailed design is not required for this type of diversion. Diversions installed to divert water off a road or right-of-way shall consist of a series of compacted ridges of soil running diagonally across the road at a 30° angle. Ridges are constructed by excavating a channel up-stream for this type of diversion.

The compacted ridge height shall be 8-12" above the original road surface; the channel depth shall be 8-12" below the original road surface. Channel bottoms and ridge tops shall be smooth enough to be crossed by vehicular traffic. The maximum spacing between diversions shall be as follows:

Road Grade (Percent)	**Distance Between Diversions** (Feet)
1	400
2	250
5	125
10	80
15	60
20	50

Stable outlets shall be provided for each diversion.

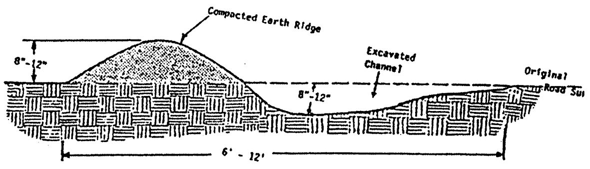


Figure 6-13.1 Typical diversion across road.

CONSTRUCTION SPECIFICATIONS

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 criteria specified herein and free of irregularities which will impede normal flow.
3. All fills shall be machine 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. Diversion channel shall be stabilized in accordance with specification **Ch - Channel Stabilization**.

Table 6-13.1 Diversion Design Criteria

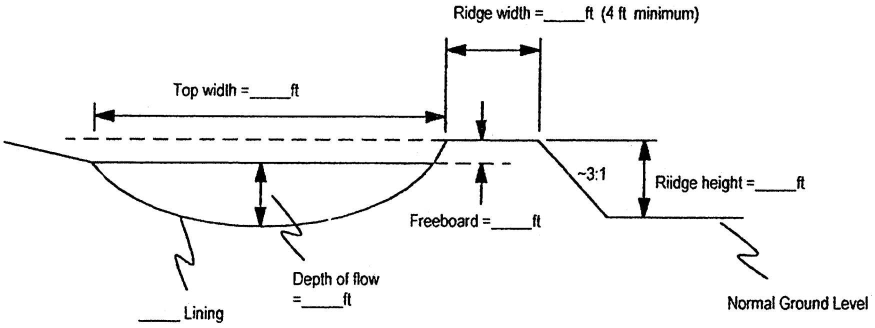
Diversion Type	Land or Improvement Protected	Storm[1] Frequency	Freeboard	Minimum Top Width
Temporary	Construction areas Building sites	10 years[2]	0.3'	4 feet
Permanent	Landscaped, recreation and similar areas.	25 years	0.3'	4 feet
	Dwellings, schools, commercial bldgs., and similar installations.	50 years	0.5'	4 feet

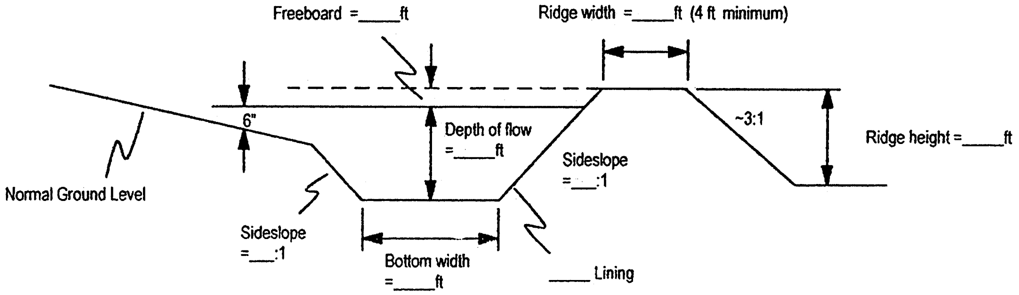
[1] Use 24-hour storm duration

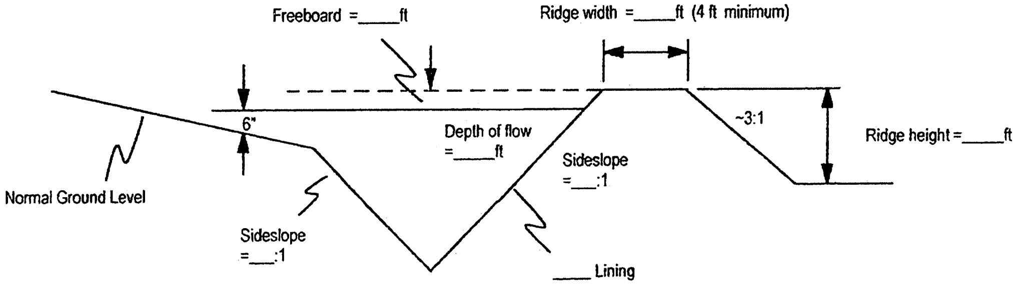
[2] Use 10 years or the storm frequency specified in Title 12 of the Official Code of Georgia Annotated

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

Complete the appropriate detail drawing for the channel cross-section of choice:







Temporary Downdrain Structure

Dn1

DEFINITION

A temporary structure used to convey concentrated storm water down the face of cut or fill slopes.

PURPOSE

To safely conduct storm runoff from one elevation to another without causing slope erosion and allowing the establishment of vegetation on the slope.

CONDITIONS

Temporary downdrains are used on slopes where a concentration of storm water could cause erosion damages. **These structures are removed once the permanent stormwater disposal system is installed.**

DESIGN CRITERIA

Formal design is not required. The following standards shall be used:

Placement

The temporary downdrain shall be located on undisturbed soil or well-compacted fill.

Diameter

The diameter of the temporary downdrain shall provide sufficient capacity required to convey the maximum runoff expected during the life of the drain. Refer to Table 6-14.1 for selecting pipe sizes.

Pipe Diameter for Temporary Downdrain Structure

Maximum Drainage Area Per Pipe (acre)	**Pipe Diameter** (inches)
0.3	10
0.5	12
1.0	18

Table 6-14.1

Downdrain Inlet and Outlet

Diversions are used to route runoff to the downdrain's Tee or "L" inlet at the top of the slope. Slope the entrance 1/2" per foot toward the outlet. Thoroughly compact selected soil around the inlet section to prevent the pipe from being washed out by seepage or piping. A stone filter ring or check dam may be placed at the inlet for added sediment filtering capacity. Refer to **Cd - Check Dam** and **Fr - Stone Filter Ring**. These sediment filtering devices should be removed if flooding or bank overwash occurs.

Rock riprap shall be placed at the outlet for energy dissipation. A Tee outlet, flared end section, or other suitable device may be used in conjunction with the riprap for additional protection. See Figure 6-14.1. Refer to **St - Storm Drain Outlet Protection**.

Pipe Material

Design the slope drain using heavy-duty, flexible materials such as non-perforated, corrugated plastic pipe or specially designed flexible tubing. Use reinforced, hold-down grommets or stakes to anchor the pipe at intervals not to exceed 10 feet with the outlet end securely fastened in place. The pipe must extend beyond the toe of the slope.

CONSTRUCTION SPECIFICATIONS

A common failure of slope drains is caused by water saturating the soil and seeping along the pipe. This creates voids from consolidation and piping causes washouts. Proper back-filling around and under the pipe "haunches" with stable soil material and hand compacting in 6-inch lifts to achieve firm contact between the pipe and the soil at all points will eliminate this type of failure.

1. Place slope drains on undisturbed soil or well-compacted fill at locations and elevations shown on the plan.
2. Slightly slope the section of pipe under the dike toward its outlet.

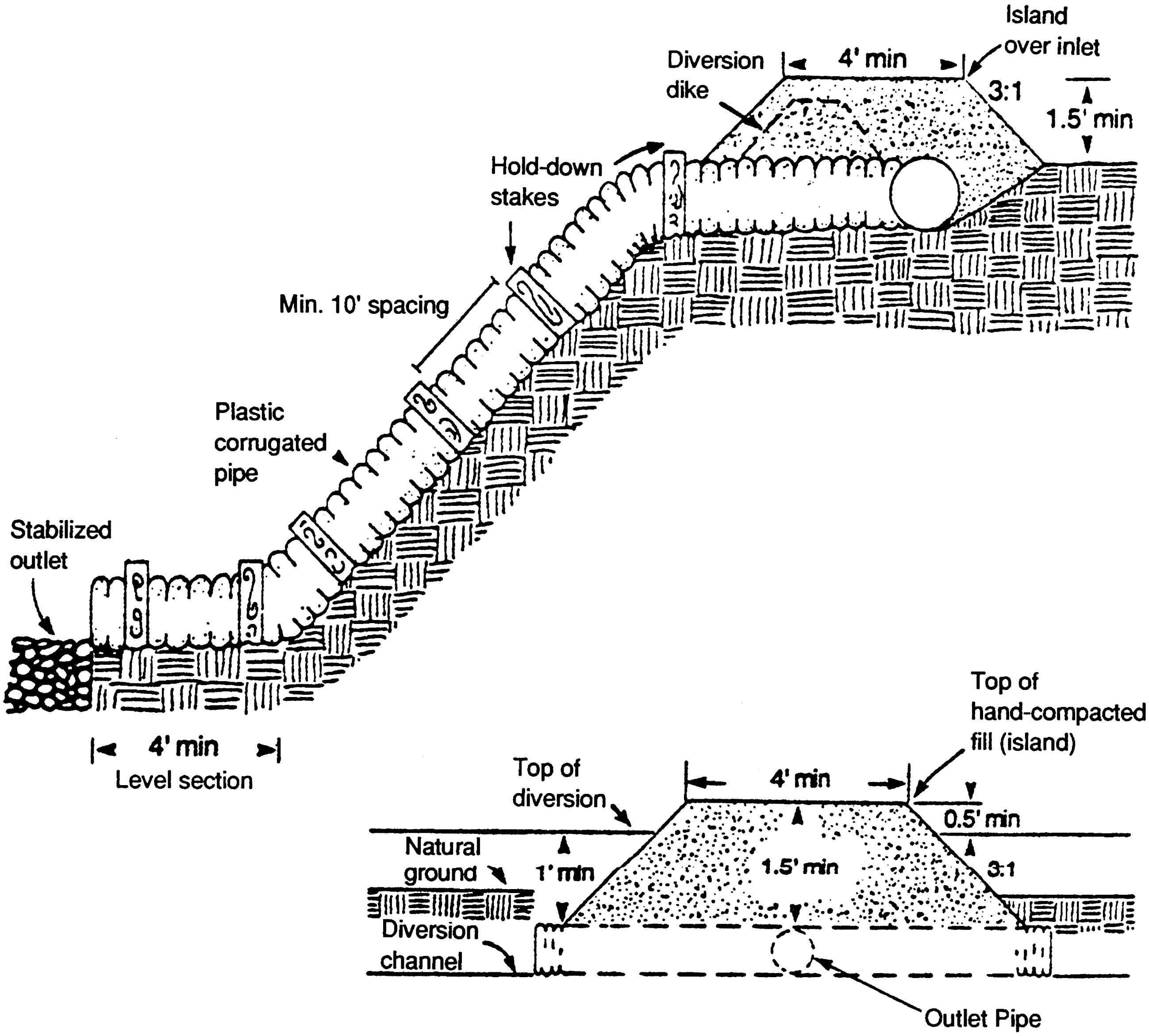
3. Hand tamp the soil under and around the entrance section in lifts not to exceed 6 inches.
4. Ensure that fill over the drain at the top of the slope has minimum dimensions of 1.5 ft. depth, 4 ft. top width, and 3:1 side slopes.
5. Ensure that all slope drain connections are watertight.
6. Ensure that all fill material is well-compacted. Securely fasten the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart.
7. Place the drain slightly diagonally across the slope, extending the drain beyond the toe of the slope. Curve the outlet uphill and adequately protect the outlet from erosion.
8. If the drain is conveying sediment-laden runoff, direct all flows into a sediment trap or sediment basin.
9. Make the settled, compacted dike ridge no less than one foot above the top of the pipe at every point.
10. Immediately stabilize all disturbed areas following construction.

MAINTENANCE

Inspect the slope drain and supporting diversion after every rainfall and promptly make necessary repairs. When the protected area has been permanently stabilized and the permanent stormwater disposal system is fully functional, temporary measures may be removed, materials disposed of properly, and all disturbed areas stabilized appropriately. Refer to specifications **Ds3 and Ds4 - Disturbed Area Stabilization (With Permanent Vegetation and Sodding),** respectively, and **Mb - Matting and Blankets**.

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

1. **The drainage area for each downdrain,** in acres.
2. **The diameter of each downdrain,** in inches, based on Table 6-14.1.
3. **The dimensions of the outlet protection**, including flow rate, velocity, and apron length, upstream and downstream widths, average stone diameter and depth.



Inlet Detail

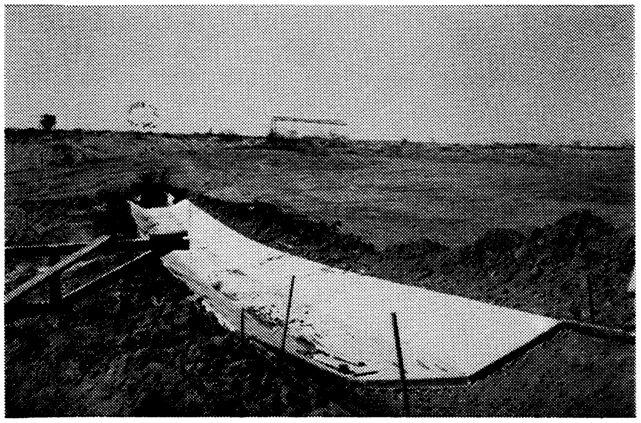
Make all pipe connections watertight and secure so that the joints will not separate in use.

DOWNDRAIN PIPE AND INLET DETAIL

Figure 6-14.1

Permanent Downdrain Structure

Dn2



DEFINITION

A permanent structure to safely convey surface runoff from the top of a slope to the bottom of the slope.

PURPOSE

The purpose of this standard is to convey storm runoff safely down cut or fill slopes to minimize erosion.

CONDITIONS

Several types of structures may be used as a permanent downdrain. All structures shall satisfy the standards and specification set forth by the Georgia Department of Transportation. The following types of structures may be used:

Paved Flume

The paved flume may have a parabolic, rectangular or trapezoidal cross-section.

Pipe

The pipe may be constructed of materials including steel, plastic, etc..

Sectional

A prefabricated sectional conduit of half round or third round pipe may be used.

Downdrain structures are to be used where concentrated water will cause excessive erosion on cut and fill slopes.

DESIGN CRITERIA

Permanent downdrain structures should be designed by professionals familiar with these structures.

Capacity

Flumes shall be adequately designed to safely convey runoff water concentrations down steep slopes based on a minimum 25-year, 24-hour storm in accordance with criteria in Appendix A of this manual.

Slope

The slope shall be sufficient to prevent the deposition of sediment.

Outlet Stabilization

Outlets must be stabilized using criteria in **St - Storm Drain Outlet Protection**.

MAINTENANCE

Inspect for damage after each rainfall.

Filter Ring

Fr

DEFINITION

A temporary stone barrier constructed at storm drain inlets and pond outlets.

PURPOSE

This structure reduces flow velocities, preventing the failure of other sediment control devices. It also prevents sediment from leaving the site or entering drainage systems, prior to permanent stabilization of the disturbed area.

CONDITIONS

Filter rings shall be used in conjunction with other sediment control measures, except where other practices defined in this manual are not appropriate (such as inlets to concrete flumes). They can be installed at or around devices such as inlet sediment traps, temporary downdrain inlets, and detention pond retrofits to provide additional sediment filtering capacity.

DESIGN CRITERIA

Formal design is not required. The following standards shall be used:

Location

The filter ring shall surround all sides of the structure receiving runoff from disturbed areas. It should be placed a minimum of four feet from the structure. The ring is not intended to substantially impound water, causing flooding or damage to adjacent areas.

The filter ring may also be placed below storm drains discharging into detention ponds, creating a centralized area, or "forebay", for sediment accumulation. This provides for easier, more localized cleanout of the pond. If utilized above a retrofit structure, it should be a minimum of 8 to 10 feet from the retrofit.

Stone Size

When utilized at inlets with diameters less than 12 inches, the filter ring shall be constructed of stone no smaller than 3-5 inches (15 - 30 lbs.).

When utilized at pipes with diameters greater than 12 inches, the filter ring shall be constructed of stone no smaller than 10-15 inches (50 - 100 lbs.).

The larger stone can be faced with smaller filter stone on the upstream side for added sediment filtering capabilities. However, the smaller filter stone is more prone to clogging, requiring higher maintenance.

Height

The filter ring shall be constructed at a height no less than two feet from grade.

CONSTRUCTION SPECIFICATIONS

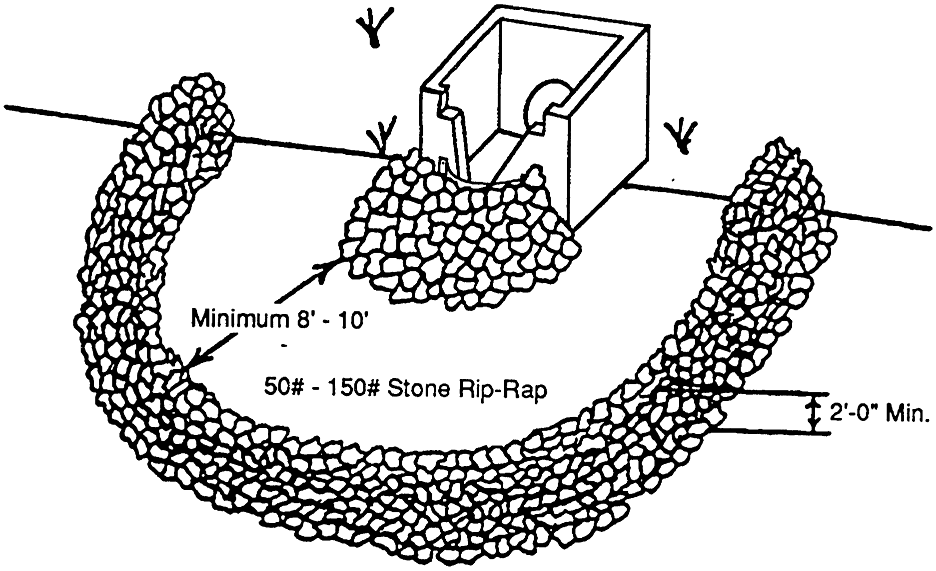
Mechanical or hand placement of stone shall be required to uniformly surround the structure to be supplemented. Refer to Appendix C for rock riprap specifications.

The filter ring may be constructed on natural ground surface, on an excavated surface, or on machine compacted fill.

A common failure of filter rings is caused by their placement too close or too high above the structure it is enhancing. When utilized below a storm drain outlet, it shall be placed such that it does not create a condition causing water to back-up into the storm drain and inhibit the function of the storm drain system.

MAINTENANCE

The filter ring must be kept clear of trash and debris. This will require continuous monitoring and maintenance, which includes sediment removal when one-half full. Structures are temporary and should be removed when the land-disturbing project has been stabilized.



STONE FILTER RING

Figure 6-15.1

Gabion

Ga

DEFINITION

Gabions are large, multi-celled, welded wire or rectangular wire mesh boxes, used in channel revetments, retaining walls, abutments, check dams, etc.

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.

DESIGN CRITERIA

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

CONSTRUCTION SPECIFICATIONS

How the Gabion is Filled

The gabion is usually filled with 4 - 8 inch pieces of stone, preferably placed by hand, but sometimes dumped mechanically, into the basket. Hand-packing allows the complete filling of the basket; allowing the basket to gain strength and maintain its integrity. 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. Details are provided by the manufacturer.

Geotextiles

It is recommended that geotextiles be used behind all gabion structures. Geotextiles shall be specified in accordance with AASHTO M288-96 Section 7.5, *Permanent Erosion Control Requirements*.

If there is seepage flow or unidirectional flow from the protected soil mass, the appropriate geotextile should be selected based on an appropriate filter design to prevent the build-up of hydrostatic pressure behind the geotextile.

Corrosion Resistance of Gabions

The wire mesh or welded wire used in gabions is heavily galvanized. For highly corrosive conditions, a PVC (polyvinyl chloride) coating must be used over the galvanizing. Such treatment is an economical solution to deterioration of the wire near the ocean, in some industrial areas, in polluted streams, and in soils such as muck and peat. However, extra care should be taken during construction and installation because the corrosion resistance of the baskets is compromised if the PVC coating is chipped-off. Also, baskets manufactured completely of plastic are available.

Flexibility

An outstanding advantage of the gabion is its flexibility of application. This property is especially important when a structure is on unstable ground or in areas where scour from waves or currents can undermine it.

Durability

Gabions are durable because they support plant growth which develops a living coating for the wire mesh and stones. After the first few years, the strength of the structure may be enhanced by the soil, silt, and roots that fill the voids between the individual stones.

Strength

Steel wire baskets have the strength and flexibility to withstand forces generated by water and earth masses. Also, the pervious nature of the gabion allows it to absorb and dissipate much of the energy developed. This is particularly so on coast protection installations where a compact gabion structure often remains long after a massive rigid structure fails.

Permeability

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 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.

Economy

Gabion installations are more economical than rigid or semi-rigid structures for a number of reasons. The following are among the more important ones.

- Little maintenance is required.
- Gabion construction is simple and does not require skilled labor.
- Preliminary foundation preparation is unnecessary; the surface needs only to be reasonably level and smooth.
- No costly drainage provision is required because of the gabion's porosity.

Landscaping

Because gabions permit the growth of natural vegetation and maintain the natural environment of the area, they provide attractive and natural building blocks for decorative landscaping.

They can be used effectively and economically in parks, along highways, including use as a sound barrier, and around bridge approaches to create walkways, rock gardens, patios, and terraces ... to beautify the banks of lakes and ponds ... to accent trees and other plantings.

In fact, their application to decorative landscaping is limited only by the ingenuity of the landscaper.

Typical Installations

- River training and flood control:
    - Gabion aprons
    - Longitudinal works
    - Training walls
    - Revetments
    - Bank paving
    - Counterforts
    - Drop structures or weirs
    - Spurs, spur dikes, or groins
- Channel linings
- Retaining walls
- Bridge abutments and wings
- Marinas and boat ramps
- Culvert headwalls and outlet aprons
- Shore and beach protection

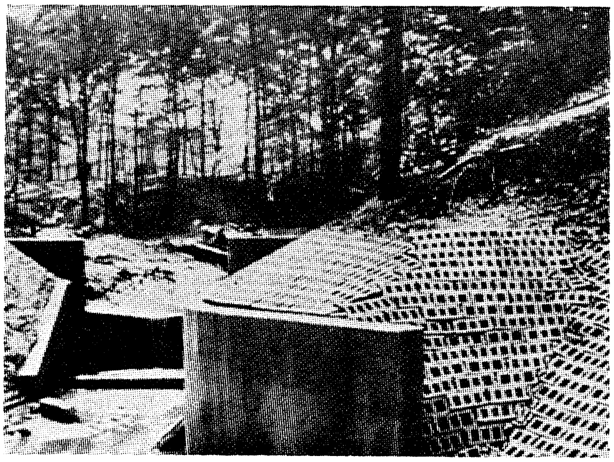
MAINTENANCE

Periodic inspection should be performed for signs of undercutting or excessive erosion at transition areas.

Source: National Crushed Stone Association

Grade Stabilization Structure

Gr



DEFINITION

A structure to stabilize the grade in natural or artificial channels.

PURPOSE

Grade stabilization structures are installed to stabilize the grade in natural or artificial channels, prevent the formation or advance of gullies, and reduce erosion and sediment pollution.

CONDITIONS

This standard applies to sites where structures are needed to stabilize channel grades but does not apply to sites where water is to be impounded.

DESIGN CRITERIA

Structures

Structures constructed of concrete, rock, masonry, steel, aluminum or treated wood or by soil bioengineering methods shall be designed in accordance with sound engineering practices. Design data for small reinforced concrete drop spillways and formless concrete chute spillways are contained herein.

Geotextile should be placed under stabilization structures such as revetment mats and riprap as part of a permanent erosion control system. The geotextile should be selected/specified in accordance with AASHTO M288-96 Section 7.5, *Permanent Erosion Control.*

Capacity

The condition of adjacent areas is considered when determining the storm frequency used to design the grade stabilization structure. Structures shall be designed to protect areas from overbank flow damage up to and including storm frequencies specified in Table 6-16.1.

Adjacent Area	Storm Frequency
Residences, commercial buildings, recreation buildings, etc.	100-year, 24-hour storm
Recreation and landscaped areas	25-year,[2] 24-hour storm[1]
Agricultural land	25-year,[2] 24-hour storm[1]

[1] 50 percent of peak flood flow may be carried around island-type structures provided overbank flow damage from erosion and flooding can be tolerated. Peak flood flow will be determined by methods contained in Appendix A.

[2] Or the storm frequency specified in Title 12 of the Official Code of Georgia Annotated.

Table 6-16.1

Embankment

Earthfill embankments shall have a minimum top width of 10 feet and side slopes of 3:1 or flatter.

Keyway

A keyway no less than 8 feet wide and 2 feet deep shall be constructed along the centerline of the structure and embankment.

Outlet

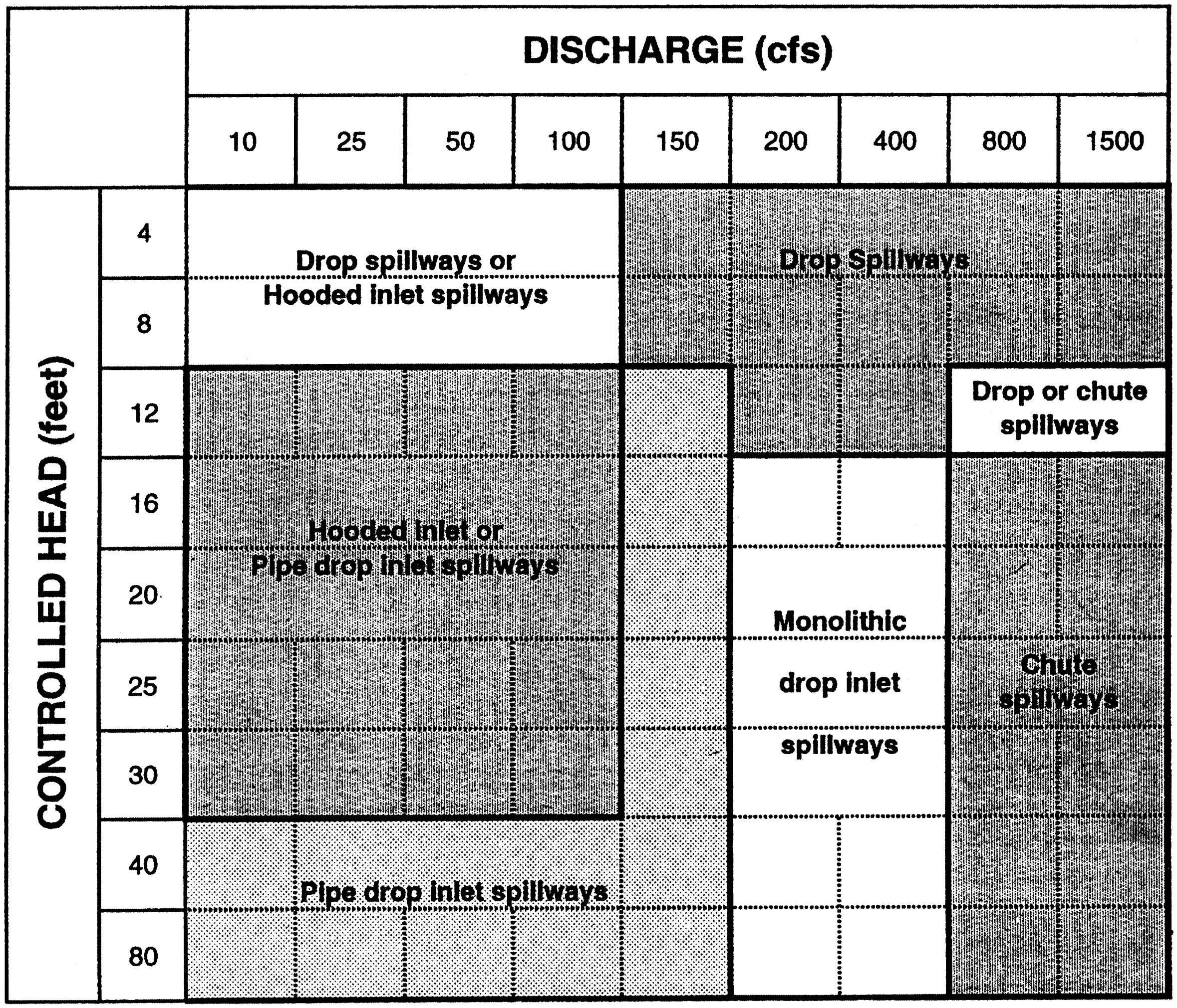
All structures shall discharge into stable outlets.

CONSTRUCTION SPECIFICATIONS

Excavations shall be dewatered prior to filling.

Structures shall be placed on compacted earthfill. Earthfill material shall be moderately to slowly permeable with the most plastic being used in the center of the embankment and adjacent to structures. Materials shall be constructed in 6 - 8 inch horizontal lifts and compacted to approximately 95% of standard density. The embankment shall be overbuilt 10% in height to allow for settlement. Embankment surfaces shall be completed to the required lines and grades.

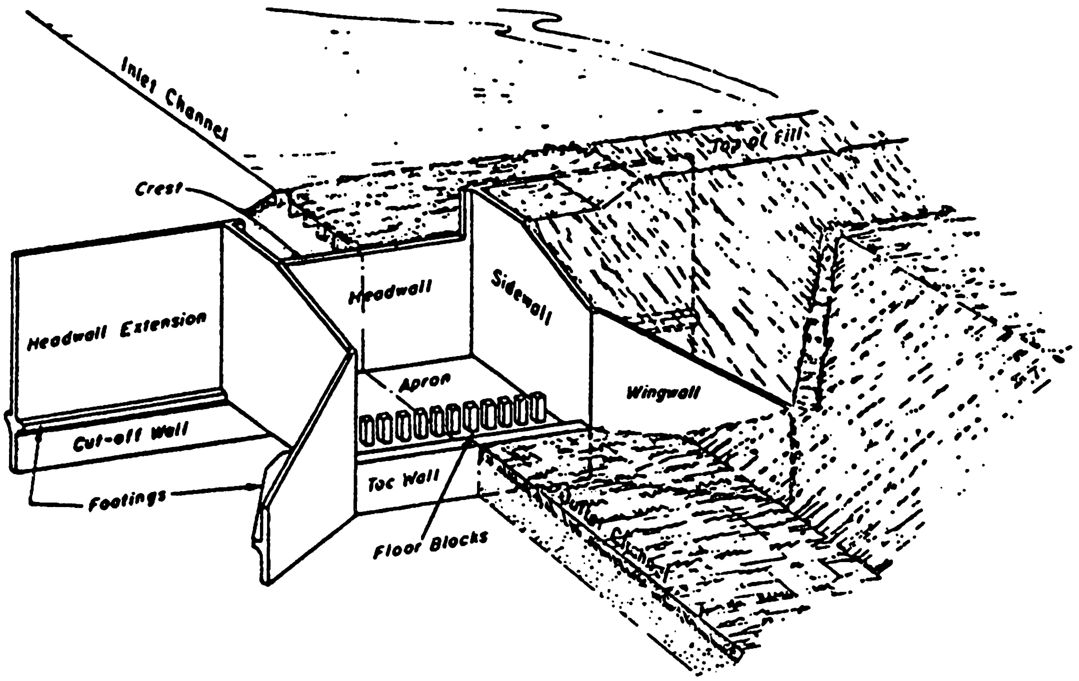
Protective cover shall be applied immediately after completion of the structure. Refer to specifications **Ds3 and Ds4 - Disturbed Area Stabilization (With Permanent Vegetation and Sodding),** respectively, and **Mb - Matting and Blankets**.



<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="9">DISCHARGE (cfs)</th></tr>
<tr><th>10</th><th>25</th><th>50</th><th>100</th><th>150</th><th>200</th><th>400</th><th>800</th><th>1500</th></tr>
<tr><td rowspan="10">CONTROLLED HEAD (feet)</td><td>4</td><td colspan="4" rowspan="2">Drop spillways or Hooded inlet spillways</td><td colspan="5" rowspan="2">Drop Spillways</td></tr>
<tr><td>8</td></tr>
<tr><td>12</td><td colspan="4" rowspan="5">Hooded inlet or Pipe drop inlet spillways</td><td rowspan="5"></td><td colspan="2"></td><td colspan="2">Drop or chute spillways</td></tr>
<tr><td>16</td><td colspan="2" rowspan="7">Monolithic drop inlet spillways</td><td colspan="2" rowspan="7">Chute spillways</td></tr>
<tr><td>20</td></tr>
<tr><td>25</td></tr>
<tr><td>30</td></tr>
<tr><td>40</td><td colspan="5" rowspan="2">Pipe drop inlet spillways</td></tr>
<tr><td>80</td></tr>
</table>

Note: Chart shows most economical structure as related to discharge and controlled head providing site conditions are adequate.

Figure 6-16.1



STRAIGHT DROP SPILLWAY
Figure 6-16.2

Planning and design of straight drop spillways normally require the assistance of an engineer. Local personnel may be trained to plan and install small drop spillway structures when standard plans are available.

Measurement locations for symbols F (overfall in feet), h (depth of weir in feet), s (depth of stilling pool in feet), and L (length of weir in feet) are shown in Figure 6-16.3

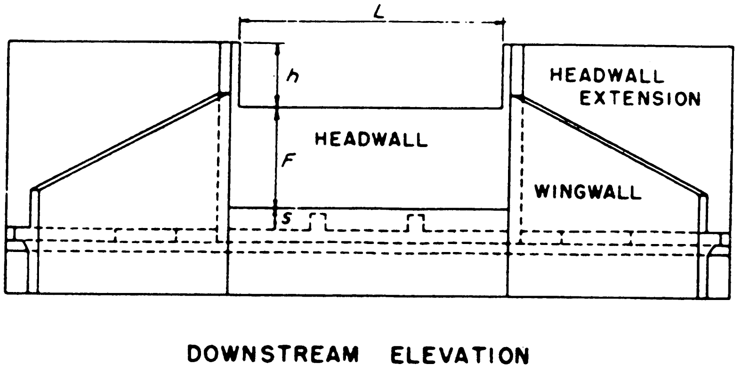
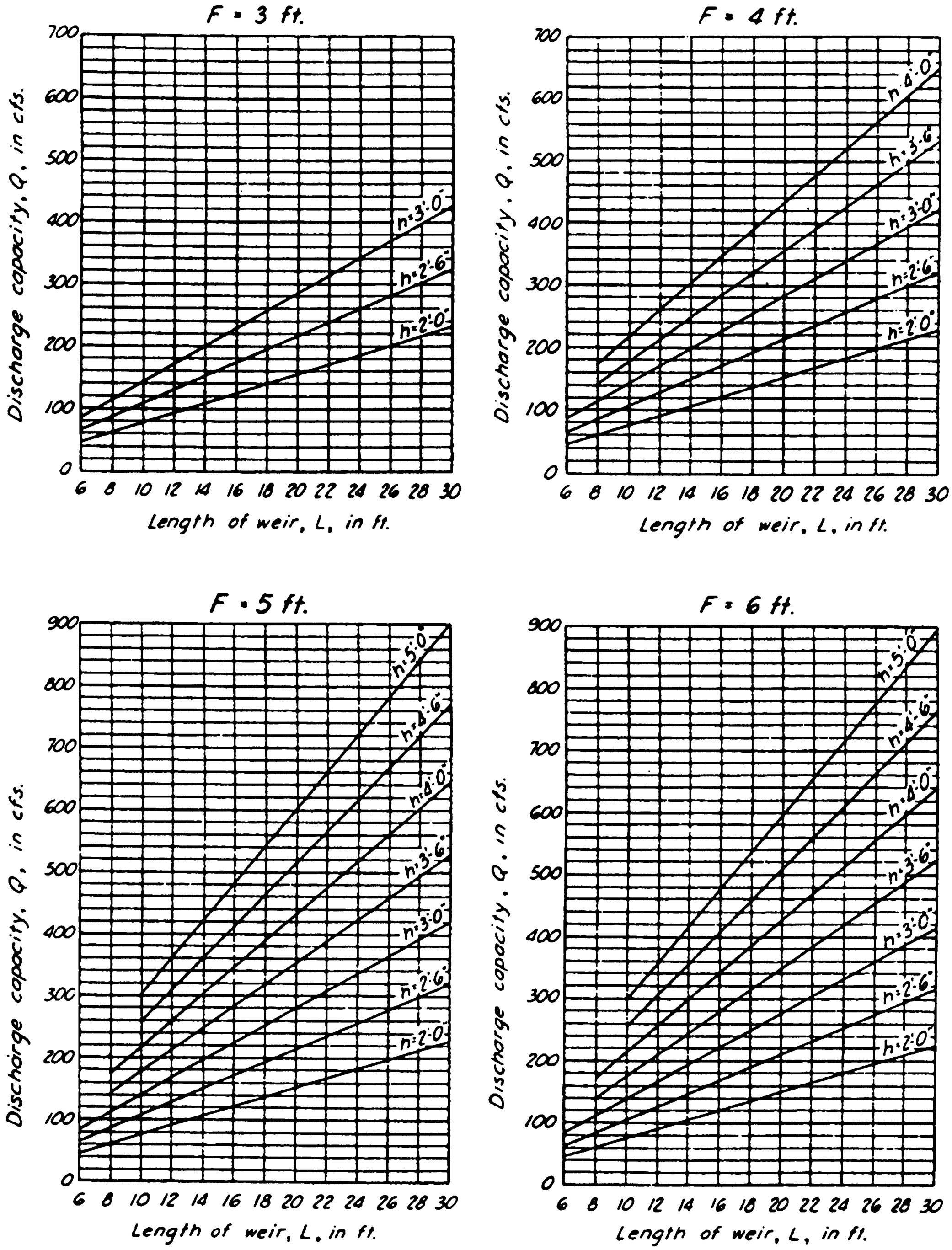


Figure 6-16.3 - Symbols for straight drop spillway.

Weir capacities for low-overall straight drop spillways can be determined from figure 6-16.4 for various combinations of F, h, and L.

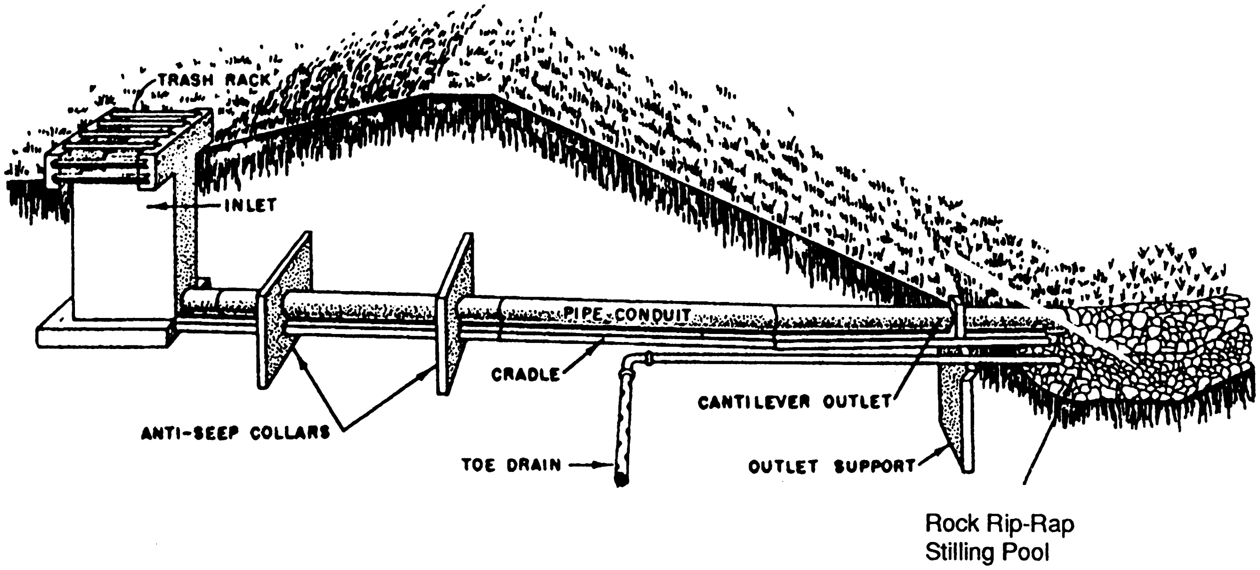


Note: h = total depth of weir, in feet (including freeboard)
F = net drop from crest to top of transverse sill, in feet
(For type B drops keep h÷F less than 0.75)

$$Q = \frac{3.1\ Lh^{3/2}}{(1.10 + 0.01\ F)}$$

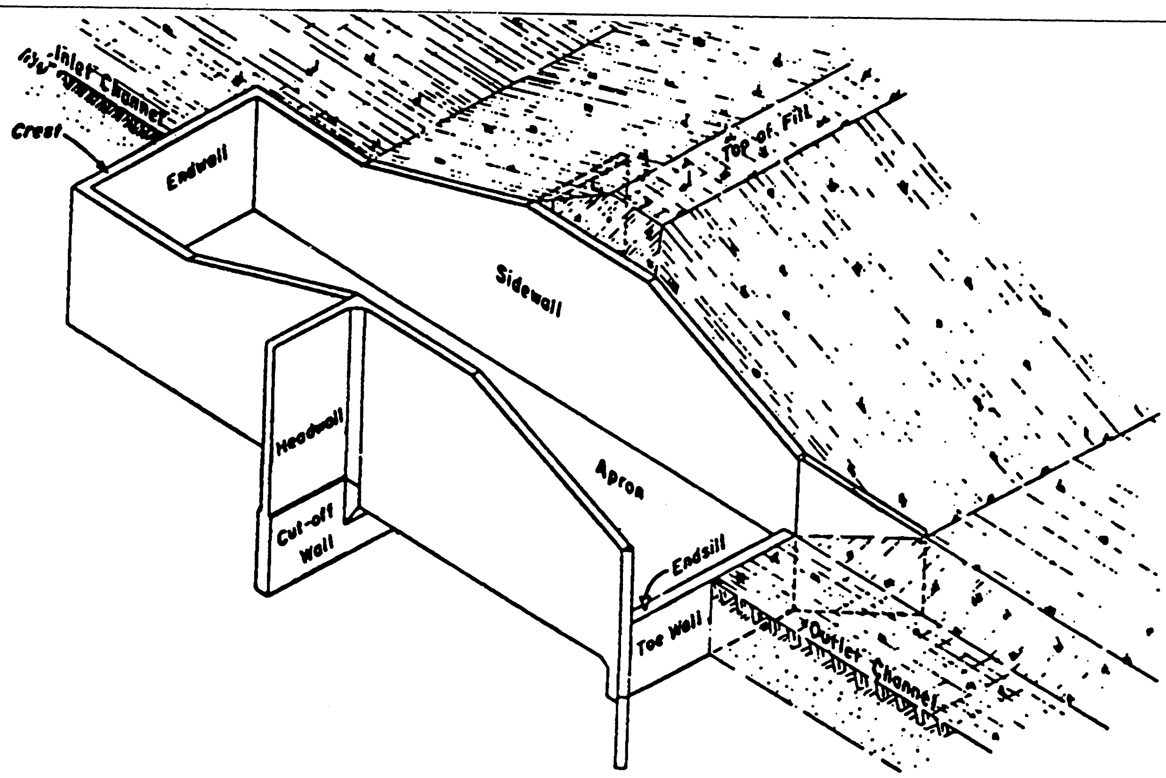
WEIR CAPACITY FOR STRAIGHT DROP SPILLWAYS

Figure 6-16.4



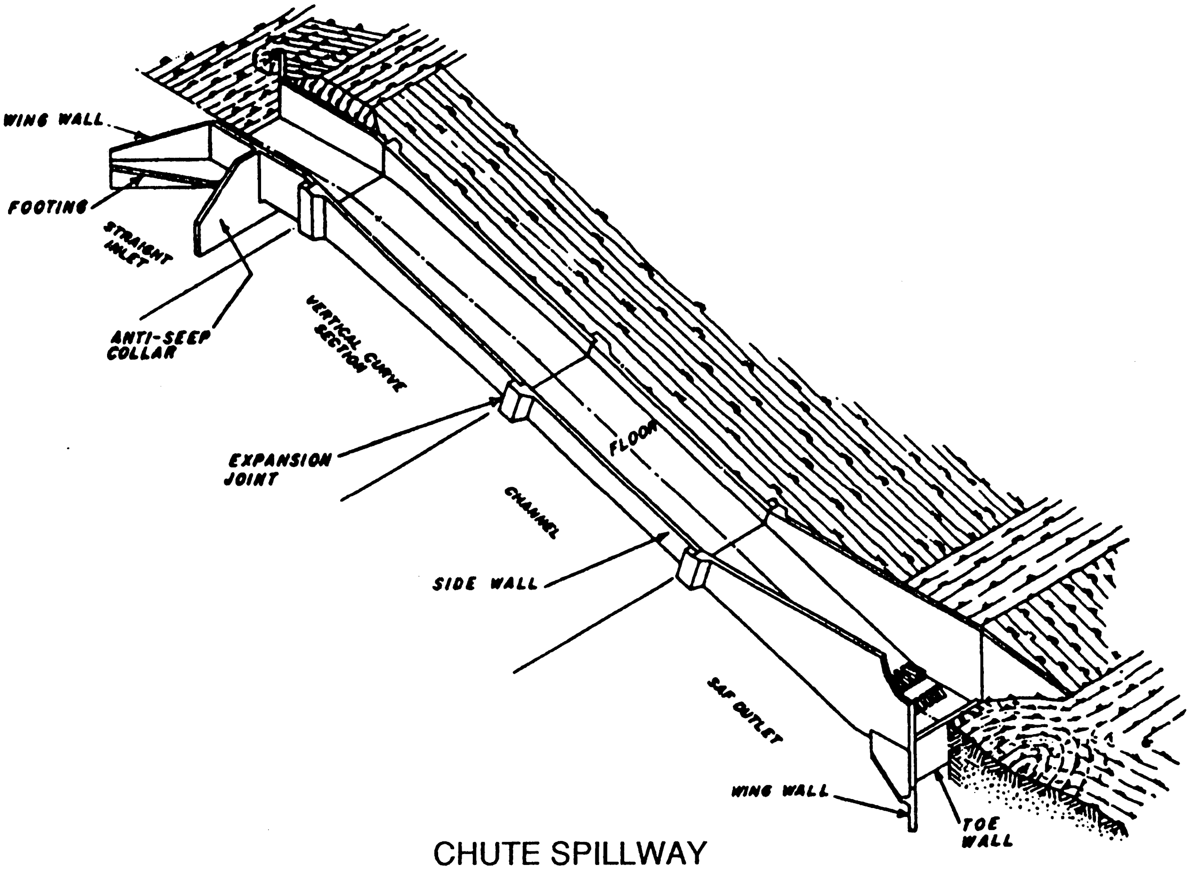
DROP INLET SPILLWAY

Figure 6-16.5



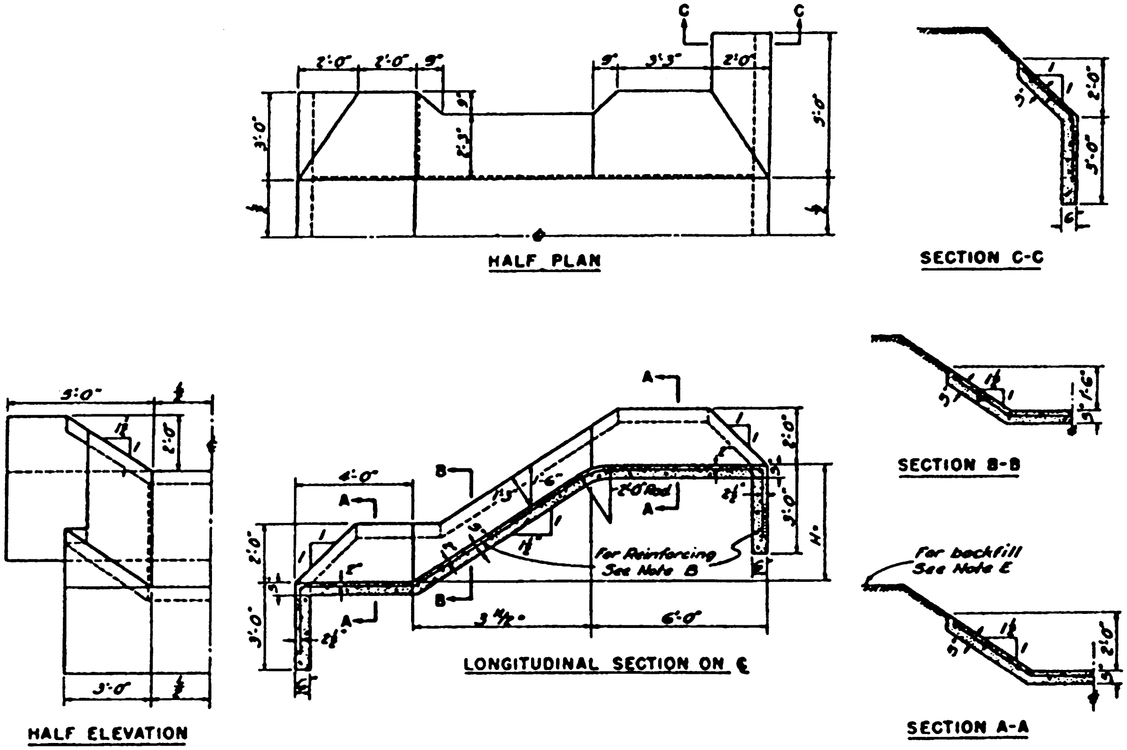
BOX INLET DROP SPILLWAY

Figure 6-16.6



CHUTE SPILLWAY

Figure 6-16.7



STRUCTURAL DETAILS

NOTES:-

A. Use 5 inch thickness of concrete throughout except as dimensioned otherwise.

B. Reinforcing as indicated shall be (1) 3/8"ϕ reinforcing steel 12"o.c. both ways; or (2) No.2 gauge welded wire fabric 6"o.c. both ways. (common designation 6x6 2/2). Reinforcing bars or mesh should be lapped one foot at all joints.

C. Spillways of this type shall be constructed on solid ground. Seep areas should be avoided or properly drained with a carefully constructed toe drainage system.

D. This spillway shall not be used as a part of a water impounding structure.

E. The disturbed area adjacent to the spillway shall be backfilled, compacted and sodded.

F. The length (L) of the spillway shall be limited by the amount of concrete that can be adequately mixed, placed and finished in one day's time with the labor and equipment available or a Max. L=8'-0"

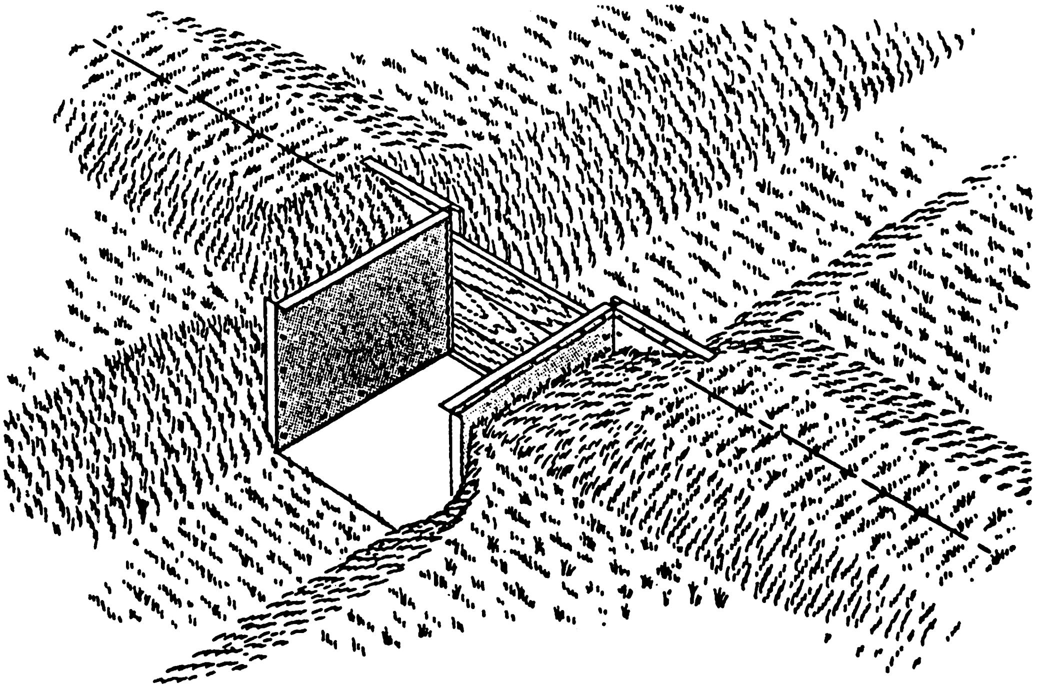
G. The maximum "H" for this spillway is 5'-0"

Discharge Capacity of Spillway in c.f.s.				
Length of Crest (L) in feet	2	4	6	8
with no freeboard	30	45	60	75
with 6" freeboard	18	28	38	48

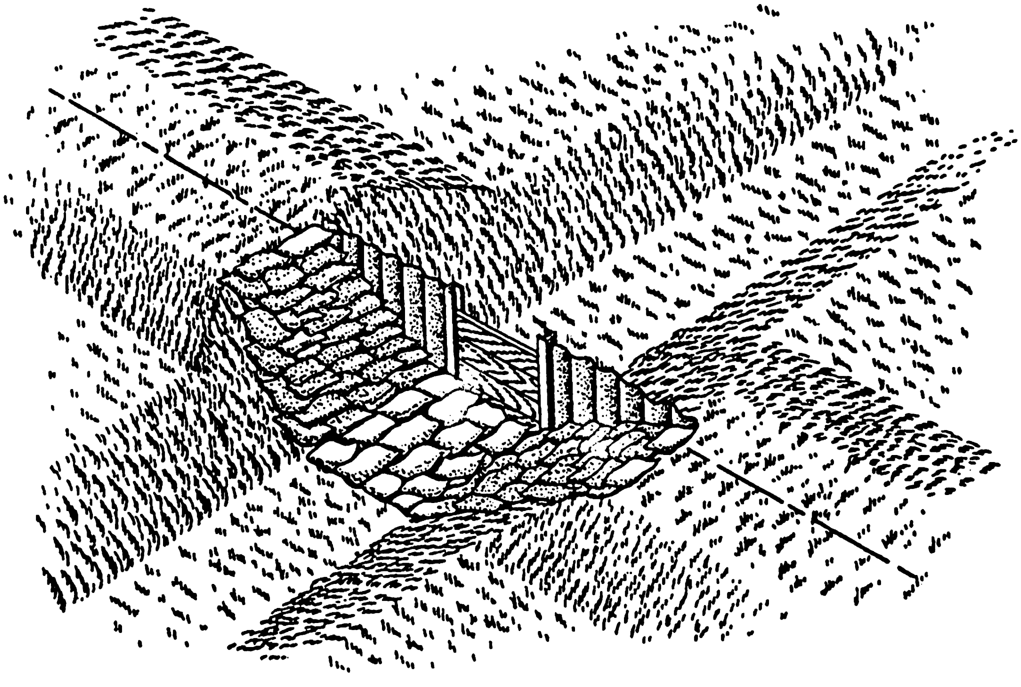
Concrete Volumes in Cubic Yards				
Head "H" Feet	Length of Crest (L) in feet			
	2' - 0"	4' - 0"	6' - 0"	8' - 0"
4' - 0"	3.5	4.2	4.9	5.6
5' - 0"	3.7	4.4	5.2	6.0

Typical Plan - Formless Concrete Chute

Figure 6-16.8



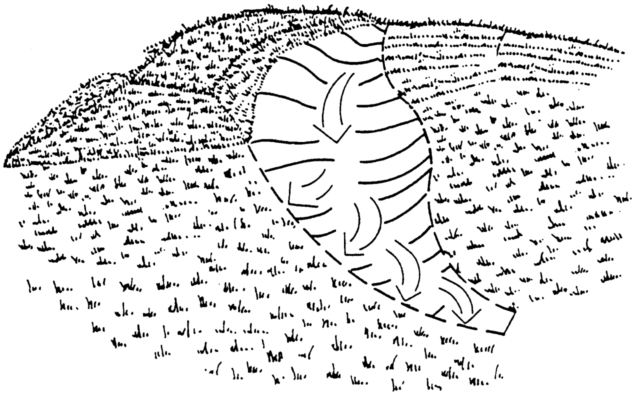
PREFABRICATED METAL STRUCTURE
Figure 6-16.9



SHEET PILING HEADWALL WITH SAND-CEMENT BAG SIDEWALLS AND APRON.
Figure 6-16.10

SMALL, LOW COST WATER CONTROL STRUCTURES

Level Spreader (Lv)



DEFINITION

A storm flow outlet device constructed at zero grade across the slope whereby concentrated runoff may be discharged at non-erosive velocities onto undisturbed areas stabilized by existing vegetation.

PURPOSE

To dissipate storm flow energy at the outlet by converting storm runoff into sheet flow and to discharge it onto areas stabilized by existing vegetation without causing erosion.

CONDITIONS

Where sediment-free storm runoff is intercepted and diverted onto undisturbed stabilized areas (*i.e.*, at diversion outlets, etc.). This practice applies only in those situations where the spreader can be constructed on undisturbed soil and where the area directly below the level lip is stabilized by existing vegetation. The water must not be allowed to reconcentrate below the point of discharge.

DESIGN CRITERIA

Length

A specific design for level spreaders will not be required. However, spreader length will be determined by estimating the peak stormflow from the 10-year, 24-hour storm or the storm specified in Title 12 of the Official Code of Georgia Annotated and selecting the appropriate length from Table 6-17.1

Designed Q10/24 (cfs)	**Minimum Length "L"** (feet)
up to 10	10
11 to 20	20
21 to 30	30
31 to 40	40
41 to 50	50

Table 6-17.1

Outlets

Final discharge will be over the level lip onto an undisturbed, stabilized area. The outlet shall be generally smooth to create uniform sheet flow.

CONSTRUCTION SPECIFICATIONS

The minimum acceptable width shall be 6 feet. The depth of the level spreader as measured from the lip shall be at least 6 inches and the depth shall be uniform across the entire length of the measure.

The grade of the channel for the last 15 feet of the dike or diversion entering the level spreader shall be less than or equal to 1%.

The level lip shall be constructed on zero percent grade to insure uniform spreading of storm runoff (converting channel flow to sheet flow). For calculation purposes, a grade of 0.1% may be needed, however, the level spreader shall be installed at zero percent grade.

Level spreaders must be constructed on undisturbed soil (not on fill).

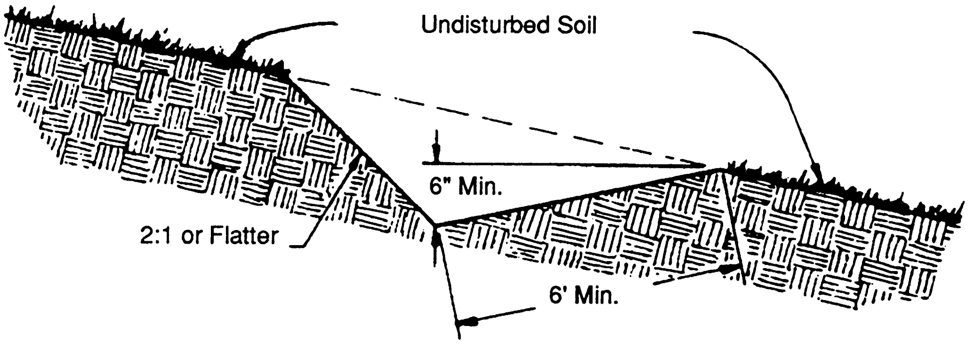
The entrance to spreader shall be graded in a manner to insure that runoff enters directly onto the zero percent graded channel.

Storm runoff converted to sheet flow must discharge onto undisturbed stabilized areas.

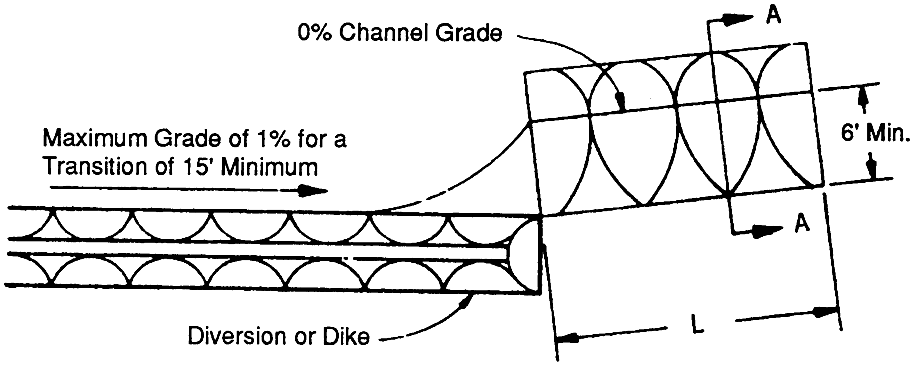
All disturbed areas shall be vegetated immediately after construction is completed. Refer to specifications **Ds3 and Ds4 - Disturbed Area Stabilization (With Permanent Vegetation and Sodding),** respectively and **Mb - Matting and Blankets**.

MAINTENANCE

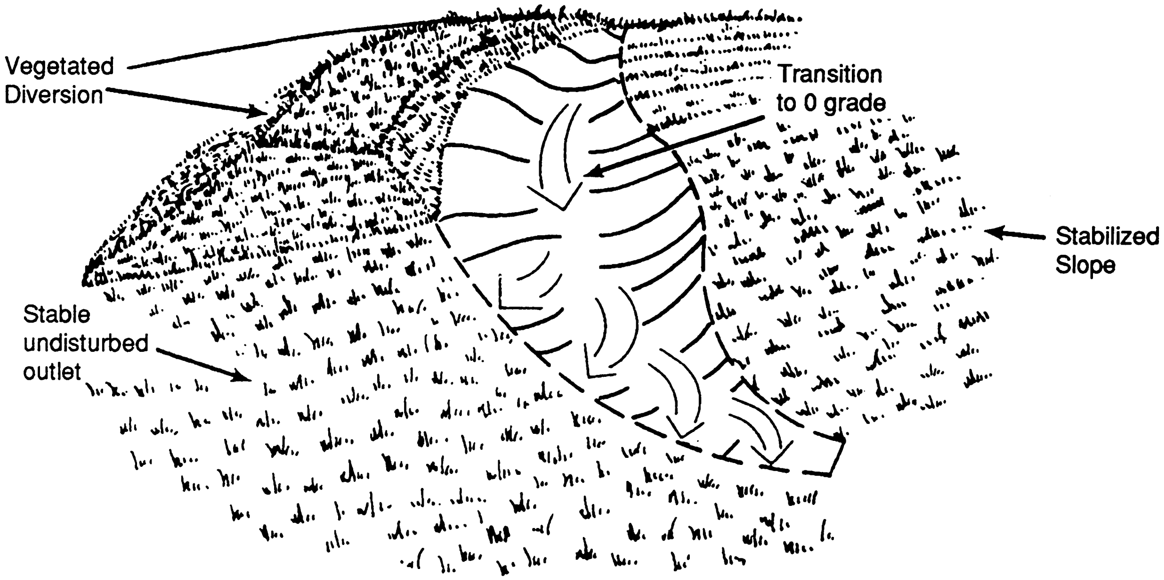
Periodic inspection and maintenance must be provided.



SECTION A-A



PLAN



ISOMETRIC VIEW - (Not to Scale)

LEVEL SPREADER

Figure 6-17.1

Rock Filter Dam

Rd

DEFINITION

A permanent or temporary stone filter dam installed across small streams or drainageways.

PURPOSE

This structure is installed to serve as a sediment filtering device in drainageways. In some cases, it may also reduce the velocity of stormwater flow through a channel. This structure is not intended to substantially impound water. Before structures of any kind are installed in flowing streams, the appropriate agencies and local officials should be contacted.

CONDITIONS

This practice is applicable for use in small channels which drain 50 acres or less. The rock filter dam must be used in conjunction with other appropriate sediment control measures to reduce the amount of sediment reaching the channel. This practice may be used:

1. as an additional sediment control measure below construction projects such as culvert installations, dam construction, or any project that may involve grading activity directly in a stream, or
2. at the upstream end of ponds or lakes to trap incoming sediment loads.

DESIGN CRITERIA

Formal design is not required, but it is recommended that a qualified engineer be consulted before a structure of any kind is installed in a flowing stream. (Refer to Figure 6-18.1)

The following standards shall be followed:

Drainage Area

The drainage area to the dam shall not exceed 50 acres.

Height

The dam should not be higher than the channel banks or exceed the elevation of the upstream property line. The center of the rock dam should be at least six inches lower than the outer edges of the dam at the channel banks.

Side Slopes

The side slopes shall be 2:1 or flatter.

Location

The dam shall be located as close to the source of sediment as possible and so that it will not cause water to back up on upstream adjacent property.

Stone Size

The stone size shall be determined by the design criteria established in **Riprap - Appendix C**. The rock dam can be faced with smaller stone on the upstream side for additional filtering effect. However, this may make the dam more prone to clogging.

Top Width

The width across the top of the dam should be no less than 6 feet.

Geotextile

Geotextiles should be used as a separator between the graded stone, the soil base, and the abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. The geotextile shall be specified in accordance with AASHTO M288-96 Section 7.5, *Permanent Erosion Control Recommendations*. The geotextile should be placed immediately adjacent to the subgrade without any voids and extend five feet beyond the downstream toe of the dam to prevent scour.

CONSTRUCTION SPECIFICATIONS

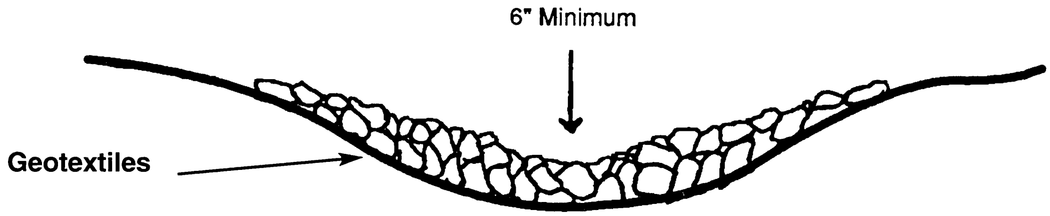
Mechanical or hand placement will be required to insure that the rock dam extends completely across the channel and securely ties into both channel banks. The center of the dam must be no less than six inches lower than the lowest side, to serve as a type of weir. Gabions can be installed to serve as rock filter dams, but should follow recommended sizing and installation specifications. Refer to specification **Ga - Gabion**.

MAINTENANCE

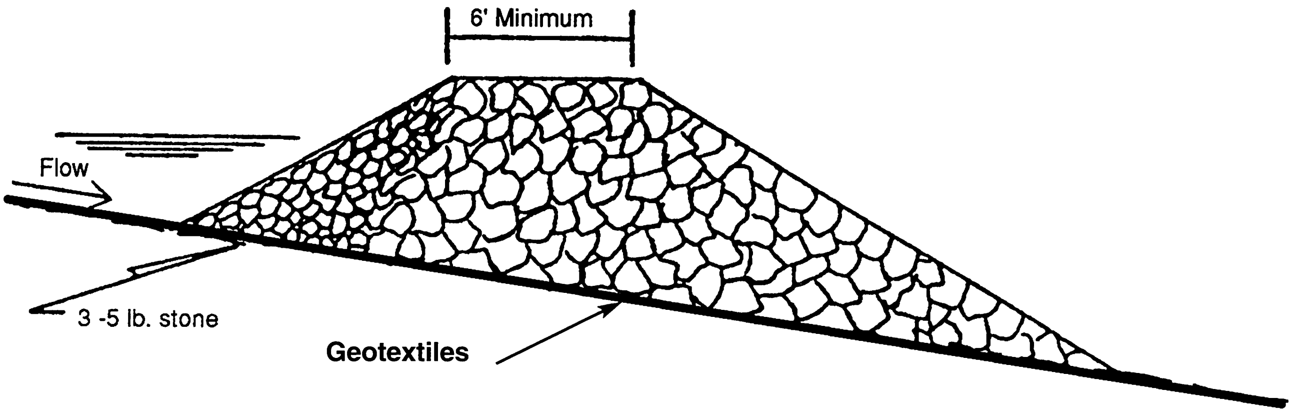
Rock dams should be removed once disturbed areas have been stabilized. Periodic inspection and required maintenance must be provided. Sediment shall be removed when it reaches a depth of one-half of the original height of the dam.

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

1. **Figure 6-18.1**, noting rock size as specified in Appendix C.



NOTE: Sediment Trap is to be cleaned out
when volume becomes half full.

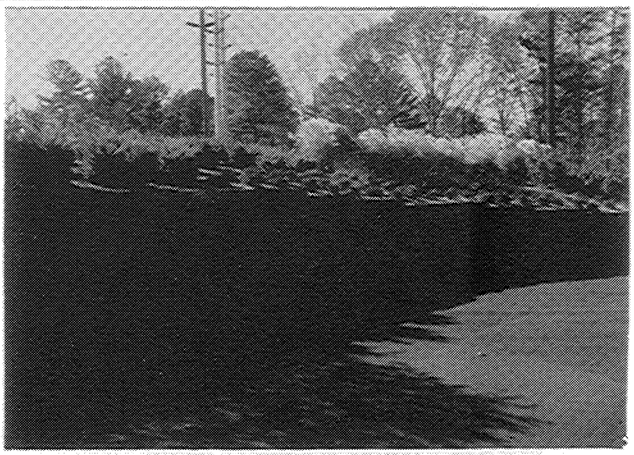


NOTE: Rock size determined according
to specifications set forth in
Appendix C.

Figure 6-18.1

Retaining Wall

Re



DEFINITION

A wall constructed of one or more of the following: concrete masonry, reinforced concrete cribbing, treated timbers, steel pilings, gabions, stone drywall, rock riprap, etc.

PURPOSE

To assist in the stabilization of cut or fill slopes where stable slopes are not attainable without the use of the wall.

CONDITIONS

Use in conjunction with cut or fill slopes which, because of space limitations or unstable material, do not allow the stable slope criteria listed above, *e.g.* cuts into steep hillsides on small lots or cuts into hillsides behind shopping centers to provide loading space.

DESIGN CRITERIA

General

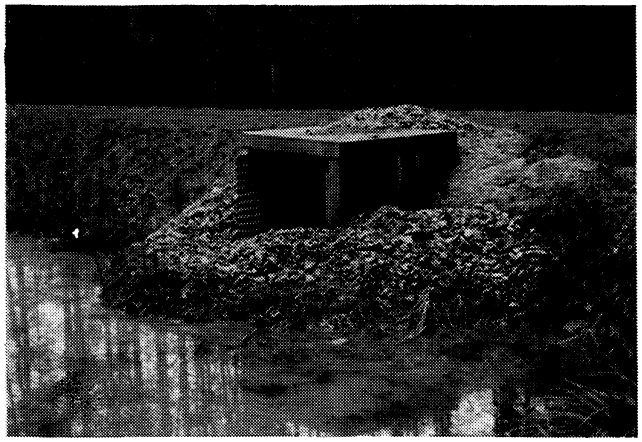
The design of a retaining wall is a complicated process. Many factors must be taken into account such as: stresses and forces outside and within the wall, allowable height, minimum thickness. Other considerations are: foundation design with respect to loadings, bearing values of soils, footing dimensions. Additional design factors are safety hazards, subsurface and surface drainage and appearance.

Each situation requires a *specific design* which is within the capabilities of the design engineer.

Consideration should be given to all of the alternative methods with regard to construction of the wall. Some methods are:

1. Concrete masonry
2. Concrete cribbing
3. Gabions
4. Steel piling
5. Stone drywall
6. Rock riprap, etc.
7. Treated timbers
8. Geotextile wrapped-face wall
9. Geotextile reinforced steep slopes

Retrofitting (Rt)



DEFINITION

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

PURPOSE

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

CONDITIONS

This standard applies under the following conditions:

1. **Shall not be used in detention basins on live streams** or in basins with a total contributing drainage area of 100 acres or more.
2. Shall only be used in detention basins large enough to store 67 cubic yards of sediment per acre of disturbed area in the project.
3. Shall be considered a temporary structure and will be removed as soon as project is permanently stabilized. All accumulated sediment shall be removed, and the pond shall be brought to final grade (if possible), prior to the removal of the retrofit.

DESIGN CRITERIA

1. The height of the retrofit should be approximately one-half the height of the stormwater management outlet structure.
2. **The pond must be capable of storing the required volume of sediment in addition to the required stormwater volume.** The required sediment storage volume shall be achieved by either excavating the basin or raising the outlet structure's invert to achieve 67 cubic yards per acre of sediment storage. Remove sediment when one-third of the sediment storage capacity, not total pond capacity, is lost to sediment accumulation. This volume shall be marked on the riser or by setting a marked post near the riser.
3. For effective trapping efficiency, the sediment delivery inlets should be at the upper end of the basin.
4. For effective trapping efficiency, the length-width ratio of the basin shall be at least 2:1. If the length-width ratio is not at least 2:1, the flow length shall be increased with the use of baffles installed within the basin.

CONSTRUCTION SPECIFICATIONS

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

Perforated Half-Round Pipe with Stone Filter
(Rt-P) (See Figure 6-19.1)

a. Should be used only in detention ponds with less than 30 acre total drainage area.
b. Never to be used on exposed pipe end or winged headwall.
c. 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.
d. Perforations and stone sizes are shown in Figure 6-19.1.
e. Shall be fixed by specified means (bolts, etc) to concrete outlet structure.

Slotted Board Dam with Stone (Rt-B)
(See Figure 6-19.3)

a. Can be used in detention ponds with drainage areas up to 100 acres.
b. Can be used with open end pipe outlets, winged headwalls, or concrete weir outlets.
c. Should be installed with minimum size 4 x 4 inch posts.
d. Boards should have 0.5-1.0 inch space between them.
e. Minimum size 3-4 inch stone filter shall be in-stalled around the upstream side of the board dam.

All disturbed areas shall be vegetated immediately after construction with permanent vegetation. Refer to **Ds3 and Ds4 - Disturbed Area Stabilization (With Permanent Vegetation) and Disturbed Area Stabilization (With Sodding)** and **Mb - Matting and Blankets**.

MAINTENANCE

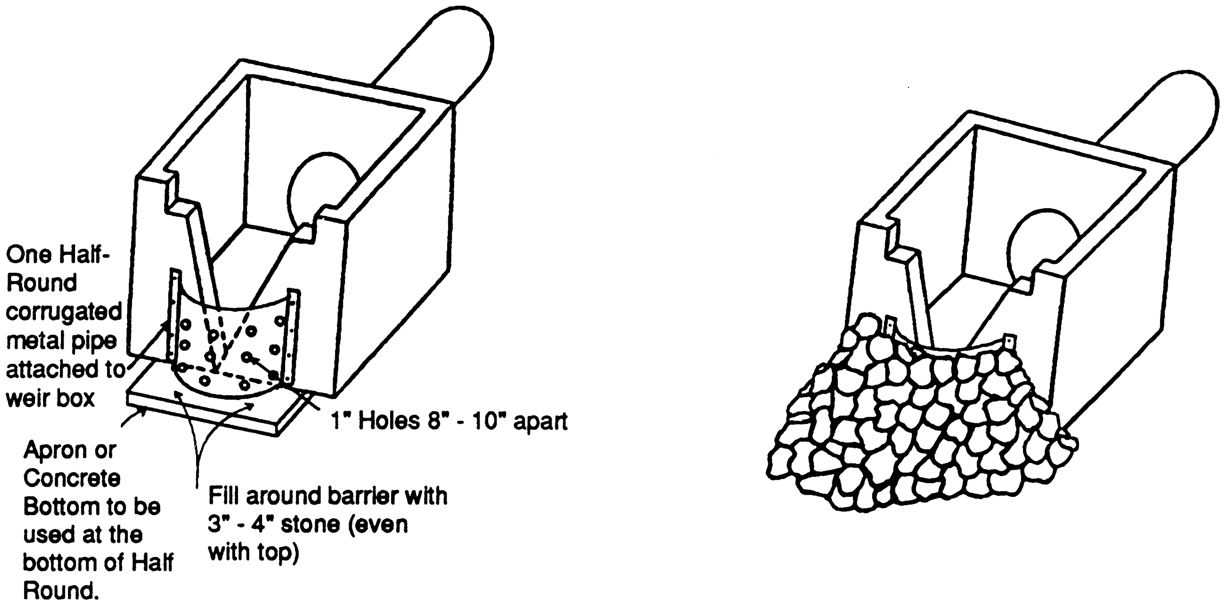
Retrofit structures shall be kept clear of trash and debris. This will require continuous monitoring and maintenance, which includes sediment removal when one-third of the sediment storage capacity has been lost. *Structures are temporary and shall be removed when disturbed areas have been permanently stabilized.*

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

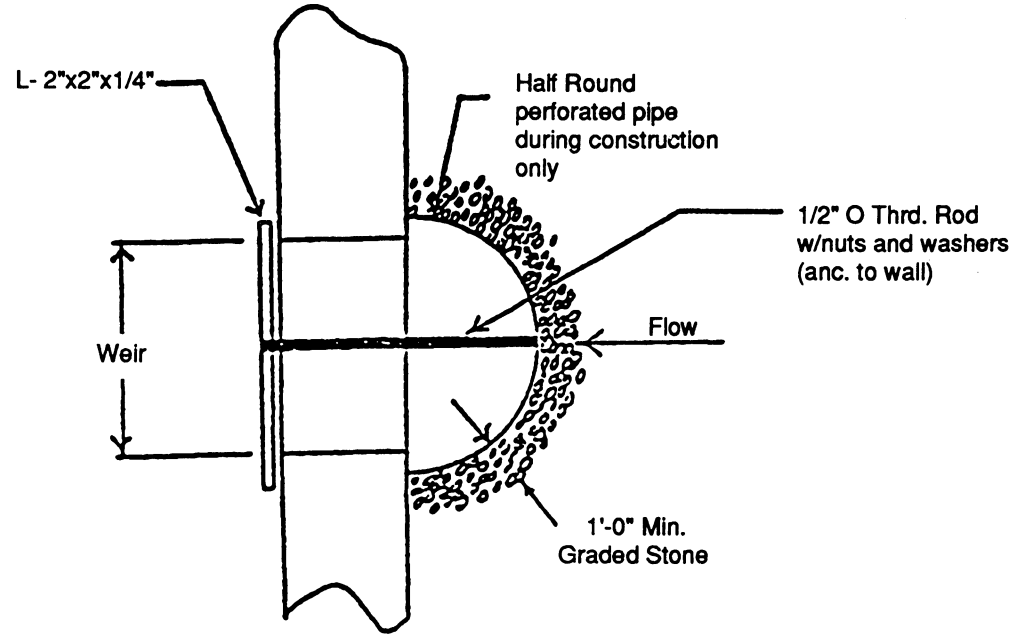
Storage Calculations

1. Required stormwater storage = ______ cy
   (as determined by local ordinance)
2. Required sediment storage = ______ cy
   (67 cy/ac * _____ ac disturbed area)
3. Total required storage = __(1)__ + __(2)__ = __(3)__ cy
4. Available storage = __(4)__ cy
5. Is the available storage (4) greater than the total required storage (3)?
   _____ yes _____ no
6. If "no", the sediment storage capacity of the pond must be increased. Choose the method to be used:
   _____ Raise the invert of the outlet structure _____ inches
   _____ Undercut the pond _____ feet
   _____ Other ______________________________
7. Clean-out elevation = ______ ft
   (Elevation corresponding to 22 cy/ac * _____ ac disturbed area)
8. Is the length-width ratio 2:1 or greater?
   _____ yes _____ no
9. If "no", the length of flow must be increased. Choose the method to be used:
   _____ Baffles (Type of baffle: ___________)
   _____ Other ______________________________

Note the CMP diameter and height if a half-round CMP retrofit is to be used.
Diameter = ______ inches Height = _____ feet



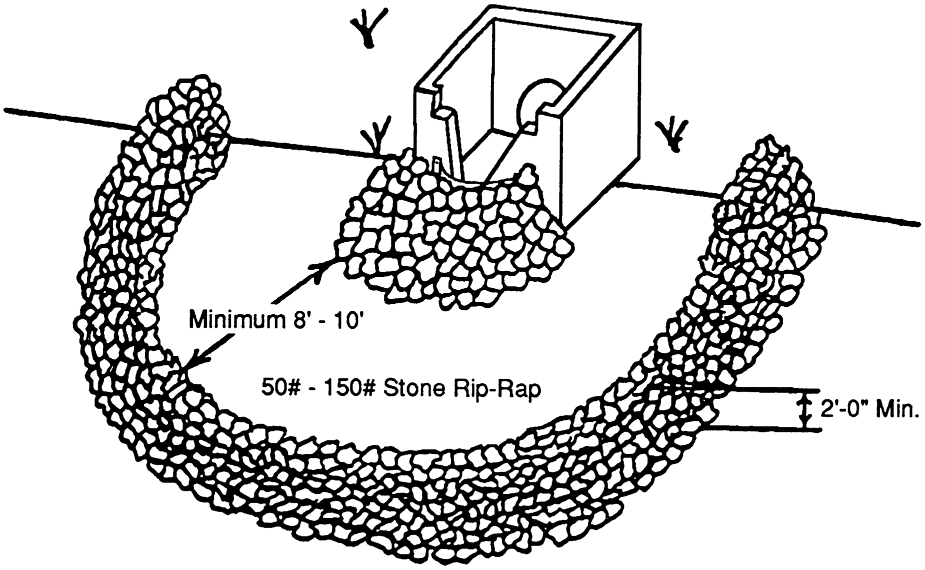
ISOMETRICS



PLAN

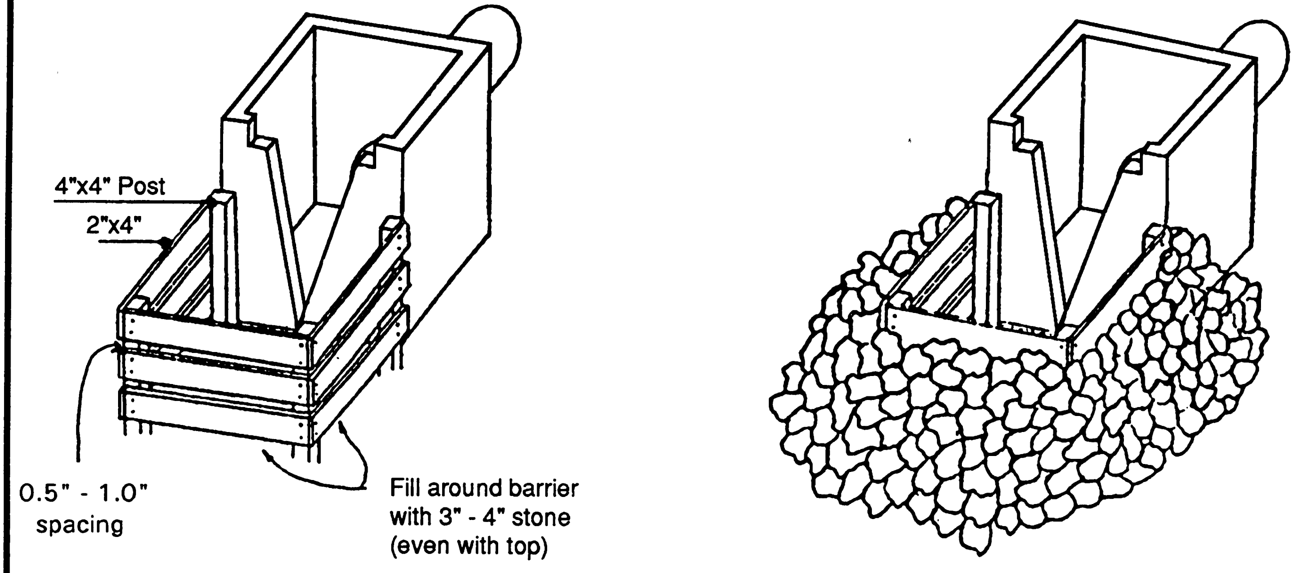
PERFORATED HALF-ROUND PIPE WITH STONE FILTER

Figure 6-19.1



STONE FILTER RING

Figure 6-19.2



SLOTTED BOARD DAM WITH STONE FILTER

Figure 6-19.3

Sediment Barrier (Sd1)

DEFINITION

Sediment barriers are temporary structures typically constructed of silt fence supported by steel or wood posts. Other types of barriers may include sandbags, straw bales, brush piles or other filtering material.

PURPOSE

To prevent sediment carried by sheet flow from leaving the site and entering natural drainage ways or storm drainage system by slowing storm water runoff and causing the deposition of sediment at the structure.

CONDITIONS

Barriers should be installed where runoff can be stored behind the barrier without damaging the fence or the submerged area behind the fence.

Silt fence shall not be installed across streams, ditches, waterways, or other concentrated flow areas.

DESIGN CRITERIA

HAY OR STRAW BALES

Hay or straw bales retain sediment load transported by sheet flow from disturbed areas. The bales' comparatively low flow rate should be considered when choosing the appropriate sediment barrier. Ponding above the bale can occur rapidly. The slope lengths contributing runoff to a bale barrier cannot exceed those listed in Table 6-20.1. Straw and hay bales shall not be used if the project duration is expected to exceed three months.

CRITERIA FOR STRAW OR HAY BALE PLACEMENT

Land Slope	Maximum Slope Length Above Bale
Percent	Feet
< 2	75
2 to 5	50
5 to 10	35
10 to 20	20
> 20	10

Table 6-20.1

SILT FENCE

Like hay or straw bales, silt fence is designed to retain sediment transported by sheet flow from disturbed areas. Silt fence performs the same function as hay or straw bales, allows a higher flow rate, and is usually faster and cheaper to install. Approved silt fence fabrics are listed in the Georgia Department of Transportation Qualified Products List #36 (QPL-36). See Table 6-20.5 for current Georgia DOT silt fence specifications.

Where all runoff is to be stored behind the fence (where no stormwater disposal system is present), maximum slope length behind a silt fence shall not exceed those shown in Table 6-20.2. The drainage area shall not exceed 1/4 acre for every 100 feet of silt fence.

CRITERIA FOR SILT FENCE PLACEMENT

Land Slope	Maximum Slope Length Above Fence
Percent	Feet
< 2	100
2 to 5	75
5 to 10	50
10 to 20	25
> 20*	15

*In areas where the slope is greater than 20%, a flat area length of 10 feet between the toe of the slope to the fence should be provided.

Table 6-20.2

Type A Silt Fence (Sd1-A)

This 36-inch wide filter fabric shall be used on developments where the life of the project is greater than or equal to six months.

Type B Silt Fence Sd1-B

Though only 22-inches wide, this filter fabric allows the same flow rate as Type A silt fence. Type B silt fence shall be limited to use on minor projects, such as residential home sites or small commercial developments where permanent stabilization will be achieved in less than six months.

Type C Silt Fence Sd1-C

Type C fence is 36-inches wide with wire reinforcement. The wire reinforcement is necessary because this fabric allows almost three times the flow rate as Type A silt fence. Type C silt fence shall be used where runoff flows or velocities are particularly high or where slopes exceed a vertical height of 10 feet.

Provide a riprap splash pad or other outlet protection device for any point where flow may top the sediment fence. Ensure that the maximum height of the fence at a protected, reinforced outlet does not exceed 1 ft. and that support post spacing does not exceed 4 ft.

CONSTRUCTION SPECIFICATIONS

Sandbags Sd1-S

(if approved by local issuing authority)

Should be installed so that flow under or between bags is minimal. Anchoring with steel rods may be required if structure height exceeds two bags.

Hay or Straw Bales Sd1-Hb

(if approved by local issuing authority)

Bales will be placed in a single row, lengthwise, on the contour and embedded in the soil to a depth of 4 inches. Bales must be securely anchored in place by stakes or bars driven through the bales or by other acceptable means to prevent displacement. See Figures 6-20.1 and 6-20.2 for installation requirements.

Brush Barrier Sd1-Bb

(only during timber clearing operations)

Brush obtained from clearing and grubbing operations may be piled in a row along the perimeter of disturbance at the time of clearing and grubbing. Brush barriers should not be used in developed areas or locations where aesthetics are a concern.

Brush should be wind-rowed on the contour as nearly as possible and may require compaction. Construction equipment may be utilized to satisfy this requirement.

The minimum base width of the brush barrier shall be 5 feet and should be no wider than 10 feet. The height of the brush barrier should be between 3 and 5 feet.

If a greater filtering capacity is required, a commercially available filter fabric may be placed on the side of the brush barrier receiving the sediment-laden runoff. The lower edge of the fabric must be buried in a 6-inch deep trench immediately uphill from the barrier. The upper edge must be stapled, tied or otherwise fastened to the brush barrier. Edges of adjacent fabric pieces must overlap each other. See Figure 6.20.3

Silt Fence

The manufacturer shall have either an approved color mark yarn in the fabric or label the fabricated silt fence with both the manufacturer and fabric name every 100 feet.

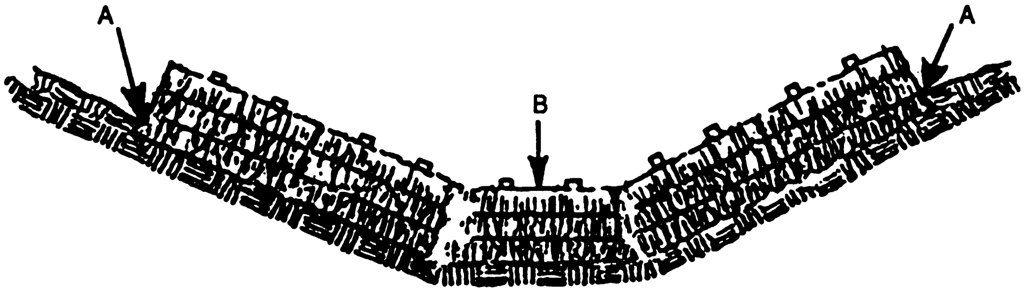
The temporary silt fence shall be installed according to this specification, as shown on the plans or as directed by the engineer. For installation of the fabric, see Figures 6-20.4, 6-20.5, and 6-20.6 respectively.

Post installation shall start at the center of the low-point (if applicable) with remaining posts spaced 6 feet apart for Type A and B silt fences and 4 feet apart for Type C silt fence. While Type A and B silt fences can be used with both wood and steel posts, only steel posts shall be used with Type C silt fence. For post size requirements, see Table 6-20.3. Fasteners for wood posts are listed in Table 6-20.4.

Along stream buffers and other sensitive areas, two rows of Type C silt fence or one row of Type C silt fence backed by haybales shall be used.

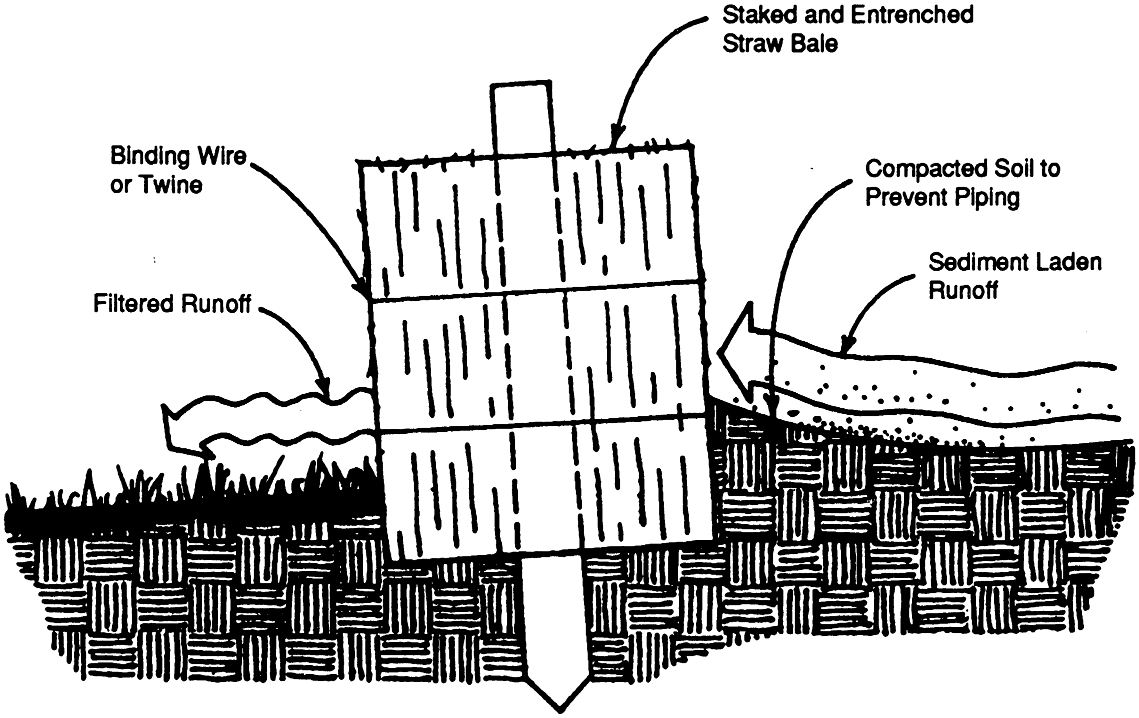
MAINTENANCE

Sediment shall be removed once it has accumulated to one-half the original height of the barrier. Filter fabric shall be replaced whenever it has deteriorated to such an extent that the effectiveness of the fabric is reduced (approximately six months). Temporary sediment barriers shall remain in place until disturbed areas have been permanently stabilized. All sediment accumulated at the barrier shall be removed and properly disposed of before the barrier is removed.



Points A should be higher than point B

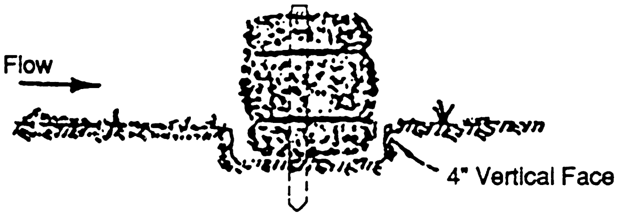
PROPER PLACEMENT OF STRAW BALE BARRIER IN DRAINAGE WAY



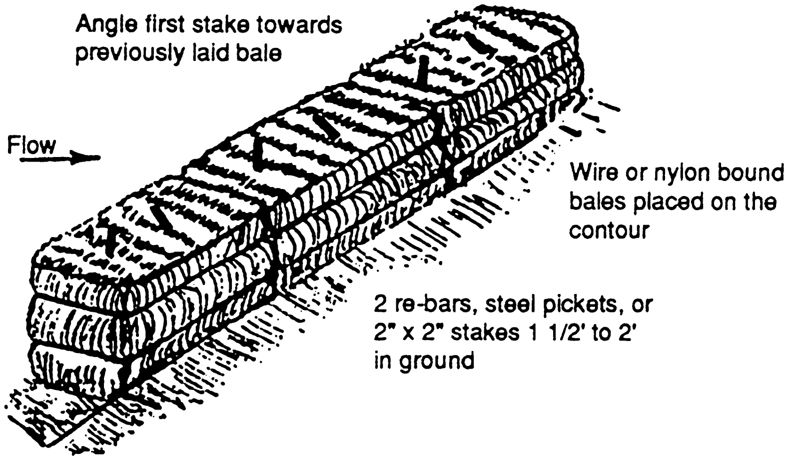
<u>Note:</u> Embed hay bales a minimum of 4 inches.

CROSS-SECTION OF A PROPERLY INSTALLED STRAW BALE

Figure 6-20.1



EMBEDDING DETAIL



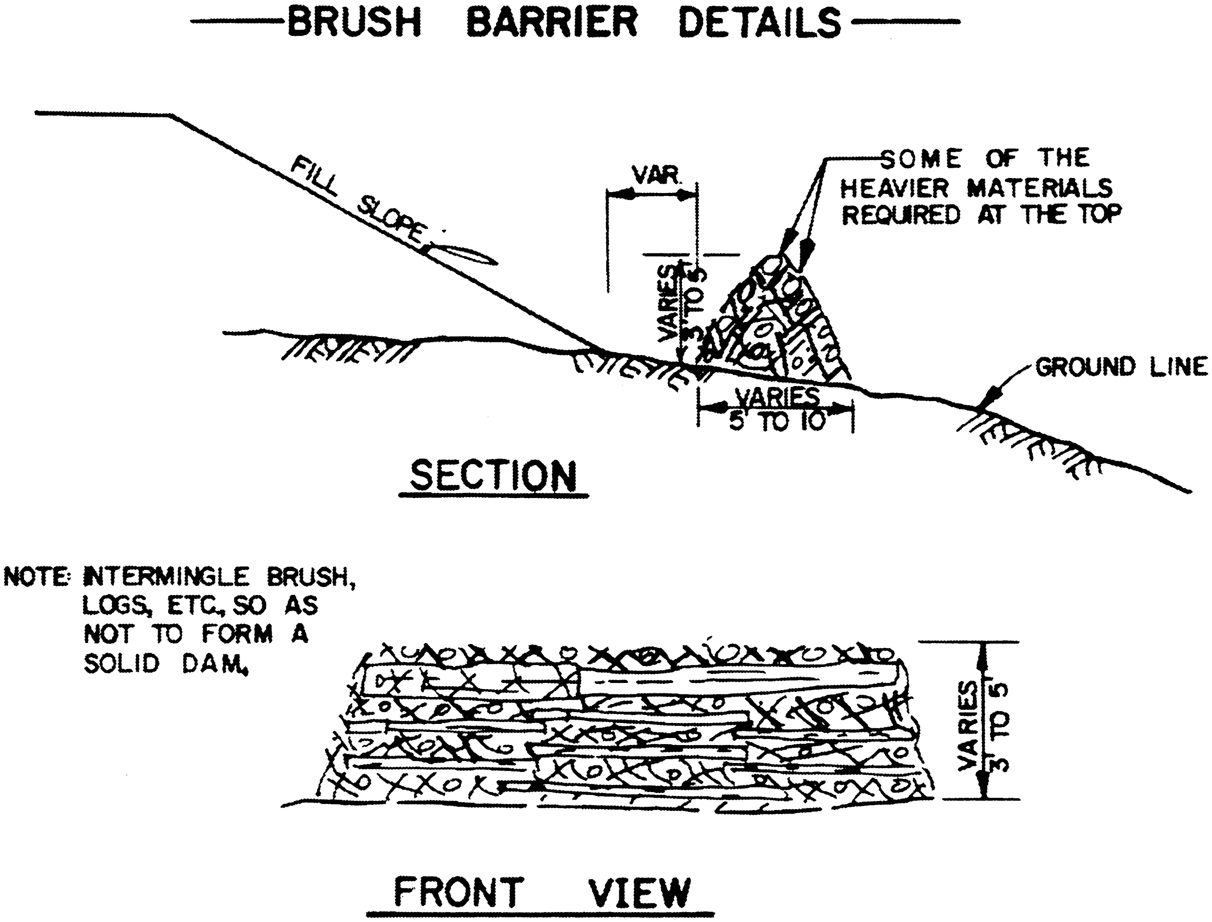
ANCHORING DETAIL

NOTE:

- Anchor and embed into soil to prevent washout or water working under barrier
- Repair or replacement must be made promptly as needed

STAKED HAYBALE BARRIERS

Figure 6-20.2



NOTE: INTERMINGLE BRUSH, LOGS, ETC., SO AS NOT TO FORM A SOLID DAM.

Figure 6-20.3

POST SIZE

Table 6-20.3

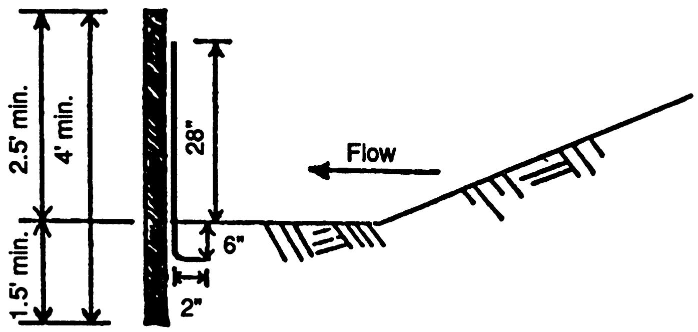
	Minimum Length	Type of Post	Size of Post
Type A	4'	Soft wood	3" dia. or 2x4
		Oak	1.5" x 1.5"
		Steel	1.3lb./ft. min.
Type B	3'	Soft wood	2" dia. or 2x2
		Oak	1" x 1"
		Steel	.75lb./ft. min.
Type C	4'	Steel	1.3lb./ft. min.

FASTENERS FOR WOOD POSTS

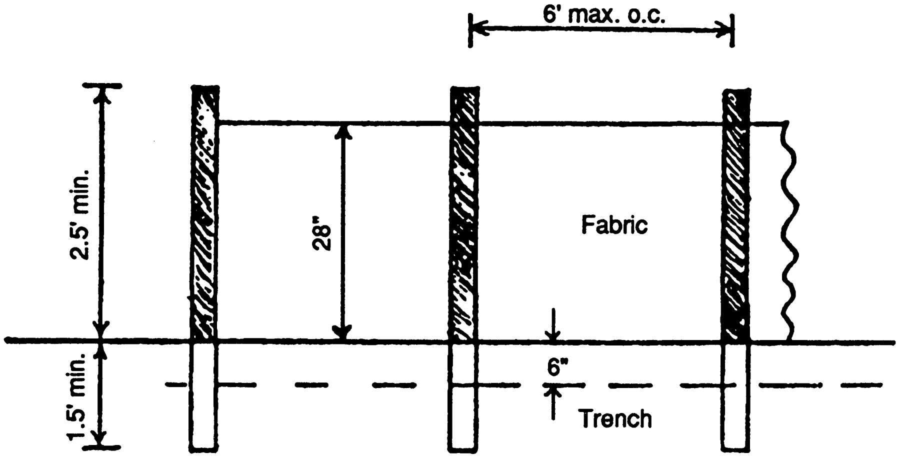
Table 6-20.4

	Gauge	Crown	Legs	Staples/Post
Wire Staples	17 min.	3/4" wide	1/2" long	5 min.
	Gauge	**Length**	**Button Heads**	**Nail/Post**
Nails	14 min.	1"	3/4"	4 min.

Note: Filter fabric may also be attached to the post by wire, cord, and pockets.



SIDE VIEW

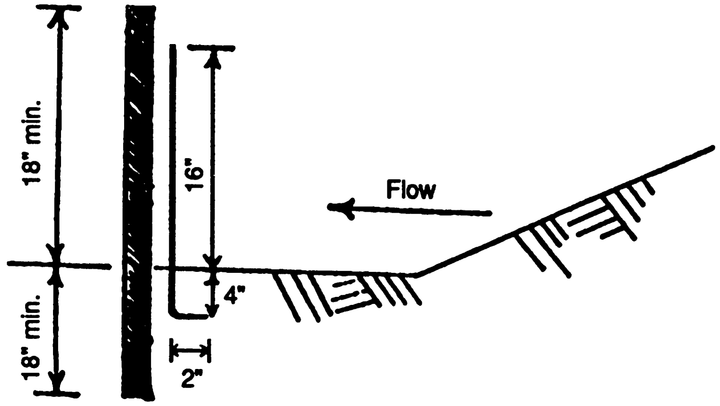


FRONT VIEW

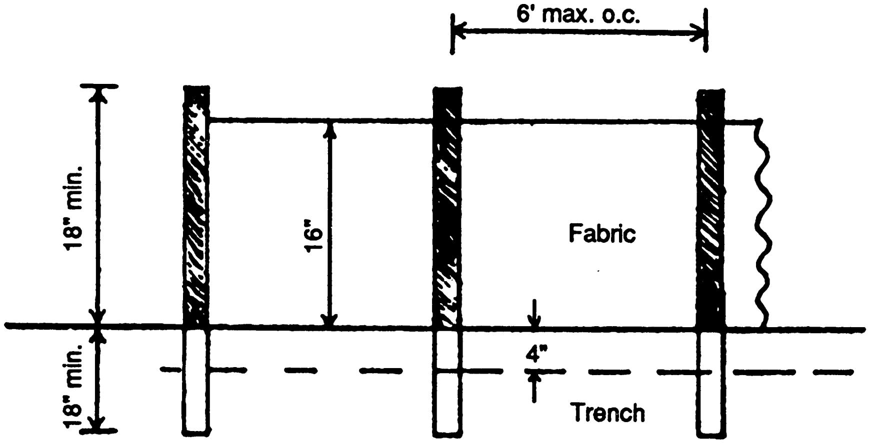
NOTE:
Use 36" D.O.T. approved fabric.
Use wood or steel posts.

SILT FENCE - TYPE A

Figure 6-20.4



SIDE VIEW

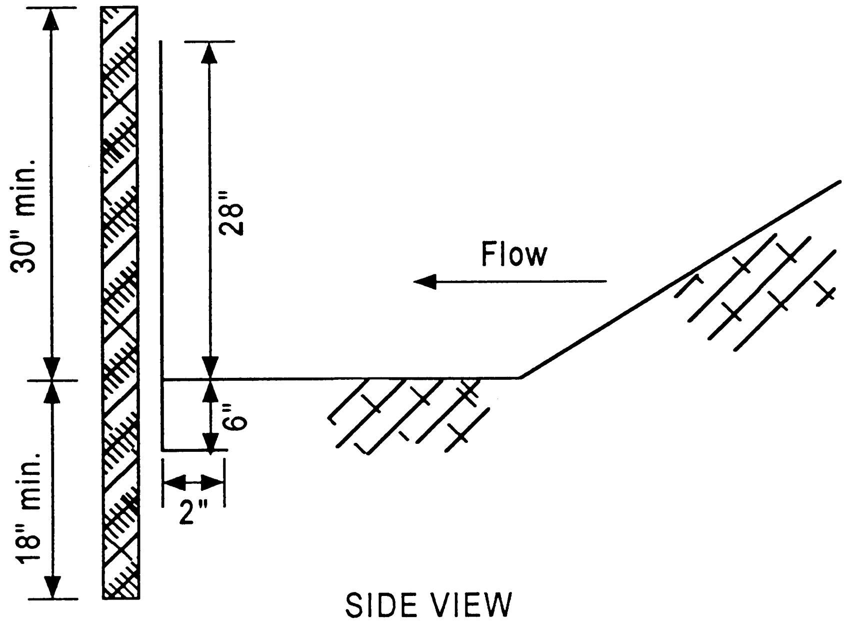


FRONT VIEW

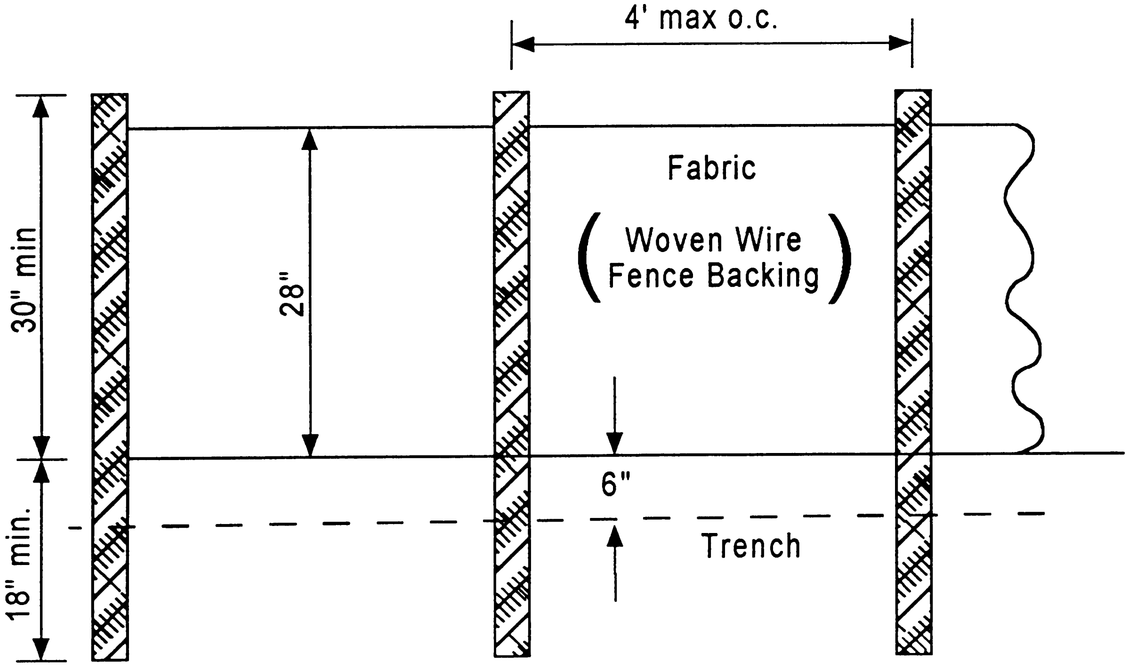
NOTE:
Use 22" D.O.T. approved fabric.
Use wood or steel posts.

SILT FENCE - TYPE B

Figure 6-20.5



SIDE VIEW

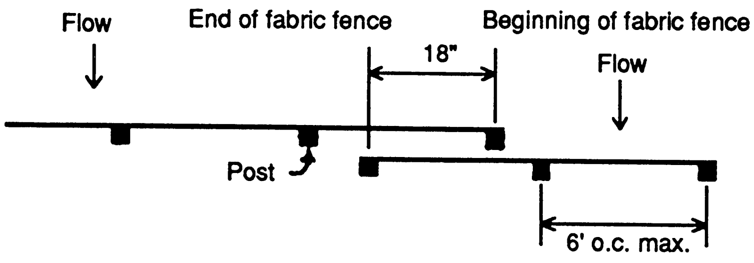


FRONT VIEW

NOTE:
Use 36" D.O.T. approved fabric.
Use steel posts.- only

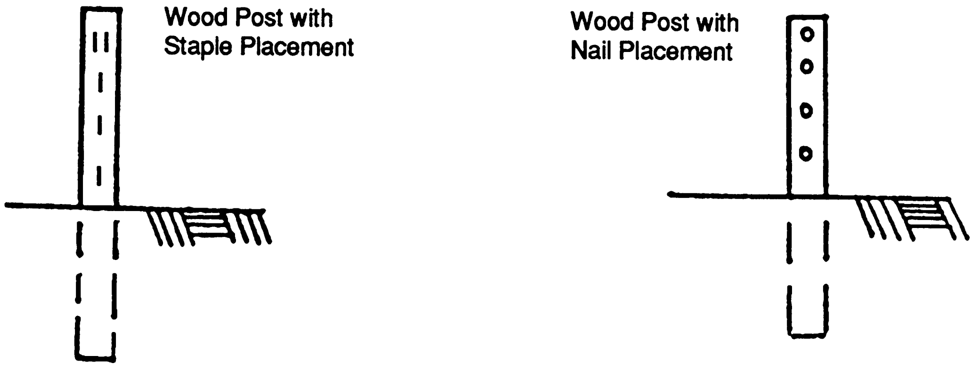
SILT FENCE - TYPE C

Figure 6-20.6



TOP VIEW - (Not to scale)

OVERLAP AT FABRIC ENDS



FRONT VIEWS

FASTENERS FOR SILT FENCES

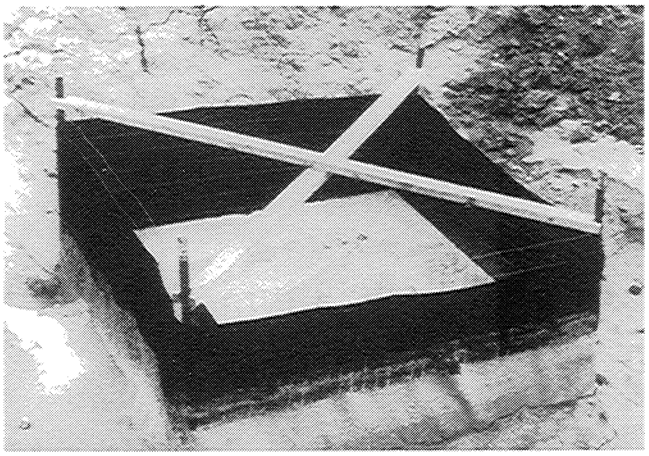
Figure 6-20.7

Table 6-20.5

TYPE FENCE	A	B	C
Tensile Strength (Lbs. Min.) (1) (ASTM D-4632)	Warp - 120 Fill - 100	Warp - 120 Fill - 100	Warp - 260 Fill - 180
Elongation (% Max.) (ASTM D-4632)	40	40	40
AOS (Apparent Opening Size) (Max. Sieve Size) (ASTM D-4751)	#30	#30	#30
Flow Rate (Gal/Min/Sq. Ft.) (GDT-87)	25	25	70
Ultraviolet Stability (2) (ASTM D-4632 after 300 hours weathering in accordance with ASTM D-4355)	80	80	80
Bursting Strength (PSI Min.) (ASTM D-3786 Diaphragm Bursting Strength Tester)	175	175	175
Minimum Fabric Width (Inches)	36	22	36

(1) Minimum roll average of five specimens.
(2) Percent of required initial minimum tensile strength.

Inlet Sediment Trap (Sd2)



DEFINITION

A temporary protective device formed around a storm drain drop inlet to trap sediment.

PURPOSE

To prevent sediment from leaving the site, or from entering storm drainage systems, prior to permanent stabilization of the disturbed area.

CONDITIONS

Sediment traps should be installed at or around all storm drain drop inlets that receive runoff from disturbed areas.

DESIGN CRITERIA

Many sediment filtering devices can be designed to serve as temporary sediment traps. Sediment traps must be self-draining unless they are otherwise protected in an approved fashion that will not present a safety hazard. *The drainage area entering the inlet sediment trap shall be no greater than one acre.*

If runoff may bypass the protected inlet, a temporary dike should be constructed on the down slope side of the structure. Also, a stone filter ring may be used on the up slope side of the inlet to slow runoff and filter larger soil particles. Refer to **Fr - Stone Filter Ring**.

Excavated Inlet Sediment Trap

An excavation may be created around the inlet sediment trap to provide additional sediment storage. The trap shall be sized to provide a minimum storage capacity calculated at the rate of 67 cubic yards per acre of drainage area. A minimum depth of 1.5 feet for sediment storage should be provided. Side slopes shall not be steeper than 2:1.

CONSTRUCTION SPECIFICATIONS

Sediment traps may be constructed on natural ground surface, on an excavated surface, or on machine compacted fill provided they have a non-erodible outlet.

Filter Fabric with Supporting Frame (Sd2-F)

This method of inlet protection is applicable where the inlet drains a relatively flat area (slope no greater than 5%) and shall not apply to inlets receiving concentrated flows, such as in street or highway medians. As shown in Figure 6-21.1, Type C silt fence supported by steel posts shall be used. The stakes shall be spaced evenly around the perimeter of the inlet a maximum of 3 feet apart, and securely driven into the ground, approximately 18 inches deep. The fabric shall be entrenched 12 inches and backfilled with crushed stone or compacted soil. Fabric and wire shall be securely fastened to the posts, and fabric ends must be overlapped a minimum of 18 inches or wrapped together around a post to provide a continuous fabric barrier around the inlet.

Baffle Box (Sd2-B)

For inlets receiving runoff with a higher volume or velocity, a baffle box inlet sediment trap should be used. As shown in Figure 6-21.2, the baffle box shall be constructed of 2" x 4" boards spaced a maximum of 1 inch apart or of plywood with weep holes 2 inches in diameter. The weep holes shall be placed approximately 6 inches on center vertically and horizontally. Gravel shall be placed outside the box, all around the inlet, to a depth of 2 to 4 inches. The entire box is wrapped in Type C filter fabric that shall be entrenched 12 inches and backfilled.

Block and Gravel Drop Inlet Protection (Sd2-Bg)

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. As shown in Figure 6-21.3, one block is placed on each side of the structure on its side in the bottom row to allow pool drainage. The foundation should be excavated at least 2 inches below the crest of the storm drain. The bottom row of blocks are placed against the edge of the storm drain for lateral support and to avoid washouts when overflow occurs. If needed, lateral support may be given to subsequent rows by placing 2" x 4" wood studs through block openings. Hardware cloth or comparable wire mesh with 1/2 inch openings shall be fitted over all block openings to hold gravel in place. Clean gravel should be placed 2 inches below the top of the block on a 2:1 slope or flatter and smoothed to an even grade. DOT #57 washed stone is recommended.

Gravel Drop Inlet Protection Sd2-G

This method of inlet protection is applicable where heavy concentrated flows are expected. As shown in Figure 6-21.4, stone and gravel are used to trap sediment. The slope toward the inlet shall be no steeper than 3:1. A minimum 1 foot wide level stone area shall be left between the structure and around the inlet to prevent gravel from entering the inlet. On the slope toward the inlet, stone 3 inches in diameter and larger should be used. On the slope away from the inlet, 1/2 to 3/4 inch gravel (#57 washed stone) should be used at a minimum thickness of 1 foot.

Sod Inlet Protection Sd2-S

This method of inlet protection is applicable only at the time of permanent seeding, to protect the inlet from sediment and mulch material until permanent vegetation has become established. As shown in Figure 6-21.6, the 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. Sod strips shall be staggered so that adjacent strip ends are not aligned.

Excavated Inlet Sediment Trap

The sediment trap shall be placed immediately around the inlet. The excavation shall be constructed immediately outside of the sediment trap and provide a minimum depth of 1.5 feet for sediment storage.

Curb Inlet Protection Sd2-P

Once pavement has been installed, a curb inlet filter shall be installed on inlets receiving runoff from disturbed areas. **This method of inlet protection shall be removed if a safety hazard is created.**

One method of curb inlet protection uses "pigs-in-a-blanket" - 8-inch concrete blocks wrapped in filter fabric. See Figure 6-21.5. Another method uses gravel bags constructed by wrapping DOT #57 stone with filter fabric, wire, plastic mesh, or equivalent material.

A gap of approximately 4 inches shall be left between the inlet filter and the inlet to allow for overflow and prevent hazardous ponding in the roadway. *Proper installation and maintenance are crucial due to possible ponding in the roadway, resulting in a hazardous condition.*

Several other methods are available to prevent the entry of sediment into storm drain inlets. Figure 6-21.7 shows of one of these alternative methods.

MAINTENANCE

The trap shall be inspected daily and after each rain and repairs made as needed.

Sediment shall be removed when the sediment has accumulated to one-half the height of the trap. Sediment shall be removed from curb inlet protection immediately. For excavated inlet sediment traps, sediment shall be removed when one-half of the sediment storage capacity has been lost to sediment accumulation. Sod inlet protection shall be maintained as specified in **Ds4 - Disturbed Area Stabilization (With Sodding)**.

Sediment shall not be washed into the inlet. It shall be removed from the sediment trap and disposed of and stabilized so that it will not enter the inlet, again.

When the contributing drainage area has been permanently stabilized, all materials and any sediment shall be removed, and either salvaged or disposed of properly. The disturbed area shall be brought to proper grade, then smoothed and compacted. Appropriately stabilize all disturbed areas around the inlet.

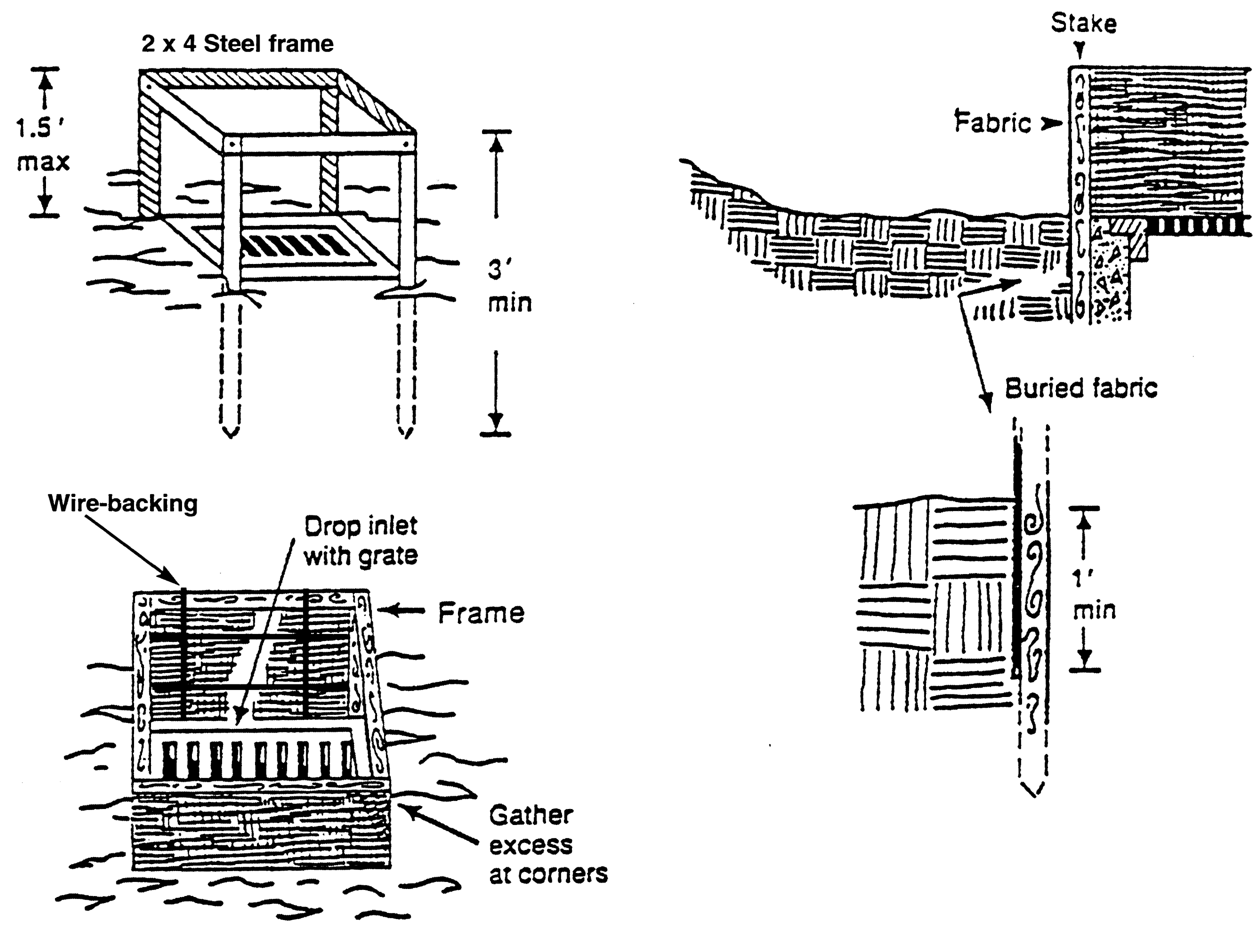
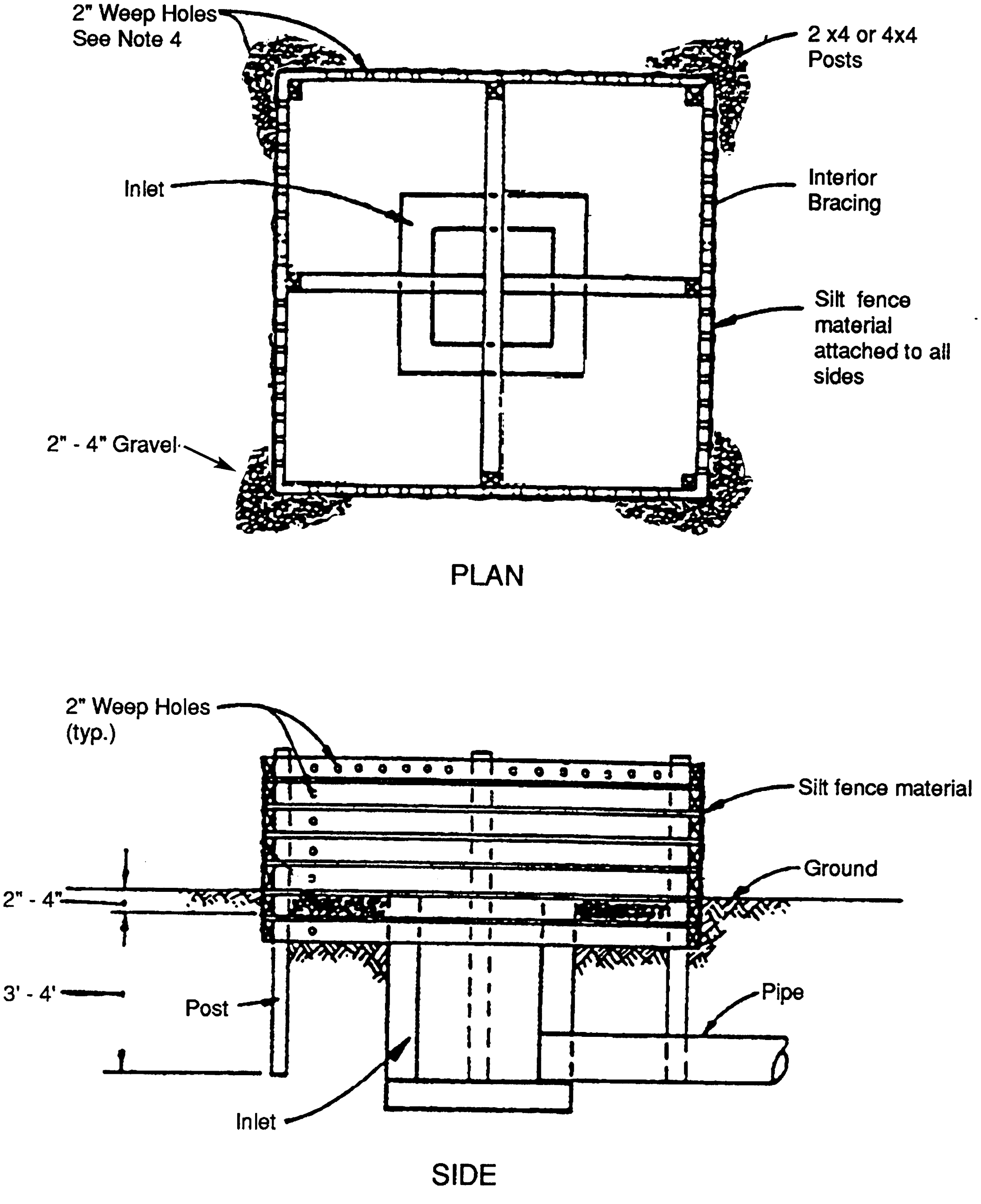
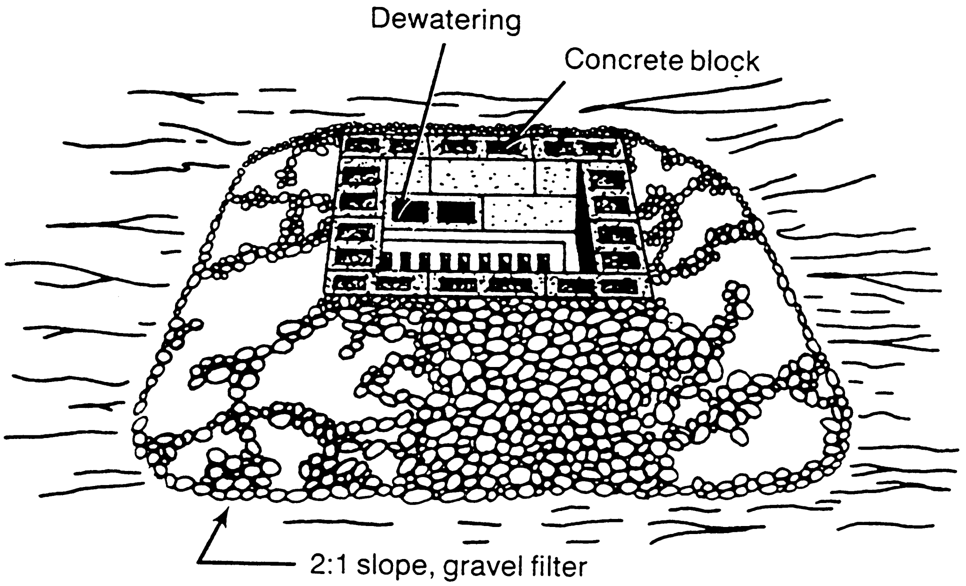


Figure 6-21.1 - Fabric and supporting frame for inlet projection



BAFFLE BOX

Figure 6-21.2



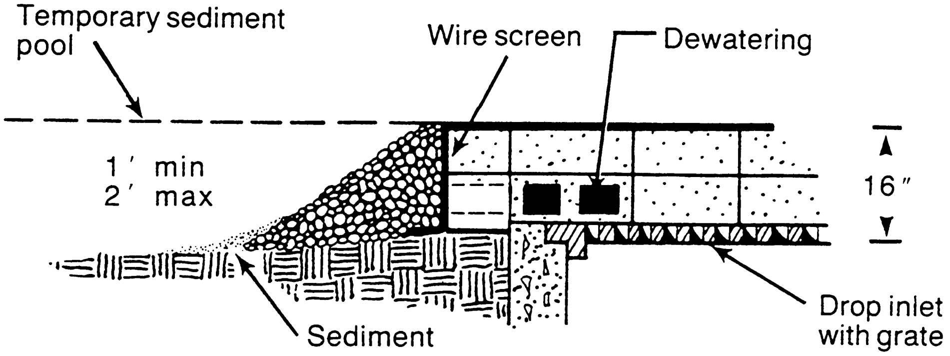


Figure 6-21.3– **Block and gravel drop inlet protection**

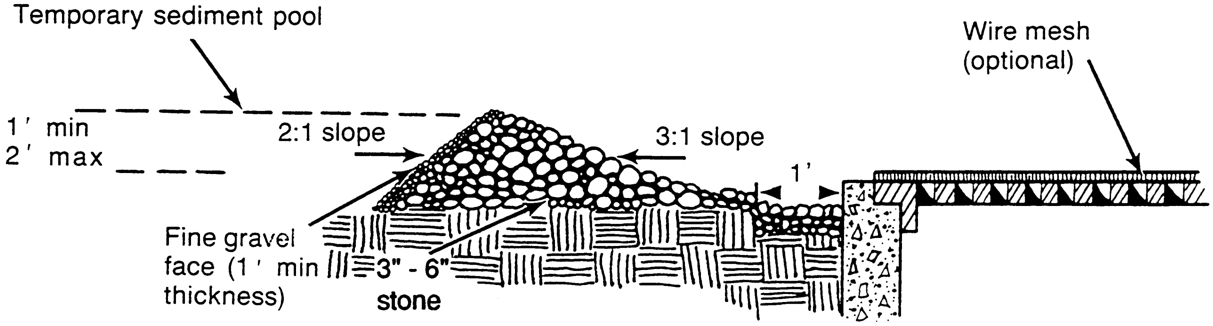
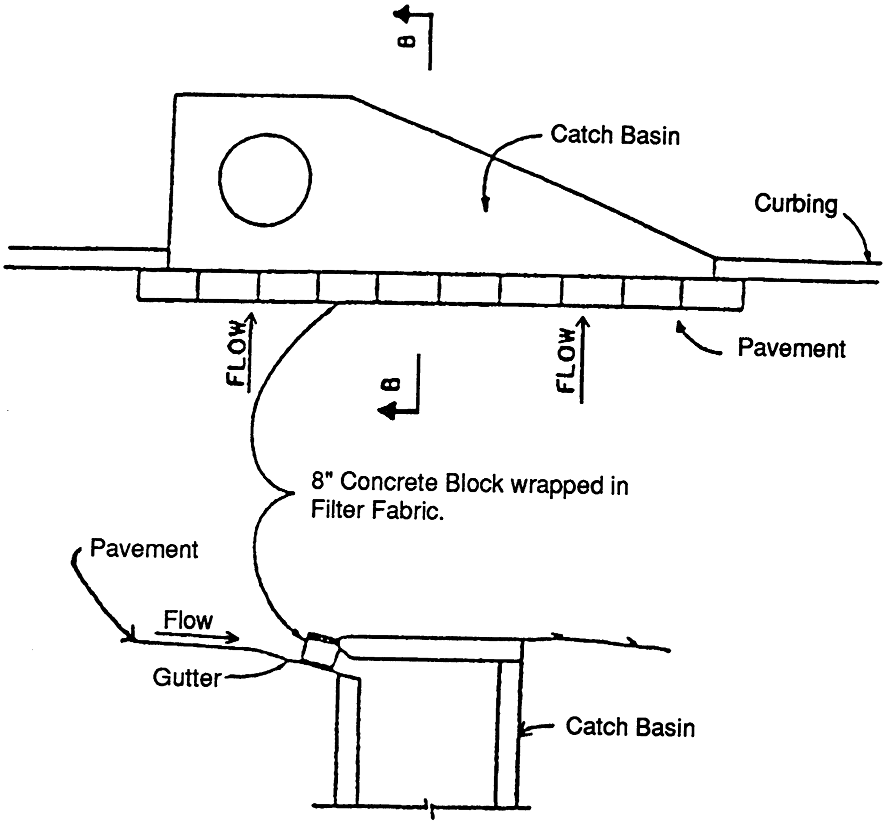


Figure 6-21.4 – **Gravel drop inlet protection (gravel donut)**



SECTION B-B

NOTE:
Install filter after any asphalt pavement installation.

CURB INLET FILTER
"PIGS IN BLANKET"

Figure 6-21.5

Figure 6-14.6 – Sod strips protect inlet area from erosion (source: Va SWCC)

Figure 6-21.7 - Alternative inlet sediment trap

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

If the **EXCAVATED INLET SEDIMENT TRAP** is used, show the following information:

1. **Drainage area** =______ ac
2. Required sediment storage = 67 cy/ac * drainage area
   Required sediment storage = 67 cy/ac * _____ ac
   Required sediment storage = _____ cy = ______ cf
3. Assume excavation **depth** (minimum of 1.5 ft.) =______ ft
4. Assume **slope of sides** (shall not be steeper than 2:1) =__:1
5. Determine required surface area
   SA_{min} = Required sediment storage / excavation depth
   SA_{min} = _____ cy /______ ft
   SA_{min} = _____ sf
6. Assume shape of excavation and determine dimensions.
   (A rectangular shape with 2:1 length to width ratio is recommended.)
   Shape: ________
   Dimensions: l =_____ ft w =_____ ft diameter (*if applicable*) = _____ft

Provide a detail showing the depth, length and width, or diameter *(if applicable)*, and side slopes of the excavation.

Temporary Sediment Basin

Sd3

DEFINITION

A basin created by the construction of a barrier or dam across a concentrated flow area or by excavating a basin or by a combination of both. A sediment basin typically consists of a dam, a pipe outlet, and an emergency spillway. The size of the structure will depend upon the location, size of the drainage area, soil type, and rainfall pattern.

PURPOSE

To detain runoff waters and trap sediment from erodible areas in order to protect properties and drainage ways below the installation from damage by excessive sedimentation and debris. The water is temporarily stored and the bulk of the sediment carried by the water drops out and is retained in the basin while the water is automatically released.

CONDITIONS

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, erosion, and sedimentation. The structure may be used in combination with other practices and should remain in effect until the sediment-producing area is permanently stabilized.

This standard applies to the installation of temporary (to be removed within 18 months) 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, and (2) the drainage area does not exceed 150 acres.

DESIGN CRITERIA

Compliance With Laws and Regulations

Design and construction shall comply with state and local laws, ordinances, rules and regulations. Basins shall be constructed according to the approved erosion and sediment control plan unless modified by the design engineer.

Location

Sediment basins shall never be placed in live streams. They should be located so that storm drains discharge into the basin. The sediment basin should be located to obtain the maximum storage benefit from the terrain and for ease of clean-out of the trapped sediment. It should be located to minimize interference with construction activities and construction of utilities.

Volume

The sediment storage volume of the basin, as measured to the elevation of the crest of the principal spillway, shall be at least 67 cubic yards per acre for the disturbed area draining into the basin (67 cubic yards is equivalent to 1/2 inch of sediment per acre of drainage area). *The entire drainage basin area should be used for this computation*, rather than the disturbed area alone, to help ensure adequate trapping efficiency. *Sediment shall be removed from the basin when approximately one-third of the storage volume has been lost to sediment accumulation.* This volume shall be marked on the riser or by setting a marked post near the riser.

Surface Area

Studies (Barfield and Clar, 1985) indicate that the following relationship between surface area and peak inflow rate gives a trapping efficiency from greater than 75% for clay loam to 95% for loamy sandy soils.

$$A = 0.01q$$

where A is basin surface area in acres and q is peak inflow rate in cfs. Area is measured at the crest of the principal spillway riser. The minimum peak inflow rate is determined from a 2-year, 24-hour storm.

Shape

It is recommended that the designer of a sediment basin incorporate features to maximize detention time within the basin. Suggested methods of accomplishing this objective are:

1. Length to width ratio greater than 2:1, where length is the distance between the inlet and outlet.
2. A wedge shape with the inlet located at the narrow end.
3. Installation of baffles or diversions.

Procedure for Determining or Altering Sediment Basin Shape

As specified in the Standard and Specification, the pool area at the elevation of crest of the principal spillway shall have a length to width ratio of at least 2:1. The purpose of this requirement is to minimize the "short-circuiting" effect of the sediment-laden inflow to the riser and thereby increasing the effectiveness of the sediment basin. The purpose of this procedure is to prescribe the parameters, procedures and methods of determining and modifying the shape of basin.

The length of the flow path (L) is the distance from the point of inflow to the riser (outflow point). The point of inflow is the point that the stream enters the normal pool (pool level at the riser crest elevation). The pool area (A) is the area of the normal pool. The effective width (We) is equal to the Area (A) divided by the length (L). The length to width ratio (L:W) is found by the equation:

L:W = l/We where We = A/L

In the event there is more than one inflow point, *any inflow point which conveys more than 30 percent of the total peak inflow rate shall meet the length-width ratio criteria.*

The required basin shape may be obtained by proper site selection, by excavation, or by constructing a baffle in the basin. The purpose of the baffle is to increase the effective flow length from the inflow point to the riser. Baffles shall be placed mid-way 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 (Le) shall be the shortest distance the water must flow from the inflow point around the end of the baffle to the outflow point. Then:

L:W = Le / We where We = A/Le

Three examples are shown on the following pages. Note that for the special case in example C the water is allowed to go around both ends of the baffle and the effective length, Le = L1a + L1b = L2a + L2d. Otherwise, the length-width ratio computations are the same as shown above. This special case procedure for computing Le is allowable only when the two flow paths are equal, *i.e.*, when L1 = L2. A baffle detail is also shown. For examples of sediment basin baffles, refer to Figure 6-22.2.

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

Spillways

Runoff may be computed by the method outlined in Appendix A. Other approved equivalent methods may be used. Runoff computations shall be based upon the worst 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 frequency storm.* Even if the principal spillway is designed to convey the peak rate of runoff from a 25-year, 24,-hour storm, an emergency spillway shall be present.

1. **Principal spillway** - A spillway consisting of a vertical pipe or box type riser joined (watertight connection) to a pipe which shall extend through the embankment and outlet beyond the downstream toe of the fill shall be provided. See figure 6-22.3. The metal gauge thickness shall comply with DOT or NRCS specifications. The discharge shall be based on a 2-year, 24-hour storm for the total drainage area without causing flow through the emergency spillway. The appropriate disturbed soil cover condition shall be used. *The minimum size of the pipe shall be 8 inches in diameter.* Principal spillway capacities may be determined from Table 6-22.1. Weir flow discharge above the crest of the riser may be determined from Table 6-22.2. Principal spillway pipe, riser pipe, and trash rack proportions are shown in Table 6-22.2.

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

c. **Dewatering the basin** - Retention time within the basin is an important factor in effective sediment retention. The method used to dewater the sediment basin may be selected from the following two methods:

Perforated Riser Pipe The perforated riser pipe is the conventional method for dewatering a sediment basin. The lower half of the riser is perforated with 1/2-inch holes spaced approximately 3-inches apart. It is covered with two feet of 3 to 4 inch stone.

Skimmer Outlet The skimmer-type dewatering device operates at the surface of the ponded water and will not withdraw sediment from the submerged volume of the basin. As compared to conventional perforated risers, skimmers discharge a 45 percent less mass of sediment. However, skimmers are mechanically more complex and will require frequent inspection and maintenance in order to operate as designed. See Figure 6-22.4.

d. **Trash rack and anti-vortex device** - A trash rack and anti-vortex device shall be securely installed on top of the riser and may be the type as shown in Figure 6-22.5.

e. **Base** - The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. *A concrete base 18" thick with the riser embedded 9-inches in the base is recommended.* Computations shall be made to design a base which will prevent flotation. See Figure 6-22.6 and Table 6-22.3 for details.

f. **Anti-Seep Collars** - One anti-seep collar shall be installed around the pipe, near the center of the dam, when **any** of the following conditions exist:

1. The settled height of the dam is greater than 15 feet.
2. The conduit is smooth pipe larger than 8" in diameter.
3. The conduit is corrugated metal pipe larger than 12" in diameter.

Use an anti-seep collar with an 18-inch projection for heads (H) less than or equal to 10 feet and a 24-inch projection for heads (H) greater than 10 feet. The anti-seep collar and its connection shall be watertight.

g. **Outlet** - An outlet shall be provided, including a means of conveying the discharge in an erosion-free manner to an existing stable area. 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 pipe spillway shall be provided. Measures may include excavated plunge pools, riprap, impact basins, revetments, or other approved methods. Refer to specification **St - Storm Drain Outlet Protection**.

h. For typical features of a temporary sediment basin, see Figure 6-22.1.

2. **Emergency Spillway** - *The entire flow area of the emergency spillway shall be constructed in undisturbed ground (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. See Figure 6-22.7.

a. **Capacity** - The minimum capacity of the emergency spillway shall be that *required to pass the peak rate of runoff from the 25-year, 24-hour frequency storm, less any reduction due to flow in the principal spillway.* The appropriate disturbed soil cover condition shall be used. Emergency spillway dimensions may be determined by using the method described in this section. Refer to Table 6-22.4 and Figure 6-22.7.

b. **Velocities** - *The velocity of flow in the exit channel shall not exceed 5 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. Vegetation, riprap, asphalt or concrete shall be provided to prevent erosion. Refer to specification **Ch - Channel Stabilization**.

c. **Freeboard** - Freeboard is the difference between the design high water elevation in the emergency spillway and the top of the settled embankment. *The freeboard shall be at least one foot.*

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. Refer to **St - Storm Drain Outlet Protection**.

CONSTRUCTION SPECIFICATIONS

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 approved methods. In order to facilitate clean-out or restoration, the pool area (measured at the top of the pipe spillway) will be cleared of all brush and trees.

Cut-off Trench

A cut-off trench will be excavated along the centerline of earth fill embankments. *The minimum depth shall be 2 feet.* The cut-off trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 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 compaction operations.

Embankment

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 be placed in the downstream section of the embankment. Areas on which fills are to be placed shall be scarified prior to placement of fill. The fill material shall contain sufficient moisture so that it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. *Fill material shall be placed in six-inch to eight-inch thick continuous layers over the entire length of the fill.* Compaction shall be obtained by routing and hauling the construction equipment over the fill so that the entire surface of the fill is traversed by at least one wheel or tread track of the equipment or by the use of a compactor. *The embankment shall be constructed to an elevation 5 percent higher than the design height to allow for settlement.*

Principal Spillway

The riser shall be securely attached to the pipe or pipe stub by welding the full circumference making a watertight structural connection. The pipe stub must be attached to the riser at the same percent (angle) of grade as the outlet conduit. The connection between the riser and the riser base shall be watertight. All connections between pipe sections must be achieved by approved watertight band assemblies The pipe and riser shall be placed on a firm, smooth foundation of impervious soil as the embankment is constructed. Breaching the embankment is unacceptable. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the pipe or anti-seep collar. *The fill material around the pipe spillway shall be placed in four inch layers and compacted under and around the pipe to at least the same density as the adjacent embankment.* Care must be taken not to raise the pipe from firm contact with its foundation when compacting under the pipe haunches. A minimum depth of two feet of hand compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment.

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. If the emergency spillway requires erosion protection other than vegetation, *the lining shall not compromise the capacity of the emergency spillway, e.g.* the emergency spillway shall be over-excavated so that the lining will be flush with the slope surface.

Vegetative Treatment

Stabilize the embankment and all other disturbed areas in accordance with the appropriate permanent vegetative measure, Ds3, immediately following construction. *In no case shall the embankment remain unstabilized for more than seven (7) days.* Refer to specifications **Ds2, Ds3, and Ds4 - Disturbed Area Stabilization (Temporary Seeding, Permanent Vegetation, and Sodding)** respectively.

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 law 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.

MAINTENANCE

Repair all damages caused by soil erosion or construction equipment 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. *Sediment shall not enter adjacent streams or drainageways during sediment removal or disposal.* The sediment shall not be deposited downstream from the embankment, adjacent to a stream or floodplain.

FINAL DISPOSAL

When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with approved sediment control plan. The proposed use of a sediment basin site will often dictate final disposition of the basin and any sediment contained therein. *If the site is scheduled for future construction, then the embankment and trapped sediment must be removed, safely disposed of, and backfilled with a structural fill.* When the basin area is to remain open space, the pond may be pumped dry, graded and backfilled.

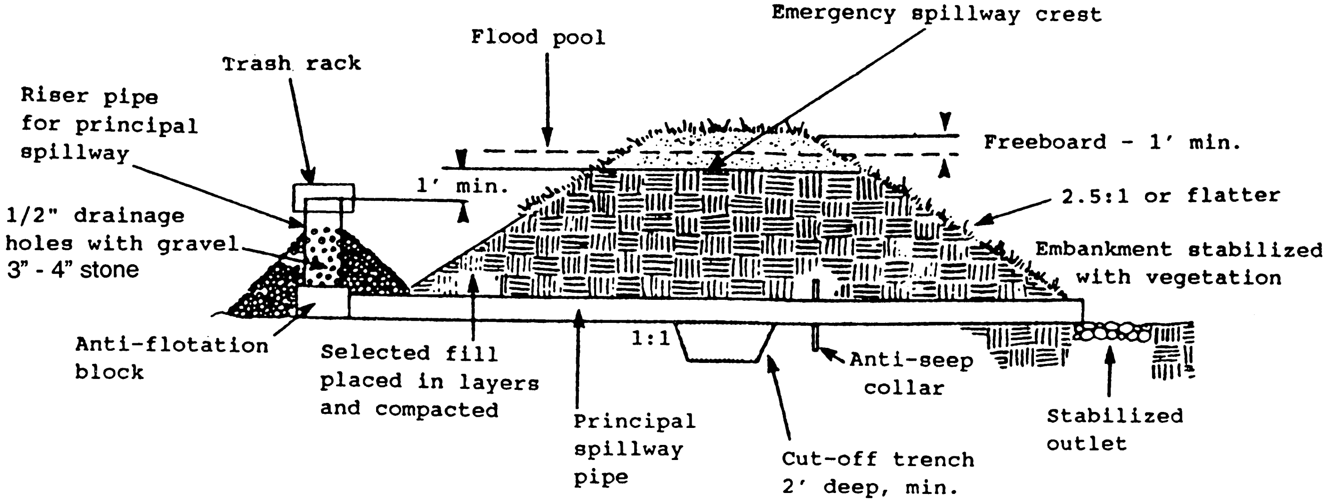
TO BE SUBMITTED WITH/ON THE EROSION AND SEDIMENT CONTROL PLAN

ON THE E&SC PLAN

1. The specific location of the basin, showing existing and proposed contours.
2. Maintenance equipment access points.
3. Completed Figures 6-22.8 and 6-22.9. (details for the cross section of dam, principal spillway, and emergency spillway, and profile of emergency spillway).
4. Details of trash rack, concrete riser base, and outlet structure assembly. (Refer to Figures 6-22.4 to 6-22.7.

ON 8 1/2" X 11" SHEET(S)

1. Hydrological study, including information regarding stage/storage relationship.
2. Temporary sediment basin design sheet, p.6-168 to 6-170.
3. Completed Figures 6-22.8 and 6-22.9 (details for the cross section of the dam, principal spillway, and emergency spillway, and profile of emergency spillway).

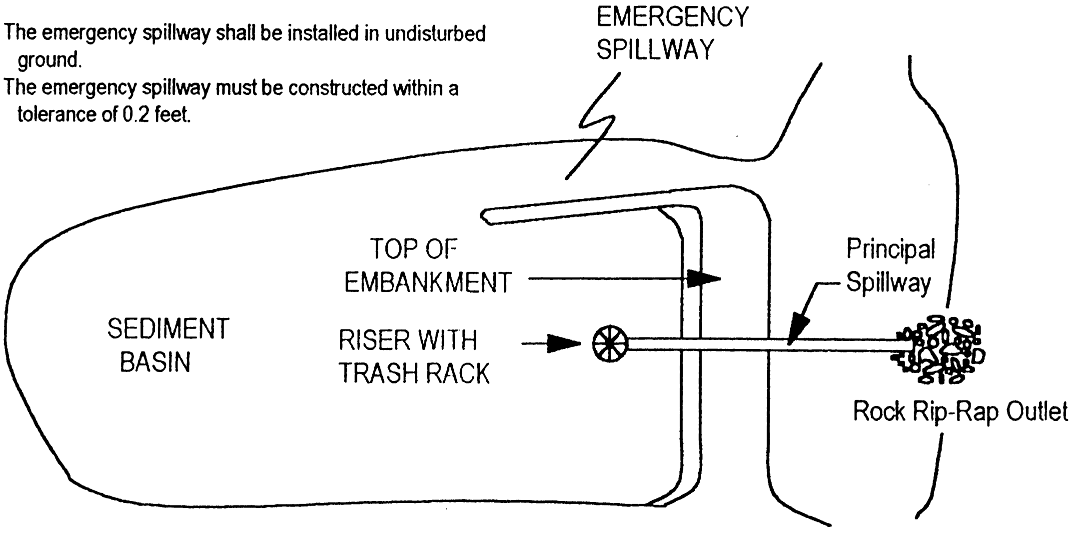


CROSS SECTION

Fill Height	Minimum Top Width
less than 10 ft	8.0 ft
10 feet to 15 ft	10.0 ft

NOTES:

1. The emergency spillway shall be installed in undisturbed ground.
2. The emergency spillway must be constructed within a tolerance of 0.2 feet.



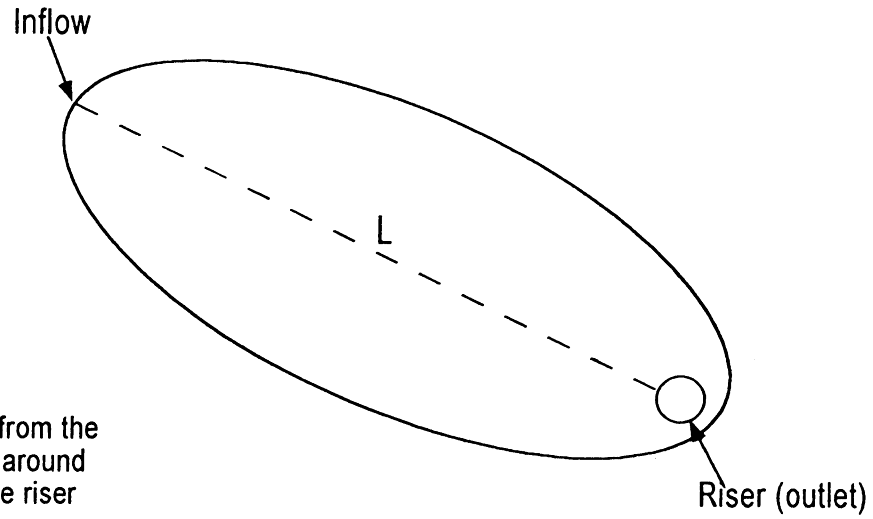
PLAN VIEW

Figure 6-22.1 - Basic components of a temporary sediment basin.

SEDIMENT BASIN BAFFLES

Examples: Plan Views - not to scale

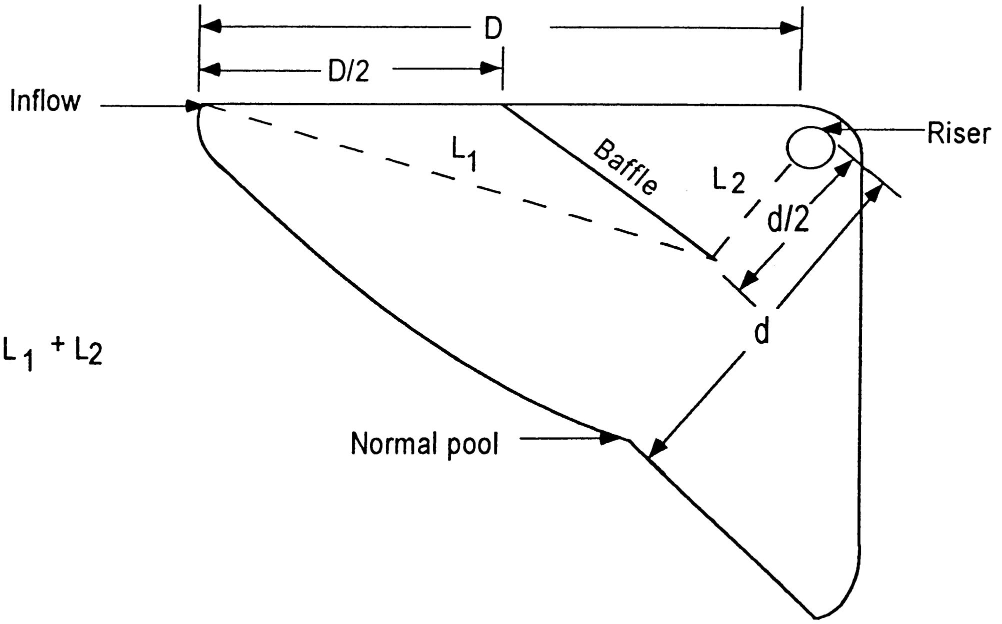
A.



$L_e = L$

L_e = Total distance from the point of inflow around the baffle to the riser

B.



$L_e = L_1 + L_2$

Figure 6-22.2

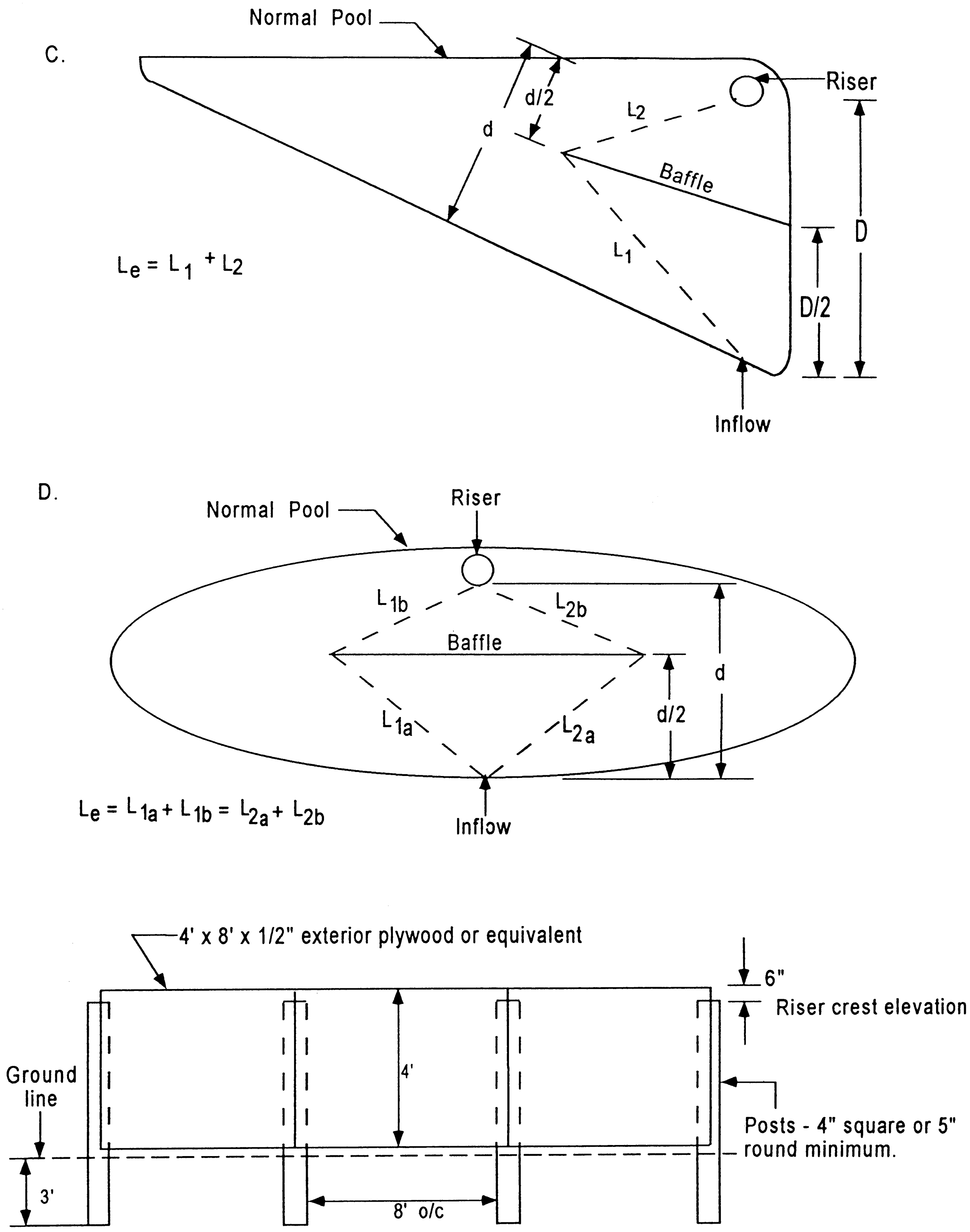
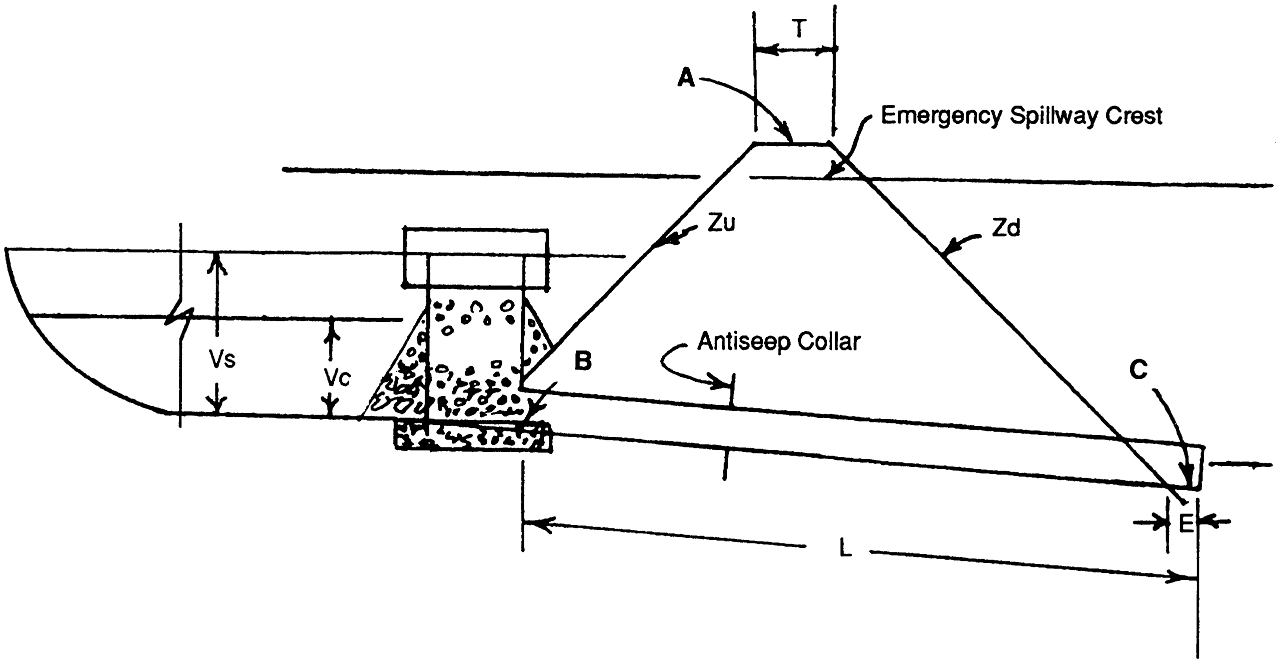


Figure 6-22.2 continued



PRINCIPAL SPILLWAY DESIGN

T = Top width of dam, ft.

Zu = Upstream side slope

Zd = Downstream side slope

A = Top of dam elevation

B = Lowest elevation of pipe at riser

C = Lowest elevation of pipe at outlet

E = Extended length of pipe beyond toe of dam

L = Total length of pipe, ft.

$L = [A - (B + C) / 2]\ [Zu + Zd] + T + E$

Figure 6-22.3

PIPE FLOW CHART FOR CORRUGATED METAL PIPE DROP INLET PRINCIPAL SPILLWAY CONDUIT

For Corrugated Metal Pipe Inlet $K_m = K_a + K_b = 1.0$ and 70 Feet of
Corrugated Metal Conduit (full flow assumed), $n = 0.025$
(Note correction factors for pipe lengths other than 70 feet)

	Diameter Of Pipe In Inches							
H, in feet	8"	12"	18"	24"	30"	36"	42"	48"
	Discharge In Cubic Feet Per Second							
3	1.22	3.43	9.48	19.1	32.6	49.9	71.2	96.5
4	1.40	3.97	10.9	22.1	37.6	57.7	82.3	111
5	1.57	4.43	12.2	24.7	42.1	64.5	92.0	125
6	1.72	4.86	13.4	27.0	46.1	70.6	101	136
7	1.86	5.25	14.5	29.2	49.8	76.3	109	147
8	1.99	5.61	15.5	31.2	53.2	81.5	116	158
9	2.11	5.95	16.4	33.1	56.4	86.5	123	167
10	2.22	6.27	17.3	34.9	59.5	91.2	130	176
11	2.33	6.58	18.2	36.6	62.4	95.6	136	185
12	2.43	6.87	19.0	38.2	65.2	99.9	142	193
13	2.53	7.15	19.7	39.8	67.8	104	148	201
14	2.63	7.42	20.5	41.3	70.4	108	154	208
15	2.72	7.68	21.2	42.8	72.8	112	159	216
16	2.81	7.93	21.9	44.2	75.2	115	165	223
17	2.90	8.18	22.6	45.5	77.5	119	170	230
18	2.98	8.41	23.2	46.8	79.8	120	174	236
19	3.06	8.64	23.9	48.1	82.0	126	179	243
20	3.14	8.87	24.5	49.4	84.1	129	184	249
L, in feet	Correction Factors For Other Pipe Lengths							
30	1.41	1.36	1.29	1.24	1.21	1.18	1.15	1.13
40	1.27	1.23	1.20	1.17	1.14	1.12	1.11	1.10
50	1.16	1.14	1.12	1.10	1.09	1.08	1.07	1.06
60	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.94	0.95	0.95	0.96	0.96	0.97	0.97	0.97
90	0.89	0.90	0.91	0.92	0.93	0.94	0.94	0.95
100	0.85	0.86	0.88	0.89	0.90	0.91	0.92	0.93
120	0.79	0.90	0.82	0.83	0.85	0.86	0.87	0.89
140	0.73	0.75	0.77	0.79	0.81	0.82	0.84	0.85
160	0.69	0.70	0.73	0.75	0.77	0.79	0.80	0.82

Table 6-22.1

Table 6-22.2

WEIR FLOW (Q) OVER RISER CREST FOR CIRCULAR RISERS WITH TRASH RACK

$$Q = CLh^{3/2}$$

$$Q = 3.1 \times (\pi) \times (D/12) \times h^{3/2}$$

HEAD-h in feet	Riser Diameter (D_r) in inches 12	18	24	30	36	48	54	60	HEAD-h in feet
	Flow In Cubic Feet Per Second								
0.1	0.3	0.5	0.6	0.8	0.9	1.2	1.4	1.5	0.1
0.2	0.9	1.3	1.7	2.2	2.6	3.5	3.9	4.4	0.2
0.3	1.6	2.4	3.2	4.0	4.8	6.4	7.2	8.0	0.3
0.4	2.5	3.7	4.9	6.2	7.4	9.9	11.1	12.3	0.4
0.6	4.5	6.8	9.1	11.3	13.6	18.1	20.4	22.6	0.6
0.8		10.5	13.9	17.4	20.9	27.9	31.4	34.8	0.8
1.0			19.5	24.3	29.2	39.0	43.8	48.7	1.0
1.2			25.6	32.0	38.4	51.2	57.6	64.0	1.2
1.4				40.3	48.4	64.5	72.6	80.7	1.4
1.6				49.3	59.1	78.8	88.7	98.6	1.6
1.8					70.6	94.1	105.8	117.6	1.8
2.0					82.6	110.2	124.0	137.7	2.0
2.2						127.1	143.0	158.9	2.2
2.4							162.9	181.0	2.4
2.6							183.7	204.1	2.6
2.8								228.1	2.8
3.0								253.0	3.0

Pipe, Riser, and Trash Rack Proportions

Eq. 6-10 $D_r \geq (1.50)\ (D_{ps})$

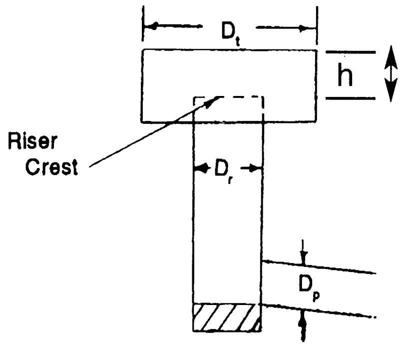
where D_r = diameter of riser

D_{ps} = diameter of principal spillway

Eq. 6-11 $D_t \geq (1.4)\ (D_r)$

where D_t = diameter of trash rack

D_r = diameter of riser



EXAMPLE: The peak runoff for a 2-year, 24-hour rain is 32 cfs. Select a pipe size for a head of 12 feet and length of 100 feet. From Table 6-15.1, 38.2 x 0.89 = 34 cfs discharge for a 24-inch diameter pipe.

Using Equation 6-10 $D_r \geq (1.5)\ (D_p)$

$D_r \geq (1.5)\ (24) \geq$ 36 inch diameter riser

Using Equation 6-11 $D_t \geq (1.4)\ (D_r)$

$D_t \geq (1.4)\ (36) \geq$ 50 inch diameter (Use 54 inch)

Determine h - From Table 6-15.2

$Q = 34$ cfs $D_r = 36"$ $h = 1.2'$

NOTE: h = minimum distance between the crest of the riser and the crest of the emergency spillway.

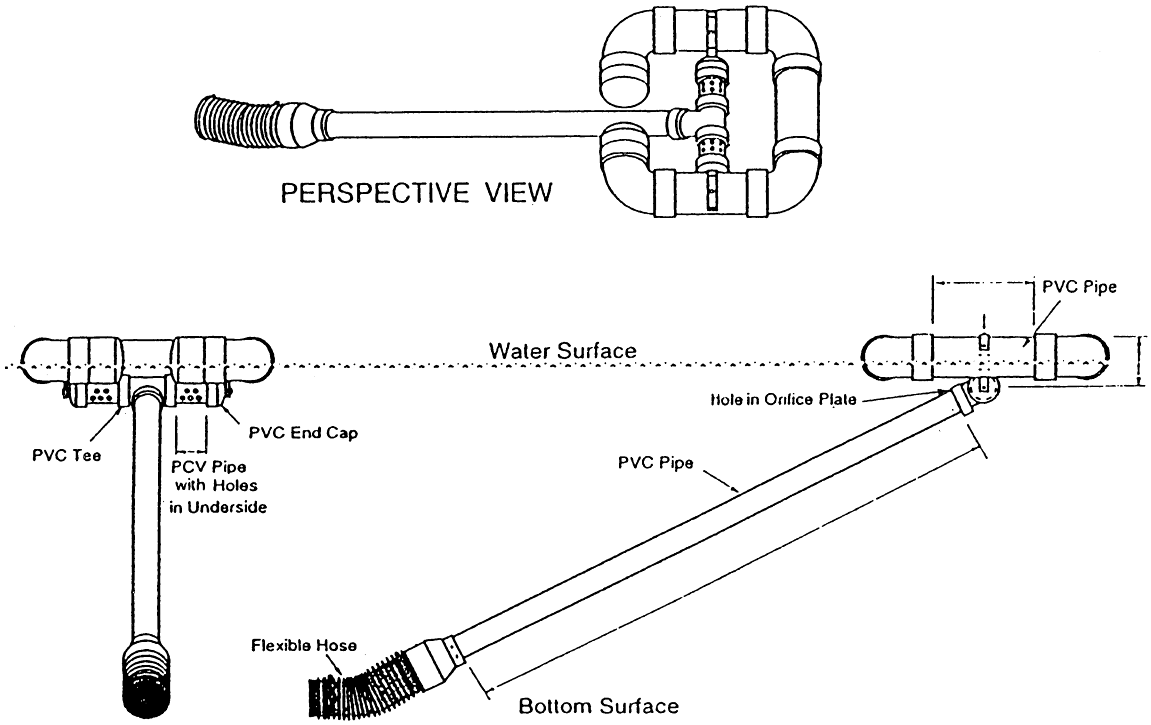
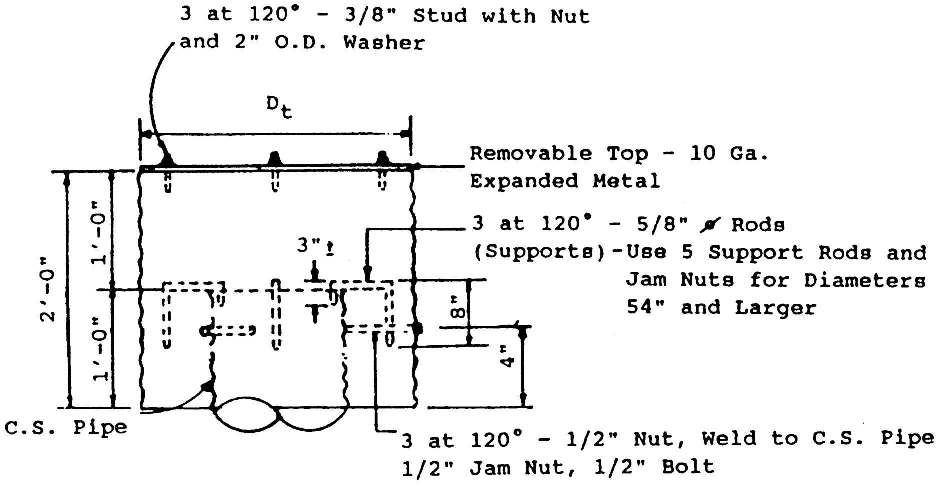
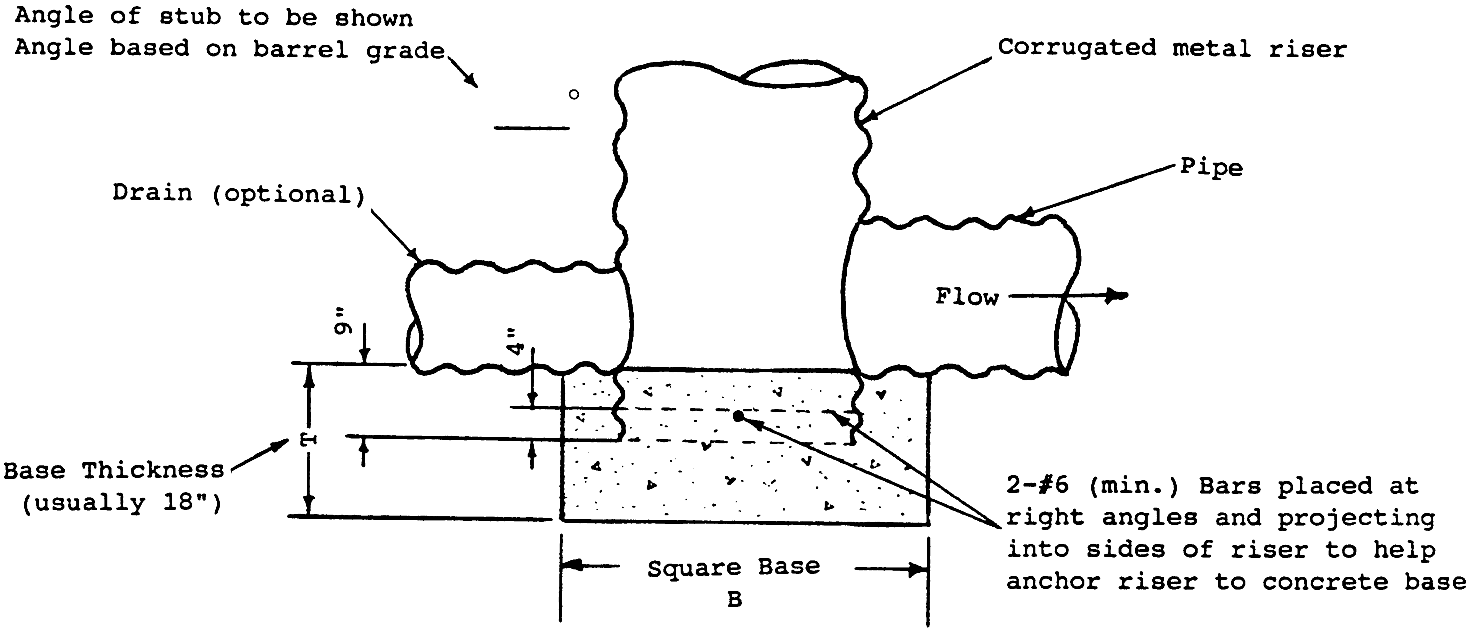


Figure 6-22.4 - Skimmer outlet



Typical Trash Rack

Figure 6-22.5



CONCRETE RISER BASE DETAIL

Figure 6-22.6

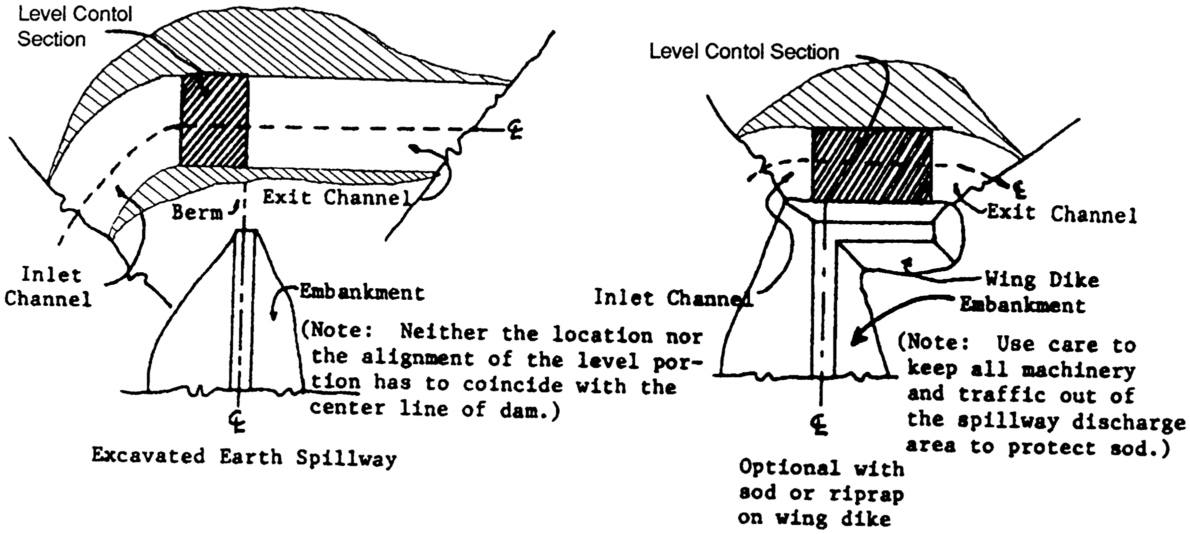
Riser Pipe Diameter (in)	Buoyant Force (lbs /V.F. of Riser Height)[1]	Volume of Concrete per Vertical Foot of Riser Height (c.f./V.F.) Needed to Prevent Flotation[2]
12	49.0	0.69
18	110.3	1.54
21	150.1	2.10
24	196.0	2.75
30	306.3	4.29
36	441.1	6.18
48	784.1	10.98
54	992.4	13.90
60	1225.2	17.16

EXAMPLE: Find the volume of concrete required to stabilize a 24 inch diameter riser 10 feet high.

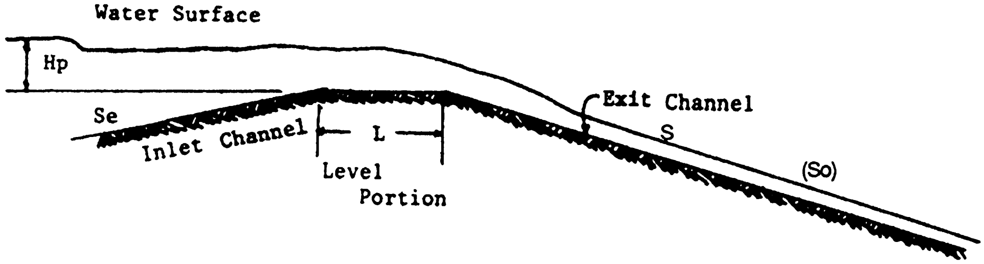
VOL. = (2.75 cu.ft./V.F.) (10 feet) = 27.5 cu. ft. = 1 cu. yd.

CONCRETE VOLUME REQUIRED TO PREVENT FLOTATION OF RISER

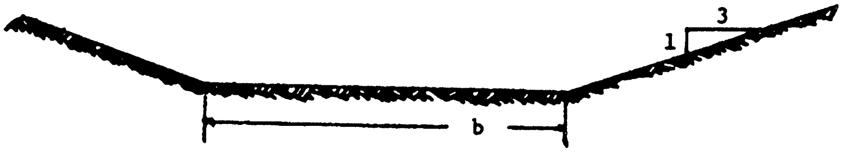
Table 6-22.3



PLAN VIEW OF EARTH SPILLWAYS



PROFILE ALONG CENTERLINE



CROSS-SECTION OF CONTROL SECTION

LEGEND:

Hp = Difference in Elevation between Crest of Earth Spillway at the Control Section and Water Surface in resevoir, in feet.

b = Bottom Width of Earth Spillway at the Control Section, in feet. (Table 6-22.4)

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. (Table 6-22.4)

S = Flattest Slope (S), in %, allowable for Channel below Control Section. (Table 6-22.4)

Se = Entry Slope

So = Exit Slope

NOTES:

1. For Q, V, S relationship see the chart on the following page.
2. For a given Hp, a decrease in the exit slope as given in the table decreases spillway discharge, but increasing the exit slope from S does not increase discharge. If an exit slope (So) is steeper than S is used, then velocity (Vo) in the exit channel will increase according to the following relationship:

$$Vo = V(So/S)^{0.3}$$

Figure 6-22.7

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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

DATA TO RIGHT OF HEAVY VERTICAL LINES SHOULD BE USED WITH CAUTION, AS THE RESULTING SECTIONS WILL BE EITHER POORLY PROPORTIONED, OR HAVE VELOCITIES IN EXCESS OF 6 FEET PER SECOND.

Source: USDA-SCS

Table 6-22.4

TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

EXAMPLE PROBLEM

Computed by____________ _ Date____________
Checked by ____________ _ Date____________

Project Name Independence School, Paradise City
Basin No. ____________ 1________________
Total area draining to basin = 18.1 acres
Disturbed area draining to basin = 18.1 acres

Volume

1. Compute minimum required storage volume (V_s)
   V_s = 67 cy/ac * 18.1 acres = 1212.7 cy
2. Compute volume of basin at clean-out (V_c)
   V_c = 22 cy/ac * 18.1 acres = 398.2 cy
3. Determine elevation corresponding to minimum required storage volume, V_s
   Minimum riser crest elevation = 1052.5 ft (determined by stage/storage relationship)
4. Determine elevation corresponding to clean-out volume, V_c
   Clean-out elevation = 1051.9 ft (determined by stage/storage relationship)
   Note: Clean-out elevation shall be clearly marked on the riser or marked by a post near the riser.
5. Compute length of riser
   Riser length = Minimum elevation of riser crest – Lowest elevation of pipe at riser
   Riser length = 1052.5 ft – 1050.0 ft
   Riser length = 2.5 ft

Stormwater Runoff

6. Compute peak discharge from a 2-yr, 24-hr storm event.
   Q_2 = 26 cfs (Attach runoff computation sheet.)
7. Compute peak discharge from a 25-yr, 24-hr storm event.
   Q_{25} = 46 cfs (Attach runoff computation sheet.)

Surface Area/Configuration Design

8. Compute minimum basin surface area (SA_{min})
   SA_{min} = 0.01 ac/cfs * Q_2
   SA_{min} = 0.01 ac/cfs * 26 cfs
   SA_{min} = 0.26 ac = 43560 sf/ac * 0.26 ac = 11310 sf
9. Check available area at elevation of riser crest
   Available area = 18532 sf (determined by stage/storage relationship)
   Available area ≥ SA_{min} ? Yes ___X___ No ______
10. Compute required length to achieve 2:1 L:W ratio
    Average width = 80 ft
    Required length = 2 * average width
    Required length = 2 * 80 ft
    Required length = 160 ft
    Available length = 170 ft
    2:1 L:W ratio satisfied? Yes ___X___ No ______
    If no, refer to Figure 6-22.2 for baffle designs. Note any required baffles on E&SC plan and include calculations and details for baffle(s).

TEMPORARY SEDIMENT BASIN DESIGN SHEET

Project Name Independence School, Paradise City
Page 2

Principal Spillway (ps)

11. Determine maximum principal spillway capacity = Q_2 = 26 cfs
12. Compute the vertical distance between the centerline of the outlet pipe and the emergency spillway crest (H)
    H = 9.75 ft
13. Compute the total pipe length of the principal spillway, L, using Figure 6-22.3.
    L = [A – (B+C)/2] [Zu+Zd] + T + E
    L = 70 ft
14. Determine diameter of principal spillway (D_{ps}) and flow through the principal spillway (Q) from Table 6-22.1 using H and Q_2.
    D_{ps} = 24 in. **Q** = 33.1 cfs (value directly from table)
15. Compute actual flow through the principal spillway, using Table 6-22.1 to determine the correction factor for pipe length, L.
    Q_{ps} = Q * correction factor = 33.1 cfs * 1.00
    Q_{ps} = 33.1 cfs
16. Compute riser diameter (D_r)
    $D_r \geq 1.5 * D_{ps}$
    $D_r \geq 1.5 *$ 24 in.
    $D_r \geq$ 36 in.
    D_r = 36 in.
17. Compute trash rack diameter (D_t)
    $D_t \geq 1.4 * D_r$
    $D_t \geq 1.4 *$ 36 in.
    $D_t \geq$ 50.4 in.
    D_t = 54 in.
18. Determine the minimum distance between the riser crest and the emergency spillway crest, **h**, using Table 6-22.2 D_r, and Q_{ps}.
    h = 1.1 ft

Concrete Riser Base Design

19. Determine the volume of concrete per vertical foot of riser height needed (from Table 6-22.3) to prevent flotation.
    Required volume of concrete per vertical foot = 6.18 cf/v.f.
20. Compute total volume of concrete required.
    Total required volume of concrete = Required volume per vertical foot * Riser length
    Total required volume of concrete = 6.18 cf/v.f. * 2.5 ft
    Total volume of concrete required = 15.45 cf
21. Assume base thickness (usually 18") (B).
    B = 18 in = 1.5 ft
22. Compute required surface area.
    Required surface area = Total volume required / B
    Required surface area = 15.45 cf / 1.5 ft
    Required surface area = 10.3 sf
23. Compute riser base length (l) and width (w) (assume square base).
    $l = w = (\text{required surface area})^{1/2}$
    $l = w = (10.3 \text{ sf})^{1/2}$
    l = **w** = 3.21 ft = 12in/ft * 3.21 ft = 39 in.

TEMPORARY SEDIMENT BASIN DESIGN SHEET

Project Name Independence School, Paradise City

Page 3

Anti-Seep Collar Design

24. Determine if anti-seep collar is required. If yes to any of the following conditions, a collar is required:

______ The settled height of the dame is greater than 15 feet.

______ The principal spillway diameter (D_{ps}) is smooth pipe larger than 8".

__X__ The principal spillway diameter (D_{ps}) is corrugated metal pipe larger than 12".

25. Determine size of anti-seep collar required.

__X__ **18-inch projection** (for heads (H) less than or equal to 10 feet).

______ **24-inch projection** (for heads (H) greater than 10 feet).

Emergency Spillway (es)

26. Compute minimum capacity of emergency spillway (Q_{es})

$Q_{es} = Q_{25} - Q_{ps}$ = 46 cfs - 33 cfs

Q_{es} = 13 cfs

27. Determine stage (H_p), bottom width (b), velocity (V) and minimum exit slope (S) using Table 6-22.4 and Q_{es}.

H_p = 0.7 ft **b** = 10 ft **V** = 3.2 fps **S** = 3.5 %

28. Actual entrance channel slope, **S_e** = 5 %

29. Actual exit channel slope, **S_o** = 7 %

Note: If S_o is steeper than S (from Table 6-22.4), then the velocity in the exit channel will increase.

a.) Calculate exit velocity (V_o)

$V_o = V (S_o / S)^{0.3}$ = 3.8 fps * (7 / 3.5) $^{0.3}$

V_o = 4.7 fps

Note: Refer to Channel Stabilization (Ch) to determine the proper lining for the emergency spillway.

Grass __X__ **Rip-rap** ______ **Concrete** ______

Design Elevations

30. **Riser crest elevation** = 1052.5 ft

31. Compute minimum emergency spillway crest elevation

Minimum emergency spillway crest elevation = Riser crest elevation + h

Minimum emergency spillway crest elevation = 1052.5 ft + 1.1 ft

Minimum emergency spillway crest elevation = 1053.6 ft

Actual emergency spillway crest elevation = 1053.6 ft

32. Determine design high water elevation

Design high water elevation = Emergency spillway crest elevation + Stage elevation (Hp)

Design high water elevation = 1053.6 ft + 0.9 ft

Design high water elevation = 1054.5 ft

33. Determine elevation of top of dam

Elevation of top of dam = Design high water elevation + 1 ft freeboard

Elevation of top of dam = 1054.5 ft + 1 ft

Elevation of top of dam = 1055.5 ft

TEMPORARY SEDIMENT BASIN DESIGN SHEET

Computed by____________ Date____________
Checked by ____________ Date____________

Project Name ________________________
Basin No. ________________________
Total area draining to basin = ________ acres
Disturbed area draining to basin = ________ acres

Volume

1. Compute minimum required storage volume (V_s).
   V_s = 67 cy/ac * ________ acres = ________ cy
2. Compute volume of basin at clean-out (V_c).
   V_c = 22 cy/ac * ________ acres = ________ cy
3. Determine elevation corresponding to minimum required storage volume, $V_{s.}$
   Minimum riser crest elevation = ________ ft (determined by stage/storage relationship)
4. Determine elevation corresponding to clean-out volume, $V_{c.}$
   Clean-out elevation = ________ ft (determined by stage/storage relationship)
   Note: Clean-out elevation shall be clearly marked on the riser or marked by a post near the riser.
5. Compute length of riser.
   Riser length = Minimum elevation of riser crest – Lowest elevation of pipe at riser
   Riser length = ________ ft - ________ ft
   Riser length = ________ ft

Stormwater Runoff

6. Compute peak discharge from a 2-yr, 24-hr storm event.
   Q_2 = ________ cfs (Attach runoff computation sheet.)
7. Compute peak discharge from a 25-yr, 24-hr storm event.
   Q_{25} = ________ cfs (Attach runoff computation sheet.)

Surface Area/Configuration Design

8. Compute minimum basin surface area (SA_{min}).
   SA_{min} = 0.01 ac/cfs * Q_2
   SA_{min} = 0.01 ac/cfs * ________ cfs
   SA_{min} = ________ ac = 43560 sf/ac * ________ ac = ________ sf
9. Check available area at elevation of riser crest.
   Available area = ________ sf (determined by stage/storage relationship)
   Available area SA_{min}? Yes ________ No ________
10. Compute required length to achieve 2:1 L:W ratio.
    Average width = ________ ft
    Required length = 2 * average width
    Required length = 2 * ________ ft
    Required length = ________ ft
    Available length = ________ ft
    2:1 L:W ratio satisfied? Yes ________ No ________
    If "no", refer to Figure 6-22.2 for baffle designs. Note any required baffles on E&SC plan and include calculations and details for baffle(s).

Principal Spillway (ps)

11. Determine maximum principal spillway capacity.
    Q_{max} = Q_2 = ________ cfs
12. Compute the vertical distance between the centerline of the outlet pipe and the emergency spillway crest (H).

TEMPORARY SEDIMENT BASIN DESIGN SHEET

Project Name ____________________
Page 2

H = ________ ft

13. Compute the total pipe length of the principal spillway, L, using Figure 6-22.3.
L = [A – (B+C)/2] [Zu+Zd] + T + E = [_____- (_____+_____)/2] [_____+_____] + _____ + _____
L = ________ ft

14. Determine diameter of principal spillway (D_{ps}) and flow through the principal spillway (Q) from Table 6-22.1 using H and Q_{max}.
D_{ps} = ________ in. **Q** = ________ cfs (value directly from table)

15. Compute actual flow through the principal spillway, using Table 6-22.1 to determine the correction factor for pipe length, L.
Q_{ps} = Q * correction factor = ________ cfs * ________
Q_{ps} = ________ cfs

16. Compute riser diameter (D_r).
$D_r = 1.5 * D_{ps}$
D_r = 1.5 * ________ in.
D_r = ________ in.
D_r = ________ in.

17. Compute trash rack diameter (D_t).
$D_t = 1.4 * D_r$
D_t = 1.4 * ________ in.
D_t = ________ in.
D_t = ________ in.

18. Determine the minimum distance between the riser crest and the emergency spillway crest, **h**, using Table 6-22.2 D_r, and Q_{ps}.
h = ________ ft

Concrete Riser Base Design

19. Determine the volume of concrete per vertical foot of riser height needed, from Table 6-22.3 to prevent flotation.
Required volume of concrete per vertical foot = ________ cf/v.f.

20. Compute total volume of concrete required.
Total required volume of concrete = Required volume per vertical foot * Riser length
Total required volume of concrete = ________ cf/v.f. * ________ ft
Total volume of concrete required = ________ cf

21. Assume base thickness, B (usually 18").
B = ________ in = ________ ft

22. Compute required surface area.
Required surface area = Total volume required / B
Required surface area = ________ cf / ________ ft
Required surface area = ________ sf

23. Compute riser base length (l) and width (w) (assume square base).
$l = w = (\text{required surface area})^{1/2}$
$l = w = (\text{\_\_\_\_\_\_\_\_ sf})^{1/2}$
l = w = ________ ft = 12in/ft * ________ ft = ________ in

Anti-Seep Collar Design

24. Determine if anti-seep collar is required. If yes, to any of the following conditions, a collar is required:
________ The settled height of the dam is greater than 15 feet.
________ The principal spillway diameter (D_{ps}) is smooth pipe larger than 8".
________ The principal spillway diameter (D_{ps}) is corrugated metal pipe larger than 12".

25. Determine size of anti-seep collar required.
________ **18-inch projection** (for heads (H) less than or equal to 10 feet).
________ **24-inch projection** (for heads (H) greater than 10 feet).

Emergency Spillway (es)

26. Compute minimum capacity of emergency spillway (Q_{es})
$Q_{es} = Q_{25} - Q_{ps}$ = ________ cfs - ________ cfs
Q_{es} = ________ cfs

27. Determine stage (H_p), bottom width (b), velocity (V) and minimum exit slope (S) using Table 6-22.4 and Q_{es}.
H_p = ________ ft **b** = ________ ft **V** = ________ fps **S** = ________ %

28. Actual entrance channel slope, **S_e** = ________ %

29. Actual exit channel slope, **S_o** = ________ %
Note: If S_o is steeper than S (from Table 6-22.4), then the velocity in the exit channel will increase.
a.) Calculate new exit velocity (V_o)
$V_o = V (S_o /S)^{0.3}$ = ________ fps * (________ / ________) $^{0.3}$
V_o = ________ fps
Note: Refer to Channel Stabilization (Ch) to determine the proper lining for the emergency spillway.
Grass ______ **Rip-rap** ________ **Concrete** ________

Design Elevations

30. **Riser crest elevation** = ________ ft

31. Compute minimum emergency spillway crest elevation.
Minimum emergency spillway crest elevation = Riser crest elevation + h
Minimum emergency spillway crest elevation = ________ ft + ________ ft
Minimum emergency spillway crest elevation = ________ ft

32. Determine design high water elevation
Design high water elevation = Minimum emergency spillway crest elevation + Stage elevation (Hp)
Design high water elevation = ________ ft + ________ ft
Design high water elevation = ________ ft

33. Determine elevation of top of dam
Elevation of top of dam = Design high water elevation + 1 ft freeboard
Elevation of top of dam = ________ ft + 1 ft
Elevation of top of dam = ________ ft

PLEASE NOTE THAT DESIGN VALUES DETERMINED BY THIS SHEET REPRESENT THE MINIMUM REQUIREMENTS FOR A TEMPORARY SEDIMENT BASIN.

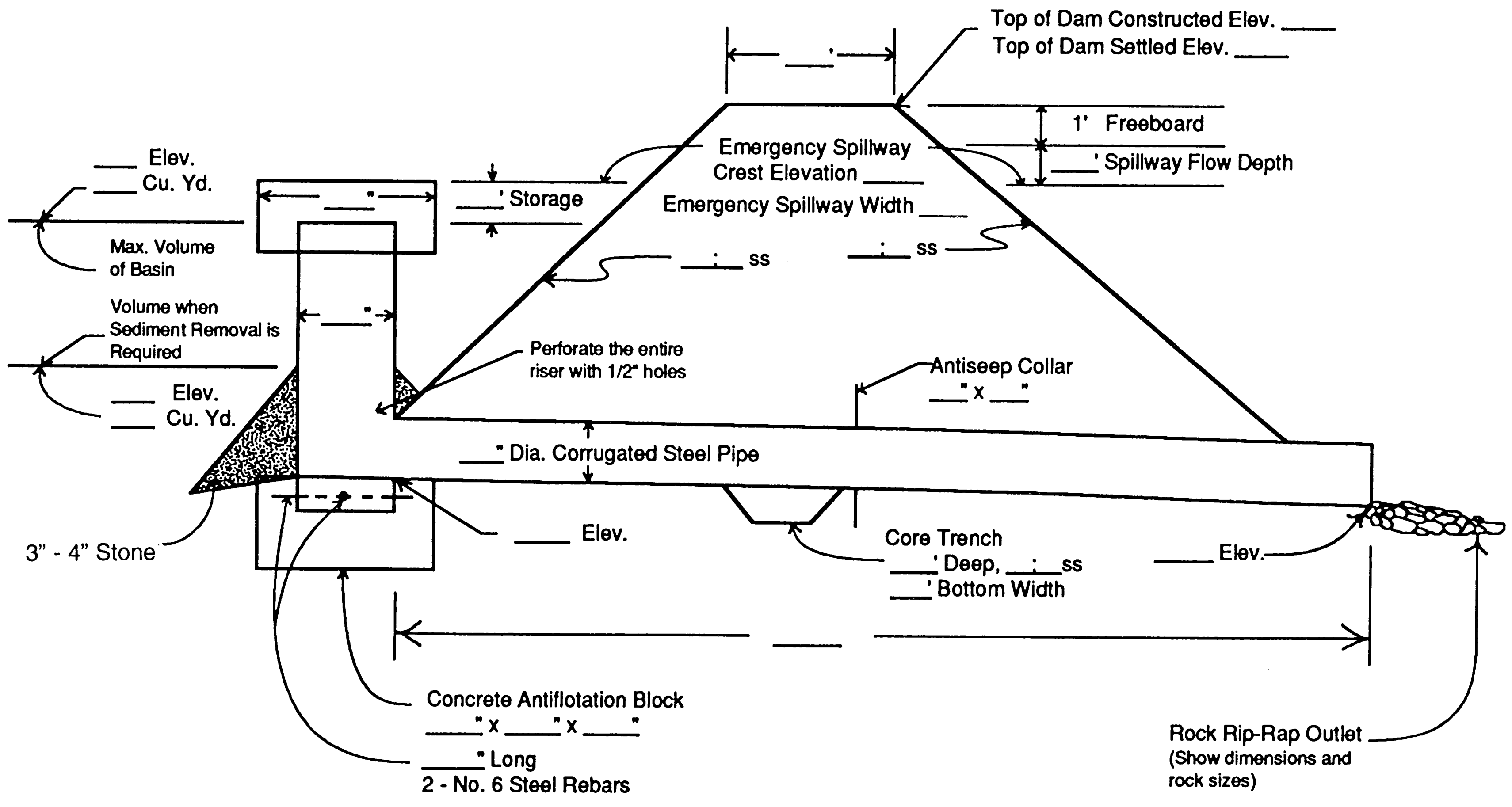
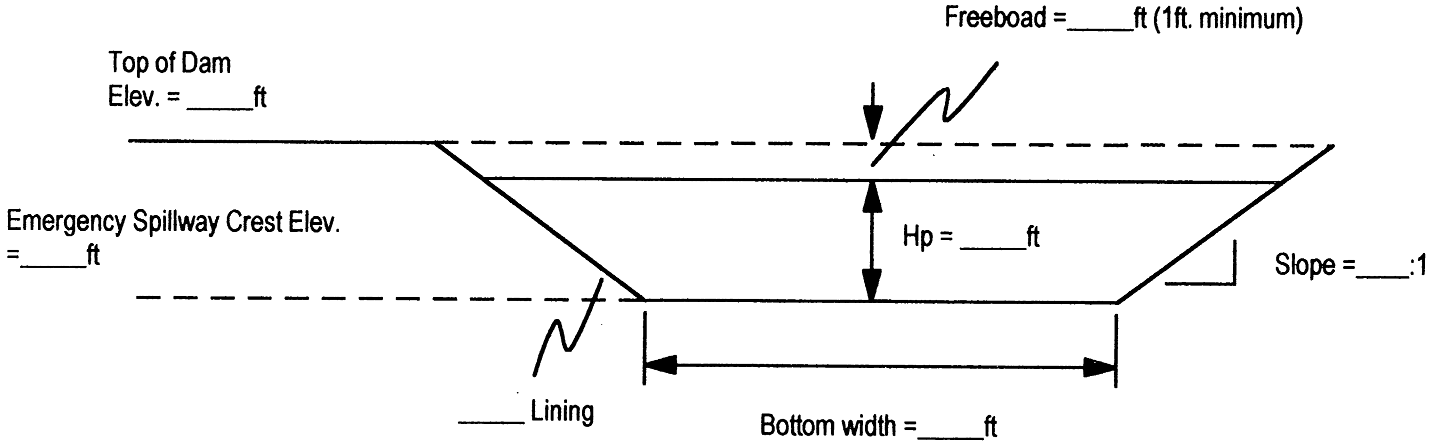
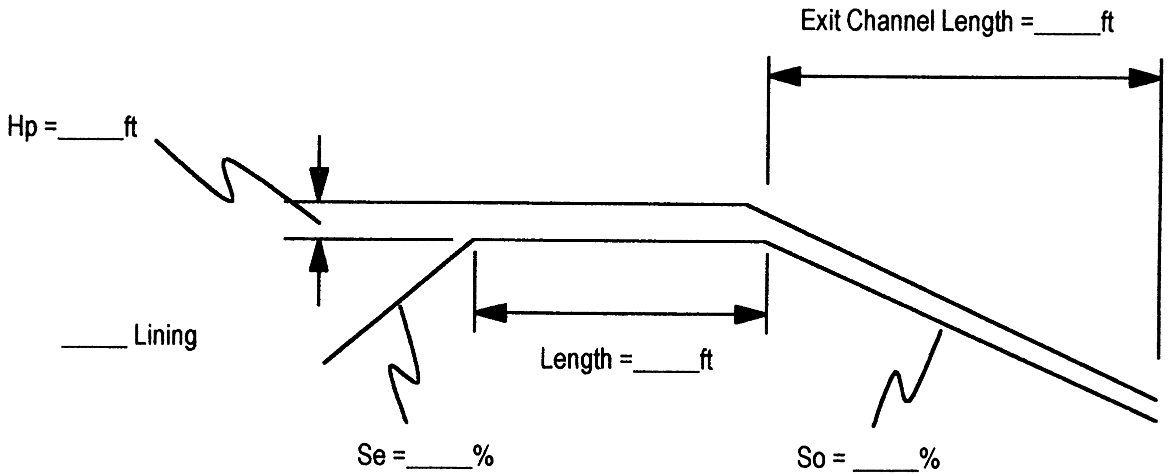


Figure 6-22.8 - Temporary sediment basin cross-sectional detail.

Cross-Sectional Detail of Emergency Spillway



Profile Along Centerline

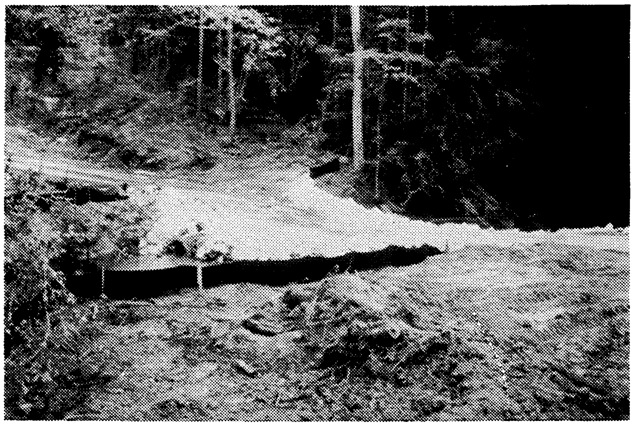


Emergency Spillway

Figure 6-22.9

Temporary Stream Crossing

Sr



DEFINITION

A *temporary* structure installed across a flowing stream or watercourse for use by construction equipment.

PURPOSE

This standard provides a means for construction vehicles to cross streams or watercourses without moving sediment into streams, damaging the streambed or channel, or causing flooding.

CONDITIONS

Temporary stream crossings shall not be used on streams with drainage areas greater than one square mile. Structures may include bridges, round pipes or pipe arches.

Temporary stream crossings should be in place for less than one year and should not be used by the general public.

DESIGN CRITERIA

Size

The structure shall be large enough to convey the full bank flow of the stream, typically flows produced by a 2-year, 24-hour frequency storm, without appreciably altering the stream flow characteristic.

Location

The temporary stream crossing shall be perpendicular to the stream. Where approach conditions dictate, the crossing may vary 15% from the perpendicular.

Overflow Protection

Structures shall be protected from washout during periods of peak discharges by diverting water around the structures. Methods to be considered for washout protection may include elevation of bridges above adjacent flood plain lands, crowning of fills over pipes, or by the use of diversions, dikes or island type structures. Two types of stream crossings that may be used are bridges and culverts. Frequency and intended use, stream channel conditions, overflow areas, potential flood damage, and surface runoff control should be considered when selecting the type of temporary stream crossing to be used.

Temporary Bridge Crossing Sr-B

A temporary access bridge causes the least erosion of the stream channel crossing when the bridge is installed and removed. It also provides the least obstruction to flow and fish migration. Provided that the bridge is properly designed and appropriate materials are used, a temporary access bridge will be long-lasting and will require little maintenance. However, it is generally the most expensive crossing to design and construct; creating the greatest safety hazard if not adequately designed, installed and maintained.

Temporary Culvert Crossing Sr-C

A temporary access culvert can control erosion effectiviely, but can cause eosion when it is installed and removed. It is the most common stream crossing. A temorary culvert can be easily constructed and enables heavy equipment loads to be used. However, culverts create the greatest obstruction to flood flows and are subject to blockage and washout.

Table 6-23.1 shall be used to determine the culvert size necessary to safely convey streamflow. *Please note that the required pipe size is based on cross-sectional area of the pipe; e.g. if a 24 inch pipe is prescribed by Table 23.1, two 12 inch pipes could not be substitued because less flow area is provided.*

CORRUGATED METAL PIPE (CMP) DIAMETERS FOR TEMPORARY STREAM CROSSINGS [a]

Drainage Area	Average Slope of Watershed			
(Acres)	1%	4%	8%	16%
1-25	24	24	30	30
26-50	24	30	36	36
51-100	30	36	42	48
101-150	30	42	48	48
151-200	36	42	48	54
201-250	36	48	54	54
251-300	36	48	54	60
301-350	42	48	60	60
351-400	42	54	60	60
401-450	42	54	60	72
451-500	42	54	60	72
501-550	48	60	60	72
551-600	48	60	60	72
601-640	48	60	72	72

Table 6-23.1

[a] Assumptions for determining the table: USDA-NRCS Peak Discharge Method; CN = 65; Rainfall depth (average for Georgia) = 3.7" for 2-year frequency. Pipe diameters shown in the table are in inches.

CONSTRUCTION SPECIFICATIONS

All Crossings

1. Clearing of the stream bed and banks shall be kept to a minimum.
2. All surface water from the construction site shall be diverted onto undisturbed areas adjoining the stream. Line unstable stream banks with riprap or otherwise appropriately stabilize them.
3. The structure shall be removed as soon as it is no longer necessary for project construction.
4. Upon removal of the structure, the stream shall immediately be restored to its original cross-section and properly stabilized.

Temporary Bridge Crossing (Sr-B)

1. The temporary bridge shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.
2. Abutments shall be placed parallel to and on stable banks.
3. Bridges shall be constructed to span the entire channel. If the channel width exceeds eight feet (as measured from the tops of the banks), a footing, pier or bridge support may be constructed within the waterway.
4. Bridges shall be securely anchored at only one end using steel cable or chain. This will prevent channel obstruction in the event that floodwaters float the bridge. Large trees, large boulders, or driven steel anchors can serve as anchors.

Temporary Culvert Crossing (Sr-C)

1. The invert elevation of the culvert shall be installed on the natural streambed grade.
2. The culvert(s) shall extend a minimum of one foot beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet in length.
3. The culvert(s) shall be covered with a minimum of one foot of aggregate. If multiple culverts are used, they shall be separated by a minimum of 12 inches of compacted aggregate fill.

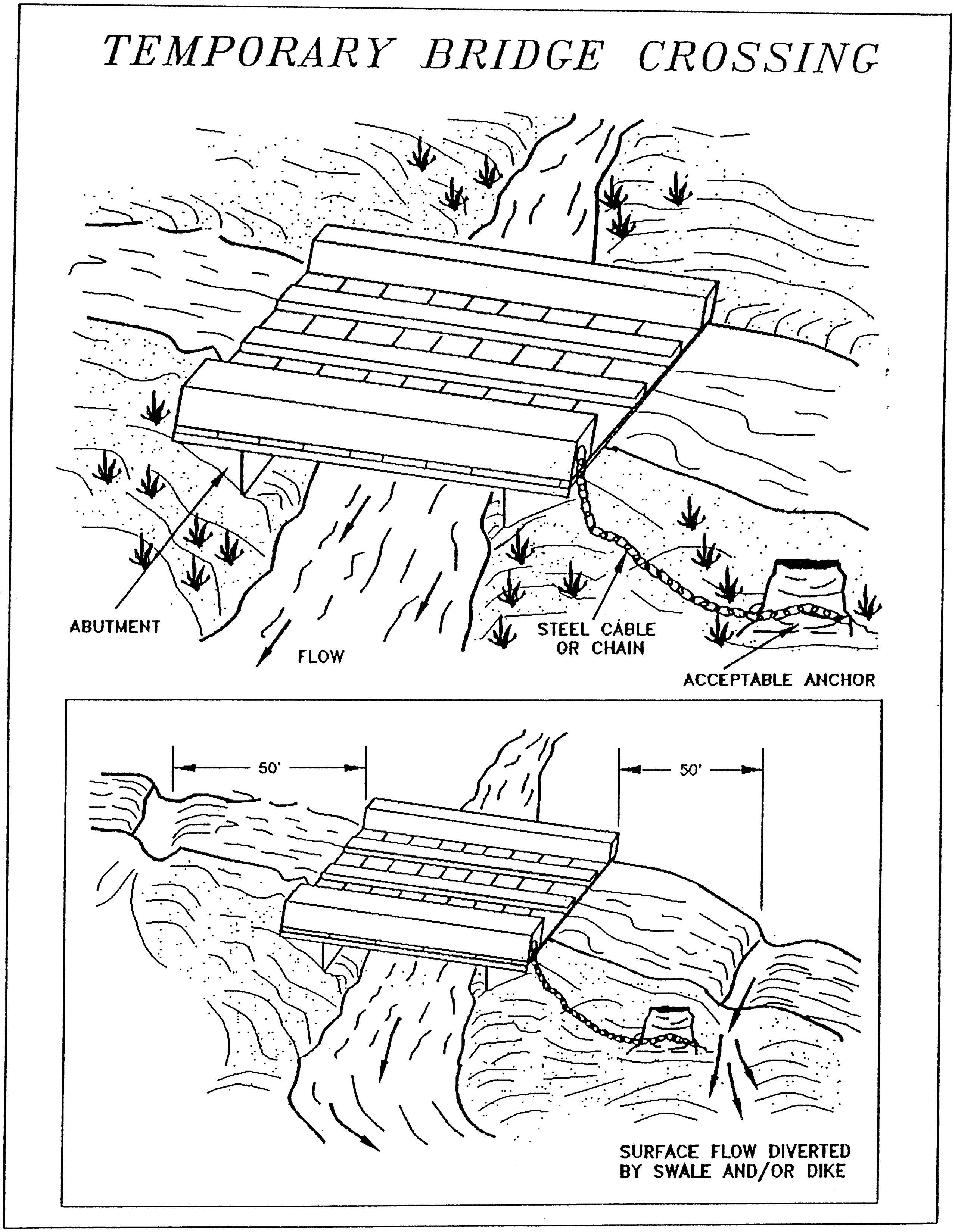
MAINTENANCE

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. The structure shall be removed immediately after construction is fininshed, and the streambed and banks must be stabilized. Refer to specification **Bf - Buffer Zone**.

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

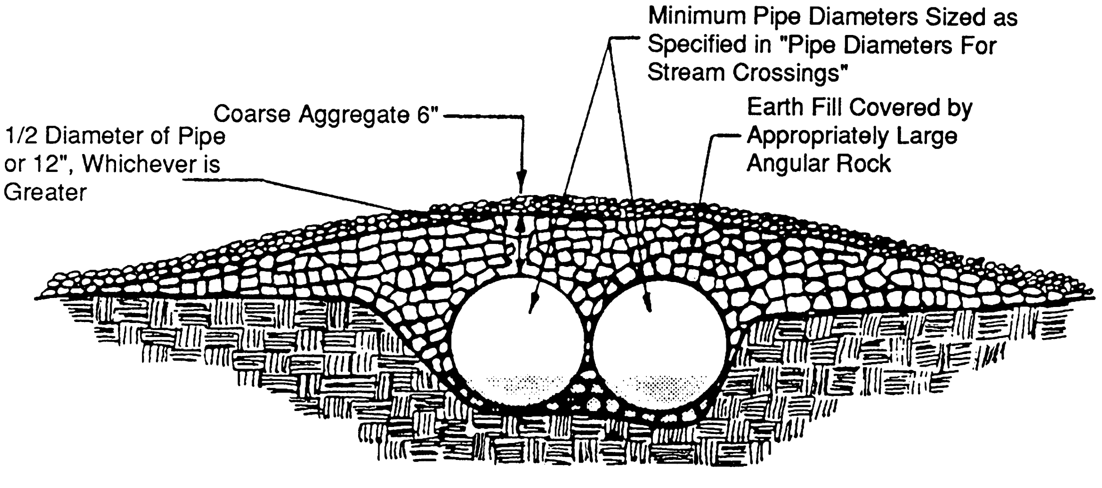
1. Drainage area (ac), average slope of watershed (%), and stream flow rate at bankfull flow (cfs).

2. Detailed dimensions of components for the type of crossing to be used.

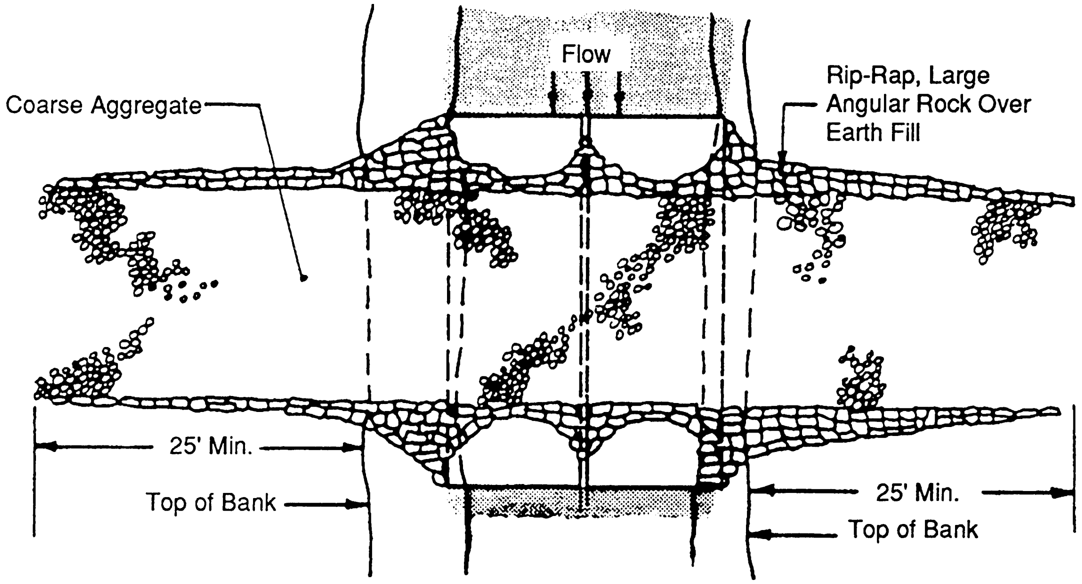


TEMPORARY BRIDGE CROSSING

Figure 6-23.1



ELEVATION

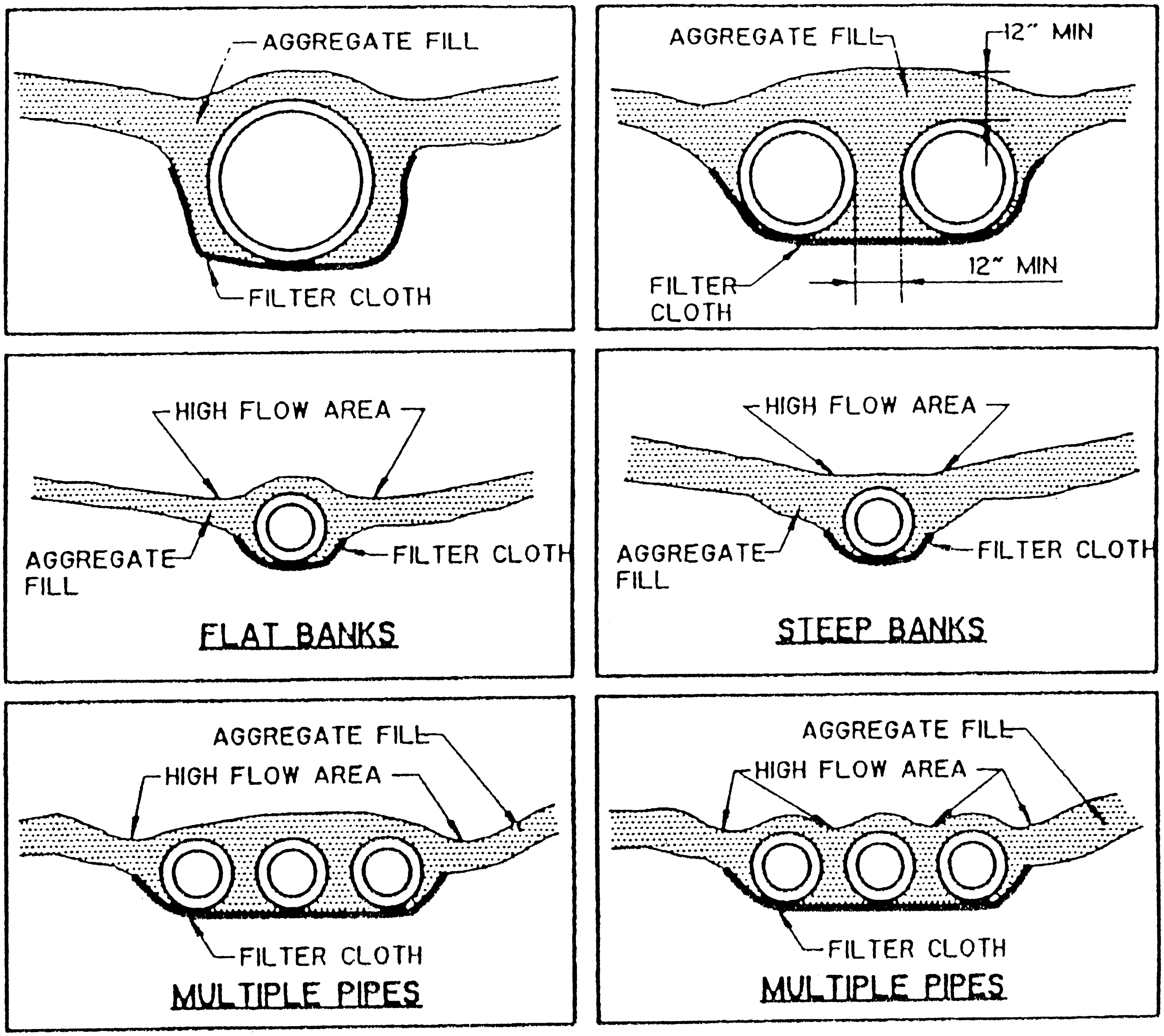


PLAN

GENERAL NOTES:

1. Not to scale.
2. This type of crossing can be installed in both a wet or dry weather stream condition where the drainage area exceeds 10 acres.
3. Remove during cleanup.

Figure 6-23.2



FLAT BANKS

STEEP BANKS

MULTIPLE PIPES

MULTIPLE PIPES

Figure 6-23.3 - Configuration of temporary culvert crossing.

Storm Drain Outlet Protection

St

DEFINITION

Paved and/or riprapped channel sections, placed below storm drain outlets.

PURPOSE

To reduce velocity of flow before entering receiving channels below storm drain outlets.

CONDITIONS

This standard applies to all storm drain outlets, road culverts, paved channel outlets, etc., discharging into natural or constructed channels. Analysis and/or treatment will extend from the end of the conduit, channel or structure to the point of entry into an existing stream or publicly maintained drainage system.

DESIGN CRITERIA

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

Capacity

Peak stormflow from the 25-year, 24-hour frequency storm or the storm specified in Title 12-7-1 of the Official Code of Georgia Annotated or the design discharge of the water conveyance structure, whichever is greater.

Tailwater Depth

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. 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 onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

Apron Length and Thickness

The apron length and d_{50}, stone median size, shall be determined from the curves according to tailwater conditions:

Minimum Tailwater- Use Figure 6-24.1
Maximum Tailwater- Use Figure 6-24.2
Maximum Stone Size = 1.5 x d50
Apron Thickness = 1.5 x dmax

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). 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. Refer to Figure 6-24.1.

c. For a Maximum Tailwater Condition, the down stream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron.
Refer to Figure 6-24.2.

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.

Alignment

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

Geotextile

Geotextiles should be used as a separator between the graded stone, the soil base, and the abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. The geotextile shall be specified in accordance with AASHTO M288-96 Section 7.5, *Permanent Erosion Control Recommendations*. The geotextile should be placed immediately adjacent to the subgrade without any voids.

Materials

The apron may be lined with riprap, grouted riprap, or concrete. The median sized stone for riprap, d_{50}, shall be determined from the curves, Figures 6-24.1and 6-24.2, according to the tailwater condition. The gradation, quality and placement of riprap shall conform to Appendix C.

Refer to Figure 6-24.4, for alternative structures to achieving energy dissipation at an outlet. For information regarding the selection and design of these alternative energy dissipators, refer to:

FHWA Standard (REF. Hydraulic Design of Energy Dissipators for Culverts and Channels; HEC No. 14, FHWA, Available from the Superintendent of Doucments, U.S. Government Printing Office, Washington, D.C. 20402.

CONSTRUCTION SPECIFICATIONS

1. Ensure that the subgrade for the filter and riprap follows the required lines and grades shown in the plan. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.
2. The riprap and gravel filter must conform to the specified grading limits shown on the plans.
3. Geotextile must meet design requirements and be properly protected from punching or tearing during installation. Repair any damage by removing the riprap and placing another piece of filter fabric over the damaged area. All connecting joints should overlap a minimum of 1 ft. If the damage is extensive, replace the entire filter fabric.
4. Riprap may be placed by equipment, but take care to avoid damaging the filter.
5. The minimum thickness of the riprap should be 1.5 times the maximum stone diameter.
6. Construct the apron on zero grade with no overfall at the end. Make the top of the riprap at the downstream end level with the receiving area or slightly below it.
7. Ensure that the apron is properly aligned with the receiving stream and preferably straight throughout its length. If a curve is needed to fit site conditions, place it in the upper section of the apron.
8. Immediately after construction, stabilize all disturbed areas with vegetation.
9. Stone quality - Select stone for riprap from field stone or quarry stone. The stone should be hard, angular, and highly weather-resistant. The specific gravity of the individual stones should be at least 2.5.
10. Filter - Install a filter to prevent soil movement through the openings in the riprap. The filter should consist of a graded gravel layer or a synthetic filter cloth. See Appendix C; p. C-1.

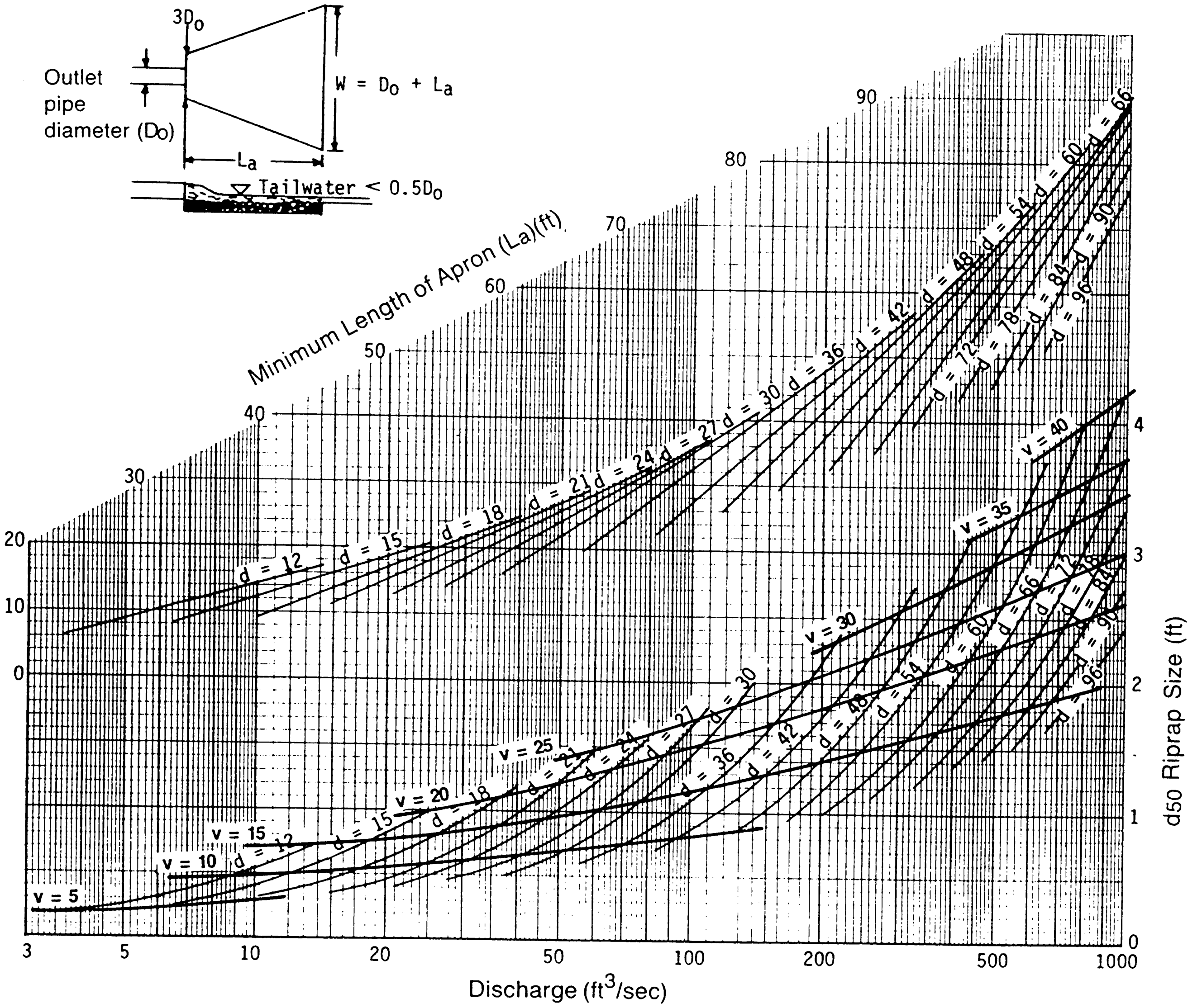
MAINTENANCE

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. Immediately make all needed repairs to prevent further damage.

TO BE SHOWN ON THE EROSION AND SEDIMENT CONTROL PLAN

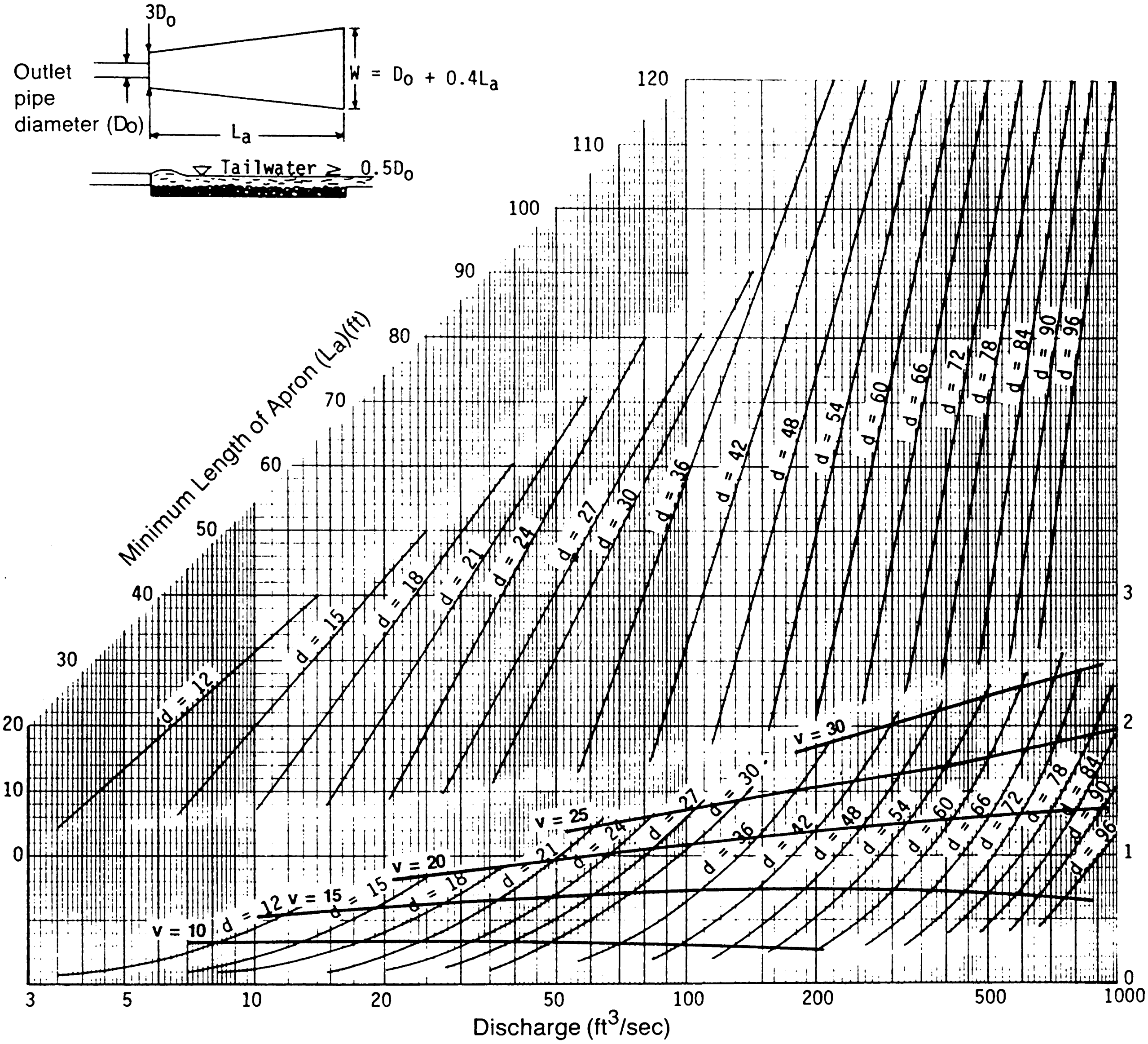
1. The flow characteristics of the pipe at full flow including pipe diameter, flow rate (cfs), velocity (fps), and tailwater condition.

2. The dimensions of the apron including length (La), width at the headwall (W_1), downstream width (W_2), average stone diameter (d50), and stone depth (D) designed in accordance with Figures 6-24.1 and 6-24.2.



Curves may not be extrapolated.

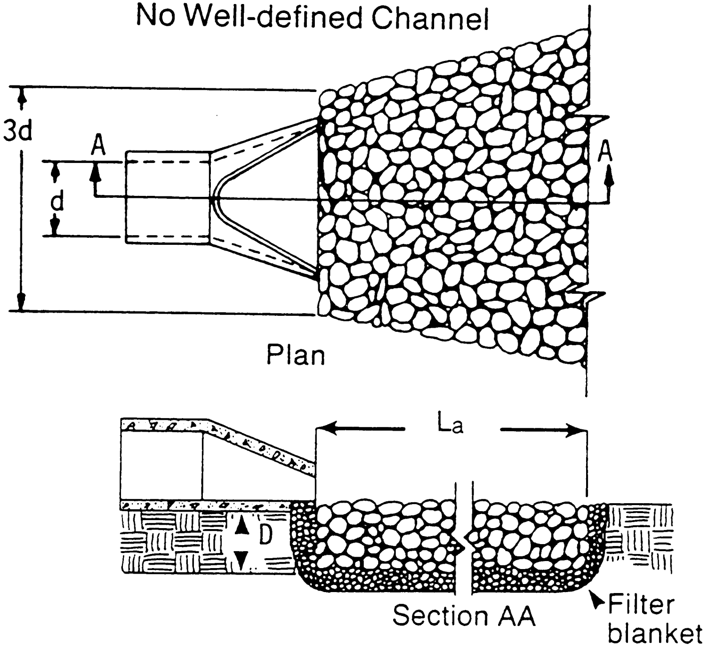
Figure 6-24.1 - Design of outlet protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).



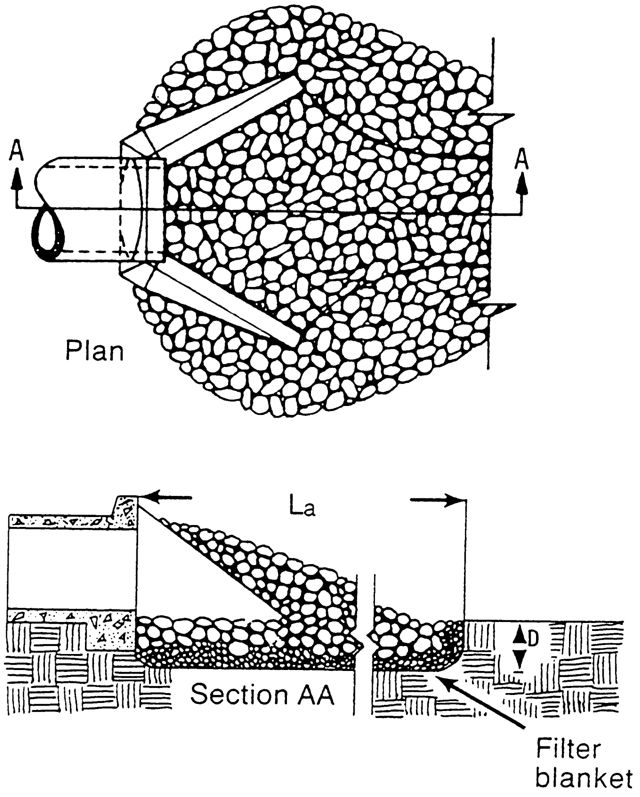
Curves may not be extrapolated.

Figure 6-24.2 - Design of outlet protection from a round pipe flowing full, maximum tailwater condition (T_w > 0.5 diameter).

Pipe Outlet to Flat Area—
No Well-defined Channel



Pipe Outlet to Well-defined
Channel

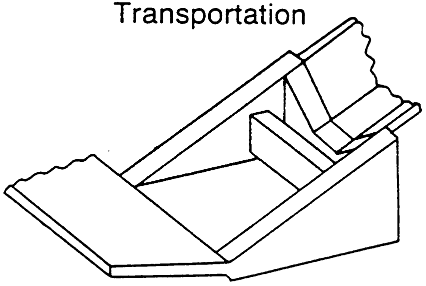


Notes

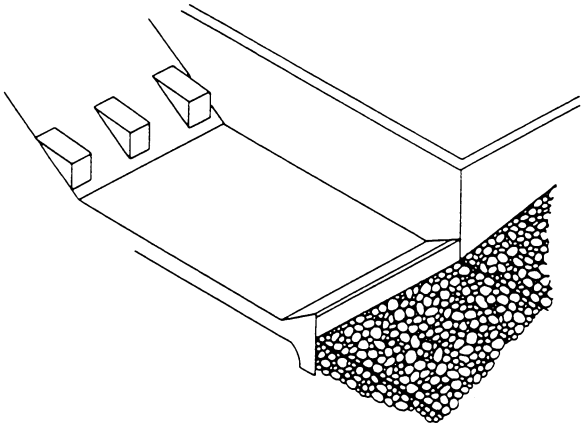
1. L_a is the length of the riprap apron.
2. D = 1.5 times the maximum stone diameter but not less than 6".
3. In a well-defined channel extend the apron up the channel banks to an elevation of 6" above the maximum tailwater depth or to the top of the bank, whichever is less.
4. A filter blanket or filter fabric should be installed between the riprap and soil foundation.

Figure 6-24.3 - Riprap outlet protection (modified from Va SWCC).

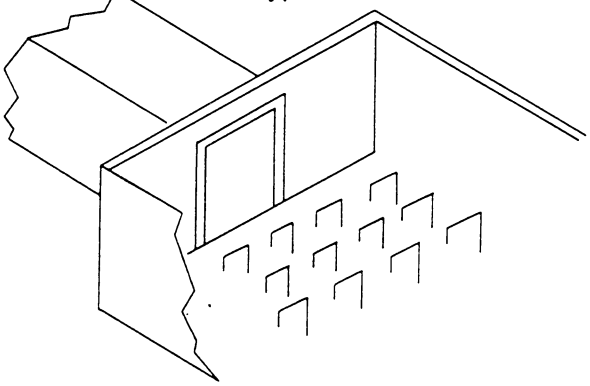
Virginia Department of Highways and Transportation



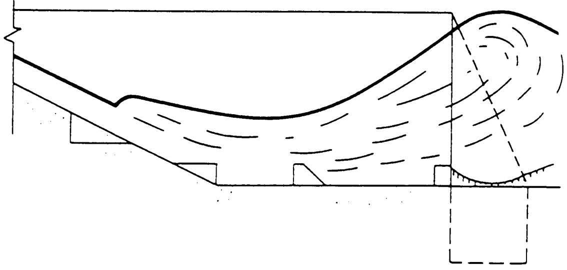
Colorado State University Rigid Boundary Basin



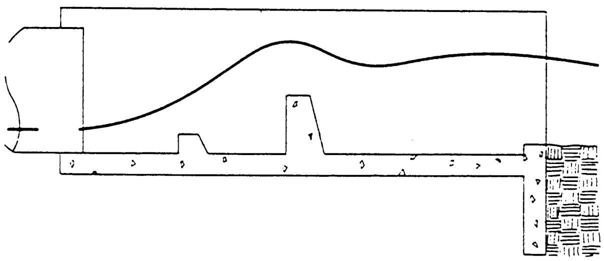
USBR Type IV Basin



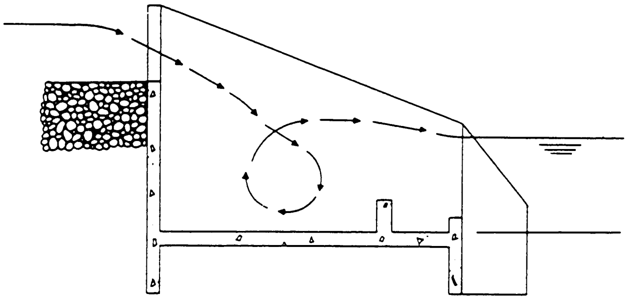
St. Anthony Falls Stilling Basin



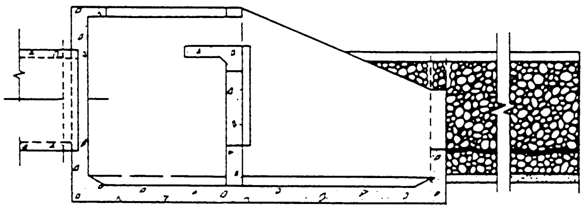
Contra Costa County, Calif.



Straight Drop Spillway Stilling Basin



USBR Type VI Baffle Wall Basin



T-fitting on CMP Outlet

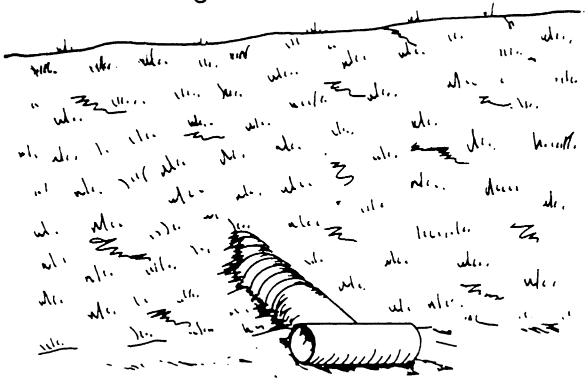
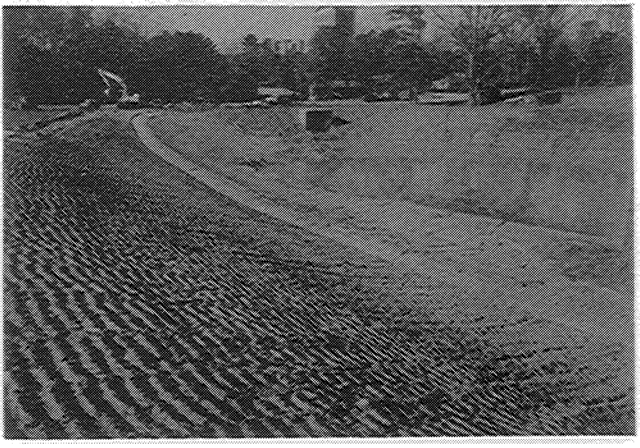


Figure 6-24.4 - Alternative structures for energy dissipation at an outlet (modified from Goldman, Jackson, and Bursztynsky).

Surface Roughening (Su)



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.

PURPOSE

The purposes of surface roughening are to aid in establishment of vegetative cover with seed, to reduce runoff velocity and increase infiltration and to reduce erosion and provide for sediment trapping.

CONDITIONS

All slopes steeper than 3:1 require surface roughening, either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation. However, if the slope is to be stabilized with erosion control blankets or soil reinforcement matting, the soil surface should not be roughened.

Areas with grades less steep than 3:1 should have the soil surface lightly roughened and loosened to a depth of 2 to 4 inches prior to seeding. Areas which have been graded and will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place. Slopes with a stable rock face do not require roughening or stabilization.

DESIGN CRITERIA

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 at first, but encourage water infiltration, speed the establishment of vegetation, and decrease 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 of 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 maybe 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 less steep 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 severly compacted and runoff is increased.

CONSTRUCTION SPECIFICATIONS

Cut Slopes Steeper than 3:1

Cut slopes with a gradient steeper than 3:1 should not be mowed. They shall be stair-step graded or grooved (see Figure 6-25.1).

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 material 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 Slopes Steeper than 3:1

Fill slopes with a gradient steeper than 3:1 should not be mowed. They 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 of "Cut Slopes Steeper than 3:1".
2. As lifts of the fill are constructed, soil and rock material may be allowed to fall naturally onto the slope surface (see Figure 6-25.1).

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.

Cuts, Fills, and Graded Areas Which Will Be Mowed (less than 3:1)

Mowed slopes should not be steeper than 3:1. 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 multipacker-seeder. 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.

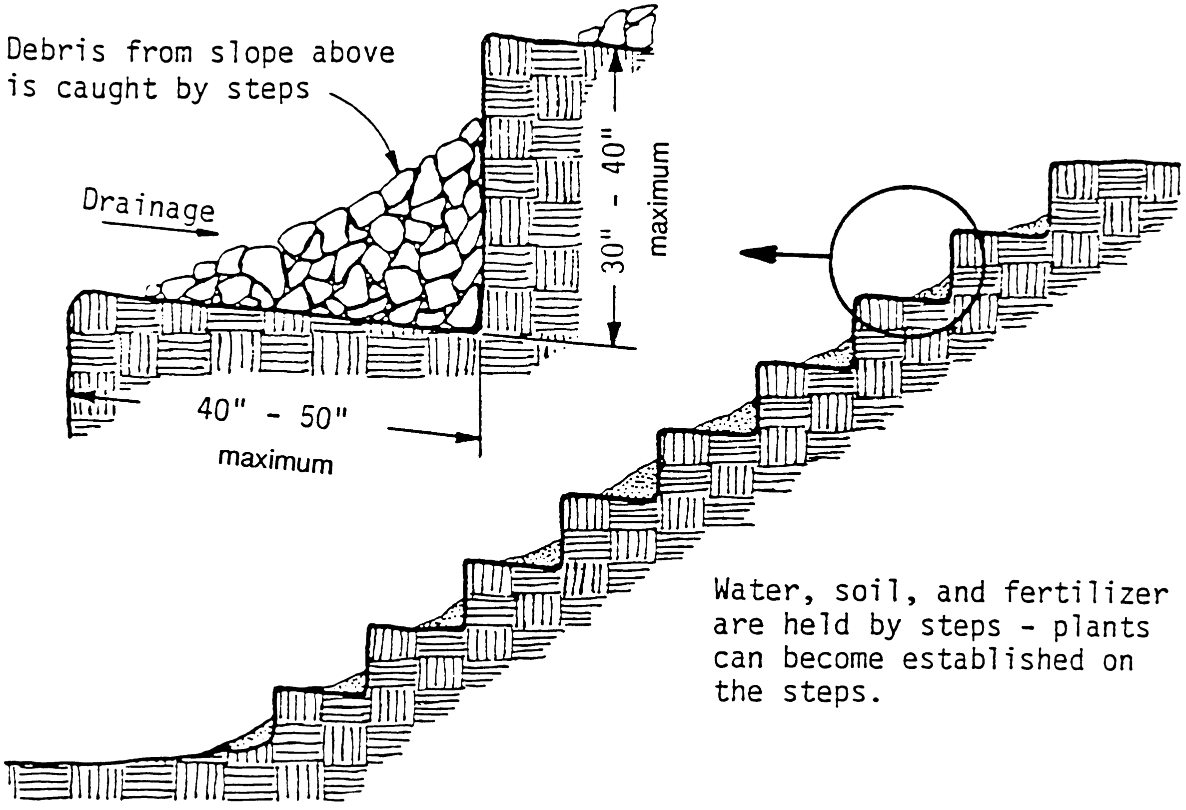
Roughening With Tracked Machinery

Roughening with tracked machinery on clayed 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 as possible should be made to minimize compaction.

Seeding

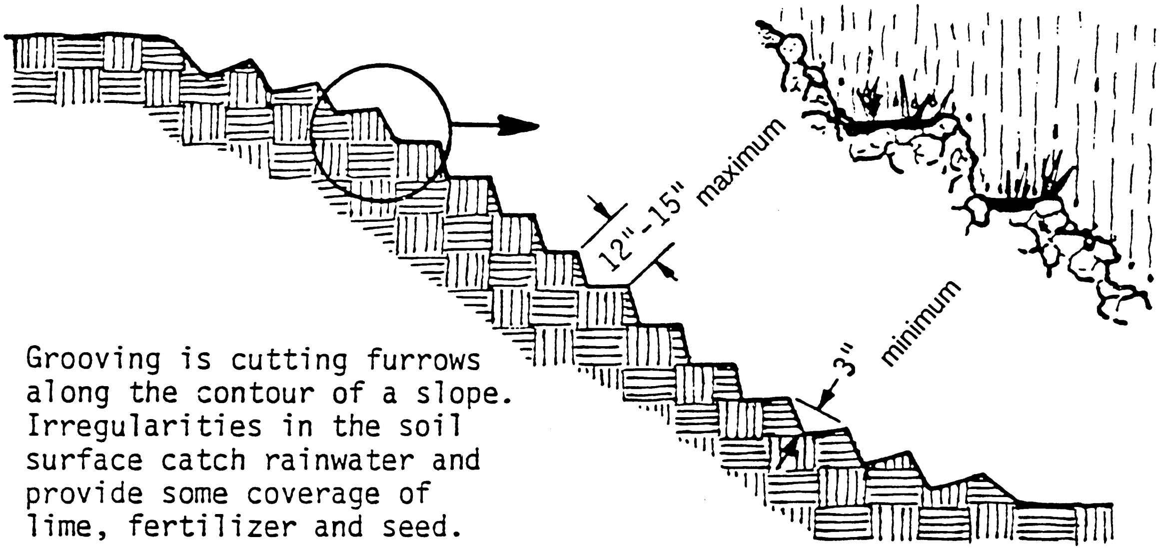
Roughened areas shall be seeded and mulched as soon as possible to obtain optimum seed germination and seeding growth. Refer to specifications **Ds1, Ds2, Ds3, and Ds4 - Disturbed Area Stabilization (With Mulching Only, Temporary Seeding, Permanent Vegetation, and Sodding),** respectively.



Debris from slope above is caught by steps

Water, soil, and fertilizer are held by steps - plants can become established on the steps.

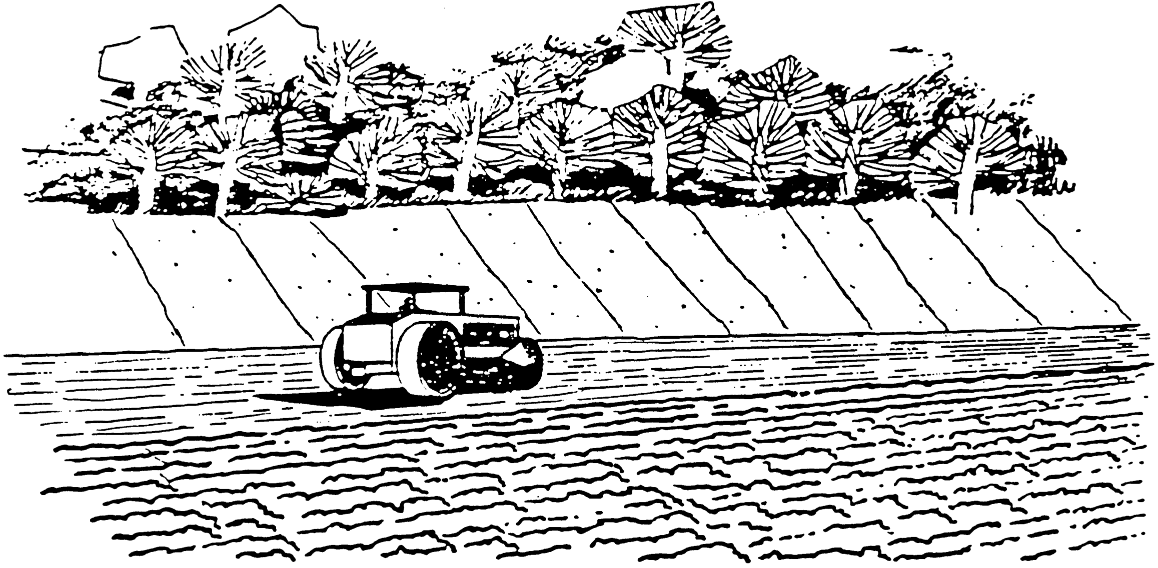
STAIR STEPPING CUT SLOPES



Grooving is cutting furrows along the contour of a slope. Irregularities in the soil surface catch rainwater and provide some coverage of lime, fertilizer and seed.

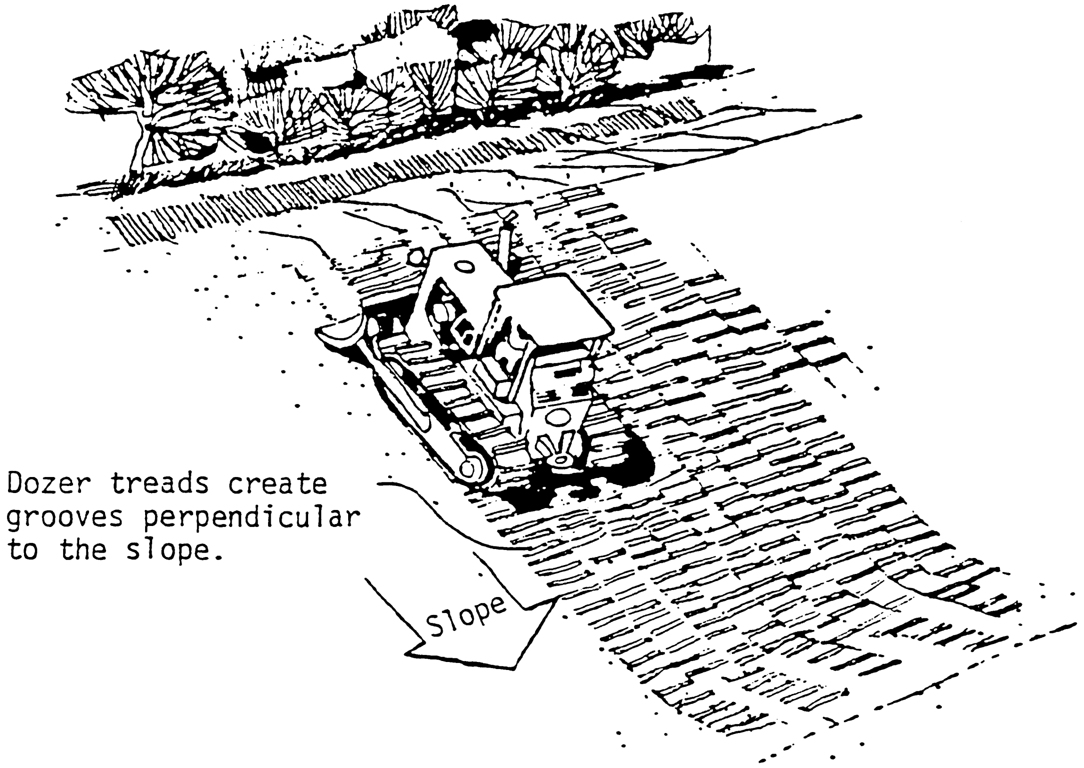
GROOVING SLOPES

Figure 6-25.1



Each lift of the fill is compacted, but the outer face of the slope is allowed to remain loose so that the rocks, clods, etc. reach the natural angle of repose.

FILL SLOPE TREATMENT



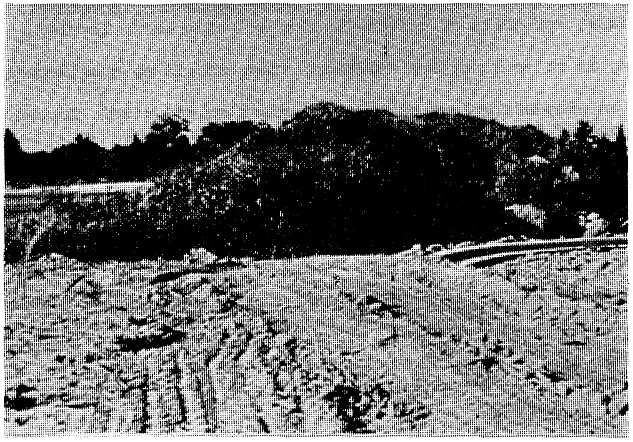
Dozer treads create grooves perpendicular to the slope.

TRACKING

Figure 6-25.2

Topsoiling

Tp



DEFINITION

Stripping off the more fertile top soil, storing it, then spreading it over the disturbed area after completion of construction activities.

PURPOSE

To provide a suitable soil medium for vegetative growth on areas where other measures will not produce or maintain a desirable stand.

CONDITIONS

This practice is recommended for sites of 2:1 or flatter slopes where:

1. The texture of the exposed subsoil or parent material is not suitable to produce adequate vegetative growth.
2. The soil material is so shallow that the rooting zone is not deep enough to support plants with continuing supplies of moisture and food.
3. The soil to be vegetated contains material toxic to plant growth.

CONSTRUCTION SPECIFICATIONS

Materials

Topsoil should be friable and loamy, free of debris, objectionable weeds and stones and contain no toxic substance that may be harmful to plant growth. A pH range of 5.0-7.5 is acceptable. Soluble salts should not exceed 500 ppm.

Testing

Field exploration should be made to determine whether the quantity and quality of surface soil justifies stripping.

Stripping

Stripping should be confined to the immediate construction area.

A 4 to 6 inch stripping depth is common, but may vary depending on the particular soil.

Topsoil pH

If pH value is less than 6.0, lime shall be applied and incorporated with the topsoil to adjust the pH to 6.5 or higher. Topsoils containing soluble salts greater than 500 parts per million shall not be used.

Stockpiles

The location of topsoil stockpiles should not obstruct natural drainage or cause off-site environmental damage.

Stabilization

Stockpiles shall be contained by sediment barriers to prevent sedimentation on adjacent areas. Stockpiles shall be stabilized in accordance with specifications **Ds1 and Ds2 - Disturbed Area Stabilization (With Mulching) and (With Temporary Grassing)**, respectively, or **Pm - Polyacrylamide** or **Tb - Tackifiers and Binders**.

Site Preparation (Where topsoil is to be added)

Topsoiling When topsoiling, maintain needed erosion control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, waterways, sediment basins, etc.

Grading Grades on the areas to be topsoiled which have been previously established shall be maintained.

Liming Soil tests should be used to determine the pH of the soil. Where the pH of the subsoil is 5.0 or less or composed of heavy clays, agricultural limestone shall be spread at the rate of 100 pounds per 1,000 square feet. Lime shall be distributed uniformly over designated areas and worked into the soil in conjunction with tillage operations as described in the following procedure.

Bonding Use one of the following methods to insure bonding of topsoil and subsoil:

1. **Tilling.** After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by discing or scarifying to a depth of at least 3 inches to permit bonding of the topsoil to the subsoil.

2. **Tracking**. Passing a bulldozer over the entire surface area of the slope to leave horizontal depressions.

Applying Topsoil

1. Topsoil should be handled only when it is dry enough to work without damaging soil structure.
2. A uniform application of 5 inches (unsettled) is recommended, but may be adjusted at the discretion of the engineer or landscape architect.

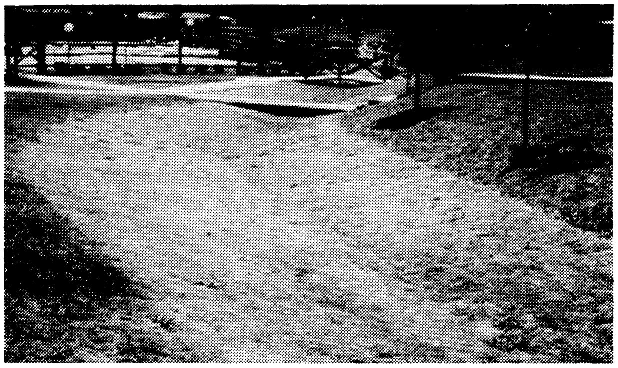
Cubic Yards Of Topsoil Required For Application To Various Depths

Depth (Inches)	Per 1,000 Square Feet	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

Table 6-26.1

Vegetated Waterway or Stormwater Conveyance Channel

Wt



DEFINITION

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

PURPOSE

To dispose of runoff without causing damage either by erosion or by flooding.

CONDITIONS

This standard applies to all sites where added channel capacity and/or stabilization is required to control erosion resulting from concentrated runoff and where such control can be achieved by this practice alone or in combination with others.

DESIGN CRITERIA

Capacity

The minimum capacity shall be that required to convey the peak runoff expected from a 25-year, 24-hour storm or the storm specified in Title 12-7-1 of the Official Code of Georgia Annotated. Peak runoff values used in determining the capacity requirements shall be as outlined in Appendix A or by other accepted methods.

The design of a waterway is based on the determination of channel dimensions that will carry the estimated flow without damage to the channel or its lining. Vegetative linings vary in their protective ability according to type and density. Therefore, safe velocities under various conditions are a matter for careful consideration.

Velocity

In designing grassed waterways, care must be taken to ensure that the design velocity is well within the limits of permissible velocities given in Table 6-27.1. These values apply to uniform good stands of each type of cover.

Cross Section

The minimum design capacity of a waterway receiving water from developing areas, diversions, or other tributary channels shall be that depth required to keep the design water surface elevation in the channel to prevent overflow.

The bottom width of waterways or outlets shall not exceed 50 feet unless multiple or divided waterways or other means are provided to control meandering of low flows within this limit. See Figure 6-27.1.

Drainage

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. See Appendix C for rock riprap specifications.

Stone Center

Stone center waterways shall be constructed as shown in Figure 6-27.2 and Table 6-27.2 and stabilized with riprap according to the specification **Riprap - Appendix C**.

Geotextiles should be used as an erosion control measure beneath the riprap center. The geotextile shall be specified in accordance with AASHTO M288-96 Section 7.5, *Permanent Erosion Control Requirements*.

Vegetative Retardance Factor

The design of a vegetated waterway is more complicated than for a bare channel since the value for "n" varies where grass linings are used. Tests show that vegetation tends to bend and oscillate under the influence of velocity and depth of flow. Thus the retardance to flow varies as these factors change.

Five general retardance curves designated as A, B, C, D, and E have been developed for various cover conditions. The vegetated conditions under which the various retardance values apply in Georgia are shown in Table 6-27.1. These cover classifications are based on tests in experimental channels when the covers were green and generally uniform.

VEGETATIVE COVER TYPE	GOOD STAND				MAXIMUM PERMISSIBLE VELOCITY, V_1, FEET PER SECOND
	FOR CAPACITY AND V_2		FOR STABILITY AND V_1		
	RETARDANCE	PLANT HT. NOT MOWED	RETARDANCE	PLANT HT. MOWED	
BERMUDAGRASS	B	12"	D	2-6"	5
BAHIA	C	6-12"	D	2-6"	4
TALL FESCUE GRASS MIXTURES[1]	B	18"	D	6"	4
SERICEA LESPEDEZA WEEPING LOVEGRASS	B	19"	D	2-6"	3
STONE CENTER	RIPRAP STONE SIZE CAN BE DETERMINED IN APPENDIX C.				

Permissible Velocities and Retardances for Vegetated and Rock-Lined Waterways

Table 6-27.1

[1] Mixtures of Tall Fescue, Bahia, and/or Bermuda.

NOTE: For Planting instructions, refer to Disturbed Area Stabilization (With Permanent Vegetation) Ds3, p. 6-139.

"The Stormwater Conveyance Channel Design Sheets" shall be used to design grass-lined channels. These design sheets include the cross-sectional detail that shall be included on the erosion and sediment control plan.

If a stone center waterway is selected, it shall be designed according to Tables 6-27.2 and 6-27.3. Cross-sectional details on the erosion and sediment control plan shall include all information noted in Figure 6-27.2, including the maximum stone size of the rock to be used.

An example of how to design a grass-lined channel with a parabolic cross-section is provided on p. 6-198

CONSTRUCTION SPECIFICATIONS

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 waterway.
2. The waterway or outlet shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein. It will be free of bank projections or other irregularities which will impede normal flow. If the channel must have erosion protection other than vegetation, *the lining shall not compromise the capacity of the emergency spillway,* i.e. the channel shall be over-excavated so that the lining will be flush with the slope surface.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed waterway
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with waterway functioning.
5. *Stabilization*

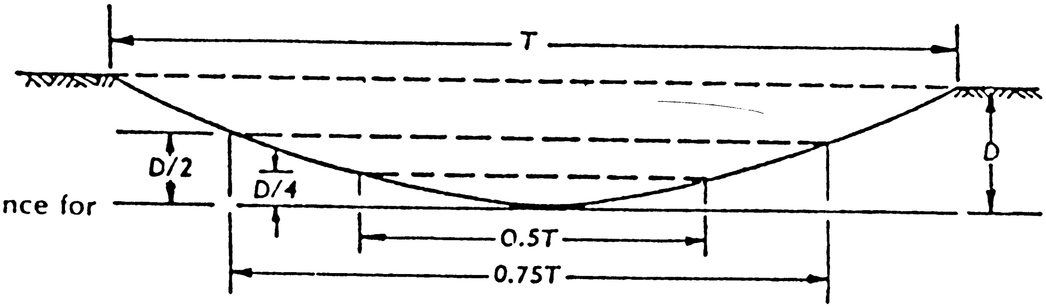
Applicable vegetative standards shall be followed for time of seeding, sprigging or sodding, liming and fertilizing, and site and seedbed preparation.

Erosion control blankets or matting or sod shall be used to aid in the establishment of vegetation. Installation methods should follow manufacturer recommendations. Refer to specification **Ds4 - Disturbed Area Stabilization (With Sodding)** and **Mb - Erosion Control Matting and Blankets**.

Mulching shall be a requirement for all seeded or sprigged channels.

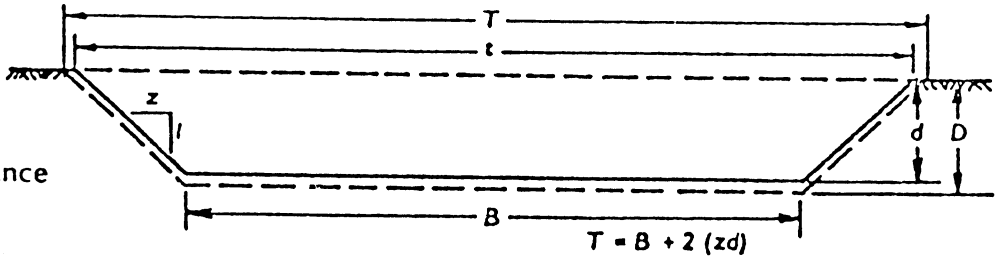
Temporary protection during establishment should be provided when conditions permit through temporary diversions or other means to dispose of water.

T = design top width
D = design depth
Both values include allowance for the vegetative lining.



PARABOLIC CROSS SECTION

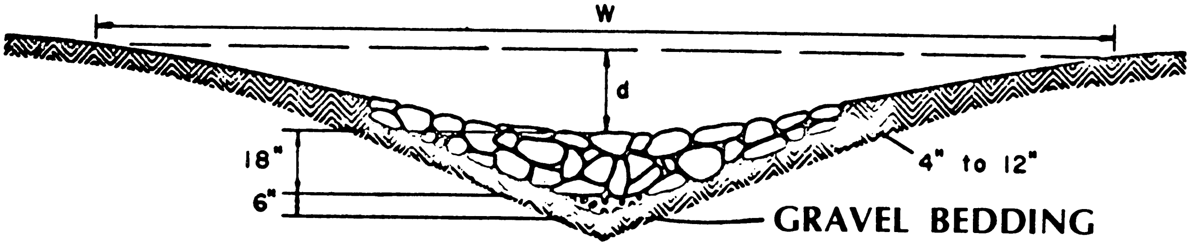
B = design bottom width
d = design depth
D = design depth plus allowance for vegetative lining
t = design top width
T = design top width plus allowance for vegetative lining
z = side slope ratio



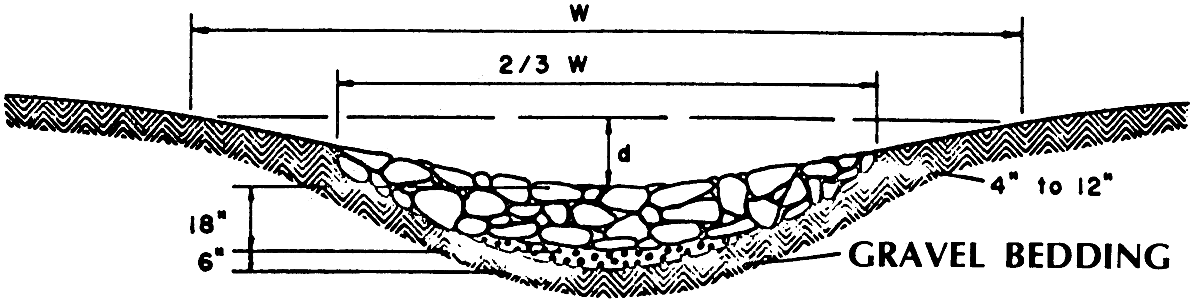
TRAPEZOIDAL CROSS SECTION

Figure 6-27.1 - Typical Waterway Cross Section

STONE CENTER WATERWAYS



Waterway with stone center drain
V section shaped by motor patrol

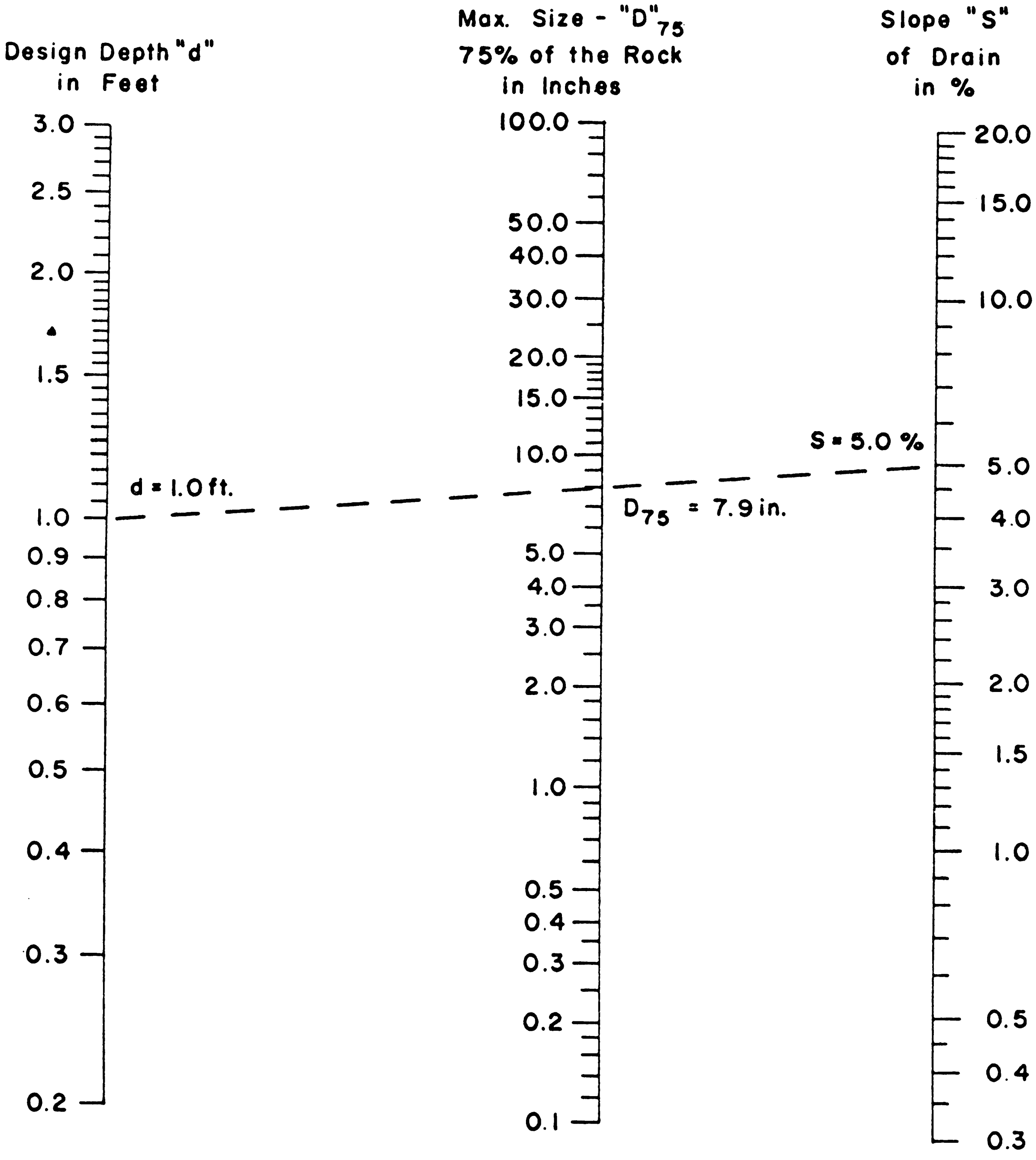


Waterway with stone center drain
Rounded section shaped by bulldozer

Figure 6-27.2 - Waterway with stone center.

Grade	6 Percent		8 Percent		10 Percent		12 Percent		15 Percent	
V	8.0	10	8.0	10	8.0	10.0	8.0	10.0	8.0	10.0
D	1.3	1.6	1.1	1.3	1.0	1.2	0.9	1.1	0.8	0.9
Q	Top Widths									
20							5		5	
25					5		6		6	4
30			5		6		7		7	5
35			6		7		8	5	8	6
40	6		7		8	5	9	6	10	7
45	7		8		9	6	10	6	11	7
50	7		9	6	10	7	11	7	12	8
55	8		9	6	11	7	12	8	13	9
60	9		10	7	12	8	13	8	14	9
65	9		11	7	12	9	14	9	16	11
70	10	7	12	8	13	9	15	10	17	11
75	11	7	13	9	14	10	16	10	18	12
80	12	8	14	9	15	10	18	11	19	13
90	13	9	15	10	17	12	20	13	21	15
100	14	10	17	11	19	13	22	14	24	16
110	16	11	19	13	21	14	24	15	26	18
120	17	11	21	14	23	16	26	17	29	20
130	19	12	22	15	25	17	29	18	31	21
140	20	13	24	16	27	18	31	19	33	23
150	22	14	26	17	29	20	33	21	36	24
160	23	15	27	18	31	21	35	22	38	26
170	25	16	29	19	33	22	37	24	40	28
180	26	17	31	20	34	23	39	25	43	29
190	27	18	32	22	36	25	42	26	45	31
200	29	19	34	23	38	26	44	28	47	33
220	32	21	38	25	42	29	48	31	52	38
240	35	23	41	27	46	31	53	33	57	39
260	38	25	44	30	50	34	57	36	62	42
280	40	27	48	32	54	36	61	39	67	45
300	43	29	51	34	57	39	66	42	71	49

Figure 6-27.2 - Velocity, Top Width and Depth for Parabolic Stone Center Waterways



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.

Figure 6-27.3 - Determination of rock size for stone center waterway

STORMWATER CONVEYANCE CHANNEL DESIGN SHEET

Vegetated Parabolic Channel

EXAMPLE

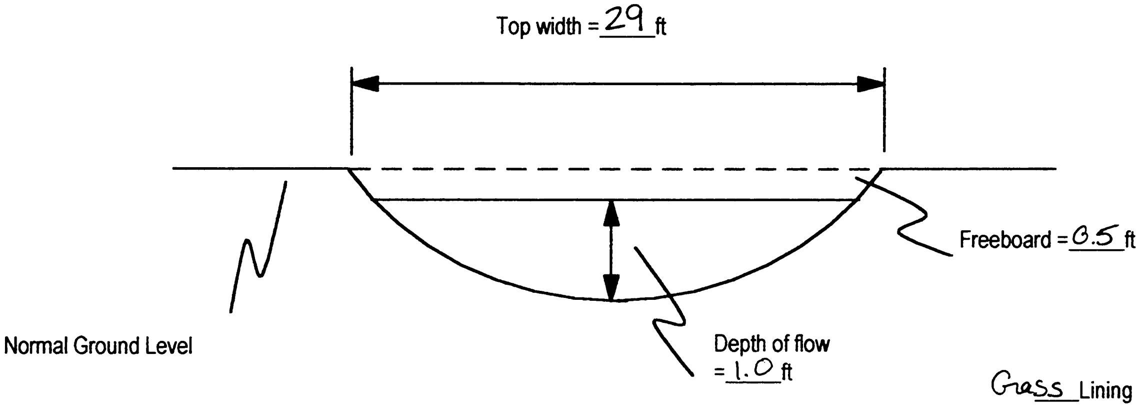
Computed by ______________ Date __________
Checked by ______________ Date __________

Project Name ____________________________

1. Compute peak rate of runoff for 25-year, 24-hour storm.
   Q_{25} = 55 cfs
2. Determine grade of channel.
   Grade = 6%
3. Determine which vegetative cover will be used. Refer to Ds3 - Disturbed Area Stabilization (Using Permanent Vegetation).
   Vegetative cover = **Bermudagrass**
4. Determine retardances and permissible velocities for channel using Table 6-27.1
   The **retardance class for capacity** (unmowed vegetation) is B.
   The **retardance class for stability** (mowed vegetation) is D.
   Maximum permissible velocity, V_1, is 5 fps.
5. Determine dimensions of the parabolic channel. **Use Table 6-28.1**, for retardances "D" and "B".
   For a grade of 6% and a Q_{25} of 55 cfs,
   Top width, T = 29.1 ft *(includes allowance for vegetative lining)*
   Depth, D = 1.0 ft *(includes allowance for vegetative lining)*
   Velocity for unmowed vegetation, V_2 = 2.8 fps.

Parabolic Channel

Example



STORMWATER CONVEYANCE CHANNEL DESIGN SHEET

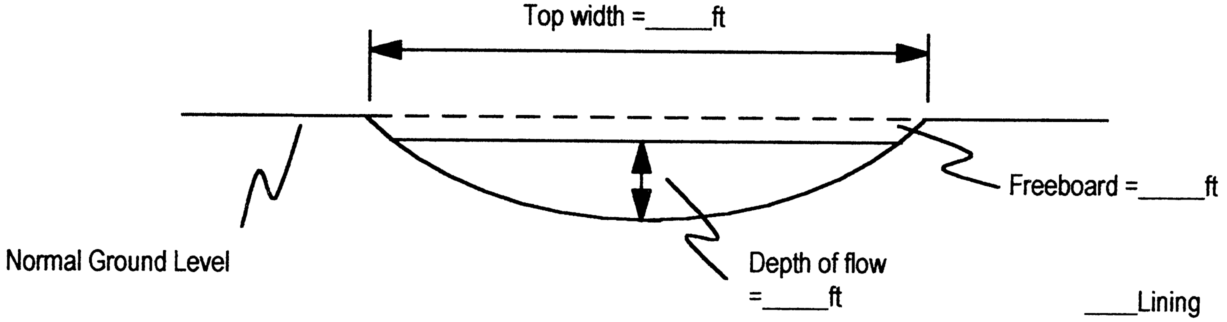
Vegetated Parabolic Channel

Computed by ______________ Date __________
Checked by ______________ Date __________

Project Name ____________________________

1. Compute peak rate of runoff for 25-year, 24-hour storm.
   Q_{25} = _________ cfs
2. Determine grade of channel.
   Grade = _________ %
3. Determine which vegetative cover will be used. Refer to Ds3 - Disturbed Area Stabilization (Using Permanent Vegetation).
   Vegetative cover = ____________________
4. Determine retardances and permissible velocities for channel using Table 6-27.1.
   The **retardance class for capacity** (unmowed vegetation) is _________ .
   The **retardance class for stability** (mowed vegetation) is _________ .
   Maximum permissible velocity, V_1, is _________ fps.
5. Determine dimensions of the parabolic channel. Use Table 6-28.1 for retardances "D" and "B". Use Table 6-28.2 for retardance "D" and "C".
   For a grade of _________% and a Q_{25} of _________ cfs,
   Top width, T = _________ ft *(includes allowance for vegetative lining)*
   Depth, D = _________ ft *(includes allowance for vegetative lining)*
   Velocity for unmowed vegetation, V_2 = _________ fps.

Parabolic



STORMWATER CONVEYANCE CHANNEL DESIGN SHEET

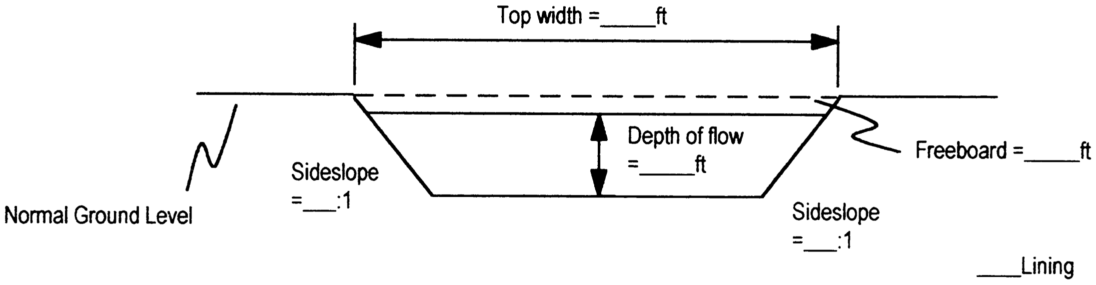
Vegetated Trapezoidal or Triangular Channel

Computed by ______________ Date __________
Checked by ______________ Date __________

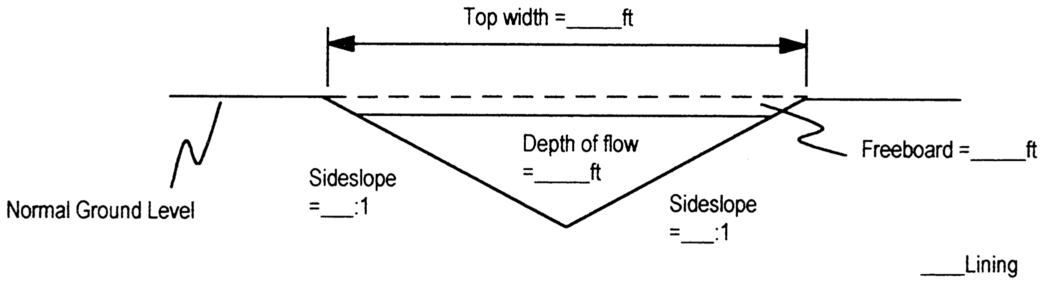
Project Name ___________________________

1. Compute peak rate of runoff for 25-year, 24-hour storm.
   Q_{25} = _________ cfs
2. Determine grade of channel.
   Grade = _________ %
3. Determine which vegetative cover will be used. Refer to Ds3 - Disturbed Area Stabilization (Using Permanent Vegetation).
   Vegetative cover = ____________________
4. Determine retardances and permissible velocities for channel using Table 6-27.1.
   The **retardance class for capacity** is _________ and the unmowed plant height is _________ in.
   The **retardance class for stability** is _________ and the mowed plant height is _________ in.
   Maximum permissible velocity, V_1, is _________ fps.
5. Determine dimensions of the channel. Use Table 6-28.3 for retardance "D". Use Table 6-28.4 for retardance "C".
   For a grade of _________% and Q_{25} of _________ cfs,
   Side slopes (z:1) = _________
   Bottom width, B = _________ ft *(0 for triangular channel)*
   Design depth, d = _________ ft
   Area of channel, A = _________ sf.
6. Calculate the constructed depth of the channel.
   Constructed depth, D = Design depth, d + Unmowed plant height
   Constructed depth, D = _________ ft + _________ ft
   Constructed depth, D = _________ ft
7. Calculate the top width of the channel.
   Top width, T = Bottom width + 2(Side slope * design depth)
   Top width, T = B + 2(z*d)
   Top width, T = _________ ft + 2(______ * _________ ft)
   Top width, T = _________ ft

Trapezoidal



Triangular



TO BE SUBMITTED WITH/ON THE EROSION AND SEDIMENT CONTROL PLAN

GRASS-LINED CHANNEL

1. **Stormwater Conveyance Channel Design Sheet** for the appropriate channel shape.

2. **Cross-sectional detail** of the channel (include with Design Sheet *and* show on E&SC plan).

STONE CENTER CHANNEL

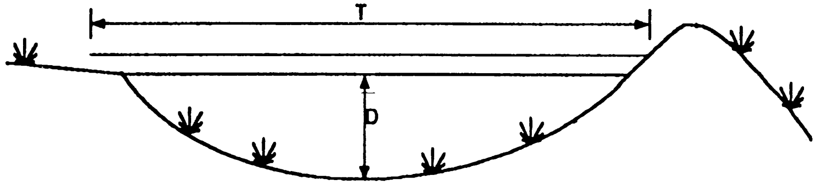
1. **Cross-sectional detail** of the channel on the E&SC plan.

SECTION IV: TABLES FOR DESIGN OF STORMWATER CONVEYENCE PRACTICES

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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			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																											
20																											
25	11.0	3.2	1.1																								
30	13.8	3.0	1.1																								
35	16.4	2.9	1.1																								
40	19.0	2.8	1.1																								
45	21.5	2.8	1.1	11.9	3.7	1.5																					
50	24.0	2.8	1.1	14.1	3.4	1.5																					
55	26.5	2.8	1.1	15.8	3.3	1.6																					
60	29.0	2.8	1.1	17.5	3.3	1.6																					
65	31.5	2.7	1.1	19.2	3.2	1.6	11.8	4.4	1.9																		
70	34.0	2.7	1.1	20.8	3.2	1.6	13.7	4.0	1.9																		
75	37.0	2.7	1.1	22.4	3.2	1.6	15.3	3.8	1.9																		
80	39.4	2.7	1.1	24.1	3.2	1.6	16.6	3.7	1.9																		
85	41.9	2.7	1.1	25.7	3.1	1.6	17.9	3.7	1.9																		
90	44.3	2.7	1.1	27.2	3.1	1.6	19.1	3.6	1.9																		
95	46.7	2.7	1.1	28.8	3.1	1.6	20.3	3.6	2.0																		
100	49.2	2.7	1.1	30.4	3.1	1.6	21.5	3.6	2.0																		
105	51.6	2.7	1.1	32.0	3.1	1.6	22.7	3.5	2.0																		
110	54.1	2.7	1.1	33.6	3.1	1.6	23.9	3.5	2.0	14.4	4.8	2.4															
115	56.5	2.7	1.1	35.1	3.1	1.6	25.1	3.5	2.0	15.7	4.6	2.4															
120	59.0	2.7	1.1	36.7	3.1	1.6	26.2	3.5	2.0	17.0	4.4	2.4															
125	61.4	2.7	1.1	38.3	3.1	1.6	27.3	3.5	2.0	17.9	4.3	2.4															
130	63.9	2.7	1.1	39.7	3.1	1.6	28.5	3.4	2.0	18.8	4.3	2.4															
135	66.3	2.7	1.1	41.3	3.1	1.6	29.7	3.4	2.0	19.7	4.2	2.4															
140	68.8	2.7	1.1	43.4	3.0	1.6	30.8	3.4	2.0	20.6	4.2	2.4															
145	71.2	2.7	1.1	44.9	3.0	1.6	32.0	3.4	2.0	21.5	4.1	2.4															
150	73.7	2.7	1.1	46.5	3.0	1.6	33.1	3.4	2.0	22.4	4.1	2.5															



T = Top width, tall vegetation
D = Depth, tall vegetation
V2 = Design velocity, tall vegetation
V1 = Permissible velocity, short vegetation

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

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						

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 2 of 14)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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			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	8.3	1.9	1.0																								
15	12.9	1.8	1.0	8.4	2.1	1.3																					
20	17.4	1.7	1.0	11.6	2.0	1.3	7.2	2.6	1.6																		
25	22.2	1.7	1.0	14.8	1.9	1.3	10.0	2.2	1.7																		
30	26.6	1.7	1.0	17.9	1.9	1.3	12.3	2.1	1.7	7.7	2.9	2.0															
35	31.0	1.7	1.0	20.9	1.9	1.4	14.5	2.1	1.7	10.0	2.5	2.1															
40	35.4	1.7	1.0	23.9	1.9	1.4	16.7	2.1	1.7	11.8	2.4	2.1															
45	39.8	1.7	1.0	27.3	1.8	1.3	18.9	2.1	1.7	13.5	2.3	2.2	8.9	3.0	2.6												
50	44.2	1.7	1.0	30.3	1.8	1.3	21.1	2.0	1.7	15.1	2.3	2.2	10.7	2.7	2.6												
55	48.7	1.7	1.0	33.3	1.8	1.3	23.3	2.0	1.7	16.7	2.3	2.2	12.1	2.6	2.6												
60	53.1	1.7	1.0	36.3	1.8	1.4	25.5	2.0	1.7	18.4	2.3	2.2	13.4	2.6	2.6												
65	57.5	1.7	1.0	39.3	1.8	1.4	28.0	2.0	1.7	20.0	2.2	2.2	14.7	2.5	2.6	9.5	3.3	3.1									
70	61.9	1.7	1.0	42.3	1.8	1.4	30.2	2.0	1.7	21.6	2.2	2.2	15.9	2.5	2.6	11.2	3.0	3.1									
75	66.3	1.7	1.0	45.3	1.8	1.4	32.3	2.0	1.7	23.2	2.2	2.2	17.2	2.5	2.6	12.3	2.9	3.1									
80	70.7	1.7	1.0	48.3	1.8	1.4	34.4	2.0	1.7	24.8	2.2	2.2	18.4	2.5	2.6	13.3	2.9	3.1									
85	75.2	1.7	1.0	51.4	1.8	1.4	36.6	2.0	1.7	26.3	2.2	2.2	19.6	2.5	2.6	14.3	2.8	3.1	10.2	3.6	3.4						
90	79.6	1.7	1.0	54.4	1.8	1.4	38.7	2.0	1.7	27.9	2.2	2.2	20.8	2.4	2.7	15.3	2.8	3.1	11.4	3.4	3.5						
95	84.0	1.7	1.0	57.4	1.8	1.4	40.9	2.0	1.7	29.5	2.2	2.2	22.0	2.4	2.7	16.3	2.8	3.1	12.7	3.2	3.5						
100	88.4	1.7	1.0	60.4	1.8	1.4	43.0	2.0	1.7	31.4	2.2	2.2	23.2	2.4	2.7	17.2	2.8	3.1	13.5	3.2	3.5						
105	92.8	1.7	1.0	63.4	1.8	1.4	45.1	2.0	1.7	33.0	2.2	2.2	24.4	2.4	2.7	18.2	2.7	3.2	14.4	3.1	3.5						
110	97.2	1.7	1.0	66.4	1.8	1.4	47.3	2.0	1.7	34.6	2.2	2.2	25.6	2.4	2.7	19.1	2.7	3.2	15.2	3.1	3.5						
115	101.7	1.7	1.0	69.4	1.8	1.4	49.4	2.0	1.7	36.1	2.2	2.2	26.8	2.4	2.7	20.0	2.7	3.2	16.0	3.0	3.5	11.6	3.8	3.9			
120	106.1	1.7	1.0	72.5	1.8	1.4	51.6	2.0	1.7	37.7	2.2	2.2	28.0	2.4	2.7	21.0	2.7	3.2	16.8	3.0	3.5	12.6	3.6	3.9			
125	110.5	1.7	1.0	75.5	1.8	1.4	53.7	2.0	1.7	39.2	2.2	2.2	29.2	2.4	2.7	21.9	2.7	3.2	17.6	3.0	3.5	13.7	3.5	3.9			
130	114.9	1.7	1.0	78.5	1.8	1.4	55.8	2.0	1.7	40.8	2.2	2.2	30.4	2.4	2.7	22.8	2.7	3.2	18.4	3.0	3.6	14.4	3.4	3.9			
135	119.3	1.7	1.0	81.5	1.8	1.4	58.0	2.0	1.7	42.4	2.2	2.2	31.6	2.4	2.7	23.8	2.7	3.2	19.1	2.9	3.6	15.1	3.4	4.0			
140	123.7	1.7	1.0	84.5	1.8	1.4	60.1	2.0	1.7	43.9	2.2	2.2	32.8	2.4	2.7	24.7	2.7	3.2	19.9	2.9	3.6	15.8	3.4	4.0			
145	128.2	1.7	1.0	87.5	1.8	1.4	62.3	2.0	1.7	45.5	2.2	2.2	34.5	2.4	2.7	25.6	2.7	3.2	20.7	2.9	3.6	16.5	3.3	4.0			
150	132.6	1.7	1.0	90.6	1.8	1.4	64.4	2.0	1.7	47.1	2.2	2.2	35.7	2.4	2.7	26.5	2.6	3.2	21.5	2.9	3.6	17.1	3.3	4.0			

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 3 of 14)

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	8.2	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

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 4 of 14)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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			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	5.0	1.8	0.8																								
10	11.1	1.4	0.9	7.4	1.6	1.2																					
15	16.9	1.4	1.0	11.6	1.5	1.3	8.1	1.8	1.6																		
20	22.8	1.4	0.9	15.6	1.5	1.3	11.1	1.7	1.6	7.8	2.0	1.9															
25	28.4	1.4	1.0	19.9	1.5	1.3	14.1	1.7	1.6	10.1	1.9	2.0	6.8	2.4	2.3												
30	34.1	1.4	1.0	23.8	1.5	1.3	17.0	1.6	1.6	12.4	1.8	2.0	9.0	2.1	2.4												
35	39.8	1.4	1.0	27.8	1.5	1.3	19.8	1.6	1.6	14.6	1.8	2.0	10.8	2.0	2.4	7.4	2.5	2.8									
40	45.4	1.4	1.0	31.7	1.5	1.3	23.0	1.6	1.6	16.8	1.8	2.0	12.5	2.0	2.5	9.3	2.3	2.9									
45	51.1	1.4	1.0	35.6	1.5	1.3	25.8	1.6	1.6	19.0	1.8	2.0	14.2	1.9	2.5	10.7	2.2	2.9									
50	56.8	1.4	1.0	39.5	1.5	1.3	28.7	1.6	1.6	21.1	1.7	2.0	15.9	1.9	2.5	12.1	2.1	2.9	8.7	2.6	3.3						
55	62.5	1.4	1.0	43.5	1.5	1.3	31.5	1.6	1.6	23.6	1.7	2.0	17.6	1.9	2.5	13.4	2.1	2.9	10.2	2.4	3.4						
60	68.1	1.4	1.0	47.4	1.5	1.3	34.4	1.6	1.6	25.7	1.7	2.0	19.2	1.9	2.5	14.7	2.1	2.9	11.3	2.4	3.4						
65	73.8	1.4	1.0	51.4	1.5	1.3	37.2	1.6	1.6	27.9	1.7	2.0	20.9	1.9	2.5	16.1	2.1	2.9	12.4	2.3	3.4	9.0	2.9	3.8			
70	79.5	1.4	1.0	55.3	1.5	1.3	40.1	1.6	1.6	30.0	1.7	2.0	22.5	1.9	2.5	17.4	2.1	2.9	13.5	2.3	3.4	10.3	2.7	3.8			
75	85.2	1.4	1.0	59.2	1.5	1.3	43.0	1.6	1.6	32.1	1.7	2.0	24.1	1.9	2.5	18.6	2.0	3.0	14.6	2.3	3.4	11.3	2.6	3.8			
80	90.8	1.4	1.0	63.2	1.5	1.3	45.8	1.6	1.6	34.2	1.7	2.0	26.1	1.9	2.5	19.9	2.0	3.0	15.7	2.2	3.4	12.2	2.5	3.9			
85	96.5	1.4	1.0	67.1	1.5	1.3	48.7	1.6	1.6	36.4	1.7	2.0	27.7	1.8	2.5	21.2	2.0	3.0	16.7	2.2	3.4	13.1	2.5	3.9			
90	102.2	1.4	1.0	71.1	1.5	1.3	51.5	1.6	1.6	38.5	1.7	2.0	29.3	1.8	2.5	22.5	2.0	3.0	17.7	2.2	3.5	14.0	2.5	3.9	10.1	3.1	4.4
95	107.9	1.4	1.0	75.0	1.5	1.3	54.4	1.6	1.6	40.6	1.7	2.0	30.9	1.8	2.5	23.8	2.0	3.0	18.8	2.2	3.5	14.9	2.5	3.9	11.3	2.9	4.4
100	113.5	1.4	1.0	79.0	1.5	1.3	57.2	1.6	1.6	42.8	1.7	2.0	32.6	1.8	2.5	25.1	2.0	3.0	19.8	2.2	3.5	15.8	2.4	3.9	12.1	2.8	4.4
105	119.2	1.4	1.0	82.9	1.5	1.3	60.1	1.6	1.6	44.9	1.7	2.0	34.2	1.8	2.5	26.4	2.0	3.0	20.8	2.2	3.5	16.6	2.4	3.9	12.8	2.8	4.4
110	124.9	1.4	1.0	86.9	1.5	1.3	63.0	1.6	1.6	47.0	1.7	2.0	35.8	1.8	2.5	27.6	2.0	3.0	21.9	2.2	3.5	17.5	2.4	3.9	13.6	2.8	4.4
115	130.6	1.4	1.0	90.8	1.5	1.3	65.8	1.6	1.6	49.2	1.7	2.0	37.4	1.8	2.5	29.3	2.0	3.0	22.9	2.2	3.5	18.3	2.4	3.9	14.3	2.7	4.4
120	136.2	1.4	1.0	94.8	1.5	1.3	68.7	1.6	1.6	51.3	1.7	2.0	39.0	1.8	2.5	30.5	2.0	3.0	23.9	2.2	3.5	19.2	2.4	3.9	15.0	2.7	4.4
125	141.9	1.4	1.0	98.7	1.5	1.3	71.5	1.6	1.6	53.4	1.7	2.0	40.6	1.8	2.5	31.8	2.0	3.0	25.0	2.2	3.5	20.0	2.4	3.9	15.8	2.7	4.4
130	147.6	1.4	1.0	102.7	1.5	1.3	74.4	1.6	1.6	55.6	1.7	2.0	42.3	1.8	2.5	33.1	2.0	3.0	26.0	2.2	3.5	20.9	2.4	3.9	16.4	2.7	4.5
135	153.3	1.4	1.0	106.6	1.5	1.3	77.3	1.6	1.6	57.7	1.7	2.0	43.9	1.8	2.5	34.3	2.0	3.0	27.0	2.2	3.5	21.7	2.4	3.9	17.1	2.6	4.5
140	158.9	1.4	1.0	110.5	1.5	1.3	80.1	1.6	1.6	59.8	1.7	2.0	45.5	1.8	2.5	35.6	2.0	3.0	28.0	2.2	3.5	22.6	2.4	3.9	17.8	2.6	4.5
145	164.6	1.4	1.0	114.5	1.5	1.3	83.0	1.6	1.6	62.0	1.7	2.0	47.1	1.8	2.5	36.9	2.0	3.0	29.1	2.2	3.5	23.4	2.4	3.9	18.5	2.6	4.5
150	170.3	1.4	1.0	118.4	1.5	1.3	85.8	1.6	1.6	64.1	1.7	2.0	48.8	1.8	2.5	38.1	2.0	3.0	30.1	2.2	3.5	24.3	2.3	4.0	19.2	2.6	4.5

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 5 of 14)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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			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	1.5	0.9																								
10	12.4	1.3	0.9	8.3	1.5	1.2	5.5	1.9	1.5																		
15	18.9	1.3	0.9	12.8	1.4	1.2	9.1	1.6	1.6	6.2	1.9	1.9															
20	25.1	1.3	0.9	17.2	1.4	1.2	12.4	1.5	1.6	9.0	1.7	1.9	6.0	2.2	2.2												
25	31.4	1.3	0.9	21.8	1.4	1.2	15.6	1.5	1.6	11.5	1.7	2.0	8.4	1.9	2.4												
30	37.7	1.3	0.9	26.1	1.4	1.2	18.8	1.5	1.6	14.0	1.6	2.0	10.4	1.8	2.4	7.6	2.1	2.8									
35	43.9	1.3	0.9	30.4	1.4	1.2	22.2	1.5	1.6	16.4	1.6	2.0	12.3	1.8	2.4	9.2	2.0	2.8									
40	50.2	1.3	0.9	34.8	1.4	1.3	25.3	1.5	1.6	18.8	1.6	2.0	14.2	1.8	2.4	10.8	2.0	2.8	7.8	2.4	3.2						
45	56.5	1.3	0.9	39.1	1.4	1.3	28.5	1.5	1.6	21.2	1.6	2.0	16.1	1.7	2.4	12.3	1.9	2.9	9.4	2.2	3.3						
50	62.7	1.3	0.9	43.5	1.4	1.3	31.7	1.5	1.6	23.9	1.6	2.0	17.9	1.7	2.4	13.8	1.9	2.9	10.6	2.1	3.3						
55	69.0	1.3	0.9	47.8	1.4	1.3	34.8	1.5	1.6	26.2	1.6	2.0	19.8	1.7	2.4	15.3	1.9	2.9	11.9	2.1	3.3	9.1	2.4	3.7			
60	75.3	1.3	0.9	52.1	1.4	1.3	38.0	1.5	1.6	28.6	1.6	2.0	21.6	1.7	2.4	16.7	1.9	2.9	13.1	2.1	3.3	10.1	2.4	3.8			
65	81.5	1.3	0.9	56.5	1.4	1.3	41.1	1.5	1.6	31.0	1.6	2.0	23.8	1.7	2.4	18.2	1.9	2.9	14.3	2.0	3.3	11.2	2.3	3.8			
70	87.8	1.3	0.9	60.8	1.4	1.3	44.3	1.5	1.6	33.3	1.6	2.0	25.6	1.7	2.4	19.6	1.8	2.9	15.5	2.0	3.3	12.2	2.3	3.8	9.2	2.7	4.2
75	94.1	1.3	0.9	65.2	1.4	1.3	47.4	1.5	1.6	35.7	1.6	2.0	27.4	1.7	2.4	21.0	1.8	2.9	16.6	2.0	3.4	13.2	2.2	3.8	10.3	2.6	4.2
80	100.3	1.3	0.9	69.5	1.4	1.3	50.6	1.5	1.6	38.1	1.6	2.0	29.1	1.7	2.4	22.5	1.8	2.9	17.8	2.0	3.4	14.2	2.2	3.8	11.2	2.5	4.3
85	106.6	1.3	0.9	73.8	1.4	1.3	53.7	1.5	1.6	40.5	1.6	2.0	30.9	1.7	2.4	23.9	1.8	2.9	18.9	2.0	3.4	15.2	2.2	3.8	12.1	2.5	4.3
90	112.9	1.3	0.9	78.2	1.4	1.3	56.9	1.5	1.6	42.8	1.6	2.0	32.7	1.7	2.4	25.7	1.8	2.9	20.1	2.0	3.4	16.1	2.2	3.9	12.9	2.4	4.3
95	119.1	1.3	0.9	82.5	1.4	1.3	60.0	1.5	1.6	45.2	1.6	2.0	34.5	1.7	2.4	27.1	1.8	2.9	21.2	2.0	3.4	17.0	2.2	3.9	13.8	2.4	4.3
100	125.4	1.3	0.9	86.9	1.4	1.3	63.2	1.5	1.6	47.6	1.6	2.0	36.3	1.7	2.4	28.5	1.8	2.9	22.4	2.0	3.4	18.0	2.2	3.9	14.6	2.4	4.3
105	131.7	1.3	0.9	91.2	1.4	1.3	66.4	1.5	1.6	50.0	1.6	2.0	38.1	1.7	2.4	29.9	1.8	2.9	23.5	2.0	3.4	19.0	2.1	3.9	15.4	2.4	4.3
110	138.0	1.3	0.9	95.5	1.4	1.3	69.5	1.5	1.6	52.3	1.6	2.0	40.0	1.7	2.4	31.3	1.8	2.9	24.7	2.0	3.4	19.9	2.1	3.9	16.2	2.3	4.3
115	144.2	1.3	0.9	99.9	1.4	1.3	72.7	1.5	1.6	54.7	1.6	2.0	41.8	1.7	2.4	32.8	1.8	2.9	25.8	2.0	3.4	20.9	2.1	3.9	17.0	2.3	4.3
120	150.5	1.3	0.9	104.2	1.4	1.3	75.8	1.5	1.6	57.1	1.6	2.0	43.6	1.7	2.4	34.2	1.8	2.9	27.0	2.0	3.4	21.8	2.1	3.9	17.8	2.3	4.4
125	156.8	1.3	0.9	108.6	1.4	1.3	79.0	1.5	1.6	59.5	1.6	2.0	45.4	1.7	2.4	35.6	1.8	2.9	28.5	2.0	3.4	22.7	2.1	3.9	18.6	2.3	4.4
130	163.0	1.3	0.9	112.9	1.4	1.3	82.2	1.5	1.6	61.8	1.6	2.0	47.2	1.7	2.4	37.0	1.8	2.9	29.6	2.0	3.4	23.7	2.1	3.9	19.3	2.3	4.4
135	169.3	1.3	0.9	117.2	1.4	1.3	85.3	1.5	1.6	64.2	1.6	2.0	49.0	1.7	2.4	38.4	1.8	2.9	30.8	1.9	3.4	24.6	2.1	3.9	20.1	2.3	4.4
140	175.6	1.3	0.9	121.6	1.4	1.3	88.5	1.5	1.6	66.6	1.6	2.0	50.8	1.7	2.4	39.8	1.8	2.9	31.9	1.9	3.4	25.6	2.1	3.9	20.9	2.3	4.4
145	181.8	1.3	0.9	125.9	1.4	1.3	91.6	1.5	1.6	69.0	1.6	2.0	52.6	1.7	2.4	41.3	1.8	2.9	33.0	1.9	3.4	26.5	2.1	3.9	21.7	2.3	4.4
150	188.1	1.3	0.9	130.3	1.4	1.3	94.8	1.5	1.6	71.3	1.6	2.0	54.4	1.7	2.4	42.7	1.8	2.9	34.2	1.9	3.4	27.4	2.1	3.9	22.5	2.3	4.4

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 6 of 14)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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			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	6.5	1.3	0.9																								
10	13.5	1.2	0.9	9.1	1.4	1.2	6.4	1.6	1.5																		
15	20.5	1.2	0.9	13.9	1.3	1.2	10.0	1.4	1.6	7.2	1.7	1.9															
20	27.3	1.2	0.9	18.8	1.3	1.2	13.6	1.4	1.6	10.0	1.6	1.9	7.3	1.8	2.3												
25	34.1	1.2	0.9	23.5	1.3	1.2	17.0	1.4	1.6	12.7	1.5	1.9	9.5	1.7	2.3	6.8	2.0	2.7									
30	40.9	1.2	0.9	28.2	1.3	1.2	20.7	1.4	1.6	15.4	1.5	1.9	11.6	1.7	2.3	8.7	1.9	2.8									
35	47.7	1.2	0.9	32.8	1.3	1.2	24.1	1.4	1.6	17.9	1.5	2.0	13.6	1.6	2.4	10.4	1.8	2.8	7.9	2.1	3.2						
40	54.5	1.2	0.9	37.5	1.3	1.2	27.5	1.4	1.6	20.8	1.5	1.9	15.7	1.6	2.4	12.1	1.8	2.8	9.3	2.0	3.2						
45	61.3	1.2	0.9	42.2	1.3	1.2	30.9	1.4	1.6	23.4	1.5	1.9	17.7	1.6	2.4	13.7	1.8	2.8	10.7	1.9	3.3	7.9	2.3	3.7			
50	68.1	1.2	0.9	46.9	1.3	1.2	34.4	1.4	1.6	26.0	1.5	1.9	19.7	1.6	2.4	15.3	1.7	2.8	12.0	1.9	3.3	9.3	2.2	3.7			
55	74.9	1.2	0.9	51.6	1.3	1.2	37.8	1.4	1.6	28.5	1.5	1.9	22.1	1.6	2.3	16.9	1.7	2.8	13.3	1.9	3.3	10.5	2.1	3.7	7.5	2.7	4.1
60	81.7	1.2	0.9	56.2	1.3	1.2	41.2	1.4	1.6	31.1	1.5	2.0	24.0	1.6	2.3	18.5	1.7	2.8	14.6	1.9	3.3	11.6	2.1	3.7	9.0	2.4	4.1
65	88.5	1.2	0.9	60.9	1.3	1.2	44.6	1.4	1.6	33.7	1.5	2.0	26.0	1.6	2.4	20.1	1.7	2.8	15.9	1.9	3.3	12.7	2.1	3.7	10.0	2.3	4.2
70	95.4	1.2	0.9	65.6	1.3	1.2	48.1	1.4	1.6	36.3	1.5	2.0	28.0	1.6	2.4	21.6	1.7	2.9	17.2	1.8	3.3	13.8	2.0	3.8	11.0	2.3	4.2
75	102.2	1.2	0.9	70.3	1.3	1.2	51.5	1.4	1.6	38.9	1.5	2.0	30.0	1.6	2.4	23.2	1.7	2.9	18.4	1.8	3.3	14.8	2.0	3.8	11.9	2.2	4.2
80	109.0	1.2	0.9	75.0	1.3	1.2	54.9	1.4	1.6	41.5	1.5	2.0	32.0	1.6	2.4	25.1	1.7	2.8	19.7	1.8	3.3	15.8	2.0	3.8	12.8	2.2	4.2
85	115.8	1.2	0.9	79.6	1.3	1.2	58.3	1.4	1.6	44.1	1.5	2.0	34.0	1.6	2.4	26.6	1.7	2.8	21.0	1.8	3.3	16.9	2.0	3.8	13.7	2.2	4.2
90	122.6	1.2	0.9	84.3	1.3	1.2	61.8	1.4	1.6	46.6	1.5	2.0	36.0	1.6	2.4	28.2	1.7	2.8	22.2	1.8	3.3	17.9	2.0	3.8	14.6	2.2	4.3
95	129.4	1.2	0.9	89.0	1.3	1.2	65.2	1.4	1.6	49.2	1.5	2.0	37.9	1.6	2.4	29.8	1.7	2.8	23.5	1.8	3.3	19.0	2.0	3.8	15.5	2.2	4.3
100	136.2	1.2	0.9	93.7	1.3	1.2	68.6	1.4	1.6	51.8	1.5	2.0	39.8	1.6	2.4	31.3	1.7	2.8	24.8	1.8	3.3	20.0	2.0	3.8	16.3	2.1	4.3
105	143.0	1.2	0.9	98.4	1.3	1.2	72.1	1.4	1.6	54.4	1.5	2.0	41.8	1.6	2.4	32.9	1.7	2.8	26.4	1.8	3.3	21.1	2.0	3.8	17.2	2.1	4.3
110	149.8	1.2	0.9	103.1	1.3	1.2	75.5	1.4	1.6	57.0	1.5	2.0	43.8	1.6	2.4	34.4	1.7	2.8	27.6	1.8	3.3	22.1	2.0	3.8	18.1	2.1	4.3
115	156.6	1.2	0.9	107.7	1.3	1.2	78.9	1.4	1.6	59.6	1.5	2.0	45.8	1.6	2.4	36.0	1.7	2.8	28.9	1.8	3.3	23.1	2.0	3.8	19.0	2.1	4.3
120	163.4	1.2	0.9	112.4	1.3	1.2	82.3	1.4	1.6	62.2	1.5	2.0	47.8	1.6	2.4	37.6	1.7	2.8	30.1	1.8	3.3	24.2	1.9	3.8	19.8	2.1	4.3
125	170.3	1.2	0.9	117.1	1.3	1.2	85.8	1.4	1.6	64.8	1.5	2.0	49.8	1.6	2.4	39.1	1.7	2.9	31.4	1.8	3.3	25.2	1.9	3.8	20.7	2.1	4.3
130	177.1	1.2	0.9	121.8	1.3	1.2	89.2	1.4	1.6	67.3	1.5	2.0	51.8	1.6	2.4	40.7	1.7	2.9	32.6	1.8	3.3	26.2	1.9	3.8	21.5	2.1	4.3
135	183.9	1.2	0.9	126.5	1.3	1.2	92.6	1.4	1.6	69.9	1.5	2.0	53.8	1.6	2.4	42.2	1.7	2.9	33.9	1.8	3.3	27.3	1.9	3.8	22.4	2.1	4.3
140	190.7	1.2	0.9	131.2	1.3	1.2	96.1	1.4	1.6	72.5	1.5	2.0	55.7	1.6	2.4	43.8	1.7	2.9	35.1	1.8	3.3	28.7	1.9	3.8	23.3	2.1	4.3
145	197.5	1.2	0.9	135.8	1.3	1.2	99.5	1.4	1.6	75.1	1.5	2.0	57.7	1.6	2.4	45.3	1.7	2.9	36.4	1.8	3.3	29.7	1.9	3.8	24.1	2.1	4.3
150	204.3	1.2	0.9	140.5	1.3	1.2	102.9	1.4	1.6	77.7	1.5	2.0	59.7	1.6	2.4	46.9	1.7	2.9	37.6	1.8	3.3	30.7	1.9	3.8	25.0	2.1	4.3

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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	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

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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			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	8.8	1.0	0.8	5.8	1.1	1.1	3.9	1.5	1.3																		
10	18.0	1.0	0.8	12.1	1.1	1.2	8.9	1.1	1.5	6.6	1.3	1.8	4.7	1.5	2.1												
15	27.0	1.0	0.8	18.3	1.1	1.2	13.5	1.1	1.5	10.3	1.2	1.8	7.9	1.3	2.2	6.0	1.5	2.5									
20	35.9	1.0	0.8	24.4	1.1	1.2	18.2	1.1	1.5	13.8	1.2	1.8	10.7	1.3	2.2	8.3	1.4	2.6	6.4	1.6	3.0						
25	44.9	1.0	0.8	30.5	1.1	1.2	22.8	1.1	1.5	17.5	1.2	1.8	13.4	1.3	2.2	10.6	1.4	2.6	8.3	1.5	3.0	6.4	1.7	3.4			
30	53.9	1.0	0.8	36.6	1.1	1.2	27.3	1.1	1.5	20.9	1.2	1.8	16.2	1.3	2.2	12.8	1.4	2.6	10.2	1.5	3.0	8.1	1.6	3.5	6.0	1.9	3.9
35	62.8	1.0	0.8	42.7	1.1	1.2	31.8	1.1	1.5	24.4	1.2	1.8	19.1	1.2	2.2	15.0	1.3	2.6	12.0	1.4	3.0	9.6	1.6	3.5	7.6	1.7	3.9
40	71.8	1.0	0.8	48.8	1.1	1.2	36.4	1.1	1.5	27.9	1.2	1.8	21.9	1.2	2.2	17.2	1.3	2.6	13.8	1.4	3.1	11.1	1.5	3.5	9.0	1.7	4.0
45	80.8	1.0	0.8	54.9	1.0	1.2	40.9	1.1	1.5	31.3	1.2	1.8	24.6	1.2	2.2	19.6	1.3	2.6	15.5	1.4	3.1	12.6	1.5	3.5	10.2	1.7	4.0
50	89.7	1.0	0.8	60.9	1.0	1.2	45.4	1.1	1.5	34.8	1.2	1.8	27.3	1.2	2.2	21.8	1.3	2.6	17.3	1.4	3.1	14.1	1.5	3.5	11.5	1.6	4.0
55	98.7	1.0	0.8	67.0	1.0	1.2	50.0	1.1	1.5	38.3	1.2	1.8	30.0	1.2	2.2	24.0	1.3	2.6	19.1	1.4	3.1	15.5	1.5	3.5	12.7	1.6	4.0
60	107.7	1.0	0.8	73.1	1.0	1.2	54.5	1.1	1.5	41.8	1.2	1.8	32.7	1.2	2.2	26.1	1.3	2.6	21.0	1.4	3.1	16.9	1.5	3.6	14.0	1.6	4.0
65	116.6	1.0	0.8	79.2	1.0	1.2	59.0	1.1	1.5	45.2	1.2	1.8	35.5	1.2	2.2	28.3	1.3	2.6	22.8	1.4	3.1	18.4	1.5	3.6	15.1	1.6	4.0
70	125.6	1.0	0.8	85.3	1.0	1.2	63.6	1.1	1.5	48.7	1.2	1.8	38.2	1.2	2.2	30.5	1.3	2.6	24.5	1.4	3.1	19.8	1.5	3.6	16.3	1.6	4.1
75	134.6	1.0	0.8	91.4	1.0	1.2	68.1	1.1	1.5	52.2	1.2	1.9	40.9	1.2	2.2	32.6	1.3	2.6	26.2	1.4	3.1	21.5	1.5	3.5	17.5	1.6	4.1
80	143.6	1.0	0.8	97.5	1.0	1.2	72.7	1.1	1.5	55.7	1.2	1.9	43.6	1.2	2.2	34.8	1.3	2.6	28.0	1.4	3.1	23.0	1.5	3.5	18.8	1.6	4.1
85	152.5	1.0	0.8	103.6	1.0	1.2	77.2	1.1	1.5	59.1	1.2	1.9	46.3	1.2	2.2	37.0	1.3	2.6	29.7	1.4	3.1	24.4	1.5	3.6	20.0	1.6	4.1
90	161.5	1.0	0.8	109.7	1.0	1.2	81.7	1.1	1.5	62.6	1.2	1.9	49.1	1.2	2.2	39.1	1.3	2.6	31.5	1.4	3.1	25.8	1.5	3.6	21.2	1.6	4.1
95	170.5	1.0	0.8	115.8	1.0	1.2	86.3	1.1	1.5	66.1	1.2	1.9	51.8	1.2	2.2	41.3	1.3	2.6	33.2	1.4	3.1	27.2	1.5	3.6	22.6	1.6	4.0
100	179.5	1.0	0.8	121.9	1.0	1.2	90.8	1.1	1.5	69.6	1.2	1.9	54.5	1.2	2.2	43.5	1.3	2.6	35.0	1.4	3.1	28.7	1.5	3.6	23.8	1.6	4.0
105	188.4	1.0	0.8	128.0	1.0	1.2	95.4	1.1	1.5	73.0	1.2	1.9	57.2	1.2	2.2	45.6	1.3	2.6	36.7	1.4	3.1	30.1	1.5	3.6	25.0	1.6	4.0
110	197.4	1.0	0.8	134.1	1.0	1.2	99.9	1.1	1.5	76.5	1.2	1.9	60.0	1.2	2.2	47.8	1.3	2.6	38.4	1.4	3.1	31.5	1.5	3.6	26.2	1.6	4.0
115	206.4	1.0	0.8	140.1	1.0	1.2	104.4	1.1	1.5	80.0	1.2	1.9	62.7	1.2	2.2	50.0	1.3	2.6	40.2	1.4	3.1	32.9	1.5	3.6	27.4	1.6	4.0
120	215.3	1.0	0.8	146.2	1.0	1.2	109.0	1.1	1.5	83.5	1.2	1.9	65.4	1.2	2.2	52.2	1.3	2.6	41.9	1.4	3.1	34.4	1.5	3.6	28.6	1.6	4.0
125	224.3	1.0	0.8	152.3	1.0	1.2	113.5	1.1	1.5	86.9	1.2	1.9	68.1	1.2	2.2	54.3	1.3	2.6	43.7	1.4	3.1	35.8	1.5	3.6	29.8	1.6	4.0
130	233.3	1.0	0.8	158.4	1.0	1.2	118.1	1.1	1.5	90.4	1.2	1.9	70.9	1.2	2.2	56.5	1.3	2.6	45.4	1.4	3.1	37.2	1.5	3.6	30.9	1.6	4.0
135	242.3	1,0	0.8	164.5	1.0	1.2	122.6	1.1	1.5	93.9	1.2	1.9	73.6	1.2	2.2	58.7	1.3	2.6	47.2	1.4	3.1	38.6	1.5	3.6	32.1	1.6	4.1
140	251.2	1.0	0.8	170.6	1.0	1.2	127.1	1.1	1.5	97.4	1.2	1.9	76.3	1.2	2.2	60.8	1.3	2.6	48.9	1.4	3.1	40.1	1.5	3.6	33.3	1.6	4.1
145	260.2	1.0	0.8	176.7	1.0	1.2	131.7	1.1	1.5	100.9	1.2	1.9	79.0	1.2	2.2	63.0	1.3	2.6	50.7	1.4	3.1	41.5	1.5	3.6	34.5	1.6	4.1
150	269.2	1.0	0.8	182.8	1.0	1.2	136.2	1.1	1.5	104.3	1.2	1.9	81.7	1.2	2.2	65.2	1.3	2.6	52.4	1.4	3.1	42.9	1.5	3.6	35.7	1.6	4.1

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 9 of 14)

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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	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

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH (D), AND V2 FOR RETARDANCE "B"

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			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	11.3	0.8	0.8	8.0	0.9	1.1	5.6	1.0	1.4	4.2	1.1	1.6															
10	22.5	0.8	0.8	16.3	0.9	1.1	11.5	0.9	1.4	8.9	1.0	1.7	7.0	1.0	2.0	5.5	1.2	2.4	4.0	1.4	2.6						
15	33.7	0.8	0.8	24.3	0.9	1.1	17.4	0.9	1.4	13.7	1.0	1.7	10.7	1.0	2.1	8.5	1.1	2.4	6.8	1.2	2.8	5.4	1.3	3.2			
20	45.0	0.8	0.8	32.4	0.9	1.1	23.2	0.9	1.4	18.2	1.0	1.7	14.5	1.0	2.1	11.5	1.1	2.5	9.3	1.1	2.8	7.5	1.2	3.2	6.1	1.4	3.7
25	56.2	0.8	0.8	40.5	0.9	1.1	28.9	0.9	1.4	22.8	1.0	1.7	18.1	1.0	2.1	14.6	1.1	2.4	11.7	1.1	2.8	9.6	1.2	3.3	7.8	1.3	3.7
30	67.4	0.8	0.8	48.7	0.9	1.1	34.7	0.9	1.4	27.3	1.0	1.7	21.7	1.0	2.1	17.5	1.1	2.4	14.1	1.1	2.8	11.6	1.2	3.3	9.5	1.3	3.7
35	78.7	0.8	0.8	56.8	0.9	1.1	40.5	0.9	1.4	31.8	1.0	1.7	25.3	1.0	2.1	20.4	1.0	2.5	16.7	1.1	2.8	13.6	1.2	3.3	11.2	1.3	3.7
40	89.9	0.8	0.8	64.9	0.9	1.1	46.3	0.9	1.4	36.4	1.0	1.7	28.8	1.0	2.1	23.3	1.0	2.5	19.1	1.1	2.8	15.6	1.2	3.3	12.9	1.2	3.7
45	101.1	0.8	0.8	73.0	0.9	1.1	52.1	0.9	1.4	40.9	1.0	1.7	32.4	1.0	2.1	26.2	1.0	2.5	21.5	1.1	2.8	17.7	1.2	3.3	14.6	1.2	3.7
50	112.4	0.8	0.8	81.1	0.9	1.1	57.9	0.9	1.4	45.5	1.0	1.7	36.0	1.0	2.1	29.1	1.0	2.5	23.9	1.1	2.8	19.7	1.2	3.3	16.2	1.2	3.7
55	123.6	0.8	0.8	89.2	0.9	1.1	63.6	0.9	1.4	50.0	1.0	1.7	39.6	1.0	2.1	32.0	1.0	2.5	26.2	1.1	2.8	21.7	1.2	3.3	18.0	1.2	3.8
60	134.8	0.8	0.8	97.3	0.9	1.1	69.4	0.9	1.4	54.5	1.0	1.7	43.2	1.0	2.1	34.9	1.0	2.5	28.6	1.1	2.8	23.6	1.2	3.3	19.7	1.2	3.8
65	146.1	0.8	0.8	105.4	0.9	1.1	75.2	0.9	1.4	59.1	1.0	1.7	46.8	1.0	2.1	37.8	1.0	2.5	31.0	1.1	2.8	25.6	1.2	3.3	21.3	1.2	3.8
70	157.3	0.8	0.8	113.5	0.9	1.1	81.0	0.9	1.4	63.6	1.0	1.7	50.4	1.0	2.1	40.7	1.0	2.5	33.4	1.1	2.8	27.5	1.2	3.3	22.9	1.2	3.8
75	168.6	0.8	0.8	121.6	0.9	1.1	86.8	0.9	1.4	68.2	1.0	1.7	54.0	1.0	2.1	43.6	1.0	2.5	35.8	1.1	2.8	29.4	1.2	3.3	24.5	1.2	3.8
80	179.8	0.8	0.8	129.7	0.9	1.1	92.6	0.9	1.4	72.7	0.9	1.7	57.6	1.0	2.1	46.5	1.0	2.5	38.1	1.1	2.8	31.4	1.2	3.3	26.2	1.2	3.8
85	191.0	0.8	0.8	137.8	0.9	1.1	98.3	0.9	1.4	77.3	0.9	1.7	61.2	1.0	2.1	49.4	1.0	2.5	40.5	1.1	2.8	33.3	1.2	3.3	27.8	1.2	3.8
90	202.3	0.8	0.8	145.9	0.9	1.1	104.1	0.9	1.4	81.8	0.9	1.7	64.9	1.0	2.1	52.3	1.0	2.5	42.9	1.1	2.8	35.3	1.2	3.3	29.4	1.2	3.8
95	213.5	0.8	0.8	154.0	0.9	1.1	109.9	0.9	1.4	86.3	0.9	1.7	68.5	1.0	2.1	55.2	1.0	2.5	45.3	1.1	2.8	37.2	1.2	3.3	31.1	1.2	3.8
100	224.7	0.8	0.8	162.1	0.9	1.1	115.7	0.9	1.4	90.9	0.9	1.7	72.1	1.0	2.1	58.1	1.0	2.5	47.7	1.1	2.8	39.2	1.2	3.3	32.7	1.2	3.8
105	236.0	0.8	0.8	170.2	0.9	1.1	121.5	0.9	1.4	95.4	0.9	1.7	75.7	1.0	2.1	61.0	1.0	2.5	50.0	1.1	2.8	41.1	1.2	3.3	34.3	1.2	3.8
110	247.2	0.8	0.8	178.3	0.9	1.1	127.3	0.9	1.4	100.0	0.9	1.7	79.3	1.0	2.1	64.0	1.0	2.5	52.4	1.1	2.8	43.1	1.2	3.3	36.0	1.2	3.8
115	258.5	0.8	0.8	186.4	0.9	1.1	133.0	0.9	1.4	104.5	0.9	1.7	82.9	1.0	2.1	66.9	1.0	2.5	54.8	1.1	2.8	45.0	1.2	3.3	37.6	1.2	3.8
120	269.7	0.8	0.8	194.6	0.9	1.1	138.8	0.9	1.4	109.1	0.9	1.7	86.5	1.0	2.1	69.8	1.0	2.5	57.2	1.1	2.8	47.0	1.2	3.3	39.2	1.2	3.8
125	280.9	0.8	0.8	202.7	0.9	1.1	144.6	0.9	1.4	113.6	0.9	1.7	90.1	1.0	2.1	72.7	1.0	2.5	59.6	1.1	2.8	48.9	1.2	3.3	40.9	1.2	3.8
130	292.2	0.8	0.8	210.8	0.9	1.1	150.4	0.9	1.4	118.2	0.9	1.7	93.7	1.0	2.1	75.6	1.0	2.5	61.9	1.1	2.8	50.9	1.2	3.3	42.5	1.2	3.8
135	303.4	0.8	0.8	218.9	0.9	1.1	156.2	0.9	1.4	122.7	0.9	1.7	97.3	1.0	2.1	78.5	1.0	2.5	64.3	1.1	2.8	52.9	1.2	3.3	44.1	1.2	3.8
140	314.6	0.8	0.8	227.0	0.9	1.1	162.0	0.9	1.4	127.2	0.9	1.7	100.9	1.0	2.1	81.4	1.0	2.5	66.7	1.1	2.8	54.8	1.2	3.3	45.8	1.2	3.8
145	325.9	0.8	0.8	235.1	0.9	1.1	167.8	0.9	1.4	131.8	0.9	1.7	104.5	1.0	2.1	84.3	1.0	2.5	69.1	1.1	2.8	56.8	1.2	3.3	47.4	1.2	3.8
150	337.1	0.8	0.8	243.2	0.9	1.1	173.5	0.9	1.4	136.3	0.9	1.7	108.1	1.0	2.1	87.2	1.0	2.5	71.5	1.1	2.8	58.7	1.2	3.3	49.0	1.2	3.8

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 11 of 14)

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

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 12 of 14)

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	39.3	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

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 13 of 14)

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	309.5	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	0.9	3.0	74.6	0.9	3.4

RETARDANCE "D" AND "B"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.1

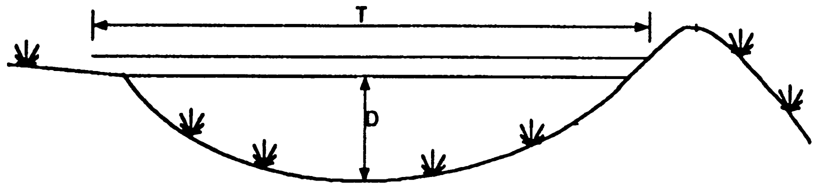
Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(Sheet 14 of 14)

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			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																											
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															



T = Top width, tall vegetation
D = Depth, tall vegetation
V2 = Design velocity, tall vegetation
V1 = Permissible velocity, short vegetation

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

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						

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	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	10.5	3.1	5.3			
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	11.4	3.0	5.3			
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	12.4	2.9	5.3			
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	13.0	2.8	5.3			
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	13.7	2.8	5.3			
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	14.3	2.8	5.3			
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	14.9	2.7	5.3			
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	15.5	2.7	5.3			

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	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	8.0	2.3	5.3			
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	9.3	2.1	5.3			
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	10.1	2.1	5.3			
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	11.0	2.0	5.3			
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	11.8	2.0	5.3			
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	12.6	2.0	5.3	9.1	2.5	5.9
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	13.4	2.0	5.4	10.2	2.4	5.9
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	14.2	2.0	5.4	10.9	2.3	5.9
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	15.0	2.0	5.4	11.6	2.3	5.9
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	15.8	2.0	5.4	12.3	2.3	5.9
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	16.6	1.9	5.4	13.0	2.2	5.9
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	17.3	1.9	5.4	13.6	2.2	5.9
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	18.1	1.9	5.4	14.3	2.2	5.9
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	18.9	1.9	5.4	14.9	2.2	5.9
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	19.6	1.9	5.4	15.6	2.2	5.9
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	20.4	1.9	5.4	16.2	2.2	5.9
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	21.2	1.9	5.4	16.9	2.2	5.9
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	21.9	1.9	5.4	17.5	2.2	5.9

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	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	8.1	1.9	5.3			
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	9.1	1.9	5.3			
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	10.0	1.8	5.3			
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	10.9	1.8	5.3	8.2	2.2	5.8
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	11.8	1.8	5.3	9.3	2.1	5.8
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	12.7	1.8	5.3	10.1	2.0	5.9
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	13.6	1.8	5.3	10.9	2.0	5.9
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	14.5	1.8	5.3	11.6	2.0	5.9
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	15.3	1.7	5.3	12.4	2.0	5.9
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	16.2	1.7	5.3	13.1	1.9	5.9
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	17.0	1.7	5.3	13.9	1.9	5.9
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	17.9	1.7	5.3	14.6	1.9	5.9
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	18.8	1.7	5.3	15.3	1.9	5.9
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	19.6	1.7	5.3	16.1	1.9	5.9
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	20.5	1.7	5.3	16.8	1.9	5.9
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	21.3	1.7	5.3	17.5	1.9	5.9
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	22.2	1.7	5.3	18.2	1.9	5.9
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	23.0	1.7	5.3	18.9	1.9	5.9
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	23.8	1.7	5.3	19.7	1.9	5.9
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	24.7	1.7	5.3	20.4	1.9	5.9

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

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			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	5.4	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	7.0	1.8	5.3			
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	8.3	1.7	5.3			
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	9.3	1.7	5.3	6.7	2.1	5.8
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	10.3	1.6	5.3	8.1	1.9	5.8
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	11.3	1.6	5.3	9.0	1.9	5.8
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	12.3	1.6	5.3	9.8	1.8	5.8
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	13.2	1.6	5.3	10.7	1.8	5.8
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	14.2	1.6	5.3	11.5	1.8	5.8
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	15.1	1.6	5.3	12.3	1.8	5.8
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	16.1	1.6	5.3	13.1	1.8	5.8
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	17.0	1.6	5.3	13.9	1.7	5.8
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	17.9	1.6	5.3	14.7	1.7	5.8
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	18.9	1.6	5.3	15.5	1.7	5.8
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	19.8	1.6	5.3	16.3	1.7	5.8
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	20.7	1.6	5.3	17.1	1.7	5.9
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	21.7	1.6	5.3	17.9	1.7	5.9
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	22.6	1.6	5.3	18.7	1.7	5.9
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	23.5	1.6	5.3	19.4	1.7	5.9
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	24.5	1.6	5.3	20.2	1.7	5.9
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	25.7	1.6	5.3	21.0	1.7	5.9
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	26.6	1.6	5.3	21.8	1.7	5.9
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	27.5	1.6	5.3	22.6	1.7	5.9

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second; Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	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	5.6	1.3	5.1			
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	7.1	1.2	5.2	5.3	1.5	5.7
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	8.4	1.2	5.2	6.7	1.4	5.7
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	9.8	1.2	5.2	7.9	1.3	5.7
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	11.1	1.2	5.2	9.1	1.3	5.7
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	12.4	1.2	5.2	10.2	1.3	5.7
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	13.7	1.2	5.2	11.3	1.3	5.7
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	14.9	1.2	5.2	12.4	1.3	5.7
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	24.6	1.0	4.0	20.0	1.1	4.5	16.2	1.2	5.2	13.5	1.3	5.7
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	17.5	1.2	5.2	14.5	1.3	5.7
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	19.1	1.2	5.1	15.6	1.3	5.7
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	20.3	1.2	5.1	16.7	1.3	5.7
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	21.6	1.2	5.1	17.8	1.2	5.7
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	22.9	1.2	5.1	18.9	1.2	5.7
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	24.1	1.2	5.1	20.2	1.2	5.7
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	25.4	1.2	5.1	21.2	1.2	5.7
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	26.7	1.2	5.1	22.3	1.2	5.7
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	27.9	1.2	5.1	23.3	1.2	5.7
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	29.2	1.2	5.1	24.4	1.2	5.7
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	30.5	1.2	5.1	25.5	1.2	5.7
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	31.7	1.2	5.1	26.5	1.2	5.7
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	33.0	1.2	5.1	27.6	1.2	5.7
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	34.3	1.2	5.1	28.6	1.2	5.7
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	35.6	1.2	5.1	29.7	1.2	5.7
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	36.8	1.2	5.1	30.7	1.2	5.7
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	38.1	1.2	5.1	31.8	1.2	5.7

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	8.7	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

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	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	4.7	1.0	5.0			
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	6.5	0.9	4.9	5.3	1.0	5.5
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	8.3	0.9	5.0	6.8	1.0	5.6
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	10.1	0.9	5.0	8.3	1.0	5.6
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	11.8	0.9	5.0	9.8	1.0	5.6
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	13.6	0.9	5.0	11.3	1.0	5.5
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	15.5	0.9	4.9	12.8	1.0	5.5
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	17.2	0.9	4.9	14.3	1.0	5.5
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	18.9	0.9	4.9	15.9	0.9	5.5
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	20.6	0.9	4.9	17.3	0.9	5.5
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	22.3	0.9	4.9	18.8	0.9	5.5
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	24.0	0.9	4.9	20.2	0.9	5.5
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	25.7	0.9	4.9	21.6	0.9	5.5
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	27.4	0.9	4.9	23.1	0.9	5.5
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	29.1	0.9	5.0	24.5	0.9	5.5
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	30.9	0.9	5.0	26.0	0.9	5.5
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	32.6	0.9	5.0	27.4	0.9	5.5
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	34.3	0.9	5.0	28.8	0.9	5.5
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	36.0	0.9	5.0	30.3	0.9	5.5
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	37.7	0.9	5.0	31.7	0.9	5.5
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	39.4	0.9	5.0	33.2	0.9	5.5
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	41.1	0.9	5.0	34.6	0.9	5.5
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	42.8	0.9	5.0	36.0	0.9	5.5
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	44.6	0.9	5.0	37.5	0.9	5.5
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	46.3	0.9	5.0	38.9	0.9	5.5
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	48.0	0.9	5.0	40.4	0.9	5.5
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	49.7	0.9	5.0	41.8	0.9	5.5
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	51.4	0.9	5.0	43.2	0.9	5.5

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	11.1	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	20.9	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

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

(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			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	5.2
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

RETARDANCE "D" AND "C"

NOTE: Width and Depth dimensions are in feet; Velocity measurements are in feet per second;
Depth "D" does not include allowance for freeboard or settlement.

Table 6-28.2

Design Chart for Parabolic Vegetated Diversion, Waterway or Stormwater Conveyance

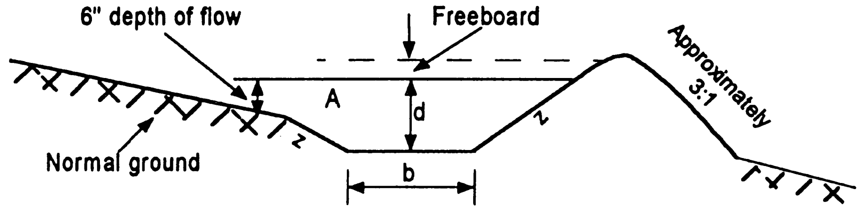
(Sheet 14 of 14)

(Based on Handbook of Channel Design, SCS-TP-61)

3:1 Side Slopes

"D" Retardance

% Grade	Triangular								6' bottom width								8' bottom width								10' bottom width								12' bottom width							
	2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5	
Q-cfs	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
10	1.9	11	1.8	10	1.7	9	1.6	8	1.3	12	1.1	10	1.0	9	0.9	8	1.2	13	1.1	11	1.0	10	0.9	9	1.1	14	1.0	12	0.9	11	0.8	10	1.0	14	0.9	12	0.8	11	0.7	10
20	2.2	15	2.1	13	1.9	11	1.8	10	1.5	16	1.4	14	1.2	12	1.1	10	1.4	17	1.3	16	1.2	14	1.1	12	1.3	18	1.2	16	1.0	13	0.9	11	1.2	19	1.1	17	1.0	15	0.9	13
30	2.5	19	2.3	16	2.2	15	2.0	12	1.8	21	1.6	17	1.5	16	1.3	13	1.7	22	1.5	19	1.4	17	1.2	14	1.5	22	1.4	20	1.2	16	1.1	15	1.3	21	1.2	19	1.2	19	1.1	17
40	2.6	20	2.5	19	2.3	16	2.2	15	2.0	24	1.8	21	1.7	19	1.5	16	1.8	24	1.7	22	1.5	19	1.4	17	1.7	26	1.5	22	1.4	20	1.2	16	1.6	27	1.5	25	1.3	21	1.2	19
60	3.0	27	2.8	24	2.7	22	2.5	19	2.3	30	2.1	26	1.9	22	1.7	19	2.1	30	1.9	26	1.8	24	1.6	21	2.0	32	1.8	28	1.7	26	1.5	22	1.8	31	1.6	27	1.5	25	1.3	21
80			3.1	29	2.9	25	2.7	22	2.5	34	2.3	30	2.1	26	1.9	22	2.4	37	2.2	32	2.0	28	1.8	24	2.3	39	2.1	34	1.9	30	1.7	26	2.1	38	1.9	34	1.8	31	1.6	27
100					3.1	29	2.9	25	2.8	40	2.5	34	2.3	30	2.1	26	2.6	41	2.4	37	2.2	32	2.0	28	2.4	41	2.2	37	2.1	34	1.9	30	2.3	44	2.1	38	1.9	34	1.7	29
120							3.0	27	3.0	45	2.8	40	2.5	34	2.3	30	2.8	46	2.5	39	2.3	34	2.1	30	2.6	46	2.4	41	2.2	37	2.0	32	2.5	50	2.3	44	2.1	38	1.9	34
140											2.9	43	2.6	36	2.4	32	2.9	48	2.7	44	2.5	39	2.3	34	2.7	49	2.5	44	2.3	39	2.1	34	2.6	52	2.4	46	2.2	41	2.0	36
160											3.0	45	2.8	40	2.6	36	3.1	51	2.9	48	2.7	44	2.5	39	2.9	54	2.7	49	2.5	44	2.3	39	2.7	54	2.5	50	2.3	44	2.1	38
180																							2.6	41	3.0	57	2.8	51	2.6	46	2.4	41	2.8	57	2.6	52	2.4	46	2.2	41
200																															2.5	44	2.9	60	2.7	54	2.5	50	2.3	44
220																																	3.0	63	2.8	57	2.7	54	2.5	50



NOTE: For diversions built on slopes under 2%, the available cross-sectional area above normal ground will allow a reduction in design depth as follows:

For land slopes of 1% or less, reduce depth of flow (taken from Design Table) 20%.

For land Slopes of 1% to 2%, reduce depth of flow (taken from Design Table) 10%.

For land slopes greater than 2%, use depth of flow taken from Design Table.

For Example: A diversion 6 feet wide with a 2.5 foot depth of flow is required to remove 120 c.f.s. on a 0.4% grade. If this is built on a 1% slope, the depth may be reduced 20%, thus obtaining a flow depth of 2.0 feet. The required cross-sectional area of the channel plus that above normal ground line will be 34 square feet corresponding to the 2.5 foot depth. The overall height of diversion will be 2.0 feet plus 0.5 foot freeboard or 2.5 feet, instead of the original 3.0 feet.

d = depth of flow, feet
b = bottom width of channel, feet
A = channel capacity, sq. ft., including area below 0.5' freeboard and excluding any area less than 0.5' depth of flow
z = side slope of channel (horizontal to vertical)

IMPORTANT: To all designed depths of flow add freeboard required by State Standards and Specifications to obtain overall height of terrace above bottom of channel. For final check on cross-sectional area, subtract required freeboard from settled height of diversion and provide for cross-sectional area shown in table.

Table 6-28.3

Diversion Design Table
D Retardance (V and Trapezoidal Section)

(Based on Handbook of Channel Design, SCS-TP-61)

4:1 Side Slopes

"D" Retardance

% Grade	Triangular								6' bottom width								8' bottom width								10' bottom width								12' bottom width							
	2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5	
Q-cfs	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
10	1.8	13	1.7	12	1.6	11	1.5	10	1.2	13	1.1	11	1.0	10	0.9	9	1.1	14	1.0	13	0.9	11	0.8	10	1.1	14	1.0	13	0.9	12	0.8	11	1.0	15	0.9	14	0.8	13	0.7	12
20	2.1	18	2.0	16	1.8	13	1.7	12	1.5	18	1.4	16	1.2	13	1.1	11	1.4	19	1.3	17	1.2	15	1.1	14	1.3	20	1.2	18	1.0	14	0.9	12	1.2	20	1.1	18	1.0	16	0.9	14
30	2.4	23	2.2	19	2.1	18	1.9	14	1.8	24	1.6	20	1.5	18	1.3	15	1.7	25	1.5	21	1.4	19	1.2	15	1.5	24	1.4	22	1.2	18	1.1	16	1.3	22	1.2	20	1.2	20	1.1	18
40	2.5	25	2.4	23	2.2	19	2.1	18	1.9	26	1.8	24	1.6	20	1.5	18	1.8	27	1.7	25	1.5	21	1.4	19	1.6	26	1.5	24	1.3	20	1.2	18	1.6	29	1.5	27	1.3	22	1.2	20
60	2.8	31	2.6	27	2.5	25	2.3	21	2.2	33	2.0	28	1.9	26	1.7	22	2.0	32	1.9	30	1.7	25	1.6	23	1.9	33	1.8	31	1.6	26	1.5	24	1.7	32	1.6	29	1.4	25	1.3	22
80	3.1	38	2.9	34	2.7	29	2.5	25	2.4	37	2.2	33	2.1	30	1.9	26	2.3	40	2.1	34	2.0	32	1.8	27	2.2	41	2.0	36	1.8	31	1.6	26	2.0	40	1.9	37	1.7	32	1.6	29
100			3.1	38	2.9	34	2.7	29	2.7	45	2.5	40	2.3	35	2.1	30	2.5	45	2.3	40	2.1	34	1.9	30	2.3	44	2.1	39	2.0	36	1.8	31	2.2	46	2.0	40	1.9	37	1.7	32
120							2.8	31	2.9	51	2.7	45	2.4	37	2.2	33	2.7	51	2.5	45	2.3	40	2.1	34	2.5	50	2.3	44	2.2	41	2.0	36	2.4	52	2.2	46	2.0	40	1.8	35
140									3.0	54	2.8	48	2.6	43	2.4	37	2.8	54	2.6	48	2.5	45	2.3	40	2.6	53	2.4	47	2.3	44	2.1	39	2.5	55	2.3	49	2.2	46	2.0	40
160									3.1	57	2.9	51	2.8	48	2.6	43	3.0	60	2.8	54	2.6	48	2.4	42	2.8	59	2.6	53	2.5	50	2.3	44	2.7	62	2.5	55	2.3	49	2.1	43
180																							2.5	45	2.9	63	2.7	56	2.6	53	2.4	47	2.8	65	2.6	58	2.4	52	2.2	46
200																															2.5	50	2.9	68	2.7	62	2.5	55	2.3	49
220																																	3.0	72	2.8	65	2.6	58	2.4	52

6:1 Side Slopes

"D" Retardance

% Grade	Triangular								6' bottom width								8' bottom width								10' bottom width								12' bottom width							
	2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5	
Q-cfs	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
10	1.6	15	1.5	14	1.4	13	1.3	11	1.2	16	1.1	14	1.0	12	0.9	10	1.1	16	1.0	14	0.9	13	0.8	11	1.1	17	1.0	15	0.9	13	0.8	12	1.0	17	0.9	15	0.8	14	0.7	12
20	1.9	22	1.8	19	1.6	15	1.5	14	1.5	23	1.4	20	1.2	16	1.1	14	1.4	23	1.3	21	1.1	16	1.0	14	1.3	21	1.2	20	1.1	18	1.0	16	1.3	25	1.2	23	1.0	17	0.9	16
30	2.1	27	2.0	24	1.8	19	1.7	17	1.7	28	1.5	23	1.4	20	1.2	16	1.6	28	1.5	26	1.3	21	1.2	18	1.4	26	1.3	23	1.2	20	1.1	18	1.4	29	1.3	27	1.1	20	1.0	18
40	2.3	32	2.2	29	2.0	24	1.8	19	1.8	30	1.7	28	1.5	23	1.4	20	1.7	31	1.6	28	1.4	23	1.3	21	1.5	29	1.4	26	1.3	23	1.2	20	1.5	32	1.4	29	1.3	27	1.2	22
60	2.5	38	2.3	32	2.2	29	2.0	24	2.0	36	1.9	33	1.7	28	1.6	25	1.9	37	1.8	34	1.6	28	1.5	26	1.8	38	1.7	34	1.5	29	1.4	26	1.6	34	1.5	32	1.4	29	1.3	27
80	2.7	44	2.5	38	2.4	35	2.2	29	2.2	42	2.1	39	1.9	33	1.8	30	2.1	43	2.0	40	1.8	34	1.7	31	2.0	44	1.9	41	1.7	34	1.6	31	1.8	41	1.7	37	1.6	34	1.5	32
100	2.9	51	2.7	44	2.6	41	2.4	35	2.4	49	2.2	42	2.1	39	1.9	33	2.3	50	2.1	43	2.0	40	1.8	34	2.2	51	2.0	44	1.9	41	1.7	34	2.1	51	1.9	45	1.8	41	1.6	34
120	3.0	54	2.8	47	2.7	44	2.5	38	2.6	56	2.4	49	2.3	46	2.1	39	2.5	58	2.3	50	2.2	47	2.0	40	2.3	55	2.2	51	2.0	44	1.9	41	2.2	55	2.0	48	1.9	45	1.7	37
140									2.7	61	2.6	56	2.4	49	2.3	46	2.6	61	2.5	58	2.3	50	2.2	47	2.5	63	2.3	55	2.2	51	2.0	44	2.4	64	2.2	55	2.1	51	1.9	45
160									2.9	68	2.8	64	2.6	56	2.5	53	2.8	67	2.6	61	2.5	58	2.3	50	2.7	71	2.5	63	2.4	59	2.2	51	2.6	70	2.4	64	2.3	59	2.1	51
180																	2.9	71	2.7	64	2.6	61	2.4	54	2.8	75	2.6	67	2.5	63	2.3	55	2.7	76	2.5	68	2.4	63	2.2	55
200																	3.0	72	2.8	67	2.6	61	2.4	54	2.9	79	2.7	77	2.6	67	2.4	59	2.8	81	2.6	72	2.5	68	2.3	59
220																							2.5	58							2.4	59	2.9	85	2.7	76	2.5	68	2.3	59
240																															2.5	63							2.4	64
260																																							2.5	68

Table 6-28.3

Diversion Design Table

D Retardance (V and Trapezoidal Section)

(Based on Handbook of Channel Design, SCS-TP-61)

3:1 Side Slopes

"C" Retardance

% Grade	Triangular								6' bottom width								8' bottom width								10' bottom width								12' bottom width							
	2		3		4		5		2		3		4		5		.2		3		4		5		2		3		4		5		2		3		4		5	
Q	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
20	2.5	19	2.3	16	2.1	13	1.9	11	1.9	22	1.7	19	1.5	16	1.4	14	1.7	22	1.5	19	1.4	17	1.3	15	1.6	24	1.4	20	1.3	18	1.2	16								
30			2.5	19	2.3	16	2.2	15	2.0	24	1.8	21	1.7	19	1.5	16	1.9	26	1.7	22	1.5	19	1.4	17	1.7	26	1.5	22	1.4	20	1.3	18	1.6	27	1.4	23	1.3	21	1.2	19
40					2.5	19	2.4	17	2.2	28	2.0	24	1.9	22	1.7	19	2.0	28	1.8	24	1.6	21	1.5	19	1.9	30	1.7	26	1.5	22	1.4	20	1.8	31	1.6	27	1.5	25	1.4	23
50							2.5	19	2.3	30	2.1	26	2.0	24	1.8	21	2.2	32	2.0	28	1.8	24	1.6	21	2.0	32	1.8	28	1.6	24	1.5	22	1.9	34	1.7	29	1.6	27	1.5	25
60									2.5	34	2.3	30	2.1	26	1.9	22	2.3	34	2.1	30	1.9	26	1.8	24	2.2	37	2.0	32	1.8	28	1.6	24	2.0	36	1.8	31	1.7	29	1.6	27
80											2.5	34	2.3	30	2.1	26	2.5	39	2.3	34	2.1	30	1.9	26	2.4	41	2.2	37	2.0	32	1.8	28	2.2	41	2.0	36	1.9	34	1.7	29
100													2.5	34	2.3	30			2.5	39	2.3	34	2.1	30			2.4	41	2.2	37	2.0	32	2.5	49	2.2	41	2.0	36	1.8	31
120															2.5	34					2.5	39	2.3	34					2.3	39	2.1	34			2.4	46	2.2	41	2.0	36
140																							2.4	36					2.5	44	2.3	39					2.3	43	2.1	38
160																															2.4	41					2.4	46	2.2	41
180																															2.5	44							2.4	46
200																																							2.5	49
220																																							2.6	51

4:1 Side Slopes

"C" Retardance

% Grade	Triangular								6' bottom width								8' bottom width								10' bottom width								12' bottom width							
	2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5	
Q	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
30	2.5	25	2.4	23	2.3	21	2.1	18	2.0	28	1.8	24	1.6	20	1.5	18	1.8	27	1.7	25	1.5	21	1.4	19	1.8	31	1.6	26	1.4	22	1.3	20	1.7	32	1.6	29	1.4	25	1.2	20
40			2.5	25	2.4	23	2.2	19	2.1	30	1.9	26	1.7	22	1.6	20	2.0	32	1.8	27	1.6	23	1.5	21	1.9	33	1.7	29	1.5	24	1.4	22	1.8	35	1.7	32	1.5	27	1.3	22
50					2.5	25	2.4	23	2.3	35	2.1	30	1.9	26	1.7	22	2.1	34	1.9	30	1.7	25	1.6	23	2.0	36	1.8	31	1.6	26	1.5	24	1.9	37	1.8	35	1.6	29	1.4	25
60							2.5	25	2.4	37	2.2	33	2.0	28	1.9	26	2.3	40	2.1	34	1.9	30	1.7	25	2.1	39	1.9	34	1.7	29	1.6	26	2.0	40	1.9	37	1.7	32	1.5	27
80											2.4	37	2.2	33	2.0	28	2.5	45	2.3	40	2.1	34	1.9	30	2.3	44	2.1	39	1.9	34	1.8	31	2.2	46	2.0	40	1.8	35	1.7	32
100											2.5	40	2.3	35	2.2	33			2.5	45	2.3	40	2.0	32	2.5	50	2.3	44	2.1	39	1.9	34	2.3	49	2.1	43	2.0	40	1.8	35
120													2.5	40	2.4	37					2.4	42	2.2	37			2.5	50	2.3	44	2.1	39	2.5	55	2.3	49	2.2	46	2.0	40
140															2.5	40					2.5	45	2.3	40					2.4	47	2.2	41			2.5	55	2.3	49	2.1	43
160																							2.5	45					2.5	50	2.3	44					2.4	52	2.2	46
180																															2.4	47					2.5	55	2.3	49
200																															2.5	50							2.4	52
220																																							2.5	55

Table 6-28.4

Diversion Design Table

C Retardance (V and Trapezoidal Section)

(Based on Handbook of Channel Design, SCS-TP-61)

6:1 Side Slopes

"C" Retardance

%	Triangular								6' bottom width								8' bottom width								10' bottom width								12' bottom width							
Grade	2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5		2		3		4		5	
Q	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A	d	A
20	2.2	29	2.1	26	1.9	22	1.8	19	1.8	30	1.7	28	1.6	25	1.4	20	1.7	31	1.6	28	1.5	26	1.3	21	1.6	31	1.5	29	1.4	26	1.2	20	1.5	32	1.4	29	1.3	27	1.2	22
30	2.4	35	2.2	29	2.1	26	1.9	22	2.0	36	1.9	33	1.7	28	1.5	23	1.8	34	1.7	31	1.6	28	1.4	23	1.8	38	1.7	34	1.5	29	1.3	23	1.7	37	1.6	34	1.4	29	1.3	27
40	2.5	38	2.3	32	2.2	29	2.0	24	2.1	39	2.0	36	1.8	30	1.6	25	2.0	40	1.9	37	1.7	31	1.5	26	1.9	41	1.8	38	1.6	31	1.4	26	1.8	41	1.7	37	1.5	32	1.3	27
50			2.5	38	2.3	32	2.1	26	2.2	42	2.1	39	1.9	33	1.7	28	2.1	43	2.0	40	1.8	34	1.6	28	2.0	44	1.9	41	1.7	34	1.5	29	1.9	45	1.8	41	1.6	34	1.4	29
60					2.4	35	2.2	29	2.3	46	2.2	42	2.0	36	1.8	30	2.2	47	2.1	43	1.9	37	1.7	31	2.1	47	2.0	44	1.8	38	1.6	31	2.0	48	1.9	45	1.8	41	1.6	34
80					2.5	38	2.3	32	2.5	53	2.3	46	2.1	39	1.9	33	2.4	54	2.2	47	2.0	40	1.8	34	2.3	55	2.1	47	1.9	41	1.7	34	2.2	55	2.1	52	1.9	45	1.7	37
100							2.5	38			2.5	53	2.3	46	2.1	39	2.5	58	2.4	54	2.2	47	2.0	40	2.4	59	2.3	55	2.1	47	1.9	41	2.3	59	2.2	55	2.0	48	1.8	41
120													2.4	49	2.2	42			2.5	58	2.3	50	2.1	43	2.5	63	2.4	59	2.2	51	2.0	44	2.4	64	2.3	59	2.1	52	1.9	45
140													2.5	53	2.3	46					2.4	54	2.2	47			2.5	63	2.3	55	2.1	47	2.5	68	2.4	64	2.2	55	2.0	48
160															2.4	49					2.5	58	2.3	50					2.4	59	2.2	51			2.5	68	2.3	59	2.1	52
180															2.5	53							2.4	54					2.5	63	2.3	55					2.4	64	2.2	55
200																							2.5	58							2.4	59					2.5	68	2.2	55
220																															2.5	63							2.3	59

Table 6-28.4

Diversion Design Table

C Retardance (V and Trapezoidal Section)

APPENDIX A-1
Estimating Runoff from Urban Areas

APPENDIX A-1

ESTIMATING RUNOFF FROM URBAN AREAS

This appendix contains the USDA Natural Resources Conservation Service's TR-55, Urban Hydrology for Small Watersheds. The pages, tables, and figures listed in the contents are applicable to this section only. This information and TR-55 software is also available on the Internet at

http://www.ftw.nrcs.usda.gov/tech_tools.html

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

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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 watershed-inch	Runoff volume
V_s	acre-ft, ft^3, or watershed-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.

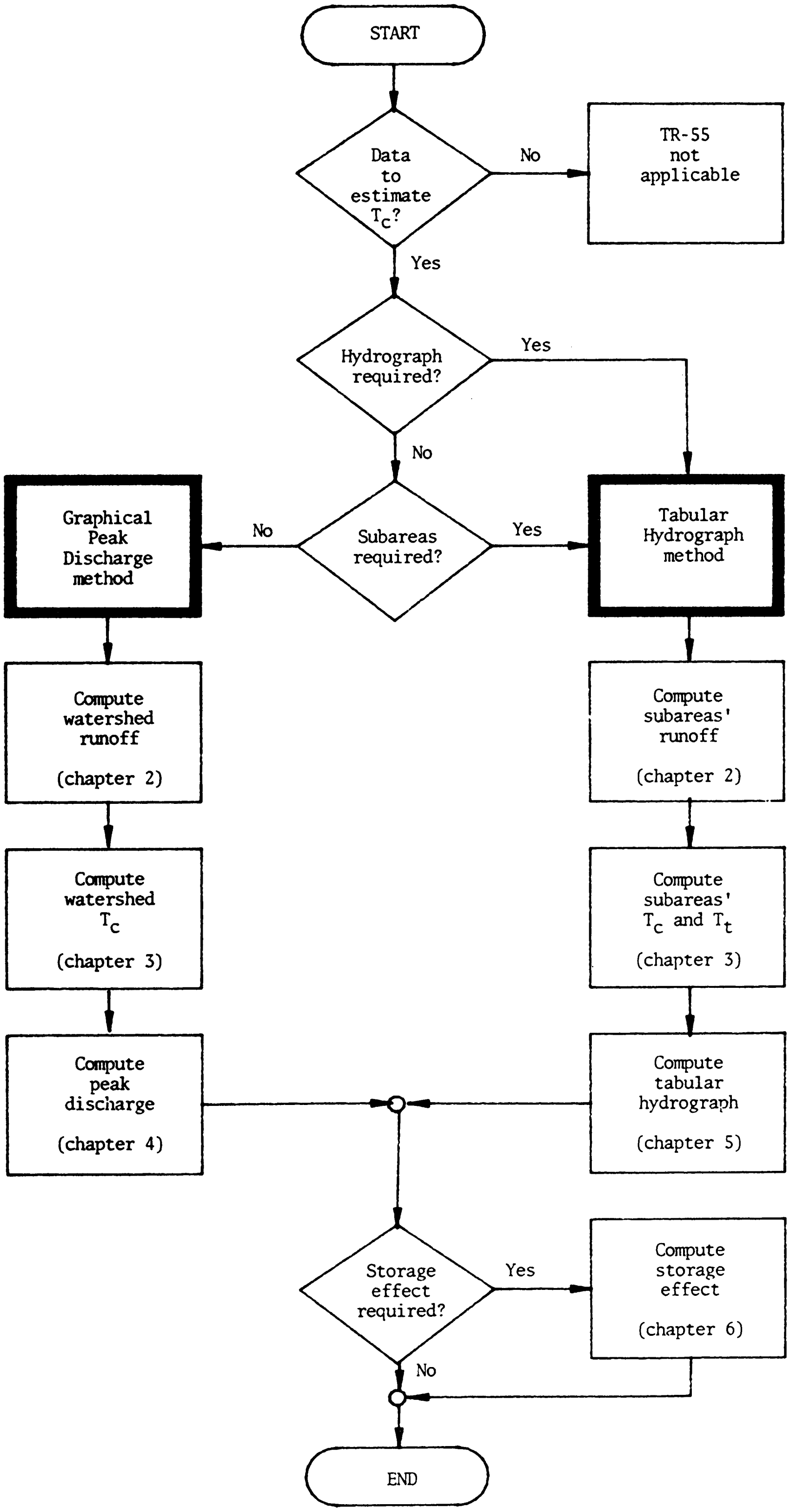

Figure 1-1.—Flow chart for selecting the appropriate procedures in TR-55.

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 the Manual for Erosion and Sediment Control in Georgia, Appendix B-1, provides a list of most of the soils and their group classifications. 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

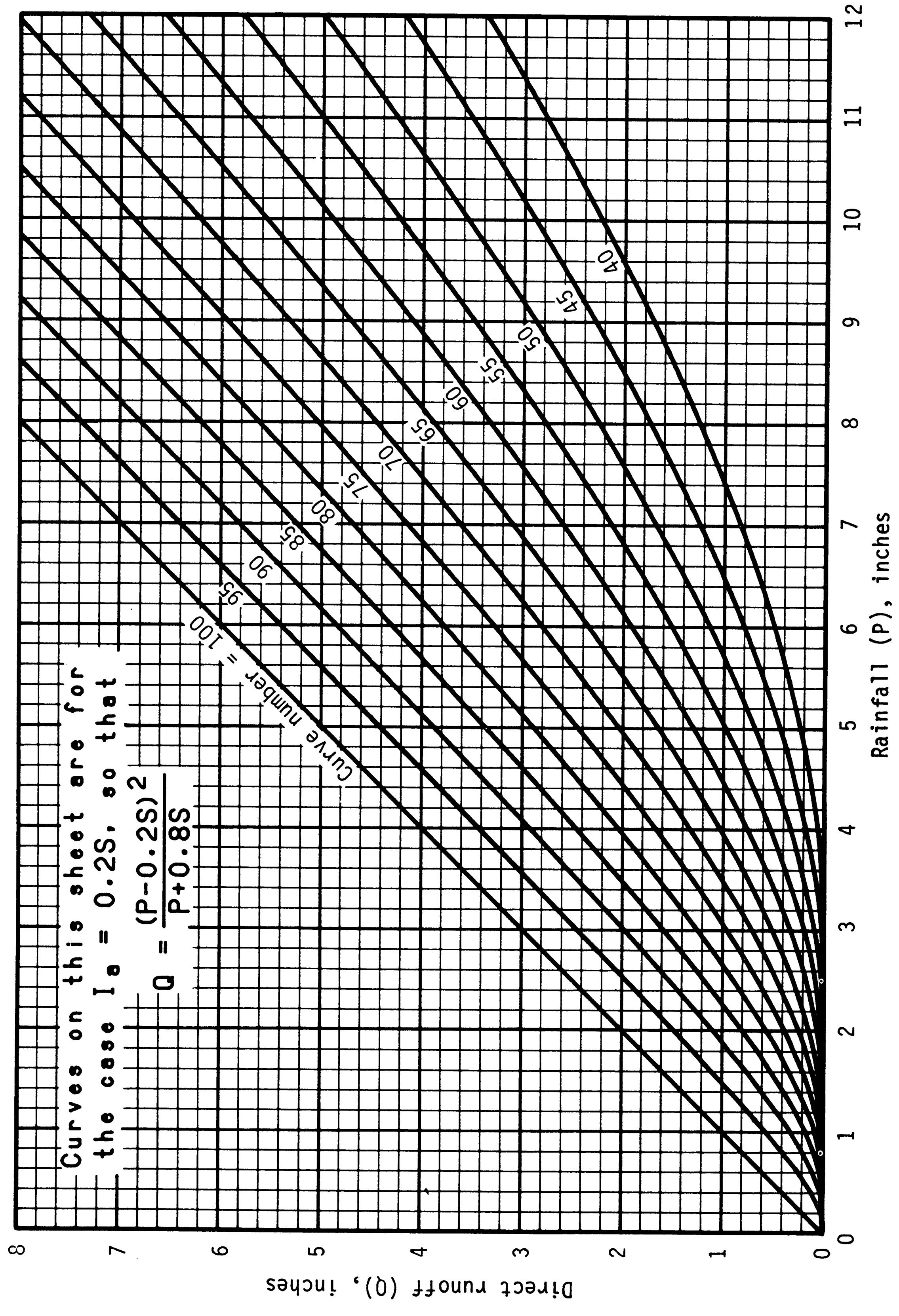

Figure 2-1.—Solution of runoff equation.

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]

Rainfall	Runoff depth for curve number of—												
	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

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[1] Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

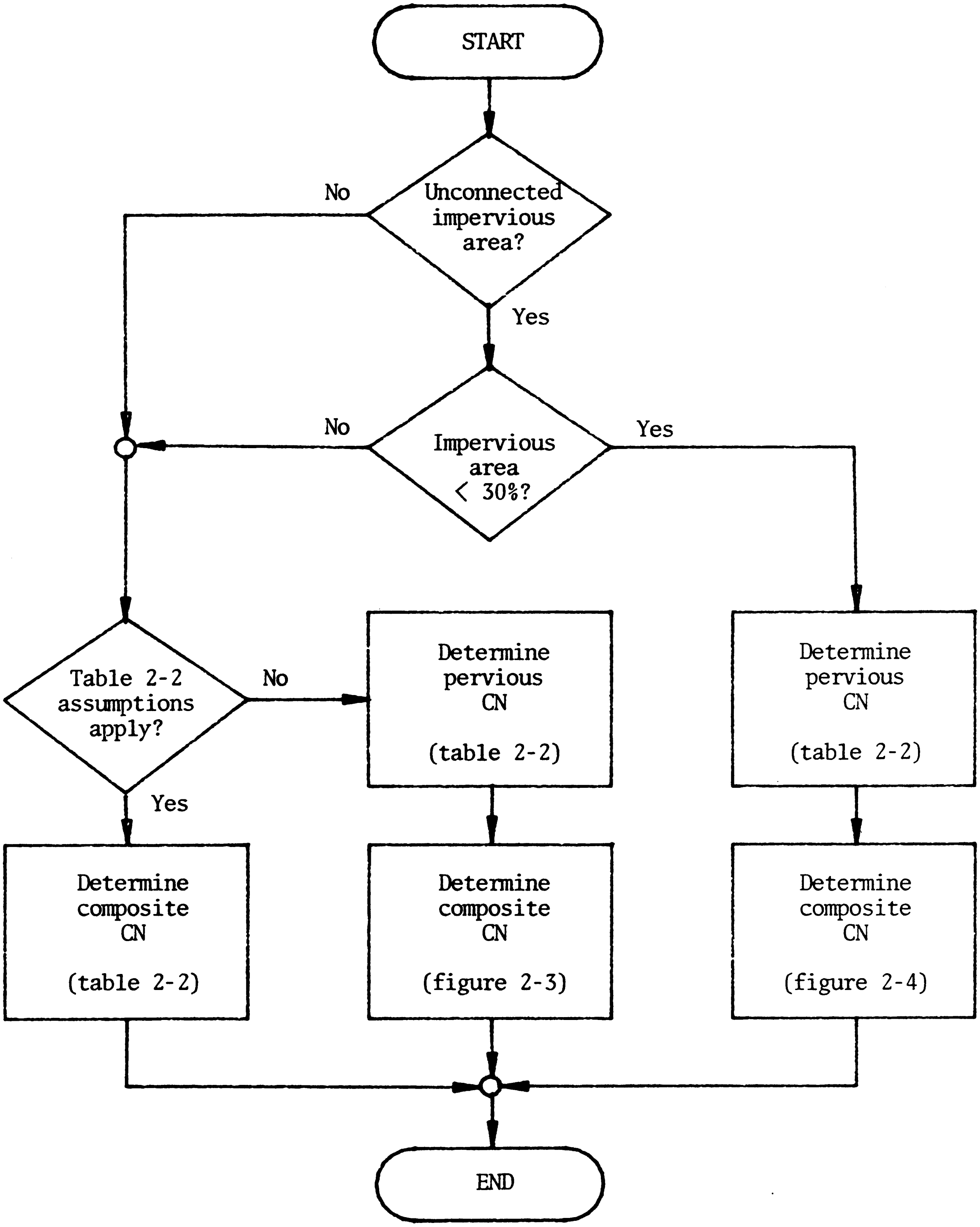


Figure 2-2.—Flow chart for selecting the appropriate figure or table for determining runoff curve numbers.

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.

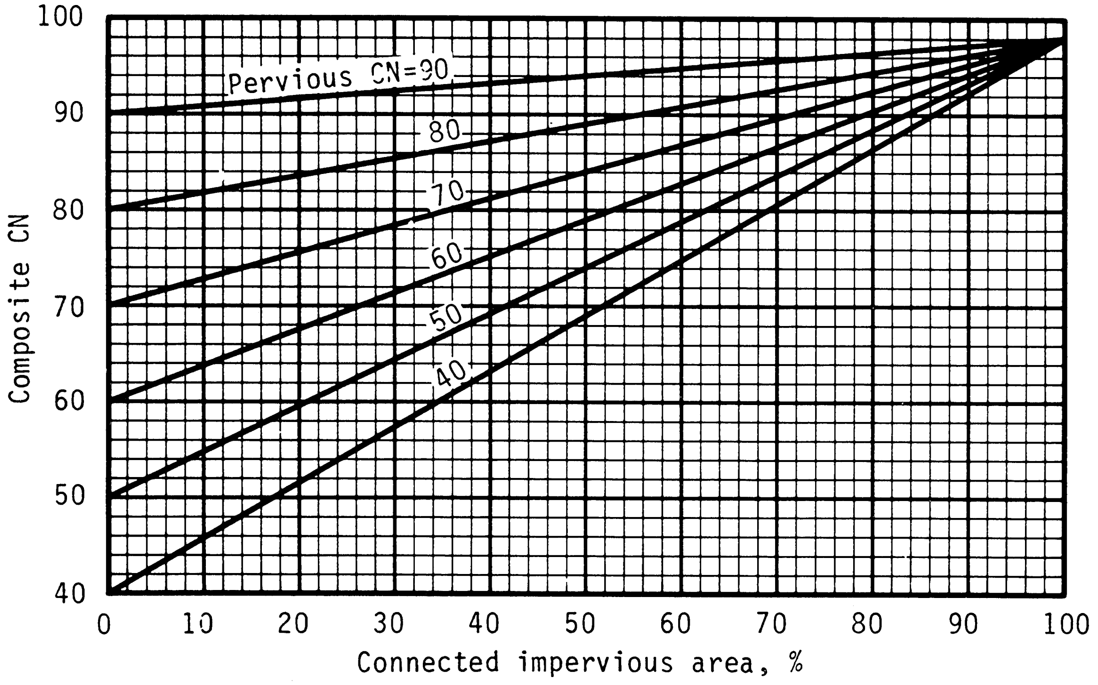


Figure 2-3.—Composite CN with connected impervious area.

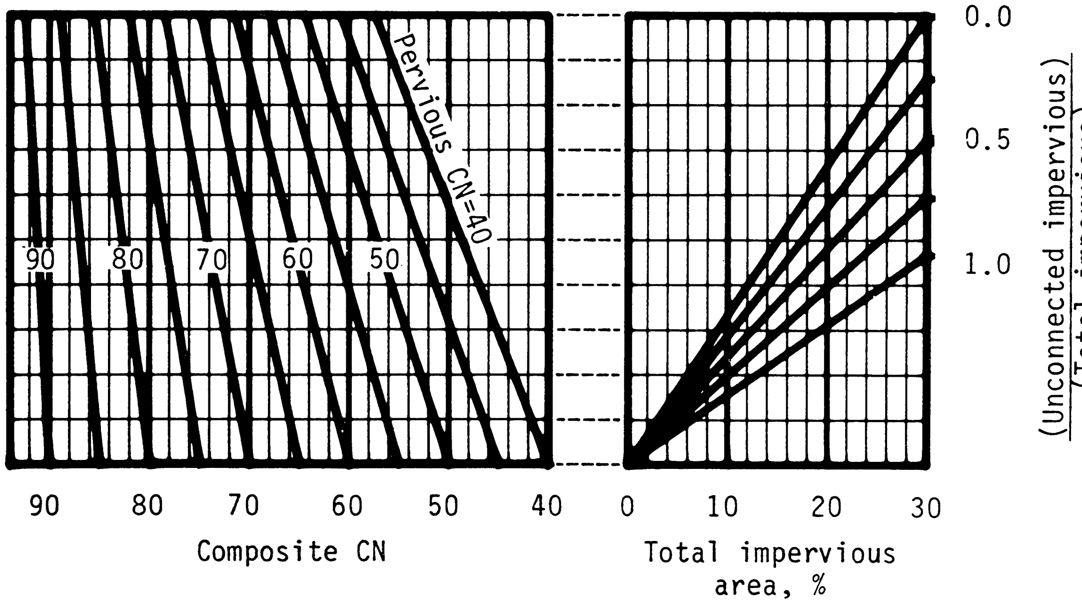


Figure 2-4.—Composite CN with unconnected impervious areas and total impervious area less than 30%.

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 NM 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]			Area	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4	☐ acres ☐ mi^2 ☒ %	
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.

$$\text{CN (weighted)} = \frac{\text{total product}}{\text{total area}} = \frac{7010}{100} = 70.1; \quad \text{Use CN} = \boxed{70}$$

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	25		
Rainfall, P (24-hour) .... in	6.0		
Runoff, Q .... in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	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 NM 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 ☐ mi^2 ☐ %	Product of CN x area
Memphis, B	25% impervious 1/2 acre lots, good condition	70			75	5250
Loring, C	25% impervious 1/2 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 NM 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/]			Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
Memphis, B	35% impervious 1/2 acre lots, good condition		74		75	5550
Loring, C	35% impervious 1/2 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 = $\boxed{77}$

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 NM 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/			Area	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4	☒ acres ☐ mi^2 ☐ %	
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	100	7800
Loring, C	Open space, good condition	74			75	5550
				Totals =	250	18,606

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 = $\boxed{74}$

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	25		
Rainfall, P (24-hour) .... in	6.0		
Runoff, Q .... in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	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.

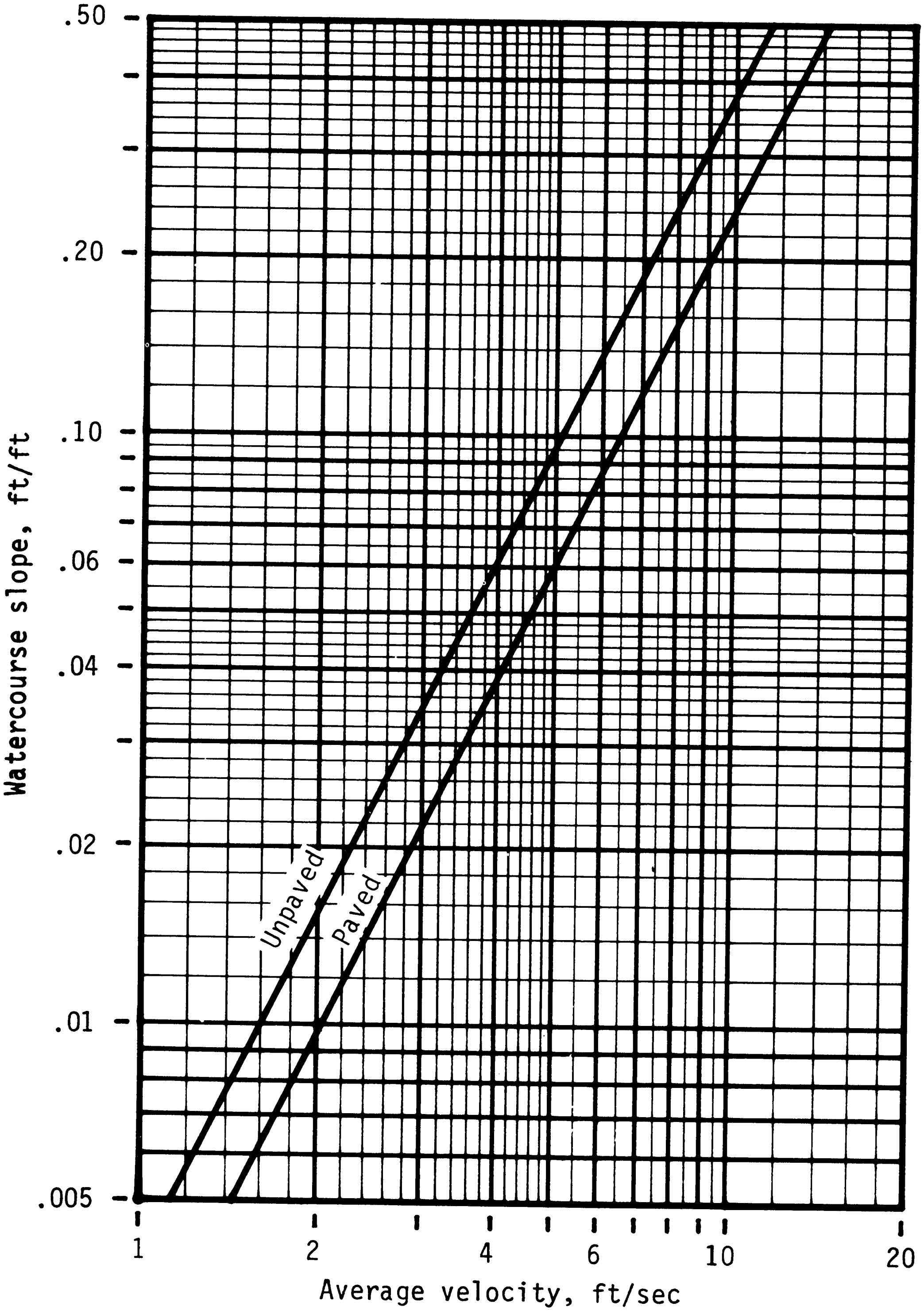


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

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.

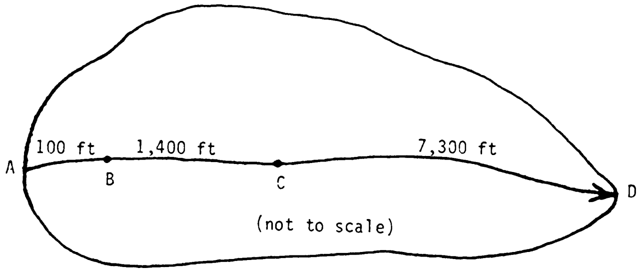
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

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 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 $\leq$ 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.

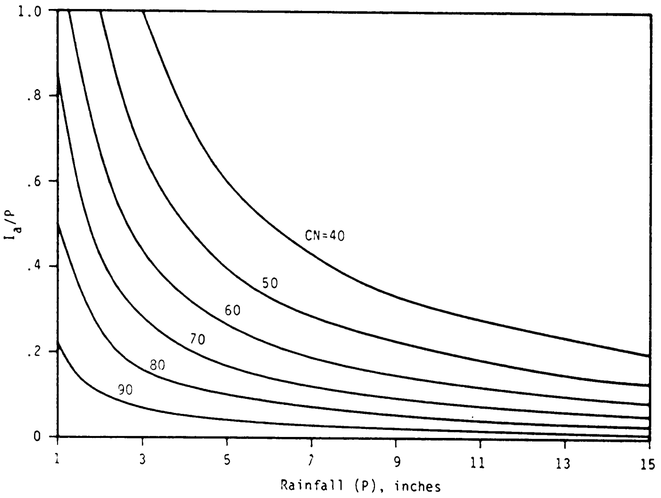


Figure 4-1.—Variation of I_a/P for P and CN.

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 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

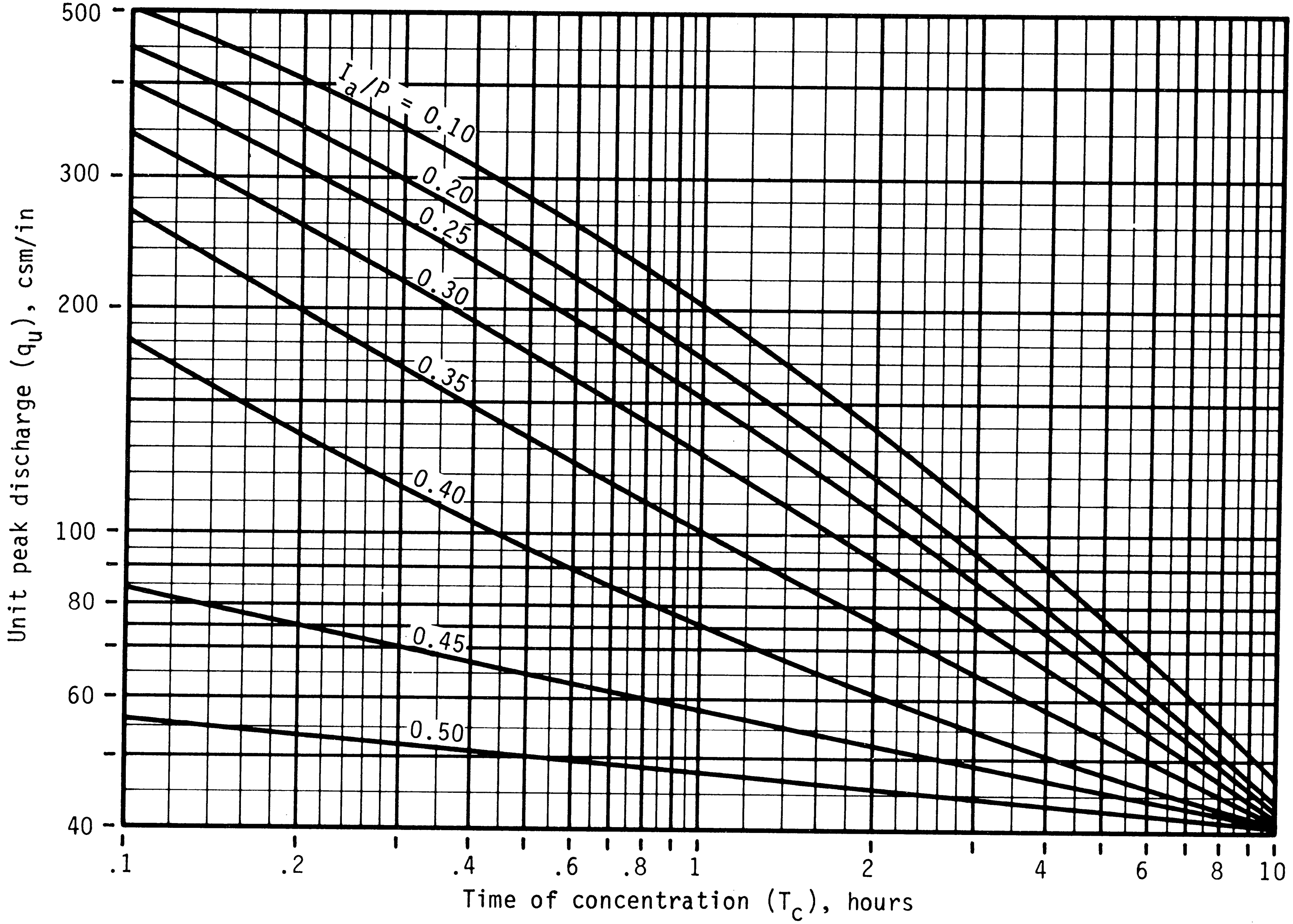


Exhibit 4-IA: Unit peak discharge (q_u) for SCS type IA rainfall distribution

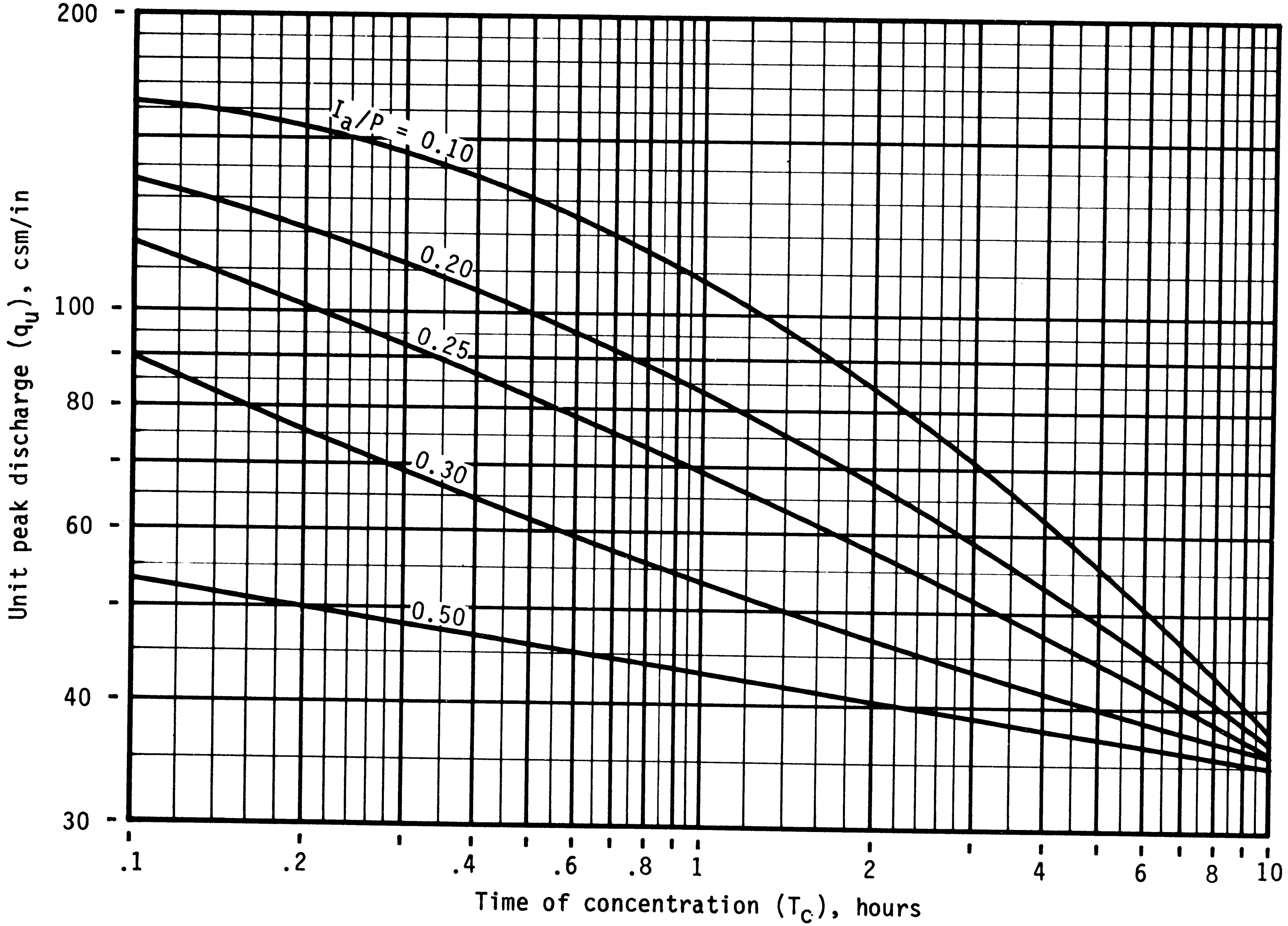


Exhibit 4-II: Unit peak discharge (q_u) for SCS type II rainfall distribution

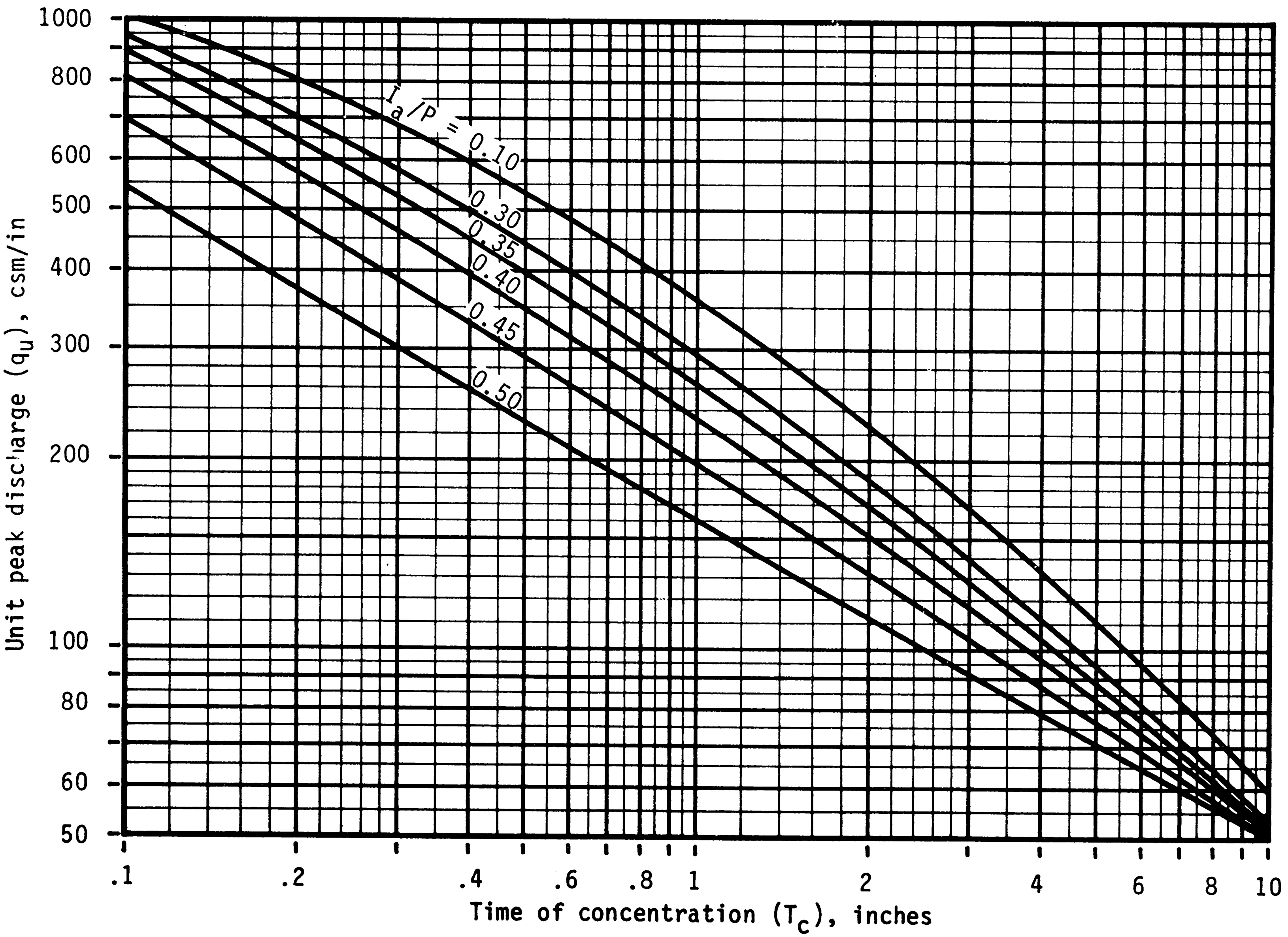
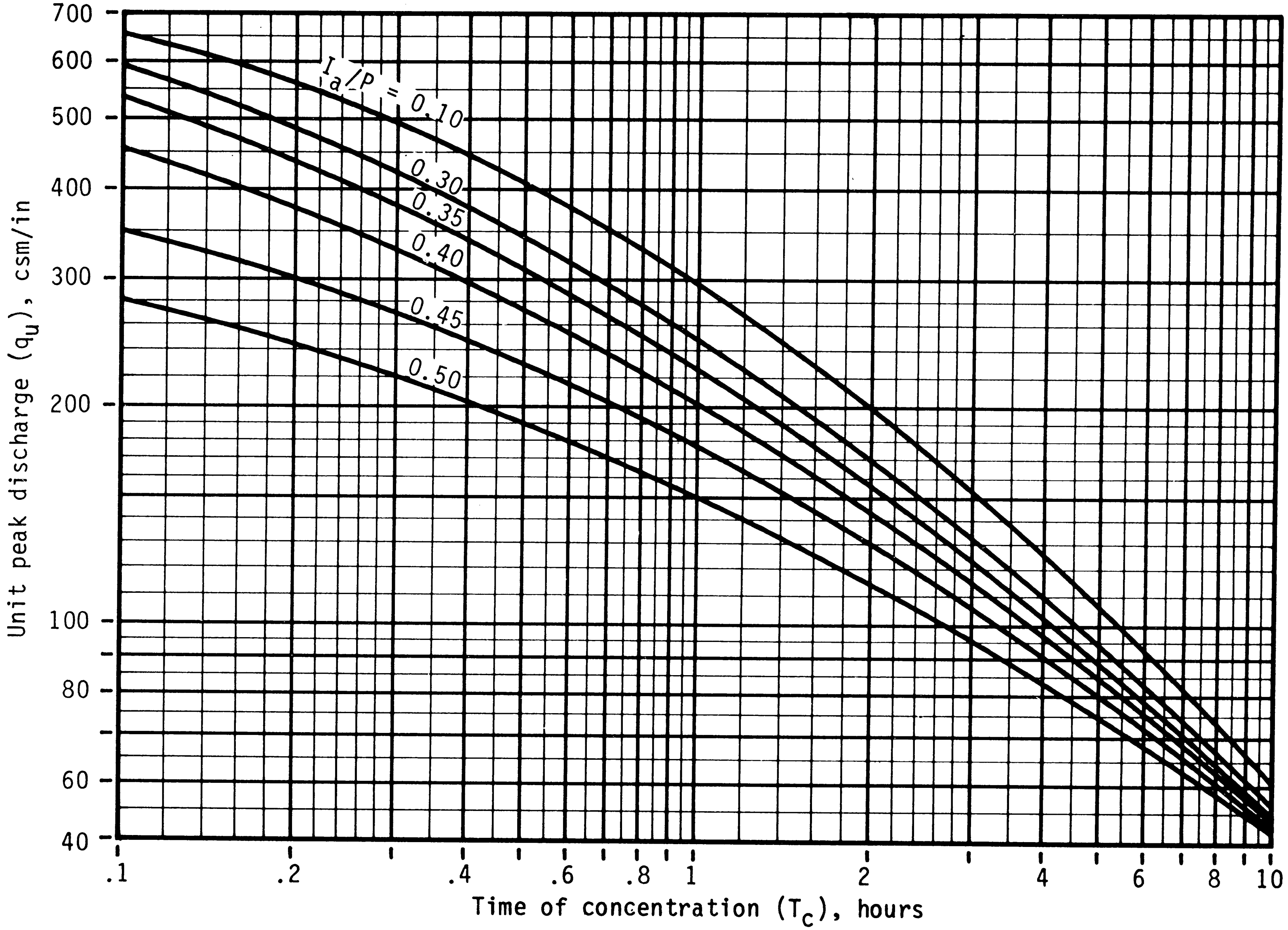


Exhibit 4-III: Unit peak discharge (q_u) for SCS type III rainfall distribution



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 (mi^2); 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).

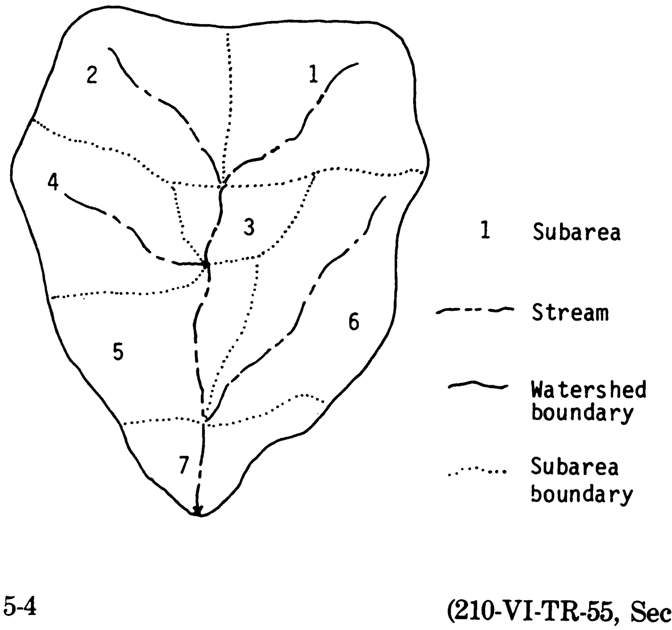
Example 5-1

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:

$$q = q_t(A_mQ) = (274)(0.70) = 192 \text{ cfs.}$$

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):

$$q = q_t(A_mQ) = (311)(1.31) = 407 \text{ cfs.}$$

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 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	2.50	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 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 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	2.00	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 (Time of concentration, Travel time through subarea)

↑ ↑ ↑ ↑ ↑ ↑ ↑ ↑ From worksheet 2 (Runoff curve number, Runoff)

↑ ↑ ↑ ↑ From table 5-1 (Initial abstraction)

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 XY 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.—Worksheet 5b for example 5-2.

Exhibit 5-I: Tabular hydrograph unit discharges (csm/in) for type I rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	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	18	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

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	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	187	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	88	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 = C.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)																														
	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 =0.3 HR * * *															IA/P = 0.10			
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			
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			
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	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

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	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

TRVL	HYDROGRAPH TIME (HOURS)																														
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	83	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

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	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	36	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	16	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	3	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

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	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)

IA/P = 0.10 * * * TC =1.25 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	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

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	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

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	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

TRVL	HYDROGRAPH TIME (HOURS)																														
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	23	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

```
TRVL  ------------------------------------------------ HYDROGRAPH TIME (HOURS) ------------------------------------------------
TIME       9.3     9.9    10.1    10.3    10.5    10.7    11.0    11.4    11.8    12.3    13.0    14.0    15.0    16.0    18.0    24.0
(HR)   9.0     9.6    10.0    10.2    10.4    10.6    10.8    11.2    11.6    12.0    12.6    13.5    14.5    15.5    17.0    20.0
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            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

TRVL	HYDROGRAPH TIME (HOURS)																														
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 * * *																															
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 * * *																															
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	40	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	40	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 * * *																															
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	HYDROGRAPH TIME (HOURS)																														
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 =0.2 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
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

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TRVL  ----------------------------------------------------------------------- HYDROGRAPH TIME (HOURS) -------------------------------------------------------------------
TIME         7.3       7.9       8.1       8.3       8.5       8.7       9.0       9.4       9.8      10.3      11.0      12.0      13.0      14.0      16.0      22.0
(HR)    7.0       7.6       8.0       8.2       8.4       8.6       8.8       9.2       9.6      10.0      10.6      11.5      12.5      13.5      15.0      18.0
----------+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+
            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
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Exhibit 5-IA, continued: Tabular hydrograph unit discharges (csm/in) for type IA rainfall distribution

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	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 * * *															IA/P = 0.10			
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 * * *															IA/P = 0.30			
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 * * *															IA/P = 0.50			
0.0	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	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	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	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	0	2	5	1	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	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	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	0	0	1	4	11	18	24	29	31	33	36	41	44	46	46
1.5	0	0	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
2.0	0	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
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	6	13	20	25	29	34	39	45	46
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	7	14	20	26	32	37	44	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)																															
	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	1C.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 = 0.1C													* * * TC =0.75 HR * * *														IA/P = 0.10			
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	1C6	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	1C7	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			
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			
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

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	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

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																														
	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

TRVL TIME (HR)	HYDROGRAPH TIME (HOURS)																															
	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	1C.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  ---------------------------------------------- HYDROGRAPH TIME (HOURS) ----------------------------------------------------
TIME      7.3/     7.9     8.1     8.3     8.5     8.7     9.0     9.4     9.8    10.3    11.0    12.0    13.0    14.0    16.0    22.0
(HR)   7.0     7.6     8.0     8.2     8.4     8.6     8.8     9.2     9.6    10.0    10.6    11.5    12.5    13.5    15.0    18.0
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
        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

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 =0.1 HR * * *														IA/P = 0.10				
0.0	24	34	53	334	647	1010	623	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

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 * * * 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

```
TRVL ------------------------------------------------- HYDROGRAPH TIME (HOURS) ----------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            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  18  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

```
TRVL ---------------------------------------------- HYDROGRAPH TIME (HOURS) ---------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
        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 ----------------------------------------------------- HYDROGRAPH TIME (HOURS) ------------------------------------------------
TIME     11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR) 11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
-----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
          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   9  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 =0.5  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  28  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 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 =0.75 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

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 =1.0 HR * * *																																
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 * * *																																
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 * * *																																
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

```
TRVL  ----------------------------------------------- HYDROGRAPH TIME (HOURS) -----------------------------------------------
TIME      11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)  11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
          IA/P = 0.10                                  * * * TC =1.5  HR * * *                                     IA/P = 0.10
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
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 * * *                                     IA/P = 0.30
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
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 * * *                                     IA/P = 0.50
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
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-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 =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

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 =0.1 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

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 =0.2 HR * * *															IA/P = 0.10			
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 * * *															IA/P = 0.30			
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 * * *															IA/P = 0.50			
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	13
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	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 =0.3 HR * * * IA/P = 0.10																															
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 * * * IA/P = 0.30																															
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 = 0.5C * * * TC =0.3 HR * * * IA/P = 0.50																															
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

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 =0.4 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	1	9	33	88	130	119	98	85	76	69	54	44	32	22	15
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	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 =0.5 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	140	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

```
TRVL ----------------------------------------------- HYDROGRAPH TIME (HOURS) ---------------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
            IA/P = 0.10                                   * * * TC =0.75 HR * * *                                IA/P = 0.10
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
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 * * *                                IA/P = 0.30
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
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 * * *                                IA/P = 0.50
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
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

```
TRVL ---------------------------------------------------- HYDROGRAPH TIME (HOURS) -------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+-
          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  83 112 185 251 276 256 213 168 118  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

```
TRVL ---------------------------------------------- HYDROGRAPH TIME (HOURS) -----------------------------------------------------
TIME    11.3    11.9    12.1    12.3    12.5    12.7    13.0    13.4    13.8    14.3    15.0    16.0    17.0    18.0    20.0    26.0
(HR)11.0    11.6    12.0    12.2    12.4    12.6    12.8    13.2    13.6    14.0    14.6    15.5    16.5    17.5    19.0    22.0
-------+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
            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   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   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   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

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

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 =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

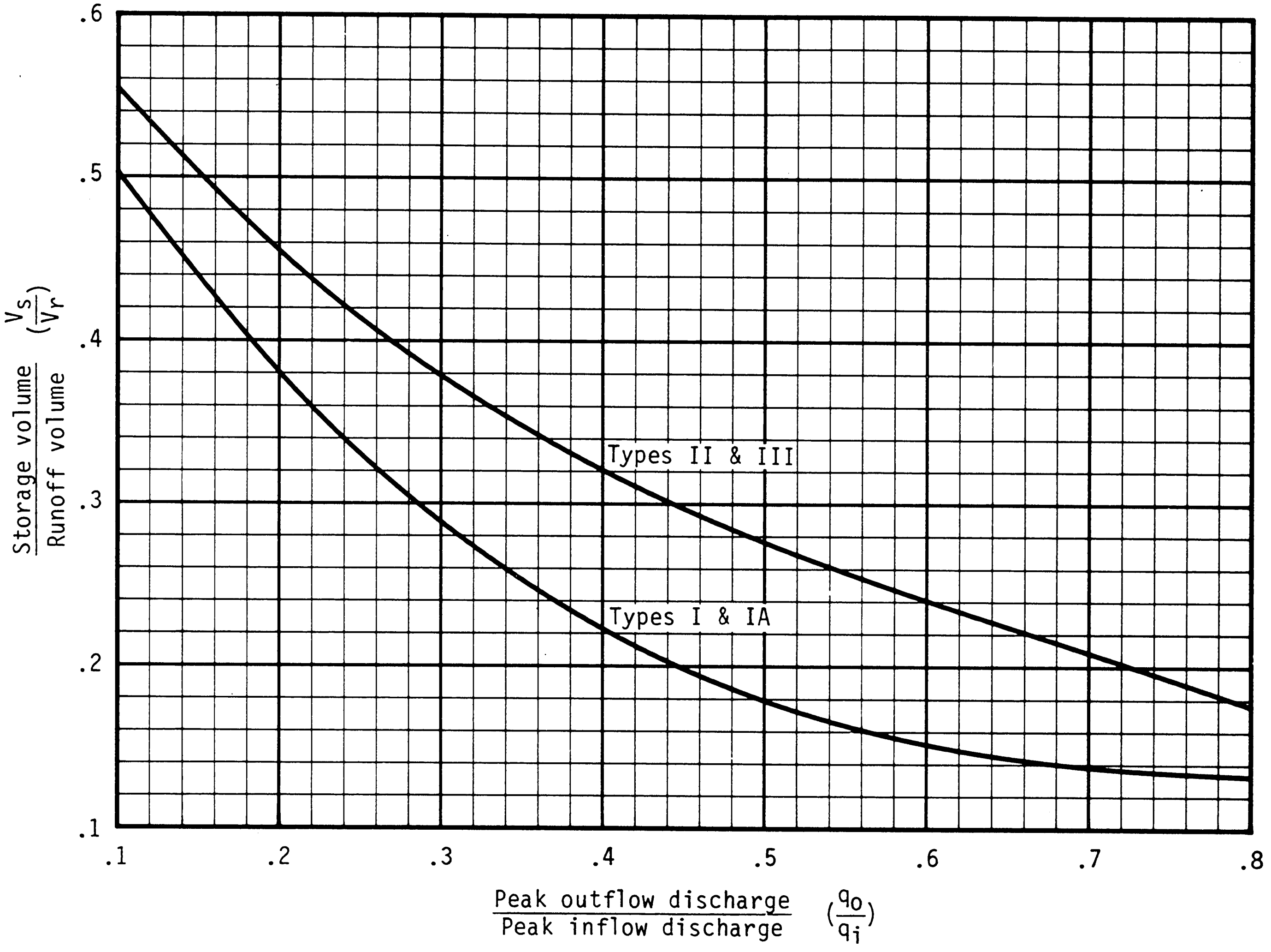


Figure 6-1.—Approximate detention basin routing for rainfall types I, IA, II, and III.

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-mi^2 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

$$L_w = \frac{q_o}{3.2\, H_w^{1.5}} \qquad \text{[Eq. 6-5]}$$

$$= \frac{180}{3.2\,(5.7)^{1.5}} = 4.1 \text{ ft.}$$

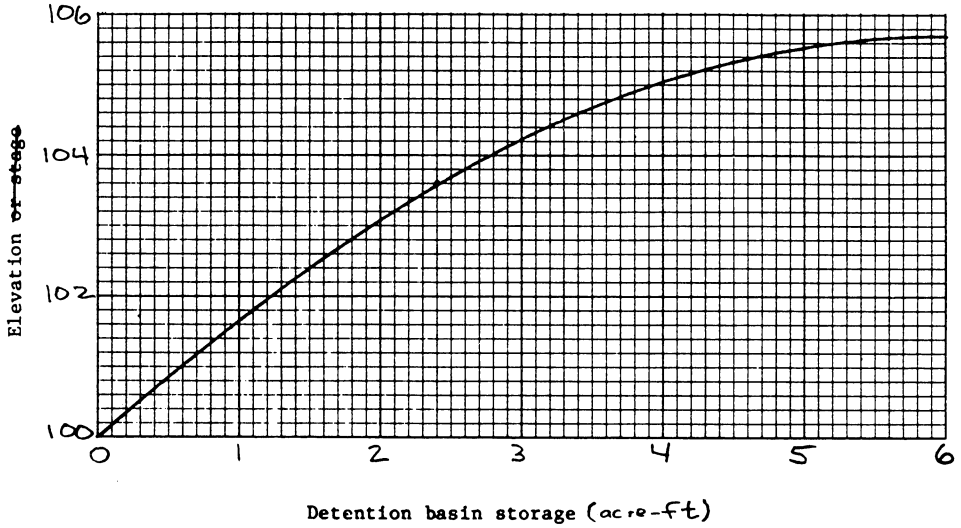
In summary, the outlet structure is a rectangular weir with crest length of 4.1 ft, H_w = 5.7 ft, and q_o = 180 cfs corresponding to a V_s = 5.9 acre-ft.

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

$$\begin{aligned} H_w &= E_{max} - \text{weir crest elevation} \\ &= 103.6 - 100.0 = 3.6 \text{ ft;} \end{aligned}$$

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.

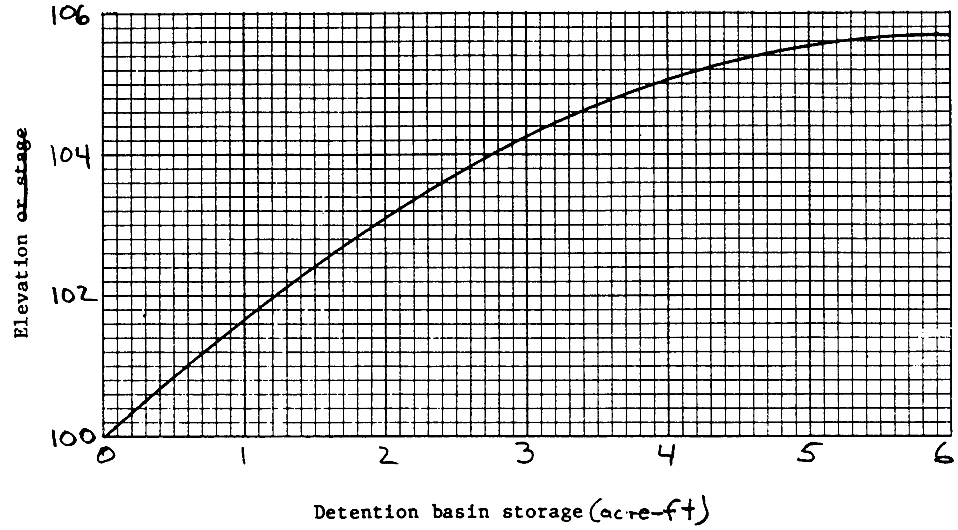
The weir equation used is probably less accurate for the two-stage example than for the single-stage example. The actual second-stage discharge will be slightly more than the one computed, but a discussion of hydraulics of outflow devices is outside the scope of this technical release. Example 6-2 is 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	50	180 1/
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.

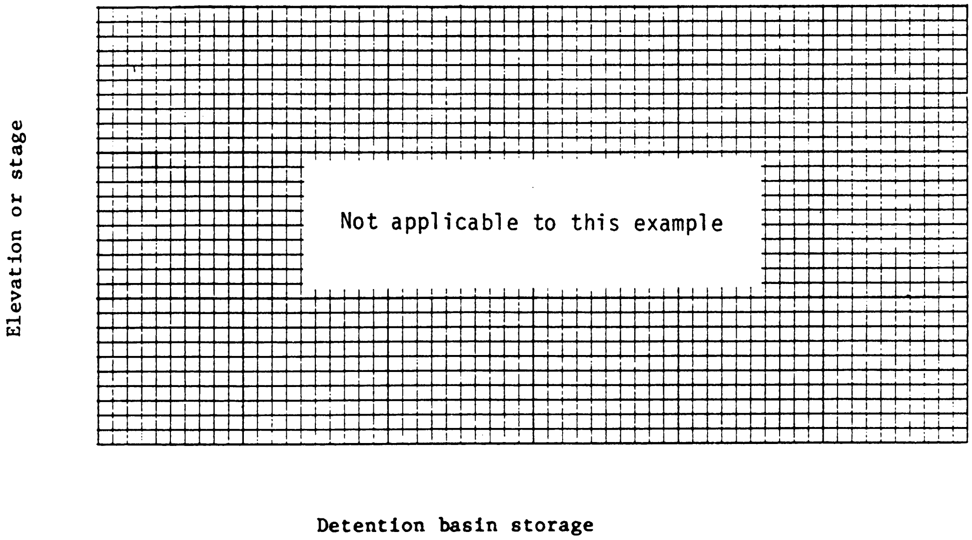
What will be the peak outflow discharge (q_o) from a detention basin that is located at the outlet and has maximum allowable storage volume (V_s) of 35,000 ft^3 and peak inflow discharge (q_i) of 42 cfs? Figure 6-4 shows how worksheet 6b is used to estimate q_o as 33 cfs, which is within the 35-cfs limit. 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]



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.

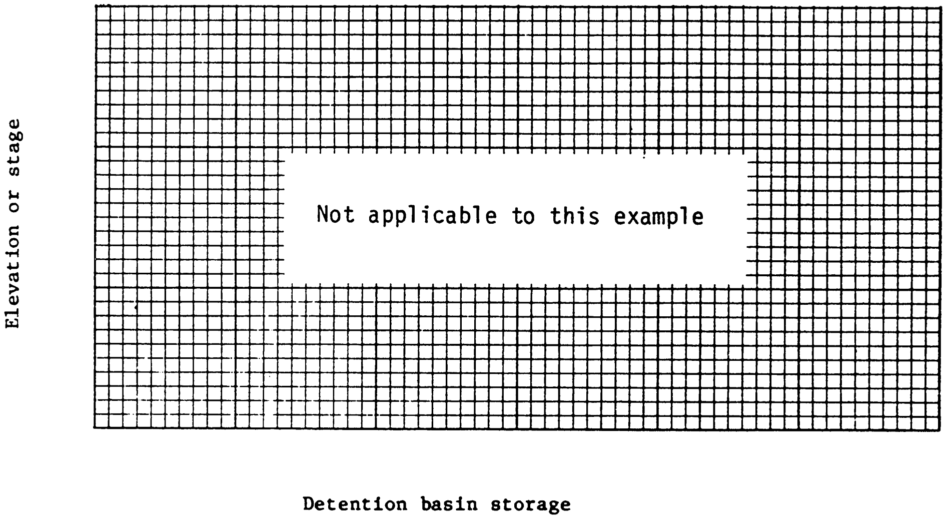
The required storage volume of 33.2 acre-ft is the basis for determining the required stage in the detention basin. This stage is a guide in proportioning a spillway that will discharge 82 cfs or less at that storage. The timing or routing effect is not considered because the outflow hydrograph will 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



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_m53.33)	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 hare 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-l 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).

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.

Note: See the Manual for Erosion and Sediment Control in Georgia, Appendix B-1, for list of soils.

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.

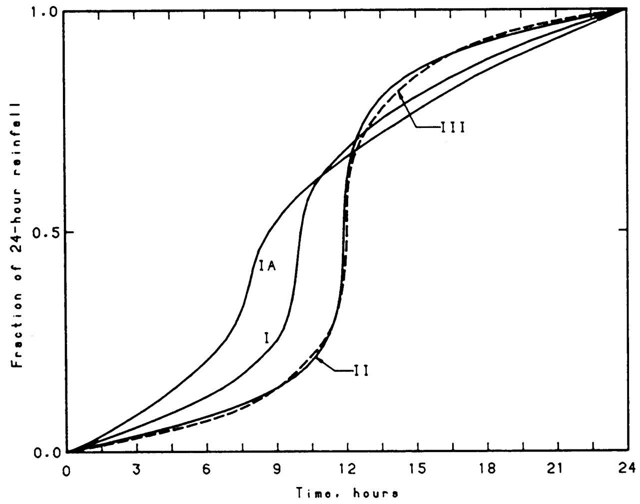


Figure B-1.—SCS 24-hour rainfall distributions.

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.

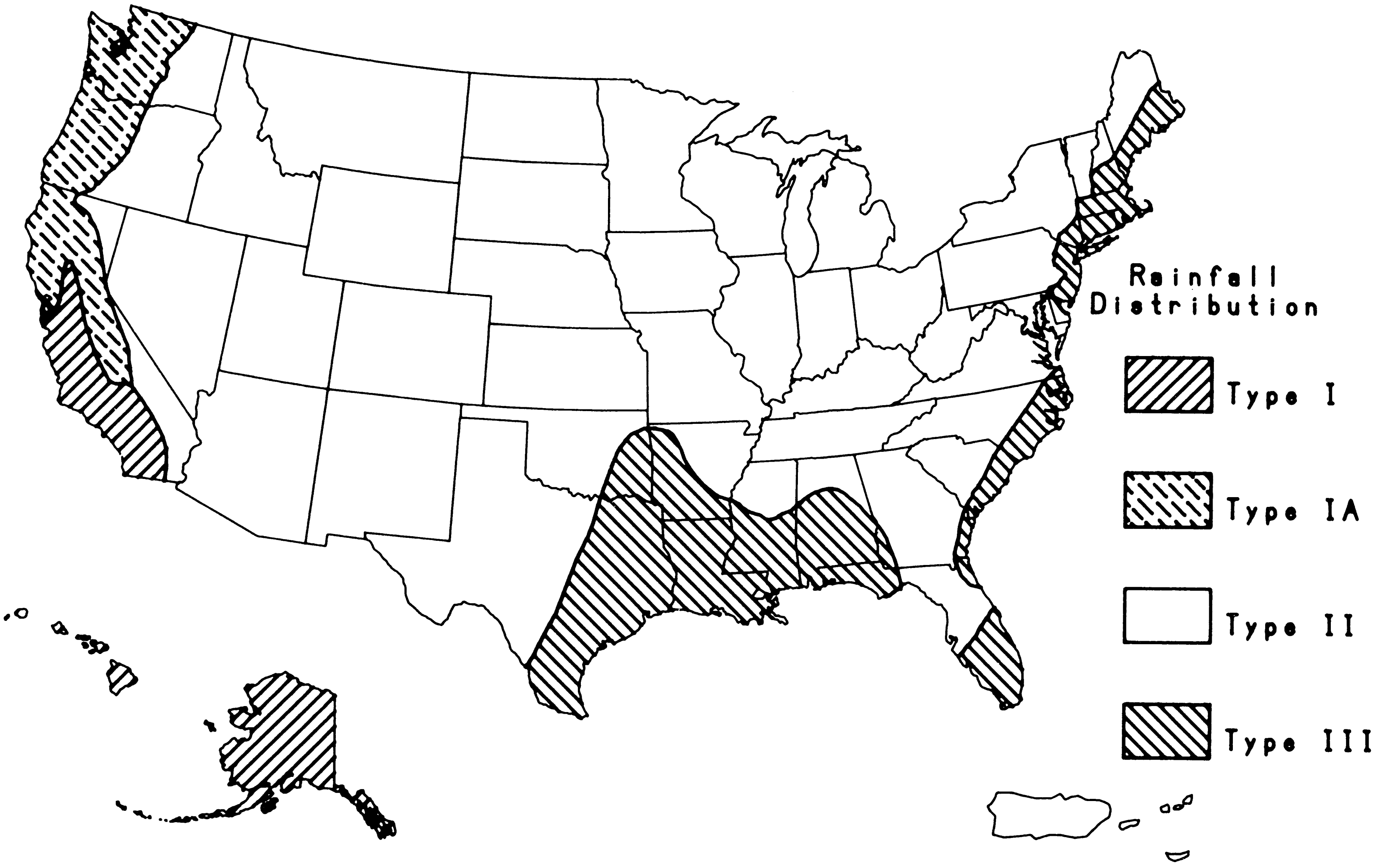


Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

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.

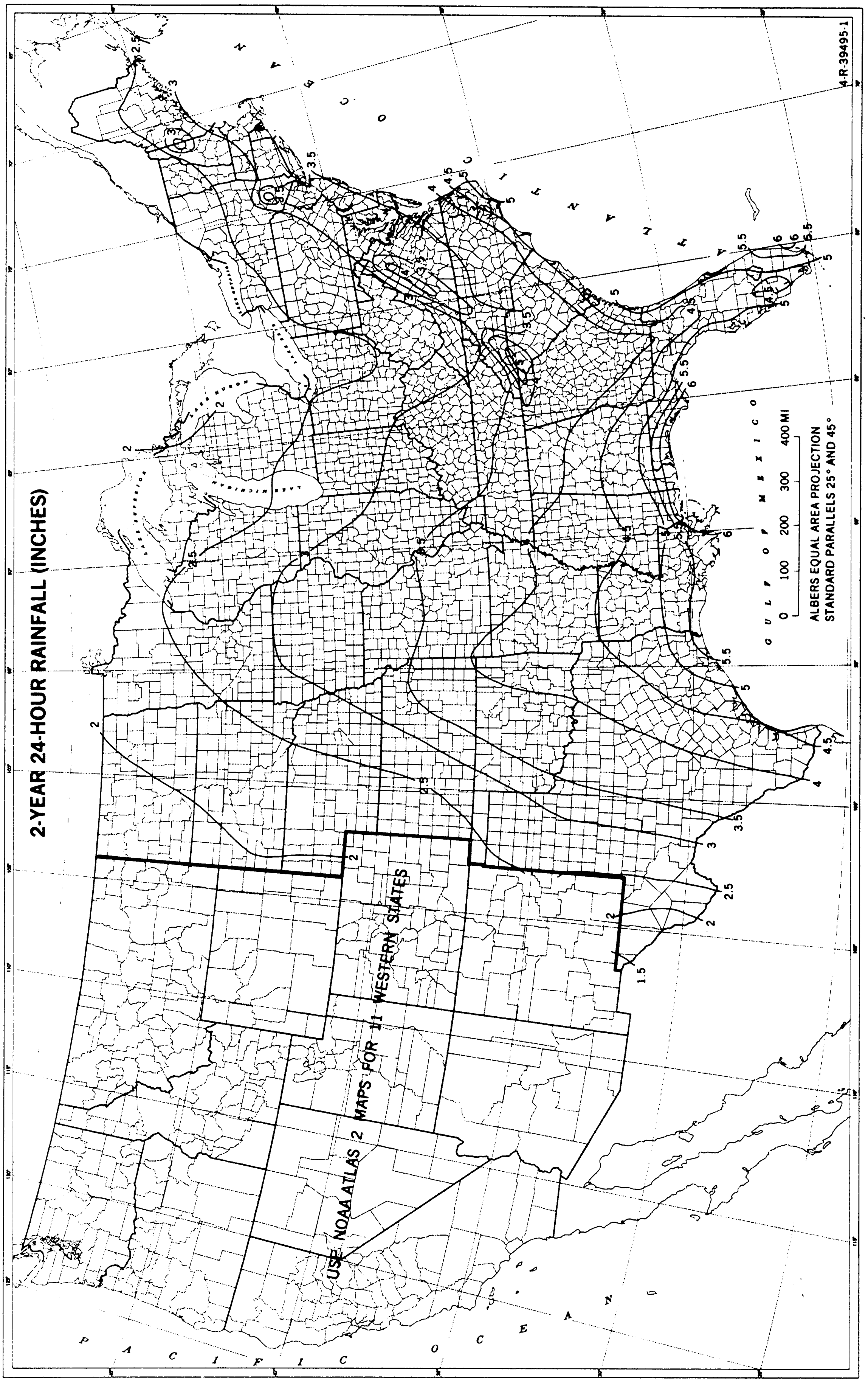


Figure B-3.—Two-year, 24-hour rainfall.

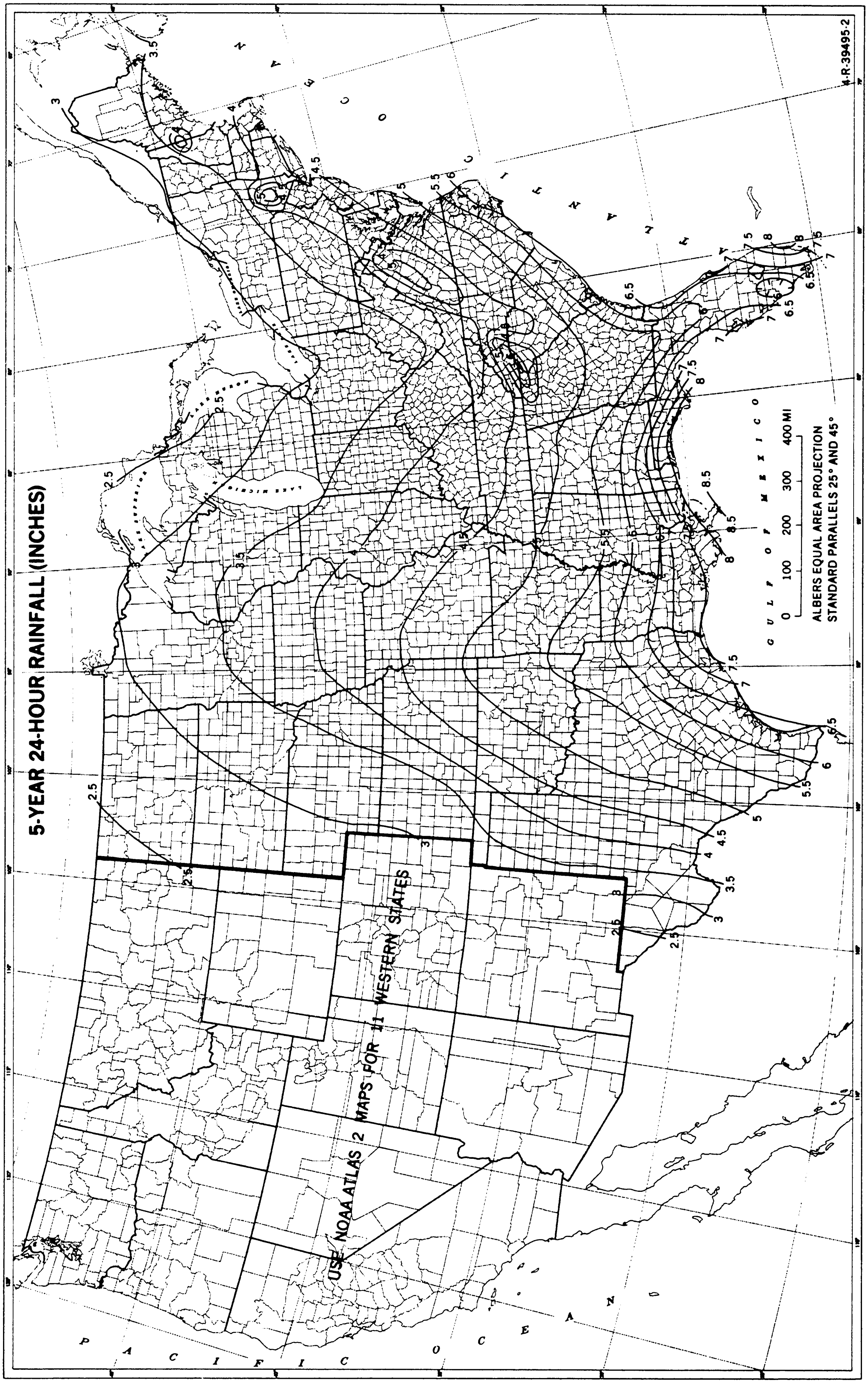


Figure B-4.—Five-year, 24-hour rainfall.

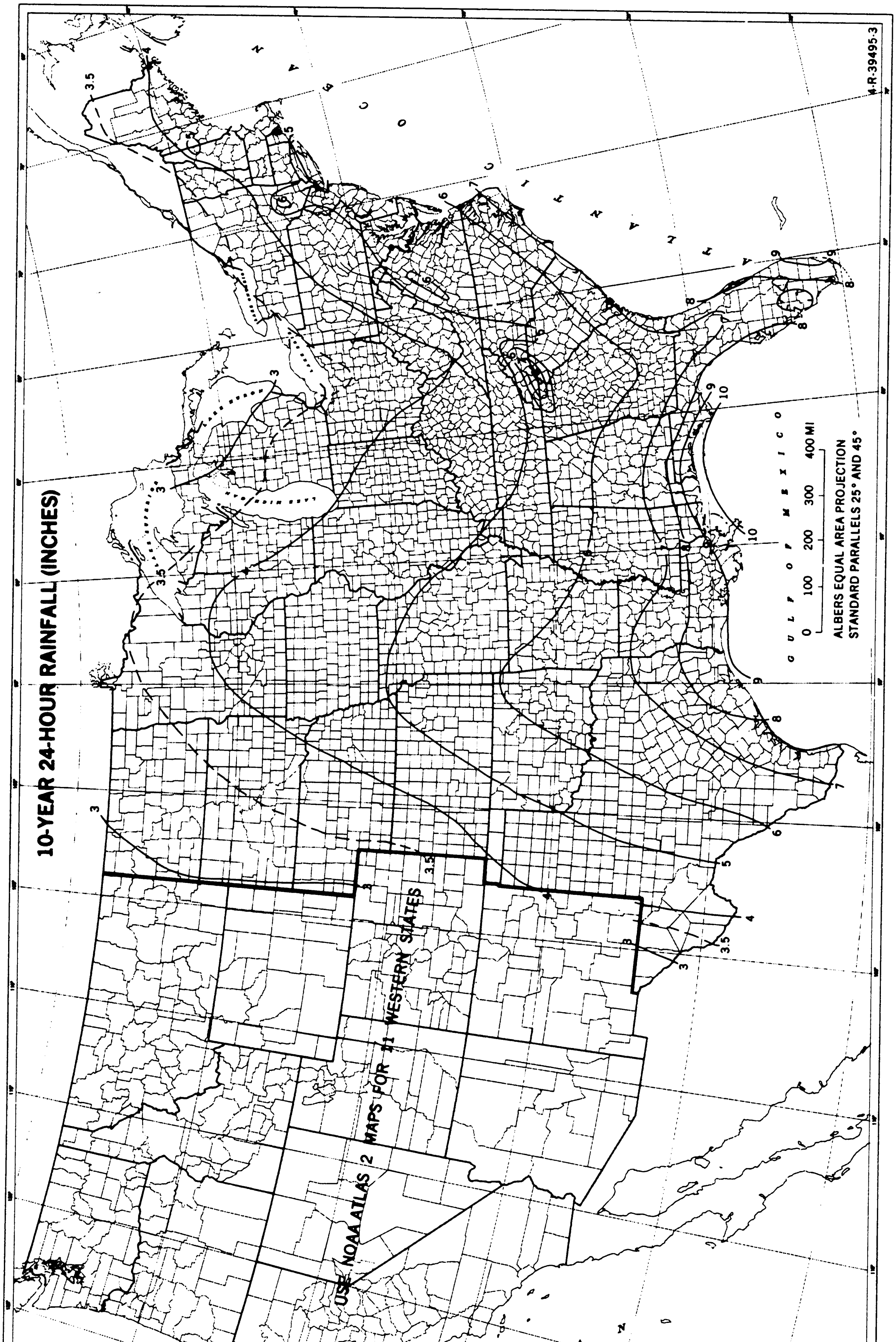


Figure B-5.—Ten-year, 24-hour rainfall.

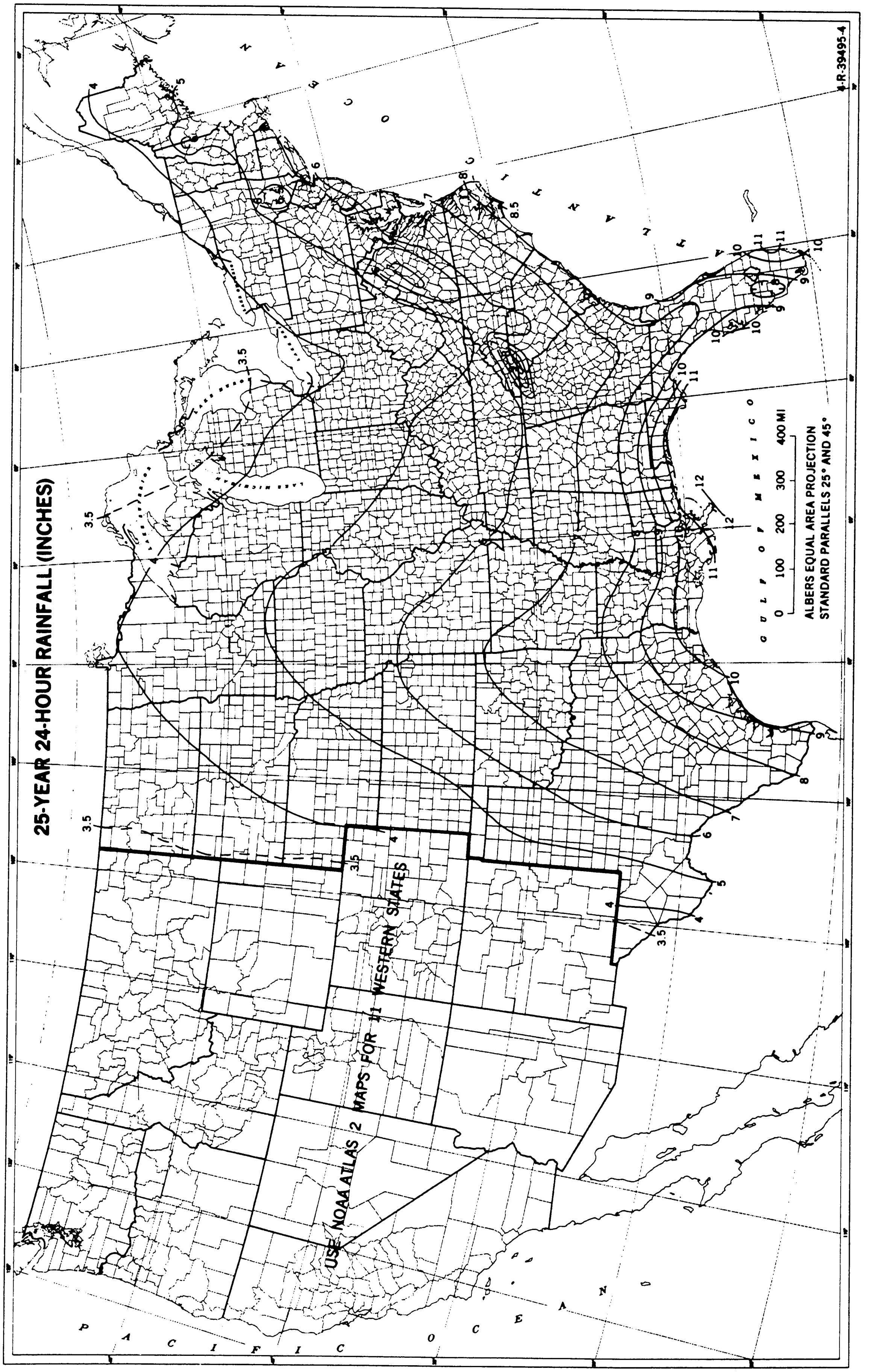


Figure B-6.—Twenty-five-year, 24-hour rainfall.

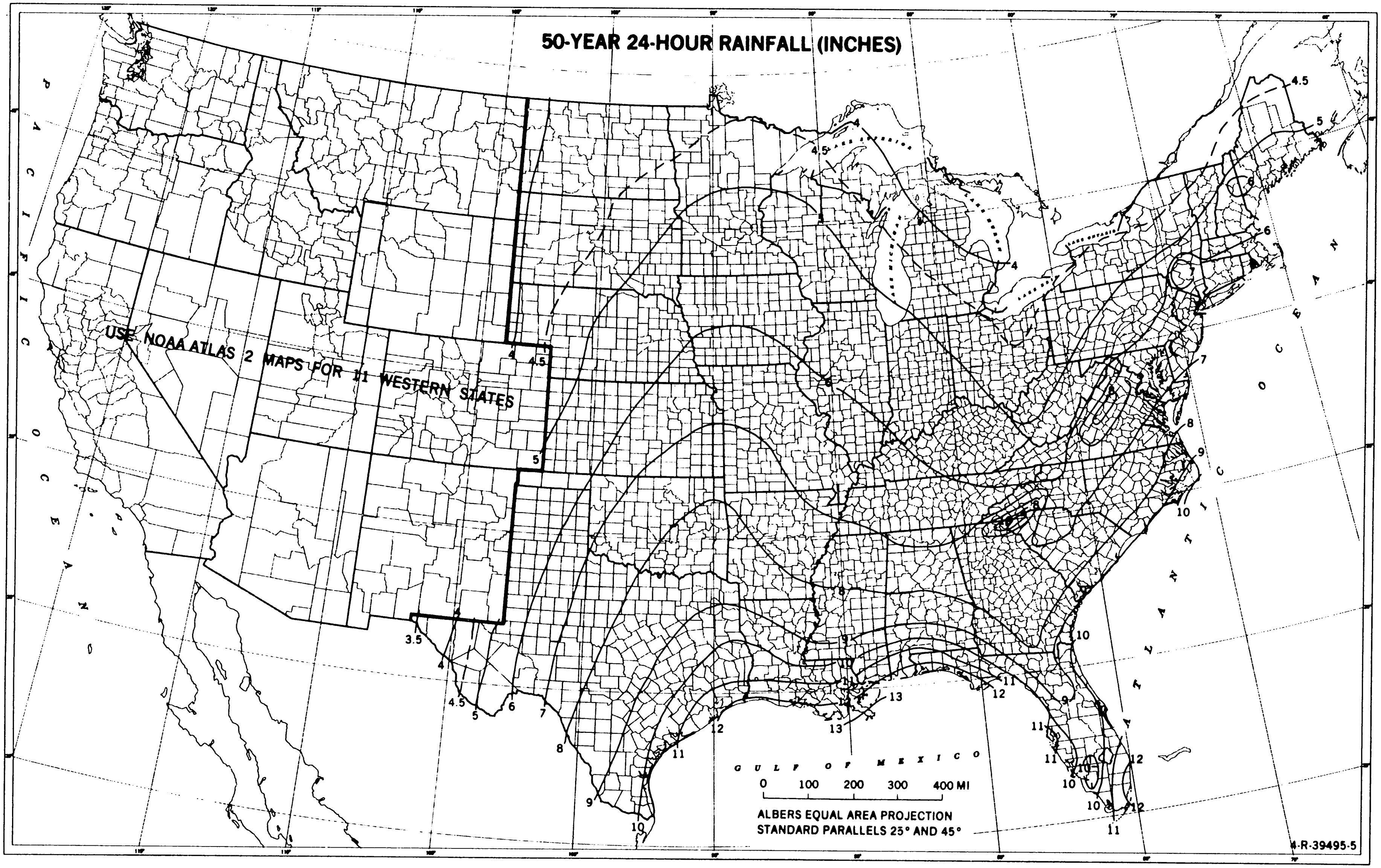


Figure B-7.—Fifty-year, 24-hour rainfall.

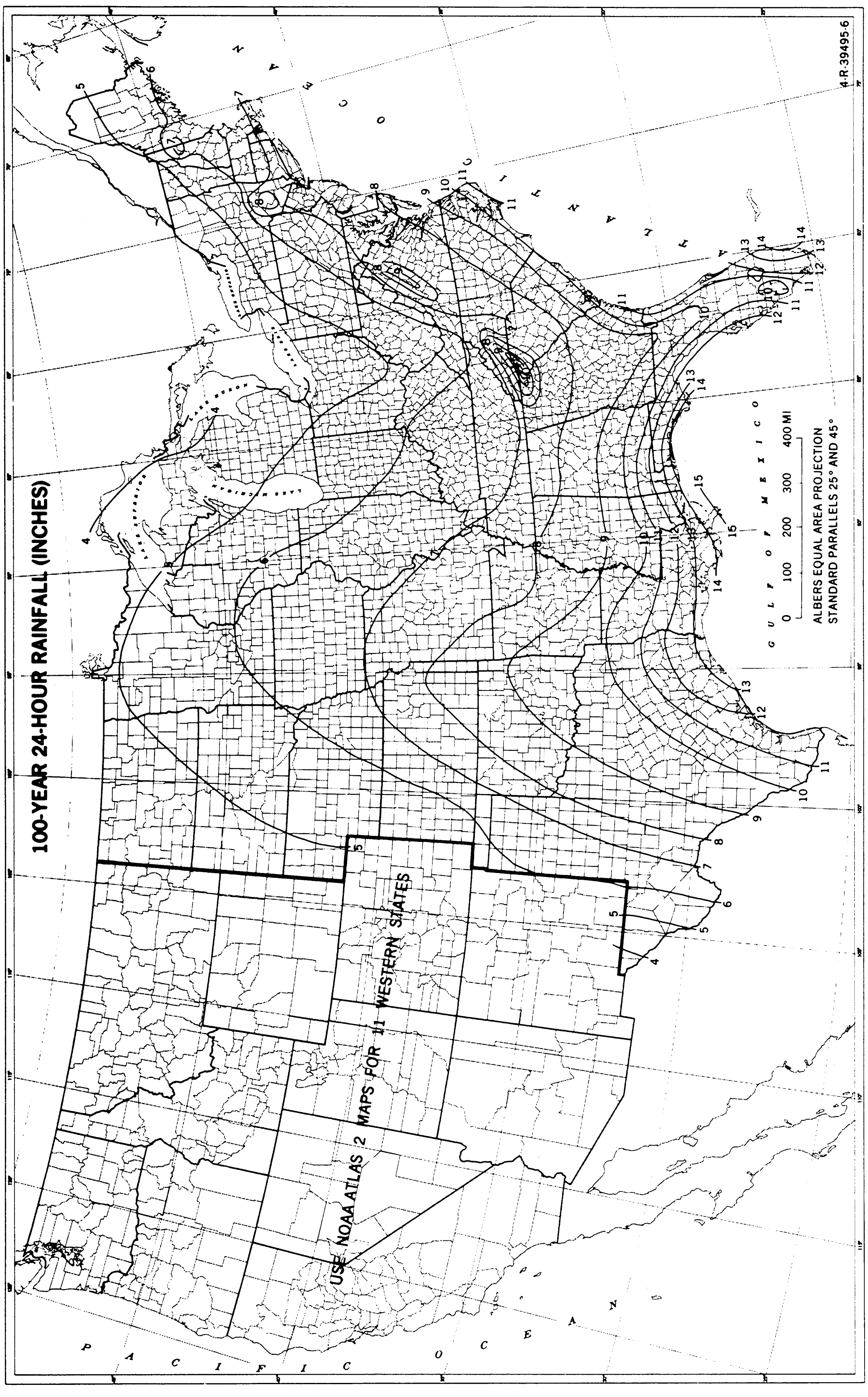


Figure B-8.—One-hundred-year, 24-hour rainfall.

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_mQ (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																

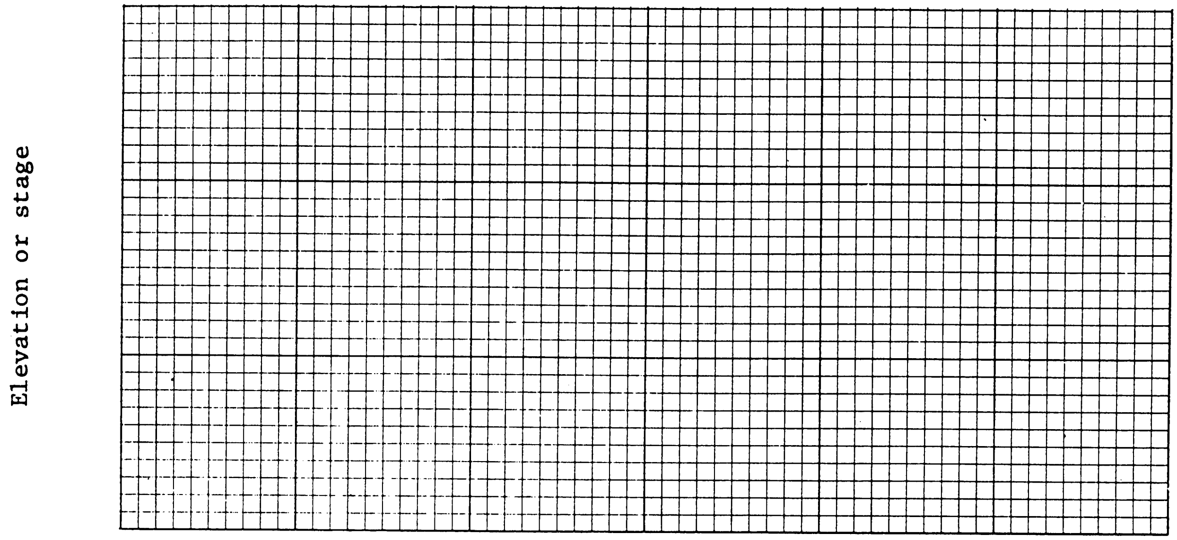
[1] Worksheet 5a. Rounded as needed for use with exhibit 5.
[2] Enter rainfall distribution type used.
[3] Hydrograph discharge for selected times is A_mQ multiplied by tabular discharge from appropriate exhibit 5.

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)		

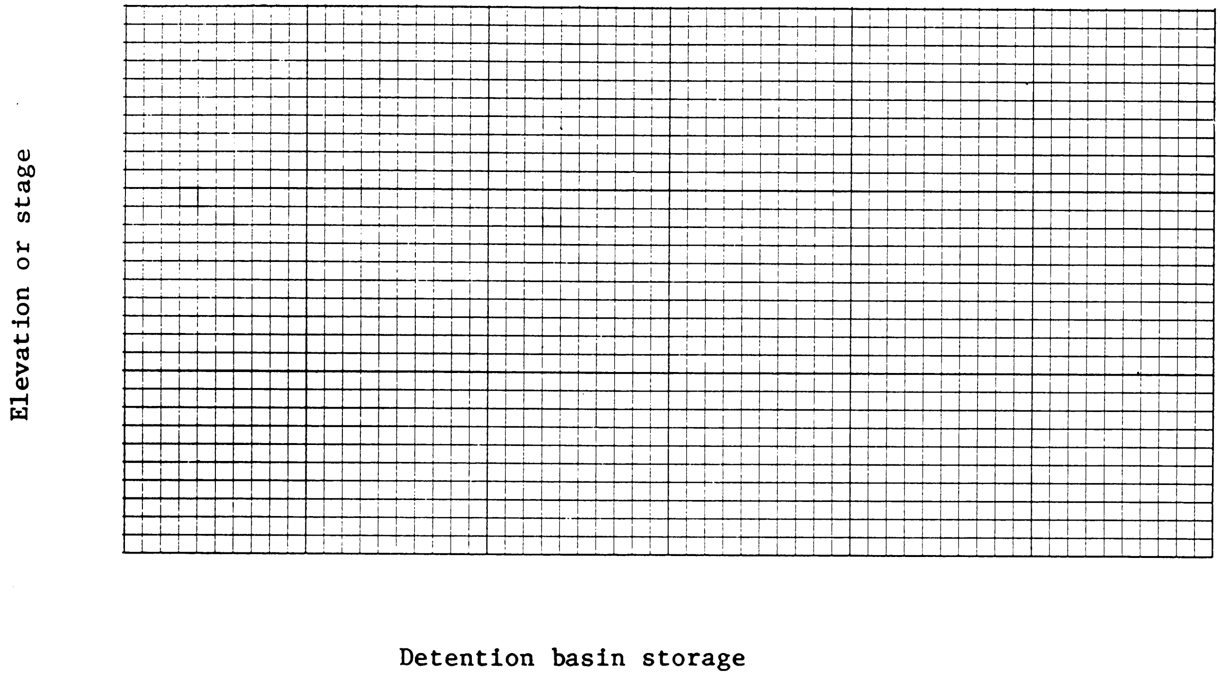
[1/] 2nd stage q_o includes 1st stage q_o.

Worksheet 6b: Detention basin peak outflow, storage volume (V_s) known

Project ______________________ By _____ Date ________

Location ______________________ Checked _____ Date ________

Circle one: Present Developed ______________________



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 E: References

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__. 1985. National engineering handbook. Section 4—Hydrology. Washington, DC.

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

APPENDIX A-2

Peak Discharges

APPENDIX A-2

PEAK DISCHARGES

NRCS CHART METHOD

INTRODUCTION

A quick and reliable method of computing peak discharges from drainage areas 1 to 2,000 acres in size is given in Figures A-2.3 through A-2.5, p. A-2-3 through A-2-5. The charts were prepared for the solution of the general relationships and are based on type-II rainfall distribution.

Type-II storms occur in regions where the high rates of runoff from small areas are usually generated from summer thunderstorms.

This chapter presents a method of adjusting peak discharges obtained from the charts to reflect the increase in peak discharge due to urbanization. Additional methods for interpolating or adjusting peak discharges for conditions not found on the charts or not represented by the general equations in this chapter are given later in this chapter.

MODIFICATION OF PEAK DISCHARGE DUE TO URBANIZATION

Research in the area of urban hydrology is developing rapidly. Research to date has been sufficient to identify the parameters that are affected by urbanization and to derive limited empirical relationships between those parameters for both agriculture and urban watersheds. The time to peak for urban watersheds is affected by a decrease in lag or time of concentration as described in TR-55 (Appendix A-1).

Figures A-2.1 and A-2.2 give factors for adjusting peaks calculated from Figures A-2.3 to A-2.5 based on the same parameters that affect watershed lag and time of concentration. The factors are applied to the peak using future-condition runoff curve numbers as follows:

Q_{MOD} = Q [Factor $_{IMP}$] [Factor $_{HLM}$] (Eq. A-2.1)

where

Q_{MOD} = modified discharge due to urbanization

Q = Discharge for future CN using charts (Figures A-2.3, A-2.4 or A-2.5)

Factor_{IMP} = adjustment factor for percent impervious areas

Factor_{HLM} = adjustment factor for percent of hydraulic length modified.

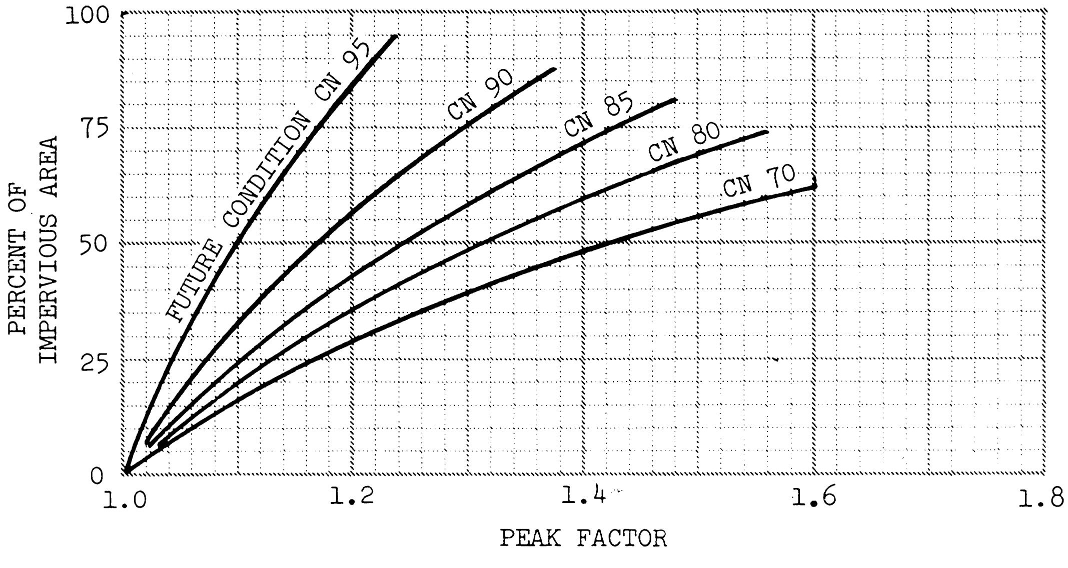


Figure A-2.1 – Factors for adjusting peak discharges for a given future-condition runoff curve number based on the percentage of impervious area in the watershed.

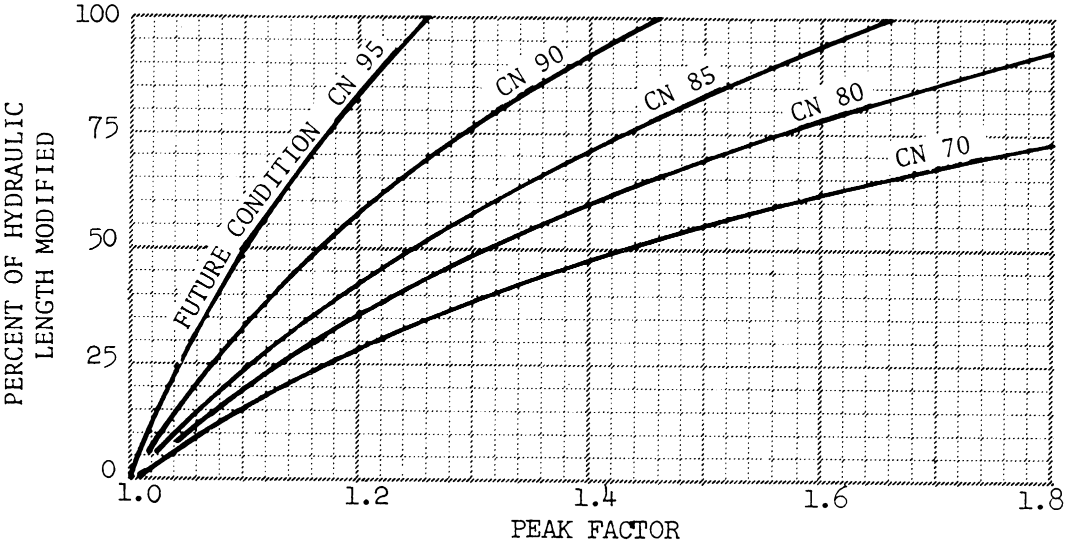


Figure A-2.2 – Factors for adjusting peak discharges for a given future-condition runoff curve number based on the percentage of hydraulic length modified.

Example A-2.1

A 300-acre watershed is to be developed. The runoff curve number for the proposed development is computed to be 80. Approximately 60 percent of the hydraulic length will be modified by the installation of street gutters and storm drains to the watershed outlet. Approximately 30 percent of the watershed will be impervious. The average watershed slope is estimated to be 4 percent. Compute the present-condition and anticipated future-condition peak discharge for a 50-year/ 24-hour storm event with 5 inches of rainfall. The present-condition runoff curve number is 75.

1. From TR-55, Table 2-1 (Appendix A-1), the runoff for present condition is 2.45 inches and for future conditions is 2.89 inches.
2. From the chart for moderate slope in Figure A-2.4 (CN = 75), the present condition peak discharge is 120 cfs (cubic feet per second) per inch of runoff. The peak discharge is then 120 x 2.45 or 294 cfs.
3. From the chart for moderate slope in Figure A-2.4 (CN = 80), the future-condition base discharge for (CN = 80) is 133 cfs per inch of runoff. The base discharge is then 133 x 2.89 or 384 cfs.
4. From Figure A-2.1 with 30 percent impervious area and future runoff curve number of 80, read peak factor = 1.16.
5. From Figure A-2.2, with 60 percent of the hydraulic length modified and future-condition curve number of 80, read peak factor = 1.42.
6. Future-condition peak discharge is:

   384 (1.16)(1.42) = 633 cfs

7. The effect of this proposal development is to increase the peak discharge from 294 to 633 cfs.

ADJUSTMENT FACTORS FOR PEAKS DETERMINED USING FIGURES A-2.3 THROUGH A-2.5

This section describes methods for adjusting peak rates of discharge for ranges of flat, moderate, and steep slopes; for conditions where swamps or ponding areas exist; and for conditions where the watershed shape factor (l/w) varies significantly from that used in the development of the charts of Figures A-2.3 through A-2.5.

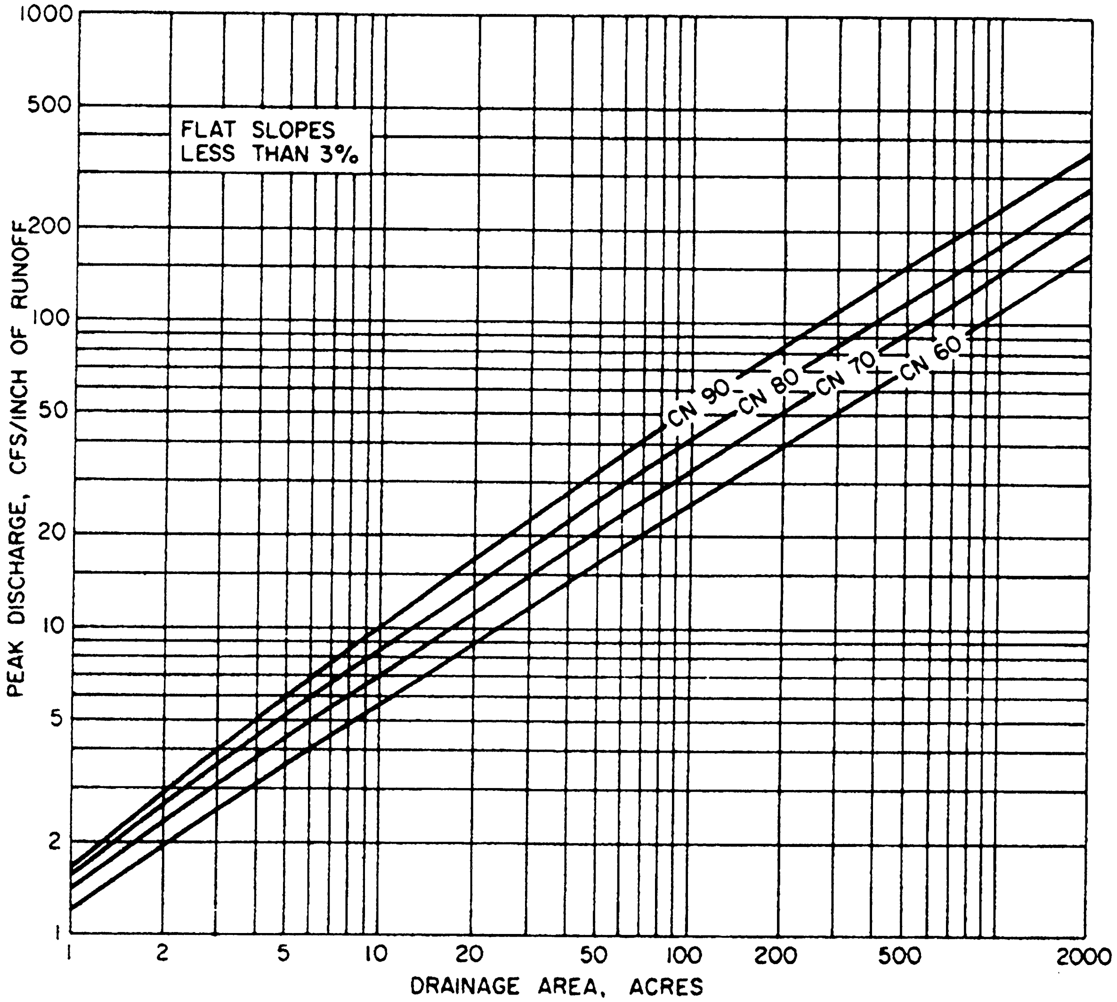
SLOPE INTERPOLATION

Table A-2.1 provides interpolation factors to be used in determining peak rates of discharge for specific slopes within ranges of flat, moderate, and steep slopes for a range of drainage areas. Figure A-2.3, for FLAT slopes is based on 1-percent slope, Figure A-2.4, for MODERATE slopes on 4-percent slope, and Figure A-2.5 for STEEP slopes on 16-percent slope. For slopes other than 1, 4, and 16 percent, use the factors shown in Table A-2.1 to modify the peak discharges.

Example A-2.2

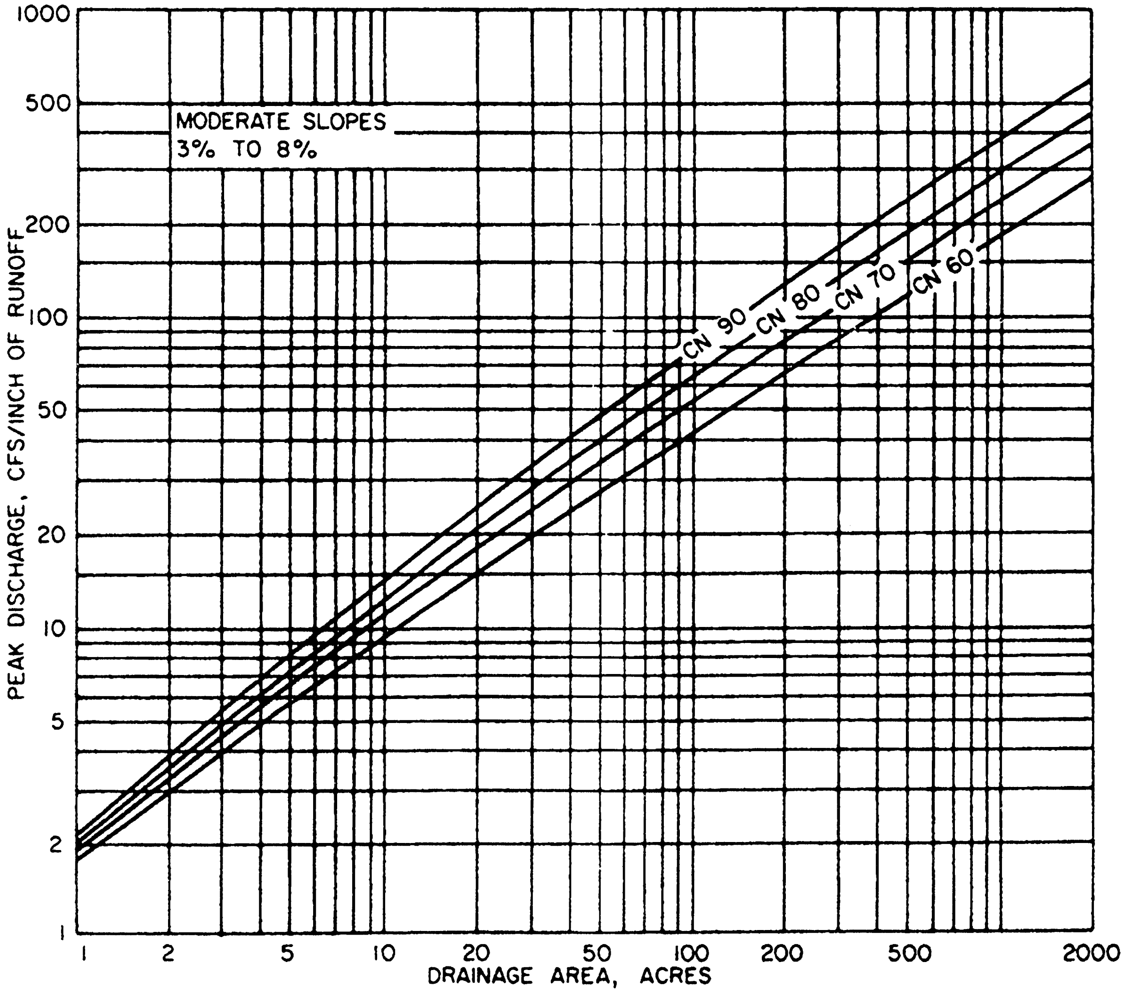
Compute the peak discharge for a 1,000-acre watershed with an average watershed slope of 7 percent and a runoff curve number (CN) of 80 for central Lee County, 2-year/24-hour storm.

1. Determine the peak discharge for a watershed with a moderate slope (4 percent). From Figure A-2.4, read a peak discharge of 295 cfs per inch of runoff for 1,000 acres and a CN of 80. From Figure A-2.8, Lee County has a P value of 4.0 inches. From TR-55,



PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
(24 HOUR, TYPE II STORM DISTRIBUTION)

Figure A-2.3



PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS
(24-HOUR, TYPE II STORM DISTRIBUTION)

Figure A-2.4

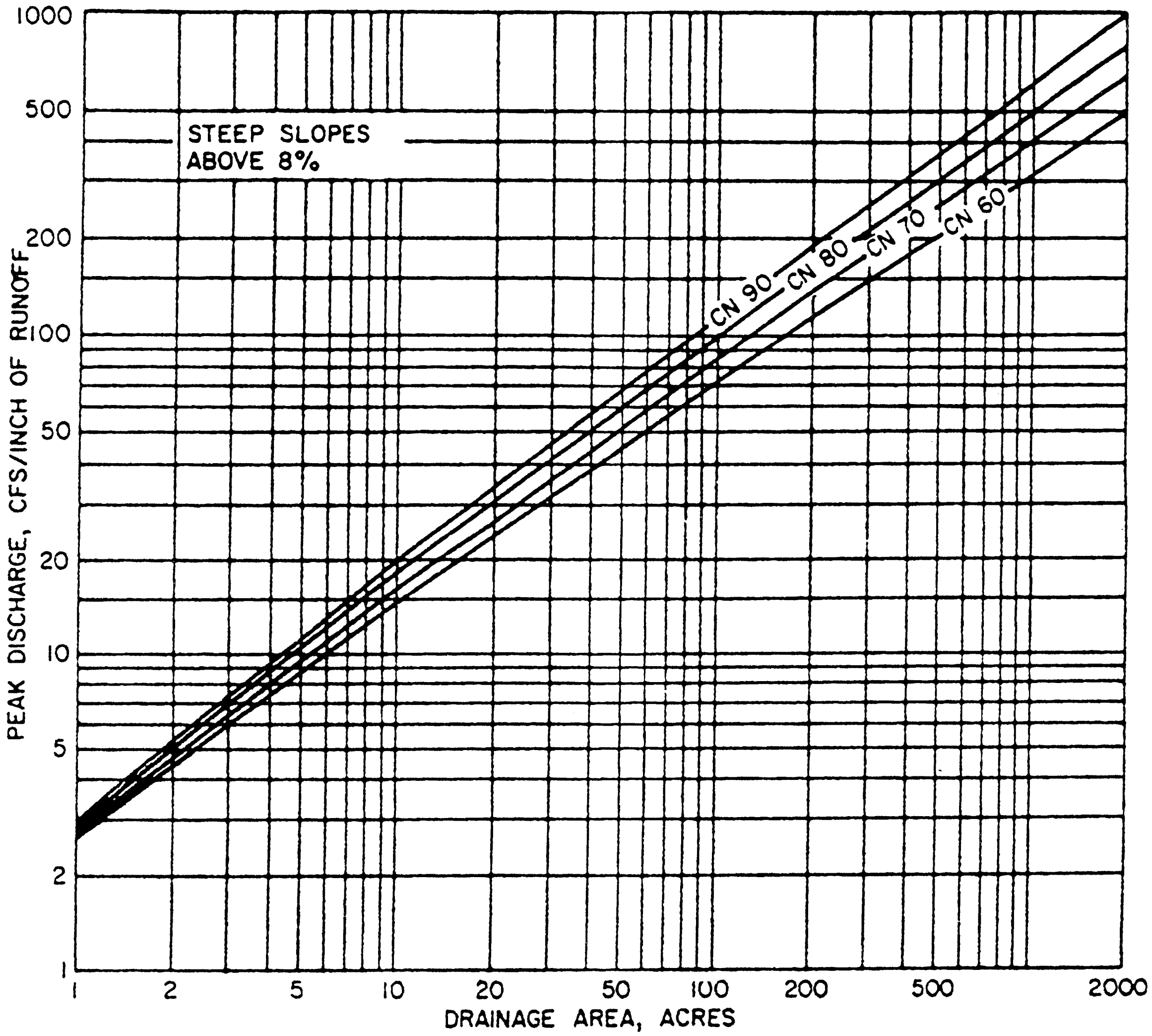


Figure A-2.5. – Peak rates of discharge for small watersheds (24-hour, type II storm distribution).

Table 2-1 (Appendix A-1) find 2.04 inches of runoff from 4 inches of rainfall and a CN of 80. The peak discharge is then 295 x 2.04 or 602 cfs.

2. Determine the interpolation factor. From Table A-2.1, find 7-percent slope under MODERATE heading and read an interpolation factor of 1.23 for a drainage area of 1,000 acres. (The peak from a 1,000-acre watershed with a watershed slope of 7 percent is 1.23 times greater than for an average watershed slope of 4 percent.)
3. Determine the peak discharge of 7-percent slope.

q = (602)(1.23) = 740 cfs

Examples A-2.3

Compute the peak discharge for a 15-acre watershed with an average slope of 0.5 percent and a runoff curve number of 80 for 4 inches of rainfall.

1. Determine the peak discharge for a watershed with a flat slope (1 percent). From Figure A-2.3 read a peak discharge of 11.2 cfs per inch of runoff for 15 acres and a CN of 80. From Table A-2.1, find 2.04 inches of runoff for 4 inches of rainfall and a CN of 80. The peak discharge is then 11.2 x 2.04 or 23 cfs.
2. Determine the interpolation factor. From Table A-2.1 find 0.5-percent slope under FLAT heading. Read a slope interpolation factor of 0.81 interpolated between the values for 10 acres and 20 acres.
3. Determine the peak discharge for 0.5-percent slope.

q = (23)(.81) = 19 cfs

Table A-2.1. – Slope adjustment factors by drainage areas.

Slope (percent)	10 acres	20 acres	50 acres	100 acres	200 acres	500 acres	1,000 acres	2,000 acres
FLAT SLOPES								
0.1	0.49	0.47	0.44	0.43	0.42	0.41	0.41	0.40
0.2	.61	.59	.56	.55	.54	.53	.53	.52
0.3	.69	.67	.65	.64	.63	.62	.62	.61
0.4	.76	.74	.72	.71	.70	.69	.69	.69
0.5	.82	.80	.78	.77	.77	.76	.76	.76
0.7	.90	.89	.88	.87	.87	.87	.87	.87
1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.5	1.13	1.14	1.14	1.15	1.16	1.17	1.17	1.17
2.0	1.21	1.24	1.26	1.28	1.29	1.30	1.31	1.31
MODERATE SLOPES								
3	.93	.92	.91	.90	.90	.90	.89	.89
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.04	1.05	1.07	1.08	1.08	1.08	1.09	1.09
6	1.07	1.10	1.12	1.14	1.15	1.16	1.17	1.17
7	1.09	1.13	1.18	1.21	1.22	1.23	1.23	1.24
STEEP SLOPES								
8	.92	.88	.84	.81	.80	.78	.78	.77
9	.94	.90	.86	.84	.83	.82	.81	.81
10	.96	.92	.88	.87	.86	.85	.84	.84
11	.96	.94	.91	.90	.89	.88	.87	.87
12	.97	.95	.93	.92	.91	.90	.90	.90
13	.97	.97	.95	.94	.94	.93	.93	92
14	.98	.98	.97	.96	.96	.96	.95	.95
15	.99	.99	.99	.98	.98	.98	.98	.98
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10
25	1.06	1.08	1.12	1.14	1.15	1.16	1.17	1.19
30	1.09	1.11	1.14	1.17	1.20	1.22	1.23	1.24
40	1.12	1.16	1.20	1.24	1.29	1.31	1.33	1.35
50	1.17	1.21	1.25	1.29	1.34	1.37	1.40	1.43

ADJUSTMENT FACTORS FOR SWAMPY AND PONDING AREAS

Peak flows determined from Figure A-2.3 through A-2.5 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 may be retained in temporary storage. The peak rate of runoff should be reduced to reflect this condition. Tables A-2.2, A-2.3, and A-2.4 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 A-2.2 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 A-2.3 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 A-2.4 contains adjustment factors to be used when a significant amount of the flow passes through ponding or swampy areas located in the upper reaches of the watershed.

These conditions may occur in a proposed or existing urban or suburban area and the adjustment factors from Tables A-2.2, A-2.3, or A-2.4 should be applied after the peaks have been adjusted for the effects of urbanization.

Table A-2.2. – Peak flow 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)						
		1	2	5	10	25	50	100
500	0.2	0.91	0.92	0.94	0.95	0.96	0.97	0.98
200	.5	.85	.86	.87	.88	.90	.92	.93
100	1.0	.79	.80	.81	.83	.85	.87	.89
50	2.0	.73	.74	.75	.76	.79	.82	.86
40	2.5	.68	.69	.70	.72	.75	.78	.82
30	3.3	.63	.64	.65	.67	.71	.75	.78
20	5.0	.58	.59	.61	.63	.67	.71	.75
15	6.7	.56	.57	.58	.60	.64	.67	.71
10	10.0	.52	.53	.54	.56	.60	.63	.68
5	20.0	.47	.48	.49	.51	.55	.59	.64

Table A-2.3. – Peak flow 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)						
		1	2	5	10	25	50	100
500	0.2	0.93	0.94	0.95	0.96	0.97	0.98	0.99
200	.5	.87	.88	.89	.90	.91	.92	.94
100	1.0	.83	.83	.84	.86	.87	.88	.90
50	2.0	.77	.78	.79	.81	.83	.85	.87
40	2.5	.72	.73	.74	.76	.78	.81	.84
30	3.3	.68	.69	.70	.71	.74	.77	.81
20	5.0	.64	.65	.66	.68	.72	.75	.78
15	6.7	.61	.62	.63	.65	.69	.72	.75
10	10.0	.57	.58	.59	.61	.65	.68	.71
5	20.0	.52	.53	.54	.56	.60	.63	.68
4	25.0	.49	.50	.51	.53	.57	.61	.66

Table A-2.4. – Peak flow 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)						
		1	2	5	10	25	50	100
500	0.2	0.95	0.96	0.97	0.98	0.98	0.99	0.99
200	.5	.92	.93	.94	.94	.95	.96	.97
100	1.0	.89	.90	.91	.92	.93	.94	.95
50	2.0	.86	.87	.88	.88	.90	.91	.93
40	2.5	.84	.85	.85	.86	.88	.89	.91
30	3.3	.81	.82	.83	.84	.86	.88	.89
20	5.0	.79	.80	.81	.82	.84	.86	.88
15	6.7	.77	.78	.79	.80	.82	.84	.86
10	10.0	.76	.77	.77	.78	.80	.82	.84
5	20.0	.73	.74	.75	.76	.78	.80	.82

Example A-2.4

A 5-acre pond is located at the downstream end of a 100-acre watershed in which a housing development is proposed. The average watershed slope is 4 percent and the present-condition curve number is 75. After the installation of the housing development, 30 percent of the watershed will be impervious and 50 percent of the hydraulic length will be modified. The future-condition curve number is estimated to be 80. For a 100-year storm 24-hour duration in central Glascock County, determine the present-condition and future-condition peak discharges downstream of the pond.

1. Determine the present-condition peak discharge assuming the pond is not in place: From Figure A-2.4, find the peak discharge to be 59 cfs per inch of runoff. From Figure A-2.13, the rainfall for central Glascock County is 8 inches. From TR-55, Table 2.1 (Appendix A-1) find the runoff to be 5.04 inches. The peak discharge is 59 x 5.04 or 297 cfs.
2. Determine the ponding adjustment factor: Since the pond is at the lower end of the watershed, use Table A-2.2. The ratio of the drainage area to pond area is 100/5 or 20. For a 100-year frequency event, the adjustment factor is 0.75.
3. Compute the present-condition peak discharge:

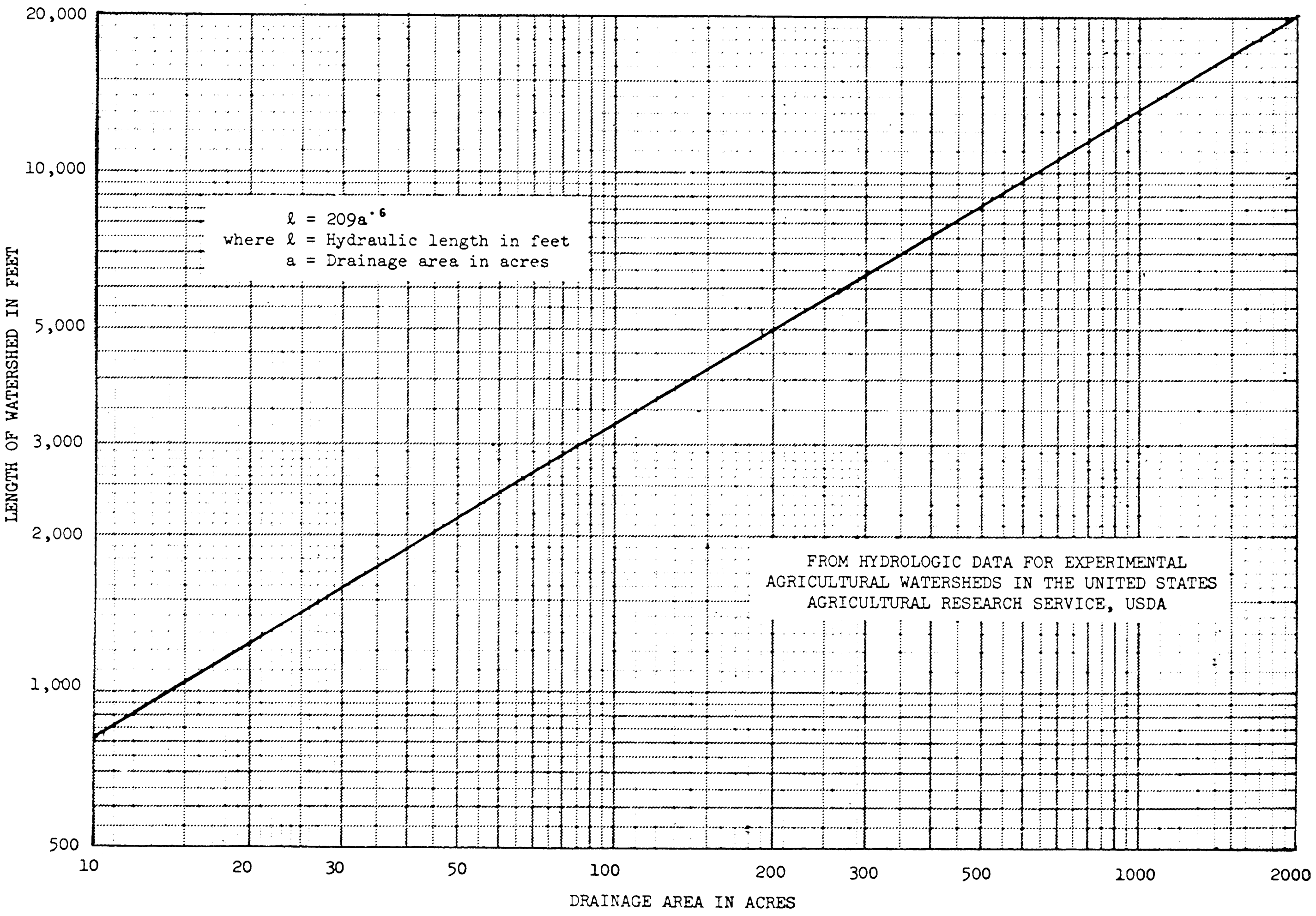
   Q = 0.75 (297) = 233 cfs

4. Compute the basic future-condition peak discharge: From Figure A-2.4, find the peak discharge to be 65 cfs per inch of runoff. From TR-55, Table 2-1, (Appendix A-1), Find the runoff to be 5.62 inches The peak discharge is then 65 x 5.62 or 365 cfs.
5. Determine the modification factors for proposed urbanization: Taken from Figures A-2.1 and A-2.2 for a curve number of 80: impervious factor = 1.16; hydraulic length factor = 1.31; urbanization factor = (1.16) (1.31) = 1.52.
6. Compute the future condition peak discharge:

   q = 1.52 (365) = 555 cfs

7. Compute the fugure-condition peak below the pond: From step 2 the ponding factor is 0.75.

   q = 0.75 (555) = 416 cfs



$\ell = 209a^{.6}$

where ℓ = Hydraulic length in feet

a = Drainage area in acres

FROM HYDROLOGIC DATA FOR EXPERIMENTAL AGRICULTURAL WATERSHEDS IN THE UNITED STATES AGRICULTURAL RESEARCH SERVICE, USDA

Figure A-2.6 – Hydraulic length and drainage area relationship.

ADJUSTMENT FOR WATERSHED SHAPE FACTOR

The equation used in computing peak discharges from Figures A-2.3 through A-2.5 was based in part on a relationship between the hydraulic length and the watershed area from Agricultural Research Services's studies on small experimental watersheds. Figure A-2.6 shows the best fit line relating length to drainage area. The equation of the line is $l = 209a^{0.6}$. A watershed shape factor, l/w (where w is the average width of the watershed), is then fixed for any given drainage area. For example, for drainage areas of 10, 100, and 1,000 acres, the watershed shape factor is 1.58, 2.51, and 3.98, respectively.

There are watersheds that deviate considerably from these relationships. The peaks can be modified for other shape factors. The procedure is as follows:

1. Determine the hydraulic length of the watershed and compute "equivalent" drainage area using $l = 209a^{0.6}$ or Figure A-2.6.
2. Determine the "equivalent" peak flow from the charts for the "equivalent" drainage area.
3. Compute the "actual" peak discharge for the watershed by multiplying the equivalent peak discharge by the ratio of actual drainage area to the equivalent drainage area.

   The factors for modifying the peak for urbanization can then be applied to the revised peak discharge.

Example A-2.5

From a topographic map the hydraulic length of a 100-acre watershed with moderate slopes and a CN of 75 was measured to be 2,200 feet. Determine the peak discharge for a 6-inch, 24-hour rainfall.

1. Determine the "equivalent" drainage area for a watershed with a hydraulic length of 2,200 feet. From Figure A-2.6, read 51 acres. (Note that in a 100-acre watershed, the hydraulic length would be 3,300 feet from Figure A-2.6).
2. Determine the "equivalent" peak flow from Figure A-2.4 for a drainage area of 51 acres and a CN of 75. Read 37 cfs per inch of runoff. From TR-55 Table 2-1 (Appendix A-1), find the runoff to be 3.28 or 121 cfs.
3. Compute the actual peak discharge for 100 acres.

$$\text{actual discharge} = \text{equivalent discharge} \left(\frac{\text{actual drainage area}}{\text{equivalent drainage area}} \right)$$

$$q = 121 \left(\frac{100}{51} \right) = 237 \text{ cfs}$$

The peak discharge for the 100-acre watershed with a hydraulic length of 2,200 feet is 237 cfs (versus 194 cfs for a "normal" 100-acre watershed). Adjustments to this peak discharge for urbanization can be made using factors discussed on page A-2-1.

4. The procedure in steps 1, 2, and 3 can be used to determine peak discharges when the actual hydraulic length is longer than that shown on Figure A-2.6. For example, if the actual length were 4,500 feet instead of 3,300 feet, the equivalent area would be 170 acres, as shown in Figure A-2.6.

GEORGIA

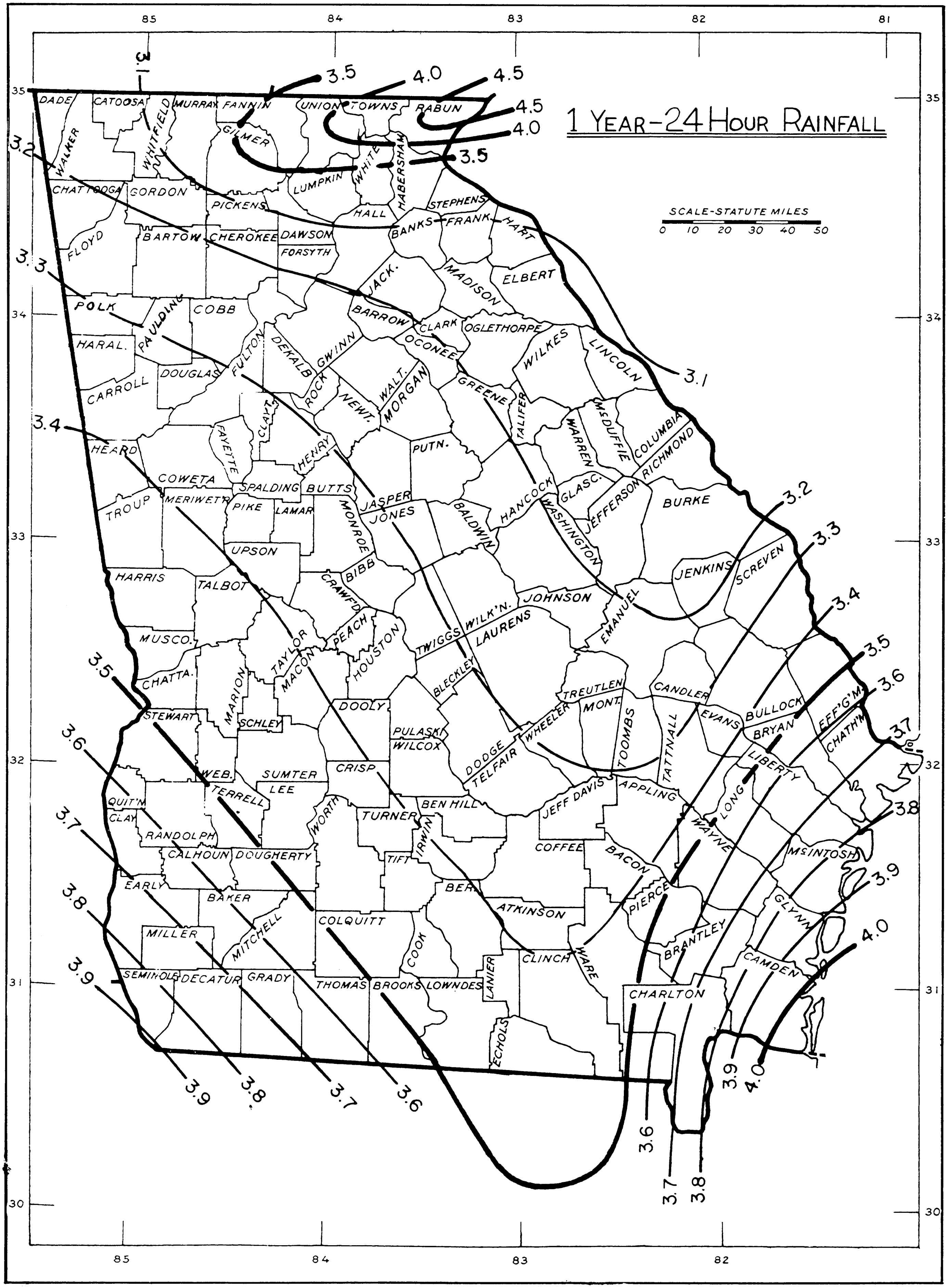


Figure A-2.7 – Total rainfall (P) for 1-year/24-hour storm.

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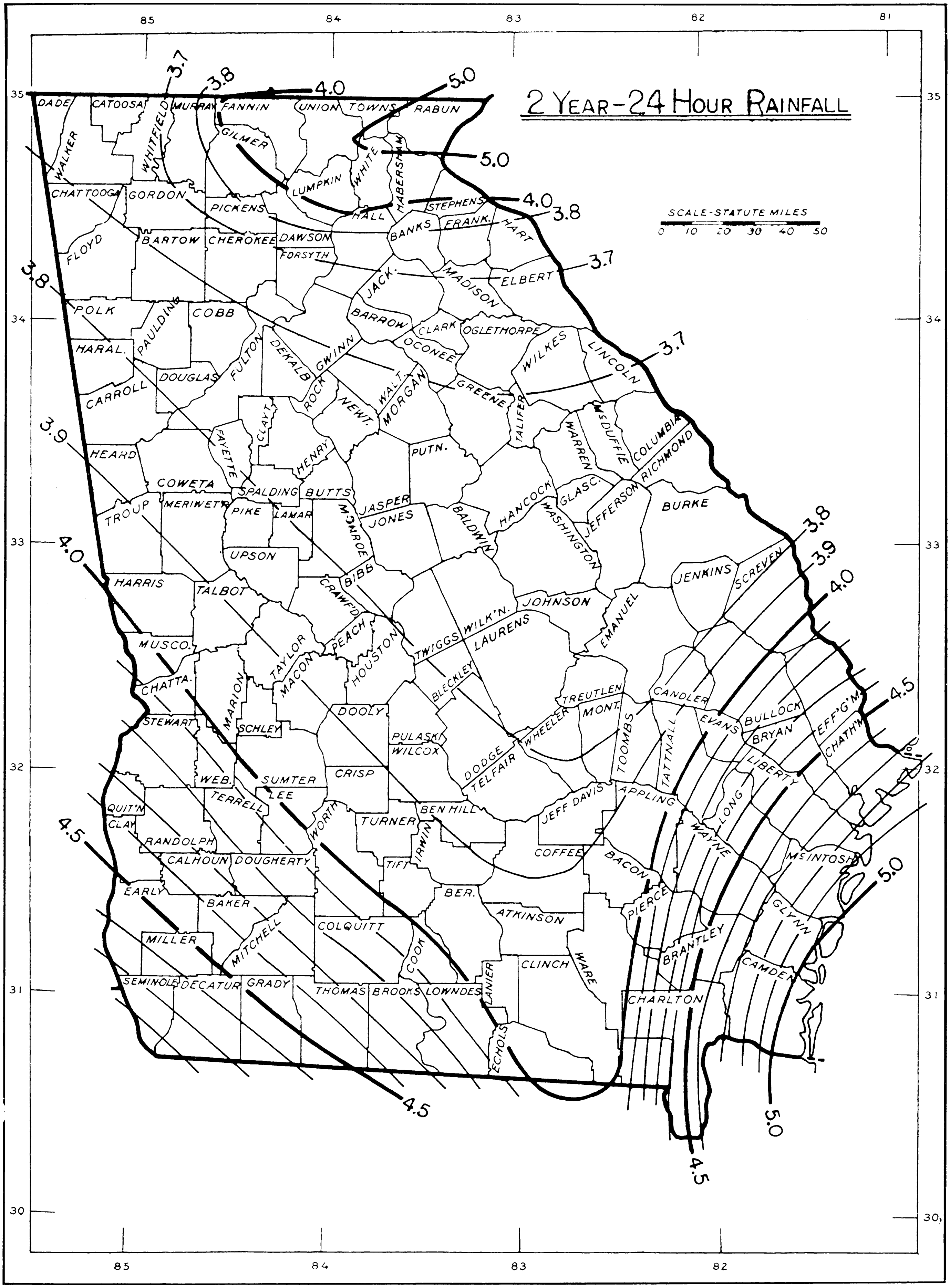


Figure A-2.8 – Total rainfall (P) for 2-year/24-hour storm.

GEORGIA

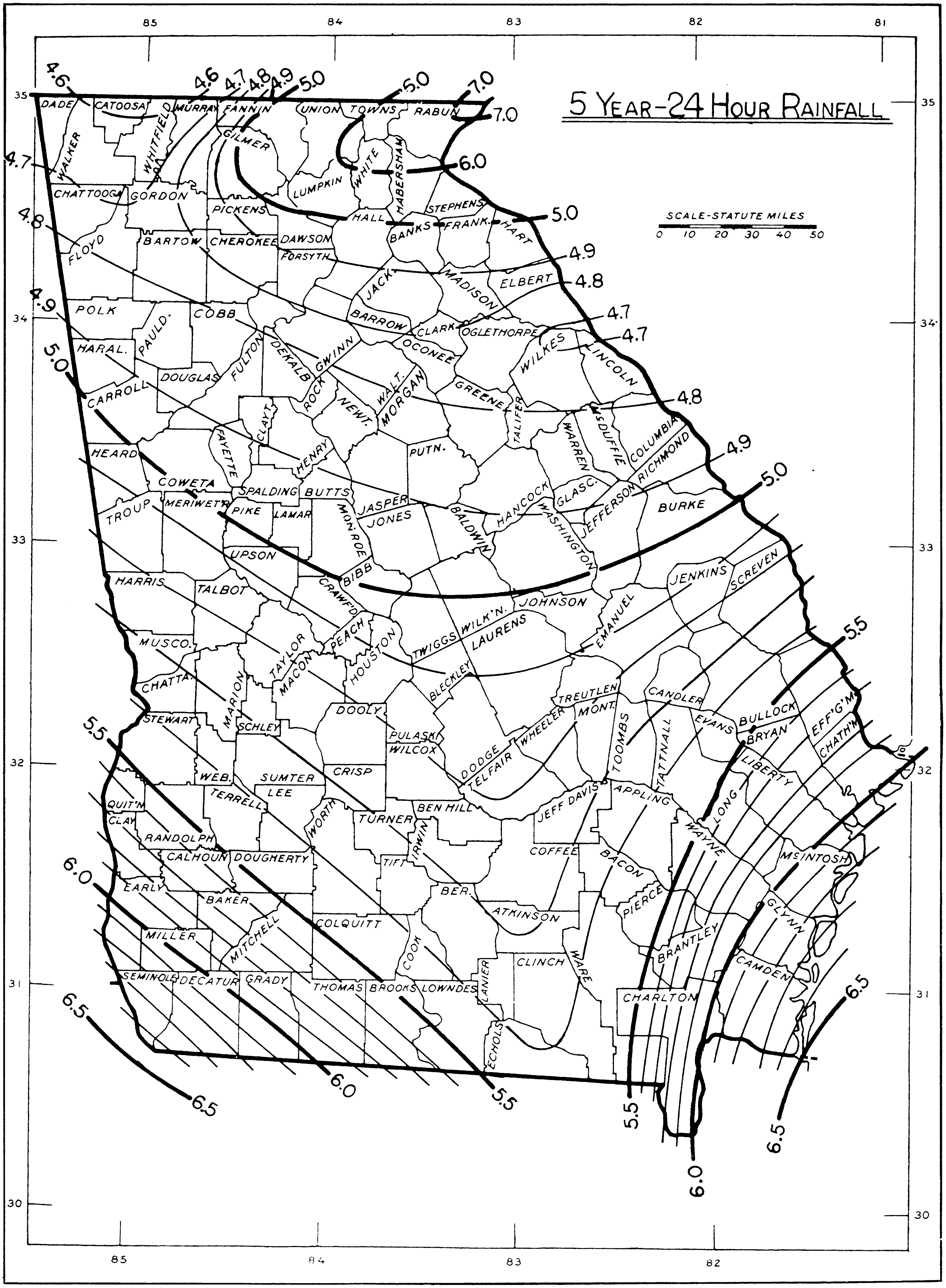


Figure A-2.9 – Total rainfall (P) for 5-year/24-hour storm.

GEORGIA

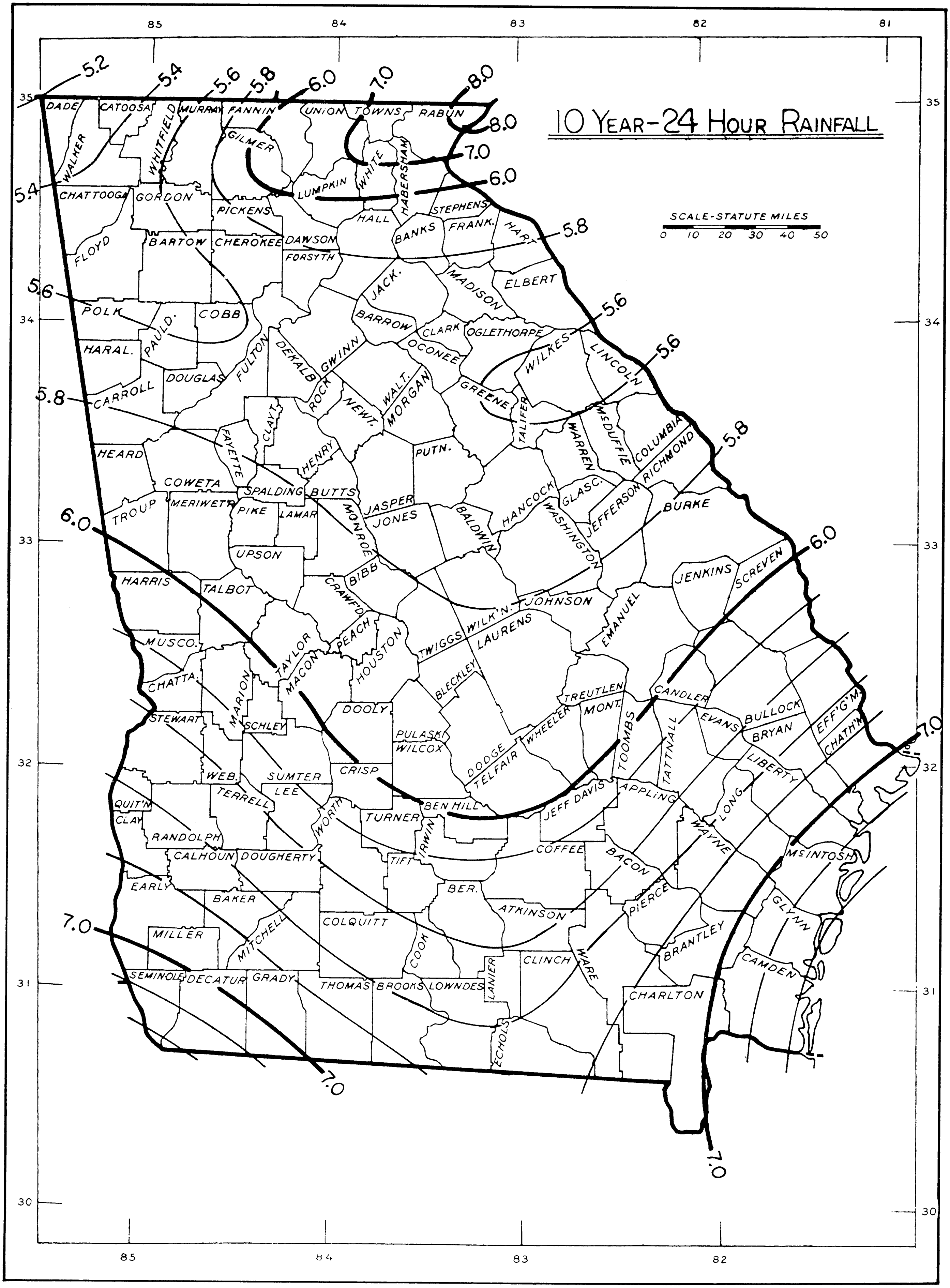


Figure A-2.10 – Total rainfall (P) for 10-year/24-hour storm.

GEORGIA

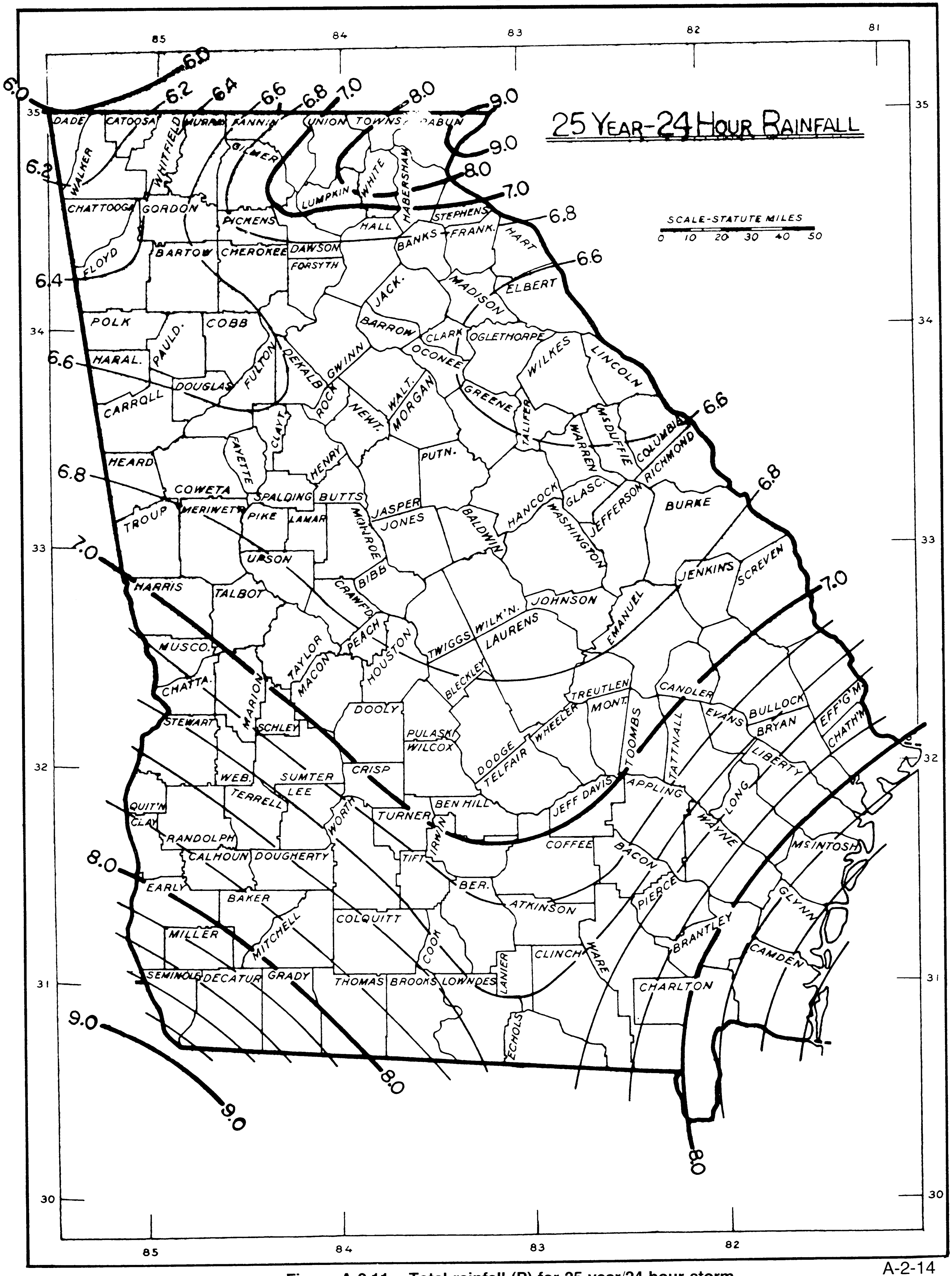


Figure A-2.11 – Total rainfall (P) for 25-year/24-hour storm.

GEORGIA

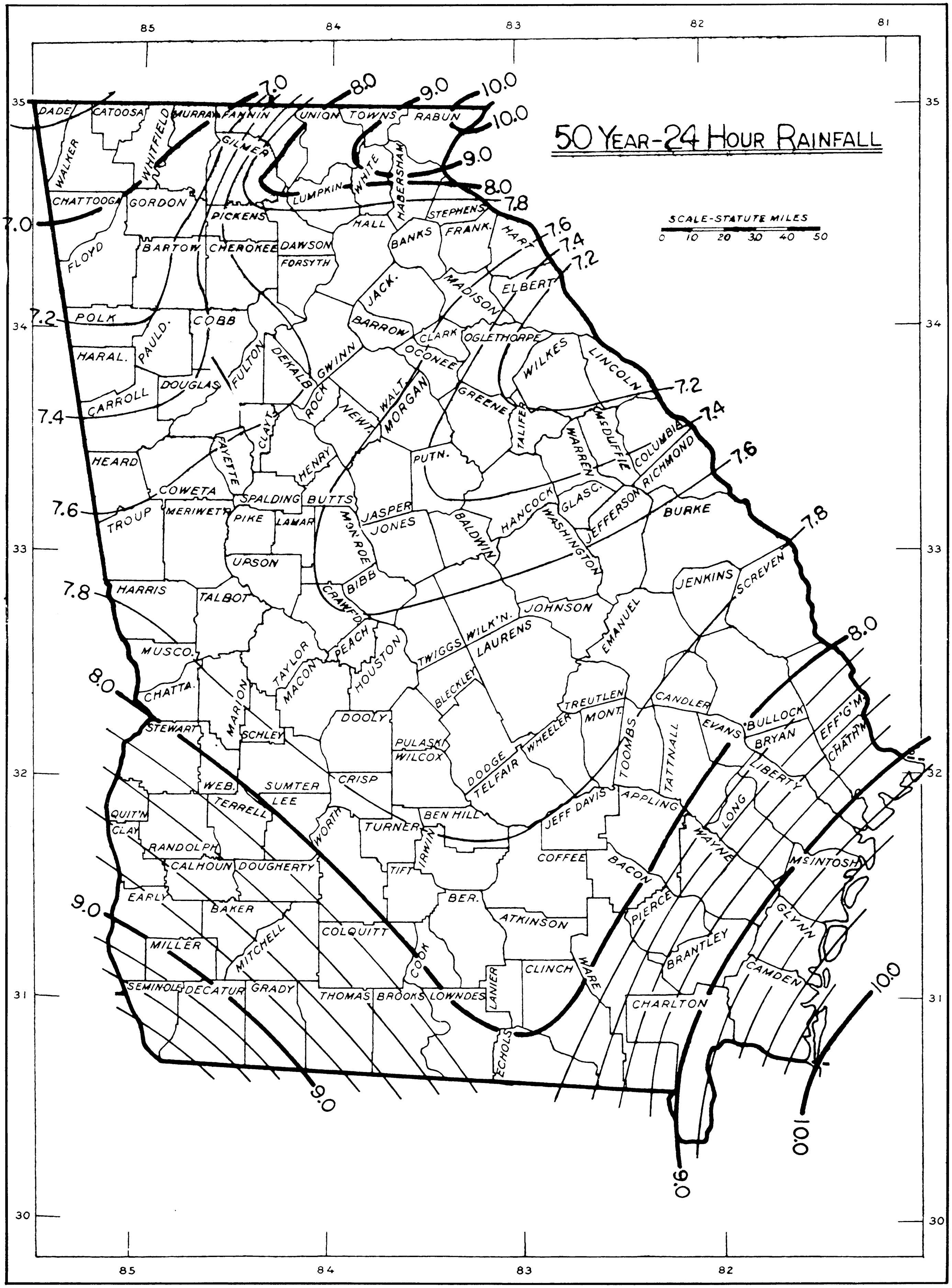


Figure A-2.12 – Total rainfall (P) for 50-year/24-hour storm.

GEORGIA

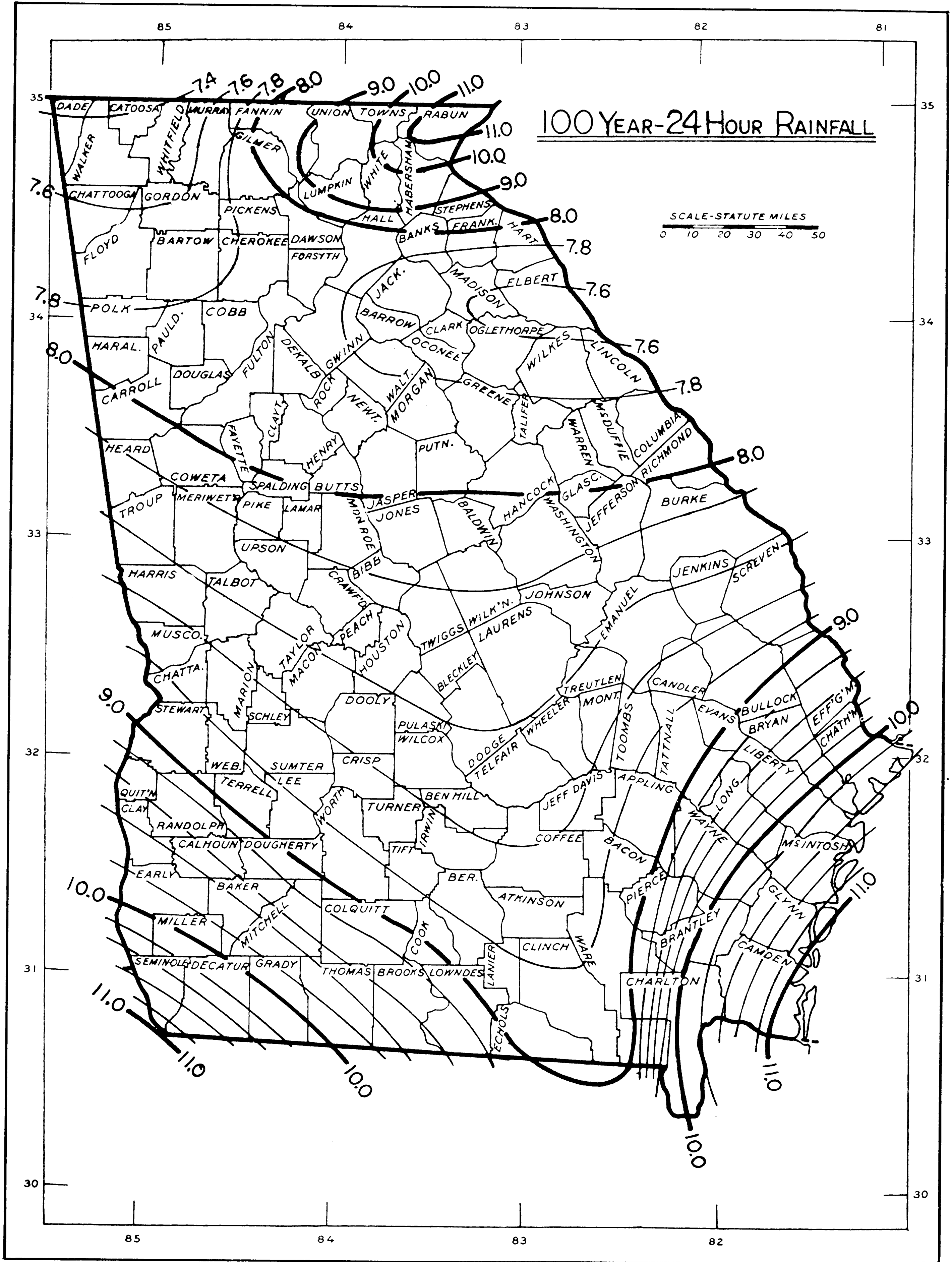


Figure A-2.13 – Total rainfall (P) for 100-year/24-hour storm.

APPENDIX A-3
Rational Method

APPENDIX A-3

PROCEDURAL GUIDE FOR COMPUTING RUN-OFF BY RATIONAL METHOD

The Rational Method is a method for determining run-off in terms of cubic feet per second at the drainage structure. It is based on the direct relationship between rainfall and run-off and may be expressed by the formula:

$$Q = CIA$$

Q = the run-off in cu. ft. per sec. from a given area.

C = a coefficient representing the ratio of run-off to rainfall (related to impervious area) i.e., 1.0 - 100% run-off.

I = the intensity of rainfall in inches per hour for a duration equal to the time of concentration and for a stated frequency.

A = the drainage area in acres.

		SOIL CLASSIFICATION			
SLOPE	LAND USE	SAND OR SANDY LOAM SOILS (Pervious)		HIGH CLAY SOILS (Impervious)	
		Min.	Max.	Min.	Max.
Flat (0% - 3%)	Woodlands	0.15	0.20	0.20	0.25
	Pasture	0.20	0.25	0.25	0.30
	Paved	0.95		0.95	
	Residential	0.35	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Rolling (3% - 7%)	Woodlands	0.15	0.20	0.18	0.25
	Pasture	0.30	0.40	0.35	0.45
	Paved	0.95		0.95	
	Residential	0.50	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Hilly (7% - 11%)	Woodlands	0.20	0.25	0.25	0.30
	Pasture	0.35	0.45	0.45	0.55
	Paved	0.95		0.95	
	Residential	0.50	0.60	0.50	0.60
	Commercial	0.60	0.95	0.60	0.95
Mountainous (11% +)	Woodlands			0.70	0.80
	Bare		0.80	0.80	0.95
Steep Grassed Slopes	Pasture	0.70		0.70	

Table A-3.1

1. Determine "C" by observation in the field of culture and soils and by use of Table A-3.1, p. A-3-1.

2. Determine "I" (intensity rate) from the time of Concentration Figure A-3.1, p. A-3-3 and Rainfall Figures A-3.3 through A-3.7, p. A-3-5 through A-3-9.

NOTE:

a. Height (ft.) is determined in the field or from contour maps. Height is the difference in elevation of the most remote point in the drainage area and the inlet flow line of the structure.

b. Maximum length of travel is determined in the field or from the contour maps. It is the greatest distance the water will travel from the most remote point of the drainage area to the inlet of the drainage structure.

c. Use height and length to determine the time of concentration by use of Figure A-3.1. Use a minimum of 10 minutes for rural and urban areas.

d. Now refer to rainfall figures - Atlanta, Macon, Augusta, Thomasville and Savannah (use figure nearest to project or combination of two figures) and by scaling the time of concentration, which is equal to the rainfall duration, along the bottom of the table and moving up to the selected return period, (10-25-50 yr.), move horizontally to the left and read the intensity "I".

3. Determine the time of concentration using the "Kinematic Wave Nomograph," Figure A-3.2, p. A-3-4. The kinematic wave table incorporates variables, the rainfall intensity and mannings "n." In using the nomograph, the designer has two unknowns starting the computations, the time of concentration and the rainfall density. The problem is attempting to determine a rainfall intensity which, in turn, actually determines the time of concentration. Thus, the problem is one of iteration. A value of "i" must be assumed, compute a time of concentration and then check back to see if the rainfall intensity that was assumed is consistent with the frequency curve of Figures A-3.3 through A-3.7. If one is the given length, slope, roughness coefficient, and intensity-duration-frequency curve the steps are as follows:

a. Assume rainfall intensity.
b. Use kinematic wave nomograph or equation to obtain first estimate of time concentration.
c. Using the time of concentration obtained from Step "b", enter Figures A-3.3 through A-3.7 for appropriate area and find rainfall intensity corresponding to the computed time of concentration. If this rainfall intensity corresponds with the assumed intensity, the problem is solved. If not, proceed to Step "d".
d. Assume a new rainfall intensity that is betwen that assumed in Step "a" and that determined in Step "c."
e. Repeat Steps "a" through "c" until there is good agreement between the assumed rainfall intensity and that obtained from Figures A-3.3 through A-3.7. Experience has shown that a solution can be found on the third iteration with little difficulty.

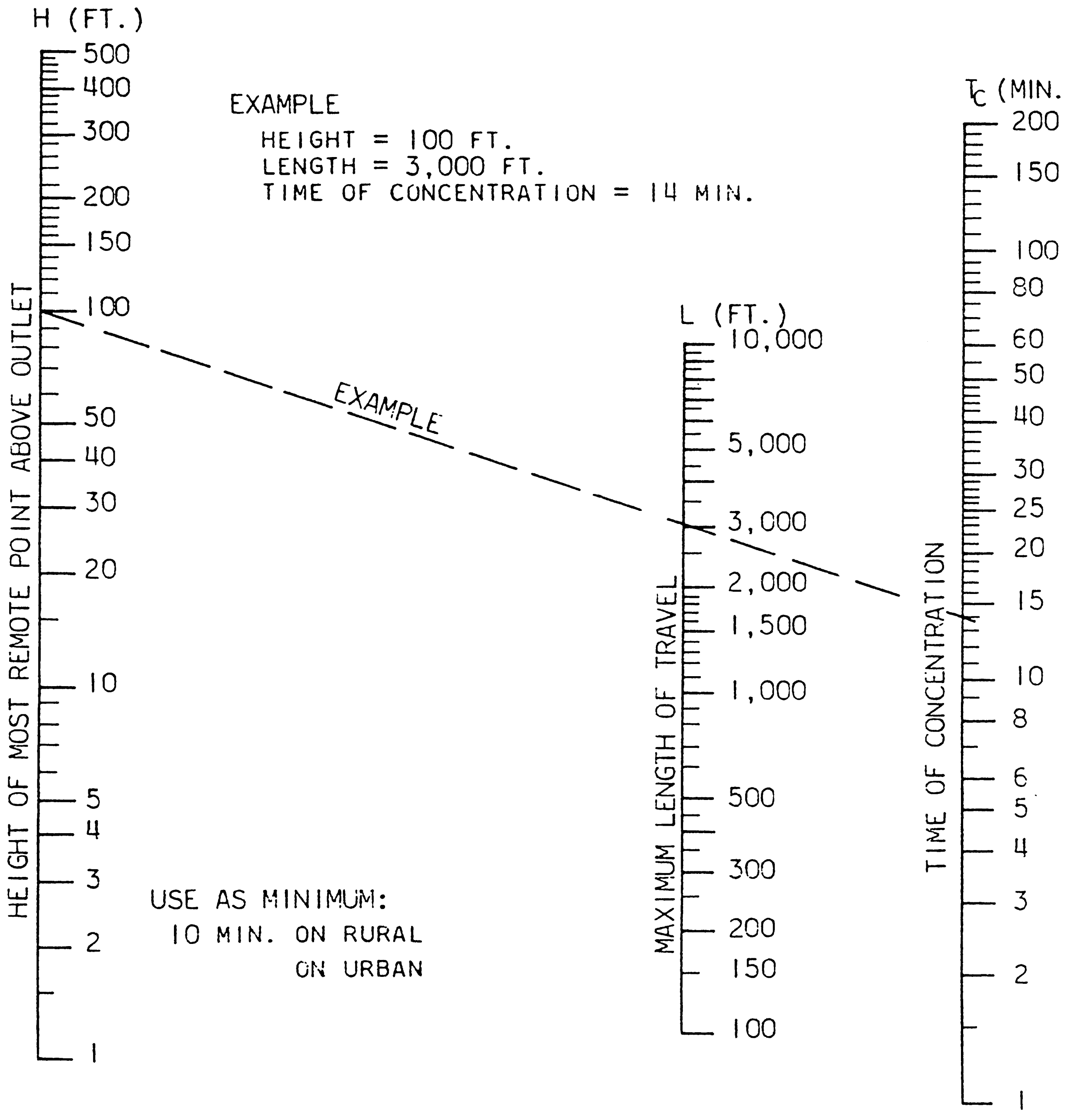
Generally, the time of concentration for overland flow is only a part of the overall design problem. Often one encounters swale flow, confined channel flow, and closed conduit flow-times that must be added as part of the overall time of concentration. When this situation is encountered, it is best to compute the confined flow-times as the first step in the overall determination of the time of concentration. This will give the designer a rough estimate of the time involved for the overland flow which will give a better first start on the rainfall intensity assumption. For example, if the flow time in a channel is 15 minutes and the overland flow time from this ridge line to the channels is 10 minutes, then the total time of concentration is 25 minutes. The channel flow can be determined by length divided by velocity.

4. Determine drainage Area "A" in the field or from contour maps.

5. Multiply the values of C x I x A to determine Q (cu. ft. per sec.).

6. Using "Q" as determined above, solve for size of structure required by use of Culvert Capacity Charts or nomographs.

Table A-3.2, p. A-3-10 may be used for organizing computation.



EXAMPLE
HEIGHT = 100 FT.
LENGTH = 3,000 FT.
TIME OF CONCENTRATION = 14 MIN.

USE AS MINIMUM:
10 MIN. ON RURAL
ON URBAN

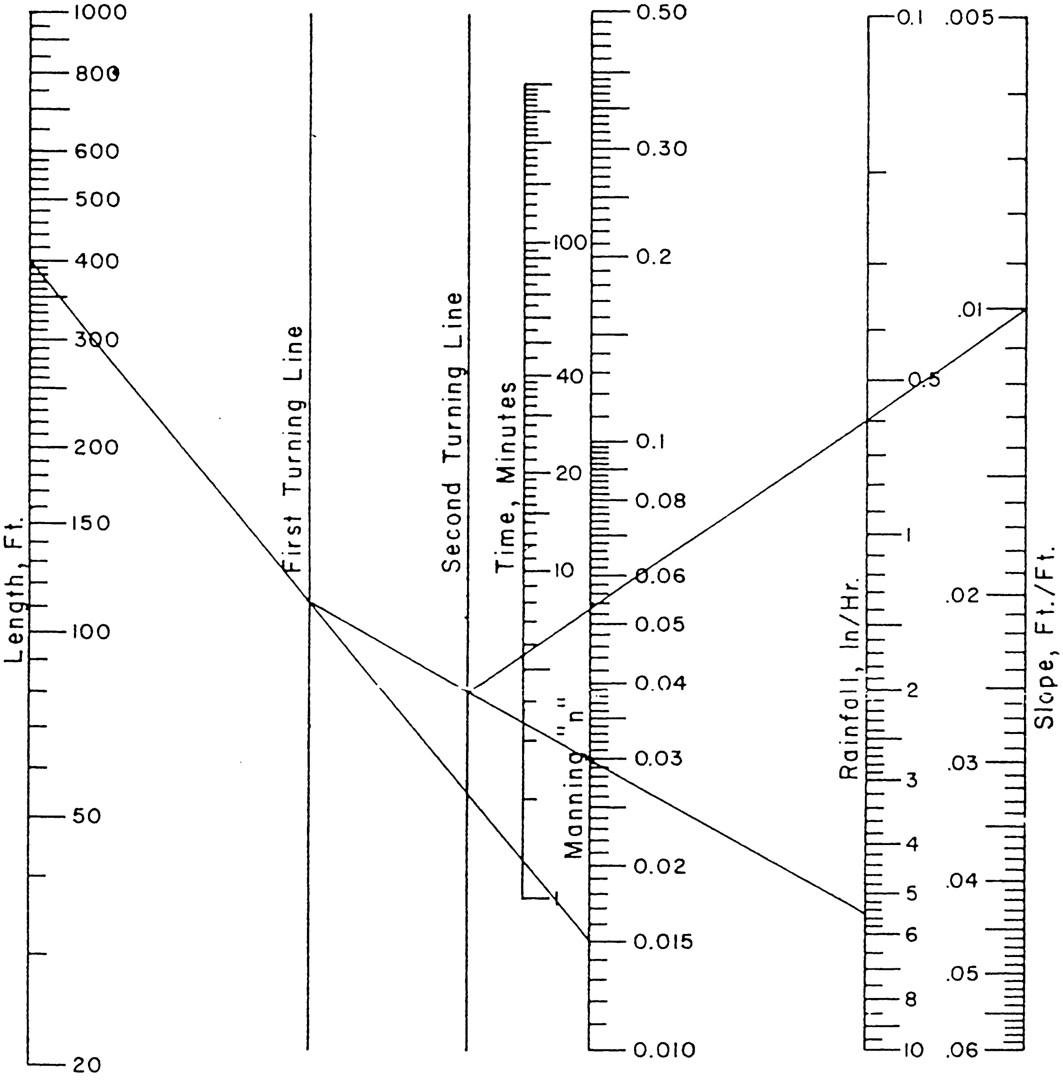
TIME OF CONCENTRATION
OF SMALL DRAINAGE BASINS

Based on study by P. Z. Kirpich,
Civil Engineering, Vol.10, No.6, June 1940, p.362

Figure A-3.1

Equation solved by nomograph:

$$t_c\,(\text{Sec}) = 56\,\frac{L_o^{.6}\,n^{.6}}{i^{.4}\,S_o^{.3}}$$



The initially assumed value of i and the nomograph value of t must be checked against the applicable intensity-duration-frequency curve by trial and error.

Example:

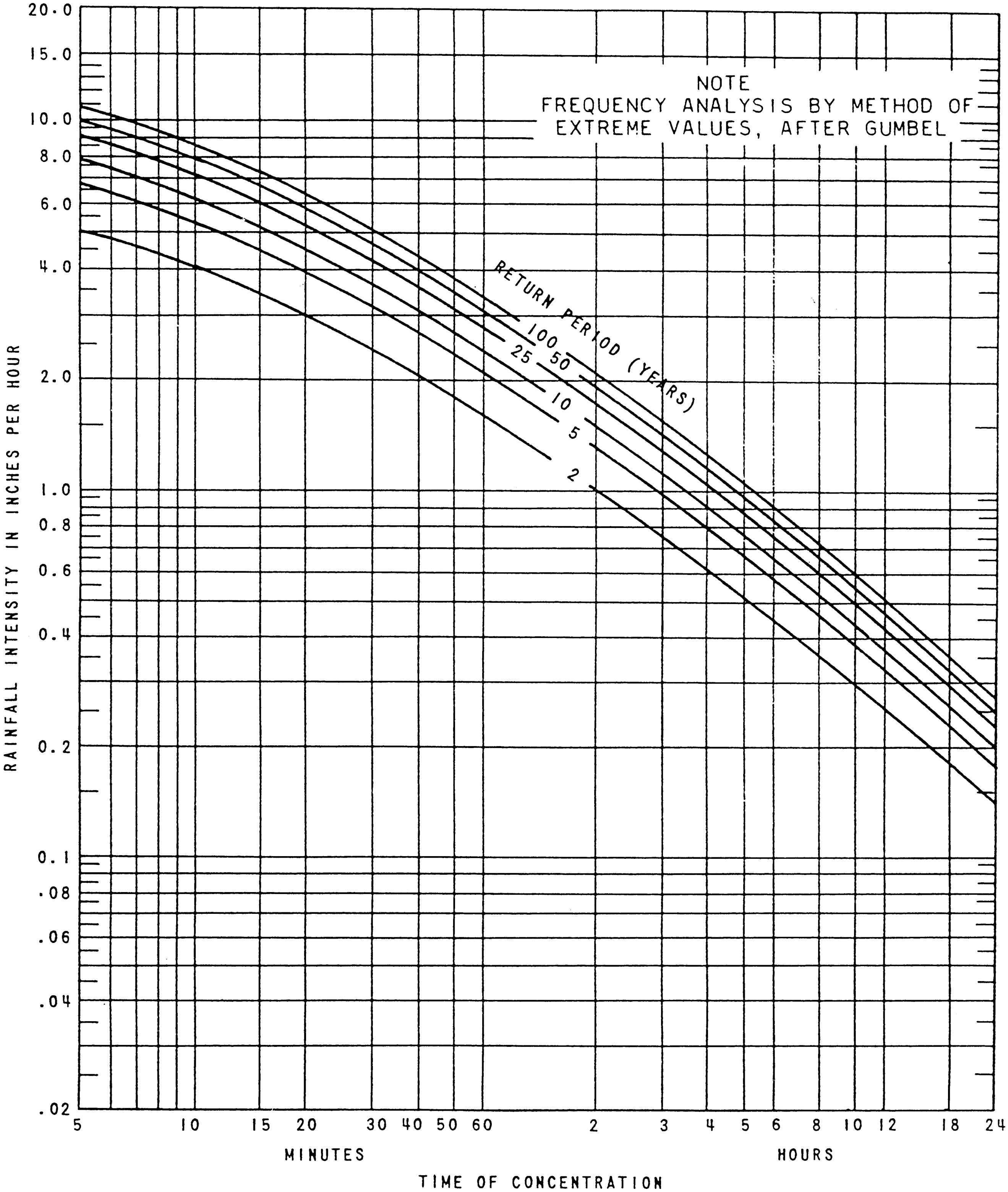
L_o = 400 ft.
n = 0.015
i = 5.5 in./hr.
S_o = 0.01
t = 5.5 min.

ONE INCH is 25.4mm
ONE FOOT is 0.3048m

Nomograph for determining time of concentration for overland flow, Kinematic Wave Formulation. *(After Ragan.)*

Figure A-3.2

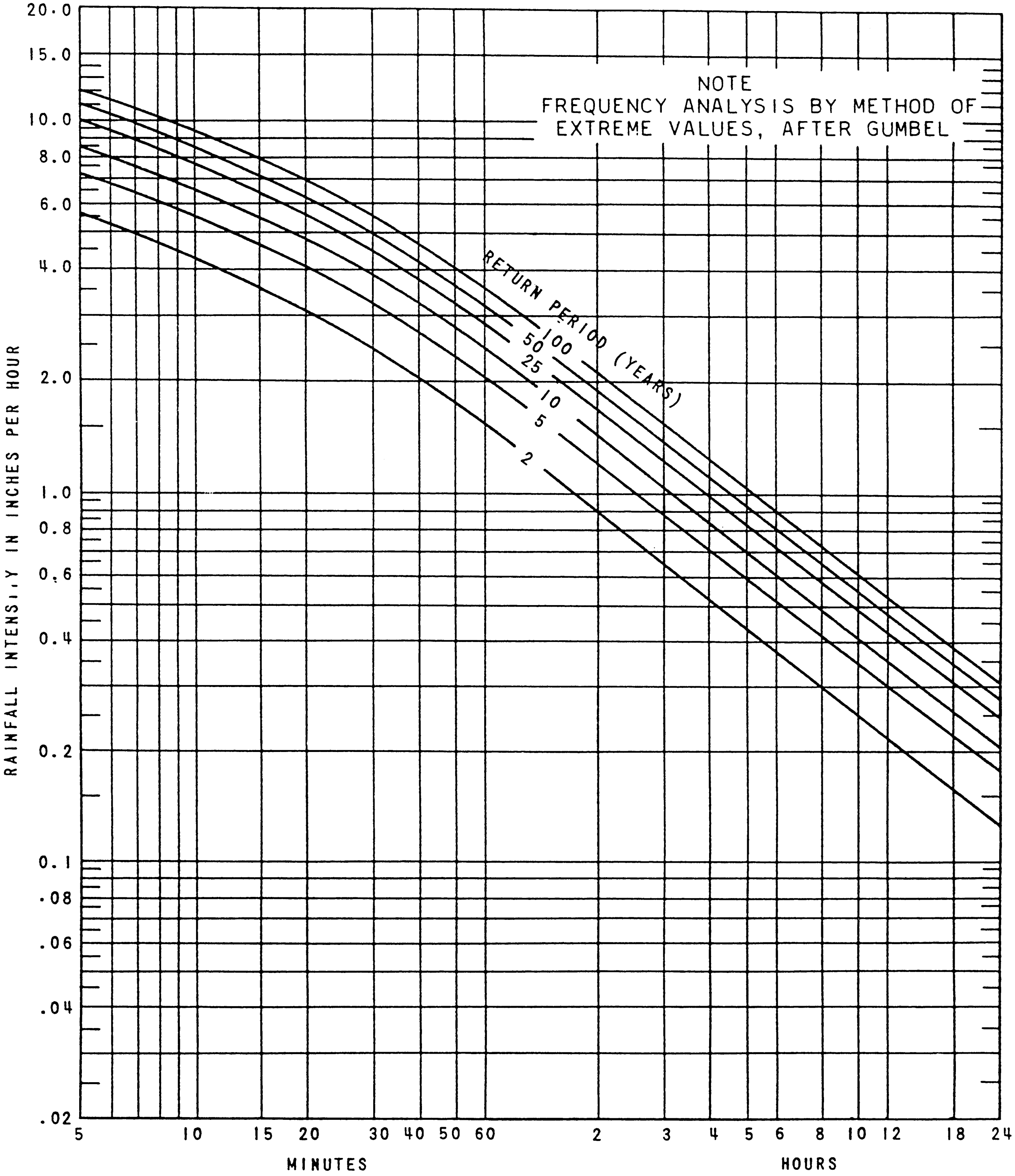
ATLANTA, GEORGIA
1903-1951



WEATHER BUREAU
TECHNICAL PAPER 25

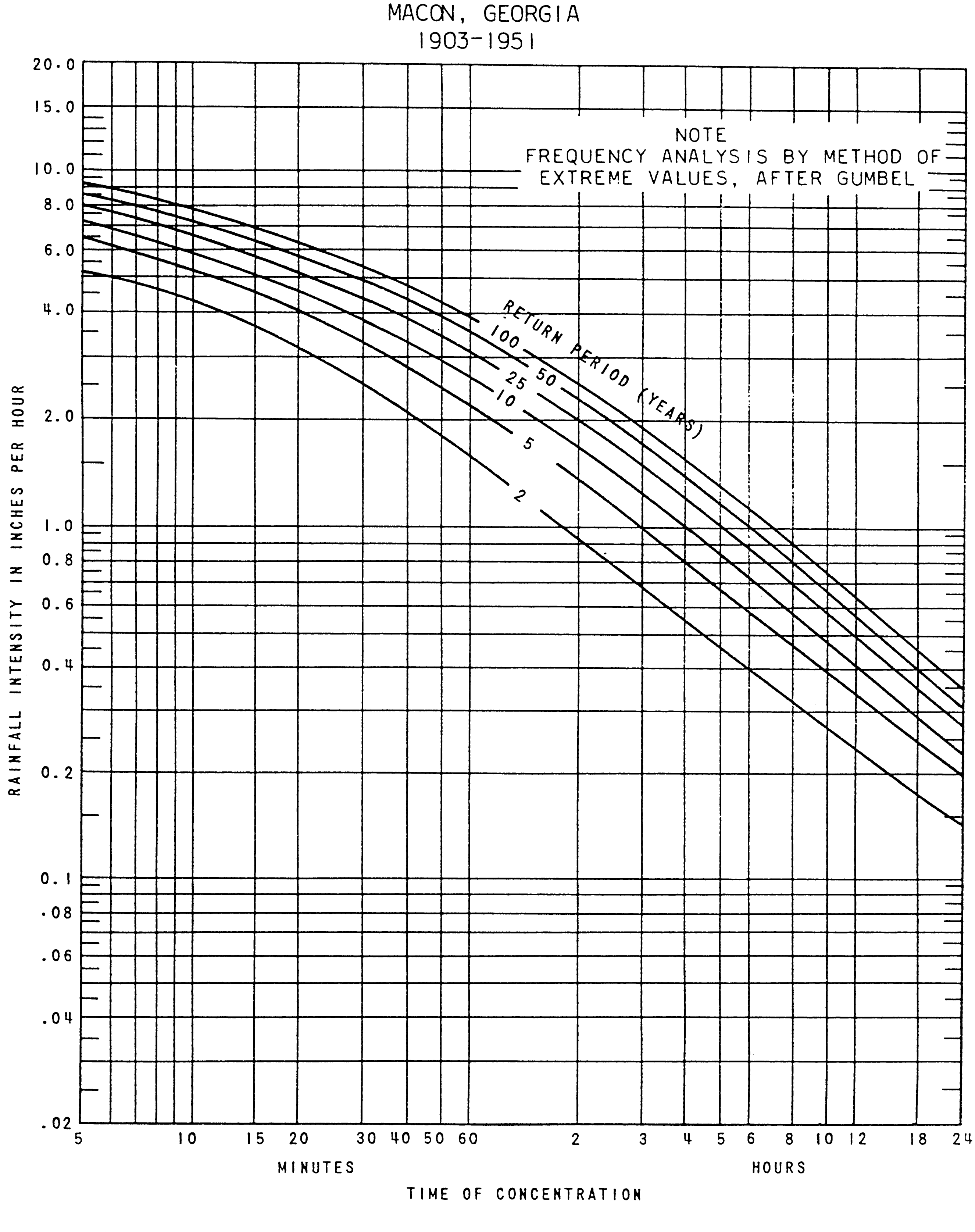
Figure A-3.3

AUGUSTA, GEORGIA
1903-1951



WEATHER BUREAU
TECHNICAL PAPER 25

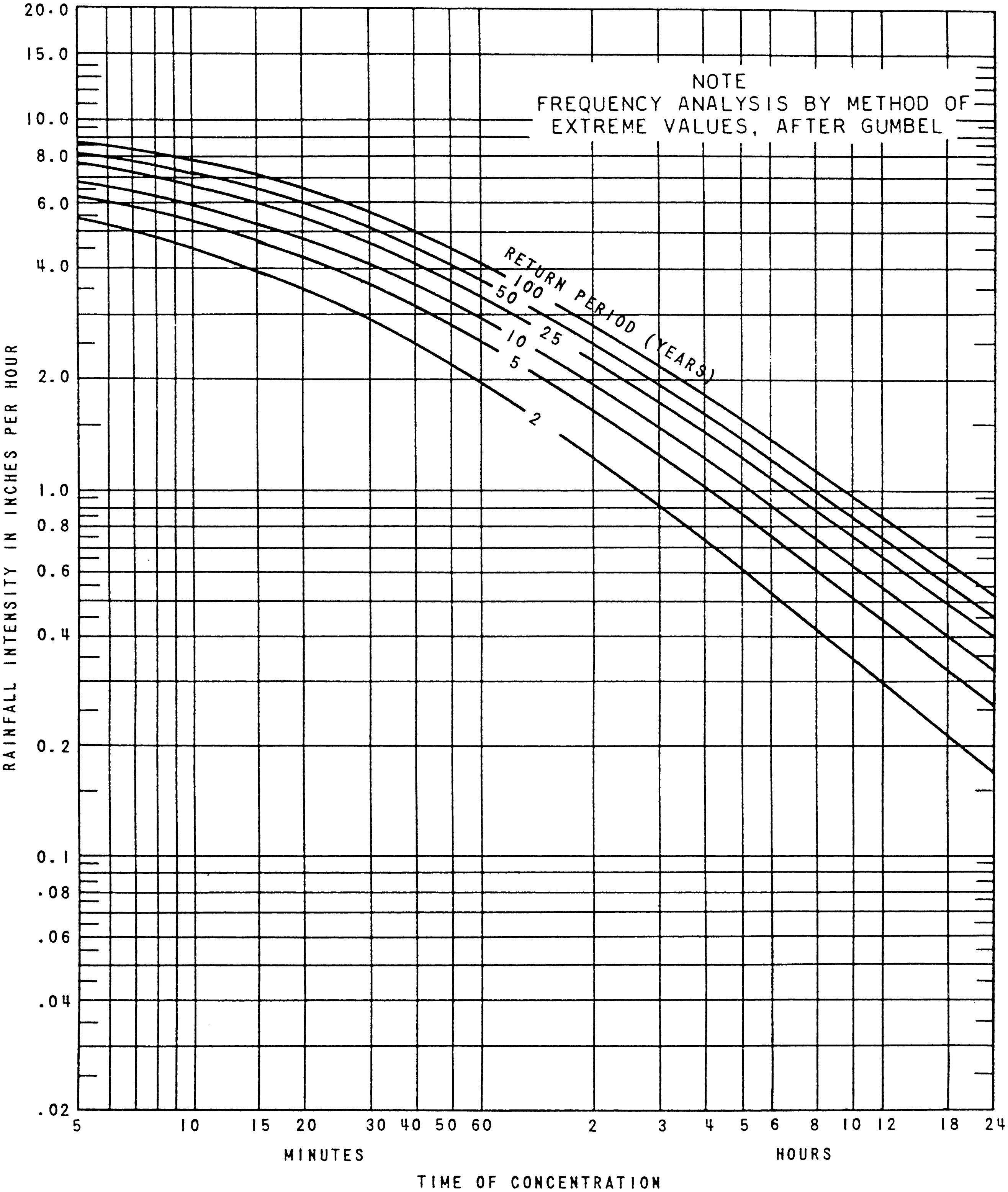
Figure A-3.4



WEATHER BUREAU
TECHNICAL PAPER 25

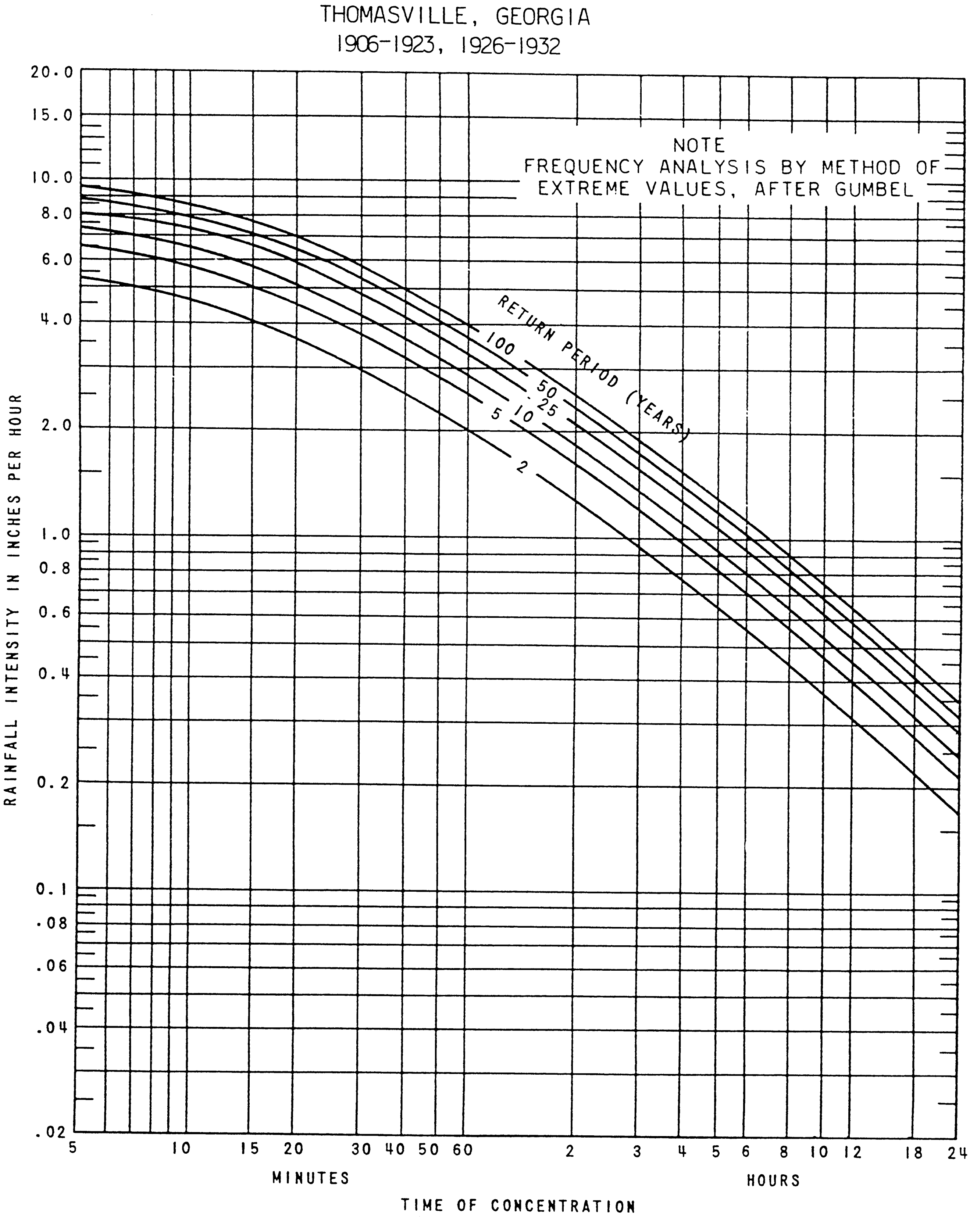
Figure A-3.5

SAVANNAH, GEORGIA
1903-1951



WEATHER BUREAU
TECHNICAL PAPER 25

Figure A-3.6



WEATHER BUREAU
TECHNICAL PAPER 25

Figure A-3.7

DRAINAGE DESIGN COMPUTATIONS

DISCHARGE "Q" COMPUTED BY RATIONAL METHOD

PROJ. NO.________________

DESIGN RETURN PERIOD______YR.

COUNTY________________

DESCRIPTION		HYDROLOGY									HYDRAULICS							
LOCATION	SKEW	DRAINAGE AREA (ACRES)	RUNOFF "C"	LENGTH (FEET)	HEIGHT (FEET)	TIME OF CONC: (MIN)	INTENSITY "I"$_{50}$ IN/HR	INTENSITY "I"$_{100}$ IN/HR	DISCHARGE "Q"$_{50}$ (CFS)	DISCHARGE "Q"$_{100}$ (CFS)	STRUCTURE SLOPE "So" (FT./FT.)	STRUCTURE LENGTH "L" (FT.)	$\frac{L}{100S_o}$	ALLOWABLE HEADWATER "AHW" (FT.)	HEADWATER "HW"$_{50}$	HEADWATER "HW"$_{100}$	SIZE AND TYPE STRUCTURE	REMARKS

Table A-3.2

APPENDIX B-1
Soil Series Interpretations

APPENDIX B-1

SOILS INFORMATION

The soils information in Appendix B has been assembled to assist the plan preparer and reviewer in accomplishing responsibilities under Act 599.

Appendix B-1 contains charts of Georgia's soils series with *estimated* soil properties and soils limitations for urban uses. These charts may be used in conjunction with published soil survey information or other soils maps available through the Soil and Water Conservation Districts and the Natural Resources Conservation Service.

Appendix B-2 contains excerpts from NRCS Technical Release No. 51, "Procedure for Computing Sheet and Rill Erosion on Project Areas." Also included is a method for *estimating* soil erodibility or "K" values and sediment delivery ratio charts. This Appendix should be of assistance in planning for land-disturbing activities.

Explanation of Charts: Appendix B-1 Soil Series Interpretations

Column 1: Soil Series

This column lists alphabetically the name of all the soil series which are used in the State of Georgia.

Column 2: Permeability

Soil permeability is the quality that enables soil to transmit water and air. Accepted as a measure of this quality is the rate at which soil transmits water while saturated. That rate is the "saturated hydraulic conductivity" of soil physics. In line with conventional usage in the engineering profession and traditional usage in the published soil surveys, this rate of flow, principally downward, continues to be expressed as "permeability". The permeability of a soil is the *rate of flow* for the most restrictive layer in the profile.

Soil permeability is rated using the numerical ranges shown below:

Permeability class	Numerical range (inches per hour)
Very slow	Less than 0.06
Slow	0.06-0.2
Moderately slow	0.2-0.6
Moderate	0.6-2.0
Moderately rapid	2.0-6.0
Rapid	6.0-20
Very Rapid	More that 20

Column 3: Soil Reaction

The degree of acidity or alkalinity of a soil is expressed in pH values. A soil with a pH 7.0 is precisely neutral in reaction. The pH ranges given in this column are the high and low values for the soil profile. The surface layer may be higher due to the addition of lime.

Column 4: Shrink-Swell Potential

Shrink-swell behavior is the quality that determines soil's volume change with change in moisture content. Building foundations, roads and other structures may be severely damaged by the shrinking and swelling of the soil. The volume change of soil is influenced by the amount of moisture change and the amount and kind of clay in the soil profile.

The shrink-swell interpretations are relevant to structures, such as houses and other low buildings, streets and roads, and parking lots. Three classes have been developed to express shrink-swell behavior; *low, moderate and high.*

Column 5 and 6: Corrosivity

Various metals and other materials corrode when on or in the soil, and some metals and materials corrode more rapidly when in contact with specific soils than when in contact with others. To be meaningful, corrosivity must be rated in relation to specific structural material. In these columns the soil series are given ratings on potential for inducing corrosion of uncoated steel (column 5) and of concrete (column 6).

Soils are assigned to one of three classes of corrosivity: *low, moderate, or high.*

Columns 7 and 8: Depth to Watertable and Bedrock

The depth to the watertable is given in feet (to the nearest half-foot). The value given is an indication of how close to the soil surface the watertable will rise during the wet season.

Depth to bedrock is given in inches. Hardness of rock may range from "rippable", which can be excavated using a single tooth ripping attachment on a 200-300 horsepower tractor, to "hard", where excavation may require blasting. Rock hardness should be determined by on-site-investigation.

Both the depth to watertable and bedrock are *estimates*—actual depths may vary from site to site.

Column 9: Flood Frequency

Flood frequency is an indicator of how often if ever, floods occur. Ratings are as follows:

None: No reasonable possibility of flooding.

Rare: Flooding unlikely but possible under unusual weather conditions.

Occasional: Flooding is expected infrequently under usual weather conditions.

Frequent: Flooding is likely to occur often under usual weather conditions.

Column 10: Hydrologic Soil Group

The hydrologic soil group parameter, A, B, C, or D, is an indication of the minimum rate of infiltration obtained for a bare soil after prolonged wetting.

The hydrologic soil groups range from A, which are deep sands or gravels with low runoff, to D, which are 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.

Some soil series may have a dual hydrologic soil group rating. The dual ratings are given for certain wet soils that can be adequately drained. The criteria used is making dual group ratings are as follows:

1. Soils are rated D in their natural condition.
2. Drainage is feasible and practical.
3. Drainage improves the hydrologic group by at least two classes (from D to A or B).

Columns 11-16: Limitation of Soils For Urban Uses

The soils are rated L for slight limitations, M for moderate limitations, or S for severe limitations.

A *slight* soil limitation (L) is the rating given soils that have properties favorable for the rated use. The degree of limitation is minor and can be overcome easily. Good performance and low maintenance can be expected.

A *moderate* soil limitation (M) is the rating given soils that have properties moderately favorable for the rated use. This degree of limitation can be overcome or modified by special planning, design, or maintenance. During some part of the year, the performance of the structure or other planned use is somewhat less desirable than for soils rated *slight*. Some soils rated *moderate* required treatment such as artificial drainage, runoff control to reduce erosion, extended sewage absorption fields, extra excavation, or some modification of certain features through manipulation of the soil. For these soils, modification is needed for those construction plans generally used for soils of slight limitation. Modification may include special foundations, extra reinforcement of structures, sump pumps, etc.

A *severe* soil limitation (S) is the rating given soils with one or more properties unfavorable for the rated use, such as steep slopes, bedrock near the surface, flooding hazard, high shrink-swell potential, a seasonal high watertable or low bearing strength. This degree of limitation generally requires major soil reclamation, special design, or intensive maintenance. Some of these soils, however, can be improved by reducing or removing the soil feature that limits use. In most situations, however, it is difficult and costly to alter the soil or to design a structure to compensate for a severe degree of limitation.

Following the limitation rating symbol will be a lower case symbol to indicate the reason for the particular rating. These symbols are s-slope, w-wetness, f-flooding, pk-slow percolation, cl-too clayey, ss-shrink-swell potential, b-low bearing strength, r-shallow depth to rock, p-seepage, st-stones, cc-cutbanks may cave, h-too much humas, pf-poor filter, d-dense layer.

A number followed by a % indicates percent slope; for example 2-6% reads two to six percent slope.

Some soil series may have a flood frequency listing of two rating (Example: None-Occasional). Such soils may consequently have a two rating limitation. For example, a listing of

None: M; w
Occ; S; f

means, if the soil is located where no flooding occurs, it is rated Moderate due to wetness and, if occasional flooding occurs, it is rated as Severe due to flooding.

Column 11: Septic Tank Absorption Fields

A septic tank absorption field is a soil absorption system for sewage disposal. It is a subsurface tile system laid in such a way that effluent from the septic tank is distributed with reasonable uniformity into the natural soil. Criteria used for rating soils *(slight, moderate, and severe)* for use as absorption fields are based on the limitations of the soil to absorb effluent.

Column 12: Sewage Lagoon Areas

A sewage lagoon (aerobic) is a shallow lake used to hold sewage for the time required for bacterial decomposition. Sewage lagoons require consideration of the soils for two functions, (1) as a vessel for the impounded area and (2) as soil material for the enclosing embankment. The requirements for this embankment are the same as for other embankments designed to impound water. Enough soil material that is suitable for the structure must be available, and, when the lagoon is properly constructed, it must be capable of holding water with minimum seepage. The material should be free of coarse fragments (over 10 inches in diameter) that interfere with compaction.

Column 13: Shallow Excavations

These excavations require excavating or trenching to a depth of 5 or 6 feet. Note that limitation ratings for shallow excavations alone, though highly relevant, are insufficient for interpretations for ultimate uses, such as for dwellings with basements, sanitary landfills, cemeteries, and underground utility lines (sewers, pipelines, and cables). Additional soil features must be considered in evaluating for those uses. For example, additional interpretation concerning shrink-swell potential and corrosivity are needed for giving ratings for the ultimate use of soils for pipelines.

Column 14: Dwellings

This column gives ratings for undisturbed soils on which single-family dwellings or other structures with similar foundation requirements can be built. Buildings of more than three stories and other buildings requiring a foundation load in excess of that of a three-story dwelling are not considered in the entries in this column.

In some cases, a rating may differ depending on whether the dwelling will or will not have a basement. In such cases, the rating is marked with an asterisk (*) for dwellings *with* basements and a pound sign (#) for ones *without* basements.

Column 15: Small Commercial Buildings

This column provides limitations for commercial buildings of 3 stories or less.

Column 16: Local Roads and Streets

The limitation ratings given in this column apply to use of soils for construction and maintenance of improved local roads and streets that have all-weather surfacing—commonly asphalt or concrete—and that are expected to carry automobile traffic all year. The roads and streets consist of (1) underlying local soil material, whether cut or fill, that is called "the subgrade"; (2) the base material of gravel, crushed rock, lime-stabilized soil, or soil-cement-stabilized soils; and (3) the actual road surface or street pavement that is either flexible (asphalt), rigid (concrete), or, in some rural areas, gravel with binder in it. These roads and streets also are graded to shed water and conventional drainage measures are provided. With probable exception of the hard surfaces, the roads and streets are built mainly from the soil at hand; cuts and fills generally are limited to less than 6 feet of thickness. Excluded from consideration in the ratings in this column are highways designed for fast moving heavy trucks.

Also, the ratings cannot substitute for basic soil data and for on site investigation.

KEY TO SYMBOLS— SOIL SURVEY INTERPRETATIONS

Limitations of Soils:
L - Slight Limitation
M - Moderate Limitation
S - Severe Limitation

Reasons for Limitations:
s - slope
w - wetness
f - flooding
pk - slow percolation
cl - too clayey
ss - shrink-swell potential
b - low bearing strength
r - depth to rock
p - seepage
st - stones
cc - cutbank may cave
pf - poor filter
h - too much humus
d - dense layer

Appendix B-2
Soil Loss Predictions

The first portion of Appendix B-2 is the SCS Technical Release No. 51, "Procedure for Computing Sheet and Rill Erosion on Project Areas." It explains the use of the Universal Soil-Loss Equation.

Also included in Appendix B-2 is a guide for developing the Soil Erodibility Factor (K).

Another section is devoted to applying sediment delivery ratio charts to the Universal Soil-Loss Equation for estimating sediment yields.

Additional information includes a textural classification chart and a chart for comparing different soil classification systems.

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
AILEY	0.06-0.2	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	0-15%:S;pk 15+%:S;S,pk	0-7%:S;p 7+%:S;s,cc	0-15%:S;cc 15+%:S;s,cc	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
ALAPAHA	0.2-0.6	4.5-5.5	Low	High	High	0-1.0	>60	None Rare Occ	D	None, Rare:S;w,pk Occ:S,w,f,pk	None,Rare:S;w,p Occ:S;w,f,p	S;w,cc	None:Sw Rare,Occ:S;w,f	None:S;w Rare:Occ:S;w,f	None,Rare:S;w Occ:S;w,f
ALBANY	0.6-2.0	4.5-6.0	Low	High	High	1.0-2.5	>60	None Rare Occ	C	None, Rare:S;w Occ:S;w,f	None,Rare:S;w Occ:S;w,f	S;w,cc	None:S;w Rare,Occ:S;w,f	None:S;w Rare:Occ:S;w,f	None,M;w Rare;M;w,f Occ:S;f
ALBERTVILLE	0.2-0.6	4.5-5.5	Mod.	Mod.	High	>6.0	40-60	None	C	2-15%:S;pk 15+%:S,s,pk	2-7%:M;s,r 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:M;ss 8-15%:M;ss,s 15+%:S;s	2-4%:M;ss 4-8%:M;s,ss 8+%:S;s	2-15%:S;b 15+%:S;s,b
ALCOVY	0.6-0.2	4.5-5.5	Low	Low	High	2.0-3.0	>60	None	B	S;w,pk	S;w	2-8%:M;w 8+%:M;w,s	2-8%:M;w 8+%:M;w,s	2-4%:M;w 4-8%:M;w,s 8+%:S;s	2-8%:M;w 8+%:M;s
ALLEN	0.6-2.0	4.5-5.5	Low	Low	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;s 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;s,b 15+%:S;s
ALTAVISTA	0.6-2.0	3.6-6.0	Low	Mod.	Mod.	1.5-2.5	>60	None Rare Occ Freq	C	None, Rare:S;w Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq: S;w,f	S;w	None:M;w# None:S;w* Rare,Occ,Freq: S;w,f	None:M;w Rare,Occ,Freq: S; f	None:M;w,b Rare:M;w,f,b Occ,Freq:S;f
AMERICUS	2.0-6.0	4.5-5.5	Low	Low	High	>6.0	>60	None	A	0.8%:L 8-15%:M;s 15+%:S;s	0-15%:S;p 15+%:S;s,0	0-15%:S;cc 15+%:S;s,cc	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
ANGELINA	0.06-0.2	4.5-5.5	Low	High	High	+2-0	>60	Occ Freq	D	S;f,pk,w	S;f,w	S;w	S;f	S;f	S;f
ANGIE	0.06-0.2	3.6-5.5	High	High	Mod.	3.0-5.0	>60	None	D	S;pk,w	0-7%:S;w 7+%:S;s,w	0-8%:M;cl,w 8-12%:M;s,cl	S;ss	0-8%:S;ss 8+%:S;s,ss	S;b,ss
APISON	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	20-40	None	B	S;r	2-7%:S;r 7+%:S;s,r	2-8%:M;r 8-15%:M;s,r	2-8%:L# 2-8%:M;r* 8-12%:M;s	2-4%:L 4-8%:M:s 8+%:S;s	2-8%:M;b 8-15%:M;s,b
APPLING	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	0-8%:M;pk 8-15%:M,s,pk	0-2%:M;p 2-7%:M;s,p 7+%:S;s	0-8%:M;cl 8-15%:M;s,cl	0-8%:L 8-15%:M;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:M;b 8-15%:M;s,b
ARAGON	0.06-0.2	3.6-5.5	Mod.	High	High	>6.0	>60	None	C	2-15%:S;pk 15+%:S;s,pk	2-7%:M;s 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:M;ss 8-15%:M;s,ss 15+%:S;s	2-4%:M;b 4-8%:M;s,ss 8+%:S;s	2-15%:M;ss 15+%:S;b,s
ARKAQUA	0.6-2.0	5.1-6.0	Low	High	Mod.	1.5-2.0	>60	Freq	C	S;f,w	S;f,w	S;w	S;f# S;f,w*	S;f	S;b,f
ARDILLA	0.2-0.6	4.5-6.0	Low	High	High	1.0-2.0	>60	None	C	S;w,pk	S;w	S;w	S;w	S;w	M;w
ARMUCHEE	0.2-0.6	4.5-5.5	Mod.	Mod.	Mod.	>6.0	20-36	None	C	5-15%:S;r 15+%:S;r	5-7%:S;r 7+%:S;s,r	5-8%:M;r,cl 8-15%:M;r,cl,s 15+%:S;s	5-8%:M;ss#,r* 8-15%:M;ss,s#,r* 15+%:S;s	5-8%:M;ss,s 8+%:S;s	5-15%:S;b 15%:S;b,s
ARUNDEL	>0.06	3.6-5.5	High	High	High	>6.0	20-40	None	C	2-15%:S;r,pk 15+%:S;r,pk,s	2-7%:S;r 7+%:S;r,s	2-8%:M;r,cl 8-15%:M;r,cl,s 15+%:S;s	2-15%:S;ss 15+%:S;ss,s	2-8%:S;ss 8+%:S;ss,s	2-15%:S;ss,b 15+%:S;ss,b,s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
ASHE	2.0-6.0	4.5-6.0	Low	Low	High	>6.0	20-40	None	B	2-15%:S;r 15+%:S;s,r	2-7%:S;r,p 7+%:S;r,s,p	2-8%:M;r 8-15%:M;r,s 15+%:S;s	2-8%:M;r # 8-15%:M;r,s # 2-15%:S;r* 15+%:S;s# r*	2-4%:M;r 4-8%:M;r,s 8+%:S;s	2-8%:M;r 8-15%:M;s,r 15+%:S;s
ASHLAR	2.0-6.0	4.5-5.5	Low	Low	High	>6.0	20-40	None	B	0-15%:S;r 15+%:S;s	0-7%:S;r,p 7+%:S;s,r,p	0-15%:S;r 15+%:S;s,r	0-15%:S;r* 0-15%:M;s,r# 15+%:S;s	0-4%:M;r 4-8%:M;r,s 8+%:S;s	0-8%:M;r 8-15%:M;s,r 15+%:S;s
AUGUSTA	0.6-2.0	4.5-6.0	Low	High	Mod.	1.0-2.0	>60	None Rare Occ Freq	C	None,Rare:S:w Occ,Freq:S;W,f	None,Rare:S;w Occ,Freq:S;w,f	S;w	None:S;w Rare,Occ,Freq:S; w,f	None:S;w Rare,Occ,Freq:S; w,f	None:M;w,b Rare:M;w,b,f Occ,Freq:S;f
BARFIELD	0.2-0.6	6.1-7.8	High	High	Low	>6.0	8-20	None	D	1-15%:S;r 15+%:S;r,s	1-7%:S;r 7+%:S;s,r,	1-15%:S;r 15+%:S;r,s	1-15%:S;r,ss 15+%:S;r,ss,s	1-8%:S;ss,r 8+%:S;ss,r,s	1-15%:S;r,b 15+%:S;r,b,s
BAYBORO	0.06-0.2	3.6-5.5	Mod.	High	High	0-0.5	>60	Occ Freq	D	S;w,pk,f	S;w,f	S;w	S;w,f	S;w,f	S;w,b,f
BIBB	0.6-2.0	4.5-5.5	Low	High	Mod.	0.5-1.5	>60	Occ Freq	C	S;f,w	S;f,w,p	S;f,w	S;w,cc	S;f,w	S;f,w
BIGBEE	6.0-20	4.5-6.0	Low	Low	Mod.	3.5-6.0	>60	Rare Occ Freq	A	Rare:S;w,pf Occ,Freq;S;f,w,pf	Rare:S;p Occ,Freq:S;p,f	S;cc	S;f	S;f	Rare:M;f Occ,Freq:S;f
BINNSVILLE	0.06-0.2	7.4-8.4	Mod.	Mod.	Low	>6.0	7-20	None	D	1-15%:S,r 15+%:S,r,s	1-7%:S:r 7+%:S;r,s	1-15%:S;r 15+%:S;r,s	1-8%:Mod;ss,r# 8-15%:Mod:ss,r,s# 1-15%:S;r* 15+%:S;S#r*	1-4%:M;ss,r 4-8%:M;ss,r,s 8+%:S;s	1-15%:S;b 15+%:S;b,s
BLADEN	0.06-0.2	3.6-5.5	Mod.	High	High	0-1.0	>60	Occ Freq	D	S;w,f	L	S;w	S;w,f	S;w,f	S;w,f,b
BLANTON	0.6-2.0	4.5-6.0	Low	High	High	4.0-6.0	>60	None	A	0-8%:M;w 8-15%:M;w,s 15+%:S;s	0-7%:S;p 7+%:S;p,s	0-15%:S;cc 15+%:S;s,cc	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8-12%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
BODINE	2.0-6.0	3.6-5.5	Low	Low	High	>6.0	>60	None	B	5-8%:M;st 8-15%:M;s,st 15+%:S;s	S;p,s	5-8%:M;st 8-15%:M;s,st 15+%:S;s	5-8%:M;st 8-15%:M;s,st 15+%:S;s	8%:M;st 8+%:S;s	5-8%:M;st 8-15%:M;s,st 15+%:S;s
BOHICKET	<0.06	6.1-8.4	High	High	High	+3-0	>60	Freq	D	S;f,pk	S;f	S;f	S;f,ss	S;f,ss	S;f,ss,b
BONIFAY	0.2-0.6	4.5-6.5	Low	Low	High	4.0-5.0	>60	None	A	0-8%:M;w,pk 8-12%:M;w,pk,s	0-7%:S;p 7+%:S;p,s	S;cc	0-8%:L# 0-8%:M;w* 8-12%:M;s#,w*	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-12%:M;s
BONNEAU	0.6-2.0	4.5-5.5	Low	Low	High	3.5-5.0	>60	None	A	S;w	0-7%:S;p 7+%:S;p,s	S;cc	0-8%:L# 0-8%:M;w* 8-12%:M;s#,w*	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-12%:M;s
BOSWELL	<0.06	4.5-5.5	High	High	Mod.	>6.0	>60	None	D	S;pk	1-2%:L 2-7%:M;s 7+%:S;s	1-8%:M;cl 8-15%:M;cl,s 15+%:S;s	1-15%:S;ss 15+%:S;s,ss	1-8%:S;ss 8+%:S;s,ss	1-15%:S;ss,b 15+%:S;s,ss,b
BRADDOCK	0.6-2.0	3.6-5.5	Mod.	High	Mod.	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;pk,s 15+%:S;s	0-7%:S;p 7+%:S;s,p	0-8%:M;cl 8-15%:M;cl,s 15+%:S;s	0-8%:M;ss 8-15%:M;ss,s 15+%:S;s	0-4%:M;ss 4-8%:M;ss,s 8+%:S;s	0-15%:S;b 15+%:S;s,b
BRADSON	0.6-2.0	4.5-6.0	Low	High	Mod.	>6.0	>60	None	B	2-8%:L 8-15%:M;s 15+%:S;s	2-7%:M;s 7+%:s;s	1-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 8+%:S;s	2-4%:L 4-8%:M;s	2-15%:S;b 15+%:S;b,s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
BRASSTOWN	0.6-2.0	4.5-6.0	Low	Mod.	High	>6.0	40-60	None	B	2-8%:M;r,pk 8-15%:M;r,pk,s 15+%:S;s	2-7%:M;r,s 7+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;b,s 15+%:S;s
BREVARD	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	2-8%:L 8-15%:M;s 15+%:S;s	2-7%:M;p,s 7+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
BROOKMAN	0.06-0.2	4.5-7.8	Mod.	Mod.	Mod.	0-1.0	>60	None Rare Occ Freq	D	None, Rare:S;w,pk Occ,Freq:S;f,w,pk	L	S;w	None:S;w Rare,Occ,Freq:S; f,w	None:S;w Rare,Occ,Freq:S; f,w	None,Rare:S;b,w Occ,Freq:S;f,w,b
BUNCOMBE	6.0-20	4.5-6.0	Low	Low	Mod.	>6.0	>60	Rare Occ Freq	A	Rare:S;pf Occ,Freq:S;f,pf	S;p,f	S;cc	S;f	S;f	Rare:M;f Occ,Freq:S;f
BURTON	0.6-6.0	3.6-6.0	Low	High	High	>6.0	20-40	None	B	5-%:S;r 15+%:S;r,s	5-7%:S;p,r 7+%:S;p,r,s	5-15%:S;r 15+%:S;r,s	5-15%:M;r# 5-15%:S;r* 15+%:S;s#,r*	5-8%:M;s,r 8+%:S;s	5-8%:M;r 8-15%:M;s,r 15+%:S;s
CAHABA	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None Rare Occ	B	None:L Rare:M;f Occ:S;f	None,Rare:S;P Occ:S;p,f	S;cc	None:L Rare,Occ:S;f	None:L Rare:Occ:S;f	None:L Rare:M;f Occ:S,f
CAINHOY	<0.06	6.6-8.4	High	High	High	+1-1.0	>60	Freq	A	S;pf	0-7%:S;p 7+%:S;p,s	S;cc	0-8%:L 8-10%:M;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-10%:M;s
CAPE FEAR	0.06-0.2	4.5-6.0	Mod.	High	High	0-1.5	>60	None Rare	D	S;w,pk	None:S;p,w Rare:S;p,w,f	S;w	None:S;w Rare:S;w,f	None:S;w Rare:S;w,f	S;b,w
CAPERS	<0.06	6.6-8.4	High	High	High	+1-1.0	>60	Freq	D	S;w,f,pk	S;f,w	S;f,w	S;f,w,ss	S;f,w,ss	S; f,b,w
CAPSHAW	0.06-0.2	5.1-7.8	Mod.	High	Mod.	3.5-5.0	48>60	None	C	S;pk	0-2%:M;r 2-7%:M;s,r 7+%:S;s	M;r,w,cl	0-8%:M;ss# 8-12%:M;ss,s# M;ss,w*r	0-4%:M;ss 4-8%:M;s,ss 8+%:S;s	S;b
CARNEGIE	0.2-0.6	4.5-5.5	Low	Low	Mod.	>6.0	>60	None	C	S;pk	2-7%:M;s 7+%:S;s	2-8%:M;cl,d 8-12%:M;s,cl,d	2-8%:M;s 8-12%:M;s	2-8%:M;s 8-12%:S;s	0-8%:M;b 8-12%:M;s,b
CARTECAY	2.0-6.0	5.1-6.5	Low	Low	Mod.	0.5-1.5	>60	Occ Freq	C	S;w,f	S;w,p,f	S;w,cc	S;f,w	S;f,w	S;f,w
CATASKA	2.0-20	4.5-5.5	Low	Low	Mod.	>6.0	20-40	None	D	10-15%:S;r 15+%:S;r,s	S;p,r,s	10-15%:S;r 15+%:S;r,s	10-15%:M;s,r# 10-15%:S;r* 15+%:S;s#r*	S;s	10-15%:M;r,s 15+%:S;s
CECIL	0.6-0.2	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;pk,s 15+%:S;s	0-2%:M;p 2-7%:M;p,s 7+%:S;s	0.8%:M;cl 8-15%:M;cl,s 15+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-18%:M;s 8+%:S;s	0-8%:M;b 0-15%:M;b,s 15+%:S;s
CEDARBLUFF	0.06-0.2	5.1-6.0	Mod.	High	Mod.	0.5-1.0	>60	Freq	C	S;f,pk,w	L	S;w	S;f,w	S;f,w	S;f,w,b
CENTENARY	2.0-0.6	4.5-6.0	Low	Mod.	High	3.5-5.0	>60	None	A	S;w,p,f	S;p	S;cc	M;w* L#	L	L
CHANDLER	2.0-0.6	4.5-6.0	Low	Low	High	>6.0	>60	None	B	S;s	S;s	S;s	S;s	S;s	S;s,b

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
CHASTAIN	0.06-0.2	4.5-6.0	Mod.	High	High	0-1.0	>60	Occ Freq	D	S;f,w,pk	S;f,p	S;w,cc	S;f,w	S;f,w	S;f,w,b
CHATUGE	0.6-2.0	4.5-6.0	Mod.	High	High	1.0-2.0	>60	Occ	D	S;w,f	S;w,f,p	S;w,f	S;w,f	S;w,f	S;w,f,
CHENNEBY	0.6-2.0	4.5-6.0	Low	High	Mod.	1.0-2.5	>60	Occ Freq	C	S;f,w	S;p,f,w	S;w	S;f,w	S;f,w	S;b,f
CHESTATEE	0.6-2.0	4.5-5.5	Low	High	High	>6.0	>60	None	B	2-8%:M;st 8-10%:M;s,st 15+%:S;s	2-7%:M;s 7+%:S;s	2-8%:M;st 8-15%:M;s,st 15+%:S;s	2-8%:M;st 8-15%:M;s,st 15+%:S;s	2-4%:M;st 4+%:S;s	2-8%:M;st 8-15%:M;s,st,b 15+%:S;s
CHEWACLA	0.6-2.0	4.5-7.8	Low	High	Mod.	0.5-1.5	>60	Rare Occ Freq	C	Rare:S;s Occ,Freq:S;f,w	Rare:S;w Occ,Freq:S;f,w	S;w	S;w,f	S;w,f	Rare:S;w,b Occ,Freq:S;w,f,b
CHIPLEY	6.0-2.0	4.5-6.0	Low	Low	High	2.0-3.0	>60	None	C	S;w,pf	S;p,w	S;cc,w	M;w# S;w*	0-4%:M;w 4-8%:M;s,w	M;w
CHIPOLA	2.0-6.0	4.5-5.5	Low	Low	High	>6.0	>60	None	A	L	0-7%:S;p 7+%:S;p,s	S;cc	L	0-4%:L 4-8%:M;s	L
CHISOLM	0.6-2.0	4.5-6.0	Low	Low	High	3.0-5.0	>60	None	A	0-8%:M;w 8-10%:M;w,s	0-7%:S;p,w 7+%:S;p,w,s	S;cc	0-8%:L# 0-8%:M;w* 8-10%:M;s#,w*	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-10%:M;s
CLARENDON	0.2-2.0	4.5-5.5	Low	Mod.	High	2.0-3.0	>60	None	C	S;pk,w	S;w	S;w	M;w# S;w*	M;w	M;w
CLIFTON	0.6-2.0	4.5-6.5	Low	Low	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;pk,s 15+%:S;s	2-7%:S;p 7+%:S;p,s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-15%:S;b 15+%:S;b,s
COLFAX	0.06-0.2	4.5-5.5	Mod.	High	High	0.5-1.5	>60	None	C	S;pk,w	0-7%:S;w 7+%:S;w,s	S;w	S;w	0-4%:S;w 4+%:S;s	M;w
COLVARD	2.0-6.0	5.1-7.8	Low	Low	Mod.	4.0-6.0	>60	Occ	B	S;f	S;p,f	S;cc	S;f	S;f	S;f
CONASAUGA	0.06-0.2	3.6-6.5	Mod.	High	High	>6.0	20-40	None	C	0-15%:S;pk,r 15+%:S;s,pk	0-7%:S;r,s 7+%:S;s,r	0-8%:M;r,cl 8-15%:M;s,r,cl 15+%:S;s	0-8%:M;ss 8-15%:M;s,ss 15+%:S;s	0-4%:M;ss 4-8%:M;s,ss 8+%:S;s	0-15%:S;b 15+%:S;s,b
CONGAREE	0.6-2.0	4.5-7.3	Low	Mod.	Mod.	2.5-4.0	>60	None Rare Occ Freq	B	None, Rare:S;w Occ,Freq:S;w	None:S;w Rare,Occ,Freq:S;w,f	None,Rare:M;w Occ,Freq:M;w,f	None:L# None:M;w* Occ,Freq:S;f	None:L Rare,Occ,Freq:S;f	None:M;b Rare:M;b,f Occ,Freq:S;f
COOSAW	0.6-2.0	4.5-5.5	Low	Mod.	High	2.0-3.0	>60	None	B	S;w,pf	S;w,p	S;w,cc	M;w# S;w*	M;w	M;w
COWARTS	0.06-0.6	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	C	S;pk	2-7%:M;s 7+%:S;s	2-8%:L 8-15%:M;s	2-8%:L 8-15%:M;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s
COWEE	0.6-2.0	4.5-6.0	Low	Mod.	High	>6.0	20-40	None	B	8-15%:S;r 15+%:S;r,s	S;r,s	8-15%:M;r,s 15+%:S;s	8-15%:M;s# 8-15%:M;r,s* 15+%:S;s	S;s	8-15%:M;s 15+%:S;s

SOIL SERIES INTERPRETATIONS

	ESTIMATED SOIL PROPERTIES									LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
COXVILLE	0.2-0.6	3.6-5.5	Mod.	High	High	0-1.5	>60	None	D	S;w,pk	S;w	S;w	S;w	S;w	S;w,b
CRAVEN	0.06-0.2	3.6-5.5	Mod.	High	High	2.0-3.0	>60	None	C	S;pk,w	0-2%:M;p 2-7%:M;p,s 7+%:S;s	S;w,cc	0-8%:M;w,ss# 8-12%:M;w,ss,s# S;w*	0-4%:M;w,ss 4-8%:M;w,ss,s 8+%:S;s	S;b
CUNNINGHAM	0.06-0.2	4.5-5.5	Mod.	High	High	>6.0	40-60	None	C	2-15%:S;pk 15+%:S;pk,s	2-7%:M;s,r 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:M;ss 8-15%:M;ss,s 15+%:S;s	2-8%:M;ss 4-8%:M;ss,s 8+%:S;s	2-15%:S;b 15+%:S;s,b
CUTHBERT	0.06-0.6	3.6-5.5	Mod.	High	High	>6.0	>60	None	C	5-15%:S;pk 15+%:S;pk,s	5-7%:M;s 7+%:S;s	5-8%:M;cl 8-15%:M;cl,s 15+%:S;s	5-8%:M;ss 8-15%:M;ss,s 15+%:S;s	5-8%:M;s,ss 8+%:S;s	5-15%:S;b 15+%:S;b,s
DASHER	2.0-6.0	3.6-4.4	Low	High	High	+3-0.5	>60	None	D	S;w,u	S;w,h	S;w,h	S;w,b	S;w,b	S;w
DAVIDSON	0.6-2.0	4.5-6.0	Low	High	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;pk,s 15+%:S;s	2-7%:M;p,s 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-15%:S;b 15+%:S;b,s
DECATUR	0.6-2.0	4.5-6.0	Mod.	High	Mod.	>6.0	>60	None	B	1-8%:L 8-15%:M;s 15+%:S;s	1-7%:M;p,s 7+%:S;s	1-8%:M;cl 8-15%:S;s 15+%:S;s	1-8%:M;ss 8-15%:M;s,ss 15+%:S;s	1-4%:M;ss 4-8%:M;s,ss 8+%:S;s	1-8%:M;b 8-15%:M;s,b 15+%:S;s
DEKALB	6.0-2.0	3.6-5.5	Low	Low	High	>6.0	20-40	None	C	0-15%:S;pf,r 15+%:S;pf,r,s	0-7%:S;r,p 7+%:S;r,s,p	0-15%:S;r 15+%:S;r,s	0-8%:M;r,st# 8-15%:M;r,st,s# 0-15%:S;,r* 15+%:S;s# 15+%:S;s;r*	0-4%:M;r,st 4-8%:M;r,st,s 8+%:S;s	0-8%:M;r,st 8-15%:M;r,st,s 15+%:S;s
DEWEY	0.6-2.0	4.5-5.5	Mod.	High	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;p,s 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:M;ss 8-15%:M;s,ss 15+%:S;s	2-4%:M;ss 4-8%:M;s,ss 8+%:S;s	2-15%:S;b 15+%:S;s,b
DILLARD	0.2-0.6	4.5-5.5	Mod.	Mod.	High	2.0-3.0	>60	None Rare	C	S;w,pk	2-7%:S;w 7+%:S;s	S;w	None:M;w# None:S;w* Rare:S;f	None:M;w,s Rare:s;f	S;b
DOCENA	0.06-0.6	4.5-6.0	Mod.	Mod.	Mod.	1.5-3.0	>60	None Rare Occ	C	None, Rare:S;w,pk Occ:S;f,w,pk	None:S;w Rare,Occ:S;f,w	S;w	None:M;w# None:S;w* Rare,Occ:S;w,f	0-4%:None:M;w 4-6%None:M;w,s Rare,Occ:S;f	None:Rare:S;b Occ:S;b,f
DOGUE	0.2-0.6	3.6-5.5	Mod.	High	High	1.5-3.0	>60	None Rare	C	S;w,pk	0-7%:None:S;p,w 7+%:None:S;p,w,s 0-7%:Rare:S;p,f,w 7+%:Rare:S;p,f,s	S;cc,w	0-15%:None:M;ss,w# 0-15%:Rare:S;f# None:S;w* Rare:S;f,w#	8%None:M;ss,w,s# 8+%:None:S;s# 0-8%:Rare:S;f* 8+%:Rare:S;f,s*	S;b
DOTHAN	0.2-0.6	4.5-6.0	Low	Mod.	Mod.	3.0-5.0	>60	None	B	M;pk,w	0-2%:L 2-7%:M;s 7+%:S;s	0-8%:M;w 8-12%:M;w,s	0-8%:L# 8-12%:M;s# 0-8%:M;w* 8-10%:M;s*	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-10%:M;s
DOWELLTON	0.06-0.2	5.1-7.8	High	High	Mod.	0.5-1.0	40-60	None	D	S;w,pk	S;w	S;w,cl	S;w,ss	S;w,ss	S;w,ss,b
DUCKSTON	>20	3.6-8.4	Low	Low	Low	1.0-2.0	>60	Occ Freq	A/D	S;w,f,pf	S;w,f,p	S;w,cc	S;w,f	S;w,f	S;f
DUNBAR	0.2-0.6	4.5-5.5	Mod.	High	High	1.0-2.5	>60	None	D	S;w,pk	S;w	S;w	S;w	S;w	S;b
DUPLIN	0.2-0.6	4.5-5.5	Mod.	High	High	2.0-3.0	>60	None	C		S;w	M;w	M;w# S;w*	0-4%:M;w 4-8%:M;s,w	S;b

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	CORROSIVITY		DEPTH TO:		FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
				STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)								
DURHAM	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	0-8%:L 8-10%:M;s	0-2%:M;p 2-7%:M;s 7+%:S;s	0-8%:L 8-10%:M;s	0-8%:L 8-10%:M;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-10%:M;s
DYKE	0.6-2.0	4.5-6.0	Mod.	High	Mod.	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;pk,s 15+%:S;s	0-2%:M;p 2-7%:M;s,s 7+%:S;s	0-8%:M;cl 8-15%:M;cl,s 15+%:S;s	0-8%:M;ss 8-15%:M;s,ss 15+%:S;s	0-4%:M;ss 4-8%:M;ss,s 8+%:S;s	0-15%:S;b 15+%:S;s,b
ECHAW	2.0-20	4.5-6.0	Low	Low	High	2.5-5.0	>60	None	A	S;w,pf	S;p,w	M;cc	L# M;w*	L	L
EDGEMONT	0.6-6.0	3.6-5.5	Low	Low	High	>6.0	>40	None	B	0-8%:M;r,pk 8-15%:M;r,pk,s 15+%:S;s	0-7%:S;p 7+%:S;p,s	0-15%:S;cc 15+%:S;cc,s	0-8%:L# 0-8%:M;r* 8-15%:M;s#r* 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
EDNEYTOWN	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	2.8%:L 8-15%:M;S 15+%:S;s	2-7%:S;p 7+%:S;p,s	2-15%:S;cc 15+%:S;cc,s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
EDNEYVILLE	0.6-2.0	4.5-6.0	Low	Low	High	>6.0	>60	None	B	6-8%:L 8-15%:M;S 15+%:S;S	S;s	6-8%:L 8-15%:M;s 15+%:S;s	6-8%:L 8-15%:M;s 15+%:S;s	6-8%:M;s 8+%:S;s	6-8%:L 8-15%:M;s 15+%:S;s
ELLABELLE	0.6-2.0	4.5-5.5	Low	High	High	+1-0.5	>60	Freq	C	S;f,w	S;f,w	S;w,cc	S;f,w	S;f,w	S;f,w
EMORY	0.6-2.0	5.1-6.0	Low	Mod.	Mod.	5.0-6.0	>60	None Rare Occ	B	None:M;pk,w Rare:M;f,w,pk Occ:S;f	0-2%:None:M;p 2-5%:None:M;p,s Rare,Occ:S;f	None,Rare:L Occ:M;f	None:L# None:M;w* Rare,Occ:S;f	None:L Rare:Occ:S;f	None,Rare:S;b Occ:S;b,f
ENDERS	<0.06	3.6-5.5	High	High	High	>6.0	40-60	None	C	1-15%:S;pk 15+%:S;s,pk	1-7%:M;s,r 7+%:S;s	1-8%:M;cl 8-15%:M;cl,s 15+%:S;s	1-15%:S;ss 15+%:S;s,ss	1-8%:S;ss 8+%:S;s,ss	1-15%:S;b,ss 15+%:S;s,b,ss
ENNIS	2.0-6.0	4.5-6.0	Low	Low	Mod.	>6.0	>60	Rare Occ	B	Rare:M;f Occ:S;f		Rare:L Occ:M;f	S;f	S;f	Rare:M;f Occ:S;f
ENON	0.06-0.2	5.1-7.8	High	High	Mod.	>6.0	>60	None	C	2-15%:S;pk 15+%:S;pk,s	2-7%:M;s 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-15%:S;ss 15+%:S;ss,s	2-8%:S;ss 8+%:S;ss,s	2-15%:S;b,ss 15+%:S;b,ss,s
ESTO	0.06-0.2	4.5-5.5	Mod.	High	High	>6.0	>60	None	B	2-15%:S;pk 15+%:S;pk,s	2-7%:M;s 7+%:S;s	0-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:M;ss 8-15%:M;ss,s 15+%:S;s	2-4%:M;ss 4-8%:M;ss,s 8+%:S;s	2-15%:S;b 15+%:S;b,s
ETOWAH	0.6-2.0	4.5-5.5	Low	Low	Mod.	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;s;pk 15+%:S;s	0-2%:M;p 2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:M;b 8-15%:M;s,b 15+%:S;s
EUHARLEE	0.2-0.6	4.5-5.5	Low	Mod.	High	>6.0	>60	None	C	S;pk	2-7%:M;s 7+%:S;s	2-8%:M;cl 8-10%:M;s,cl	2-8%:L 8-10%:M;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:S;b 8-10%:S;s,b
EULONIA	0.2-0.6	4.5-6.5	Low	Mod.	High	1.5-3.5	>60	None	C	S;pk,w	L	S;w	M;w# S;w*	0-4%:M;w 4-6%:M;w,s	M;b,w
EUNOLA	0.6-2.0	4.5-5.5	Low	Low	High	1.5-2.5	>60	None Rare Occ	C	None,Rare:S;w Occ:S;w,f	None,Rare:S;w,p Occ:S;w,e,f	S;w,cc	None:M;w# None:S;w* Occ:S;f	None:M;w Rare,Occ:S;f	None:M;w Rare:M;wf Occ:S;f
EUSTIS	6.0-20	4.5-5.5	Low	Low	High	>6.0	>60	None	A	0-8%:L 8-15%:M;s 15+%:S;s	0-7%:S;p 7+%:S;p,s	0-15%:S;cc 15+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	CORROSIVITY		DEPTH TO:		FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
				STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)								
EUTAW	<0.06	4.5-7.8	High	High	Mod.	0.5-1.5	>60	None	C	S;pk,w	L	S;w	M;w# S;w*	0-4%:M;w 4-6%:M;w,s	M;b,w
EVARD	0.6-2.0	4.5-6.0	Low	Mod.	High	>6.0	>60	None	B	2-8%:L 8-15%:M;s 15+%:S;s	2-7%:M;p,s 7+%:S;s	2-15%:S;cc 15%+:S;cc,s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
FACEVILLE	0.6-2.0	4.5-6.0	Low	Low	Mod.	>6.0	>60	None	B	0-8%:L 8-15%:M;s	0-2%:M;p 2-7%:M;s,p 7+%:S;s	0-8%:M;cl 8-15%:M;cl,s	0-8%:L 8-15%:M;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:M;b 8-15%:M;s,b
FANNIN	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;p,s 7+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-15%:S;b 15+%:S;b,s
FARRAGUT	0.2-0.6	4.5-5.5	Mod.	High	Mod.	>6.0	>48	None	C	2-15%:S;pk 15+%:S;s,pk	2-7%:M;s,s 7+%:S;s	2-8%:M;cl,s 8-15%:M;cl,s 15+%:S;s	2-8%:M;ss 8-15%:M;s,ss 8+%:S;s	2-4%:M;ss 4-8%:M;s,ss 8+%:S;s	2-15%:S;b 15+%:S;s,b
FLOMATION	6.0-2.0	4.5-6.0	Low	Low	Mod.	>6.0	>60	None	A	2-15%:S;pf 15+%:S;pf,s	2-7%:S;p 7+%:S;p,s	2-15%:S;cc 15+%:S;cc,s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
FOXWOTH	>20	4.5-6.0	Low	Low	High	3.5-6.0	>60	None	A	M;w	0-7%:S;s 7+%:S;p,s	S;cc	L# M;w*	0-4%:L 4-8%:M;s	L
FREEMANVILLE	0.2-0.6	5.1-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	S;pk	0-2%:L 2-7%:M;s 7+%:S;s	0-8%:M;cl 8-12%:M;cl,s	0-8%:L 8-12%:M;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:M;b 8-12%:M;b,s
FRENCH	0.6-2.0	5.1-6.5	Low	Mod.	Mod.	1.0-2.5	>60	Occ Freq	C	S;f,w	S;f,w	S;cc,w	S;f,w	S;f,w	S;f
FRIPP	6.0-2.0	5.6-7.8	Low	Low	Low	>6.0	>60	None Rare	A	2-15%:S;pf 15+%:S;pf,s	2-7%:S;p 7+%:S;s,p	2-15%:S;cc 15+%:S;c,s	2-15%:None:M;s 15+%:None:S;s 2-15%:Rare:S;f 15+%:Rare:S;f,s	2-8%:None:M;s 8+%:None:S;s 2-8%:Rare:S;f 8+%:Rare:S;f,s	2-15%:None:M;s 2-15%:Rare:M;f,s
FULLERTON	0.6-2.0	4.5-5.5	Mod.	High	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:S;s 15+%:M;pk,s	2-7%:M;p,s 7+%:S:s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:M;ss 8-15%:None:M;s,ss 15+%:S;s	2-4%:M;ss 4-8%:M;s,ss 8+%:S;s	2-8%:M;ss,b 8-15%:M;ss,b,s 15+%:M;ss,b,s
FUQUAY	0.06-0.2	4.5-6.0	Low	Low	High	4.0-6.0	>60	None	B	0-8%:M;pk 8-10%:M;pk,s	0-2%:L 2-7%:M;s 7+%:S;s	0-8%:L 8-10%:M;s	0-8%:L# 8-10%:M;s# 0-8%:M;w* 8-10%:M;w,s*	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-10%:M;s
GALESTOWN	>6.0	3.6-5.5	Low	Low	High	>6.0	>60	None	A	0-15%:S;pf 15+%:S;pf,s	0-7%S;p 7+%:S;p,s	0-15%:S;cc 15+%:S;cc,s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S:s
GAYLESVILLE	0.06-0.2	3.6-6.0	Mod.	High	High	0-1.5	>60	Freq	D	S;f,w,pk	L	S;w	S;w,f	S;w,f	S;w,f,b
GEORGEVILLE	0.6-2.0	4.5-5.5	Low	High	High	>6.0	>60	None	B	2-8%:M;pk 8-15:M;s,pk 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4:L 4-8%:M;s 8+%:S;s	2-15%:S;b 15+%:S;s,b
GILEAD	0.06-0.6	4.5-5.5	Low	Mod.	High	1.5-2.5	>60	None	C	S;pk,w	0-2%:L 2-7%:M;s 7+%:S;s	S;w	0-8%:M;w# 8-15%:M;s,w# S;w*	0-4%:M;w 4-8%:M;s,w 8+%:S;s	S;b
GILPIN	0.6-2.0	3.6-5.5	Low	Low	High	>6.0	20-40	None	C	0-15%:S;r 15+%:S;r,s	0-7%:S;r 7+%:S;r,s	0-8%:M;r 8-15%:M;r,s 15+%:S;s	0-8%:L# 0-8%:M;r* 8-15%:M;s#,r* 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
GOLDSBORO	0.6-2.0	3.6-5.5	Low	Mod.	High	2.0-3.0	>60	None	B	S;w	S;w	S;w	M;w# S;w*	0-4%:M;w 4-8%:M;s,w	M;w
GOLDSTON	2.0-6.0	3.6-5.5	Low	Mod.	High	>6.0	10-20	None	C	2-15%:S;r 15+%:S;r,s	2-7%:S;r,p 7+%:S;r,s,p	2-15%:S;r 15+%:S;r,s	2-15%:M;r,s# 15+%:S;s S;r*	2-4%:M;r,s# 4-8%:M;s,r,st 8+%:S;s	2-8%:M;r,st 8-15%:S;s 15+%:S;s
GORGAS	2.0-6.0	4.5-5.5	Low	Low	Mod.	>6.0	10-20	None	D	2-15%:S;r 15+%:S;r,s	2-7%:S;p,k 7+%:S;p,r,s	2-15%:S;r 15+%:S;r,s	2-15%:S;r 15+%:S;r,s	2-8%:S;r 8+%:S;r,s	2-15%:s,r 15+%:S;r,s
GRADY	0.06-0.2	3.6-5.5	Mod.	High	High	+2-1.0	>60	None	D	S;pk,w	S;w	S;w	S;s	S;w	S;w
GREENVILLE	0.6-2.0	4.5-6.0	Low	Mod.	High	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;s,pk	0-2%:M;p 2-7%:M;s,p 7+%:S;s	0-8%:M;cl 8-15%:M;s,cl	0-8%:L 8-15%:M;s	0-4%:L 4-8%:M;s 8-15%:S;s	0-8%:L 8-15%:M;s
GRITNEY	0.06-0.2	4.5-5.5	High	High	Mod.	>6.0	>60	None	C	S;pk	2-7%:M;s 7+%:S;s	M;cl	S;ss	2-8%:S;ss 8+%:S;ss,s	S;ss,b
GROVER	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	2-8%:L 8-15%:M;s 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;s,b 15+%:S;s
GUTHRIE	0.6-0.2	3.6-5.0	Low	High	High	0.5-1.0	>60	None Occ Freq	D	None, Rare:S;w,pk Occ,Freq:S;w,pk	L	S:w	None:S;w Rare,Occ,Freq:S;f,w	None:S;w Rare,Occ,Freq:S;f,w	None,Rare:S;b,w Occ,Freq:S;b,w,f
GWINNETT	0.6-2.0	5.1-6.6	Low	High	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:M:cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;s,b 15+%:S;s
HAMBLEN	0.6-2.0	4.5-7.3	Low	Mod.	Mod.	2.0-3.0	>60	None Rare Occ Freq	C	None,Rare:S;w Occ,Freq:S;f,w	None,Rare:S;w Occ,Freq:S;f,w	None,Rare:M;w Occ,Freq:M;w,f	None:M;w# Rare,Occ,Freq:S;f# None:S;w* Rare,Occ,Freq:S;f,w*	None:M;w Rare,Occ,Freq:S;r	None,Rare:M;b,w Occ,Freq:S;f
HANCEVILLE	0.6-2.0	4.5-5.5	Mod.	High	High	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;pk,s 15+%:S;s	0-2%:M;p 2-7%:M;p,s 7+%:S;s	0-8%:M;cl 8-15%:M;cl,s 15+%:S;s	0-8%:M;ss 8-15%:M;ss,s 15+%:S;s	0-4%:M;ss 4-8%:M;ss,s 8+%:S;s	0-15%:S;b 15+%:S;b,s
HARTSELLS	0.6-2.0	3.6-5.5	Low	Mod.	High	>6.0	20-40	None	B	2-15%:S;r 15+%:S;r,s	2-7%:S;r 7+%:S;r,s	2-15%:S;r 15+%:S;r,s	2-15%:M;r,s# 15+%:S;s S;r	2-4%:M;r 4-8%:M;s,r 8+%:S;s	2-8%:M;r 8-15%:M;s,r 15+%:S;s
HATBORO	0.6-2.0	4.5-7.3	Low	High	Mod.	0-0.5	>60	Occ Freq	D	S;f,w	S;f,w,p	S;w	S;f,w	S;f,w	S;f,w
HAYESVILLE	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;pk,s 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;b,s 15-25%:S;s
HAYWOOD	6.0-2.0	5.1-6.5	Low	Low	Mod.	>6.0	>60	None	B	2-8%:S;pf 8-15%:M;s,pf 15+%:S;s,pf	2-7%:S;p 7+%:S;s,p	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
HAZLEHURST	0.06-0.2	4.5-5.5	Low	High	High	0.5-2.0	>60	None	C	S;w,pk	0-2%:L 2-3%:M;s	S;w	S;w	S;w	S;w
HECTOR	2.0-6.0	4.5-5.5	Low	Low	Mod.	>6.0	10-20	None	D	2-15%:S;r 15+%:S;s,r	2-7%:S;r,p 7+%:S;s,r,p	2-15%:S;r 15+%:S;s,r	2-15%:S;r 2-8%:S;r* 15+%:S;r	2-8%:S;r 8+%:S;s,r	2-15%:S;r 15+%:S;s,r

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
HELENA	0.06-0.2	4.5-5.5	High	High	High	1.5-2.5	>60	None	C	S;pk,w	0-2%:L 2-7%:M;s 7+%:S;s	S;w	S;ss# S;ss,w*	0-8%:S;ss 8+%:S;s,ss	S;ss,b
HENDERSON	0.06-0.2	4.5-5.5	Low	High	Mod.	>6.0	>60	None	B	2-15%:S;pk 15+%:S;pk,s	2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-15%:S;b 15+%:S;s,b
HERNDON	0.6-2.0	3.6-5.5	Low	High	High	>6.0	>60	None	B	2-8%:M;cl 8-15%:M;s,cl	2-7%:M;p,s 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl	2-8%:L 8-15%:M;s	2-4%:L 4-8%:M;s 8+%:S;s	S;b
HEROD	0.6-2.0	5.1-7.3	Low	High	Mod.	0.5-1.5	>60	Freq	D	S;f,w	S;f,w	S;w	S;f,w	S;f,w	S;f,w
HIWASSEE	0.6-2.0	4.5-6.5	Mod.	Mod.	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%M;pk,s 15+%:S;s	0-7%:M;p,s 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-15%:S;b 15+%:S;s,b
HOLSTON	0.6-2.0	4.5-5.5	Low	Mod.	High	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;s,pk 15+%:S;s	0-2%:M;p 2-7%:M;s,p 7+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
HORNSVILLE	.02-.06	4.5-6.0	Low	High	High	2.5-3.5	>60	None Rare	C	S;w,pk	0-7%:None:S;w 7+%:None:S;w,s Rare:S;w	M;cl,w	None:L# None:M;w* Rare:S;f	0-4%:None:L 4-8%:None:M;s Rare:S;f	None:M;b Rare:M;b,f
HULETT	0.6-2.0	4.5-5.5	Low	High	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk	2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl	2-8%:M;cl 8-15%:M;s	2-8%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:S;s,b
IREDELL	0.06-0.2	5.5-7.8	High	High	Low	1.0-2.0	>60	None	D	S;w,pk	0-7%:S;w 7+%:S;s,w	S;w	S;ss,w	0-8%:S;w,ss 8+%:S;w,ss,s	S;ss,b
IRVINGTON	0.06-0.2	4.5-5.5	Low	Mod.	Mod.	1.5-3.5	>60	None	C	S;w,pk	0-2%:L 2-5%:M;s	S;w	M;w# S;w*	M;w	M;w
IUKA	0.6-2.0	4.5-5.5	Low	Mod.	High	1.0-3.0	>60	Rare Occ Freq	C	Rare:S;w Occ, Freq:S; w,f	S;f,w	S;w	S;w,f	S;w,f	Rare:M;w,f Occ,Freq:S;f
IZAGORA	0.06-0.2	3.6-5.5	Mod.	Mod.	High	2.0-3.0	>60	None Rare Occ	C	None,Rare:S;W,pk Occ:S;f,w,pk	0-7%:None:S;w 7+%:None:S;w,s 0-7%:Rare,Occ:S;f,w 7+%:Rare,Occ:S;f,w,s	S;w	None:M;w# None:S;w* Rare,Occ:S;f,w	None:M;w Rare,Occ:S;f,w	None,Rare:S;b Occ:S;b,f
JOHNS	0.6-2.0	4.5-5.5	Low	Mod.	High	1.5-3.0	>60	None Rare	C	S;w	None:S;w,p Rare:S;w,f,p	S;w	None:M;w# None:S;w* Rare:S;w,f	None:M;w Rare:S;f	None:M;w Rare:M;w,f
JOHNSTON	2.0-6.0	4.5-5.5	Low	High	High	+1-1.5	>60	Freq	D	S;f,w	S;f,w,p	S;w	S;f,w	S;f,w	S;f,w
JUNALUSKA	0.6-2.0	4.5-6.0	Low	Mod.	High	>6.0	20-40	None	B	8-15%:S;r 15+%:S;r,s	S;r,s	S;f,w	8-15%:M;s# 8-15%:M;s,r* 15+%:S;s	S;s	8-15%:M;b,s 15+%:S;s
KALMIA	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None Rare	B	L	None:S;s Rare:S;f,p	8-15%:M;r,s 15+%:S;s	None:L Rare:S;f	0-4%:None:L 4-6%:None:M;s Rare:S;f	None:L Rare:M;f
KERSHAW	>20	4.5-6.0	Low	Low	High	>6.0	>60	None	A	S;pf	2-7%:S;s 7+%:S;s,p	S;cc	2-8%:L 8-15%:M;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
KINGSLAND	6.0-20	4.5-6.5	Low	Mod.	Mod.	0-0.5	>60	Occ Freq	A/D	S;f,w	S;f,p,h	S;w,h	S;f,w	S;f,w	S;f,w
KINSTON	0.6-2.0	4.5-5.5	Low	High	High	0-1.0	>60	Occ Freq	B/D	S;f,w	S;f,w	S;f,w	S;w	S;f,w	S;f,w,b
KOLOMOKI	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None Rare	B	None:L Rare:M;f	None:S;p Rare:S;p,f	S;cc	None:L Rare:S;f	0-4%:L 4-8%:M;s 8+%:S;f	None:M;b Rare:M;b,f
KUREB	6.0-20	4.5-7.3	Low	Low	Low	>6.0	>60	None	A	0-15%:S;pf 15+%:S; p,f,s	0-15%:S;p 15+%:S;p,s	0-15%:S;cc 15+%:S;s,cc	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
LAKELAND	6.0-20	4.5-6.0	Low	Low	Mod.	>6.0	>60	None	A	0-8%:L 8-15%:M;s 15+%:S;s	0-7%:S;p 7+%:S;s,p	0-15%:S;cc 15+%:S;s,cc	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
LEADVALE	0.06-0.6	4.5-5.5	Low	Mod.	Mod.	2.0-3.0	>48	None Rare	C	S;w,pk	0-7%:None:S;w 7+%:None:S;s,w 0-7%:Rare:S;f,w 7+%:Rare:S;f,w,s	S;w	None:M;w# None:S;w* Rare:S;f	0.8%:None:M;w 8+%:None:S;s Rare:S;f	0-8%:M;b,w 8-15%:M;sw,b
LEAF	0.06-0.2	3.6-5.5	High	High	Mod.	0.5-1.5	>60	None Rare Occ Freq	D	None,Rare:S;w,pk Occ,Freq:S;f,w,pk	None,Rare:L Occ,Freq:S;f	S;w	None:S;w,ss Rare,Occ,Freq:S;f, w,ss	None:S;w,ss Rare,Occ,Freq:S;f, w,ss	S;w,ss,b
LEEFIELD	.02-.06	4.5-5.5	Low	Mod.	High	1.5-2.5	>60	None	C	S;w,pk	M;w,p	S;w	M;w# S;w*	M;w	M;w
LEESBURG	0.6-2.0	4.5-5.5	Mod.	Low	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;pk,s 15+%:S;s	2-7%:M;p,s 7+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
LEON	0.6-6.0	3.6-5.5	Low	High	High	0-1.0	>60	None	B/D	S;w,pf	S;w,p	S;w,cc	S;w	S;w	S;w
LEVY	0.06-0.2	3.6-5.5	High	High	High	+2-+1	>60	Freq	D	S;f,pk	S;f	S;f	S;f,ss	S;f,ss	S;f,f
LILY	2.0-6.0	3.6-5.5	Low	Mod.	High	>6.0	20-40	None	B	0-15%:S;r 15+%:S;r,s	0-7%:S;p,r 7+%:S;p,r,s	0-15%:S;r 15+%:S;r,s	0-15%:M;r,s# 0-15%:S;r* 15+%:S;s#,r*	0-4%:M;r 4-8%:M;r,s 8+%:S;s	0-8%:M;r 8-15%:M;r,s 15+%:S;s
LINKER	0.6-2.0	3.6-5.5	Low	Low	High	>6.0	20-40	None	B	1-15%:S;r 15+%:S;s,r	1-7%:S;r 7+%:S;s,r	1-15%:S;r 15+%:S;s,r	1-8%:M;r# 8-15%:M;r,s# 1-15%:S;r* 15+%:S;s	1-4%:S;r 4-8%:M;r,s 8+%:S;s	1-8%:M;r 8-15%:M;r,s 15+%:S;s
LOCKHART	2.0-6.0	5.1-6.5	Low	Low	Mod.	>6.0	>60	None	B	2-8%:L 8-15%:M;S 15+%:S;s	2-7%:S;p 7+%:S;s,p	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
LOCUST	0.06-0.2	4.5-5.5	Low	Mod.	High	1.5-2.0	>60	None	C	S;pk,w	0-7%:S;w 7+%:S;s,w	S;w	0-8%:M;w# 8-10%:M;s# S;w*	0-4%:M;w 4-8%:M;s,w 8+%:S;s	0-8%:M;w 8-10%:M;s,w
LOUISA	2.0-6.0	4.5-6.0	Low	Low	Mod.	>6.0	>60	None	B	6-8%:L 8-15%:M;s 15+%:S;s	S;p,s	6-8%:L 8-15%:M;s 15+%:S;s	6-8%:L 8-15%:M;s 15+%:S;s	6-8%:M;s 8+%:S;s	6-8%:L 8-15%:M;s 15+%:S;s
LOUISBURG	6.0-20	4.5-6.0	Low	Low	Mod.	>6.0	>40	None	B	2-8%:M;r 8-15%:M;r,s 15+%:S;s	2-7%:S;p 7+%:S;p,s	2-8%:M;r 8-15%:M;r,s 15+%:S;s	2-8%:M;r* 2-8%:L# 8-15%:M;s# 8-15%:M;r,s*	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
LOWNDES	0.6-2.0	4.5-6.0	Low	Mod.	High	>6.0	>60	None	B	5-8%:M;pk 8-15%:M;s,pk 15+%:S;s	5-7%:S;p 7+%:S;s,p	5-15%:S;cc 15+%:S;s,cc	15+%:S;s 5-8%:L 8-15%:M;s 15+%:S;s	5-8%:M;s 8+%:S;s	5-8%:L 8-15%:M;s 15+%:S;s
LUCY	0.6-2.0	4.5-5.5	Low	Low	High	>6.0	>60	None	A	0-8%:L 8-15%:M;s 15+%:S;s	0-7%:S;p 7+%:S;p,s	0-8%:M;cc 8-15%:M;s,cc 15+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
LUMBEE	0.6-2.0	4.5-5.5	Low	High	High	0-1.5	>60	Rare Occ Freq	B/D	Rare:S;w Occ,Freq:S;w,f	Rare:S;p,w Occ,Freq:S;p,w,f	S;w,cc	S;w,f	S;w,f	Rare:S;w Occ,Freq:S;w,f
LYERLY	<0.06	4.5-7.3	High	High	Mod.	>6.0	20-40	None	D	S;pk,r	1-7%:S;r 7+%:S;s,r	S;r	S;ss S;r,ss	1-8%:S;ss 8+%:S;s,ss	S;ss,b
LYNCHBURG	0.6-2.0	3.6-5.5	Low	High	High	0.5-1.5	>60	None	C	S;w	S;w	S;w	S;w	S;w	S;w
LYNN HAVEN	0.6-6.0	3.6-5.5	Low	High	High	0-1.0	>60	None	B/D	S;w,pf	S;p,w	S;cc,w	S;w	S;w	S;w
MADISON	0.6-2.0	4.5-6.0	Low	High	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;pk,s 15+%:S;s	2-7%:M;p 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	0-15%:S;b 15+%:S;s,b
MANDARIN	0.6-2.0	3.6-7.3	Low	Mod.	High	1.5-3.5	>60	None	C	S;w,pf	S;pw	S;cc,w	M;w# S;w*	M;w	M;w
MARLBORO	0.6-2.0	4.5-6.0	Low	High	High	>6.0	>60	None	B	0-8%:M;pk 8-15%:M;pk,s	0-2%:M;p 2-7%:M;s,p 7+%:S;s	0-8%:M;cl 8-15%:M;cl,s	0-8%:L 8-15%:M;s	0-4%:L 4-8%:M;s 8-15%:S;s	0-8%:M;b 8-15%:M;b,s
MASADA	0.6-2.0	4.5-5.5	Mod.	Mod.	High	>6.0	>60	None	C	0-8%:M;pk 8-15%:M;pk,s 15+%:S;s	0-2%:M;p 2-7%:M;p,s 7+%:S;s	0-8%:M;cl 8-15%:M;cl,s 15+%:S;s	0-8%:M;ss 8-15%:M;ss,s 15+%:S;s	0-4%:M;ss 4-8%:M;s,ss 8+%:S;s	0-15%:S;b 15+%:S;b,s
MASCOTTE	0.6-2.0	3.6-5.5	Low	High	High	0-1.0	>60	None	B/D	S;w,pf	S;w,p	S;w,cc	S;w	S;w	S;w
MAXTON	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None Rare	B	L	S;p	S;cc	None:L Rare:S;f	0-4%:None:L 4-8%:None:M;s Rare:S;f	None:L Rare:M;f
MECKLENBURG	0.06-0.2	5.6-7.3	Mod.	High	Mod.	>6.0	>48	None	C	2-15%:S;pk 15+%:S;s,pk	2-7%:M;s,r,p 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:S;ss 8-15%:M;ss,s 15+%:S;s	2-4%:M;ss 4-8%:M;ss,s 8+%:S;s	2-15%:S;b 15+%:S;s,b
MEGGETT	0.06-0.2	5.1-8.4	High	High	Mod.	0-1.0	>60	None Rare Occ Freq	D	None,Rare:S;pk,w Occ,Freq:S;pk,w,f	None,Rare:S;w Occ,Freq:S;w,f	S;w	None:S;w,ss Occ,Freq:S;f,w,ss	None:S;w,ss Occ,Freq:S;f,w,ss	None:Rare:S;w,ss Occ,Freq:S;f,w,ss
MINVALE	0.6-2.0	4.5-5.5	Low	Mod.	Low	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:L 8-15%:S;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;b,s 15+%:S;s
MOLENA	6.0-2.0	4.5-6.0	Low	Low	High	>6.0	>60	None Rare	A	0-15%:S;pf 15+%:S;pf,s	0-7%:S;p 7+%:S;s	0-15%:S;cc 15+%:S;cc,s	0-8%:None:L 8-15%:None:M;s 15+%:None:S;s 0-15%:Rare:S;f 15+%:Rare:S;f,s	0-4%:L 4-8%:M;s 8-15%:S;s Rare:S;f	0-8%:L 8-15%:M;s 15+%:S;s Rare:M;f
MONTEVALLO	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	10-20	None	D	2-15%:S;r 15+%:S;s,r	2-7%:S;r 7+%:S;s,r	2-15%:S;r 15+%:S;s,r	2-8%:M;r# 8-15%:S;s,r# 15+%:S;s 2-15%:S;r*	2-4%:M;r 4-8%:M;r,s 8+%:S;s	2-8%:M;r 8-15%:M;s,r 15+%:S;s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
MOUNTAINBURG	2.0-6.0	4.5-5.5	Low	Low	High	>6.0	12-20	None	D	1-15%:S;r 15+%:S;s,r	1-7%:S;r,p 7+%:S;s,r,p	1-15%:S;r 15+%:S;s,r	1-15%:S;r 15+%:S;r,s	1-8%:S;r 8+%:S;r,s	1-15%:S;r 15+%:S;r,s
MOUNTAINVIEW	0.6-2.0	4.5-5.5	Mod.	Mod.	Mod.	>6.0	>60	None	B	2-8%:L 8-15%:M;s	2-7%:M;s,p 7–15%:S;s	2-8%:L 8-15%:M;s	2-8%:L 8-15%:M;s	2-4%:L 4-8%:M;s 8-15%:S;s	2-8%:L 8-15%:M;s
MUCKALEE	0.6-2.0	5.1-8.4	Low	High	Mod.	0.5-1.5	>60	Freq	D	S;f,w	S;f,w	S;w,cc	S;f,w	S;f,w	S;f,w
MUSELLA	0.6-2.0	5.1-6.5	Low	Mod.	Mod.	>6.0	14-20	None	B	6-15%:S;r 15+%:S;r,s	S;r,s	6-15%:S;r 15+%:S;r,s	6-15%:M;r# 15+%:S;s# 6-15%:S;r* 15+%:S;r,s*	6-8%:M;s,r 8+%:S;s	6-15%:M;r,s 15+%:S;s
MYATT	0.2-2.0	3.5-5.5	Low	High	High	0-1.0	>60	None Rare Occ Freq	D	None, Rare:S;w,pk Occ, Freq:S;w,f,pk	None,Rare:S;w Occ,Freq:S;w,f	S;w	None:S;w Rare,Occ,Freq:S;w, f	None:S;w Rare,Occ,Freq:S;w, f	None,Rare:S;w Occ,Freq:S;w,f
NANKIN	0.2-0.6	4.5-5.5	Low	High	High	>6.0	>60	None	C	0-15%:S;pk 15+%:S;pk,s	0-2%:M;p 2-7%:M;p,s 7+%:S;s	0-8%:M;cl 8-15%:M;s,cl 15+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
NANTAHALA	0.6-2.0	4.5-6.0	Mod.	High	Mod.	>6.0	40-60	None	B	2-8%:M;r,pk 8-15%:M;r,pk,s 15+%:S;s	2-7%:M;r,s 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:M;ss 8-15%:M;ss,s 15+%:S;s	2-4%:M;ss 4-8%:M;ss,s 8+%:S;s	2-15%:S;b 15+%:S;b,s
NASON	0.6-2.0	4.5-5.5	Mod.	Mod.	High	>6.0	40-60	None	C	0-8%:M;pk,r 8-15%:M;s,r,pk 15+%:S;s	0-2%:M;p,r 2-7%:M;pk,r,s 7+%:S;s	0-8%:M;c 8-15%:S;s,cl 15+%:S;s	0-8%:M;ss 8-15%:M;s,ss 15+%:S;s	0-4%:M;ss 4-8%:M;s,ss 8+%:S;s	0-15%:S;b 15+%:S;s,b
NAUVOO	0.6-2.0	4.5-6.0	Low	Low	High	>6.0	40-60	None	B	2-8%:M;r,pk 8-15%:M;r,pk,s 15+%:S;s	2-7%:M;p,r,s 7+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;b,s 15+%:S;s
NELLA	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M,s,pk 15+%:S;s	2-7%:M;s,p,st 7+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
NORFOLK	0.6-2.0	4.5-5.5	Low	Mod.	High	4.0-6.0	>60	None	B	0-8%:M;w 8-10%:M;s,w	0-7%:M;p 7+%:S;s	0-8%:M;w 8+%:M;s,w	0-8%:L# 8-10%:M;s# 0-8%:M;w* 8-10%:M;w,s*	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-10%:M;s
OCHLOCKONEE	2.0-6.0	4.5-5.5	Low	Low	High	3.0-5.0	>60	Rare Occ	B	Rare:S;w Occ, Freq:S;w,f	S;f,p,w	M;w	S;f	S;f	Rare:M;f Occ,Freq:S;f
OCILLA	0.6-2.0	4.5-5.5	Low	High	Mod.	1.0-2.5	>60	None	C	S;w	S;w,p	S;w,cc	None:M;w# None:S;w* Rare:S;w,f	None:S;w Rare:S;f,w	None:M;w Rare:M;w,f
OGEECHEE	0.6-2.0	4.5-6.0	Low	High	High	0-1.0	>60	None Rare Occ Freq	B/D	None, Rare:S;w Occ, Freq:S;w,f	None,Rare:S;w Occ,Freq:S;w,f	S;w	None:S;w Rare,Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq:S;w,f	None:Rare:S;w Occ,Freq:S;w,f
OKTIBBEHA	>0.06	4.5-8.4	High	High	High	>6.0	>60	None	D	1-15%:S;pk 15+%:S;pk,s	1-2%:L 2-7%:M;s 7+%:S;s	1-8%:M;cl 8-15%:M;cl,s 15+%:S;s	1-15%:S;ss 15+%:S;ss,s	1-8%:S;ss 15+%:S;ss,s	1-15%:S;ss,b 15+%:S;ss,b,s
OLUSTEE	0.6-2.0	4.5-5.5	Mod.	High	High	0-1.0	>60	None	B/D	S;w	S;w,p	S;w,cc	S;w	S;w	S;w
ORANGEBURG	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	0-8%:L 8-15%:M;s 15+%:S;s	0-2%:M;p 2-7%:M;s,p 7+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s	0-8%L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
OSIER	6.0-2.0	3.6-6.0	Low	High	High	0-1.0	>60	None Rare Occ Freq	A/D	None, Rare:S;w,pf Occ, Freq:S;w,f,pf	None,Rare:S;w,p Occ,Freq:S;w,f,p	S;w,cc	None:S;w Rare,Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq:S;w,f	None:Rare:S;w Occ,Freq:S;w,f
OUSLEY	6.0-20	4.5-5.5	Low	Low	High	1.5-3.0	>60	Occ Freq	C	S;f,w,pf	S;f,p,w	S;cc,w	S;f# S;f,w*	S;f	S;f
PACOLET	0.6-2.0	4.5-6.0	Low	High	High	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;s,b 15+%:S;s
PASQUATANK	0.6-2.0	4.5-5.5	Low	High	Mod.	1.0-2.0	>60	None	B/D	S;w	S;w,p	S;w	S;w	S;w	M;w
PELHAM	0.6-2.0	3.6-5.5	Low	High	High	0-1.0	>60	None Rare Occ Freq	B/D	None, Rare:S;w Occ, Freq:S;w,f	None,Rare:S;w,p Occ,Freq:S;w,f,p	S;w,cc	None:S;w Rare,Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq:S;w,f	None:Rare:S;w Occ,Freq:S;f,w
PELION	.06-0.6	3.6-5.5	Low	High	High	1.0-2.5	>60	None	B/D	S;pk,w	0-7%:S;w 7+%:S;s	S;w	S;w	0-8%:S;w 8+%:S;s,w	0-8%:M;w 8-15%:M;w,s
PERSANTI	0.06-0.2	3.6-5.5	Mod.	High	High	2.0-3.5	>60	None	C	S;w,pk	0-2%:L 2-6%:M;s	S;w	M;ss,w# S;w*	0-4%:M;w,ss 4-6%:M;w,ss,s	M;b,ss,w
PICKNEY	6.0-20	3.6-6.0	Low	High	High	+1-1.0	>60	None	A/D	S;w,pf	S;w,p	S;w,cc	S;w	S;w	S;w
PLUMMER	0.6-2.0	3.6-5.5	Low	Mod.	High	0-1.0	>60	None Rare Occ Freq	B/D	None, Rare:S;w,pf Occ, Freq:S;w,f,pf	None,Rare:S;w,p Occ,Freq:S;w,f.p	S;w,cc	None:S;w Rare,Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq:S;w,f	None:Rare:S;w Occ,Freq:S;w,f
POINDEXTER	0.6-2.0	5.1-7.3	Low	Mod.	Mod.	>6.0	20-40	None	B	2-15%:S;r 15+%:S;r,s	2-7%:S;p,r 7+%:S;p,r,s	2-8%:M;r 8-15%:M;r,s 15+%:S;s	2-8%:L#r* 8-15%:M;s# 8-15%:M;s,r* 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
PONZER	0.06-2.0	3.6-7.8	Low	High	High	0-1.0	>60	None Rare Occ Freq	D	Rare:S;w,pk Occ, Freq:S;f,w,pk	S;f,w,h	S;h,w	S;f,w,b	S;w,f,b	Rare:S;w,b Occ,Freq:S;f,w,b
POOLER	0.06-0.2	3.6-5.5	Mod.	High	High	0-1.0	>60	None	D	S;pk,w	L	S;w	S;w	S;w	S;w,b
PORTERS	2.0-6.0	4.5-6.0	Low	Low	High	>6.0	40-60	None	B	8-15%:M;r,s 6-8%:M;r 15+%:S;s	S;s,p	6-8%:M;r 8-15%:M;r,s 15+%:S;s	6-8%:L# 8-15%:M;s# 6-15%:M;r,s* 15+%:S;s	6-8%:M;s 8+%:S;s	6-8%:L 8-15%:M;s
PORTSMOUTH	0.6-2.0	3.6-6.0	Low	High	High	0-1.0	>60	None	B/D	S;w,pf	S; w,p	S;w,cc	None:S;w Rare:S;w,f	None:S;w Rare:S;w,f	S;w
POTTSBURG	0.6-2.0	3.6-6.0	Low	High	High	0-1.0	>60	None Rare Occ	B/D	None,Rare:S;w,pf Occ:S;f,w,pf	None,Rare:S;w Occ:S;p,f,w,	S;w,cc	None:S;w Rare,Occ:S;f,w	None:S;w Rare,Occ:S;f,w	None,Rare:S;w Occ:S;w,f
RABUN	0.6-2.0	5.1-6.5	Low	High	Mod.	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 8+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;s,b 15+%:S;s
RAINS	0.6-2.0	3.6-5.5	Low	High	High	0-1.0	>60	None Rare Occ Freq	B/D	None,Rare:S;w Occ.Freq:S;f,w	None,Rare:S;w Occ,Freq:S;w,f	S;w	None:S;w Rare,Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq:S;w,f	None,Rare:S;w Occ,Freq:S;w,f

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
RAMSEY	6.-20	4.5-5.5	Low	Low	Mod.	>6.0	10-20	None	D	3-15%:S;r, 15+%:S;r,s	3-7%:S;p,r 7+%:S;p,r,s	3-15%:S;r 15+%:S;r,s	3-15%:S;r 15+%:S;r,s	3-8%:S;r 8+%:S;r,s	3-15%:S;r 15+%:S;r,s
RED BAY	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	B	0-8%:L 8-15%:M;s	2-7%:M;p 2-7%:M;p,s 7+%:S;s	0-8%:L 8-15%:M;s	0-8%:L 8-15%:M;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s
REMBERT	0.06-0.2	4.5-5.5	Low	High	High	0-1.0	>60	None Rare	D	S;w,pk	M;p,w	S;w,cc	S;w	S;w	S;w
RICEBORO	0.06-0.2	4.5-5.5	Mod.	High	High	0.5-1.0	>60	Occ Freq	B/D	S;f,w,pk	S;f,w	S;cc,w	S;f,w	S;f,w	S;f,w
RIDGELAND	0.6-6.0	3.6-6.5	Low	Mod.	High	1.5-2.5	>60	None Rare	B/D	S;w,pf	None:S;p,w Rare:S;p,w,f	S;cc,w	None:M;w# None:S;w* Rare:S;f	None:M;w Rare:S;f	None:M;w Rare:M;w,f
RIGDON	0.6-2.0	4.5-5.5	Low	High	High	1.5-2.5	>60	None	C	S;w	S;w	S;cc,w	M;w# S;w*	M;w	M;w
RION	0.6-2.0	4.5-6.5	Low	Mod.	High	>6.0	>60	None	B	2-8%:L 8-15%:M;s 15+%:S;s	0-7%:S;p 7+%:S;p,s	2-15%:S;cc 15+%:S;cc,s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
RIVERVIEW	0.6-2.0	4.5-5.5	Low	Low	Mod.	3.0-5.0	>60	Occ Freq	B	S;f,w	S;f,p,w	S;cc	S;f	S;f	S;f
ROANOKE	0.06-0.2	3.6-6.5	Mod.	High	High	0-1.0	>60	None Rare Occ Freq	D	None, Rare:S;w,pk Occ,Freq:S;w,f,pk	None,Rare:S;w,p Occ,Freq:S;w,f,p	S;w	None:S;w Rare,Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq:S;w,f	None,Rare:S;w,b Occ,Freq:S;w,b,f
ROBERTSDALE	0.06-0.2	4.5-5.5	Low	High	Mod.	1.0-2.5	>60	None	C	S;w,pk	L	S;w	S;w	S;w	M;w
ROME	0.6-2.0	4.5-5.5	Low	Low	High	>6.0	>60	None Rare Occ	B	None:L Rare:M;f Occ:S;f	0-2%:Rare:M;p 2-6%:None,Rare:M;p,s Occ:S;f	None,Rare:L Occ:M;f	None:L Rare,Occ:S;f	0-4%:None:L 4-6%:None:M;s Rare,Occ:S;f	None:M;b Rare:M;b,f Occ:S;f
RUTLEDGE	6.0-20	3.6-5.5	Low	High	High	0-10	>60	Occ Freq	B/D	S;w,f,pf	S;w,f,p	S;w,cc	S;w,f	S;w,f	S;w,f
SALUDA	0.6-2.0	4.5-5.5	Low	Mod.	High	>6.0	10-20	None	C	10-15%:S;r 15+%:S;s,r	S;s,r	10-15%:S;r 15+%:S;s,r	10-15%:M;s,r# 15+%:S;s# 10-15%:S;r* 15+%:S;r,s*	S;s	10-15%:M;s,r 15+%:S;s
SAPELO	0.6-2.0	3.6-5.5	Low	High	High	0.5-1.5	>60	None	D	S;w,pf	S;w,p	S;w,cc	S;w	S;w	S;w
SATILLA	2.0-6.0	4.5-6.0	Mod.	High	High	0-1.5	>60	None Rare Occ Freq	D	None,Rare:S;w Occ,Freq;S;f,w	None,Rare:S;p,h,w Occ,Freq:S;p,f,h	S;h,w	None:S;w,b Rare,Occ,Freq:S;f,w,b	None:S;w,b Rare,Ccc,Freq:S;f,w,b	None,Rare:S;w Occ,Freq:S;f,w
SAWYER	0.06-0.2	4.5-5.5	High	High	High	2.0-3.0	>60	None	C	S;pk,w	1-7%:S;w 7+%:S;w,s	S;w	M;w,ss# S;ss,w*	1-4%:M;w,ss 4-8%:M;w,ss,s	S;b
SCRANTON	6.0-20	4.5-6.0	Low	Low	High	0.5-1.5	>60	None Rare	A/D	S;w,pf	S;p,w	S;cc,w	None:S;w Rare:S;f,w	None:S;w Rare:S;f,w	S;w

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
SEQUATCHIE	0.6-2.0	4.5-5.5	Low	Low	Mod.	>6.0	>60	None Rare Occ Freq	B	None:L Rare:M;f Occ,Freq:S;f	0-7%:None:M;p 7+%:None:S;s 0-7%:Rare,Occ,Freq:S;f 7%:Rare,Occ,Freq:S;s,f	0-8%:None,Rare:L 8-12%:None,Rare:M;s 0-8%:Occ,Freq:M;f 8-12%:Occ:Freq:M;s	0-8%:None:L 8-12%:None:M;s Occ,Freq:S;f	0-4%:None:L 4-8%:None:M;s 8+%:None:S;s Rare,Occ,Freq:S;f	None:L Rare:M;f Occ,Freq:S;f
SHACK	0.2-0.6	4.5-5.5	Low	Mod.	High	2.0-4.0	>60	None	B	2-15%:S;w,pk 15+%:S;w,pk,s	2-7%:S;w 7+%:S;s,w	2-15%:M;w 15+%:S;s	2-15%:M;w,s# 15+%:S;s# S;w*	2-4%:M;w 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;b,s 15+%:S;s
SHELLBLUFF	0.6-2.0	4.5-6.5	Low	Mod.	Mod.	3.0-5.0	>60	Occ Freq	B	S;f,w	S;f,w	M;w,f	S;f	S;f	S;f,b
SOCO	2.0-6.0	3.6-5.5	Low	Mod.	High	>6.0	20-40	None	B	8-15%:S;r 15+%:S;r,s	S;p,r,s	8-15%:M;r,s 15+%:S;s	8-15%:M;s# 8-15%:M;r,s* 15+%:S;s	S;s	8-15%:M;s 15+%:S;s
STARR	0.6-2.0	5.1-6.5	Mod.	Mod.	Mod.	>6.0	>60	Rare Occ	C	Rare:M;f Occ:S;f	S;f	Rare:L Occ:M;f	S;f	S;f	Rare:M;ss,b,f Occ:S;f
STASER	0.6-6.0	5.6-7.3	Low	Low	Low	3.0-4.0	>60	Rare Occ	B	Rare:S;w Occ:S;w,f	S;f,w,p	Rare:M;w Occ:M;w,f	S;f	S;f	Rare:M;f Occ:S;f
STATE	0.6-2.0	4.5-6.5	Low	Mod.	High	4.0-6.0	>60	None Rare Occ	B	None:M;w,pk Rare:M;f,w,pk Occ:S;f	None,Rare:S;p Occ:S;p,f	S;cc	None:L# None:M;w* Rare,Occ:S;f	0-4%:None:L 4-6%:None:M;s Rare,Occ:S;f	None:M;b Rare:M;b,f Occ:S;f
STEEKEE	2.0-6.0	4.5-5.5	Low	Low	Mod.	>6.0	20-40	None	C	10-15%:S;r 15+%:S;r,s	S; r,s,p	10-15%:S;r 15+%:S;r,s	10-15%:M;s,r# 15+%:S;s# 10-15%:S;r 15+%:S;r,s	S;s	10-15%:M;r,s 15+%:S;s
STILSON	0.6-2.0	4.5-5.5	Low	Mod.	High	2.5-3.0	>60	None	B	S;w	S;w	S;cc	L# M;w*	0-4%:L 4-8%:M;s	L
SUBLIGNA	6.0-20	4.5-5.5	Low	Low	High	>6.0	>60	Rare Occ	B	Rare:S;pf Occ:S;f,pf	S;p,f	Rare:L Occ:M;f	S;f	S;f	Rare:M;f Occ:S;f
SUCHES	0.6-2.0	4.5-6.0	Low	High	Mod.	2.5-4.0	>60	Occ Freq	B	S;w,f	S;w,f	M;w,f	S;f	S;f	S;f
SUFFOLK	0.6-2.0	3.6-6.0	Low	Mod.	High	>6.0	>60	None	B	0-8%:L 8-15%:M;s 15+%:S;s	0-7%:S;p 7+%:S;p,s	0-15%:S;cc 15+%:S;cc,s	0-8%:L 8-15%:M;S; 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
SULLIVAN	0.6-2.0	5.1-7.3	Low	Low	Low	4.0-6.0	>60	Occ Freq	B	S;f	S;f	M;f,w	S;f	S;f	S;f
SUMTER	0.6-2.0	7.4-8.4	High	Mod.	Low	>6.0	20-40	None	C	1-15%:S;r,pk 15+%:S;r,pk,s	1-7%:S;r 7+%:S;r,s	1-15%:M;r,cl 8-15%:M;r,cl,s 15+%:S;s	1-15%:S;ss 15+%:S;ss,s	1-8%:S;ss 8+%:S;ss,s	1-15%:S;ss,b 15+%:S;ss,b,s
SUNLIGHT	0.6-2.0	4.5-5.5	Low	Low	High	>6.0	10-20	None	D	8-15%:S;r 15+%:S;r,s	S;p,r,s	8-15%:S;r 15+%:S;r,s	8-15%:M;s,r# 15+%:S;s# 8-15%:S;r* 15+%:S;r,s	S;s	8-15%:M;r,s 15+%:S;s
SUNSWEET	0.2-0.6	4.5-5.5	Low	Mod.	Mod.	>6.0	>60	None	C	2-15%:S;pk 15+%:S;pk,s	2-7%:M;s 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;s,b 15+%:S;s
SURRENCY	0.6-2.0	3.6-5.5	Low	High	High	0-0.5	>60	Occ Freq	D	S;w,f	S;w,f,p	S;w,cc	S;w,f	S;w,f	S;w,f

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
SUSQUEHANNA	<0.06	4.5-5.5	High	High	High	>6.0	>60	None	D	1-15%:S;pk 15+%:S;pk,s	1-2%:L 2-7%:M;s 7+%:S;s	1-8%:M;cl 8-15%:M;cl,s 15+%:S;s	1-15%:S;ss 15+%:S;ss,s	1-8%:S;ss 8+%:S;ss,s	1-15%:S;b,ss 15+%:S;b,ss,s
SWAFFORD	0.2-0.6	4.5-5.5	Low	Mod.	Mod.	2.0-3.0	>60	None Rare	C	S;w,pk	S;w	S;w	None:M;w # None:S;w* Rare:S;f# Rare:S;f,w,*	0-4%:None:M;w 4-5%:None:M;w,s Rare:S;f	None:M;w,b Rare:M;w,b,f
SWEETAPPLE	0.2-0.6	4.0-5.5	Low	Mod.	Mod.	>6.0	>60	None	C	2-15%:S;pk 15+%:S;pk,s	2-7%:M;s 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;b,s 15+%:S;s
TAFT	0.06-0.2	4.0-5.5	High	High	High	1.0-2.0	>60	None	C	S;p,w	S;w	S;w	S;w	S;w	S;b
TALBOTT	0.2-0.6	5.1-7.8	Mod.	High	Mod.	>6.0	20-40	None	C	0-15%:S;pk,r 15+%:S;s,pk,r	0-7%:S;r 7+%:S;s,r	0-15%:S;r 15+%:S;s,r	0-15%:M;ss,r,s# 15+%:S;s# S;r	0-4%:M;ss,r 4-8%:M;s,ss,r 8+%:S;s	0-15%:S;b 15+%:S;s,b
TALLADEGA	0.6-2.0	4.5-5.5	Low	Mod.	High	>6.0	20-40	None	C	6-15%:S;r 15+%:S;r,s	S;r,s	6-8%:M;r 8-15%:M;r,s 15+%:S;s	6-15%:M;r# 6-15%:M;r,s* 15+%:S;s	6-8%:M;s 8+%:S;s	6-8%:L 8-15%:M;r 15+%:S;s
TALLAPOOSA	0.6-2.0	4.5-5.0	Low	Low	High	>6.0	10-20	None	C	5-15%:S;r 15+%:S;s,r	5-7%:S;r 7+%:S;s,r	8-15%:S;r 15+%:S;s,r	5-15%:M;r,s# 15+%:S;s# S;r*	5-8%:M;r,s 8+%:S;s	5-8%:M;r 8-15%:M;s,r 15+%:S;s
TANYARD	0.2-2.0	4.5-7.8	Low	Mod.	Mod.	1.5-2.5	>60	Occ Freq	C	S;f,w,pk	S;f,w	S;w	S;f	S;f	S;f,b
TATE	0.6-2.0	5.1-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	2-8%:L 8-15%:M;s 15+%:S;s	2-7%:S;p 7+%:S;s,p	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
TATUM	0.6-2.0	4.5-5.5	Mod.	High	High	>6.0	40-60	None	B	0-8%:M;pk,r 8-15%:M;s,r,pk 15+%:S;s	0-2%:M;p,r 2-7%:M;p,s,r 7+%:S;s	0-8%:M;cl 8-15%:M;s,cl 15+%:S;s	0-8%:M;ss 8-15%:M;s,ss 15+%:S;ss	0-4%:M;ss 4-8%:M;s.ss 8+%:S;s	0-15%:S;b 15+%:S;b,s
TAWCAW	0.06-0.2	4.5-6.5	Mod.	High	High	1.5-2.5	>60	Occ Freq	C	S;f,w,pk	S;f,w	S;w	S;f	S;f	S;f,b
THURMONT	0.6-2.0	4.5-5.5	Low	Mod.	High	4.0-6.0	>60	None	B	2-8%:M;w,pk 8-15%:M;w,pk,s 15+%:S;s	2-7%:M;p,s,w 7+%:S;s	2-8%:M;w 8-15%:M;w,s 15+%:S;s	2-8%:L# 2-8%:M;w* 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
TIDINGS	0.6-2.0	4.5-5.5	Low	Low	High	>6.0	40-60	None	B	2-8%:M;r,pk 8-15%:M;r,pk,s 15+%:S;s	2-7%:M;r,p,s 7+%:S;s	2-8%:M;r 8-15%:M;r,s 15+%:S;s	2-8%:L#M;r,s* 2-15%:M;s#,r* 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:M;b 8-15%:M;s,b 15+%:S;s
TIFTON	0.2-0.6	4.5-5.5	Low	Low	Mod.	3.5-6.0	>60	None	B	M;pk,w	0-2%:M;p 2-7%:M;s,p 7+%:S;s	M;w	L#	0-4%:L 4-8%:M;s	L
TOCCOA	2.0-6.0	5.1-6.5	Low	Low	Mod.	2.5-5.0	>60	None Rare Occ Freq	B	None,Rare:S;w Occ,Freq:S;w,f	None,Rare:S;w,p Occ,Freq:S;w,f,p	None,Rare:M;w Occ:Freq.:M;w,f	None:M;w Rare,Occ,Freq:S;f	None:M;w Rare,Occ,Freq:S;f	None:M;w Rare:M;w,f Occ,Freq:S;f
TOWNLEY	0.06-0.2	3.6-5.5	Mod.	Mod.	High	>6.0	20-40	None	C	2-15%:S;r 15+%:S;s,r	2-7%:S;r 7+%:S;s,r	2-8%:M;r,cl 8-15%:M;s,r,cl 15+%:S;s	2-8%:M;r,ss*ss# 8-15%:M;s,r,ss* 8-15%:M:ss,s# 15+%:S;s	2-4%:M;ss 4-8%:M;s,ss 8+%:S;s	2-15%:M;b 15+%:S;s,b
TOXAWAY	0.6-2.0	5.1-6.0	Low	High	Mod.	0-1.0	>60	Freq	B	S;w,f	S;w,f,p	S;w	S;w,f	S;w,f	S;w,f,b

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
TRANSYLVANIA	0.6-2.0	4.5-6.0	Low	High	High	2.5-3.5	>60	Freq	B	S;f,w	S;f,w	S;f,w	S;f	S;f	S;f,b
TROUP	0.6-2.0	4.5-5.5	Low	Low	Mod.	>6.0	>60	None	A	0-8%:L 8-15%:M;s 15+%:S;s	0-7%:S;p 7+%:S;s,p	0-15%:S;cc 15+%:S;cc,s	0-8%:L 8-15%:M;s 15+%:S;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s 15+%:S;s
TSALI	0.6-2.0	4.0-6.0	Low	Mod.	High	>6.0	10-20	None	C	8-15%:S;r 15+%:S;r,s	S;r,s	8-15%:S;r 15+%:S;r,s	8-15%:M;r,s# 15+%:S;s# 8-15%:S;r* 15+%:S;r,s*	S;s	8-15%:M;r,b,s 15+%:S;s
TUPELO	0.06-0.2	4.5-8.4	High	High	Mod.	1.0-2.0	40-70	None Rare Occ Freq	D	None, Rare:S;w,pk Occ,Freq:S;w,pk,s	None,Rare:S;w Occ,Freq:S;f,w	S;w	None:S;ss,w Rare,Occ,Freq:S;f,w,ss	None:S;ss,w Rare,Occ,Freq:S;f,w,ss	None,Rare:S;ss,b Occ,Freq:S;ss,b,f
TUSQUITTEE	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	2-8%:L 8-15%:M;s 15+%:S;s	2-7%:S;p 7+%:S;s,p	2-8%:L 8-15%:M;s 15+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 8-15%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
VALDOSTA	6.0-2.0	4.5-6.0	Low	Mod.	High	>6.0	>60	None	A	S;pf	S;p	S;cc	L	L	L
VANCE	0.06-0.2	4.5-5.5	Mod.	High	High	>6.0	>60	None	C	2-15%:S;pk 15+%:S;pk,s	2-7%:M;s 7+%:S;s	2-8%:M;cl 8-15%:M;cl,s 15+%:S;s	2-8%:M;ss 8-15%:M;ss,s 15+%:S;s	2-4%:M;ss 4-8%:M;ss,s 8+%:S;s	2-15%:S;b 15+%:S;b,s
VARINA	0.06-0.2	4.5-5.5	Low	Mod.	High	4.0-5.0	>60	None	C	S;pk	0-2%:L 2-7%:M;s 7+%:S;s	2-8%:M;cl,w 8-10%:M;s,cl,w	0-8%:L# 8-10%:M;s# 0-8%:M;w* 8-10%:M;w,s*	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:M;b 8-10%:M;s,b
VAUCLUSE	0.06-0.6	3.6-5.5	Low	Low	High	>6.0	>60	None	C	2-15%:S;pk 15+%:S;pk,s	2-7%:S;p 7+%:S;s,p	2-15%:S;cc 2-8%:S;cc 15+%:S;s,cc	2-8%:L 8-15%:M;s 15+%:S;s	2-4%:L 4-8%:M;s 8+%:S;s	2-8%:L 8-15%:M;s 15+%:S;s
WAGRAM	0.6-2.0	4.5-6.0	Low	Low	High	>6.0	>60	None	A	0-8%:L 8-15%:M;s	0-7%:S;p 7+%:S;s	0-8%:L 8-15%:M;S;	0-8%:L 8-15%:M;s	0-4%:L 4-8%:M;s 8+%:S;s	0-8%:L 8-15%:M;s
WAHEE	0.06-0.2	3.6-5.5	Mod.	High	High	0.5-1.5	>60	None Rare Occ Freq	D	None,Rare:S;w,pk Occ,Freq:S;w,f,pk	0-2%:None,Rare:L 2-4%:None,Rare:M;s Occ,Freq:S;f	S;w	None:S;w Rare,Occ,Freq:S;w,f	None:S;w Rare,Occ,Freq:S;w,f	None,Rare:S;b,w Occ,Freq:S;f,b,w
WATAUGA	0.6-2.0	4.5-6.0	Low	Mod.	Mod.	>6.0	>60	None	B	5-8%:L 8-15%:M;s 15+%:S;s	6-7%:M;r,s,p 7+%:S;s	5-8%:L 8-15%:M;s 15+%:S;s	5-8%:S; 8-15%:M;s 15+%:S;s	5-8%:M;s 8+%:S;s	5-15%:S;b 15+%:S;s,b
WAX	0.06-2.0	4.5-5.5	Low	Mod.	Mod.	1.5-3.0	>60	Occ Freq	C	S;pk,f	S;w,f	S;w	S;f,w	S;f	S;f
WAYNESBORO	0.6-2.0	4.5-5.5	Mod.	High	High	>6.0	>60	None	B	2-8%:M;pk 8-15%:M;s,pk 15+%:S;s	2-7%:M;s,p 7+%:S;s	2-8%:M;cl 8-15%:M;s,cl 15+%:S;s	2-8%:M;ss 8-15%:M;s,ss 15+%:S;s	2-4%:M;ss 4-8%:M;s,ss 8+%:S;s	2-8%:M;b,ss 8-15%:M;s,b,ss 15+%:S;s
WEDOWEE	0.6-2.0	4.5-5.5	Mod.	Mod.	High	>6.0	>60	None	B	0-2%:M;pk 8-15%:M;s,pk 15+%:S;s	0-2%:M;b 2-7%:M;s,p 7+%:S;s	0-8%:M;cl 8-15%:M;s,cl 15+%:S;s	0-8%:M;ss 8-15%:M;s,ss 8+%:S;s	0-4%:M;ss 4-8%:M;s,ss 8+%:S;s	0-8%:M;b,ss 8-15%:M;s,b,ss 8+%:S;s
WEHADKEE	0.6-2.0	4.5-6.5	Low	High	Mod.	0-0.5	>60	Occ Freq	D	S;f,w	S;f,w	S;w	S;f,w	S;f,w	S;f,w
WESTON	0.06-6.0	4.5.5.0	Low	High	High	0-1.0	>60	None	D	S;w,pk	S;p,w	S;cc,w	S;w	S;w	S;w

SOIL SERIES INTERPRETATIONS

ESTIMATED SOIL PROPERTIES										LIMITATION OF SOILS FOR URBAN USES					
				CORROSIVITY		DEPTH TO:									
SOIL SERIES	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)	FLOOD FRE-QUENCY	HYDRO-GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
WHITWELL	0.6-2.0	4.5-5.5	Low	Mod.	Mod.	2.0-3.0	>60	None Rare Occ	C	None,Rare:S;w Occ:S;w,f	None,Rare:S;w Occ:S;f,w	S;w	None:M;w# None:S;w* Occ:S;f,w	0-4%:None:M;w 4-6%:None:M;w,s Rare,Occ:S;f	None:M;w Rare:M;w,f Occ:S;f
WICKHAM	0.6-2.0	4.5-6.0	Low	Mod.	High	>6.0	>60	None Rare	B	0-8%:L 8-15%:M;s Rare:M;f	0-7%:M;p,s 7+%:S;s Rare:S;f	0-8%:L 8-15%:M;s	0-8%:M;ss 8-15%:M;s,ss Rare:S;f	0-4%:L 4-8%:M;s 8+%:S;s Rare:S;s,f	0-8%:L 8-15%:M;s Rare:M;f
WICKSBURG	0.06-0.2	4.5-5.5	Mod.	High	High	>6.0	>60	None	B	S;pk,pf	0-7%:S;p 7+%:S;s,p	0-8%:M;cc 8-12%:M;s,cc	0-8%:M;ss 8-12%:M;s,ss	0-4%:L 4-8%:M;s 8-12%:S;s	0-8%:L 8-12%:M;s
WILKES	0.2-0.6	5.1-7.8	Mod.	Mod.	Mod.	>6.0	10-20	None	C	2-15%:S;r 15+%:S;s,r	2-7%:S;r 7+%:S;s,r	2-15%:S;r 15+%:S;s,r	2-15%:M;ss,r# 15+%:S;s# 2-15%:S;r* 15+%:S;r,s*	2-8%:M;r,ss 8+%:S;s	2-8%:M;r,ss 8-15%:M;s,r,ss 15+%:S;s
WOLFTEVER	0.2-0.6	4.5-5.5	Mod.	High	Mod.	2.5-3.5	>60	None Rare Occ	C	None, Rare:S;w,pk Occ:S;f,w,pk	0-7%:None:S;w 7+%:None:S;w,s 0-7%Rare,Occ:S;w,f 7+%Rare,Occ:S;l,w,s	None,Rare:M;cl,w Occ:M;cl,w,f	0-8%:None:M;w,ss 8-15%:None:M;w,ss,s Rara,Occ:S;f	0-8%:None:M;ss 8+%:None:S;s 0-8%:Rare,Occ:S;f 8+%:Rare:,Occ:S;f,s	None,Rare:S;b Occ:S;b,f
WORSHAM	<0.06	4.5-5.5	Mod.	High	Mod.	0-1.0	>60	None	D	S;pk,w	0-2%:L 2-7%:M;s 7+%:S;s	S;w	S;w	S;w	S;w,b
ZION	0.06-0.6	4.5-7.3	High	High	Mod.	>6.0	20-40	None	C	2-15%:S;r,pk 15+%:S;r,pk,s	2-7%:S;r 7+%:S;r,s	2-15%:S;r 15+%:S;r,s	2-15%:S;ss# 15+%:S;ss,s# 2-15%:S;r,ss* 15+%:S,r,ss,s*	2-8%:S;ss 8+%:S;s,ss	2-15%:S;b,ss 15+%:S;b,ss,s

SOIL SERIES INTERPRETATIONS

SOIL SERIES	ESTIMATED SOIL PROPERTIES									LIMITATIONS OF SOILS FOR URBAN USES					
	PERMEABILITY (In./Hrs.)	SOIL REACTION (pH)	SHRINK-SWELL POTENTIAL	CORROSIVITY		DEPTH TO		FLOOD FREQUENCY	HYDRO GROUP	SEPTIC TANK ABSORPTION FIELDS	SEWAGE LAGOON AREAS	SHALLOW EXCAVATIONS	DWELLINGS *w/basement #w/o basement	SMALL COMMERCIAL BUILDINGS	LOCAL ROADS AND STREETS
				STEEL	CONCRETE	WATER TABLE (Ft.)	BEDROCK (In.)								
Allanton	2.00-6.00	3.6-5.5	Low	High	High	-2.0-0.0	>60	None	D	S;p	S;p	S;cc,p	S;p	S;p	S;p
Arkabutla	0.60-2.00	4.5-5.5	Low	High	High	1.0-1.5	>60	Occasional	C	S;f,w	S;f,w	S;w	S;f,w	S;f,w	S;b,f
Badin	0.60-2.00	3.5-6.5	Low	High	High	>6.0	20-40	None	B	2-10%:S;r 10+%:S;r,s	2-10%:S;r 10+%:S;r,s	M;r,cl	M;r,ss* M;ss#	M;ss,s	S;b
Bethera	0.06-0.60	3.6-6.0	Moderate	High	High	0.0-1.5	>60	Occasional	D	S;f,w,pk	S;f,w	S;w	S;f,w	S;f,w	S;b,w,f
Blaney	0.20-0.60	4.5-6.0	Low	Moderate	High	>6.0	>60	None	B	S;pk,pf	S;p	S;cc	L	M;s	L
Buckhead	0.60-2.00	4.5-6.5	Low	Moderate	High	>6.0	>60	None	B	M;s	S;p,s	S;cc	M;s	S;s	M;s
Cheoah	2.00-6.00	3.5-5.5	Low	Low	High	>6.0	40-60	None	B	5-15%:M;r,s, 15+%:S;s	S;p,s	M;s	M;s	S;s	M;s
Chestnut	2.00-6.00	3.6-6.0	Low	Low	High	>6.0	20-40	None	B	S;r,s	S;p,r,s	S;s	S;s	S;s	S;s
Craigsville	2.00-20.00	4.5-5.5	Low	Low	Moderate	>6.0	>60	Frequent	B	S;f,pf,st	S;p,f,st	S;cc,st	S;f,st	S;f,st	S;f,st
Fork	0.60-2.00	4.5-7.3	Low	High	High	1.0-2.0	>60	Occasional	C	S;f,w	S;f,w	S;w	S;f,w	S;f,w	S;f
Jefferson	2.00-6.00	4.5-5.5	Low	Moderate	High	>6.0	>60	None	B	S;s	S;p,s	S;s	S;s	S;s	S;s
Ketona	0.06-0.20	6.1-8.4	High	High	Moderate	0.5-1.0	40-72	Frequent	D	S;f,w,pk	S;f	S;w	S;f,w,ss	S;f,w,ss	S;ss,b,w
Kingsferry	0.6-2.00	3.6-5.5	Low	High	High	0.0-0.5	>60	None	B/D	S;w,pf	S;p,w	S;cc,w	S;w	S;w	S;w
Lloyd	0.60-2.00	4.5-6.5	Low	Moderate	Moderate	>6.0	>60	None	B	2-15%:M;pk,s 15+%:S;s	2-6%:M;p,s 6+%:S;s	M;cl,s	L	M;s	M;b
Pageland	0.20-0.60	3.6-6.0	Low	Moderate	Moderate	1.5-3.0	20-40	None	C	S;r,w,pk	S;r,w	S;w	S;w* MS;w#	M;w	S;b
Panama	0.60-2.00	4.5-6.0	Low	Moderate	High	3.5-5.0	>80	None	B	S;w,pk,s	S;s	S;s	S;s	S;s	S;s
Pigeonroost	0.60-2.00	3.5-6.0	Low	Moderate	High	>6.0	20-40	None	B	S;r	S;r,s	M;r,s	M;r,s* M;s#	S;s	M;s
Rawlings	0.60-6.00	4.5-7.3	Low	Moderate	High	>6.0	20-40	None	B	S;r	S;p,r,s	S;r	S;r* M;s,r#	S;s	M;r,s
Saunook	0.60-2.00	3.6-6.5	Low	Low	High	>6.0	>60	None	B	S;s	S;p,s	S;s	S;s	S;s	S;s
Sedgefield	0.06-0.20	4.5-6.5	Moderate	High	Moderate	1.0-1.5	>60	None	C	S;w,pk	S;s	S;w	S;w,ss	S;w,ss,s	S;ss,b
Shelocta	0.60-2.00	4.5-5.5	Low	Low	High	>6.0	>40	None	B	M;pk,s	S;p,s	M;s	M;s	S;s	M;s
Sipsey	0.60-2.00	4.5-6.0	Low	Moderate	High	>6.0	20-40	None	B	S;r,s	S;p,r,s	M;r,s	M;r,s* M;s#	S;s	M;s
Wake	6.00-20.00	4.5-6.0	Low	Moderate	Moderate	>6.0	8-20	None	D	2-10%:S;r 10+%:S;r,s	S;p,r	S;r	S;r	S;r	S;r
Wateree	2.00-6.00	4.5-6.0	Low	Low	High	>6.0	20-40	None	B	S;r	S;p,r	S;cc	M;r* L#	M;s	L
Wynott	0.06-0.20	4.5-6.5	Low	High	Moderate	>6.0	20-40	None	C	S;r,pk,s	S;p,r,s	S;s	S;ss,s	S;ss,s	S;ss,b,s

APPENDIX B-2
Soil Loss Predictions

APPENDIX B-2

Estimating Soil Erosion With the Universal Soil Loss Equation (USLE)

Scientific planning for soil erosion reduction requires knowledge of the relations between those factors that cause loss of soil and water and those that help to reduce such losses. The Universal Soil Loss Equation (USLE) is used to estimate the quantity of soil erosion (sheet and rill) caused by water and to design water erosion control systems.

Developing equations to calculate field soil loss began about 1940 in the Corn Belt. The USLE was developed by the USDA Agricultural Research Service (ARS) and 49 research locations across the U.S. contributed more than 10,000 plot years of basic runoff and soil loss data to ARS for summarizing and overall statistical analyses. Since the early 1960's, the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service) and others have used the USLE to predict soil losses and to plan conservation treatment.

The USLE permits methodical decision making in soil conservation planning on a site basis. The USLE was designed to predict long-term average annual soil losses from sheet and rill erosion on given field slopes under specified land use and management.

Many variables and interactions influence sheet and rill erosion. The USLE groups these variables under six major erosion factors, the product of which represents the average annual soil loss.

The soil loss predicted by the USLE is that of soil moved off the particular slope segment in sheet and rill erosion. Sheet erosion is defined as the removal of layer of soil from the land surface by the action of rainfall and runoff. It is the first stage in water erosion. This is followed by rill erosion. Rills are small, occur in cropland situations, are removed by normal farming operations, and usually do not reoccur in the same place.

Widespread use of the USLE has substantiated its usefulness and validity for cropland, pasture and hay land, forest land and for non-agricultural conditions such as construction sites.

The USLE does not predict sediment deposition or soil erosion caused by gully, streambank, streambed, mass movement, or wind erosion.

Detailed instructions for using the USLE are in Agriculture Handbook No.537, USDA, *Predicting Rainfall Erosion Losses.*

The USLE is:

$$A = R\,K\,L\,S\,C\,P$$

A is the computed average annual soil loss in tons per acre per year.

R is the rainfall factor. The R factor value quantifies the raindrop impact effect. Rainfall energy is directly related to rain intensity. The energy of a rainstorm is a function of the amount of rain and of all the storm's component intensities. Median raindrop size increases with rain intensity and the terminal velocity of free-falling waterdrops increase with increased dropsize.

The R factors assigned represent 22-year average annual values for the delineated areas. In Georgia, USLE R factor values range from 250 to 425. They are listed by county on Table B-2.1, p. B-2-4.

K is the soil erodibility factor. Some soils erode more readily than others even when all other factors are the same. The K factors assigned to soils found in Georgia range from 0.05 to 0.43 and may be obtained from the USDA Natural Resources Conservation Service.

LS is the topographic factor. Both the length and the steepness of the land slope substantially affect the rate of soil erosion by water.

Slope length is defined as the distance from the point of origin of overland flow of water to the point where either the slope gradient decreases enough that deposition begins, or the runoff water enters a well-defined channel (terrace channel, concentrated flow area, gully, ditch, grass waterway, etc.). It is not the total length or width of the field in most cases.

The two effects have been evaluated separately in research. In field applications, however, the two are considered as a single topographic factor. LS factors are listed in Table B-2.2, p. B-2-6.

C is the cover and management factor. C is the ratio of soil loss from land with a specified type and amount of cover to the corresponding loss from a clean tilled, continuous fallow site. The C for a continuous fallow condition is 1.00. Any amount of ground cover present (canopy or residue) reduces the C factor and the soil loss for the site. C factor values are listed for different land uses in Table B-2.3 through B-2.5, p. B-2-7 through B-2-10.

P is the support practice factor. P is the ratio of soil loss with a specific support practice to the corresponding loss with up-and-down slope farming. The maximum P factor value is 1.00. Conservation practices that reduce the P factor are contour farming, cross-slope farming, and stripcropping. P is used only in USLE calculations for row cropped land. In all other land uses, the P is always 1.00.

Soil Loss Tolerance

The term "soil loss tolerance", sometimes called the "T" value, denotes the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely. Any cropping and management combination for which the predicted erosion rate is less than the tolerance may be expected to provide satisfactory erosion control. Soil loss tolerances range from 1 to 5 tons/acre/year for soils of the U.S.

Soil loss limits are sometimes established primarily for water quality control. The criteria for defining field soil loss limits for this purpose are not the same as those for tolerances designed to preserve cropland productivity. If the soil loss tolerance designed for sustained cropland productivity fails to attain the desired water quality standard, flexible limits that consider other factors should be developed rather than uniformly lowering the soil loss tolerance. Limits of sediment yield would provide more uniform water quality control than lowering the limits on soil movement from field slopes.

Sample Problem #1

Present Condition (Before Treatment):

Location: Cobb County, GA (R = 300)
Land Use: Cropland, Soybeans, Conventionally Tilled (C = 0.46)
Soil Type: Cecil sandy loam (K = 0.28)
Length of Slope: 120 feet
Slope: 5% (LS = 0.59)
Row Pattern: Up and Down Hill Farming (P = 1.0)

A = RKLSCP
A = 300 x 0.28 x 0.59 x 0.46 x 1.0 = 22.8 tons/acre/year

Future Condition (After Treatment):

Location: Cobb County, GA (R = 300)
Land Use: Tall fescue pasture, 95 - 100% cover (C = 0.003)
Soil Type: Cecil sandy loam (K = 0.28)
Length of Slope: 120 feet
Slope: 5% (LS = 0.59)

A = RKLSCP
A = 300 x 0.28 x 0.59 x 0.003 x 1.0 = 0.15 tons/acre/year

Sample Problem #2

Present Condition (Before Treatment):

Location: Thomas County, GA (R = 400)
Land Use: Disturbed Construction Site (C = 1.0)
Soil Type: Orangeburg sandy loam (K = 0.24)
Length of Slope: 120 feet
Slope: 20% (LS = 4.47)

A = RKLSCP
A = 400 x 0.24 x 4.47 x 1.0 x 1.0 = 429 tons/acre/year

Future Conditon: (After Treatment):

Location: Thomas County, GA (R = 400)
Land Use: Weeping lovegrass (60% cover) (C = 0.042)
Soil Type: Orangeburg sandy loam (K = 0.24)
Length of Slope: 120 feet
Slope: 20% (LS = 4.47)

A = RKLSCP
A = 400 x 0.24 x 4.47 x 0.042 x 1.0 = 18 tons/acre/year

Additional Soil Erosion Prediction Models

Revised Universal Soil Loss Equation (RUSLE)

The revised Universal Soil Loss Equation (RUSLE) has been developed by USDA/ARS. The RUSLE retains the six factors of the USLE, but the technology has been altered and new data has been added. The technology has been computerized to assist with the calculations. Soil loss calculations can be made with the RUSLE for some conditions not included in the USLE if the fundamental information is available.

Copies of the RUSLE program may be purchased from:

Soil and Water Conservation Society of America
7515 N.E. Ankeny Road
Ankeny, Iowa 50021-9764
Phone: (515) 289-2331
1-800-THE-SOIL

Water Erosion Prediction Project (WEPP)

The development of a new generation of technology for predicting water erosion is under way by a USDA team in the Water Erosion Prediction Project (WEPP). Working with other agencies and academic institutions, the goal of the WEPP is a process oriented model or family of models that are conceptually superior to the lumped model RUSLE and are more versatile as to the conditions that can be evaluated. The WEPP technology is expected to replace RUSLE sometime in the future.

Table B-2.1. – Rainfall-Erosion Index Factor "R" Values

County	R
Appling	350
Atkinson	325
Bacon	350
Baker	375
Baldwin	275
Banks	300
Barrow	275
Bartow	300
Ben Hill	325
Berrien	350
Bibb	300
Bleckley	300
Brantley	375
Brooks	375
Bryan	350
Bulloch	325
Burke	275
Butts	300
Calhoun	375
Camden	400
Candler	300
Carroll	325
Catoosa	275
Charlton	375
Chatham	350
Chattahoochee	350
Chattooga	300
Cherokee	300
Clarke	275
Clay	375
Clayton	300
Clinch	350
Cobb	300
Coffee	325
Colquitt	350
Columbia	250
Cook	350
Coweta	325
Crawford	300
Crisp	325
Dade	275
Dawson	275
Decatur	425
DeKalb	300
Dodge	300
Dooly	325
Dougherty	350
Douglas	300
Early	400
Echols	350
Effingham	350
Elbert	250
Emanuel	300
Evans	325
Fannin	275
Fayette	300
Floyd	300
Forsyth	275
Franklin	300
Fulton	300
Gilmer	275
Glascock	250
Glynn	400
Gordon	300
Grady	400
Greene	250
Gwinnett	300
Habersham	300
Hall	275
Hancock	250
Haralson	325
Harris	325
Hart	275
Heard	325
Henry	300
Houston	300
Irwin	325
Jackson	275
Jasper	275
Jeff Davis	325
Jefferson	275
Jenkins	300
Johnson	300
Jones	275
Lamar	300
Lanier	350
Laurens	300

County	R
Lee	350
Liberty	350
Lincoln	250
Long	350
Lowndes	350
Lumpkin	275
McDuffie	250
McIntosh	400
Macon	325
Madison	275
Marion	325
Meriwether	325
Miller	400
Mitchell	375
Monroe	300
Montgomery	300
Morgan	275
Murray	275
Muscogee	325
Newton	300
Oconee	275
Oglethorpe	250
Paulding	300
Peach	300
Pickens	275
Pierce	350
Pike	325
Polk	300
Pulaski	300
Putnam	275
Quitman	375
Rabun	300
Randolph	350
Richmond	250
Rockdale	300
Schley	325
Screven	300
Seminole	425
Spalding	300
Stephens	300
Stewart	350
Sumter	325
Talbot	325
Taliaferro	250
Tattnall	325
Taylor	325
Telfair	325
Terrell	350
Thomas	400
Tift	350
Toombs	325
Towns	300
Treutlen	300
Troup	325
Turner	325
Twiggs	300
Union	300
Upson	325
Walker	275
Walton	275
Ware	350
Warren	250
Washington	275
Wayne	375
Webster	350
Wheeler	300
White	300
Whitfield	275
Wilcox	325
Wilkes	250
Wilkinson	275
Worth	350

Table B-2.2 – Slope-Effect Table (Topographic Factor, LS)

Percent Slope	Slope Length in Feet																		
	10	20	40	60	80	100	120	140	160	180	200	250	300	350	400	500	600	800	1000
0.5	0.05	0.06	0.08	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.20
1.0	0.06	0.08	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.24	0.26
2.0	0.10	0.12	0.15	0.17	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.28	0.29	0.31	0.33	0.34	0.38	0.40
3.0	0.14	0.18	0.22	0.25	0.27	0.29	0.30	0.32	0.33	0.34	0.35	0.38	0.40	0.42	0.44	0.47	0.49	0.54	0.57
4.0	0.16	0.21	0.28	0.33	0.37	0.40	0.43	0.46	0.48	0.51	0.53	0.58	0.62	0.66	0.70	0.76	0.82	0.92	1.01
5.0	0.17	0.24	0.34	0.41	0.48	0.54	0.59	0.63	0.68	0.72	0.76	0.85	0.93	1.00	1.07	1.20	1.31	1.52	1.69
6.0	0.21	0.30	0.43	0.52	0.60	0.67	0.74	0.80	0.85	0.90	0.95	1.06	1.17	1.26	1.35	1.50	1.65	1.90	2.13
7.0	0.26	0.37	0.52	0.64	0.74	0.83	0.90	0.98	1.04	1.11	1.17	1.30	1.43	1.54	1.65	1.84	2.02	2.23	2.51
8.0	0.31	0.44	0.63	0.77	0.89	0.99	1.09	1.17	1.25	1.33	1.40	1.57	1.72	1.86	1.98	2.22	2.43	2.81	3.14
9.0	0.37	0.52	0.74	0.91	1.05	1.17	1.29	1.39	1.48	1.57	1.66	1.86	2.03	2.20	2.35	2.62	2.87	3.19	3.57
10.0 (10:1)	0.43	0.61	0.87	1.06	1.23	1.37	1.50	1.62	1.73	1.84	1.94	2.17	2.37	2.56	2.74	3.06	3.36	3.87	4.33
12.0	0.57	0.81	1.14	1.40	1.61	1.80	1.98	2.14	2.28	2.42	2.55	2.85	3.13	3.38	3.61	4.04	4.42	5.10	5.71
14.0	0.73	1.03	1.45	1.78	2.05	2.29	2.51	2.72	2.90	3.08	3.25	3.63	3.98	4.29	4.59	5.13	5.62	6.49	7.26
16.0	0.90	1.27	1.80	2.20	2.54	2.84	3.11	3.36	3.59	3.81	4.01	4.49	4.92	5.31	5.68	6.35	6.95	8.03	8.98
18.0	1.09	1.54	2.17	2.66	3.07	3.43	3.76	4.06	4.34	4.61	4.86	5.43	5.95	6.43	6.87	7.68	8.41	9.71	10.86
20.0 (5:1)	1.29	1.82	2.58	3.16	3.65	4.08	4.47	4.83	5.16	5.47	5.77	6.45	7.07	7.63	8.16	9.12	9.99	11.54	12.90
25.0 (4:1)	1.86	2.63	3.73	4.56	5.27	5.89	6.45	6.97	7.45	7.90	8.33	9.31	10.20	11.02	11.78	13.17	14.43	16.66	
30.0	2.52	3.56	5.03	6.16	7.11	7.95	8.71	9.41	10.06	10.67	11.25	12.58	13.78	14.88	15.91	17.79	19.48	22.50	
33.33 (3:1)	2.99	4.22	5.97	7.32	8.45	9.45	10.35	11.18	11.95	12.67	13.36	14.93	16.36	17.67	18.89	21.12			
40.0 (2½:1)	4.00	5.66	8.00	9.80	11.32	12.65	13.86	14.97	16.01	16.98	17.90	20.01	21.92	23.67	25.31	28.30			
50.0 (2:1)	5.64	7.97	11.27	13.81	15.94	17.82	19.53	21.09	22.55	23.91	25.21	28.18	30.87	33.35	35.65	39.86			
60.0	7.32	10.35	14.64	17.93	20.71	23.15	25.36	27.39	29.29	31.06	32.74	36.61	40.10	43.31	46.30	51.77			
66.67 (1½:1)	8.43	11.93	16.87	22.66	23.85	26.67	29.21	31.56	33.73	35.78	37.72	42.17	46.19	49.89	53.34	59.63			

Table B-2.3 – CROP MANAGEMENT "C" FACTORS FOR GEORGIA
(All Medium Yields)

Rotation Cycle (Years)	Crop Sequence	Conventional Tillage Systems		Conservation Tillage Systems				Combinations of Tillage Systems					
				No-till[1] Systems	All Crops Conservation Tilled			Summer Crop Conven. & Winter Cons. Till.			Summer Crop Cons. Till. & Winter Conventional		
		RdL	RdR		30%[2]	50%	70%	30%	50%	70%	30%	50%	70%
1	Corn	0.33	0.50	0.07	0.15	0.11	0.07	–[4]	–	–	–	–	–
1	Corn & Small Grain	0.31	0.44	0.04	0.16	0.11	0.08	0.30	0.29	0.28	0.17	0.14	0.13
1	Cotton	0.48	0.54	0.23	0.25	–	–	–	–	–	–	–	–
1	Cotton & Small Grain	0.45	0.52	0.18	0.22	–	–	0.48	–	–	0.24	0.22	0.21
1	Grain Sorghum	0.37	0.55	0.12	0.22	0.17	0.12	–	–	–	–	–	–
1	Grain Sorghum & Small Grain	0.32	0.42	0.06	0.15	0.10	0.07	0.30	0.29	0.28	0.16	0.13	0.11
1	Peanuts	0.46	0.58	0.27	0.27	–	–	–	–	–	–	–	–
1	Peanuts & Small Grain	0.38	0.44	0.07	0.16	0.11	–	0.40	–	–	0.19	0.16	0.13
1	Soybeans	0.46	0.60	0.27	0.27	–	–	–	–	–	–	–	–
1	Soybeans & Small Grain	0.41	0.54	0.08	0.19	0.12	–	0.35	–	–	0.23	0.19	0.17
1	Tobacco	0.41	0.44	0.17	0.21	–	–	–	–	–	–	–	–
1	Tobacco & Small Grain	0.41	0.43	0.16	0.23	0.19	–	0.35	0.34	–	0.26	0.22	0.20
1	Millet	0.27	0.52	0.09	0.13	0.11	0.09	–	–	–	–	–	–
1	Millet & Small Grain	0.25	0.30	0.05	0.10	0.08	0.05	0.22	0.21	0.20	0.14	0.12	0.10
1	Small Grain[3]	0.13	0.26	0.07	0.09	0.08	0.07	–	–	–	–	–	–

[1] The soil is left undisturbed prior to all plantings. Planting is completed in a narrow seedbed. Weeds are controlled primarily with herbicides.

[2] Percent of soil surface covered by crop residues immediately following planting.

[3] Followed by weeds.

[4] Does not apply, or either the crops do not provide this much residue.

NOTE: Add 0.05 to the "C" value when the cover crop is grazed. For example: "C" for Corn & Small Grain (conven.) = 0.31
If grazed, add 0.05 +0.05
Use "C" value of 0.36

Table B-2.4 – AVERAGE ANNUAL "C" FACTOR VALUES
"C" Factors for Undisturbed Forest Land[1]

Percent of area covered by canopy of trees and undergrowth	Percent of area covered by duff	Factor "C" [2]
100 - 75	100-90	.0001 - .001
70 - 45	85-75	.002 - .004
40 - 20	70-40	.003 - .009

---

[1] Where effective litter cover is less than 40 percent or canopy cover is less than 20 percent, use factors from Table II. Also use Table II where woodlands are being grazed, harvested, or burned.

[2] The ranges listed in "C" values are caused by ranges in the specified forest litter and canopy covers and by variations in effective canopy heights. Use lower range where heavy ground litter is present or where low understory vegetation is dense.

Table B-2.5 – AVERAGE ANNUAL "C" FACTOR VALUES

Factors for Perennial Pasture, Idle Land, or Grazed Woodland[1]

Vegetative Canopy			Cover That Contacts the Surface					
			Percent Ground Cover					
Type and Height of Raised Canopy[2]	**Canopy Cover[3] %**	**Type[4]**	**0**	**20**	**40**	**60**	**80**	**95-100**
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.25	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5m or 20 inches fall height)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or brushes (2m or 79 inches fall height)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.09	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable low brush (4m or 157 inches fall height)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

---

[1] The listed "C" values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Average fall height of waterdrops from canopy to soil surface: m = meters.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: Cover at surface is grass, grasslike plants, or decaying compacted duff.

W: Cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

Table B-2.5 – "C" FACTORS AND SLOPE LENGTHS FOR CONSTRUCTION SITES

Type Cover	Tons/Acre	Slope Per Cent	C Value	Maximum Allowable Slope Length
Bare (No cover)	–	All	1.0	–
Straw[1] [2] (Tied down by anchoring equipment)	1	5	.20	200
		6-10	.20	100
	1.5	5	.12	300
		6-10	.12	150
	2.0	5	.06	400
		6-10	.06	200
		11-15	.07	150
		16-20	.11	100
		21-25	.14	75
		26-50	.18	35
Crushed Stone	60	15	.07	200
(Road gravel)	135	15	.05	200
		16-20	.05	150
		21-33	.05	100
		34-50	.05	75
	240	20	.02	300
		21-33	.02	200
Wood Chips[2]	7	15	.08	75
		16-20	.08	50
	12	15	.05	150
		16-20	.05	100
		21-33	.05	75
	25	15	.02	200
		16-20	.02	150
		21-33	.02	100

Seeding	Mulch	C Value for Cover Stages 3-5 weeks	C Value for Cover Stages 4-10 weeks[3]
Temporary or (permanent with fast-growing grass)	0	.50 - .70	.05 - .10
	1 T/Ac Straw	.20	.07
	1 1/2 t/Ac Straw	.12	.05

Permanent Seedings - Remainder of first year - .05
Permanent Seedings - Second Year - .01
Sod - Immediately - .01

---

[1] Double the C value if straw not anchored to control rilling beneath the mulch on soils having a K value greater than .30 or slopes steeper than 10 per cent.

[2] The effective life of all mulches except stone will vary from 2 months to 6 months. Thereafter, the C value for mulches reverts to 1.0 if vegetation is not established.

[3] The plants used, time of seeding, temperature, moisture, and fertility all affect establishment time of vegetation.

GUIDE FOR DEVELOPING THE SOIL ERODIBILITY FACTOR (K) IN THE UNIVERSAL SOIL LOSS EQUATION

The soil erodibility factor (K) used in the universal soil loss equation is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. It is a value determined experimentally for selected benchmark soils. Based on knowledge of the behavior of soil properties and their interactions, these data are synthesized and values assigned to other kinds of soil.

A single K value can be given the dominant textural phase of a soil series if the erosion potential is about the same for all horizons and textural phases of that series. Where horizons or textural phases of a series differ greatly in erosion potential, say two or more K value classes, more than one K value needs to be assigned to the named kind of soil.

K values that have been obtained experimentally range from .01 to .64. For ease of use, twelve K value classes are used as follows: .10,.15,.17,.20,.24, .28, .32,.37,.43,.49,.55 and .64.

In developing K values for soils, use all applicable data. In additon, consider the following soil properties that have been found to affect soil erodibility:

1. Soil texture, especially percent of silt plus very fine sand.
2. Percent of sand greater than 0.10 mm.
3. Soil organic matter content.
4. Soil structure (type, grade).
5. Soil permeability.
6. Clay mineralogy.
7. Coarse fragments in soil layer being evaluated.

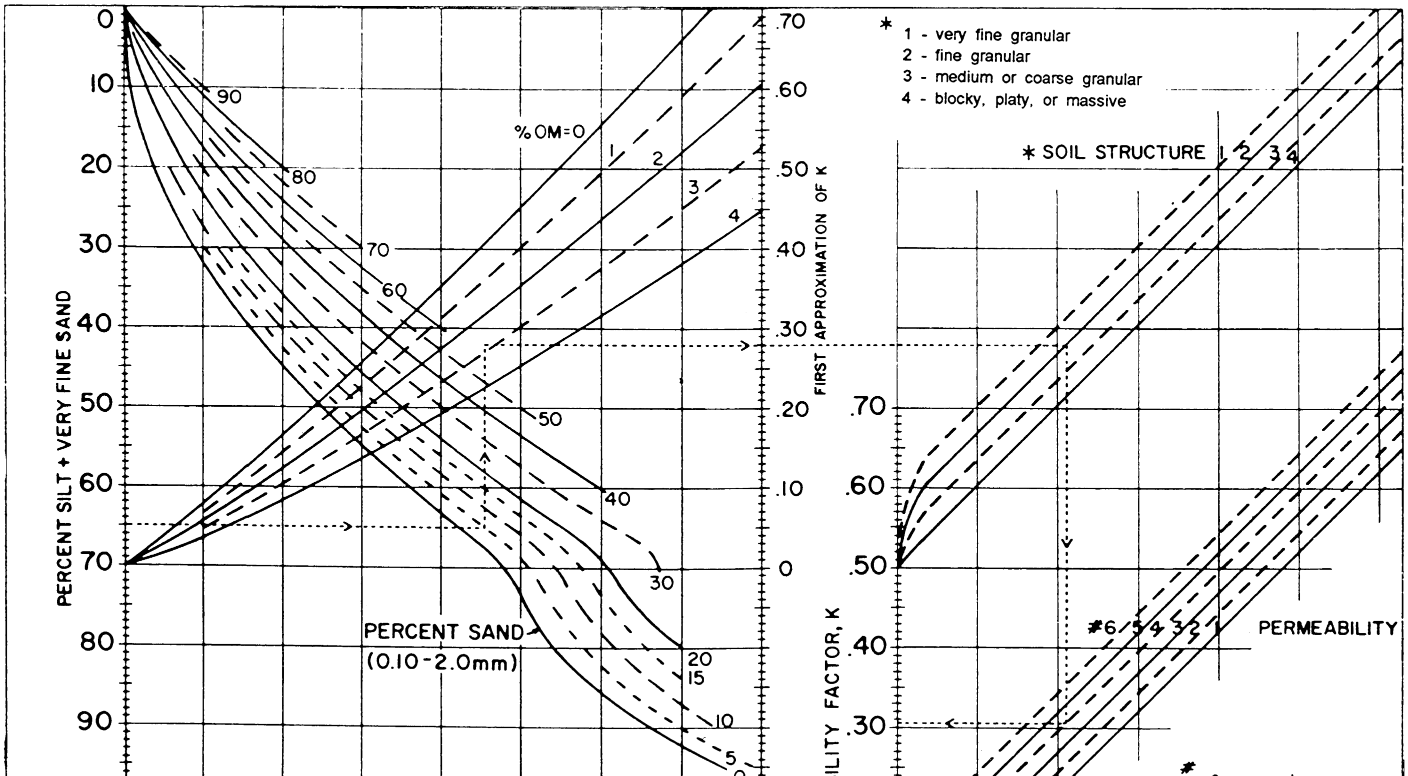
Rainfall intensity, distribution, amount, length and steepness of slope, vegetative cover and erosion control practices all influence soil erodibility but these are taken care of by other variables in the equation.

The Agricultural Research Service has developed a nomograph which shows the influence of various selected soil properties on K values (42). A copy of this nomograph is attached for information and guidance.

When using the nomograph, care should be taken to select those soil properties that are most representative of the horizon being considered. For horizons having organic matter in excess of 4 percent, do not extrapolate - use the 4 percent curve.

The K values derived from the nomograph must be adjusted for coarse fragments. K values for soils high

Figure B-2.1 – SOIL ERODIBILITY NOMOGRAPH



PROCEDURE: With appropriate data, enter scale at left and proceed to points representing the soil's % sand (0.10 - 2.0mm), % organic matter, structure, and permeability, in that sequence. Interpolate between plotted curves. The dollted line illustrates procedure for a soil having: sf + vsf 65%, sand 5%, OM 2.8%, structure 2, permeability 4. Solution: K = 0.31

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in coarse fragments (gravelly, chanery, shaly, slaty. cherty, cobbly, or flaggy) are reduced by one or two classes. Soils that are very gravelly, very chanery, very shaly, very slaty, very cherty, very cobbly. or very flaggy are reduced by two or three classes.

Soil scientists using the ARS nomograph have noted that for some soils, the K values obtained from the nomograph differ from those they have been using for many years. The nomograph commonly gives higher K values for silty soils and lower values for soils high in clay and in sand than values now in use. Where these values differ more than two K value classes, there is need to study the soils carefully and see how they behave under field conditions. For some soils, the best value may be somewhere between these two values. For other soils, the original estimated value may be more representative. The nomograph is based on a limited number of different kinds of soil and experience with its use is limited. Therefore, it should be used only as a guide at this time.

APPENDIX C

Riprap

DEFINITION

A revetment of loose rock or similar material installed on a cut or fill slope or a channel side slope to protect the slope from erosion.

PURPOSE

The purpose of the riprap is to provide a protective, non-erosive cover on a slope.

CONDITIONS

This standard applies to channels where velocities do not exceed 10 feet per second or to cut or fill slopes where soil conditions, water turbulence and velocity are such that it will not be stable.

DESIGN CRITERIA

An appropriate geotextile fabric shall be placed between the riprap and soil base. Use NRCS, DOT or the manufacturer's specifications for type and weight of fabric.

The toe of the revetment shall be entrenched in stable channel bottoms for a depth of 1.5 to 3 feet depending on the size of the riprap.

Riprap shall extend up the bank to an elevation where vegetation will provide adequate protection.

For channels, riprap shall be sized as required by channel velocity at full bank flow. Use Table C-1 and Figure C-1. The filter size is also shown in Table C-1.

Riprap shall not be placed on slopes steeper than 1.5 horizontal to 1.0 vertical.

The stone should be reasonably well graded within the gradation curves for each size designated, and any stone gradation, as determined from a field test sample, that lies within these limits shall be acceptable.

The designer should establish the size of graded quarry stone required for the project using acceptable design criteria. Consideration should then be given to using one of the standardized sizes contained in the following tables.

The thickness of the graded quarry stone layer and the gradation are interrelated. The thickness specified normally will vary form 1.0 to 1.5 times the maximum stone size in the gradation. In high turbulence areas, the layer thickness should be 1.5 times the maximum stone size. In low turbulence areas, the layer thickness can be reduced to the dimension of the largest stone in the gradation band.

CONSTRUCTION SPECIFICATIONS

The channel side slope and the toe excavation shall be prepared to the required lines and grades.

Filter material and riprap shall be placed in succession to the required thicknesses and elevations. Riprap shall be handplaced around structures to prevent damage to the structures.

Terminology:

Graded Riprap - durable, dense, specifically selected and graded, quarried stone, placed to prevent erosion.

Filter Bedding Stone - stone generally less than 6 inches in size, that may be placed under graded riprap stone in a layer or combination of layers, designed and installed in such a manner as to prevent loss of underlying soil or finer materials because of moving water.

Surge Stone - a quarry run ungraded, unscreened material which may or may not have fines.

The standard sizes of quarried stone for erosion control specifications may be produced by any suitable commercial quarrying method and by the use of any type of sizing device, necessary to produce the desired sizes.

Standard sizes of stone for erosion and sediment control are defined by their weight or square sieve openings. In Georgia two stone classification systems exist: the National Stone Association (N.S.A.) classification and the Department of Transportation (D.O.T.) classification system. Each system separates the stone sizes into two categories: graded riprap stone sizes and filter bedding stone sizes.

N.S.A. Graded riprap stone sizes are shown in Table C-1.

N.S.A. Filter bedding stone sizes are shown in Table C-1 and C-2.

D.O.T. Graded riprap stone sizes are shown in Table C-3.

D.O.T. Filter bedding stone sizes are shown in Table C-4.

Data for stone center waterways are shown in Table C-5 and Figure C-3.

Table C-1

Graded Rip-Rap Stone

Flow Velocity (ft./sec.)	N.S.A. No.[1]	Size Inches (Sq. Opening) Max.	Avg.[2]	Min.	Filter Stone N.S.A. No.[1]
2.5	R-1	1 1/2	3/4	No.8	FS-1
4.5	R-2	3	1 1/2	1	FS-1
6.5	R-3	6	3	2	FS-2
9.0	R-4	12	6	3	FS-2
11.5	R-5	18	9	5	FS-2
13.0	R-6	24	12	7	FS-3
14.5	R-7	30	15	12	FS-3

[1] National Stone Association

[2] At least 50% of the individual stone particles must be equal or larger than this listed size

Table C-2

Filter Bedding Stone

N.S.A. No[1]	Size Inches (Sq. opening) Max.	Avg.[2]	Min.[3]
FS-1	3/8	#30 mesh	#100 mesh
FS-2	2	#4	#100 mesh
FS-3	6 1/2	2 1/2	#16

[1] National Stone Association

[2] At least 50% of the individual stone particles must be equal or larger than this listed size

[3] 85-100% of the individual stone particles may be less than listed size

Table C-3

Graded Rip-Rap Stone

D.O.T. No.[1]	Size inches (Sq. opening) Max.	Avg.	Min.	Common Uses
Type 3	12	9	5	Creek Banks Pipe Outlets Lakes & Shorelines Rivers
Type 1	24	12	7	

[1] Georgia Department of Transportation

Table C-4

Filter Bedding Stone

D.O.T. No.[1]	Nominal Sizes (inches)
3	2" - 1"
4	1 1/2" - 3/4"
5	1" - 1/2"
6	3/4" - 3/8"
57	1" - No. 4

[1] Georgia Department of Transportation

Maximum weight of stone required	Minimum and maximum range in weight of stones	Weight range of 75 percent of stones
(lbs.)	(lbs.)	(lbs.)
150	25 — 150	50 — 150
200	25 — 200	50 — 200
250	25 — 250	50 — 250
400	25 — 400	100 — 400
600	25 — 600	150 — 600
800	25 — 800	200 — 800
1000	50 — 1000	250 — 1000
1300	50 — 1300	325 — 1300
1600	50 — 1600	400 — 1600
2000	75 — 2000	600 — 2000
2700	100 — 2700	800 — 2700

Table C-5 – Gradation of riprap.

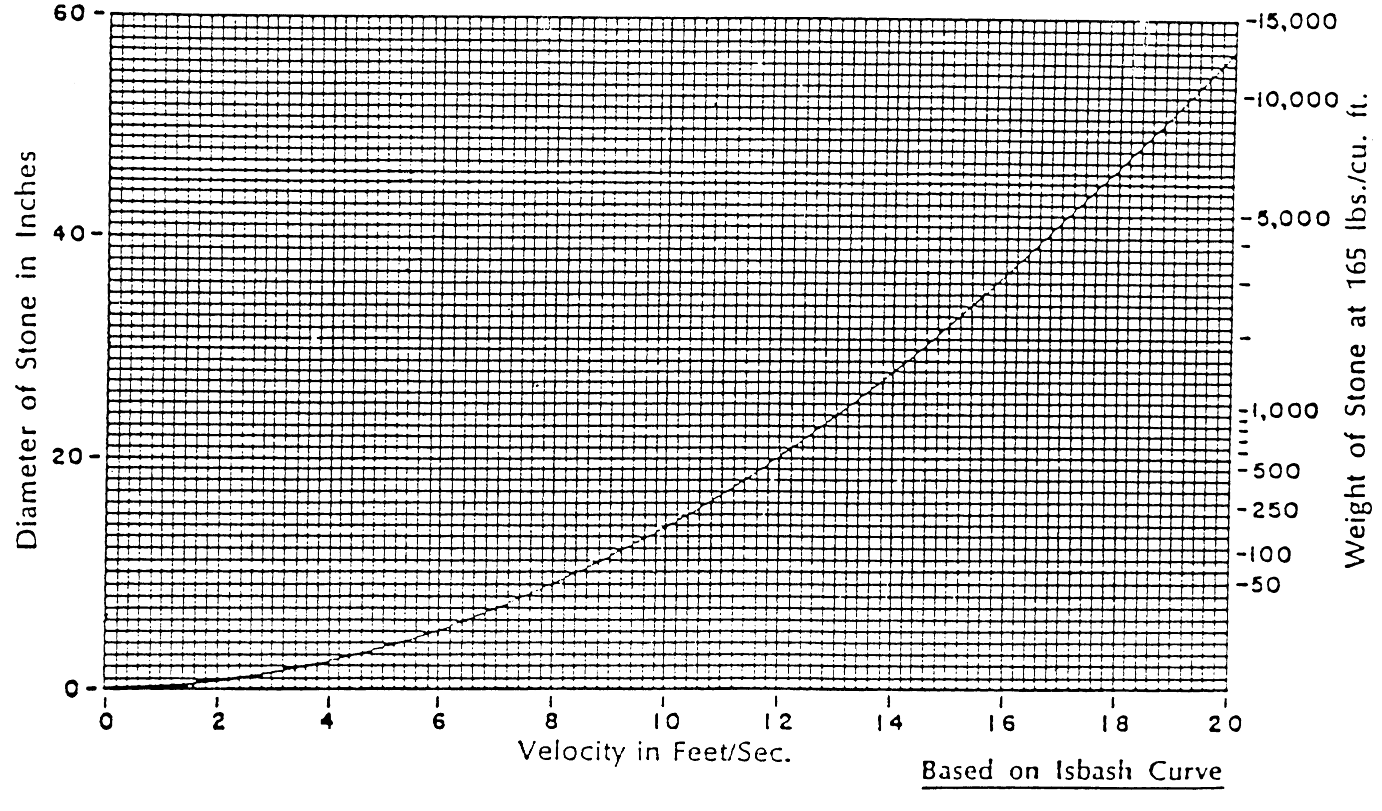
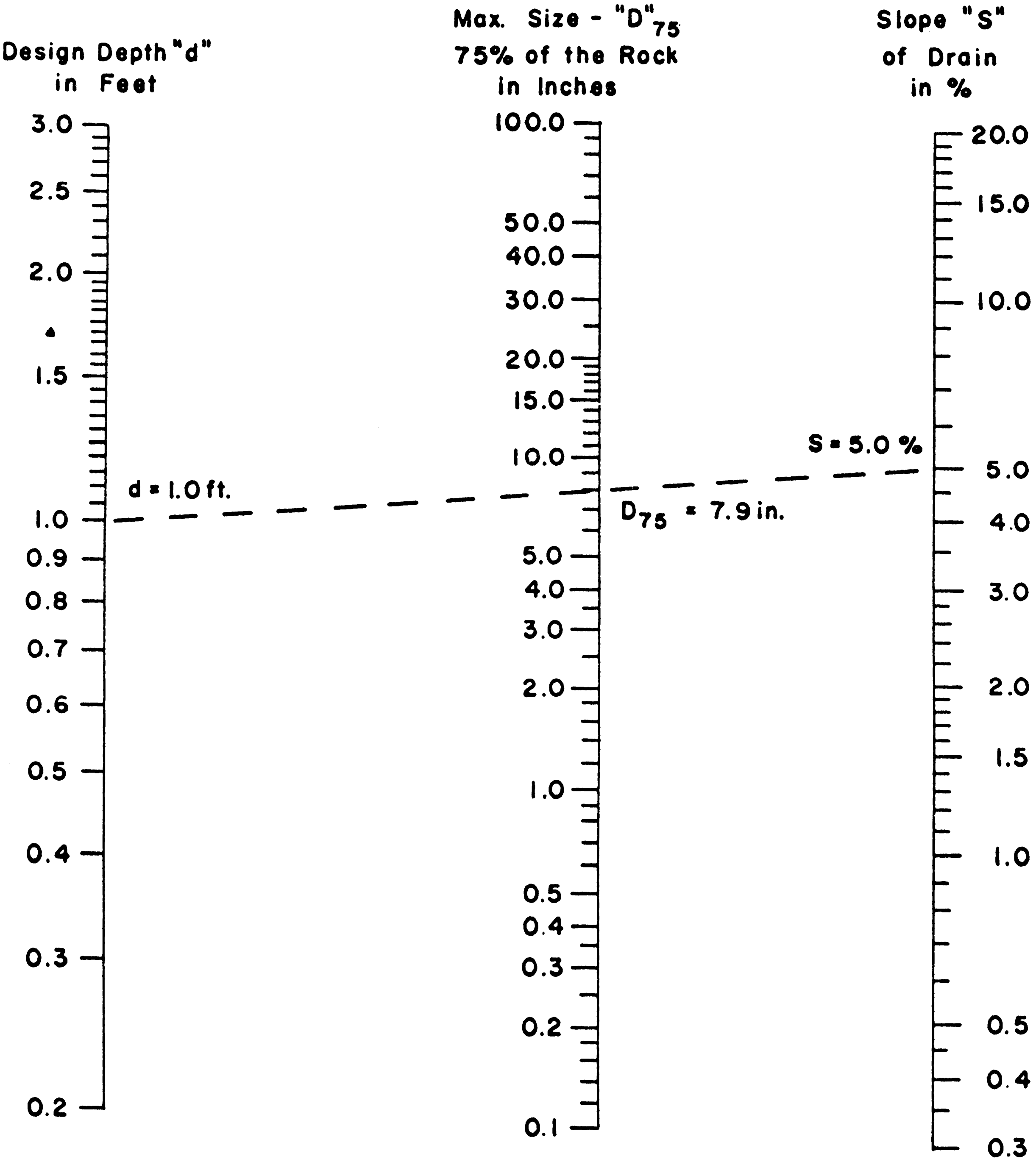


Figure C-1 – Maximum Stone Size for riprap.



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:

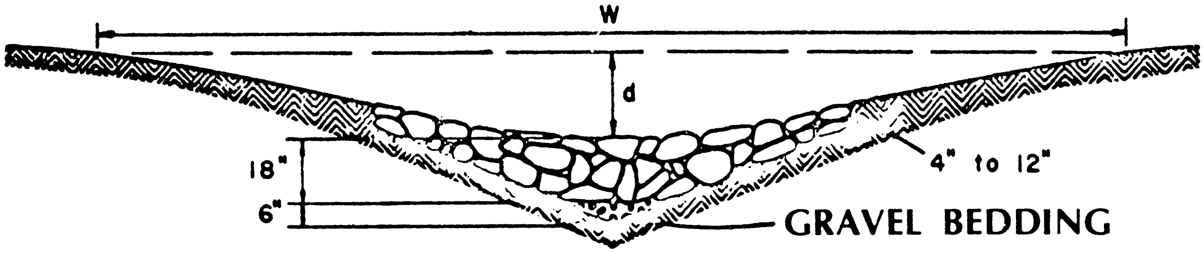
25% of the rock by volume should be in sizes of 8 inches or slightly larger. The remaining 75% or less should be of well graded material, smaller than 8 inches, including sufficient sands and gravels to fill the voids between the larger rock.

Figure C-2 – Determination of rock size for stone center waterway.

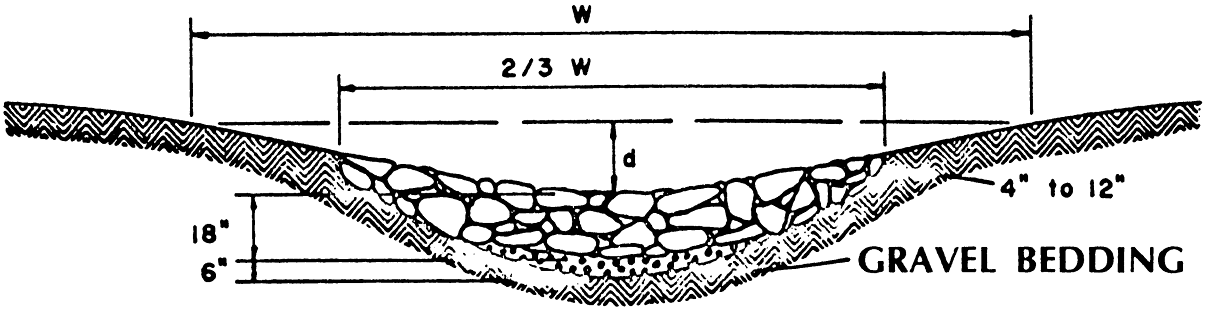
Grade	6 Percent		8 Percent		10 Percent		12 Percent		15 Percent	
V D	8.0 1.3	10 1.6	8.0 1.1	10 1.3	8.0 1.0	10.0 1.2	8.0 0.9	10.0 1.1	8.0 0.8	10.0 0.9
Q					Top Widths					
20							5		5	
25					5		6		6	4
30			5		6		7		7	5
35			6		7		8	5	8	6
40	6		7		8	5	9	6	10	7
45	7		8		9	6	10	6	11	7
50	7		9	6	10	7	11	7	12	8
55	8		9	6	11	7	12	8	13	9
60	9		10	7	12	8	13	8	14	9
65	9		11	7	12	9	14	9	16	11
70	10	7	12	8	13	9	15	10	17	11
75	11	7	13	9	14	10	16	10	18	12
80	12	8	14	9	15	10	18	11	19	13
90	13	9	15	10	17	12	20	13	21	15
100	14	10	17	11	19	13	22	14	24	16
110	16	11	19	13	21	14	24	15	26	18
120	17	11	21	14	23	16	26	17	29	20
130	19	12	22	15	25	17	29	18	31	21
140	20	13	24	16	27	18	31	19	33	23
150	22	14	26	17	29	20	33	21	36	24
160	23	15	27	18	31	21	35	22	38	26
170	25	16	29	19	33	22	37	24	40	28
180	26	17	31	20	34	23	39	25	43	29
190	27	18	32	22	36	25	42	26	45	31
200	29	19	34	23	38	26	44	28	47	33
220	32	21	38	25	42	29	48	31	52	38
240	35	23	41	27	46	31	53	33	57	39
260	38	25	44	30	50	34	57	36	62	42
280	40	27	48	32	54	36	61	39	67	45
300	43	29	51	34	57	39	66	42	71	49

Table C-6 – Velocity, top width and depth for Parabolic Stone Center Waterways.

STONE CENTER WATERWAYS



Waterway with stone center drain
V section shaped by motor patrol



Waterway with stone center drain
Rounded section shaped by bulldozer

Figure C-3 – Waterway with stone center.

APPENDIX D
Model Ordinance

APPENDIX D

Model Soil Erosion and Sedimentation Control Ordinance

INSTRUCTIONS

This model ordinance contains 21 blanks which must be filled to complete certification. All the information entered, except for blanks 7 & 8, is considered substantive and necessary for implementation and compliance. Asterisks in the left and right margins of the pages indicate location of these blanks. Additionally, each blank is numbered and corresponds to the below listed guide.

Page	Blank#	Information
3	1	Zoning Board, Council, County Commission, Official, Etc.
3	2	County or Municipality Name
3	3	County or Municipality Name (same as Blank #2)
3	4	District Names - available from the State Soil and Water Conservation Commission at (706) 542-3065
4	5	Appropriate District Name - available from the State Soil and Water Conservation Commission at (706) 542-3065 (same as Blank #4)
9	6	County or Municipality name (same as Blank #2)
9	7	Office of Issuing Authority that processes permits
9	8	Office of Issuing Authority that processes permits (same as Blank #7)
9	9	Number of Copies
9	10	Dollar Amount
12	11	Office liable for collecting ad valorem taxes
12	12	Office of Issuing Authority that conducts inspections
12	13	Office of Issuing Authority that processes permits (same as Blank #8)
14	14	Zoning Board, Council, County Commission, Official, etc. (same as Blank #1)
14	15	Number of Days
14	16	County or Judicial Circuit
14	17	Day
14	18	Month
14	19	Year
14	20	Signature of Elected Official
14	21	Signature of Witness (usually clerk or recorder)

Upon adoption, a copy of the ordinance must be submitted for certification to the Georgia Department of Natural Resources Environmental Protection Division with an information copy to the State Soil and Water Conservation Commission at the following addresses:

Georgia Department of Natural Resources
Environmental Protection Division
Nonpoint Source Program
Erosion and Sediment Control Unit
Tradeport
4220 International Parkway, Suite 101
Atlanta, Georgia 30354
Telephone: (404) 675-6240

State Soil and Water Conservation Commission
P. O. Box 8024
Athens, Georgia 30603
Telephone: (706) 542-3065

Model Soil Erosion And Sedimentation Control Ordinance

NOW, THEREFORE, BE IT ORDAINED, BY THE

______(1)______OF______(2)__________

SECTION I TITLE

This ordinance will be known as " ____(3)____ 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. **Best Management Practices (BMP's):** A collection of structural practices and vegetative measures which, when properly designed, installed and maintained, will provide effective erosion and sedimentation control for all rainfall events up to and including a 25-year, 24-hour rainfall event.
2. **Board:** The Board of Natural Resources.
3. **Buffer:** The area of land immediately adjacent to the banks of state waters in its natural state of vegetation, which facilitates the protection of water quality and aquatic habitat.
4. **Commission:** The State Soil & Water Conservation Commission.
5. **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 known as excavation.
6. **Department:** The Department of Natural Resources.
7. **Director:** The Director of the Environmental Protection Division of the Department of Natural Resources.
8. **District:** The ____(4)____Soil and Water Conservation District.
9. **Division:** The Environmental Protection Division of the Department of Natural Resources.
10. **Drainage Structure:** A device composed of a virtually nonerodible material such as concrete, steel, plastic or other such material that conveys water from one place to another by intercepting the flow and carrying it to a release point for storm-water management, drainage control, or flood control purposes.
11. **Erosion:** The process by which land surface is worn away by the action of wind, water, ice or gravity.
12. **Erosion and Sedimentation Control Plan:** A plan for the control of soil erosion and sedimentation resulting from a land-disturbing activity. Also known as the "plan"'.
13. **Ground Elevation:** The original elevation of the ground surface prior to cutting or filling.
14. **Fill:** A portion of land surface to which soil or other solid material has been added; the depth above the original ground.
15. **Finished Grade:** The final elevation and contour of the ground after cutting or filling and conforming to the proposed design.
16. **Grading:** Altering the shape of ground surfaces to a predetermined condition; this includes stripping, cutting, filling, stockpiling and shaping or any combination thereof and shall include the land in its cut or filled condition.
17. **Issuing Authority:** The governing authority of any 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, or the Division in those instances where an application for a permit is submitted to the Division.
18. **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.

19. **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.
20. **Natural Ground Surface**: The ground surface in its original state before any grading, excavation or filling.
21. **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.
22. **Permit**: The authorization necessary to conduct a land-disturbing activity under the provisions of this ordinance.
23. **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.
24. **Project**: The entire proposed development project regardless of the size of the area of land to be disturbed.
25. **Roadway Drainage Structure**: A device such as a bridge, culvert, or ditch, composed of a virtually nonerodible material such as concrete, steel, plastic, or other such material that conveys water under a roadway by intercepting the flow on one side of a traveled way consisting of one or more defined lanes, with or without shoulder areas, and carrying water to a release point on the other side.
26. **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.
27. **Sedimentation**: The process by which eroded material is transported and deposited by the action of water, wind, ice or gravity.
28. **Soil and Water Conservation District Approved Plan**: An erosion and sedimentation control plan approved in writing by the ____(5)____soil and water conservation district.
29. **Stabilization:** The process of establishing an enduring soil cover of vegetation by the installation of 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.
30. **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 or 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.
31. **Structural Erosion and Sedimentation Control Practices**: Practices for the stabilization of erodible 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 and land grading, etc. Such practices can be found in the publication *Manual for Erosion and Sediment Control in Georgia.*
32. **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. First order trout waters are streams into which no other streams flow except springs.

33. **Vegetative Erosion and Sedimentation Control Measures**: Measures for the stabilization of erodible or sediment-producing areas by covering the soil with:
    A. Permanent seeding, sprigging or planting, producing long-term vegetative cover; or
    B. Temporary seeding, producing short-term vegetative cover; or
    C. Sodding, covering areas with a turf of perennial sod-forming grass.

    Such measures can be found in the publication *Manual for Erosion and Sediment Control in Georgia*.
34. **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.
35. **Wetlands**: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

SECTION III EXEMPTIONS

This ordinance shall apply to any land-disturbing activity undertaken by any person on any land except for the following:

A. 1. Surface mining, as the same is defined in O.C.G.A. 12-4-72, "Mineral Resources and Caves Act";
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. The construction of single-family residences, when such are constructed by or under contract with the owner for his or her own occupancy, or the construction of single-family residences not a part of a platted subdivision, a planned community, or an association of other residential lots consisting of more than two lots and not otherwise exempted under this paragraph; provided, however, that construction of any such residence shall conform to the minimum requirements as set forth in Section IV of this ordinance. For single-family residence construction covered by the provisions of this paragraph, there shall be a buffer zone between the residence and any state waters classified as trout streams pursuant to Article 2 of Chapter 5 of the Georgia Water Quality Control Act. In any such buffer zone, no land-disturbing activity shall be constructed between the residence and the point where vegetation has been wrested by normal stream flow or wave action from the banks of the trout waters. For primary trout waters, the buffer zone shall be at least 50 horizontal feet, and no variance to a smaller buffer shall be granted. For secondary trout waters, the buffer zone shall be at least 50 horizontal feet, but the Director may grant variances to no less than 25 feet. Regardless of whether a trout stream is primary or secondary, for first order trout waters, which are streams into which no other streams flow except for springs, the buffer shall be at least 25 horizontal feet, and no variance to a smaller buffer shall be granted. The minimum requirements of Section IV of this ordinance and the buffer zones provided by this section shall be enforced by the issuing authority;
5. Agricultural operations as defined in O.C.G.A. 1-3-3, "definitions", to include

raising, harvesting or storing of products of the field or orchard; feeding, breeding or managing livestock or poultry; producing or storing feed for use in the production of livestock, including but not limited to cattle, calves, swine, hogs, goats, sheep, and rabbits or for use in the production of poultry, including but not limited to chickens, hens and turkeys; producing plants, trees, fowl, or animals; the production of aqua culture, horticultural, dairy, livestock, poultry, eggs and apiarian products; farm buildings and farm ponds;

6. Forestry land management practices, including harvesting; provided, however, that when such exempt forestry practices cause or result in land-disturbing or other activities otherwise prohibited in a buffer, as established in paragraphs (15) and (16) of Section IV C. of this ordinance, no other land-disturbing activities, except for normal forest management practices, shall be allowed on the entire property upon which the forestry practices were conducted for a period of three years after completion of such forestry practices;
7. Any project carried out under the technical supervision of the Natural Resources Conservation Service of the United States Department of Agriculture;
8. 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 paragraphs 1, 2, 3, 4, 5, 6, 7, 9 or 10 of this section;
9. 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 State Tollway Authority; or any road construction or maintenance project, or both, undertaken by any county or municipality; provided, however, that such projects shall conform to the minimum requirements set forth in Section IV B. & C. of this ordinance; provided further that construction or maintenance projects of Department of Transportation or State Tollway Authority which disturb five or more contiguous acres of land shall be subject to provisions of Code Section 12-7-7.1; and;
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 B. & C.

B. Where this section requires compliance with the minimum requirements set forth in Section IV B. & C. of this ordinance, Issuing Authorities shall enforce compliance with the minimum requirements as if a permit had been issued and violations shall be subject to the same penalties as violations by permit holders.

SECTION IV MINIMUM REQUIREMENTS. FOR EROSION AND SEDIMENTATION CONTROL USING BEST MANAGEMENT PRACTICES

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 sedimentation control measures and practices. The provisions shall be incorporated into the erosion and sedimentation control plans. Soil erosion and sedimentation control measures and practices shall conform to the minimum requirements of Section IV B. & C. of this ordinance. The application of measures and practices 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 sedimentation pollution during all stages of any land-disturbing activity.

B. MINIMUM REQUIREMENTS/BMP's

1. Best management practices as set forth in Section IV B. & C. of this ordinance shall be required for all land-disturbing activities. Proper design, installation, and maintenance of best management practices shall constitute a complete defense to any action by the Director or to any other allegation of noncompliance with paragraph (2) of this subsection or any substantially similar terms contained in a permit for the discharge of stormwater issued pursuant to subsection (f) of Code Section 12-5-30, the "Georgia Water Quality Control Act". As used in this subsection the terms "proper design" and "properly designed" mean designed to control soil erosion and sedimentation for all rainfall events up to and including a 25-year, 24-hour rainfall event.
2. A discharge of stormwater runoff from disturbed areas where best management practices have not been properly designed, installed, and maintained shall constitute a separate violation of any land-disturbing permit issued by a local Issuing Authority or by the Division or of any general permit for construction activities issued by the Division pursuant to subsection (f) of Code Section 12-5-30, the "Georgia Water Quality Control Act", for each day on which such discharge results in the turbidity of receiving waters being increased by more than 25 nephelometric turbidity units for waters supporting warm water fisheries or by more than ten nephelometric turbidity units for waters classified as trout waters. The turbidity of the receiving waters shall be measured in accordance with guidelines to be issued by the Director.
3. Failure to properly design, install, or maintain best management practices shall constitute a violation of any land-disturbing permit issued by a local Issuing Authority or by the Division or any general permit for construction activities issued by the Division pursuant to subsection (f) of Code Section 12-5-30, the "Georgia Water Quality Control Act", for each day on which such failure occurs.
4. The Director may require, in accordance with regulations adopted by the Board, reasonable and prudent monitoring of the turbidity level of receiving waters into which discharges from land disturbing activities occur.

C. The rules and regulations, ordinances, or resolutions adopted pursuant to this chapter for the purpose of governing land-disturbing activities shall require, as a minimum, best management practices, including sound conservation and engineering practices to prevent and minimize erosion and resultant sedimentation, which are consistent with, and no less stringent than, those practices contained in the *Manual for Erosion and Sediment Control in Georgia* published by the Georgia Soil and Water Conservation Commission as of January 1 of the year in which the land-disturbing activity was permitted, as well as the following:

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 practices 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. As used in this paragraph, a disturbed area is stabilized when it is brought to a condition of continuous compliance with the requirements of O.C.G.A. 12-7-1 et. seq.;
10. Adequate provisions must be provided to minimize damage from surface water to the cut face of excavations or the sloping 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, provided, in any case, that such crossings are kept to a minimum;
14. Land-disturbing activity plans for erosion and sedimentation control shall include provisions for treatment or control of any source of sediments and adequate sedimentation control facilities to retain sediments on-site or preclude sedimentation of adjacent waters beyond the levels specified in Section IV B. 2. of this ordinance;
15. Except as provided in paragraph (16) of this subsection, there is established a 25 foot buffer along the banks of all state waters, as measured horizontally from the point where vegetation has been wrested by normal stream flow or wave action, except where the Director determines to allow a variance that is at least as protective of natural resources and the environment, where otherwise allowed by the Director pursuant to O.C.G.A. 12-2-8, or where a drainage structure or a roadway drainage structure must be constructed, provided that adequate erosion control measures are incorporated in the project plans and specifications, and are implemented; provided, however, the buffers of at least 25 feet established pursuant to part 6 of Article 5, Chapter 5 of Title 12, the "Georgia Water Quality Control Act", shall remain in force unless a variance is granted by the Director as provided in this paragraph. The following requirements shall apply to any such buffer:

    No land-disturbing activities shall be conducted within a buffer and a buffer shall remain in its natural, undisturbed state of vegetation until all land-disturbing activities on the construction site are completed. Once the final stabilization of the site is achieved, a buffer may be thinned or trimmed of vegetation as long as a protective vegetative cover remains to protect water quality and aquatic habitat and a natural canopy is left in sufficient quantity to keep shade on the stream bed; provided, however, that any person constructing a single-family residence, when such residence is constructed by or under contract with the owner for his or her own occupancy, may thin or trim vegetation in a buffer at any time as long as protective vegetative cover remains to protect water quality and aquatic habitat and a natural canopy is left in sufficient quantity to keep shade on the stream bed; and
16. There is established a 50 foot buffer as measured horizontally from the point where vegetation has been wrested by normal stream flow or wave action, along the banks of any state waters classified as "trout streams" pursuant to Article 2 of Chapter 5 of Title 12, the "Georgia Water Quality Control

Act", except where a roadway drainage structure must be constructed ; provided, however, that small springs and streams classified as trout streams which discharge an average annual flow of 25 gallons per minute or less shall have a 25 foot buffer or they may be piped, at the discretion of the landowner, pursuant to the terms of a rule providing for a general variance promulgated by the Board, so long as any such pipe stops short of the downstream landowner's property and the landowner complies with the buffer requirement for any adjacent trout streams. The Director may grant a variance from such buffer to allow land-disturbing activity, provided that adequate erosion control measures are incorporated in the project plans and specifications and are implemented. The following requirements shall apply to such buffer:

No land-disturbing activities shall be conducted within a buffer and a buffer shall remain in its natural, undisturbed, state of vegetation until all land-disturbing activities on the construction site are completed. Once the final stabilization of the site is achieved, a buffer may be thinned or trimmed of vegetation as long as a protective vegetative cover remains to protect water quality and aquatic habitat and a natural canopy is left in sufficient quantity to keep shade on the stream bed: provided, however, that any person constructing a single–family residence, when such residence is constructed by or under contract with the owner for his or her own occupancy, may thin or trim vegetation in a buffer at any time as long as protective vegetative cover remains to protect water quality and aquatic habitat and a natural canopy is left in sufficient quantity to keep shade on the stream bed; and

D. Nothing contained in this chapter shall prevent an Issuing Authority from adopting rules and regulations, ordinances, or resolutions which contain requirements that exceed the minimum requirements in Section IV B. & C. of this ordinance.

E. The fact that land-disturbing activity for which a permit has been issued results in injury to the property of another shall neither constitute proof of nor create a presumption of a violation of the standards provided for in this ordinance or the terms of the permit.

SECTION V APPLICATION/PERMIT PROCESS

A. GENERAL

The property owner, developer and designated planners and engineers 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, stormwater management ordinance, subdivision ordinance, flood damage prevention ordinance, this ordinance, and other ordinances which regulate the development of land within the jurisdictional boundaries of the Issuing Authority. However, the property owner is the only party who may obtain a permit.

B. APPLICATION REQUIREMENTS

1. No person shall conduct any land-disturbing activity within the jurisdictional boundaries of the ____(6)____ without first obtaining a permit from the ____(7)____ to perform such activity.
2. The application for a permit shall be submitted to the ____(8)____ 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 B. & C. of this ordinance. Applications for a permit will not be accepted unless accompanied by ____(9)____ copies of the applicant's soil erosion and sedimentation control plans.
3. A fee, in the amount of $____(10)____ shall be charged for each acre or fraction thereof in the project area.
4. Immediately upon receipt of an application and plan for a permit, the Issuing Authority shall refer the

application and plan to the District for its review and approval or disapproval concerning the adequacy of the erosion and sedimentation 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 approved by the District, and any variances required by Section IV C. 15. & 16. and bonding, if required as per Section V B.5. (b), 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. (a) If a permit applicant has had two or more violations of previous permits, this ordinance section, or the Erosion and Sedimentation Act, as amended, within three years prior to the date of filing of the application under consideration, the Issuing Authority may deny the permit application.

   (b) The Issuing Authority may require the permit applicant to post a bond in the form of government security, cash, irrevocable letter of credit, or any combination thereof up to, but not exceeding, $3,000.00 per acre or fraction thereof 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. These provisions shall not apply unless there is in effect an ordinance or statute specifically providing for hearing and judicial review of any determination or order of the Issuing Authority with respect to alleged permit violations.

A. PLAN REQUIREMENTS

1. Plans must be prepared to meet the minimum requirements as contained in Section IV B. & C. of this ordinance. Conformance with the minimum requirements may be attained through the use of design criteria in the current issue of the *Manual for Erosion and Sediment Control in Georgia*, published by the State Soil and Water Conservation Commission as a guide; or through the use of more stringent, 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 the property owner.

   (d) Name and phone number of 24-hour local contact who is responsible for erosion and sedimentation controls.

   (e) Size of project, or phase under construction, in acres.

   (f) Activity schedule showing anticipated starting and completion dates for the project. Include the statement in **bold letters**,

that "the installation of erosion and sedimentation control measures and practices shall occur prior to or concurrent with land-disturbing activities."
(g) Stormwater and sedimentation management systems-storage capacity, hydrologic study, and calculations, including off-site drainage areas.
(h) Vegetative plan for all temporary and permanent vegetative measures, including species, planting dates, and seeding, fertilizer, lime, and mulching rates. The 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 and sedimentation control measures will be maintained at all times. Additional erosion and sedimentation control measures and practices 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. The certified plans shall contain:
(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 an interval in accordance with with the following:

Map Scale	**Ground Slope**	**Contour Interval, ft.**
1 inch = 100 ft. or larger scale	Flat 0-2% Rolling 2-8% Steep 8% +	0.5 or 1 1 or 2 2, 5 or 10

(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 the 25-foot horizontal buffer adjacent to state waters and the specified width in MRPA areas.
(i) Delineate the specified horizontal buffer along designated trout streams, where applicable.
(j) Location of erosion and sedimentation control measures and practices using coding symbols from the *Manual for Erosion and Sediment Control in Georgia*, Chapter 6.

4. Maintenance of all soil erosion and sedimentation control practices, whether temporary or permanent, shall be at all times the responsibility of the property 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 Section IV C. 15. & 16. are obtained, bonding requirements, if necessary, as per Section V B. 5. (b) are met and all ordinances and rules and regulations

in effect within the jurisdictional boundaries of the Issuing Authority are met. If the permit is denied, the reason for denial shall be furnished to 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 sedimentation 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.
5. No permit shall be issued unless the applicant provides a statement by the ______(11)______certifying that all ad valorem taxes levied against the property and due and owing have been paid.

SECTION VI INSPECTION AND ENFORCEMENT

A. The _____(12)____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 _____(13)______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 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.

D. The Districts or the Commission or both shall periodically review the actions of counties and municipalities which have been certified as Issuing Authorities pursuant to O.C.G.A. 12-7-8 (a). The Districts or the Commission or both may provide technical assistance to any county or municipality for the purpose of improving the effectiveness of the county's or municipality's erosion and sedimentation control program. The Districts or the Commission shall notify the Division and request investigation by the Division if any deficient or ineffective local program is found.

E. The Division may periodically review the actions of counties and municipalities which have been certified as Issuing Authorities pursuant to Code Section 12-7-8 (a). Such review may include, but shall not be limited to, review of the administration and enforcement of a governing authority's ordinance and review of conformance with an agreement, if any, between the district and the governing authority. If such review indicates that the governing authority of any county or municipality certified pursuant to O.C.G.A. 12-7-8 (a) has not administered or enforced its ordinances or has not conducted the program in accordance with any agreement entered into pursuant to O.C.G.A. 12-7-7 (d), the Division shall notify the governing authority of the county or municipality in writing. The governing authority of any county or municipality so notified shall have 30 days within which to take the necessary corrective action to retain certification as an Issuing Authority. If the county or municipality does not take necessary corrective action within 30 days after notification by the division, the division may revoke the certification of the county or municipality as an Issuing Authority.

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

1. For the first and second violations of the provisions of this ordinance, the Director or the Issuing Authority shall issue a written warning to the violator. The violator shall have five days to correct the violation. If the violation is not corrected within five days, the Director or the Issuing Authority shall issue a stop-work order requiring that land-disturbing activities be stopped until necessary corrective action or mitigation has occurred; provided, however, that, if the violation presents an imminent threat to public health or waters of the state or if the land-disturbing activities are conducted without obtaining the necessary permit, the Director or Issuing Authority shall issue an immediate stop-work order in lieu of a warning;
2. For a third and each subsequent violation, the Director or Issuing Authority shall issue an immediate stop-work order; and;
3. All stop-work orders shall be effective immediately upon issuance and shall be in effect until the necessary corrective action or mitigation has occurred.

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. (b). 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. MONETARY PENALTIES

1. Except as provided in paragraph (2) of this subsection, any person who violates any provisions of this ordinance, the rules and regulations adopted pursuant hereto, or any permit condition or limitation established pursuant to this ordinance or who negligently or intentionally fails or refuses to comply with any final or emergency order of the Director issued as provided in this ordinance shall be liable for a civil penalty not to exceed $2,500.00 per day. For the purpose of enforcing the provisions of this ordinance, notwithstanding any provisions in any City charter to the contrary, municipal courts shall be authorized to impose penalty not to exceed $2,500.00 for each violation. Notwithstanding any limitation of law as to penalties which can be assessed for violations of county ordinances, any magistrate court or any

other court of competent jurisdiction trying cases brought as violations of this ordinance under county ordinances approved under this ordinance shall be authorized to impose penalties for such violations not to exceed $2,500.00 for each violation. Each day during which violation or failure or refusal to comply continues shall be a separate violation.

2. The following penalties shall apply to land-disturbing activities performed in violation of any provision of this ordinance, any rules and regulations adopted pursuant hereto, or any permit condition or limitation established pursuant to this ordinance;
   - (A) There shall be a minimum penalty of $250.00 per day for each violation involving the construction of a single–family dwelling by or under contract with the owner for his or her own occupancy; and;
   - (B) There shall be a minimum penalty of $1,000.00 per day for each violation involving land-disturbing activities other than as provided in subsection (A) of this paragraph.

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 ______(14)______within ______(15)______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 denovo to the Superior Court of ______(16)______.

SECTION IX EFFECTIVITY, VALIDITY AND LIABILITY

A. EFFECTIVITY

This ordinance shall become effective on the ____(17)____day of ______(18)______, 20(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 effect the remaining portions of this ordinance.

C. LIABILITY

1. 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 Issuing Authority or District for damage to any person or property.
2. The fact that a land-disturbing activity for which a permit has been issued results in injury to the property of another shall neither constitute proof of nor create a presumption of a violation of the standards provided for in this ordinance or the terms of the permit.
3. No provision of this ordinance shall permit any persons to violate the Georgia Erosion and Sedimentation Act of 1975, the Georgia Water Quality Control Act or the rules and regulations promulgated and approved thereunder or pollute any Waters of the State as defined thereby.

ATTEST:

__________(20)__________
Signature

__________(21)__________
Signature

APPENDIX E
Conversion Factors

CONVERSION FACTORS

TO CONVERT:	MULTIPLY BY:	TO OBTAIN:
acres	1.60×10^{2}	sq. rods
acres	4.047×10^{-1}	hectares
acres	4.35×10^{4}	sq. ft.
acres	4.047×10^{3}	sq. meters
acres	1.562×10^{-3}	sq. miles
acres	4.840×10^{3}	sq. yards
acre-feet	4.356×10^{4}	cu. feet
acre-feet	3.259×10^{5}	gallons
centimeters	3.937×10^{-1}	inches
cubic feet	2.832×10^{-2}	cu. meters
cubic feet	7.48052	gallons
cubic feet	2.832×10^{1}	liters
cubic feet/min.	1.247×10^{-1}	gallons/sec.
cubic feet/sec.	6.46317×10^{-1}	million gals/day
cubic meters	3.531×10^{1}	cu. ft.
cubic meters	1.308	cu. yards
cubic meters	2.642×10^{2}	gallons
cubic yards	2.02×10^{2}	gallons
cubic yards	7.646×10^{2}	liters
feet	3.048×10^{1}	centimeters
feet	3.048×10^{-1}	meters
feet	1.894×10^{-4}	miles
feet of water	4.335×10^{-1}	pounds/sq. in.
gallons	1.337×10^{-1}	cu. feet
gallons	3.785×10^{-3}	cu. meters
gallons	4.951×10^{-3}	cu. yards
gallons	3.785	liters
gallons of water	8.337	pounds of water
gallons/min.	2.228×10^{-3}	cu. ft/sec.
gallons/min.	6.308×10^{-2}	liters/sec.
grams	2.205×10^{-3}	pounds
hectares	2.471	acres
hectares	1.076×10^{5}	sq. feet
inches	2.540	centimeters
kilograms	2.2046	pounds
kilograms	1.102×10^{-3}	tons
kilometers	3.281×10^{3}	feet
kilometer	6.214×10^{-1}	miles
kilometers	1.0936×10^{3}	yards
liters	2.642×10^{-1}	gallons
meters	3.281	feet
meters	1.094	yards
miles	5.280×10^{3}	feet
miles	1.609	kilometers
miles	1.760×10^{3}	yards
million gals/day	1.54723	cu. ft/sec.
rods	1.65×10^{1}	feet
square feet	2.296×10^{-5}	acres
square feet	9.29×10^{-2}	sq. meters
square meters	1.076×10^{1}	sq. ft.
square meters	3.861×10^{-7}	sq. miles
square meters	1.196	sq. yards
square miles	6.40×10^{2}	acres
square miles	2.590	sq. kms.
square miles	3.098×10^{6}	sq. yards
square yards	2.066×10^{-4}	acres
square yards	9.0	sq. ft.
square yards	8.361×10^{-1}	sq. meters
square yards	3.228×10^{-7}	sq. miles
tons	9.0718×10^{2}	kilograms
yards	9.144×10^{-1}	meters
yards	5.682×10^{-4}	miles

APPENDIX F
Glossary

APPENDIX F

Glossary

The list of terms that follows is representative of those used by soil scientists, engineers, developers,conservationist planners, etc. The terms are not necessarily used in the text, nonetheless they are in common use in conservation matters.

AASHTO CLASSIFICATION (soil engineering) — The official classification of soil materials and soil aggregate mixtures for highway construction used by the American Association of State Highway Transportation Officials.

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 less than 6.6, the values obtained vary greatly with the method used consequently there is no unanimous agreement on what constitutes an acid soil. The term is usually applied to the surface layer or to the root zone unless specified otherwise.

ACRE-FOOT — The volume of water that will cover 1 acre to a depth of 1 foot.

AGGRADATION — The process of building up a surface by deposition. This is a long-term or geologic trend in sedimentation.

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 — Pertaining to material that is transported and deposited by running water.

ALLUVIAL LAND — Areas of unconsolidated alluvium, generally stratified and varying widely in texture, recently deposited by streams, and subject to frequent flooding. A miscellaneous land type.

ALLUVIAL SOILS - An axonal great soil group of soils, developed from transported and 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, silt, clay, and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

ANGLE OF REPOSE — Angle between the horizontal and the maximum slope that a soil assumes through natural processes.

ANTECEDENT SOIL WATER — Degree of wetness of a soil prior to irrigation or at the beginning of a runoff period, expressed as an index or as total inches soil water.

ANTI-SEEP COLLAR — A device constructed around a pipe or other conduit and placed through a dam, levee, or dike for the purpose of reducing seepage losses 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 (soil engineering) — A floor or lining to protect a surface from erosion. An example is the pavement below chutes, spillways, or at the toes of dams.

AUXILIARY SPILLWAY — A dam spillway built to carry runoff in excess of that carried by the principal spillway. See *Emergency Spillway*.

BACKFILL — The material used to refill a ditch or other excavation, or the process of doing so.

BEDROCK — The solid rock underlying soils and the regolith in depths ranging from zero (where exposed by erosion) to several hundred feet.

BEDLOAD — The sediment that moves by sliding, rolling, or bounding on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both but at velocities less than the surrounding flow.

BEST MANAGEMENT PRACTICES (BMP) — A collection of structural practices and vegetative measures which, when properly designed, installed and maintained, will provide effective erosion and sedimentation control for all rainfall events up to and including a 25-year, 24-hour rainfall event.

BLINDING MATERIAL — Material placed on top and around a closed drain to improve the flow of water to the drain and to prevent displacement during backfilling of the trench.

BLIND INLET — Inlet to a drain in which entrance of water is by percolation rather than open flow channels.

BORROW AREA — A source of earth fill material used in the construction of embankments or other earthfill structures.

BOTTOM LANDS — A term often used to define lowlands adjacent to streams.

BOX-CUT — The initial cut driven in a property where no open side exists, resulting in a highwall on both sides at the cut.

BRUSH MATTING

(1) A matting of branches placed on badly eroded land to conserve moisture and reduce erosion while trees or other vegetative covers are being established.

(2) A matting of mesh wire and brush used to retard streambank erosion.

CHANNEL — A natural stream that conveys water; a ditch or channel excavated for the flow of water. See Watercourse.

CHANNEL IMPROVEMENT — The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its capacity. Sometimes used to connote channel stabilization.

CHANNEL SLOPE — Natural or excavated sides (banks) of a watercourse.

CHANNEL STABILIZATION — Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

CHANNEL STORAGE — Water temporarily stored in channels while enroute to an outlet.

COLLOID — In soil, organic or inorganic matter having very small particle size and a correspondingly large surface area per unit of mass. Most colloidal particles are too small to be seen with the ordinary compound microscope.

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.

CONDUIT — Any channel intended for the conveyance of water, whether open or closed.

CONSERVATION — The protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.

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.Often called a soil conservation district or a soil and water conservation district.

CONTOUR

(1) An imaginary line on the surface of the earth connecting points of the same elevation.

(2) A line drawn on a map connecting points of the same elevation.

COVER CROP — A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of permanent vegetation.

CRADLE — A device, usually concrete, used to support a pipe conduit or barrel.

CREEP (SOIL) — Slow mass movement of soil and soil material down relatively steep slopes, primarily under the influence of gravity but facilitated by saturation with water and by alternate freezing and thawing.

CRITICAL AREA — A severely eroded sediment producing area that requires special management to establish and maintain vegetation to stabilize soil conditions.

CUT — A portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below the original ground surface to the excavated surface. Syn. *Excavation.*

CUT-AND-FILL — Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

CUTOFF — A wall, collar or other structure, such as a trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

DAM — A barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion, or for retention or soil, rock, or other debris.

DEBRIS — The loose material arising from the disintegration of rocks and vegetative material; transportable by streams, ice or floods.

DEBRIS DAM — A barrier built across a stream channel to retain rock, sand, gravel, silt, or other material.

DEBRIS GUARD — A screen or grate at the intake of a channel, drainage, or pump structure for the purpose of stopping debris.

DEGRADATION — To wear down by erosion, especially through stream action.

DESIGN HIGHWATER — The elevation of the water surface as determined by the flow conditions of the design floods.

DESIGN LIFE — The period of time for which a facility is expected to perform its intended function.

DESILTING AREA — An area of grass, shrubs, or other vegetation used for inducing deposition of silt and other debris from flowing water; located above a stock tank, pond, field, or other area needing protection from sediment accumulation. See *Filter Strip.*

DETENTION DAM — A dam constructed for the purpose of temporary storage of streamflow or surface runoff and for releasing the stored water at controlled rates.

DIKE (engineering) — An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee. (geology) A tabular body of igneous rock that cuts across the structure of adjacent rocks or cuts massive rocks.

DISCHARGE (hydraulics) — Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, or cubic meters per second.

DISCHARGE COEFFICIENT (hydraulics) — The ratio of actual rate of flow to the theoretical rate of flow through orifices, weirs, or other hydraulic structures.

DISCHARGE FORMULA (hydraulics) — A formula to calculate rate of flow of fluid in a conduit or through an opening. For steady flow discharge, Q =

AV,wherein Q is rate of flow, A is cross-sectional area and V is mean velocity. Common units are cubic feet per second, square feet, and feet per second, respectively. To calculate the mean velocity, V for uniform flow in pipes or open channels see Manning's Formula.

DISPERSION, SOIL — The breaking down of soil aggregates into individual particles, resulting in single-grain structure. Ease of dispersion is an important factor influencing the erodibility of soils. Generally speaking, the more easily dispersed the soil, the more erodible it is.

DIVERSION — A channel with or without a supporting ridge on the lower side constructed across the top or bottom of a slope for the purpose of intercepting surface runoff.

DIVERISION DAM — A barrier built to divert part or all of the water from a stream into a different course.

DRAIN

(1) A buried pipe or other conduit (closed drain).
(2) A ditch (open drain) for carrying off surplus surface water of groundwater.
(3) To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or by internal flow.
(4) To lose water (from the soil) by percolation.

DRAINAGE

(1) The removal of excess surface water or groundwater from land by means of surface or subsurface drains.
(2) Soil characteristics that affect natural drainage.

DRAINAGE, SOIL — As a natural condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation; for example, in well-drained soils the water is removed readily but not rapidly; in poorly drained soils the root zone is waterlogged for long periods unless artificially drained, and the roots of ordinary crop plants cannot get enough oxygen: in excessively drained soils the water is removed so completely that most crop plants suffer from lack of water. Strictly speaking, excessively drained soils are a result of excessive runoff due to steep slopes or low available water holding capacity due to small amounts of silt and clay in the soil material. The following classes are used to describe soil drainage:

Well drained — excess water drains away rapidly and no mottling occurs within 36 inches of the surface.

Moderately well drained — water is removed from the soil somewhat slowly, resulting in small but significant periods of wetness. Mottling occurs between 8 and 18 inches.

Somewhat poorly drained - water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Mottling occurs between 0 to 18 inches.

Poorly drained — water is removed so slowly that the soil is wet for a large part of the time. Mottling occurs between 0 to 8 inches.

Very poorly drained — water is removed so slowly that the water table remains at or near the surface for the greater part of the time. There may also be periods of surface ponding. The soil has a black to gray surface layer with mottles up to the surface.

DRAWDOWN — Lowering of the water surface (in open channel flow), water table, or piezometric surface (in groundwater flow) resulting from a withdrawal of water.

DROP-INLET SPILLWAY — An overfall structure in which the water drops through a vertical riser connected to a discharge conduit.

DROP SPILLWAY — An overfall 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; a fall. A drop may be vertical or inclined.

EARTH DAM — Dam constructed of compacted soil material.

EMBANKMENT — A man-made deposit of soil, rock, or other material used to form an impoundment.

EMERGENCY SPILLWAY — A spillway used to carry runoff exceeding a given design flood. Syn. *Auxiliary Spillway.*

ENERGY DISSIPATOR — A device used to reduce the energy of flowing water.

ERODIBLE (geology and soils) — Susceptible to erosion.

EROSION

(1) The wearing away of the land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep.
(2) Detachment and movement of soil or rock fragments by water, wind, ice, or gravity. 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 influence of the activities of man, or in some cases, of other animals or natural catastrophes that expose base surfaces, for example, fires.

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 water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.

NATURAL EROSION — Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man. See *Geological Erosion.*

NORMAL EROSION — The gradual erosion of land used by man which does not greatly exceed natural erosion. See **Natural Erosion.**

RILL EROSION — An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils. See *Rill.*

SHEET EROSION — The removal of fairly uniform layer of soil from the land surface by runoff water.

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.

EROSION AND SEDIMENTATION CONTROL PLAN — A plan for the control of erosion and sediment resulting from a land-disturbing activity.

EROSION CLASSES (soil survey) — A grouping of erosion conditions based on the degree of erosion or on characteristic patterns; applied to accelerated erosion, not to normal, natural, or geological erosion. Four erosion classes are recognized for water erosion and three for wind erosion.

EROSION INDEX — An interaction term of kinetic energy times maximum 30-minute rainfall intensity that reflects the combined potential of raindrop impact and turbulence of runoff to transport dislodged soil particles from a field.

EROSIVE — Having sufficient velocity to cause erosion; refers to wind or water. Not to be confused with erodible as a quality of soil.

ESCARPMENT — A steep face or ridge of highland; the scarpenet of a mountain range is generally on that side nearest the sea.

EXISTING GRADE — The vertical location of the existing ground surface prior to cutting or filling.

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 (P205) and 6 percent water-soluble potash (K2O). Minor elements may also be included. Recent analysis expresses the percentages in terms of the elemental fertilizer (nitrogen, phosphorus, potassium).

FILLING — The placement of any soil or other solid material either organic or inorganic on a natural ground surface or an excavation.

FILTER STRIP — A long, narrow vegetative planting used to retard or collect sediment for the protection of diversions, drainage basins or other structures.

FINAL CUT — The last cut or line of excavation made when mining a specific property or area.

FINISHED GRADE — The final grade or elevation of the ground surface forming proposed design.

FLOOD — An overflow or inundation that comes from a river or other body of water and causes or threatens damage.

FLOOD CONTROL — Methods or facilities for reducing flood flows.

FLOOD CONTROL PROJECT — A structural system installed for protection of land and improvements from floods by the construction of dikes, river embankments, channels, or dams.

FLOODGATE — A gate placed in a channel or closed conduit to keep out floodwater or tidal backwater.

FLOODPEAK — The highest value of the stage or discharge attained by a flood. The peak stage or peak discharge.

FLOODPLAIN — Nearly level land situated on either side of a channel which is subject to overflow flooding.

FLOODROUTING — Determining the changes in the rise and fall of floodwater as it proceeds downstream through a valley or reservoir.

FLOOD STAGE — The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

FLOODWATER RETARDING STRUCTURE — A structure providing for temporary storage and controlled release of floodwater.

FLOODWAY — A channel, either natural, excavated, or bounded by dikes and levees, used to carry excessive flood flows to reduce flooding; sometimes considered to be the transitional area between the active channel and the floodplain.

FLUME — A device constructed to convey water on steep grades lined with erosion resistant materials.

FRAGIPAN — A natural subsurface horizon with high bulk density relative to the solum above, seemingly cemented when dry but showing a moderate to weak brittleness when moist. The layer is low in organic matter, mottled, slowly or very slowly permeable to water, and usually shows occasional or frequent bleached cracks forming polygons. It may be found in profiles of either cultivated or virgin soils but not in calcareous material.

FREEBOARD (hydraulics) — Vertical distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures provided to prevent overtopping because of unforeseen conditions.

GAGE OR GAUGE — Device for registering precipitation, water level, discharge, velocity, pressure, temperature, etc.

GAGING STATION — A selected section of a stream channel equipped with a gage, recorder, or other facilities for determining stream discharge.

GEOTEXTILE — A term used to describe woven or non-woven fabric materials used to reinforce or separate soil and other materials.

GRADATION (geology) — The bringing of a surface or a streambed to grade by running water. As used in connection with sedimentation and fragmental products for engineering evaluation, the term gradation refers to the frequency distribution of the various sized grains that constitute a sediment, soil, or material.

GRADE

(1) The slope of a road, channel, or natural ground.
(2) The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction like paving or laying a conduit.
(3) To finish the surface of canal bed, roadbed, top of embankment, or bottom of excavation.

GRADED STREAM — A stream in which, over a period of years, the slope is delicately adjusted to provide, with available discharge and with prevailing channel characteristics, just the velocity required for transportation of the load (of sediment) supplied from the drainage basin. The graded profile is a slope of transportation. It is a phenomenon in which the element of time has a restricted connotation. Works of man are limited to his experience and of design and construction.

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 grade.

GRADIENT — Change of elevation, velocity, pressure, or other characteristics per unit length; slope.

GRADING — Altering 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.

GRASS — A member of the botanical family Gramineae, characterized by bladelike leaves arranged on the culm or stem in two ranks.

GRASSED WATERWAY — A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from cropland.

GULLY — A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains or during the melting of snow. A gully may be dendritic, or branching, or it may be linear; rather long, narrow, and of uniform width. The distinction between gully and rill is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lesser depth and would be smoothed by use of ordinary tillage equipment. See Erosion, *Rill.*

GULLY EROSION — See *Erosion.*

GULLY CONTROL PLANTINGS — The planting of forage, legume, or woody plant seeds, seedlings, cuttings, or transplants in gullies to establish or re-establish a vegetative cover adequate to control runoff and erosion and incidentally produce useful products.

HABITAT — The environment in which the life needs of a plant or animal organism, population or community are supplied.

HEAD (hydraulics)

(1) The height of water above any plane of reference.
(2) 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, velocity head, and lost head.
(3) The internal pressure expressed in "feet" or pounds per square inch of an enclosed conduit.

HEAD GATE — Water control structure; the gate at the entrance to a conduit.

HEAD LOSS — Energy loss due to friction, eddies, changes in velocity, or direction of flow. Syn. *friction-head.*

HEADWATER

(1) The source of stream.
(2) The water upstream from a structure or point on a stream.

HOOD INLET — Entrance to a closed conduit that has been shaped to induce full flow at minimum water surface elevation.

HYDROGRAPH — A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

IMPOUNDMENT — Generally an artificial collection or storage of water, as a reservoir, pit, dugout, sump, etc. Syn. *reservoir.*

INFILTRATION — The gradual downward flow of water from the surface through soil to ground water and water table reservoirs.

INFILTRATION RATE — A soil characteristic determining or describing the maximum rate at which water can enter the soil under specified conditions, including the presence of an excess of water.

INLET (hydraulics)

(1) A surface connection to a closed drain.
(2) A structure at the diversion end of a conduit.
(3) The upstream end of any structure through which water may flow.

INOCULATION — The process of introducing pure or mixed cultures or micro-organisms into natural or artificial cultural media.

INTAKE

(1) The headworks of a conduit, the place of diversion.

(2) Entry of water into soil. See *Infiltration.*

INTAKE RATE — The rate of entry of water into soil. See *Infiltration Rate.*

INTENSITY — Rainfall rate usually in/hr.

INTERCEPTION (hydraulics) — The process by which precipitation is caught and held by foliage, twigs, and branches of trees, shrubs, and other vegetation. Often used for "interception loss" or the amount of water evaporated from the precipitation intercepted.

INTERCEPTION CHANNEL — A channel excavated at the top of earth cuts, at the foot of slopes or at other critical places to intercept surface flow; a catch drain. Syn. Interception Ditchs of water.

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INTERCEPTOR DRAIN — Surface or subsurface drain, or a combination of both, designed and installed to intercept flowing water.

INTERFLOW — That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface at some point downslope from its point of infiltration.

INTERMITTENT STREAM — A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. It is dry for a large part of the year, ordinarily more than 3 months.

INTERNAL SOIL DRAINAGE — The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are: none, very slow, slow, medium, rapid, and very rapid.

LAND — The total natural and cultural environment within which production takes place; a broader term than soil. In addition to soil, its attributes include other physical conditions, such as mineral deposits, climate, and water supply; location in relation to centers of commerce, population,and other land; the size of the individual tracts or holdings; and existing plant cover, works of improvement, and the like. Some use the terms loosely in other senses: as defined above but without the economic or cultural criteria; especially in the expression "natural land" as a synonym for "soil"; for the solid surface of the earth; and also for earthy surface formations, especially in the geomorphological expression "land form".

LAND CAPABILITY — The suitability of land for use without permanent damage. Land capability, as ordinarily used in the United States, is an expression of the effect of physical land conditions, including climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife. Land capability involves consideration of (1) the risks of land damage from erosion and other causes and (2) the difficulties in land use owing to physical land characteristics, including climate.

LAND CAPABILITY CLASSIFICATION — A grouping of kinds of soils into special units, subclasses, and classes according to their capability for intensive use and the treatments required for sustained use. (Prepared by the Natural Resources Conservation Service, USDA.)

LAND CAPABILITY MAP — A map showing land capability units, subclasses and classes, or a soil survey map colored to show land capability classes.

LAND CAPABILITY UNIT — Capability units provide more specific and detailed information for application to specific fields on a farm or ranch than the subclass of the land capability classification. A capability unit is group of soils that are nearly alike in suitability for plant growth and responses to the same kinds of soil management.

LAND CLASSIFICATION — The arrangement of land units into various categories based on the properties of the land or its suitability for some particular purpose.

LAND-DISTURBING ACTIVITY — Any land change which may result in soil erosion from water or wind and the movement of sediments into State water or onto lands within the State, including, but not limited to, clearing, dredging, grading, excavating, transporting and filling of land.

LAND FORM — A discernible natural landscape, such as a floodplain, stream terrace, plateau, valley, etc.

LAND RECLAMATION — Making land capable of more intensive use by changing its general character, as by drainage of excessively wet land; irrigation of arid or semiarid land; or recovery of submerged land from seas, lakes, and rivers. Large-scale reclamation projects usually are carried out through collective effort. Simple improvements, such as cleaning of stumps or stones from land, should not be referred to as land reclamation.

LEACHING — The removal from the soil in solution of the more soluble materials by percolating waters.

LEGUME — A member of the legume or pulse family, Leguminosae. One of the most important and widely distributed plant families. The fruit is a "legume" or pod that opens along two sutures when ripe. Flowers are usually papilionaceous (butterflylike). Leaves are alternate, have stipules, and are usually compound. Includes many valuable food and forage species, such as the peas, beans, peanuts, clover, alfalfas, sweet clovers, lespedezas, vetches, and kudzu. Practically all legumes are nitrogen-fixing plants.

LEVEL SPREADER — A shallow channel excavation at the outlet end of a diversion with a level section for the purpose of diffusing the diversion out-flow.

LIME — Lime, from the strictly chemical standpoint, refers to only one compound, calcium oxid (CaO); however, the term ``lime" is commonly used in agriculture to include a great variety of materials which are usually composed of the oxide, hydroxide, or carbonate of calcium or of calcium and magnesium. The most commonly used forms of agriculture lime are ground limestone (carbonates), hydrated lime (hydroxides), burnt lime (oxides), marl, and oyster shells.

LIME, AGRICULTURAL — A soil amendment consisting principally of calcium carbonate, but including magnesium carbonate and perhaps other materials, used to furnish calcium and magnesium as essential elements for the growth of plants and to neutralize soil acidity.

LIMING — The application of lime to land, primarily to reduce soil acidity and supply calcium for plant growth. Dolomitic limestone supplies both calcium and magnesium. It may also improve soil structure, organic matter content, and nitrogen content of the soil by encouraging the growth of legumes and soil microorganisms. Liming an acid soil to pH value of about 6.5 is desirable for maintaining a high degree of availability of most of the nutrient elements required by plants.

LIQUEFICATION (spontaneous liquefication) — The sudden large decrease of the shearing resistance of a cohesionless soil, caused by a collapse of the structure from shock or other type of strain and associated with a sudden but temporary increase in the pore-fluid pressure. It involves a temporary transformation of the material into a fluid mass.

LIQUID LIMIT (LL) — The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil.

LITTER — In forestry, a surface layer of loose organic debris in forests, consisting of freshly fallen or slightly decomposed organic materials.

LOAMY — Intermediate in texture and properties between fine-textured and coarse-textured materials.

LOOSE ROCK DAM — A dam built of rock without the use of mortar, a rubble dam. See *Rock-Fill Dam.*

MADE LAND — Areas filled with earth or earth and trash mixed, usually made by or under the control of man. A miscellaneous land type.

MANNING'S FORMULA (hydraulics) — A formula used to predict the velocity of water flow in an open channel or pipelines:

$$\frac{V = 1.486r2/3\ S1/2}{n}$$

wherein V is the mean velocity of flow in feet per second; r is the hydraulic radius; s is the slope of the energy gradient or for assumed uniform flow the slope of the channel in feet per foot; and n is the roughness coefficient or retardance factor of the channel lining.

MEAN DEPTH (hydraulics) — Average depth; cross-sectional area of a stream or channel divided by its surface or top width.

MEAN VELOCITY — Average velocity obtained by dividing the flow rate discharge by the cross-sectional area for that given cross-section.

MEASURING WEIR — A shaped notch through which water flows are measured. Common shapes are rectangular, trapezoidal, and triangular.

MECHANICAL ANALYSIS — The analytical procedure by which soil particles are separated to determine the particle size distribution.

MECHANICAL PRACTICES — Soil and water conservation practices that primarily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion. See *Structural Practices.*

MONOLITHIC — Of or pertaining to a structure formed from a single mass of stone.

MOUNTAIN TOP REMOVAL — A mining method in which 100 percent of the overburden covering a mineral deposit is removed in order to recover 100 percent of the mineral. Excess spoil material is hauled to a nearby hollow to create valley fill.

MOVEABLE DAM — A moveable barrier that may be opened in whole or in part, permitting control of the flow of water through or over the dam.

MUCK SOIL
(1) An organic soil in which the organic matter is well decomposed (USA usage).
(2) A soil containing 20 to 50 percent organic matter.

MULCH — A natural or artificial layer of plant residue or other materials, such as sand or paper, on the soil surface.

NATURAL GROUND SURFACE — The ground surface in its original state before any grading, excavation or filling.

NOISE POLLUTION — The persistent intrusion of noise into the environment at a level that may be injurious to human health.

NORMAL DEPTH — Depth of flow in an open conduit during uniform flow for the given conditions. See *Uniform Flow.*

OPEN DRAIN — Natural watercourse or constructed open channel that conveys drainage water.

OUTFALL — Point where water flows from a conduit, stream, or drain.

OUTLET — Point of water disposal from a stream, river, lake, tidewater, or artificial dam.

OUTLET CHANNEL — A waterway constructed or altered primarily to carry water from man-made structures, such as terraces, tile lines, and diversions.

OVERFALL — Abrupt change in stream channel elevation; the part of a dam or weir over which the water flows.

OVERHAUL — Transportation of excavated material beyond a specified haul limit, usually expressed in cubic yard stations (1 cubic yard hauled 100 feet).

PARENT MATERIAL (soils) — The unconsolidated, more or less chemically weathered, mineral or organic matter from which the solum of soils has developed by pedogenic processes. The C horizon may or may not consist of materials similar to those from which the A and B horizons developed.

PEAK DISCHARGE — The maximum instantaneous flow from a given storm condition at a specific location.

PERCOLATION — The downward movement of water through soil, especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 of less.

PERMEABILITY — Capacity for transmitting a fluid. It is measured by the rate at which a fluid of standard viscosity can move through material in a given interval of time under a given hydraulic gradient.

PERMEABILITY, soil — The quality of soil horizon that enables water or air to move through it. The permeability of a soil may be limited by the presence of one nearly impermeable horizon even though the others are permeable.

pH — A numerical measure of the acidity or hydrogen ion activity. The neutral point is pH 7.0. All pH values below 7.0 are acid and all above are alkaline.

PIPE DROP — A circular conduit used to convey water down steep grades.

PLASTICITY INDEX (PI) — The numerical difference between the liquid limit and the plastic limit.

PLASTIC LIMIT (PL) — The water content corresponding to an arbitrary limit between the plastic and semisolid states of consistency of soil.

PLASTIC SOIL — A soil capable of being molded or deformed continuously and permanently by relatively moderate pressure.

PLUNGE POOL — A device used to dissipate the energy of flowing water that may be constructed or made by the action of flowing. These facilities may be protected by various lining materials.

POOLS — Areas of a stream where the velocity provides a favorable habitat for plankton. Silts and other loose materials that settle to the bottom of pools are favorable for burrowing forms of benthos. Syn. *riffle.*

PRINCIPAL SPILLWAY — A water conveying device 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.

PURE LIVE SEED (PLS) — A term used to express the quality of seed, even if it is not shown on the label. Expressed as a percentage of the seeds that are pure and will germinate. Determined by multiplying the percent of pure seed times the percents of germination and dividing by 100.

RATIONAL FORMULA — Q = CIA. Where ``Q" is the peak discharge measured in cubic feet per second, ``C" is the runoff coefficient reflecting the ratio of runoff to rainfall, ``I" is the rainfall intensity for the duration of the storm measured in inches per hour, and ``A" is the area contributing drainage measured in acres.

RELIEF DRAIN — A drain designed to remove water from the soil in order to lower the water table and reduce hydrostatic pressure.

RELIEF WELL — Well, pit, or bore penetrating the water table to relieve hydrostatic pressure by allowing flow from the aquifer.

RESTORATION — The process of restoring site conditions as they were before the land disturbance.

RETURN FLOW — That portion of the water diverted from a stream that finds its way back to the stream channel either as surface or underground flow.

RILL — A small intermittent watercourse with steep sides, usually only a few inches deep and thus no obstacle to tillage operations.

RILL EROSION — See *Erosion.*

RIPRAP — Broken rock, cobbles, or boulders place on earth surfaces, such as the face of a dam or the bank of a stream for protection against the action of water (waves); also applied to brush or pole mattresses, or brush and stone, or other similar materials used for soil erosion control.

RISER — The inlet portions of drop inlet spillway that extend vertically from the pipe conduit barrel to the water surface.

RIVER BASIN — A major water resource region. The United States has been divided into 20 river basin areas.

ROCK-FILL DAM — A dam composed of loose rock usually dumped in place, often with the upstream part constructed of handplaced or derrick-placed rock and faced with rolled earth or with an impervious surface of concrete, timber, or steel.

RUNOFF (hydraulics) — That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include runoff, groundwater runoff, or seepage.

SCARIFY — To abrade, scratch, or modify the surface; for example, to scratch the impervious seed coat of hard seed or to break the surface of the soil with a narrow-bladed implement.

SCREENING — The use of any vegetative planting, fencing, ornamental wall of masonry, or other architectural treatment, earthen embankment, or a combination of any of these which will effectively hide from view any undesirable areas from the main traveled way.

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, as a product of erosion.

SEDIMENT BASIN — A depression formed from the construction of a barrier or dam built at a suitable location to retain sediment and debris.

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 LOAD — See Sediment Discharge.

SEDIMENT POOL — The reservoir space allotted to the accumulation of submerged 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.

SEEPAGE

(1) Water escaping through or emerging from the ground along an extensive line or surface as contrasted with a spring where the water emerges from a localized spot.

(2) (percolation) The slow movement of gravitational water through the soil.

SHEET FLOW — Water, usually storm runoff, flowing in a thin layer over the ground surface; also called overland flow.

SHRINK-SWELL POTENTIAL - Susceptibility to volume change due to loss or gain in moisture content.

SHRINKAGE INDEX (SI) — The numerical difference between the plastic and shrinkage limits.

SHRINKAGE LIMIT (SL) — The maximum water content at which a reduction in water content will not cause a decrease in the volume of the soil mass. This defines the arbitrary limit between the solid and semisolid states.

SIDE SLOPE —Generic term used to describe slope of earth-moving operations, generally stated in horizontal to vertical ratio.

SILT

(1) A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter.

(2) A soil textural class.

SILTING — See *Sediment.*

SILT LOAM — A soil textural class containing a large amount of silt and small quantities of sand and clay.

SILTY CLAY — A soil textural class containing a relatively large amount of silt and clay and a small amount of sand.

SILTY CLAY LOAM — A soil textural class containing a relatively large amount of silt, a lesser quantity of clay, and a still smaller quantity of sand.

SLOPE — The degree of deviation of a surface from horizontal, measured in a numerical ratio, percent, or degrees. Expressed as a ratio or percentage, the first number is the vertical distance (rise) and the second is the horizontal distance (run), as 2:1 or 200 percent. Expressed in degrees, it is the angle of the slope from the horizontal plane with a 90l slope being vertical (maximum) and 45l being a 1:1 slope.

SLOPE CHARACTERISTICS — Slopes may be characterized as concave (decrease in steepness in lower portion), uniform, or convex (increase in steepness at base). Erosion is strongly affected by shape, ranked in order of increasing erodibility from concave to uniform to convex.

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 AMENDMENT — Any material, such as lime, gypsum, sawdust, or synthetic conditioner, that is worked into the soil to make it more amenable to plant growth.

SOIL HORIZON — A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics, such as color, structure, texture consistence, kinds and numbers of organisms present, degree of alkalinity, etc.

SOIL PROFILE — A vertical section of the soil from the surface through all horizons, including C horizons.

SPILLWAY — 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.

SPOIL — Soil or rock material excavated from a canal, ditch, basin, or similar construction.

STABILIZATION — The process of establishing an enduring soil cover of vegetation and/or mulch or other ground cover in combination with installing temporary or permanent structures for the purpose of reducing to a minimum the transport of sediment by wind, water, ice or gravity.

STABILIZED GRADE — The slope of a channel at which neither erosion nor deposition occurs.

STAGE (hydraulics) — The variable water surface or the water surface elevation above any chosen datum. See *Gaging Station.*

STATE SOIL AND WATER CONSERVATION COMMISSION — The state agency established by soil and water conservation district enabling legislation to assist with the administration of the provisions of that law.

STORM DRAIN OUTLET PROTECTION STRUCTURE — A device used to dissipate the energy of flowing water. Generally constructed of concrete or rock in the form of a partially depressed or partially submerged vessel and may utilize baffles to dissipate velocities.

STORM FREQUENCY — An expression or measure of how often a hydrologic event of a given size or magnitude should on an average occur, based on a reasonable sample.

STREAMBANKS — The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

STREAM GAGING — The quantitative determination of stream flow using gages, current meters, weirs, or other measuring instruments at selected locations. See *Gaging Station.*

STREAM LOAD — Quantity of solid and dissolved material carried by a stream. See *Sediment Load.*

STRUCTURAL PRACTICES — Soil and water conservation measures, other than vegetation, 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. Including but not limited to riprap, sediment basins, dikes, level spreaders, waterways or outlets, diversions, grade stabilization structures, sediment traps, land grading, etc. See *Mechanical Practices.*

SUBSOIL — The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when ``soil" was conceived only as the plowed soil and that under it as the ``subsoil".

SUBWATERSHED — A watershed subdivision of unspecified size that forms a convenient natural unit.

TERRACE — An embankment or combination of an embankment and channel across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down from the soil.

TILE, DRAIN — Pipe made of burned clay, concrete, or similar material, in short lengths, usually laid with open joints to collect and carry excess water from the soil.

TILE DRAINAGE — Land drainage by means of a series of tile lines laid at a specified depth and grade.

TILTH — A soil's physical condition as related to its ease to work (till).

TOE (engineering) — Terminal edge or edges of a structure.

TOE DRAIN — Interceptor drain located near the downstream toe of a structure.

TOPSOIL — Earthy material used as top-dressing for house lots, grounds for large buildings, gardens, road cuts, or similar areas. It has favorable characteristics for production of desired kinds of vegetation or can be made favorable.

TRASH RACK — A structural device used to prevent debris from entering a spillway or other hydraulic structure.

UNIFIED SOIL CLASSIFICATION SYSTEM (engineering) — 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 are equal at all sections of a reach.

UNIVERSAL SOIL LOSS EQUATION — An equation used for the design of water erosion control systems: A = RKLSCP wherein A = average annual soil loss in tons per acre per year; R = rainfall factor; K = soil erodibility factor; L = length of slope; S = percent of slope; C = cropping and management factor; and P = conservation practice factor.

VEGETATIVE MEASURES — Stabilization of erosive or sediment-producing areas by covering the soil with:

(a) Permanent seeding, producing long-term vegetative cover, or

(b) Short-term seeding, producing temporary vegetative cover, or

(c) Sodding, producing areas covered with a turf of perennial sod-forming grass.

WATER CLASSIFICATION — separation of water of an area into classes according to usage, such as domestic consumption, fisheries, recreation, industrial, agricultural, navigation, waste disposal, etc.

WATER CONSERVATION — The physical control, protection, management, and use of water resources in such a way as to maintain crop, grazing, and forest lands; vegetal cover; wildlife; and wildlife habitat for maximum sustained benefits to people, agriculture, industry, commerce, and other segments of the national economy.

WATER CONTROL (soil and water conservation) The physical control of water by such measures as conservation practices on the land, channel improvement, and installation of structures for water retardation and sediment detention (does not refer to legal control or water rights as defined).

WATER CUSHION — Pool of water maintained to absorb the impact of water flowing from an overfall structure.

WATER DEMAND — Water requirements for a particular purpose, such as irrigation, power, municipal supply, plant transpiration, or storage.

WATER DISPOSAL SYSTEM — The complete system for removing excess water from land with minimum erosion. For sloping land, it may include a terrace system, terrace outlet channels, dams and grassed waterways. For level land, it may include surface drains or both surface and subsurface drains.

WATER QUALITY STANDARDS — Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonates, pH total dissolved salts, etc.

WATER RESOURCES — The supply of groundwater and surface water in a given area.

WATERCOURSE — Any natural or artificial watercourse, stream, river, creek, channel, ditch, canal, conduit, 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.

WATERSHED AREA — All land and water within the confines of a drainage divide or a water problem area consisting in whole or in part of land needing drainage or irrigation.

WATERSHED LAG — Time from center of mass of effective rainfall to peak of hydrograph.

WATERSHED MANAGEMENT — Use, regulation, and treatment of water and land resources of a watershed to accomplish stated objectives.

WATERSHED PLANNING — Formulation of a plan to use and treat water and land resources.

WATERWAY — An natural course or constructed channel for the flow of water. See *Grassed Waterway.*

WEIR — Device for measuring or regulating the flow of water.

WEIR NOTCH — The opening in a weir for the passage of water.

WETTING AGENT — A chemical that reduces the surface tension of water and enables it to soak into porous material more readily.

This glossary was compiled from definitions supplied by the Natural Resources Conservation Service, Soil and Water Conservation Society of America, Resource Conservation Glossary, and other state and federal publications.

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