Erosion & Sediment Control Guidelines for Developing Areas of the Sierra Foothills and Mountains

Prepared by the High Sierra RC&D Council October 1991

EROSION AND SEDIMENT CONTROL GUIDELINES

FOR

DEVELOPING AREAS OF THE SIERRA FOOTHILLS AND MOUNTAINS

This handbook is an updated version of the original handbook printed in 1981. New materials and technology, plus the need to clarify some practices and approaches to erosion and sediment control, prompted this update. Loren Schilder, SCS Engineer, reviewed and prepared the sections on structural practices. Comments and recommendations on the vegetative sections were provided by personnel of the Soil Conservation Service and the Resource Conservation District in the Sierra foothill counties.

The original handbook was developed by the High Sierra Resource Conservation and Development Council. The handbook was prepared in part under a grant from the Environmental Protection Agency under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. That grant was administered through the California Water Resources Control Board by the Regional Water Quality Control Board - Central Valley Region.

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PREFACE

This handbook of erosion and sediment control guidelines was prepared to address erosion and sedimentation related to construction activities in the Sierra foothills. The handbook gives a general description of the construction related problems and the principles to reduce them.

The handbook was designed for the engineer who will develop erosion and sediment control plans along with the site development plans. It will also provide guidance to the contractors and developers who will install the practices, and those officials who must approve and inspect these projects.

The practices are separated into structural and vegetative. Structural practices are for the control of flowing water, preventing erosion by flowing water or trapping sediment. Vegetative practices are designed to stabilize the soil surface and prevent erosion.

Most construction activities require a combination of structural and vegetative practices to provide adequate protection at reasonable costs.

The practices are also organized as temporary or permanent. Temporary practices are designed to provide short term protection until the permanent practices can be installed. Permanent practices are installed with completion of the construction activities and provide protection for an indefinite period of time.

The practices listed in this handbook contain most of the planning criteria needed to design them. The users of this handbook will need a few references that pertain to local criteria such as soils data and the accepted method(s) of determining run-off. These are available at the local Soil Conservation Service office and the County Departments of Public Works or Transportation.

INTRODUCTION

STATEMENT OF THE PROBLEM

In the foothill and mountain counties, a significant erosion problem and contributor of sediment is soil disturbance associated with construction activities (building pads, roads, driveways, utilities). Soil disturbance in the foothills and mountains has a high potential for erosion/sedimentation due to the nature of the area: sloping land, high rainfall, erodible soils and a delicate vegetative cover. These counties are experiencing tremendous growth. As an area, between 1980 and 1990, the change in population was a 50% increase.

Although construction activities disturb a minor percentage of the landscape, they represent the major sediment producers in small sub-watersheds undergoing development. These situations often cause severe local problems.

Obstruction of stream channels and rivers by masses of sediment reduces their hydraulic capacity which causes an increase in flood crests and flood damage. Sediment fills drainage channels, especially along roads, and plugs culverts and storm drainage systems - necessitating frequent and costly maintenance. Municipal and industrial water supply reservoirs lose storage capacity, the usefulness of recreational water is impaired or destroyed, and filtering muddy water for domestic or industrial use is very costly. The general effect of fine grained sediments, such as clays, silts, and fine sands, in an aquatic environment is to reduce drastically both the kinds and the amounts of organisms and animal life present. Often the aesthetic attraction of an area and its water are impaired by erosion and sediment.

Erosion and sedimentation is also a serious consumer problem. Erosion undermines and makes impassable roads and driveways, damages housepads and often the houses themselves. Mud removal from roads and houses is an added expense to landowners.

Erosion removes topsoil containing most of the plant nutrients and greatly reduces the ability of the soil to support plant growth.

EROSION

Erosion is a two part process involving the detachment of soil particles by raindrop impact, freeze-thaw, or wetting and drying cycles and the transportation of the particles by flowing water. When the soil surface is directly exposed to raindrop impact, splashed particles are moved down slope in a shallow sheet flow. As the surface flow begins to concentrate the energy of this flow is able to both detach and transport soil particles forming tiny channels called rills. Gullies are formed when several rills come together forming a large channel which can be enlarged in both the upstream and down stream directions.

Natural stream channels have adjusted over time to the quantities of run-off and sediments normally produced by the watershed. When the watershed is altered by the land development activities, such as removing vegetation and paving, the peak flow velocities are increased. These changes can destroy the equilibrium of the stream, causing meandering and bank erosion or deepening of the channel.

Soils with a high clay content are the most erosion resistant because the clay's stickiness binds the soil particles together. Conversely, soils that are high in silt and fine sand are generally most erodible.

Soil characteristics and ground cover conditions greatly influence the potential erosion rate. Earth moving activities commonly alter the soils surface texture, organic matter content, structure, and permeability. These alterations, plus the removal of the protective vegetation, result in increased run-off and erodibility at the site which must be mitigated using a variety of erosion control practices. Foremost, the replacement of ground cover or vegetation is without question the single most effective form of erosion control. Vegetation and mulches shield the soil surface from the impact of falling rain and retard run-off. Secondly, concentrated run-off must be collected, channelized and conveyed to a safe outlet.

SEDIMENTATION

Sedimentation is the process of deposition of the eroded materials transported by flowing water. Even with the sediment control measures described in this manual, it is extremely difficult to remove clay and fine silt particles from flowing water. Particles of clay and fine silt are the worst water pollutants because they are carried miles downstream and will typically settle out in a large water body, such as a bay or lake.

PRINCIPLES OF REDUCED EROSION AND SEDIMENTATION FROM DEVELOPING AREAS

The following six principles can be integrated into an effective system of erosion and sedimentation control. This system consists of vegetative and structural measures and management practices. The development and use of this system can reduce the damage of erosion caused by land development and reduce costly clean-up procedures.

1. Plan the development to fit the particular topography, soils, waterways, and natural conditions at a site.

Watershed area, slope length and gradient are key elements in determining the volume and velocity of the run-off and erosion. Where possible, steep slopes should be left undisturbed. Erosion hazards, and run-off volumes and velocity can be reduced by limiting the length and steepness of slopes.

Soils high in silt and very fine sands are generally the most erodible. Erodibility decreases as the percentage of clay or organic matter content increases. Even a highly erodible soil may show little evidence of erosion, by reducing the length and steepness of a given slope. Long steep slopes should be broken by benching, terracing or constructing diversion structures.

2. Expose the smallest practical area of land for the shortest possible time.

When the soil is to be disturbed and vegetation removed, keep the site and duration of exposure to a minimum. Phase the project so that only the areas currently being developed are left exposed. Grading should be completed as soon as possible. Vegetation (temporary or permanent) with mulching should be in place before the rainy season starts (about October 15).

After the best decision has been made as to land use, and the development process begins, effective erosion control and sediment reduction depend upon careful site planning, judicious selection of conservation practices, adequate design, accurate installation in a timely fashion and sufficient maintenance to insure the intended result.

3. Retain natural vegetation wherever feasible.

Natural vegetation is extremely important in controlling erosion since it: (a) shields the soil surface from rain, (b) increases infiltration, (c) reduces the velocity of run-off and (d) holds the soil in place as well as acting as a filter.

Trees to be saved should be clearly marked. Areas where natural vegetation can be saved should be delineated by fences, flags or stakes. For larger lots it is not necessary to clear the entire site; only foundation areas, cut and fill slopes and streets and driveways need to be cleared.

On disturbed areas it takes from 3 to 5 years to re-establish the original level of protection provided by the natural cover.

4. Apply "Soil Erosion" control practices as a first line of defense against on-site damage.

Numerous practices can be used on-site to minimize potential damage. These practices can be used independently or with other methods. Soil should be kept covered as much as possible with temporary or permanent vegetation or with various mulches. Other practices include diversions to keep surface run-off from exposed areas and grade stabilization structures to control surface water. When erosion is not adequately controlled, sediment control is more difficult and expensive.

5. Apply "Sediment Control" practices as a perimeter protection to prevent off-site damage.

Control sediment once it is produced to prevent it from leaving the site. Diversion ditches, sediment traps, vegetative filters and sediment basins are examples. Generally, sediment can be retained by two methods: (a) filtering run-off as it flows through an area and (b) impounding the sediment laden water to settle it out.

6. Implement a thorough maintenance and follow-up operation.

A site cannot be effectively controlled without thorough, periodic checks of the erosion and sediment control practices.

THE USE OF THIS HANDBOOK

The purpose of this handbook of practices is to establish uniform criteria for the design, review, approval, installation and maintenance of erosion control and sediment reduction practices on land undergoing grading, construction or development. Those responsible for the selection, design and installation of these practices should evaluate the conditions existing at the specific site and determine if the minimum criteria contained herein are adequate or if more stringent criteria should be employed.

These practices were written to be generally applicable to all development and construction sites in the Sierra foothill counties. However, there may be many specific problems or sites not appropriately covered by these practice criteria. Modifications of these practices and innovative practices can be substituted as long as the intent of erosion and sediment control is kept intact.

These practices have been organized into four general areas:

I. Temporary Structural Practices
II. Permanent Structural Practices
III. Vegetative Practices (Temporary and Permanent)
IV. Protection of Trees in Urbanizing Areas

Structural practices are constructed for the purpose of controlling the flow of water, preventing erosion by flowing water or trapping sediment. Vegetative practices are concerned with covering the soil surface with vegetation, usually with the help of such things as soil amendments or mulches, in order to stabilize the soil surface and prevent erosion.

Temporary practices are those used for relatively short periods of time to control erosion and sedimentation during some stage of construction. These practices must not be used for longer than the periods of time prescribed. Two temporary practices, straw bale dike and sediment trap, are "stop gap" measures and should be used only when nothing else will work. Permanent practices are to be used for permanent features, for an indefinite period of time or when temporary practices are not adequate. The criteria are such that the permanent practices will accomplish their intended function with a minimum of maintenance over long periods of time.

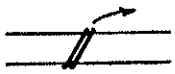
THE EROSION AND SEDIMENT CONTROL PLAN

The erosion and sediment control plan should be a part of the total site development plan and prescribes all the steps necessary, including scheduling, to assure erosion and sediment control during all phases of construction, including final stabilization.

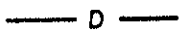
Planning for sediment control should begin with first-hand knowledge of the site by the designer. The plan should be based on a topographic map of the existing topography and site conditions. Adjacent off-site areas effecting the site or affected by the site and its development shall be shown on the plans in sufficient detail to accomplish the need.

The plan consists of the selection of practices, temporary and permanent, which best protects the site from erosion and reduces sediment leaving the area. No one practice is sufficient to do the job, so a mixing of vegetative and structural practices is required. The use of standard map symbols (pg. x) will facilitate the development and review of plans. The typical Mediterranean climate allows time flexibility in installing temporary and permanent practices. The rainy season ends about the 1st of May and does not start again until mid October. If earth moving work is completed within this time frame permanent practices, including revegetation, should be installed by the 15th of October. However, if more work needs to be done, those permanent practices which will not be affected by that work should be installed and the affected area stabilized and/or protected from erosion and transfer of sediment by temporary practices (or permanent where the site condition or situation warrants). In those areas where summer rain is a threat, temporary and permanent practices need to be planned and installed along with the development of the site.

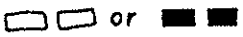
Diversion Dike



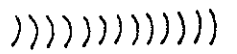
Cross Road Drain



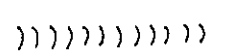
Perimeter Dike



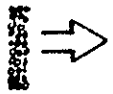
Straw Bale Dike



Interceptor Swale

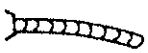


Perimeter Swale

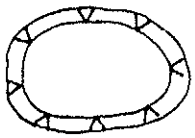


Stone Outlet Str.

Paved Flume

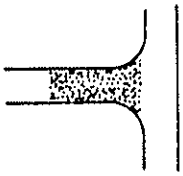


Flexible Pipe Slope Drain

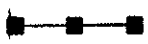


Sediment Basin

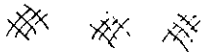
Sediment Trap



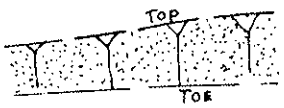
Gravel Construct-ion Entrance



Silt Fence

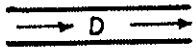


Straw Mulching

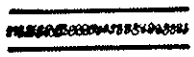


Seeded and Mulched Slope

TEMPORARY & VEGETATIVE PRACTICES



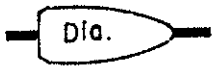
Diversion



Stone Center Grassed Waterway

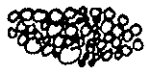
Level Spreader

Storm Drain Outlet Protection



Storm Drain Pipe

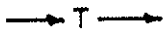
Storm Drain Inlet



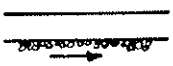
Riprap

Subsurface Drain

Infiltration Trench

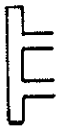


Slope Terracing



Access Road Rock Lined Ditch

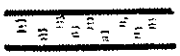
Pipe Slope Drain



Gabion Drop Str.

Rock Lined Ditch

Conc. Lined Ditch



Grass Lined Ditch

Lot Grading

PERMANENT STRUCTURAL PRACTICES

HIGH SIERRA R. C. & D.

Erosion & Sediment Control Guide

STANDARD MAP SYMBOLS for EROSION AND SEDIMENT CONTROL PLANS

CALCULATIONS FOR PEAK STORM RUN-OFF

AND

STORM RUN-OFF VOLUME

Of paramount importance is the sizing of the components of the various erosion control practices by determining the peak run-off flow and the storm run-off volume. Many methods and systems have been developed to determine peak flow and volume. Counties and cities have adopted specific rules on how to calculate these figures. Developers and contractors need to contact the local public works department or department of transportation to determine the acceptable method(s).

The USDA - Soil Conservation Service has developed an easy to use, computer run system called "Urban Hydrology for Small Watersheds" (TR-55). It has proved to be an effective tool in determining peak run-off flow and storm run-off volume, plus allowing the developer to produce a hydrograph and a storage routing procedure. This program is available from the local SCS office.

RUN-OFF AND DRAINAGE

Construction often impacts natural or man-made drainage systems. The impacts vary, depending on the extent of the project. Small projects may slightly increase run-off of the drainway. Large projects can redirect drainage or completely remove the waterway. Construction will increase run-off (volume and peak flow) due to impervious surfaces. This run-off can cause streambank erosion and scouring of stream channels. Flooding is also associated with developments along drainways.

Anytime a stream channel is involved, an experienced engineer should be consulted as to the impacts of the development. In addition, the State of California and most counties have ordinances relating to activities that affect drainage. The agencies to contact about permits are: California Department of Fish and Game, U.S. Army - Corps of Engineers, California Water Resources Control Board - Water Rights, County Planning Department and County Department of Public Works or Transportation. Some counties are forming flood

PART I

TEMPORARY STRUCTURAL PRACTICES

CONTENTS

I.A

DIVERSION DIKE

Definition: A temporary diversion dike is a channel constructed across a slope using a ridge of compacted soil.

Purpose: The purpose of a diversion dike is to intercept storm run-off from small upland areas and route it away from exposed slopes, or other disturbed areas, to a stable outlet.

Applicability: Temporary diversion dikes are intended for sites where permanent diversion channels are not planned. They are used at the top of newly constructed slopes to divert run-off until vegetative cover is established. They are also used to divert clean run-off from protected areas around construction sites so as to reduce the volume of run-off that must be treated. The diversion dike is used only during the period of construction and until permanent storm water control practices are installed and/or slopes are stabilized.

Planning Criteria: For an upland drainage area of less than 5 acres a design is not required. For larger areas the design is based on the criteria for permanent Diversion, Section II.A. Depending upon the potential for damage, the capacity can be reduced to a 5-year return interval storm. A stable outlet is required for the discharge.

Methods and Materials: The following criteria shall be used when upland areas are less than 5 acres:

Top Width - 2 feet minimum.

Ridge Height - 1 1/2 feet minimum, measured from the finished ground at the upslope toe to the top of the dike.

Side Slopes - 2:1 or flatter.

Flow Area Grade - Channel must have a positive grade to a stabilized drainage outlet.

Flow Area Stabilization - Where slope of channel (flow area) is:

0-5% - stabilization is required for soils of high erosion potential.
over 5% - stabilization shall be required in all soil types.

Methods and Materials: Continued

Stabilization Method - Acceptable stabilization practices for the flow area shall be:

(1) in accordance with criteria for permanent Diversion, Section II.A; or,
(2) by lining the flow area with hard, dense, durable rock, well graded from a minimum size of 1/4 inch to a maximum size of 2 inches, which is placed in a 3 inch layer and pressed into the soil. The area covered by the stone shall extend up both sides of the flow area at least 8 inches measured vertically, and shall extend a minimum of 7 feet upslope from the upslope toe of the dike.

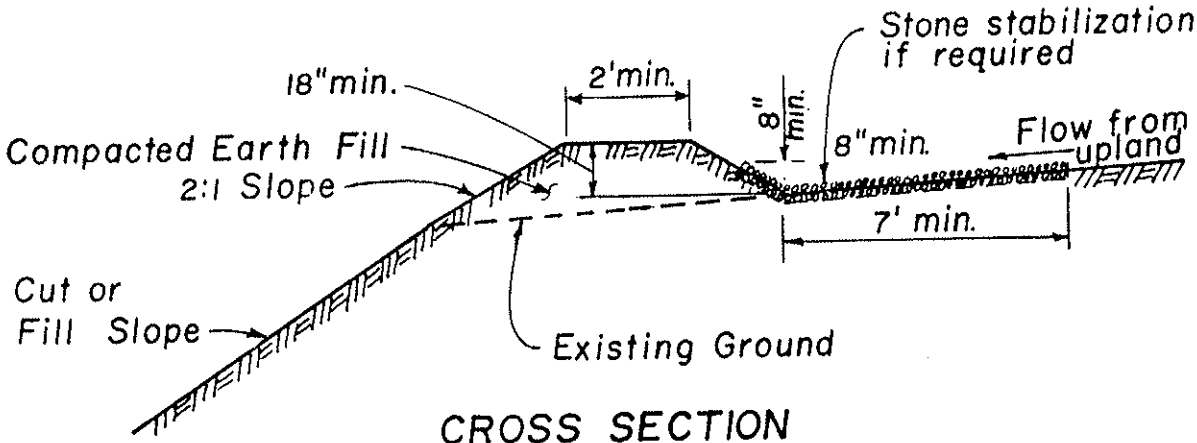
Dike Compaction - In general, all dikes shall be machine compacted. In sites with no access to the top of the slope, an uncompacted dike covered with plastic sheeting is acceptable.

Plastic Sheeting - Where uncompacted dikes are used, construct a berm to the dimensions recommended for a diversion dike. Remove all rocks and protrusions from the surface of the dike. Cover the dike with plastic sheeting having a thickness of not less than 6 mils. The outside edges of the plastic shall extend at least 1 foot beyond the upstream and downstream toe of the dike and be covered with clean gravel, or the edges shall be buried a minimum of 6 inches in the soil. At joints in the plastic along the dike, provide a minimum of 2 feet of overlap. The flow area stabilization criteria for the conventional diversion dike apply.

Discharge of Diverted Run-off -

(A) Diverted run-off from a protected or stabilized area shall outlet directly to an undisturbed stabilized swale or into a level spreader or grade stabilization structure.
(B) Diverted run-off from a distributed or exposed upland area shall be conveyed to a sediment trapping device, such as a sediment trap or a sediment basin, or to an area protected by any of these practices.

Operation and Maintenance: Periodic inspection and maintenance shall be required. Inspect the dike on a daily basis when construction activity is nearby to locate areas damaged by personnel or equipment. Inspect the dike following each storm period. The diversion dike shall be removed when permanent stabilization practices are completed.



CROSS SECTION
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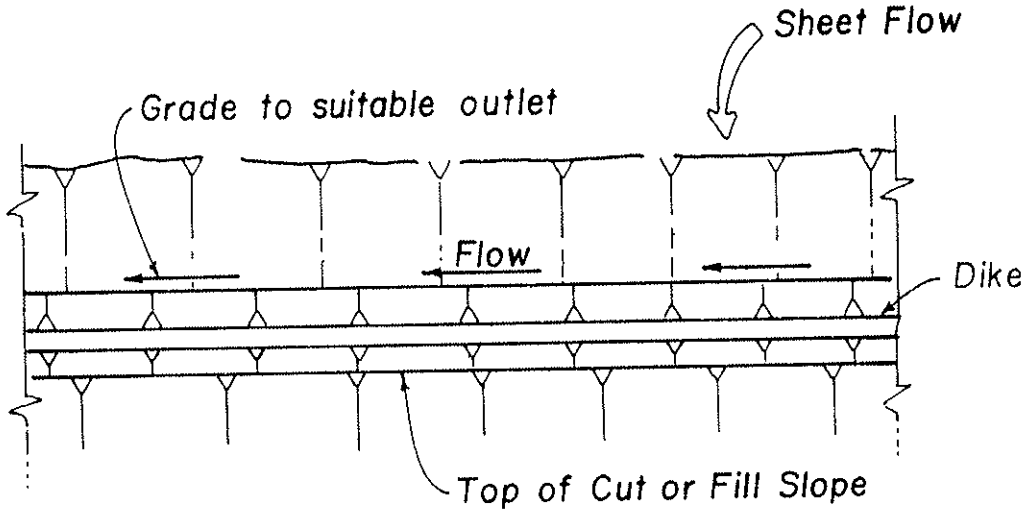

PLAN VIEW
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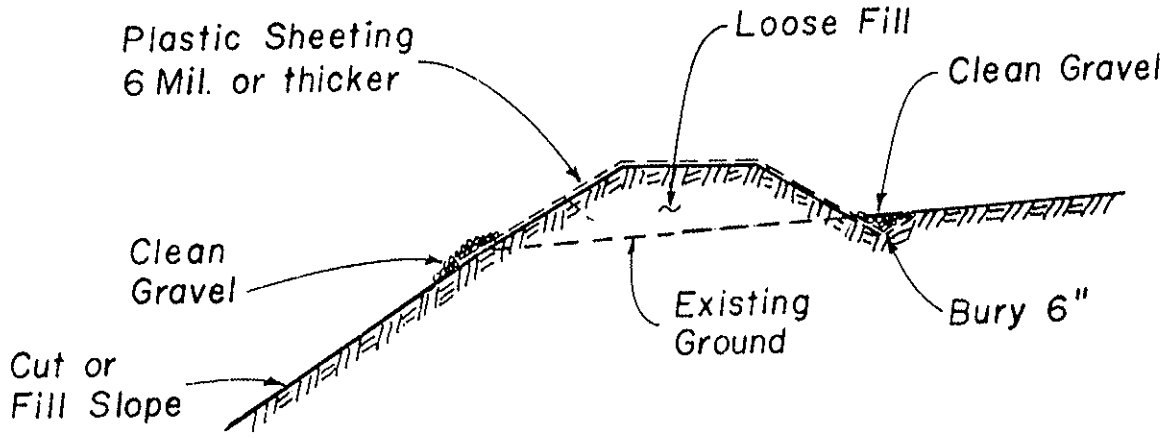

UNCOMPACTED DIKE DETAIL
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I.B

CROSS-ROAD DRAIN

Definition: A temporary water bar, dike, or swale with dike built diagonally across a road or right-of-way.

Purpose: The purpose of a cross-road drain is to remove run-off from the graded area before it gains sufficient volume to become erosive. This is done by shortening the distance run-off must flow across disturbed areas before reaching a stabilized outlet or sediment trapping device.

Applicability: Used for disturbed rights-of-way such as for pipelines and streets, or other graded areas such as parking lots and land fills, that have not been stabilized by gravel surfacing or vegatative means because of on-going construction activities. The cross-road drain is used only during the period of construction or until permanent storm water control practices are installed.

Planning Criteria: For a cross-road drain receiving flow from an area less than 5 acres a design is not required. For larger drainage areas a temporary culvert or diversion dike should be used. For drainage areas larger than 0.25 acres a sediment trap at the outlet is required.

This practice is easily damaged by vehicle crossings and should only be selected where crossings will not be made during storm periods.

Methods and Materials: The following criteria shall be used when the tributary drainage area is less than 5 acres:

Spacing - Table I.B-1 lists maximum allowable spacing of cross-road drains for a given grade. Actual distance between drains will depend upon the type of soil and degree of compaction of the surface.

Table I.B-1

Interceptor Dike Spacing

Disturbed Area Grade (percent)	Spacing Between Dikes (feet)
2- 5	300
5-10	150
10-15	75
15-20	50

Methods and Materials: Continued

Top Width - 2 feet minimum. Width may be increased to facilitate movement of construction equipment.

Ridge Height - 1 1/2 feet minimum, measured from the finished ground at the upslope toe to the top of the dike.

Side Slopes - 2:1 or flatter. Side slopes may be flatter as necessary to allow construction traffic to cross.

Flow Area Grade - Channel must have a positive grade to a stabilized drainage outlet. The recommended slope is 0.5% to 2.0%.

Stabilization - Stabilization is generally not required. However, when channel slopes are greater than recommended above stabilization may be required. When required, stabilization practices for the flow area shall be by lining the flow area with hard, dense, durable, coarse aggregate, well graded from a minimum size of 1/4 inch to a maximum size of 2 inches, which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall extend up both sides of the flow area at least 8 inches measured vertically, and shall extend a minimum of 7 feet upslope from the upslope toe of the dike.

Traffic Crossings - At all points where one or more vehicle crossings per day will be made, the dike shall be covered with a layer of coarse aggregate for the full width of the traffic crossing. The limits of the traffic crossing shall be marked with stakes or some other method.

Dike Compaction - All dikes shall be machine compacted.

Outlet - Where the cross-road drain goes over a fill slope, the outlet shall be protected by placing coarse aggregate, rock riprap, or a pipe slope drain.

Discharge of Diverted Run-off -

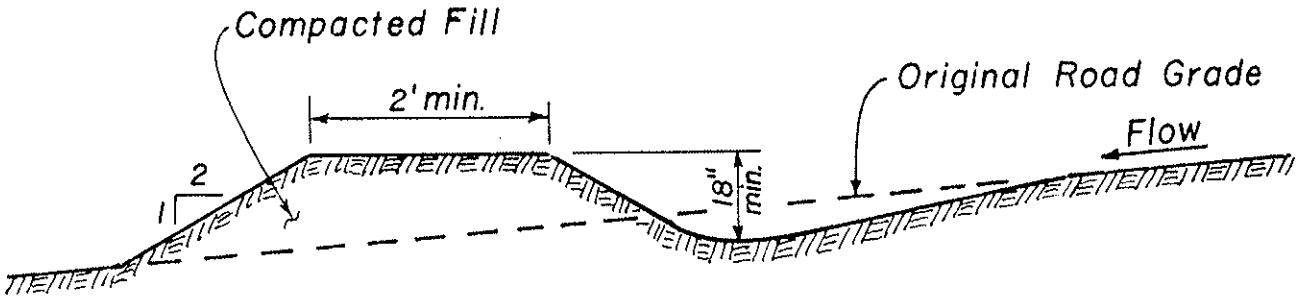
(A) Diverted run-off from areas less than 0.25 acres in area, and more than 100 feet from a stream or property line, shall outlet directly to an undisturbed stabilized area.

Methods and Materials:
Discharge of Diverted Run-off - Continued

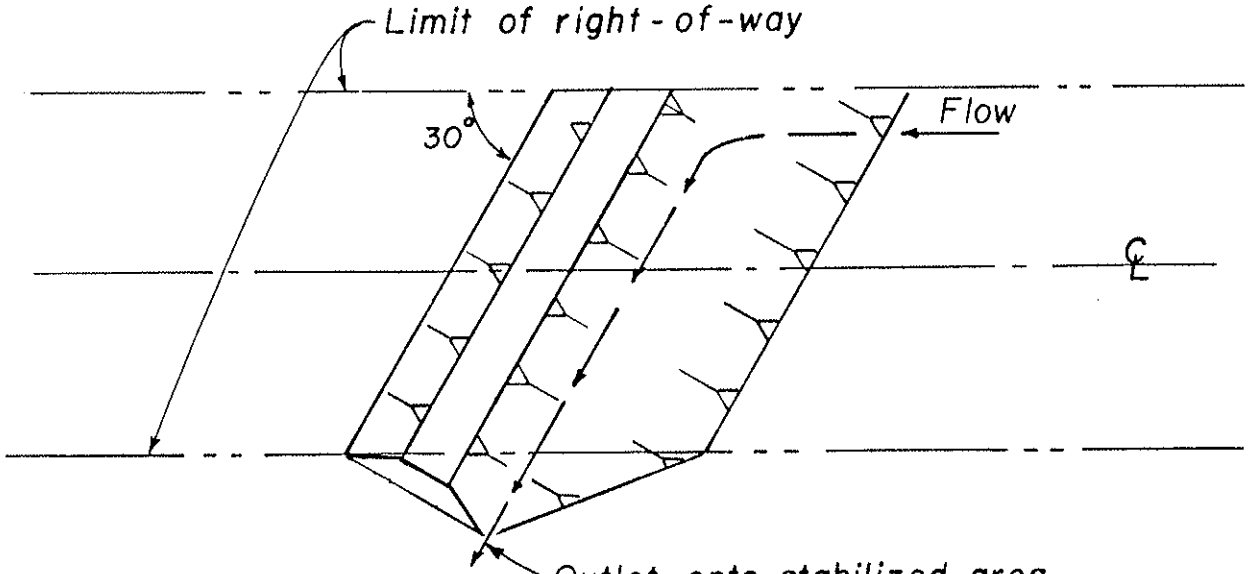
(B) Diverted run-off from disturbed areas 0.25 acres or larger, or within 100 feet of a stream or property line, shall be conveyed to a sediment trapping device such as a sediment trap, straw bale sediment barrier or sediment basin, or to an area protected by any of these practices.

To utilize the most suitable outlet, the field location of the cross-road drains may be adjusted to meet field conditions.

Operation and Maintenance: Inspect and repair the drain on a daily basis when construction activity is nearby to locate areas damaged by personnel or equipment. Inspect the dike following each storm period. The water bar shall be removed when paving or other permanent stabilization practices are completed.



PROFILE



PLAN VIEW
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High Sierra R. C. & D. Erosion & Sediment Control Guide Pg. 7	CROSS ROAD DRAIN

I.C

PERIMETER DIKE

Definition: A temporary perimeter dike is a ridge of compacted soil located around the edge of the site or disturbed area.

Purpose: The purpose of a perimeter dike is to prevent sediment laden storm run-off from leaving the construction site or disturbed area.

Applicability: Temporary perimeter dikes are installed around the edges of a disturbed area to transport sediment laden water to a sediment trapping device such as a sediment trap or sediment basin. The perimeter dike is used only during the period of construction and until permanent storm water control practices are installed, and/or slopes are stabilized.

Planning Criteria: For an interceptor dike receiving flow from an area less than 5 acres a design is not required. For larger areas the design is based on the criteria given for Diversion, Section II.A. A sediment trapping device is required before discharge to a stable outlet.

Outlet Structure - See Sediment Trap-Section I.K or Stone Outlet Structure-Section I.G for planning details.

Methods and Materials: The following criteria shall be used when the tributary area is less than 5 acres:

Top Width - 2 feet minimum. Width may be increased to facilitate movement of construction equipment.

Ridge Height - 1 1/2 feet minimum, measured from the finished ground at the upslope toe to the top of the dike.

Side Slopes - 2:1 or flatter. Side slopes may be flatter as necessary to allow construction traffic to cross.

Flow Area Grade - Channel must have positive grade to a sediment trapping device.

Flow Area Stabilization - Where slope of channel is:

0-5% - stabilization is required for soils of high erosion potential.

over 5% - stabilization shall be required in all soil types.

Methods and Materials: Continued

Stabilization Method - Acceptable stabilization practices for the flow area shall be:

(1) in accordance with criteria for Diversion-Section II.A; or,

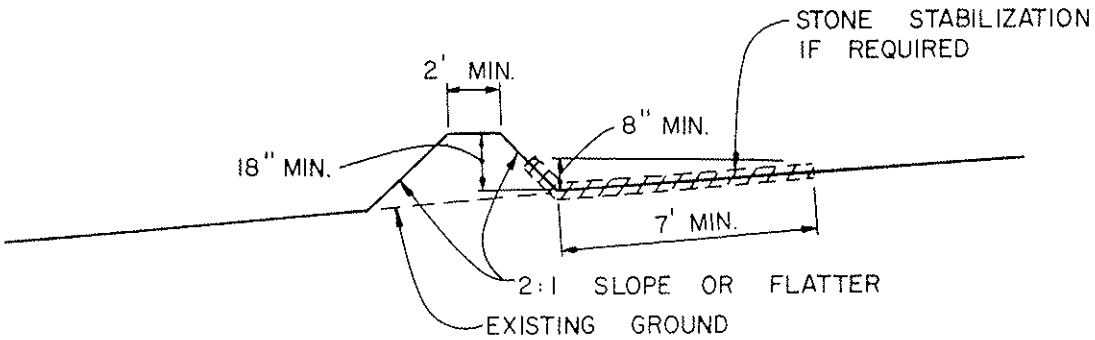
(2) by lining the flow area with hard, dense, durable rock, well graded from a minimum size of 1/4 inch to a maximum size of 2 inches, which is placed in a 3 inch thick layer and pressed into the soil. The area covered by the stone shall extend up both sides of the flow area at least 8 inches measured vertically, and shall extend a minimum of 7 feet upslope from the upslope toe of the dike.

Traffic Crossings - At all points where several or more vehicle crossings per day will be made, the dike shall be stabilized according to No. 2 above, except the stone shall be at least 6 inches in thickness for the full width of the traffic crossing. The limits of the traffic crossing shall be marked with stakes or some other method.

Dike Compaction - All dikes shall be machine compacted.

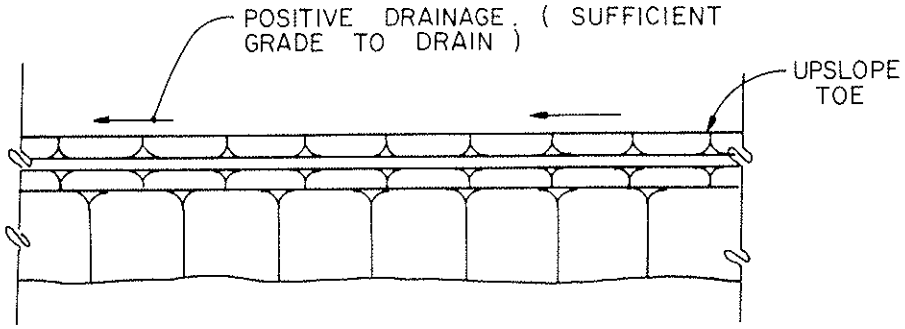
Discharge of Diverted Run-off - Diverted run-off from a disturbed area shall be conveyed to a sediment trapping device, such as a sediment trap or sediment basin, or to an area protected by any of these practices.

Operation and Maintenance: Periodic inspection and maintenance shall be required. Inspect the dike on a daily basis when construction activity is nearby to locate areas damaged by personnel or equipment. Inspect the dike following each storm period. The perimeter dike shall be removed when permanent stabilization practices are completed.



CROSS SECTION

N.T.S.



PLAN VIEW

N.T.S.

NOTE : DRAINAGE AREA LESS THAN 5 ACRES.

PERIMETER DIKE

I.D

STRAW BALE DIKE

Definition: A straw bale dike is a temporary sediment barrier constructed of straw bales located downslope of a disturbed area or around a storm drainage inlet.

Purpose: The purpose of a straw bale dike is to prevent sediment transport from disturbed areas and also to prevent transported sediment from being discharged to a specific point, such as a storm drain inlet.

Applicability: A straw bale dike is installed in areas requiring protection from sedimentation caused by sheet and rill erosion during a limited time period (less than 3 months). There should be no stream channels or drainage ways above the barrier. The straw bale dike is used only until the unprotected areas can be stabilized.

Planning Criteria: No design is required for contributing drainage areas within the limits which follow:

The allowable contributing drainage area and length of slope above the barrier are given in Table I.D-1.

Table I.D-1

Allowable Drainage Area for Straw Bale Dike

Slope (percent)	Maximum Drainage Area (acres)	Length of Slope (feet)
0-15	1	200
15+	1/2	100

Larger areas and longer slopes will require sediment removal by sediment basins or sediment traps.

Methods and Materials: The following criteria shall be used for straw bale dikes meeting the drainage area specifications in Table I.D-1:

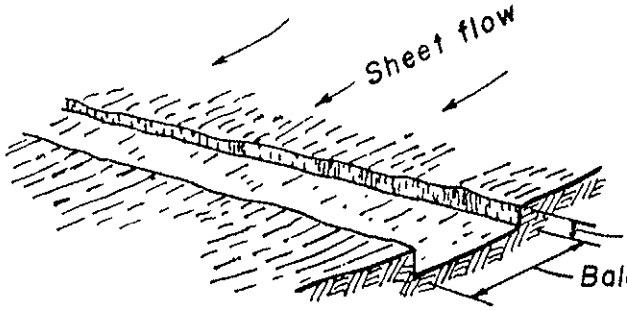
Straw Bales - Bales shall be bound with wire or nylon string. Twine bound bales are less durable.

Methods and Materials: Continued

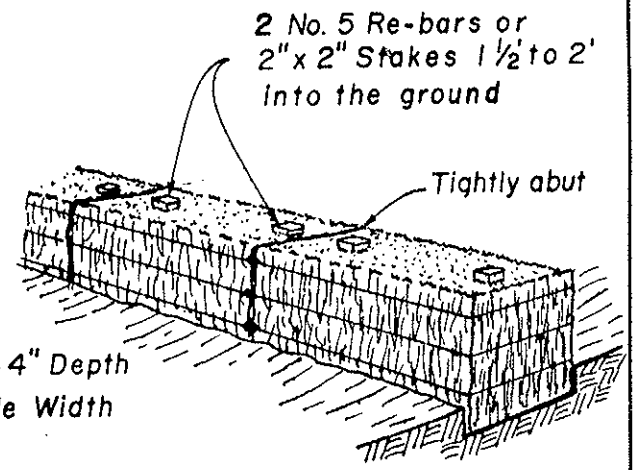
Bale Placement - Bales shall be placed in a row with ends tightly abutting the adjacent bales. Some loose straw may be compressed between adjacent bales to close voids. The tops of the bales shall all be level and set at the same elevation.

Anchorage - Each bale shall be embedded in the soil a minimum of 4 inches. Drive 2 x 2 stakes or rebar through bales and into ground 1 1/2 to 2 feet for anchorage. The first stake in each bale shall be driven toward a previously laid bale to force the bales together.

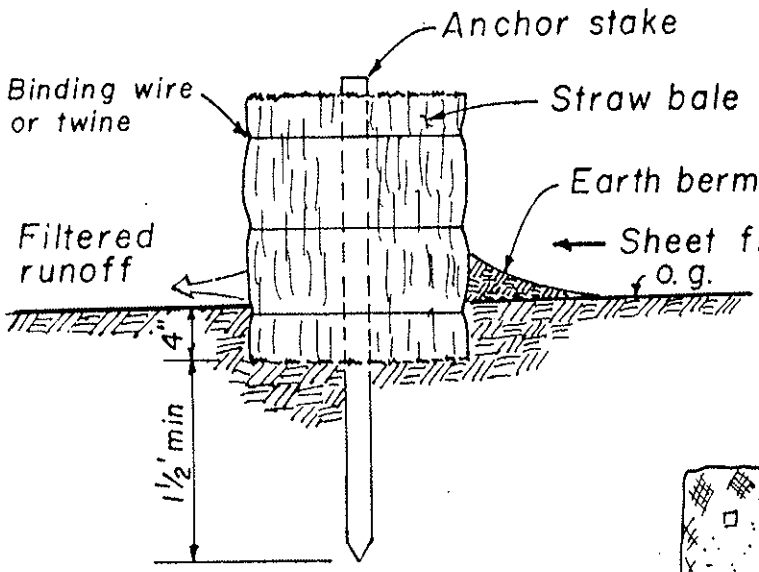
Operation and Maintenance: Periodic inspection and maintenance is required. Inspect the dike on a daily basis when construction activity is nearby to locate areas damaged by personnel or equipment. Inspect the dike and provide necessary maintenance following each storm period. The straw bales shall be removed once permanent drainage and stabilization practices are established. It is important to assure that loose straw is prevented from entering storm drainage facilities. Mixtures of straw and mud can severely clog pipeline and inlet structures. Once removed from the dike, the used straw can be used as mulch in other areas.



TRENCH DETAIL



BALE PLACEMENT



EMBEDDING DETAIL
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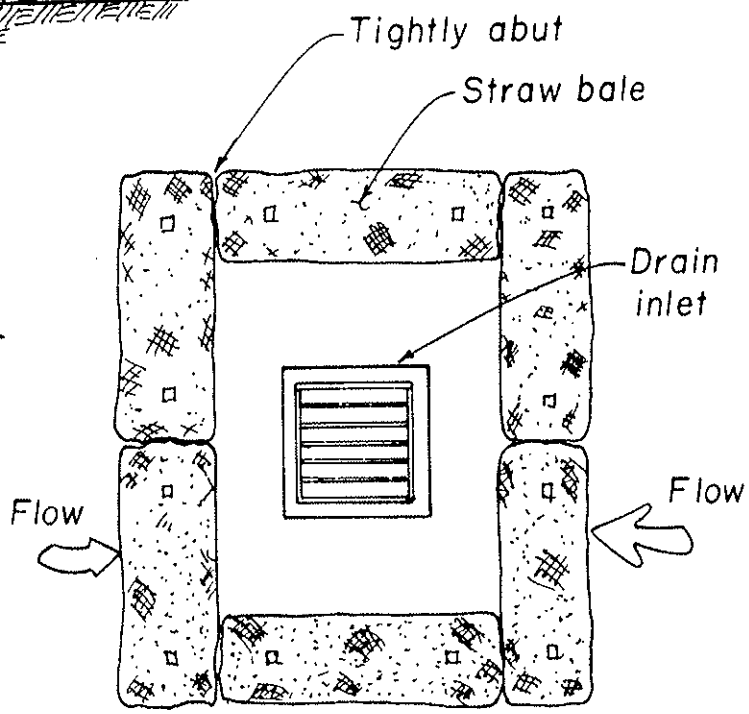


PLAN VIEW
STORM DRAIN PROTECTION
N. T. S.

High Sierra R. C. & D. Erosion & Sediment Control Guide 3/90 LCS	STRAW BALE SEDIMENT BARRIER 13

I.E

INTERCEPTOR SWALE

Definition: A temporary drive over a dip or excavated drainageway, built diagonally across a road or right-of-way.

Purpose: The purpose of an interceptor swale is to remove run-off from disturbed areas before it gains sufficient volume to become erosive. This is done to shorten the distance run-off must flow across disturbed areas before reaching a stabilized outlet and sediment trapping device.

Applicability: Used for disturbed rights-of-way such as for pipelines and streets that require frequent crossings with equipment where road grade does not exceed 10 percent. Applicable to other areas such as graded parking lots or land fills that have not been stabilized by gravel surfacing or vegetative means because of on going construction practices. The interceptor swale is used only during the period of construction and until permanent storm water control practices are installed.

Planning Criteria: For an interceptor swale receiving flow from an area less than 5 acres a design is not required. For larger drainage areas use a culvert or see the design criteria for Diversion-Section II.A. A stable outlet and sediment trapping device is required for the discharge.

Speed - The safe vehicle crossing speed for these types of dips is usually 10 miles per hour or less. Signs should be posted to warn equipment operators of this hazard.

Methods and Materials: The following criteria shall be used when the tributary drainage is less than 5 acres.

Spacing - Table I.E-1 lists the allowable spacing of interceptor swales for a given grade.

Table I.E-1

Interceptor Swale

Disturbed Area Grade (percent)	Spacing Between Swales (feet)
5 or less	300
5-10	150
Greater than 10	Not recommended

Methods and Materials: Continued

Depth - 4 inches minimum, measured from the end of the dip on the downhill side to the hydraulic bottom of the swale.

Side Slopes - 4:1 or flatter. Side slopes may be flatter as necessary to allow construction traffic to cross.

Flow Area Grade - The channel must have a minimum grade of 2% and flow to an adequate outlet. The recommended slope is 2% greater than the road grade.

Stabilization - Interceptor swales graded as above require stabilization when:

1) Soils have a high erosion potential; or,

2) Flow area grade is 5 percent or steeper; or,

3) Frequent crossings will be made with water in the channel.

Stabilization shall be by lining the flow area with hard, dense, durable, coarse gravel, well graded from a minimum size of 1/4 inch to a maximum size of 2 inches, which is placed in a 4 inch layer and pressed into the soil. The area covered by the stone shall extend across the bottom and up both sides of the channel to a height of at least 4 inches, measured vertically from the bottom.

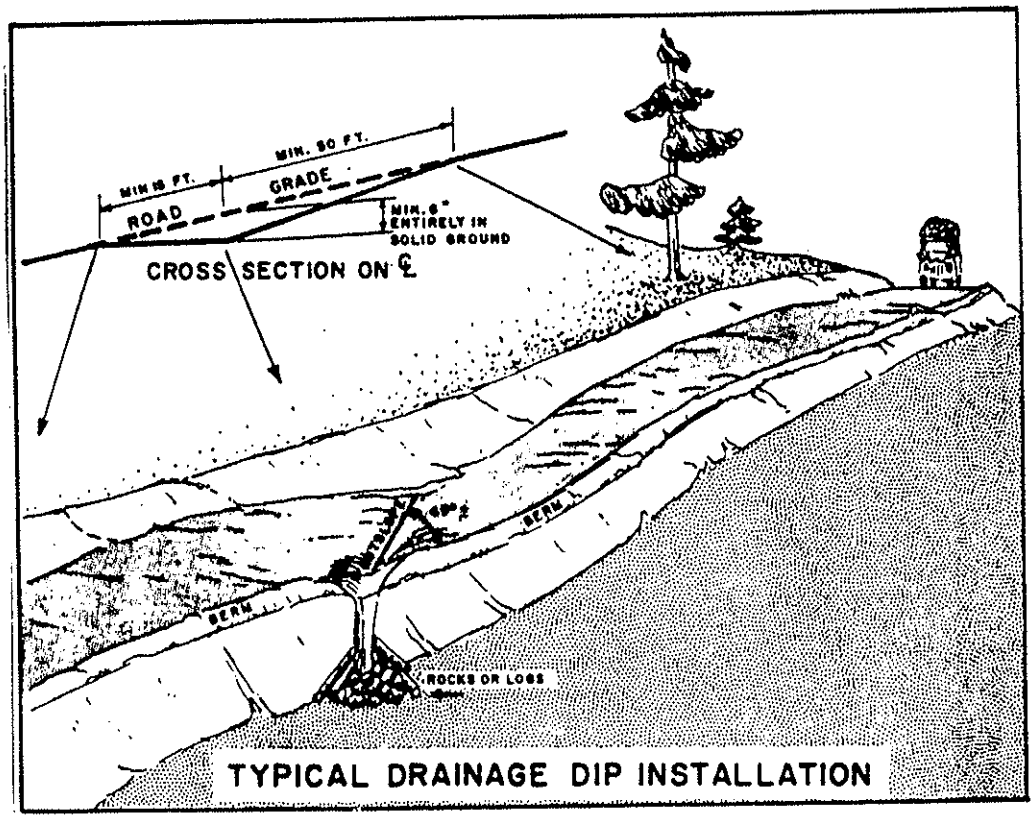
Compaction - Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed swale.

Outlet Protection - The outlet shall be protected by placement of coarse gravel, rock riprap, or a metal chute.

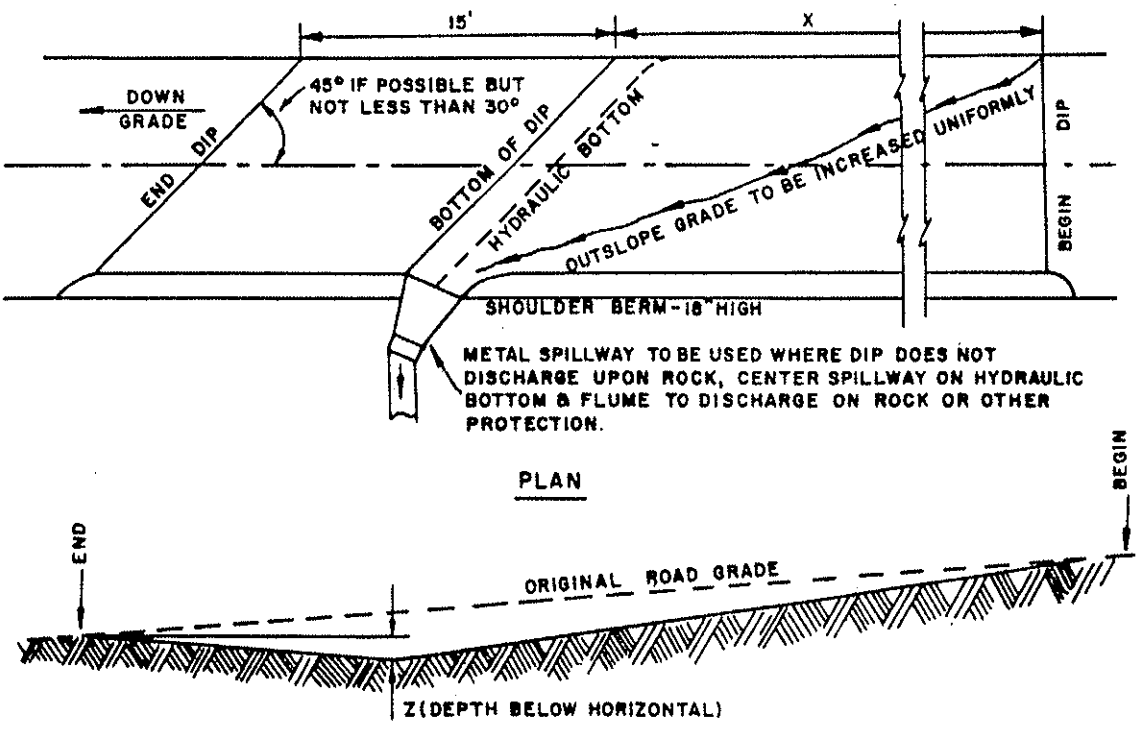
Discharge of Diverted Run-off - Diverted run-off from a disturbed or exposed area shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin, or to an area protected by any of these practices.

To utilize the most suitable outlet, the field location of the swale may be adjusted to meet field conditions.

Operation and Maintenance: Periodic inspection and maintenance shall be required. Inspect the swale on a daily basis when construction activity is nearby to locate areas damaged by personnel or equipment. Inspect the swale following each storm period. The interceptor swale shall be removed when permanent stabilization practices are completed.



TYPICAL DRAINAGE DIP INSTALLATION



PROFILE - UPPER SIDE

NOTE:
X = (% GRADE x 5) + 25
or 50' Minimum
Z = 4 Inches minimum

ADAPTED FROM:
CALIFORNIA DEPARTMENT of FORESTRY & FIRE
Handbook No. 2310

I.F

PERIMETER SWALE

Definition: A temporary excavated drainageway located along the perimeter of the construction site or disturbed area.

Purpose: The purpose of a perimeter swale is to prevent offsite storm run-off from entering the disturbed area, and to prevent sediment laden storm run-off from leaving the construction site or disturbed area.

Applicability: Perimeter swales are constructed around the edge of a disturbed area to transport sediment laden run-off to a sediment trapping device such as a sediment trap or sediment basin. Perimeter swales are used only during the period of construction and shall remain in place until the disturbed area is permanently stabilized.

Planning Criteria: For a perimeter swale receiving flow from an area less than 5 acres a design is not required. For larger drainage areas the design is based on the criteria for Diversion-Section II.A. A sediment trapping device is required for the discharge of run-off from disturbed areas. Run-off diverted around the disturbed area shall be routed so as to prevent damage due to flooding or erosion of adjacent property.

Methods and Materials: The following criteria shall be used when the tributary drainage is less than 5 acres.

Bottom Width - 7 feet minimum, measured from the toe of each side slope. The bottom shall be level.

Depth - 1 foot minimum, measured from the toe of the downhill side slope to the projection of the existing ground grade.

Side Slopes - 2:1 or flatter. Side slopes may be flatter as necessary to allow construction traffic to cross.

Flow Area Grade - The channel grade may be adjusted to suit the topography. However, a minimum grade of 1% to an adequate outlet is required.

Methods and Materials: Continued

Stabilization - Where the slope of the perimeter swale channel is:

1-5% - Stabilization may be required to meet specific site conditions such as highly erodible soils.

Over 5% - Stabilization shall be required.

Acceptable stabilization practices for the flow area shall be:

(1) in accordance with the Standards and Specifications for Grassed Waterways; or,

(2) by lining the flow area with hard, dense, durable rock, well graded from a minimum size of 1/4 inch to a maximum size of 2 inches which is placed in a 3 inch layer and pressed into the soil. The area covered by the stone shall extend across the bottom and up both sides of the channel to a height of at least 8 inches, measured vertically from the bottom.

Traffic Crossings - At all points where one or more vehicle crossings per day will be made, the swale shall be stabilized according to No. 2 above, except the stone shall be at least 6 inches in thickness for the full width of the traffic crossing. The limits of the traffic crossing shall be marked with stakes or be easily located.

Site Preparation - All trees, basins, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper operation of the swale. The swale shall be excavated and/or shaped to line, grade, and cross section as required to meet the criteria specified herein.

Compaction - Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed swale.

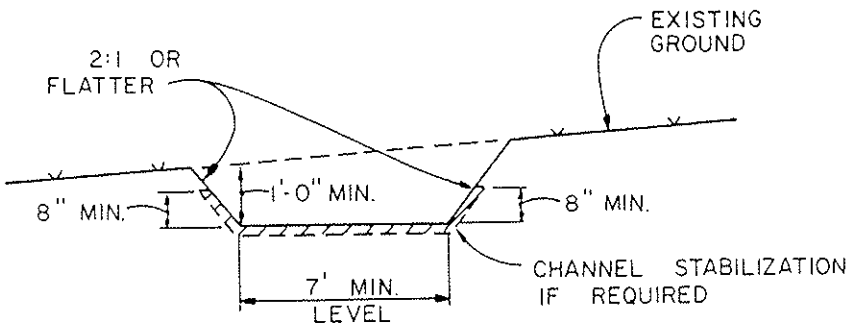
Excess Soil Removal - All soil removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the swale, and will not create a sediment problem.

Methods and Materials: Continued

Outlet Protection - The outlet shall be protected by a layer of coarse gravel, rock riprap or a paved chute as indicated by field conditions.

Discharge of Diverted Run-off - Diverted run-off from a disturbed or exposed area shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin, or to an area protected by any of these practices.

Operation and Maintenance: Periodic inspection and maintenance shall be required. Inspect the swale on a daily basis when construction activity is nearby to locate areas damaged by personnel or equipment. Inspect the swale following each storm period. The perimeter swale shall be removed when permanent stabilization practices are completed.



CROSS SECTION

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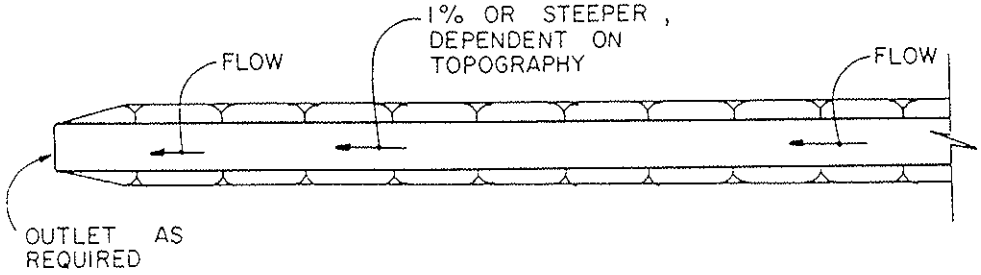


PLAN VIEW

N.T.S.

NOTE: DRAINAGE AREA LESS THAN 5 ACRES

PERIMETER SWALE

I.G

STONE OUTLET STRUCTURE

Definition: A temporary section of a diversion dike, interceptor dike, or perimeter dike, constructed of crushed stone.

Purpose: The purpose of the stone outlet structure is to provide a protected outlet for other temporary measures such as a diversion dike, straw bale dike, or perimeter dike, and to provide for diffusion of concentrated flow. Functions both as a spillway and dewatering device.

Applicability: Stone outlet structures are to be used at points of discharge where a grade control structure is not required. It is a temporary measure, used until permanent structures are installed and the drainage area is stabilized.

Planning Criteria: A stone outlet structure shall be used only where the drainage area is less than 5 acres. In areas where the drainage area is unstabilized, a sediment trap must be provided above the stone outlet structure. For drainage areas larger than 5 acres flow computations and design of the stone size are required.

Methods and Materials: The following criteria shall be used when the tributary drainage is less than 5 acres:

Minimum Length - The minimum length of the crest of the stone outlet structure in feet shall be equal to six times the number of acres of the tributary drainage area.

Dike Crest - The crest of the stone outlet weir shall be a minimum of 6 inches below the lowest elevation of the adjacent earth dike. The outlet crest shall be level.

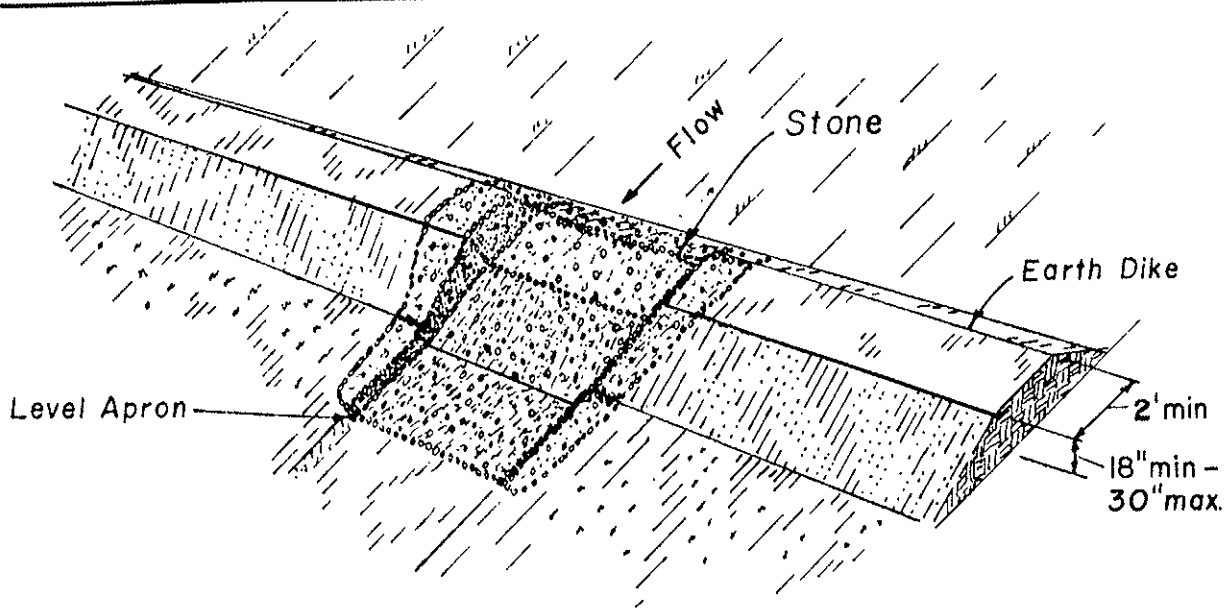
Stone - The stone outlet structure shall be constructed of crushed stone. The crushed stone shall be well graded from a minimum size of 1/4 inches to a maximum size of 2 inches. Class 1 Type B permeable material as specified in Section 68-1.025 of CalTrans Standard Specifications is suitable for stone dikes.

Discharge - The stone outlet structure shall discharge onto a stabilized area or into a stable water course.

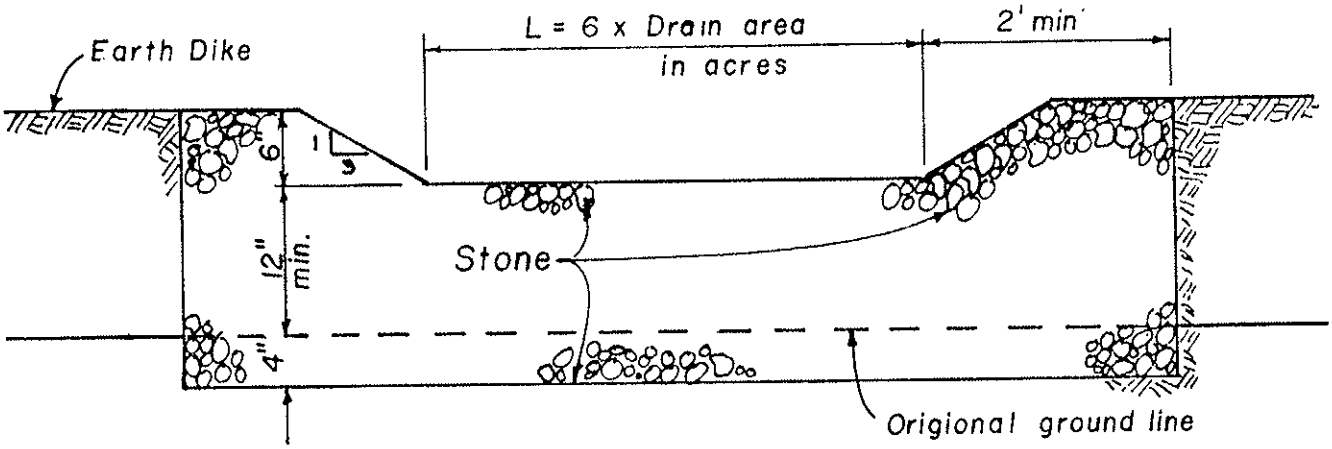
Methods and Materials: Continued

Foundation - The base of the outlet structure shall be embedded at least 4 inches into the soil.

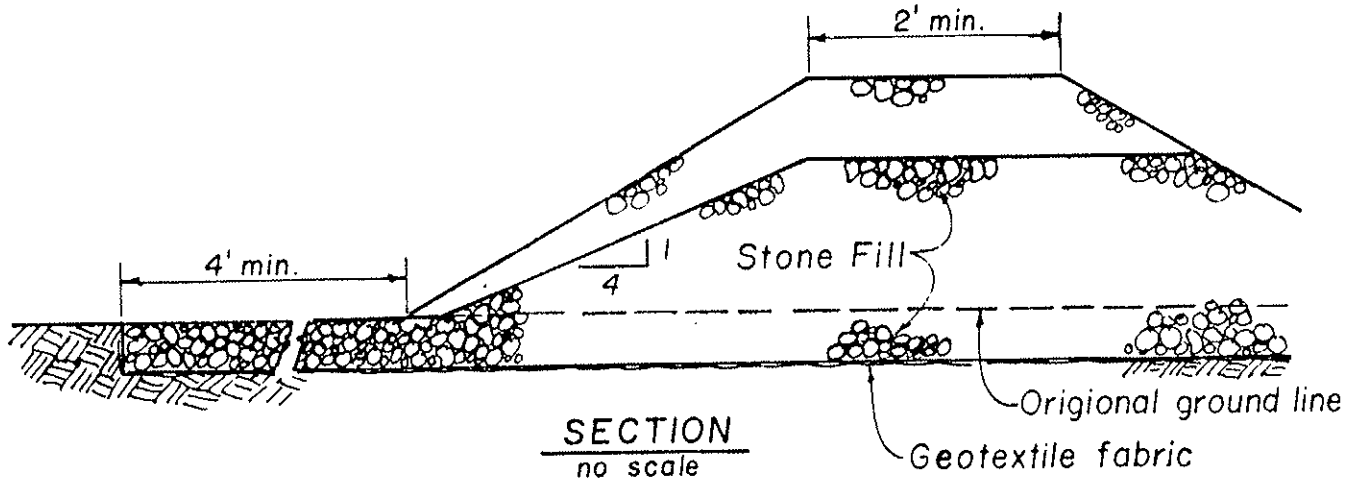
Operation and Maintenance: The stone outlet structure shall be inspected following each rain. Stone shall be replaced when silt accumulations clog the voids between the stone. The outlet shall be repaired following a washout or damage by construction activity.



PERSPECTIVE VIEW



PROFILE ON ℄ OF DIKE



SECTION
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High Sierra R.C. & D. Erosion & Sediment Control Guide 3/90	STONE OUTLET STRUCTURE 23

I.H

GRADE STABILIZATION STRUCTURE

(PAVED CHUTE OR FLUME)

Definition: A temporary channel lined with bituminous concrete, portland cement concrete, or a comparable non-erodible material, placed to extend from the top of a slope to the bottom of a slope.

Purpose: The purpose of the grade stabilization structure is to convey surface run-off safely down slopes, without causing erosion in temporary diversion channels and to prevent the formation or advance of gullies.

Applicability: For use with temporary diversion channels and perimeter dikes where storm run-off exceeds the capacity of a pipe slope drain. Should not be used where failure of the structure would result in loss of life, damage to homes or buildings, or interruption of the use of public roads or utilities.

Planning Criteria: The size of the grade stabilization structure is dependent on the peak run-off. The selection of the design storm shall be based upon a careful evaluation of the potential damages at the site and the following criteria:

Capacity - The minimum capacity shall be as follows:

(a) For single lot developments with tributary areas of less than 5 acres, drop height 5 feet or less, and no downstream structures that would be damaged, the peak rate of run-off from a 5-year return interval storm.

(b) For multiple lot developments and lots with tributary areas of less than 25 acres, drop height 10 feet or less, and no downstream structures that would be damaged, the peak rate of run-off from a 10-year return interval storm.

Outlet Protection - To prevent erosion at the outlet adequate energy dissipating devices shall be used. As a minimum, the downstream channel shall be protected with rock riprap.

Methods and Materials: Two size groups are used which define the height (h) of the dike entrance; depth (d) of the chute down the slope; and the length (L) of the inlet and outlet sections. Table I.H-1 gives the minimum dimensions for the two sizes.

Table I.H-1
Size Group

Dimension	A	B
h	1.5'	2.0'
d	8"	10"
L	5.0'	6.0'

Each size group has various bottom widths and allowable flow rates as shown in Table I.H-2

Table I.H-2

Size (a) (feet)	Bottom Width, b	Maximum Flow Rate (cfs)
A-2	2	7
A-4	4	12
A-6	6	17
A-8	8	23
A-10	10	28
B-4	4	19
B-6	6	28
B-8	8	35
B-10	10	43
B-12	12	52

(a) The size is designated with a letter and number. The letter designates the size group and the number indicates the bottom width (b).

Chute Foundation - The structure shall be placed on undisturbed soil or on well compacted fill. A 3 inch drainage blanket of gravel shall be placed beneath the full width of the outlet.

Methods and Materials: Continued

Slope - Cut or fill slopes shall not be steeper than 1.5 horizontal to 1 vertical, and shall not be flatter than 20 horizontal to 1 vertical.

Entrance Dikes - The top of the earth dikes directing flow to the chute shall not be lower than the top of the lining at the structure entrance.

Lining Placement - The lining shall be placed beginning at the lower end and proceeding up the slope to the upper end. The lining shall be well compacted and free of voids. The lining surface shall be reasonably smooth.

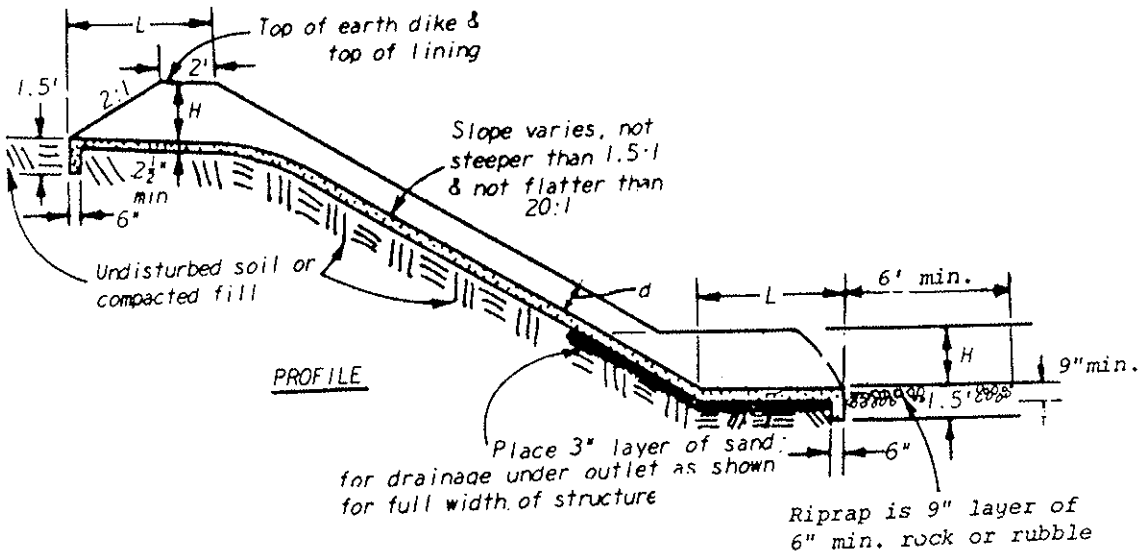
Entrance Floor - The entrance floor at the upper end of the structure shall have a slope toward the outlet of 1/4 to 1/2 inch per foot.

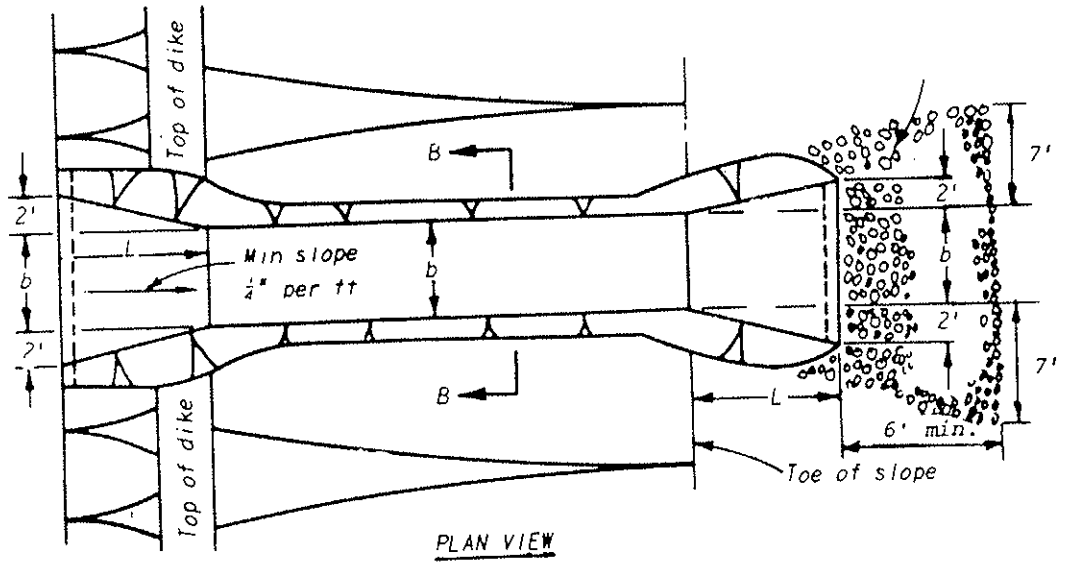
Cutoff Walls - The cutoff walls at the entrance and downstream end of the discharge apron shall be cast or formed as a continuous part of the lining.

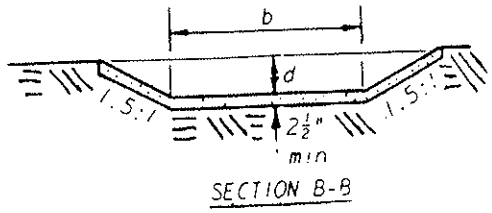
Lining Material - The lining shall consist of portland cement concrete, bituminous concrete, or comparable non-erodible material.

Reinforcement - To control cracking of a portland cement concrete chute, reinforcement with welded wire is recommended.

Operation and Maintenance: Periodic inspections are recommended to assure proper operation of the grade stabilization structure. Lining deterioration, channel erosion, or other structural failure should be identified and the source of the problem repaired as soon as possible.







SECTION B-B

PAVED CHUTE OR FLUME

mbc

I.I

FLEXIBLE PIPE SLOPE DRAIN

Definition: A flexible conduit made from corrugated plastic tubing used to convey storm water from the top to the bottom of a slope. A temporary measure used until permanent facilities are installed and the slope is stabilized with vegetation. Usually used in conjunction with a top-of slope diversion dike.

Purpose: The purpose is to prevent rill and gully erosion of cut or fill slopes and other steep areas during construction and to convey run-off to a stable discharge point.

Applicability: For all construction sites where run-off water can accumulate above a cut or fill slope.

Planning Criteria:

1. A flexible pipe slope drain shall not receive flow from an area larger than 2.5 acres.

2. If sediment laden water is being conveyed by the slope drain, a sediment trapping device shall be installed below the outlet.

3. The diameter of the pipe shall be sufficient to convey run-off from a 5-year return interval storm. Table I.I-1 shows pipe sizes for drainage areas located below 1000 feet elevation. Where failure would cause damage to structures or offsite property the design storm should be increased.

Table I.I-1

Pipe/Tubing Diameter (inches)	Maximum Drainage Area (acres)
4	0.1
6	0.2
8	0.4
10	0.7
12	1.0
14	1.4
16	1.8
18	2.5

Methods and Materials: It is very important that these temporary structures be installed properly, since failure can cause gully erosion.

Inlet - A prefabricated metal inlet structure with starter pipe shall be used to prevent seepage around the pipe. The inlet structure shall be placed on undisturbed or compacted fill, driven into the soil, and securely entrenched by hand tamping fill around the discharge pipe. The top of the inlet pipe shall be at least 1 foot lower than the top of the diversion dike.

Pipe Entrance - The entrance section of the pipe shall have a slope of 3% or steeper toward the outlet.

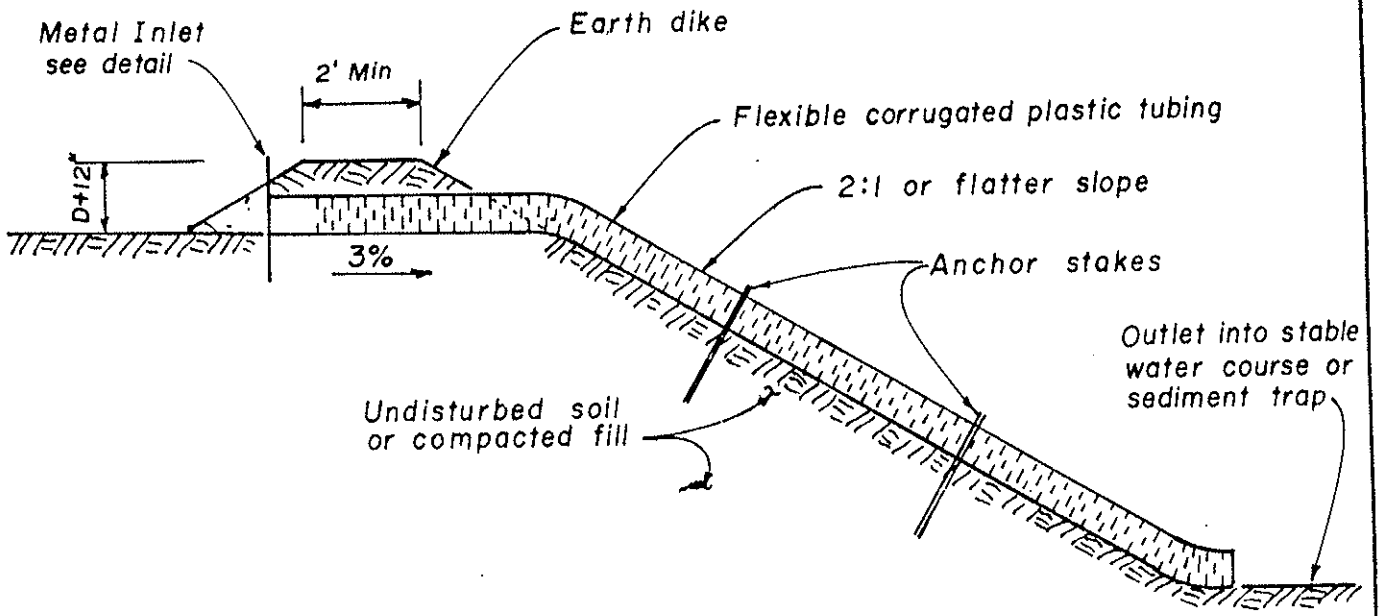
Trash Screen - A screen or grate may be installed to reduce plugging with straw and other debris. Screen should be staked in a semi circle 2 feet or more clear of the inlet.

Flexible Tubing - The flexible tubing shall be the same diameter as the inlet pipe and shall be constructed of corrugated plastic tubing. All joints and connections must be reasonably water tight.

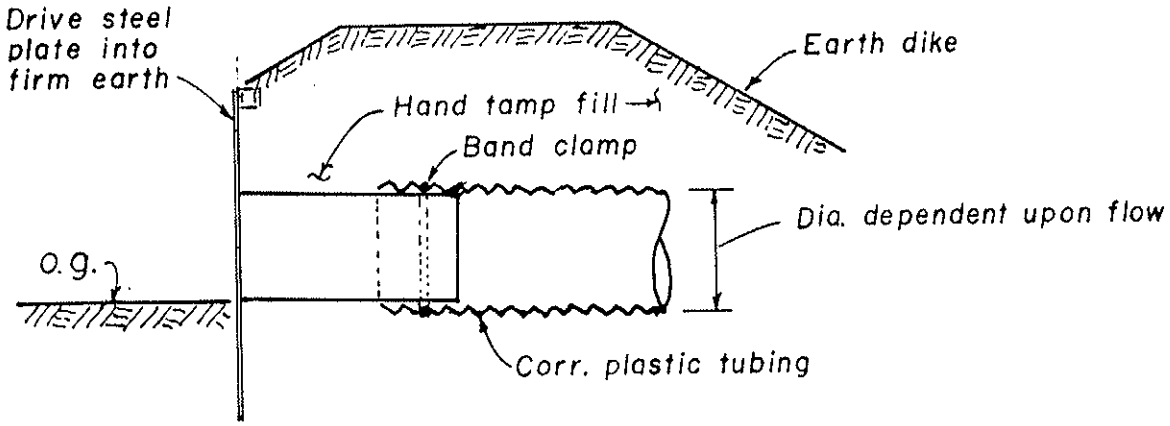
Anchor Stakes - To prevent dragging and wind damage a secure anchorage for the flexible tubing shall be provided by staking to the slope at intervals of 10 feet.

Outlet - The pipe slope drain shall outlet onto a stabilized watercourse or a sediment trap.

Operation and Maintenance: Periodic inspections are recommended to assure proper operation of the pipe slope drain. Inspect the structure following each rainfall period. Remove debris or sediment buildup and repair damaged structures.



SECTION
no scale



INLET INSTALLATION DETAIL
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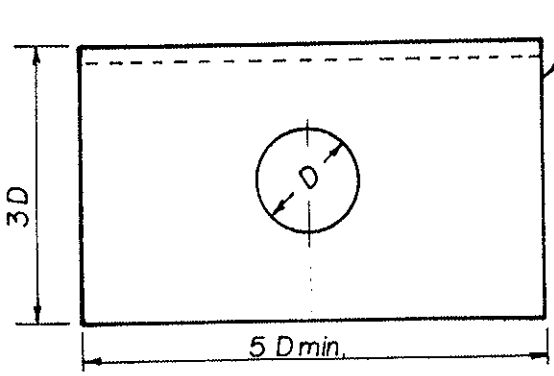
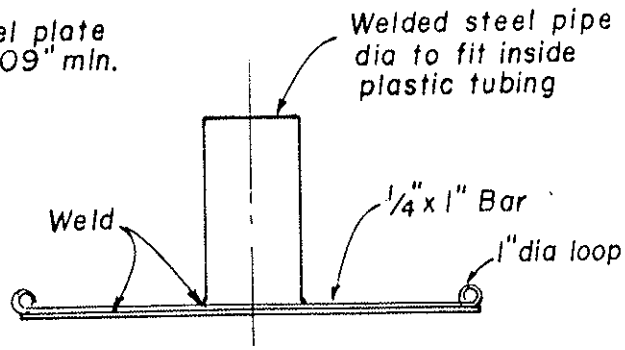


ELEVATION



PLAN DETAIL

High Sierra R.C. & D.
Erosion & Sediment Control Guide
2/90

FLEXIBLE PIPE SLOPE DRAIN

I.J

SEDIMENT BASIN

Definition: A temporary barrier or dam constructed across a waterway, or at other suitable locations, to intercept sediment-laden run-off and to trap and retain the sediment.

Purpose: The purpose of the sediment basin is to intercept sediment-laden run-off and reduce the amount of sediment leaving the disturbed area, in order to protect drainageways, properties, and roadways below the sediment basin.

Applicability: Basins are secondary measures used below ongoing construction sites which may not be adequately treated. Sediment basins are constructed where physical site conditions or construction schedule restrictions preclude installation of alternative erosion control measures that would normally control run-off, erosion and sedimentation. The basin shall be operable until the disturbed area is protected from erosion by permanent stabilization.

Planning Criteria: Sediment basins should be constructed where: (1) failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use of public roads or utilities; (2) the drainage area does not exceed 100 acres; (3) the basin is to be removed within 36 months after completion of the basin.

Site - The basin should be located to maximize natural storage from the terrain and for ease of sediment removal. Select a site that does not receive significant amounts of run-off from offsite drainage areas. It should also be located to minimize interference of construction activities.

Laws - The basin shall comply with the applicable laws, rules, regulations and ordinances of the California Division of Safety of Dams and county grading ordinances.

Capacity - The combined capacity of the pipe and emergency spillway shall be adequate to carry the peak rate of run-off from a 50-year return interval storm, or as specified by the permit issuing authority. Run-off calculations shall be based upon the most severe soil cover conditions expected to prevail in the drainage area throughout the life of the basin.

Planning Criteria: Continued

Classification - For the purpose of this standard, sediment basins are classified as follows:

Classification of Temporary Sediment Basins

Size	Max. Drainage Area acres	Max. Height* of Dam, ft.	Min. Embankment Top Width, ft.	Embankment Side Slopes	Anti-Seep Collar Req'd
1	100	10	8	2.5:1 or flatter	Verify by Design
2	100	15	10	3:1 or flatter	Yes

*** Height is measured from the low point of original ground along the centerline of dam to the top of the dam.**

Basin Size - The basin shall meet the following criteria:

Volume - Minimum 67 cubic yards/acres or 0.5 watershed inches; measured from basin bottom to crest of principal spillway.

Shape - Length to width ratio = 2:1 or greater. The basin shape may be obtained by excavation to the required shape or installation of baffles to increase flow length.

Methods and Materials:

Spillways: Two spillways shall be provided, an open channel emergency spillway and a pipe principal spillway.

A. **Pipe Spillway** - This spillway consists of a vertical watertight pipe riser connected to a watertight pipe extending through the embankment to the point of discharge into a natural or constructed channel. The outlet shall be protected from erosion by a storm drain outlet protection in accordance with the applicable Standard and Specification.

The minimum capacity of pipe spillway when the water elevation is at the crest of the emergency spillway shall be the larger value computed as follows:

(1) Minimum 0.2 cfs/acre of drainage area.

(2) The peak flow of a 2-year return interval storm.

A. Pipe Spillway Continued

Size - Refer to Appendix I.J-1 Sediment Basin Design for riser and discharge pipe size. Minimum discharge pipe size shall be 8 inches.

Crest Elevation of Riser - Minimum 1 foot below crest of emergency spillway.

Appurtenances - The following appurtenances shall be used on all pipe spillways:

1. Riser - The riser shall be completely watertight, except for the inlet opening and dewatering openings.

2. Antivortex Device - The antivortex device shall be concentric with the riser. This device shall extend above and below the riser crest a minimum of 1 foot.

3. Trash Rack - A covered concentric trash rack as shown in Appendix I.J shall be placed over the pipe riser.

4. Base - The riser shall have a base attached with a watertight connection and shall have a footing of sufficient weight to prevent flotation of the riser. Two approved bases for risers 10 feet or less in height are:

   (a) A concrete base 18" thick with the riser embedded 6" in the base.

   (b) A 1/4" minimum thickness steel plate attached to the riser by a continuous weld around the circumference of the riser for a watertight connection. The plate shall have 2.5 feet of stone, grave, or tamped earth placed on it to prevent flotation. In either case, each side of the square base shall be twice the riser diameter. For risers greater than 10 feet high, computations shall be made to check flotation. The minimum factor of safety shall be 1.25 (downward forces = 1.25 x upward forces).

A. Pipe Spillway Continued

5. Anti-seep Collars - Anti-seep collars shall be installed around the pipe conduit within the normal saturation zone to increase the seepage length at least 10% when any of the following conditions exist:

   (a) The settled height of dam exceeds 10 ft.; or,

   (b) The embankment material has a low silt-clay content (Unified Soil Classes SM or GM) and the pipe diameter is 10 inches or greater.

   The phreatic line may be approximated with a line drawn downward on a 4:1 slope from the intersection of the normal pool (corresponding to the top of the riser and the upstream face of the embankment). The seepage length is the length of the flow path of a particle of water along the conduit from the riser to the point of intersection between the approximate phreatic line and the invert of the pipe conduit. When anti-seep collars are used, the equation for revised seepage length becomes:

   $L_S + 2nV > 1.1\ L_S s$ or $n > \cdot\frac{05Ls}{V}$

   Where: L_S = Saturated length is length (in feet) of pipe between riser and intersection of phreatic line and pipe invert.

   n = number of anti-seep collars. v = vertical projection of collar from pipe, in feet.

   See Appendix I.J-1 for ANTI-SEEP COLLAR DESIGN.

   The anti-seep collar and its connection to the pipe shall be watertight. The maximum spacing, in feet, between collars shall be 14 times the minimum projection of the collar measured perpendicular to the pipe. The anti-seep collar(s) shall be located below the phreatic line in the embankment and should be equally spaced. They shall not be located closer than 2 feet to a pipe joint. There shall be sufficient distance between collars to allow space for the hauling and compacting equipment.

A. Pipe Spillway Continued

6. Outlet - An outlet shall be provided, including a means of conveying the discharge, in an erosion-free manner to a natural or constructed channel. Drainage easements shall be obtained if this discharge crosses the property line before reaching the stream. Protection against scour at the discharge end of the pipe spillway shall be provided. Measures may include impact basin, riprap, revetment, excavated plunge pools, or other approved methods. See the Standards and Specifications for Storm Drain Outlet Protection.

B. Emergency Spillways - Emergency spillways are open channels that augment the pipe spillway during storm periods. Emergency spillways shall conform to the following criteria:

Size - Size is based upon design storm less discharge through the pipe spillway. Dimensions shall be determined as outlined in Appendix I.J-1, Sediment Basin Design.

Cross Section:

Shape:	Trapezoidal
Bottom width:	Minimum 8 feet
Side slope:	Concrete - 1-1/2:1
	Riprap - 2:1
	Vegetation - 2:1

Lining - Refer to permissible velocities presented in Section II.D, Storm Drain Outlet Protection and Section II.E, Riprap.

Freeboard - One foot minimum measured from high water in reservoir to top of settled embankment.

Cutoff Trench: A cut-off trench shall be excavated along the centerline of earth filled embankments. The trench shall meet the following criteria:

Depth:	1/2 height of dam or to a competent impervious layer
Bottom width:	4 feet minimum
Side slope:	1:1 maximum
Limits:	Trench shall extend up both abutments to riser crest elevation

Basin Entrance: Entrance points shall be stabilized to prevent erosion and to direct run-off into the basin. Stabilization shall conform to Standards and Specifications for Diversion or Grade Stabilization structures. Entrance points shall be located to maximize run-off travel distance to the discharge point.

Disposal: Adequate provisions shall be made for removal and disposal of trapped sediment. These provisions shall not cause incidental erosion from their construction or operation.

Safety: The entire perimeter of a sediment basin shall be fenced with a 6 foot high chain link fence with barbs on top. All gates shall be locked. The basin shall be posted for hazards of soft sediment and floodwater, and an emergency phone number shall be given.

Dewatering: Means for dewatering the detention pool shall be provided in all basins. Means for dewatering the pool shall be included in the sediment basin plans submitted for approval and shall be installed during construction of the basin.

Usually the detention pool may be dewatered by installing a length of perforated drain pipe with gravel filter. Other methods may be approved by the permit issuing agency.

Site Preparation: Areas under embankment and structures shall be cleared, grubbed, and stripped of trees, vegetation, other organic matter, topsoil, or other deleterious or objectionable material. Dispose of strippings at an approved location.

Excavation: Where it is necessary to excavate for the sediment basin. Topsoil and other excavated material shall be stockpiled at a suitable site, protected from erosion, and saved for restoring the site when the basin is no longer needed.

Embankment: Embankment cross sections shall be as shown in the classification chart (see page 32). Fill material shall be obtained from approved borrow areas. It shall be clean mineral soil, free of roots, vegetation, organic matter, rocks, or other deleterious material. Pervious material, such as sand or gravel, Unified Soil Classes GW, GP, SW & SP shall not be used. Fill shall not be frozen nor placed on frozen material.

Fill shall be placed at its optimum moisture, which can be field or laboratory determined. Optimum moisture shall enable a fill sample to be formed into a ball without crumbling or relieving water when squeezed.

Compaction: Fill shall be placed in horizontal layers not exceeding 8 inches. Compaction shall result in densities equal to a greater than 95% of the maximum obtained by laboratory compaction of a like soil at optimum moisture in accordance with ASTM D-698, Method A. Embankment shall be constructed to 10% above design height to allow for settlement after compaction.

Fill may be hand or machine compacted. Acceptable machine compactors are smooth or sheepsfoot rollers. Hand compact fill near or above structures for a minimum of two feet in all directions.

Required Submittals: In addition to California Division of Safety of Dams requirements, Sediment Soil Basin designs and construction plans submitted for review to the permit issuing agency shall include the following:

A. Specific location of the dam.

B. Plan view of dam, storage basin and emergency spillway.

C. Cross section of the dam, principal spillway and emergency spillway; profile of emergency spillway.

D. Details of pipe materials, connections, riser to pipe connection, riser base, anti-seep collars, trash rack and anti-vortex device.

E. Map showing drainage area, land use cover conditions assumed and run-off calculations for the design storms.

F. Storage Computation:

1. Total required.

2. Total available.

3. Level of sediment at which clean out shall be required; to be stated as a distance from the riser crest to the sediment surface.

G. Calculations showing design of pipe and emergency spillway.

H. A copy of the operation and maintenance instructions.

Operation and Maintenance: Provide operation and maintenance instructions to the responsible party, giving an estimated number of clean outs required and the location of sediment disposal sites. These instructions shall include normal and emergency operation and repairs.

TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

Computed By _____ Date _____
Checked By _____ Date _____

Project _____

Basin # _____ Location _____

Total Area draining to basin, _____ Acres.

BASIN VOLUME DESIGN

1. Min. required vol. = 67 cu. yds. x _____ ac. drainage = _____ cu. yds.

2. Vol. of basin = _____ = _____ cu. yds.

3. Excavate _____ cu. yds. to obtain required capacity.
   Min. vol. before cleanout = 27 cu. yds. x _____ ac. drainage = _____ cu. yds.
   Elevation corresponding to scheduled time to clean out _____
   Distance below top of riser _____

DESIGN OF SPILLWAYS

Run-off

4. Q_p = _____ cfs

Pipe Spillway (Q_{ps})

5. Min. pipe spillway capacity, Q_{ps} = 0.2 x _____ ac. drainage = _____ cfs
   Note: If there is no emergency spillway, then req'd. $Q_{ps} = Q_p$ = _____ cfs

6. H = _____ ft. Barrel length = _____ ft.

7. Barrel: Diam. _____; Q_{ps} = (Q) _____ x (cor. fac.) _____ = _____ cfs

8. Riser: Diam. _____ inches; Length _____ ft.; h = _____ ft.

9. Trash Rack: Diam. _____ inches; H = _____ in.

Emergency Spillway Design (Q_{es})

10. Emergency Spillway Flow, $Q_{es} = Q_p - Q_{ps}$ = _____ - _____ = _____ cfs

11. Width _____ ft. H_p _____ ft.
    Exit channel flow depth _____ ft. Exit channel slope _____%
    Velocity _____ ft./sec. Lining type: _____

ANTI-SEEP COLLAR DESIGN (If Required)

12. y = _____ ft.; z = _____:1; pipe slope = _____%, L_s = _____ ft.
    Use _____ collars, _____ - _____" square; projection = _____ ft.

DESIGN ELEVATIONS

13. Riser Crest = _____
    Em. Spwy. Crest = _____

Design High Water = _____
Top of Dam = _____

TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

Instructions for Use of Form

1. Minimum required detention volume is 67 cubic yards per acre from each acre of drainage area. Values larger than 67 cubic yards per acre may be used for greater protection. Compute volume using entire drainage area although only part may be disturbed.

2. The volume of a naturally shaped (no excavation in basin) basin may be approximated by the formula V = 0.4A d, where V is in cubic feet, A is the surface area of the basin, in square feet, and d is the maximum depth of the basin, in feet. Volume may be computed from contour information or other suitable methods.

3. If volume of basin is not adequate for required storage, excavate to obtain the required volume.

4. The method described in the SCS Engineering Field Manual, Chapter 2, is the preferred method for run-off computation. If rational method is used to compute run-off, obtain appropriate values for "I" and "C", depending on watershed conditions during development.

5. Required discharge from pipe spillway equals 0.2 cfs/ac. times total drainage area. (This is equivalent to a uniform run-off of 5" per 24 hours). The pipe shall be designed to carry Q_p if site conditions preclude installation of an emergency spillway to protect the structure.

6. Determine value of "H" from field conditions; "H" is interval between the centerline of the outlet pipe and the emergency spillway crest, or if there is no emergency spillway to the design high water.

7. See Pipe Spillway Design Charts.

8. See Riser Inflow Curves.

9. See Trash Rack and Anti-Vortex Device Design.

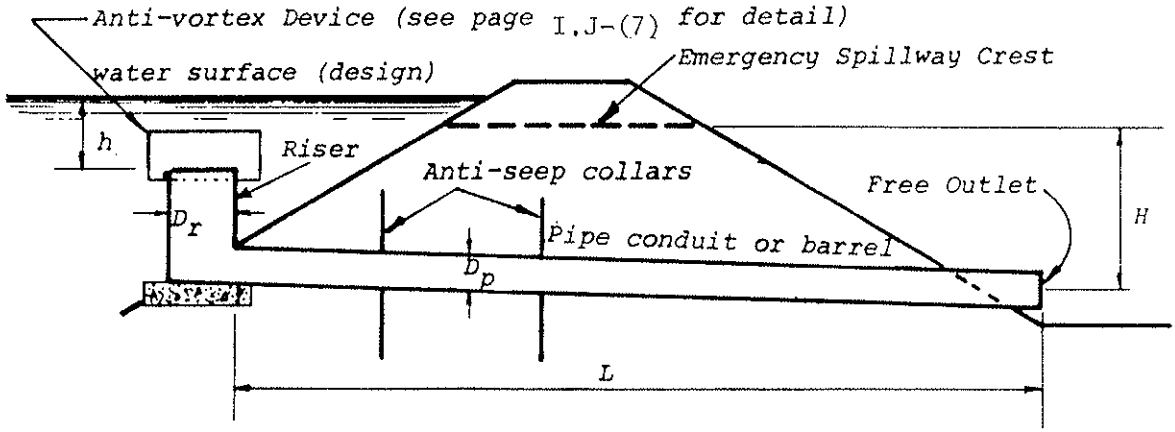
10 Compute Q_{es} by subtracting actual flow carried by the pipe spillway from the total inflow, Q_p.

11. Use appropriate tables to obtain values of H_p, bottom width, and actual Q_{es}. If no emergency spillway is to be used, so state, giving reason(s).

12. See Anti-Seep Collar Design.

13. Fill in design elevations. The emergency spillway crest must be set no closer to riser crest than value of h which causes pipe spillway to carry the minimum required Q. Therefore, the elevation difference between spillways shall be equal to the value of h, or one foot, whichever is greater. Design high water is the elevation of the emergency spillway crest plus the value of H_p, or if there is no emergency spillway, it is the elevation of the riser crest plus h required to handle the 10-year storm. Minimum top of dam elevation requires 1.0 ft. of freeboard above design high water.

PIPE SPILLWAY DESIGN



H = Head on pipe spillway (pipe flow), ft. (centerline of outlet to emergency spillway crest or to design high water if no emergency spillway)

h = Head over riser crest, ft.

L = Length of pipe in ft.

D_p = Diameter of pipe conduit (barrel)

D_r = Diameter of riser

To use charts:

Enter chart, page I.J-1(5) or I.J-1(6) with H and required discharge.

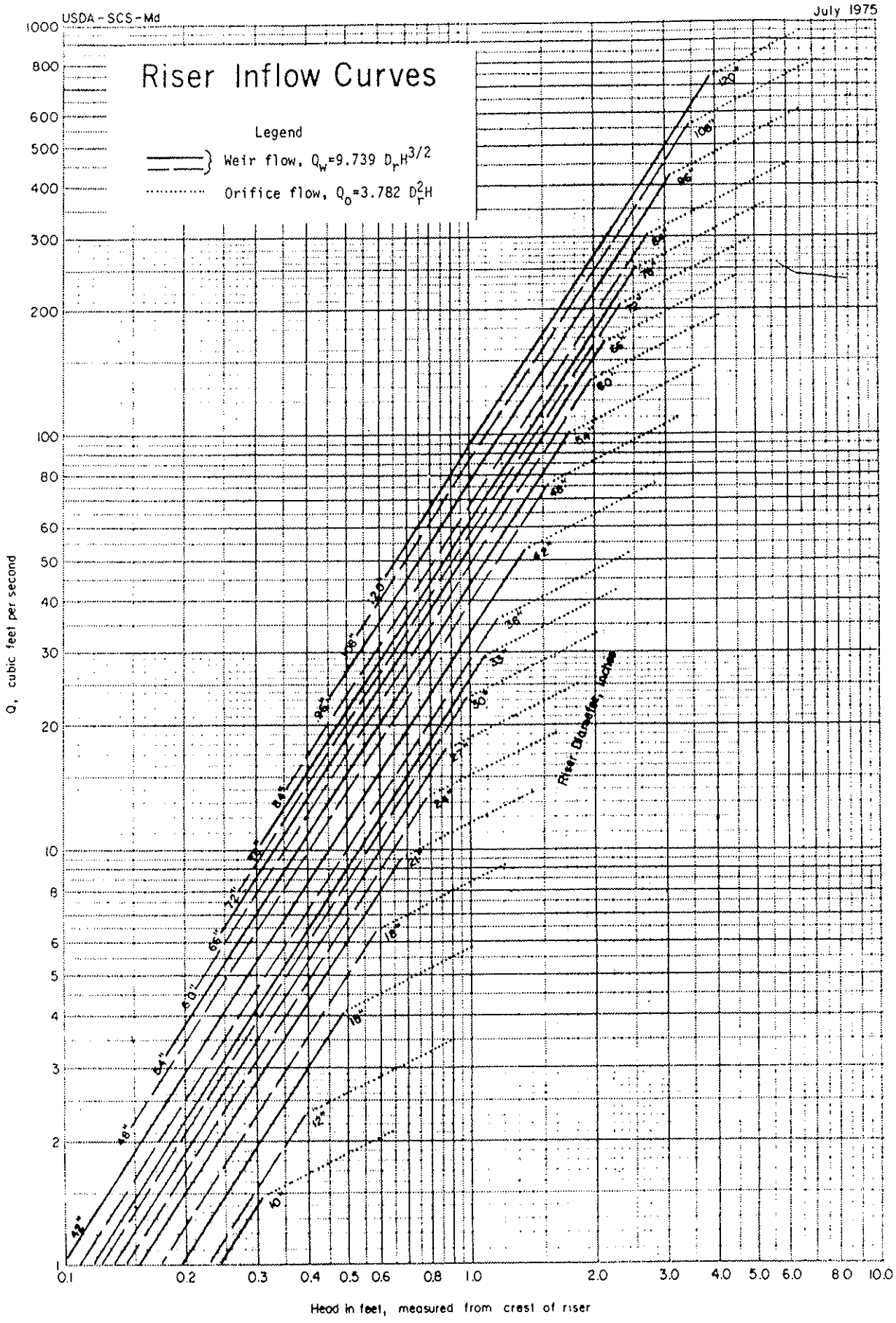
Find diameter of pipe conduit that provides equal or greater discharge.

Enter chart, page I.J-1(4), with actual pipe discharge. Read across to select smallest riser that provides discharge within weir flow portion of rating curve. Read down to find corresponding h required.

Example

Given: Q (required) = 5.8 cfs
L = 60'
H = 9' to centerline of pipe = Free outlet

Find: Pipe size, actual Q and size of riser.
Q of 12" pipe = 6.0 cfs x (correction factor) 1.07 = 6.4 cfs from the Pipe Flow Chart.
From Riser Inflow Curves, smallest riser = 18" (@ h = 0.6)


USDA - SCS - Md
July 1975
Riser Inflow Curves
Legend
Weir flow, $Q_w = 9.739\ D_r H^{3/2}$
Orifice flow, $Q_o = 3.782\ D_r^2 H$
Riser Diameter, inches
Q, cubic feet per second
Head in feet, measured from crest of riser
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
4
3
2
1
0.1
0.2
0.3
0.4
0.5
0.6
0.8
1.0
2.0
3.0
4.0
5.0
6.0
8.0
10.0

PIPE FLOW CHART $n = 0.013$

FOR REINFORCED CONCRETE PIPE INLET $K_m = K_e + K_b = 0.65$ AND 70 FEET OF REINFORCED CONCRETE PIPE CONDUIT (full flow assumed)

Note correction factors for pipe lengths other than 70 feet

diameter of pipe in inches

H, in feet	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	3.22	5.44	8.29	11.8	15.9	26.0	38.6	53.8	71.4	91.5	114	139	167	197	229	264	302	342
2	4.55	7.69	11.7	16.7	22.5	36.8	54.6	76.0	101	129	161	197	236	278	324	374	427	483
3	5.57	9.42	14.4	20.4	27.5	45.0	66.9	93.1	124	159	198	241	289	341	397	458	523	592
4	6.43	10.9	16.6	23.5	31.8	52.0	77.3	108	143	183	228	278	334	394	459	529	604	683
5	7.19	12.2	18.5	26.3	35.5	58.1	86.4	120	160	205	255	311	373	440	513	591	675	764
6	7.88	13.3	20.3	28.8	38.9	63.7	94.6	132	175	224	280	341	409	482	562	647	739	837
7	8.51	14.4	21.9	31.1	42.0	68.8	102	142	189	242	302	368	441	521	607	699	798	904
8	9.10	15.4	23.5	33.3	44.9	73.5	109	152	202	259	323	394	472	557	685	748	854	966
9	9.65	16.3	24.9	35.3	47.7	78.0	116	161	214	275	342	418	500	590	688	793	905	1025
10	10.2	17.2	26.2	37.2	50.2	82.2	122	170	226	289	361	440	527	622	725	836	954	1080
11	10.7	18.0	27.5	39.0	52.7	86.2	128	178	237	304	379	462	553	653	761	877	1001	1133
12	11.1	18.9	28.7	40.8	55.0	90.1	134	186	247	317	395	482	578	682	794	916	1045	1184
13	11.6	19.6	29.9	42.4	57.3	93.7	139	194	257	330	411	502	601	710	827	953	1088	1232
14	12.0	20.4	31.0	44.1	59.4	97.3	145	201	267	342	427	521	624	736	858	989	1129	1278
15	12.5	21.1	32.1	45.6	61.5	101	150	208	277	354	442	539	646	762	888	1024	1169	1323
16	12.9	21.8	33.2	47.1	63.5	104	155	215	286	366	457	557	667	787	917	1057	1207	1367
17	13.3	22.4	34.2	48.5	65.5	107	159	222	294	377	471	574	688	812	946	1090	1244	1409
18	13.7	23.1	35.2	49.9	67.4	110	164	228	303	388	484	591	708	835	973	1121	1280	1450
19	14.0	23.7	36.1	51.3	69.2	113	168	234	311	399	497	607	727	858	1000	1152	1315	1489
20	14.4	24.3	37.1	52.6	71.0	116	173	240	319	409	510	623	746	880	1026	1182	1350	1528
21	14.7	24.9	38.0	53.9	72.8	119	177	246	327	419	523	638	764	902	1051	1211	1383	1566
22	15.1	25.5	38.9	55.2	74.5	122	181	252	335	429	535	653	782	923	1076	1240	1415	1603
23	15.4	26.1	39.8	56.5	76.2	125	186	258	342	439	547	668	800	944	1100	1268	1447	1639
24	15.8	26.7	40.6	57.7	77.8	127	189	263	350	448	559	682	817	964	1123	1295	1478	1674
25	16.1	27.2	41.5	58.9	79.4	130	193	269	357	458	571	696	834	984	1147	1322	1509	1708
26	16.4	27.7	42.3	60.0	81.0	133	197	274	364	467	582	710	850	1004	1169	1348	1539	1742
27	16.7	28.3	43.1	61.2	82.5	135	201	279	371	476	593	723	867	1023	1192	1373	1568	1775
28	17.0	28.8	43.9	62.3	84.1	138	204	285	378	484	604	737	883	1041	1214	1399	1597	1808
29	17.3	29.3	44.7	63.4	85.5	140	208	290	384	493	615	750	898	1060	1235	1423	1625	1840
30	17.6	29.8	45.4	64.5	87.0	142	212	294	391	501	625	763	913	1078	1256	1448	1653	1871
L, in feet	Correction Factors For Other Pipe Lengths																	
20	1.30	1.24	1.21	1.18	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.03
30	1.22	1.18	1.15	1.13	1.12	1.09	1.08	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02
40	1.15	1.13	1.11	1.10	1.08	1.07	1.05	1.05	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01
60	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.96	.97	.97	.97	.98	.98	.98	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
90	.93	.94	.94	.95	.95	.96	.97	.97	.98	.98	.98	.98	.98	.99	.99	.99	.99	.99
100	.90	.91	.92	.93	.93	.95	.95	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99
120	.84	.86	.87	.89	.90	.91	.93	.94	.94	.95	.96	.96	.96	.97	.97	.97	.97	.98
140	.80	.82	.83	.85	.86	.88	.90	.91	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97
160	.76	.78	.80	.82	.83	.86	.88	.89	.90	.91	.92	.93	.94	.94	.95	.95	.95	.96

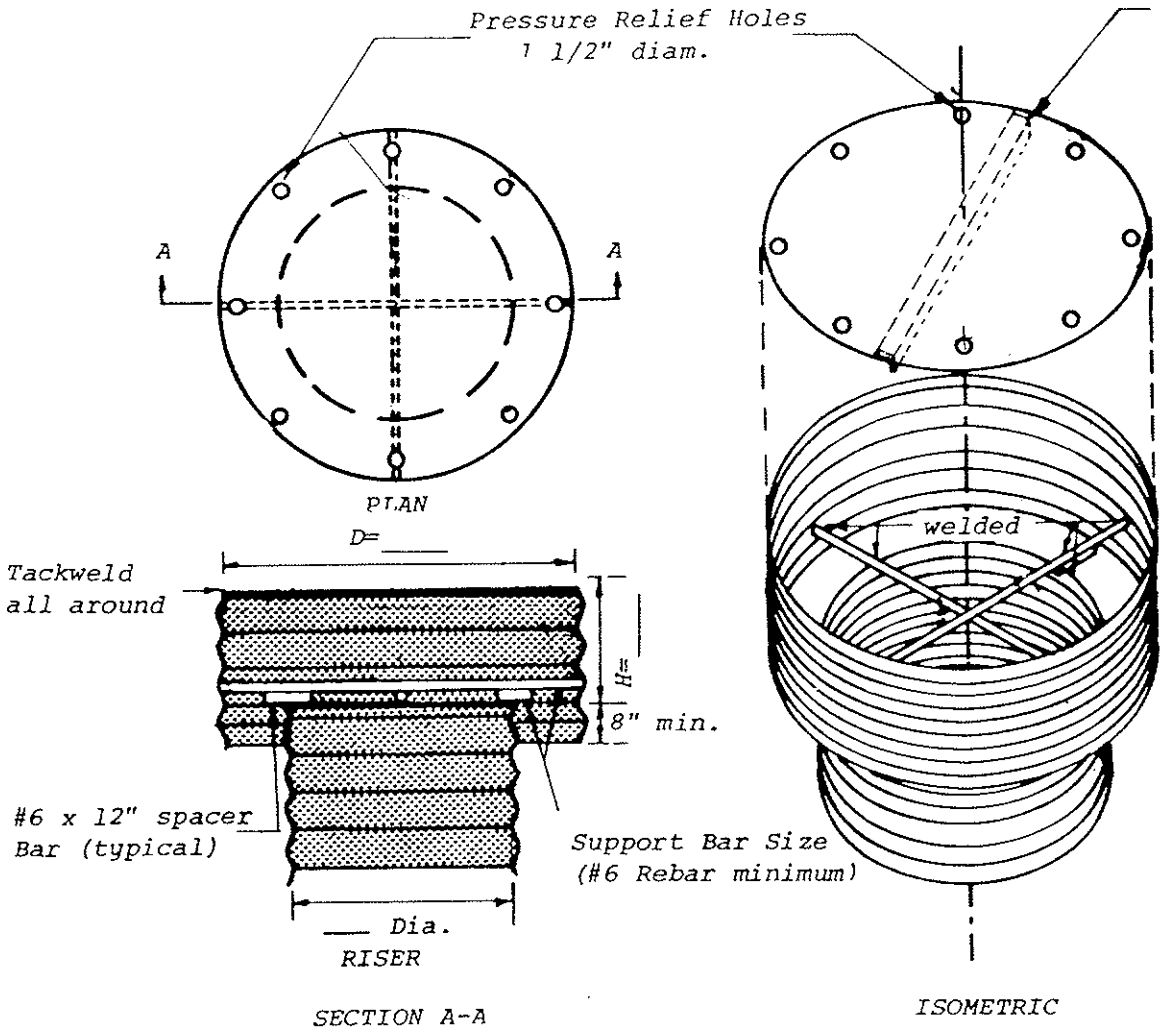
PIPE FLOW CHART n = 0.025

FOR CORRUGATED METAL PIPE INLET $K_m = K_e + K_b = 1.0$ AND 70 FEET OF CORRUGATED METAL PIPE CONDUIT (full flow assumed)

Note correction factors for pipe lengths other than 70 feet

diameter of pipe in inches

H, in feet	6"	8"	10"	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	0.33	0.70	1.25	1.98	3.48	5.47	7.99	11.0	18.8	28.8	41.1	55.7	72.6	91.8	113	137	163	191	222	255	290
2	0.47	0.99	1.76	2.80	4.92	7.74	11.3	15.6	26.6	40.8	58.2	78.8	103	130	160	194	231	271	314	360	410
3	0.58	1.22	2.16	3.43	6.02	9.48	13.8	19.1	32.6	49.9	71.2	96.5	126	159	196	237	282	331	384	441	502
4	0.67	1.40	2.49	3.97	6.96	10.9	16.0	22.1	37.6	57.7	82.3	111	145	184	226	274	326	383	444	510	580
5	0.74	1.57	2.79	4.43	7.78	12.2	17.9	24.7	42.1	64.5	92.0	125	162	205	253	306	365	428	496	570	648
6	0.82	1.72	3.05	4.86	8.52	13.4	19.6	27.0	46.1	70.6	101	136	178	225	277	336	399	469	544	624	710
7	0.88	1.86	3.30	5.25	9.20	14.5	21.1	29.2	49.8	76.3	109	147	192	243	300	362	431	506	587	674	767
8	0.94	1.99	3.53	5.61	9.84	15.5	22.6	31.2	53.2	81.5	116	158	205	260	320	388	461	541	628	721	820
9	1.00	2.11	3.74	5.95	10.4	16.4	24.0	33.1	56.4	86.5	123	167	218	275	340	411	489	574	666	764	870
10	1.05	2.22	3.94	6.27	11.0	17.3	25.3	34.9	59.5	91.2	130	176	230	290	358	433	516	605	702	806	917
11	1.10	2.33	4.13	6.58	11.5	18.2	26.5	36.6	62.4	95.6	136	185	241	304	376	454	541	635	736	845	962
12	1.15	2.43	4.32	6.87	12.1	19.0	27.7	38.2	65.2	99.9	142	193	252	318	392	475	565	663	769	883	1004
13	1.20	2.53	4.49	7.15	12.6	19.7	28.8	39.8	67.8	104	148	201	262	331	408	494	588	690	800	919	1045
14	1.25	2.63	4.66	7.42	13.0	20.5	29.9	41.3	70.4	108	154	208	272	343	424	513	610	716	830	953	1085
15	1.29	2.72	4.83	7.68	13.5	21.2	30.9	42.8	72.8	112	159	216	281	355	439	531	631	741	860	987	1123
16	1.33	2.81	4.99	7.93	13.9	21.9	32.0	44.2	75.2	115	165	223	290	367	453	548	652	765	888	1019	1160
17	1.37	2.90	5.14	8.18	14.3	22.6	32.9	45.5	77.5	119	170	230	229	378	467	565	672	789	915	1051	1195
18	1.41	2.98	5.29	8.41	14.8	23.2	33.9	46.8	79.8	120	174	236	308	389	480	581	692	812	942	1081	1230
19	1.45	3.06	5.43	8.64	15.2	23.9	34.8	48.1	82.0	126	179	243	316	400	494	597	711	834	967	1111	1264
20	1.49	3.14	5.57	8.87	15.6	24.5	35.7	49.4	84.1	129	184	249	325	410	506	613	729	856	993	1139	1297
21	1.53	3.22	5.71	9.09	15.9	25.1	36.6	50.6	86.2	132	188	255	333	421	519	628	747	877	1017	1168	1329
22	1.56	3.29	5.85	9.30	16.3	25.7	37.5	51.8	88.2	135	193	261	341	430	531	643	765	898	1041	1195	1360
23	1.60	3.37	5.98	9.51	16.7	26.2	38.3	53.0	90.2	138	197	267	348	440	543	657	782	918	1064	1222	1390
24	1.63	3.44	6.11	9.72	17.0	26.8	39.1	54.1	92.1	141	201	273	356	450	555	671	799	937	1087	1248	1420
25	1.66	3.51	6.23	9.92	17.4	27.4	39.9	55.2	94.0	144	206	279	363	459	566	685	815	957	1110	1274	1450
26	1.70	3.58	6.36	10.1	17.7	27.9	40.7	56.3	95.9	147	210	284	370	468	577	699	831	976	1132	1299	1478
27	1.73	3.65	6.48	10.3	18.1	28.4	41.5	57.4	97.7	150	214	290	377	477	588	712	847	994	1153	1324	1507
28	1.76	3.72	6.60	10.5	18.4	29.0	42.3	58.4	99.5	153	218	295	384	486	599	725	863	1013	1174	1348	1534
29	1.79	3.78	6.71	10.7	18.7	29.5	43.0	59.5	101	155	221	300	391	494	610	738	878	1030	1195	1372	1561
30	1.82	3.85	6.83	10.9	19.1	30.0	43.7	60.5	103	158	225	305	398	503	620	750	893	1048	1216	1396	1588
L, in feet	Correction Factors For Other Pipe Lengths																				
20	1.69	1.63	1.58	1.53	1.47	1.42	1.37	1.34	1.28	1.24	1.20	1.18	1.16	1.14	1.13	1.11	1.10	1.10	1.09	1.08	1.08
30	1.44	1.41	1.39	1.36	1.32	1.29	1.27	1.24	1.21	1.18	1.15	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.07	1.06	1.06
40	1.28	1.27	1.25	1.23	1.21	1.20	1.18	1.17	1.14	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.05	1.04
50	1.16	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.04	1.03	1.03	1.03
60	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.94	.94	.95	.95	.95	.95	.96	.96	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99	.99	.99
90	.89	.89	.90	.90	.91	.91	.92	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97	.97	.97	.97	.94
100	.85	.85	.86	.86	.87	.88	.89	.89	.90	.91	.92	.93	.93	.94	.94	.95	.95	.95	.96	.96	.94
120	.78	.79	.79	.90	.81	.82	.83	.83	.85	.86	.87	.89	.89	.90	.91	.89	.92	.93	.93	.94	.92
140	.72	.73	.74	.75	.76	.77	.78	.79	.81	.82	.84	.85	.86	.87	.88	.86	.89	.90	.91	.91	.90
160	.68	.69	.69	.70	.71	.73	.74	.75	.77	.79	.80	.82	.83	.84	.85	.92	.87	.88	.89	.89	



Top stiffener (if required) is ____x____x____ angle welded to top and oriented perpendicular to corrugations.

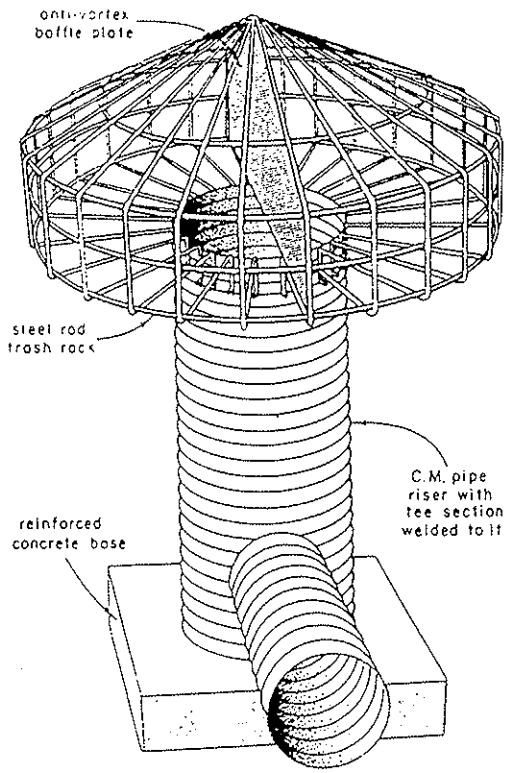
Top is _____ gage corrugated metal or 1/8" steel plate. Pressure relief holes may be ommitted, if ends of corrugations are left fully open when corrugated top is welded to cylinder.

Cylinder is _____ gage corrugated metal pipe or fabricated from 1/8" steel plate.

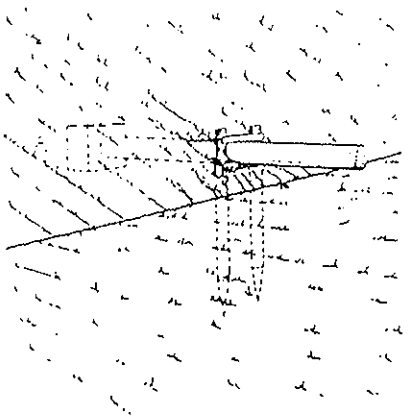
Notes:

1) The cylinder must be firmly fastened to the top of the riser.
2) Support bars are welded to the top of the riser or attached by straps bolted to top of riser.

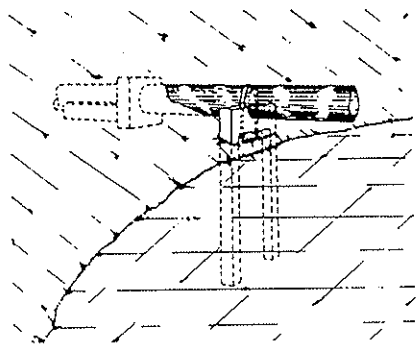
CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE
(not to scale)



CORRUGATED METAL PIPE RISER
WITH CONICAL TRASH RACK AND BAFFLE

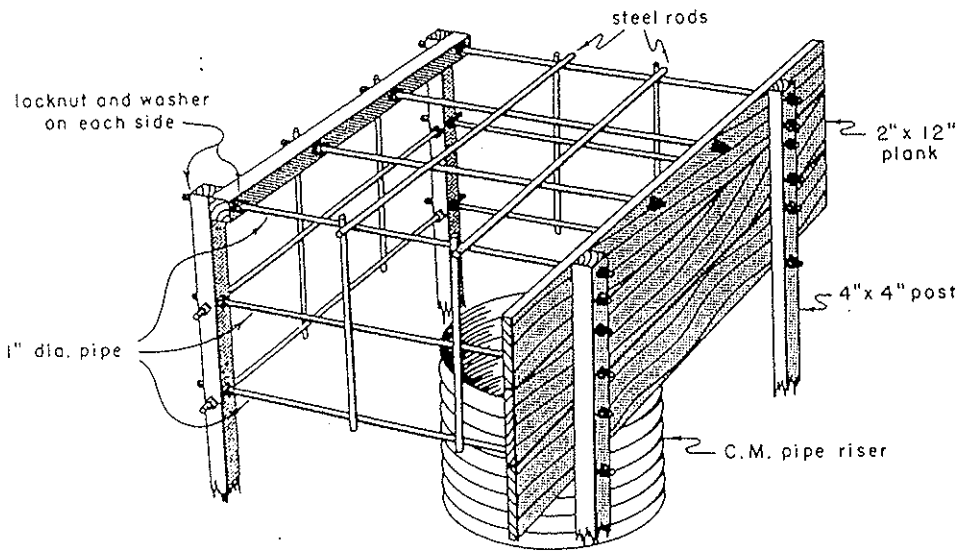


TIMBER SUPPORT



REINFORCED CONCRETE SUPPORT

TYPE OF SUPPORT FOR
CANTILEVER OUTLETS



TIMBER HEADWALL AND TRASH RACK

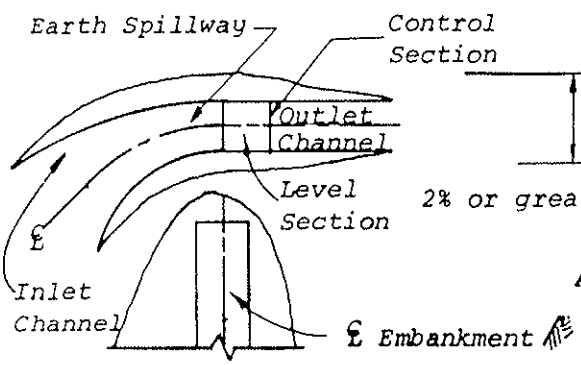
Appurtenance for metal pipe drop inlets

CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE

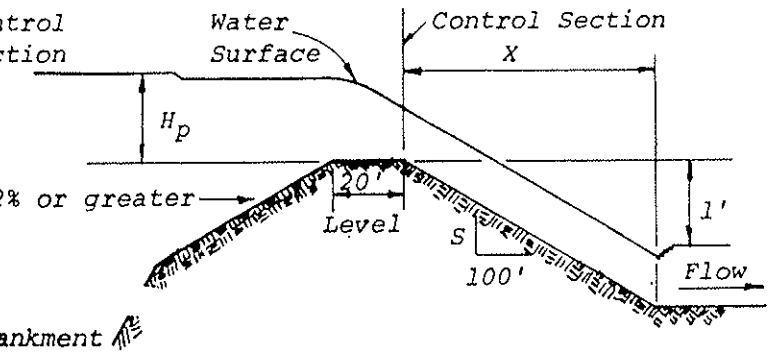
DESIGN TABLE

Cylinder Riser Diam., in.	Cylinder Diam in.	Thick., gage	H, in.	Minimum Size Support Bar	Minimum Top Thickness	Minimum Top Stiffner
12	18	16	6	#6 Rebar	16 ga.	-
15	21	16	7	"	"	-
18	27	16	8	"	"	-
21	30	16	11	"	"	-
24	36	16	13	"	14 ga.	-
27	42	16	15	"	14 ga.	-
36	54	14	17	#8 Rebar	12 ga.	-
42	60	14	19	"	"	-
48	72	12	21	1 1/4" pipe or 1 1/4" x 1 1/4" x 1/4" angle	10 ga.	-
54	78	12	25	"	"	-
60	90	12	29	1 1/2" pipe or 1 1/2" x 1 1/2" x 1/4" angle	8 ga.	-
66	96	10	33	2" pipe or 2" x 2" x 3/16" angle	8 ga., w/stiffner	2" x 2" x 1/4" angle
72	102	10	36	"	"	2 1/2" x 2 1/2" x 1/4" angle
78	114	10	39	2 1/2" pipe or 2" x 2" x 1/4" angle	"	"
84	120	10	42	2 1/2" pipe or 2 1/2" x 2 1/2" x 1/4" angle	"	2 1/2" x 2 1/2" x 5/16" angle

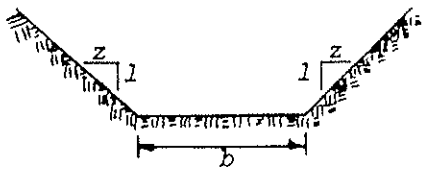
Note: The criteria for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.



PLAN OF EARTH SPILLWAY



PROFILE ALONG ℄ OF EARTH SPILLWAY



CROSS SECTION OF EARTH SPILLWAY AT CONTROL SECTION

LEGEND

n = Manning's Coefficient of Roughness.
H_p = Difference in Elevation between Crest of Earth Spillway at the Control Section and Water Surface in Reservoir, in feet.
b = Bottom Width of Earth Spillway at the Control Section, in feet.
Q = Total Discharge, in cfs.
V = Velocity, in feet per second, that will exist in Channel below Control Section, at Design Q, if constructed to slope (S) that is shown.
S = Flattest Slope (S), in %, allowable for Channel below Control Section.
X = Minimum Length of Channel below Control Section, in feet.
z = Side Slope Ratio.

NOTES:

1) For a given H_p a decrease in the exit slope from S as given in the table decreases spillway discharge but increasing the exit slope from S does not increase discharge. If an exit slope (S_e) steeper than S is used, then velocity (V_e) in the exit channel will increase according to the following relationship:

$$V_e = V\left(\frac{S_e}{S}\right)^{0.3}$$

2) Data to right of heavy vertical lines on drawings should be used with caution, as the resulting sections will be either poorly proportioned or have velocities in excess of 6 ft/sec.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	DESIGN DATA FOR EARTH SPILLWAYS	Ref: Engineering Field Manual

ANTI-SEEP COLLAR DESIGN

This procedure provides the anti-seep collar dimensions for only temporary sediment basins to increase the seepage length by 10% for various pipe slopes, embankment slopes and riser heights. This does not apply to permanent structures, which must have an increase of 15% in the seepage length.

The first step in designing anti-seep collars is to determine the length of pipe within the saturated zone of the embankment. This can be done graphically or by the following equation, assuming that the upstream slope of the embankment intersects the invert of the pipe at its upstream end. (See embankment-invert intersection on the drawing below:

$$L_s = y\ (z + 4)\left[1 + \frac{\text{pipe slope}}{0.25\text{-pipe slope}}\right]$$

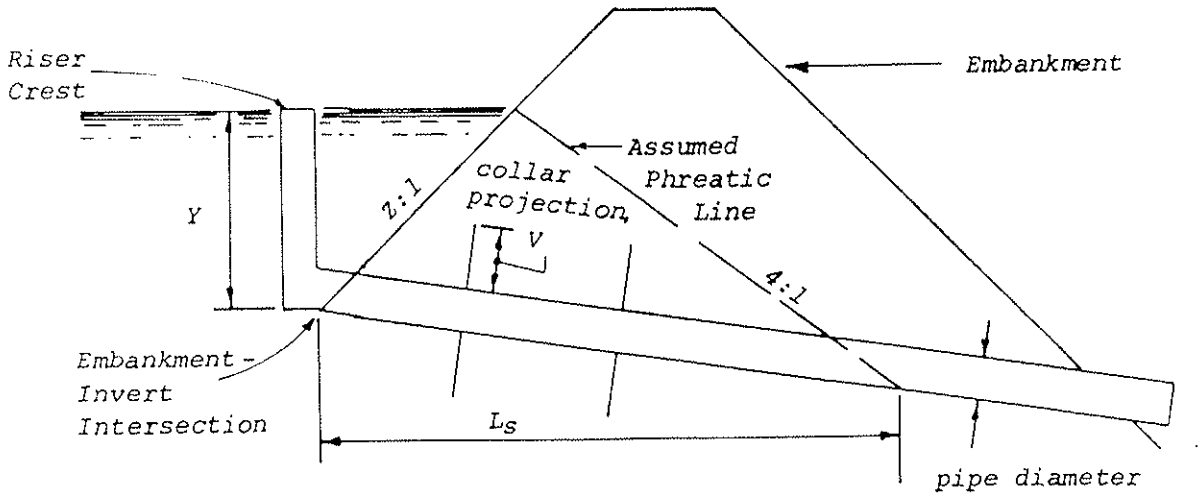
where: L_s = length of pipe in the saturated zone (ft.)

y = distance in feet from upstream invert of pipe to highest normal water level expected to occur during the life of the structure, usually the top of the riser.

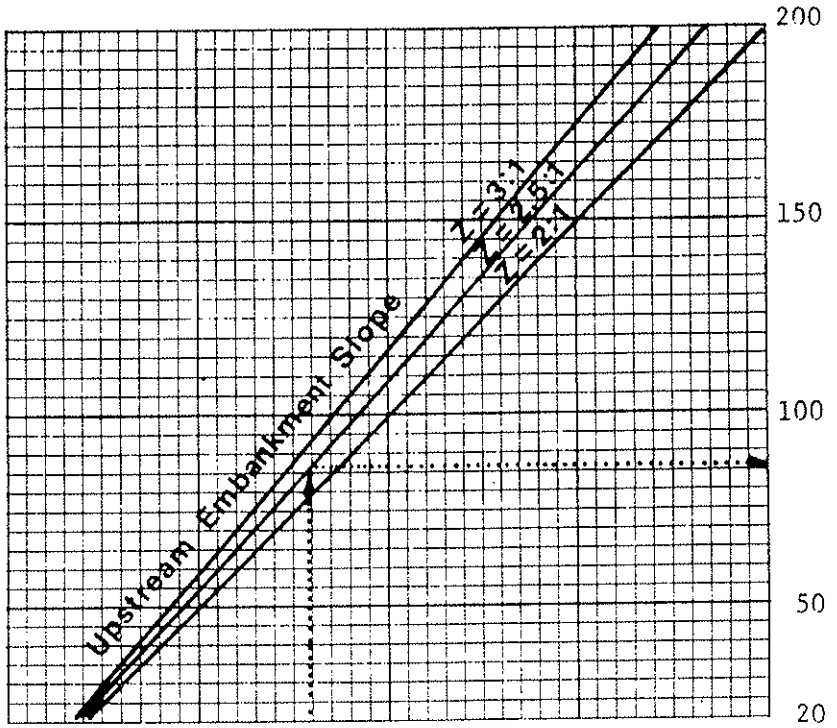
z = slope of upstream embankment as a ratio of z ft. horizontal to one ft. vertical.

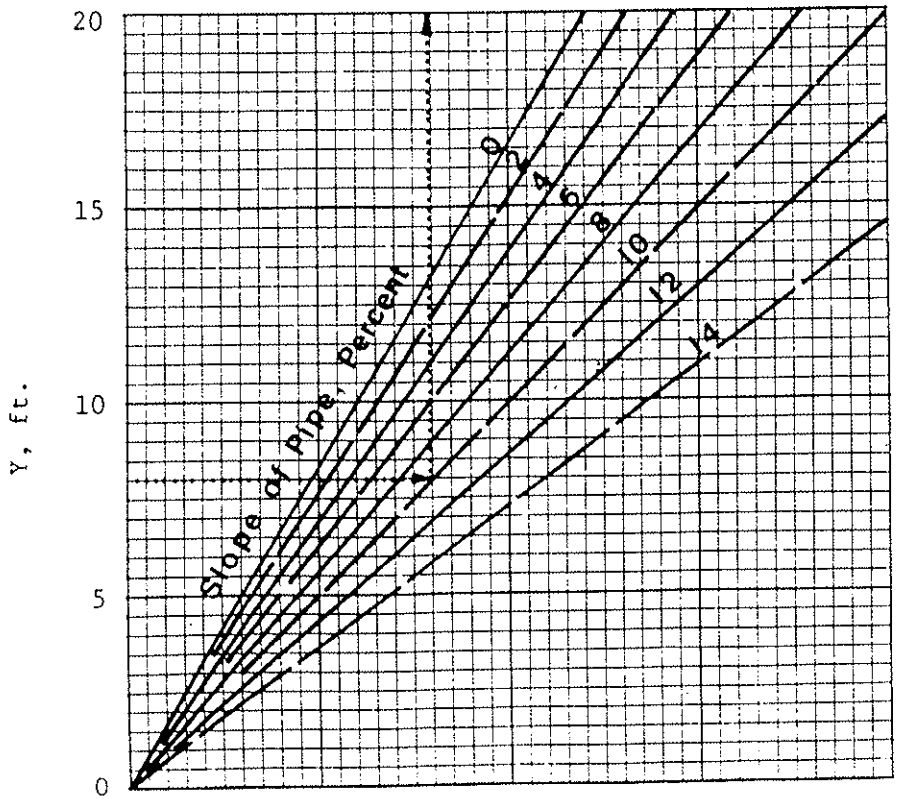
pipe slope = slope of pipe in feet per foot.

This procedure is based on the approximation of the phreatic line as shown in the drawing below:

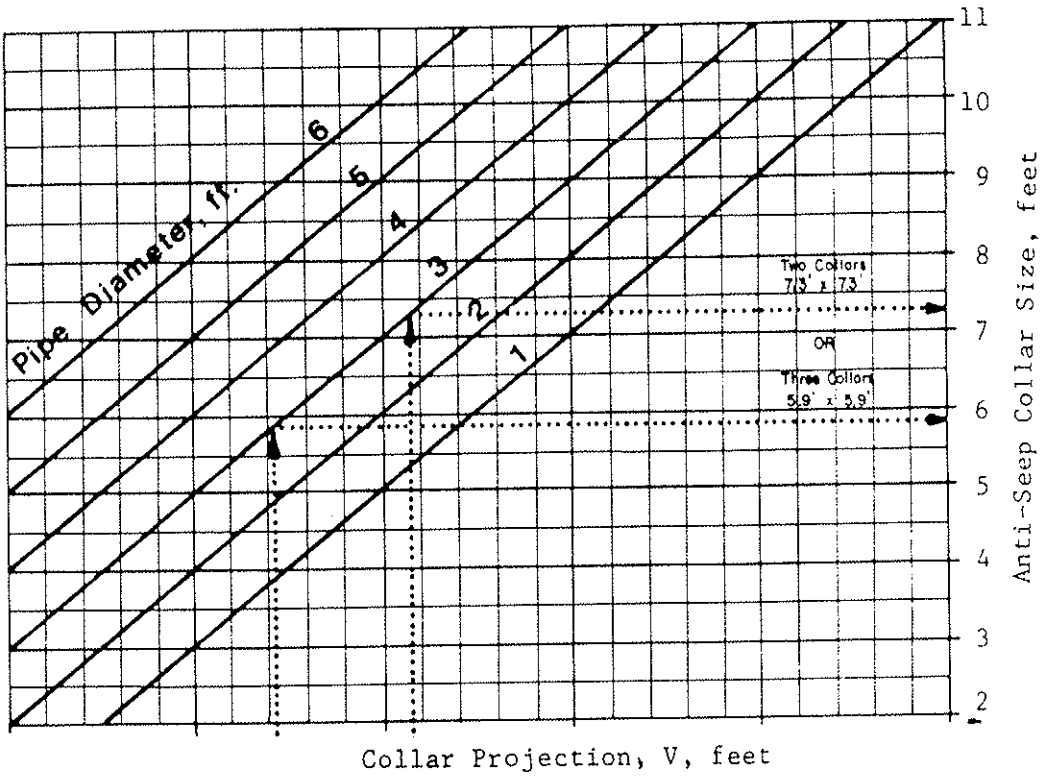


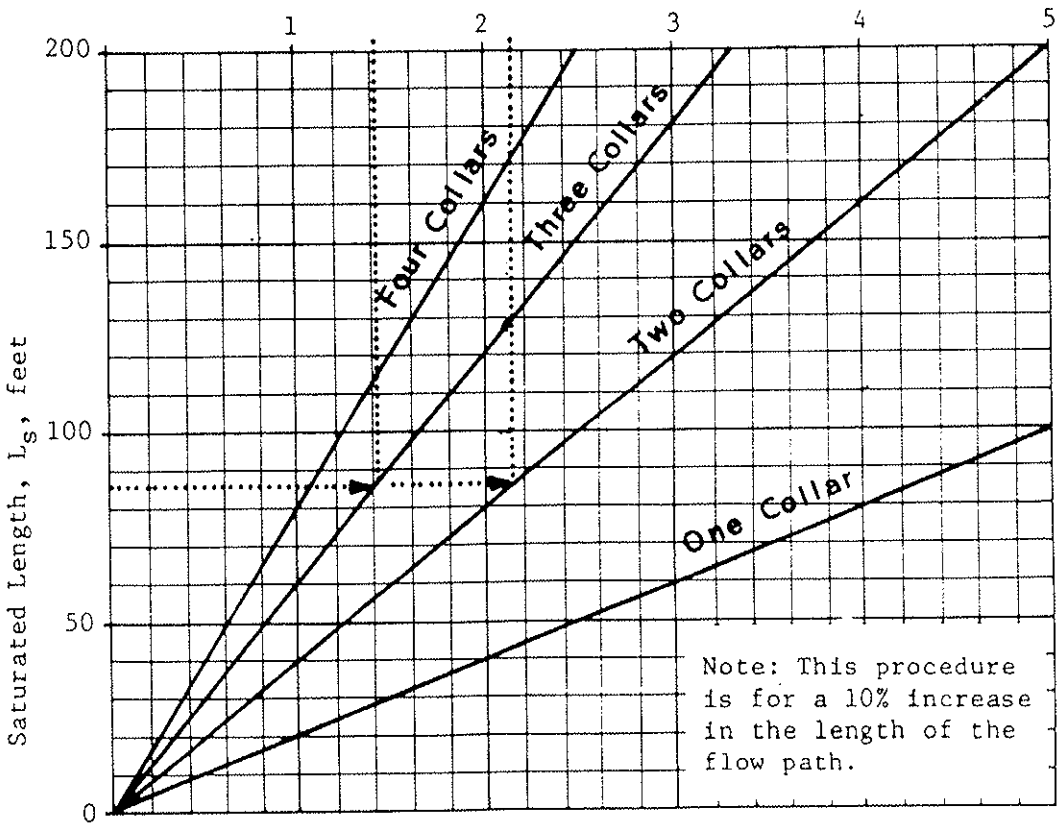
PIPE LENGTH IN SATURATED ZONE

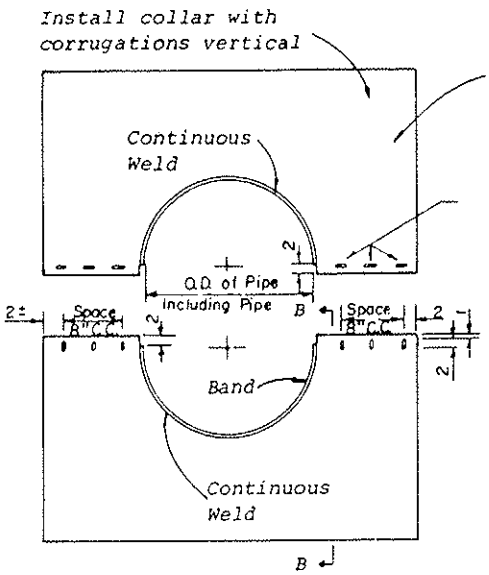




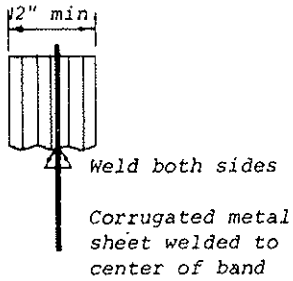
ANTI-SEEP COLLAR DESIGN







ELEVATION OF UNASSEMBLED COLLAR



SECTION B-B

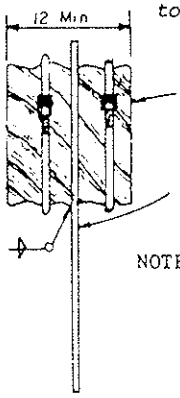
NOTES FOR COLLARS:

1. All materials to be in accordance with construction and construction material specifications.
2. When specified on the plans, coating of collars shall be in accordance with construction and construction material specifications.
3. Unassembled collars shall be marked by painting or tagging to identify matching pairs.
4. The lap between the two half sections and between the pipe and connecting band shall be caulked with asphalt mastic at time of installation.
5. Each collar shall be furnished with two 1/2" diameter rods with standard tank lugs for connecting collars to pipe.

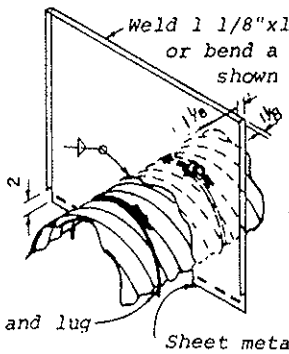
DETAILS OF CORRUGATED METAL ANTI-SEEP COLLAR

Size and spacing of slotted openings shall be the same as shown for CM collar

Use rods and lugs to clamp bands securely to pipe



PARTIAL ELEVATION



NOTE FOR BANDS AND COLLARS: Modifications of the details shown may be used providing equal watertightness is maintained and detailed drawings are submitted and approved by the Engineer prior to delivery.

Sheet metal collar shall be cut to fit corrugations of helical band, and welded with a continuous weld.

ISOMETRIC VIEW

NOTE: For details of fabrication dimensions, minimum gages, slotted holes, and notes, see detail above.

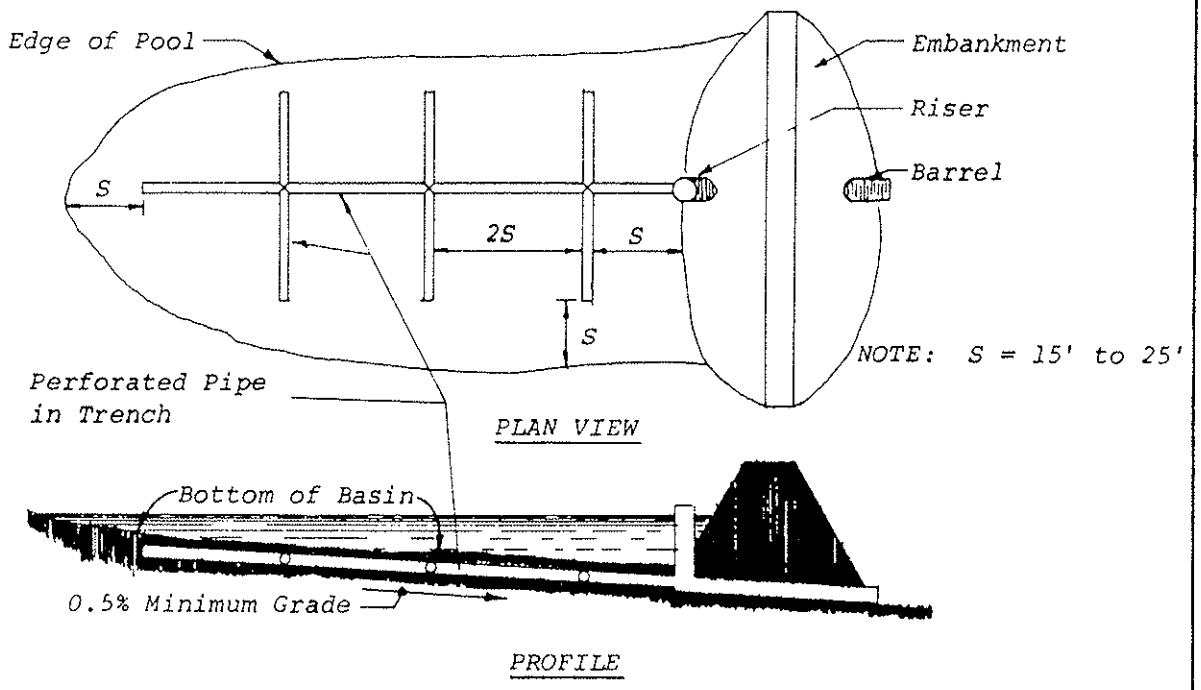
DETAILS OF HELICAL PIPE ANTI-SEEP COLLAR

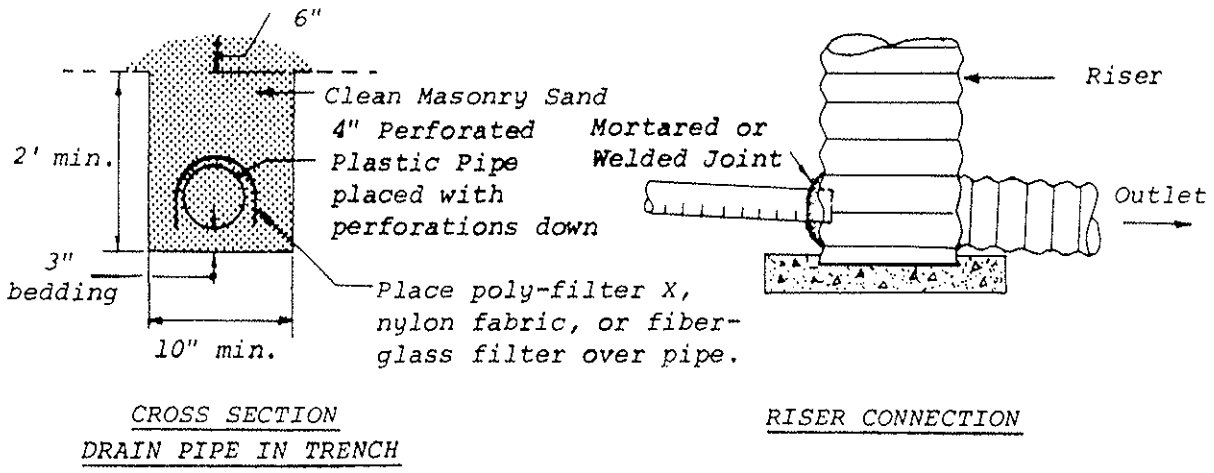
NOTE: Two other types of anti-seep collars are:

1. Corrugated metal, similar to upper detail, except shop welded to a short (4 ft.) section of the pipe and connected with connecting bands to the pipe.
2. Concrete, six inches thick formed around the pipe with #3 rebar spaced 15" horizontally and vertically.

Ref: Engr. Field Manual

DEWATERING SEDIMENT BASIN WITH SUBSURFACE DRAIN





U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE	DEWATERING SEDIMENT BASIN WITH SUBSURFACE DRAIN	

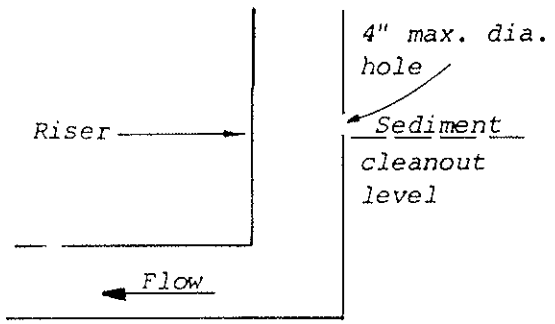
METHODS OF DEWATERING SEDIMENT BASIN DETENTION POOLS

The dewatering methods shown here are inexpensive and operate automatically. Other methods, such as pumping, may also be used.

METHOD

COMMENTS

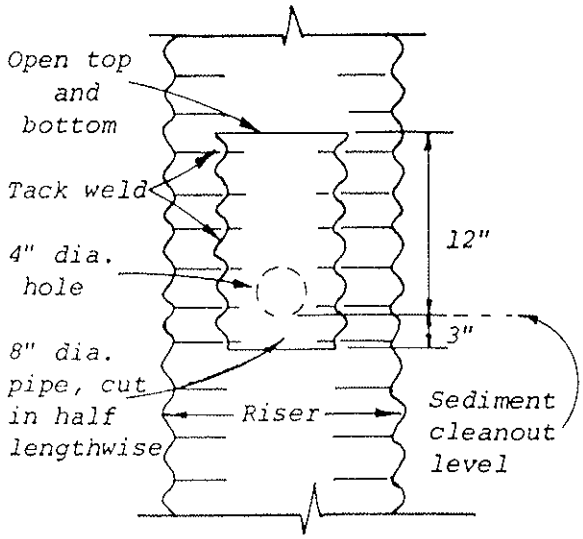
A.



CROSS-SECTION

Easy to construct
May clog with trash
Non-skimming
Capable of draining down to sediment clean-out level
Passes base flow without storage of water

B. Same as "A" except for skimming device, detailed below:



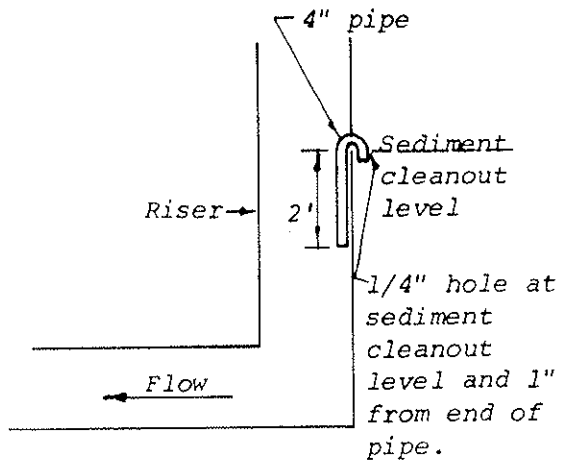
ELEVATION

Efficient skimmer
Non-clogging
Fairly easy to construct
Capable of draining down to sediment cleanout level
Passes base flow without storage of water

METHOD

COMMENTS

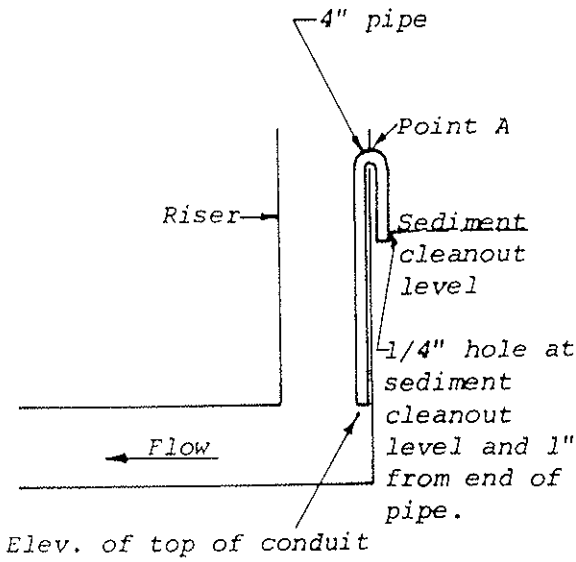
C.



CROSS-SECTION

Efficient skimmer
Capable of always draining down to sediment cleanout level
Passes base flow without storage of water
Higher discharge rate than "A" or "B".

D.



CROSS-SECTION

Efficient skimmer
Water must inundate point A to prime siphon. Therefore, small storms or low base flow rates will not prime siphon and drain pool.
Passes base flow (but with storage of water)
Higher discharge rate than "C"

PROCEDURE FOR DETERMINING OR ALTERING SEDIMENT BASIN SHAPE

As specified in the Standard & Specification, the pool area at the elevation of crest of the principal spillway shall have a length to width ratio of at least 2.0 to 1. The purpose of this requirement is to minimize the "short-circuiting" effect of the sediment laden inflow to the riser and thereby increase the effectiveness of the sediment basin. The purpose of this procedure is to prescribe the parameters, procedures and methods of determining and modifying the shape of the basin.

The length of the flow path (L) is the distance from the point of inflow to the riser (cutflow 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 (W_e) is found by the equation:

$$W_e = \frac{A}{L}$$

$$\text{and L:W ratio} = \frac{L}{W_e}$$

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

Then:

$$W_e = \frac{A}{L_e}$$

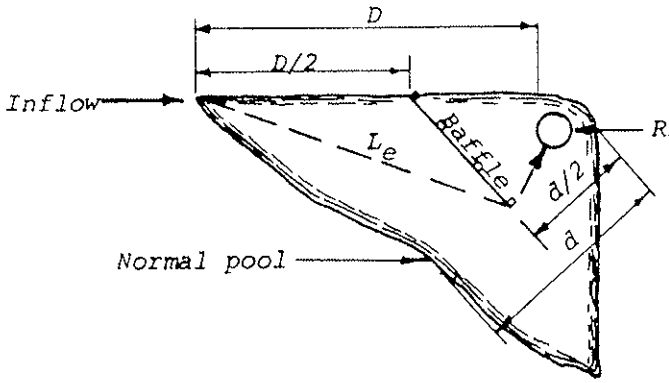
$$\text{and L:W ratio} = \frac{L_e}{W_e}$$

Three examples are shown on the following page. 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, $L_e = L_1 + L_2$. Otherwise, the length-width ratio computations are the same as shown above. This special case procedure for computing L_e is allowable only when the two flow paths are equal, i.e., when $L_1 = L_2$. A baffle detail is also shown.

SEDIMENT BASIN BAFFLES

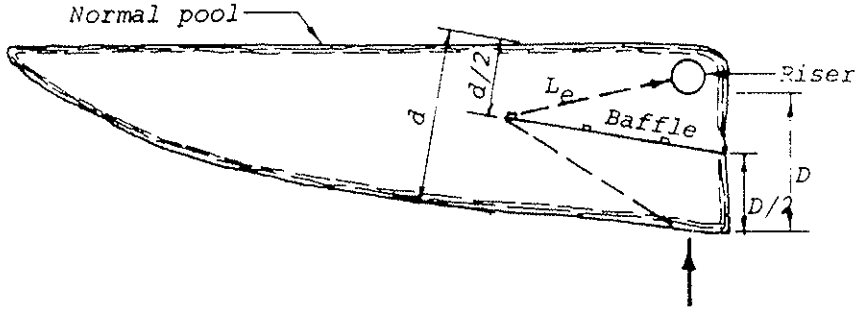
Examples: Plan Views - not to scale

A.

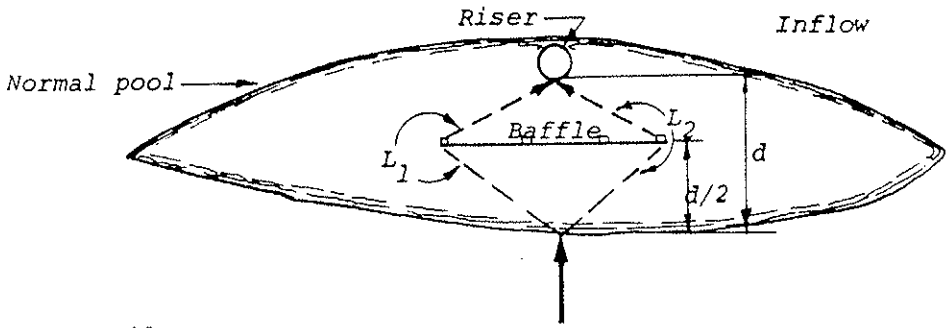


L_e = Total distance from the point of inflow around the baffle to the riser.

B.

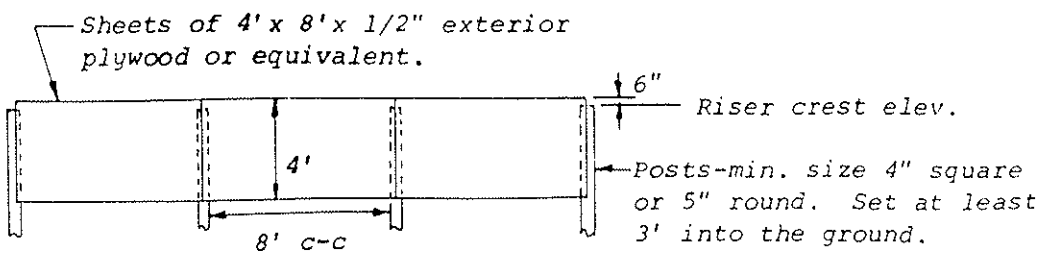


C.



$L_e = L_1 + L_2$

Baffle Detail



ELEVATION

I.K

SEDIMENT TRAP

Definition: A small temporary basin formed by excavation and/or embankment to intercept sediment laden run-off.

Purpose: The purpose of a sediment trap is to intercept sediment laden run-off and trap the sediment, thereby protecting drainageways, properties, and roadways below the sediment trap.

Applicability: A sediment trap is usually installed in front of a drainageway, a storm drain inlet, or other points of discharge from a disturbed area.

Planning Criteria: Sediment traps shall receive run-off from areas less than 5 acres. The traps shall be located to obtain maximum storage benefit from the terrain, for ease of cleanout and disposal of trapped sediment, and to minimize interference with construction activities. The structure shall be removed and the area stabilized when the remaining area has been stabilized.

Methods and Materials:

Trap Size - Volume of a sediment trap as measured from the bottom to the crest of the outlet shall be at least 1800 cubic feet per acre of drainage area. This volume of still water is necessary to allow the finer soil particles to settle. The volume of a natural basin can be approximated by:

Volume (cu.ft.)	=	0.4 x surface area (sq.ft.)	x	max. depth (ft.)

Embankment - All embankments shall meet the following criteria:

Height - shall not exceed 5 feet (measured from toe to the crest of the outlet pipe or spillway).

Top Width - minimum 6 feet.

Side Slope - 2:1 or flatter.

Excavation - All excavations to increase trap volume shall have slopes 2:1 or flatter.

Methods and Materials: Continued

Outlets - There are four types of outlets for sediment traps. Traps are named according to their type of outlet and each has specific design criteria. A trap may have several different outlets of varying capacity, based on specific outlet criteria, cumulatively totaling the peak capacity. A short description and design criteria for each outlet follows:

Earth Outlet Sediment Trap - Earth outlet sediment traps consist of a basin formed by excavation and/or embankment. The discharge is over or cut into natural ground and protected from erosion by lining with coarse gravel. The outlet width (in feet) shall be equal to 6 times the drainage area (in acres). All embankments shall be at least 1 foot above the discharge outlet.

Pipe Outlet Sediment Trap - Pipe outlet sediment traps have a conduit with a drop inlet through the embankment. The riser is perforated to allow drainage of the sediments. The outlet pipe and riser shall be made of corrugated metal pipe. Diameter of the riser shall be approximately 1.5 times the diameter of the discharge pipe. Table I.K-1 defines the appropriate discharge pipe diameter.

Table I.K-1

Minimum Pipe Diameter (inches)	Maximum Drainage Area (acres)
12	1
15	2
18	3
21	4
24	5

Weighted Base - The base of the riser must be anchored to prevent the riser from floating. This can be accomplished by welding a metal plate to the bottom of the riser and weighting it down with coarse gravel. The width of the metal plate should be twice the diameter of the riser. The gravel will also serve as a drain filter.

Methods and Materials:

Pipe Outlet Sediment Trap - Continued

Perforations - The riser shall be perforated with 1 inch diameter holes spaced 12 inches on center horizontally, and 6 inches on center vertically. The embankment shall be at least 1.5 feet above the top of the riser.

Outlet Protection - A rock riprap apron shall be constructed in accordance with the Standards and Specifications for Storm Drain Outlet Protection.

Joints - All couplings and joints of the discharge pipe should be watertight. The connection of the riser to the outlet pipe should be welded.

Antiseep Collars - Antiseep collars are required for larger basins, fill height exceeding 8 feet, and for SM and ML soils.

Trash Rack - A trash rack is needed for keeping the discharge pipe clear and as a safety device. A conical structure made of galvanized pipe is preferred to a flat drive over grating because of the greater surface area and lesser tendency to plug with small debris.

Stone Outlet Sediment Trap - This trap consists of a basin formed by an embankment with a stone filled section. This stone filled section functions as a spillway and drainage structure. Outlet for the trap is over a level stone section.

Minimum length (feet) of the outlet shall be equal to 6 times the drainage area (acres). The crest of the stone shall be at least 1 foot below the top of the embankment. An semi-pervious core of timber, gravel, or straw bales, shall be placed in the stone. The core shall be covered by 6 inches of stone.

Storm Inlet Sediment Trap - Storm inlet sediment traps consist of a basin formed by excavation of natural ground whose outlet is through a storm drain inlet. Refer to the drain manufacturer's standards for inlet capacity.

Cleanout - Sediment shall be removed and the trap restored to original dimensions and capacity when the sediment has accumulated to one-half the design depth. Disposal of sediment shall be in a suitable area, where it will not cause erosion and can re-enter a water course.

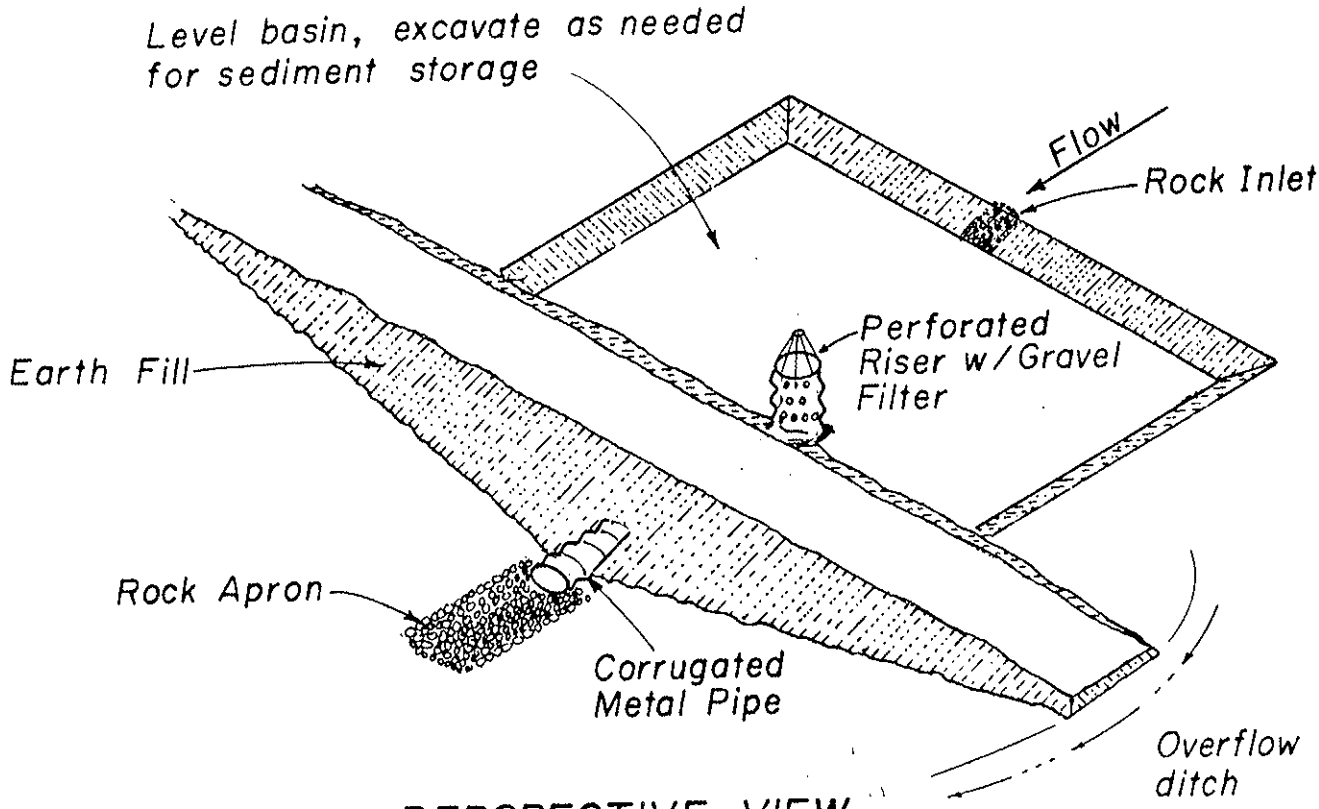
Methods and Materials: Continued

Site Preparation - Embankment areas shall be cleared, grubbed and stripped of organic matter to the required lines and grades. Dispose of debris in an acceptable manner that does not cause erosion or interfere with the operation of the trap.

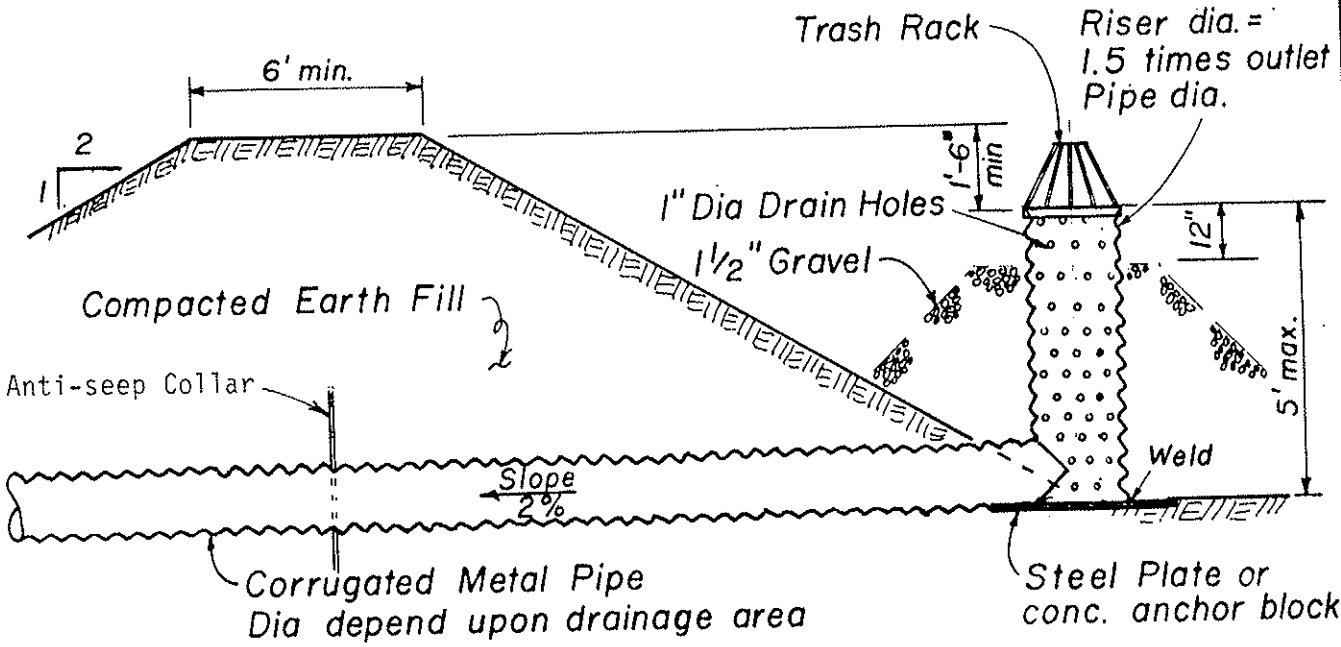
Fill - Fill material for embankment shall be free of roots, vegetation or other organic matter, large boulders, or other objectionable material. A minimum of two feet of embankment shall be placed over discharge piping.

Compaction - Embankment shall be placed in lifts not to exceed 8 inches and either hand or machine compacted to a density of adjacent material. Embankment near the spillway or near structures shall be placed in lifts not exceeding 4 inches and hand compacted.

Operation and Maintenance: Inspect trap after all storms for sediment accumulation and embankment or spillway failures. Remove sediment as specified herein. Repair embankments as necessary to match design capacity according to the specifications herein. Remove and properly dispose of excess trapped vegetation.



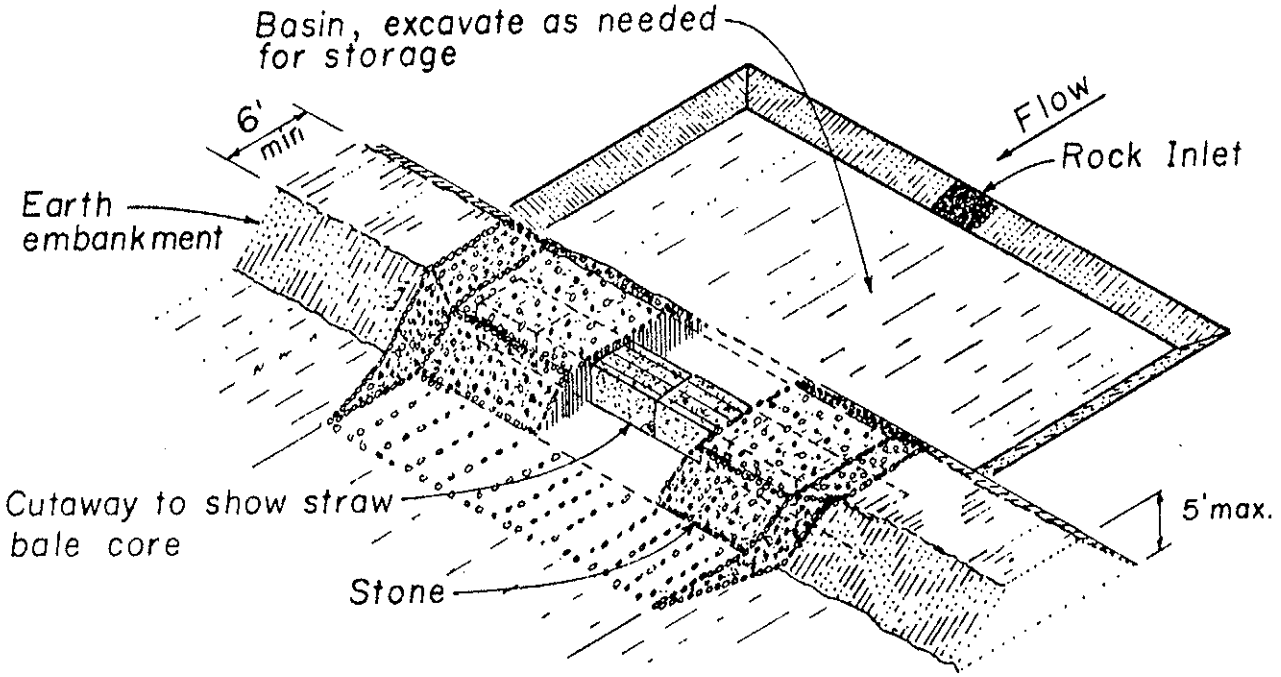
PERSPECTIVE VIEW

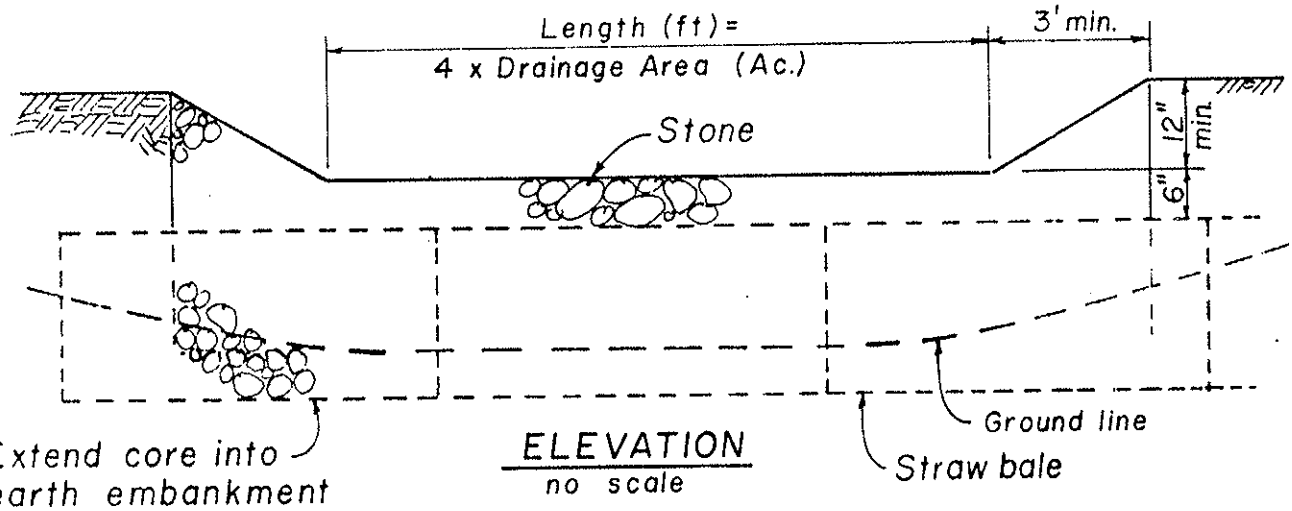


EMBANKMENT SECTION THRU RISER

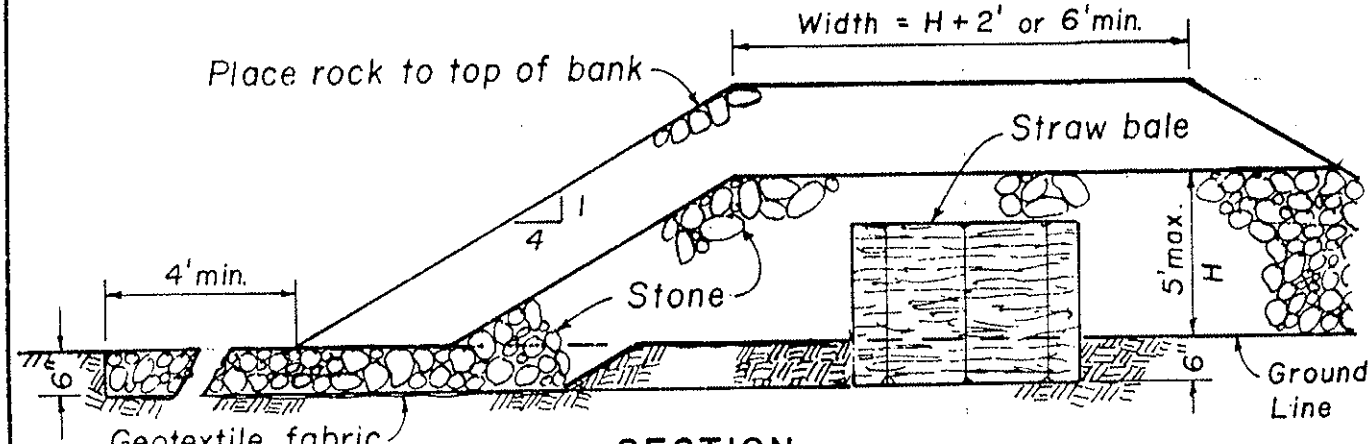
no scale

High Sierra R. C. & D. Erosion & Sediment Control Guide	PIPE OUTLET SEDIMENT TRAP





ELEVATION
no scale



SECTION
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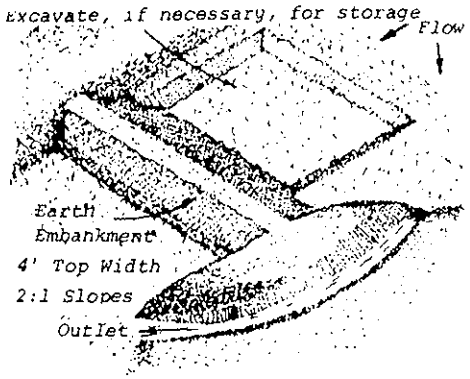
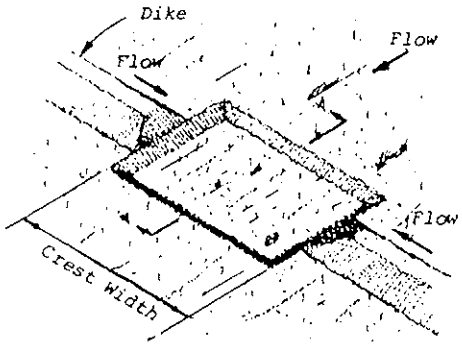
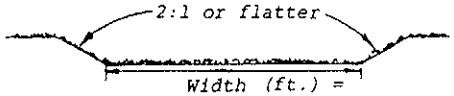
Erosion & Sediment Control Guide
3/90 Pg 62

STONE OUTLET SEDIMENT TRAP

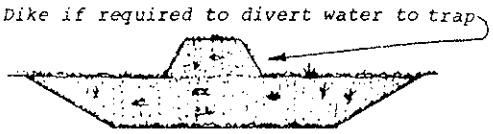






OUTLET SECTION

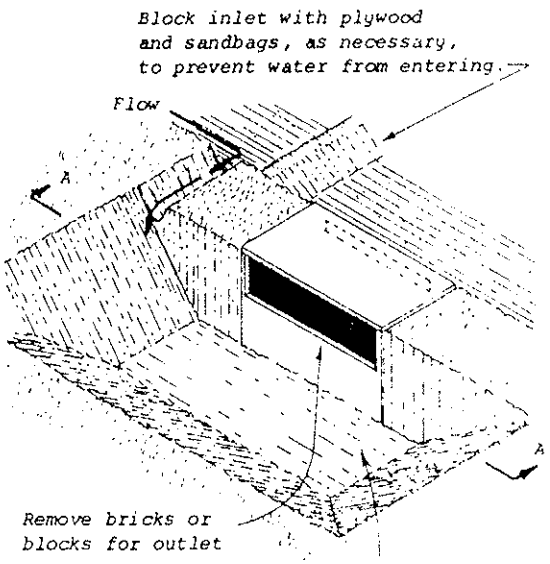
EMBANKMENT EARTH OUTLET SEDIMENT TRAP

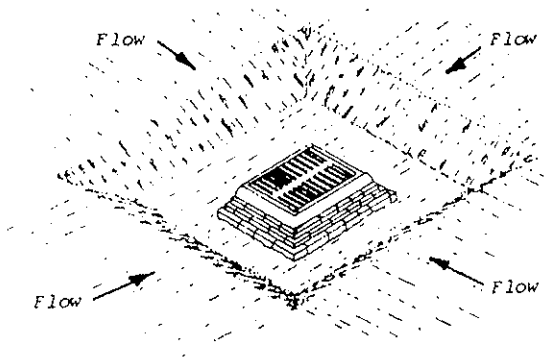


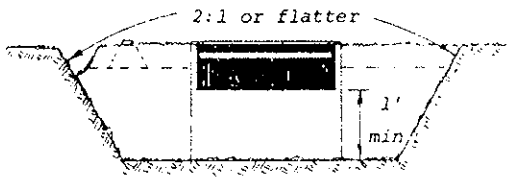
SECTION A-A

EXCAVATED EARTH OUTLET SEDIMENT TRAP

EARTH OUTLET SEDIMENT TRAP



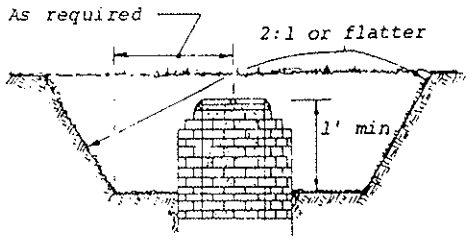




SECTION A-A

CURB DRAIN

NOTE: Where curb is in place, provide a 1 ft. wide opening in the curb or use a sandbag dam to force water over the curb to the trap.



CROSS-SECTION

YARD DRAIN

STORM INLET SEDIMENT TRAP

PART II

PERMANENT STRUCTURAL PRACTICES

CONTENTS

II.A

DIVERSION

Definition: A drainageway or channel constructed across the slope with a supporting embankment ridge on the downslope side.

Purpose: The purpose of a diversion is to divert run-off away from cut or fill slopes, and to intercept and convey run-off to stable outlets at nonerosive velocities.

Applicability: Diversions shall be used only below stabilized or protected areas as follows:

a) At the top of a cut or fill slope to prevent erosion on steep slopes.

b) Midslope on benches or terraces.

c) Where surface and/or shallow subsurface flow has the potential for damaging or affecting the slope stability.

d) Where it is desirable to shorten the length of the slope to control run-off velocity and soil loss.

e) Vegetatively lined channels shall only be used where conditions are suitable for the establishment of a proper stand of grass within 2 years.

Planning Criteria: The location of diversion channels shall be determined by outlet conditions, topography and slope benching requirements. Diversion shall be used with caution on soils subject to slippage. Applicable State drainage and water laws shall be observed.

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm, or as specified by the permit issuing authority. Capacity shall be computed using a Manning's N value based on the expected before mowing height of the vegetation considering the level of maintenance prescribed in the operations and maintenance plan.

Velocity and Grade - Maximum permissible velocities for specific methods of lining or stabilization shall determine the maximum grade. Maximum permissible velocities for stabilization with vegetation are presented in Table II.A-1. See Section II.L for permissible velocities on Lined Ditches. Design velocity shall be computed assuming that vegetation is at the specified mowing level.

Table II.A-1

Permissible Velocities for Well Maintained Grass Channels

Cover <1>	Slope Percent	Permissible Velocity (fps) Erosion Resistant Soils	Permissible Velocity (fps) Easily Eroded Soils
Annual ryegrass Blando brome Zorro fescue Luna wheatgrass Topar wheatgrass Harding grass	0 - 5 5 - 10 over 10	4.0 NR<3> NR<3>	3.5 NR<3> NR<3>
Bermuda grass (Hybrid)	0 - 5 5 - 10 over 10	8.0<2> 7.0<2> 6.0<2>	6.0<2> 4.0<2> 3.0<2>
Alta or Fawn fescue Kentucky bluegrass	0 - 5 5 - 10 over 10	5.0 4.0 3.0	4.0 3.0 NR<3>
Reed canary grass <4>	0 - 5 5 - 10 over 10	5.0 4.0 NR<3>	4.0 3.0 NR<3>

<1> The permissible velocities are for dense stands of grasses and require a temporary erosion control lining of jute netting, straw secured with nylon netting, or straw-coconut fiber blankets for establishment. The vegetative species chosen must be compatible with climatic and soil conditions. Check with the local Soil Conservation Service office for planting mix recommendations.

<2> For channels with flow velocities greater than 5 feet/second, a nylon fiber blanket is required for seeded or sprigged plantings. Sodding may be used without blanket but requires irrigation.

<3> Not recommended. Use grade control structures or other types of lining.

<4> Requires irrigation and tolerates flooding and standing water.

Planning Criteria: Continued

Protective Lining - When design velocities are less than 2.5 feet/second, straw mulching may be used for the establishment of the vegetation. The straw shall be anchored with nylon netting and wire staples. The protective lining is not required when a temporary diversion can be utilized to prevent run-off from entering the permanent diversion until vegetation has been established.

When design velocities are greater than 3.5 feet/second, the diversion shall be stabilized by sod or by seeding, protected with a jute netting, coconut fiber, or straw-coconut fiber erosion control blanket. The latter two require a nylon netting to secure the straw or coconut fibers.

For design velocities exceeding 5 feet/second, use nylon filament, concrete, or rock as described in Section II.L, Lined Ditch.

Outlets - Each diversion shall have a stable outlet structure such as a constructed or natural waterway, a stabilized open channel, or grade stabilization structure. All outlets must be constructed and stabilized prior to operation of the diversion and must not cause erosion during discharge.

Table II.A-2
Degree of Flow Retardance by Vegetation Cover Type

Retardance	Cover type	Stand<1>	Condition
A	Reed canary grass	excellent	36" tall
B	Alta or Fawn fescue	good	uncut
	Reed canary grass	good	mowed 18"
C	Harding grass	good	uncut
	Luna or Topar wheatgrass	good	uncut
	Reed canary grass	good	mowed 12"
	Kentucky bluegrass	good	6"-12"
D	Annual ryegrass	good	uncut
	Blando brome	good	uncut
	Zorro fescue	good	uncut
	Bermuda grass	good	3"-6" tall
	Kentucky bluegrass	good	mowed 3"
E	Bermuda grass (Hybrid)	good	mowed 1.5"
	Annual ryegrass	good	mowed 6"
	Blando brome	good	mowed 6"
	Zorro fescue	good	mowed 6"

Methods and Materials:

Cross Section - Grass lined diversions shall be parabolic, triangular, or trapezoidal in shape. Design criteria for parabolic and trapezoidal channels are presented in Appendix II.A-2. Side slopes shall not be steeper than 2:1 and shall be flat enough to insure proper maintenance of the channel and the protective vegetative cover.

The ridge shall have a minimum 4 foot width at the design water surface elevation. A minimum of 0.5 feet of freeboard above the design water surface shall be provided.

Layout - Figures depicting parabolic channels show the relationship between top width (T) and depth (D) at one pair of intermediate points. For proper construction, staking of the channel cross sections wider than 20 feet, additional pairs of points on the cross section may be necessary. It is recommended that a maximum spacing of 5 feet be used. The following procedure and example should clarify the calculations necessary to establish the parabolic cross section.

1. From design tables in Appendix II.A-2 (pgs. 77-86) determine channel top width (T) and depth (D).

2. Determine the horizontal distance X_i from the center of the channel to the required point on the cross section.

3. Calculate the intermediate channel depth (Y_i) at X_i from step 2.

$$Y_i = \frac{4X_1^2 D}{T^2}$$

EXAMPLE

Given: Channel width (T) = 40 feet
depth (D) = 2.2 feet

Calculations:

1. First intermediate point, this would be adequate for channels with T less than 20 feet.

$$X_1 = T/4 = 40'/4 = 10 \text{ feet}$$

$$Y_1 = D/4 = 2.2'/4 = 0.55 \text{ feet}$$

EXAMPLE Continued

Calculations:

2. At a point 5 feet from the center of the channel.

$$X_2 = 5 \text{ feet}$$

$$Y_i = \frac{4\ X_2^a\ D}{T^2} = \frac{4\ (5)^2\ \ (2.2)}{(40)^2} = 0.14 \text{ feet}$$

3. At a point 15 feet from the channel center.

$$X = 15 \text{ feet}$$

$$Y_3 = \frac{4\ (15)^2\ \ (2.2)}{(40)^2} = 1.24 \text{ feet}$$

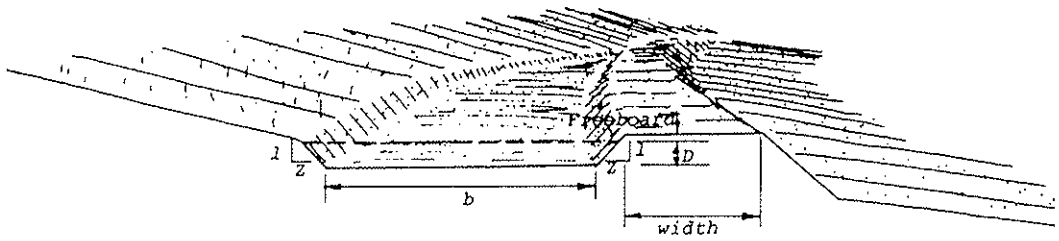
Planting - The seed mix, seeding rates, and fertilization requirements shall be in accordance with the appropriate Standards for Part III.

Site Preparation - All trees, basins, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper operation of the diversion. The diversion shall be excavated and/or shaped to line, grade, and cross section as required to meet the criteria specified herein.

Compaction - Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed diversion.

Excess Soil Removal - All soil removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the diversion, and will not create a sediment problem.

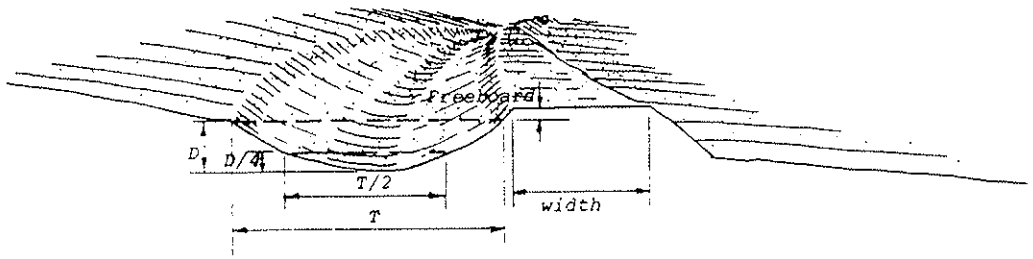
Operation and Maintenance: Grassed lined channels require periodic mowing and fertilization to maintain proper vegetative height and prevent intrusion of undesirable vegetation. After a period of time reseeding may be required. For all lining types, inspection and maintenance should be performed on a regular basis with accumulated debris or sediments being removed as needed to preserve the channel capacity.



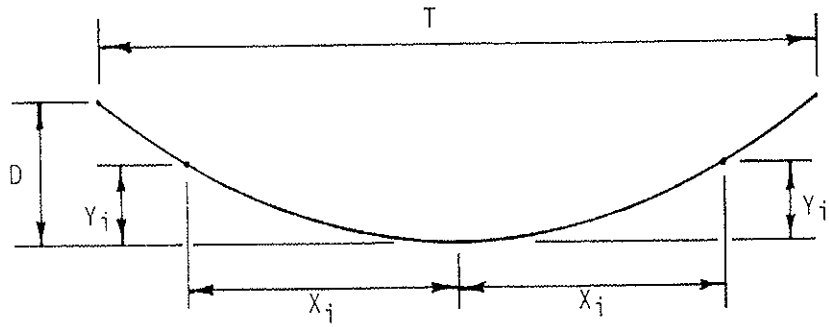
TRAPEZOIDAL CROSS-SECTION

b = bottom width of trapezoidal channel

D = depth of channel



PARABOLIC CROSS-SECTION



PARABOLIC CROSS-SECTION

T = width of parabolic channel

D = depth of channel

DIVERSION

Appendix II.A-1

WATERWAY AND DIVERSION DESIGN

The following material is provided to assist in the design of grassed waterways and diversions:

1. Graph of the Product of Velocity and Hydraulic Radius versus Manning's "n" for different degrees of vegetal retardance. (Figure II.A-1, page 76).

2. Table II.A-2 giving classification of vegetal cover based on degree of flow retardance by the vegetation type. (page 67)

3. Parabolic Water Design Tables for various grades and velocities for retardance "D", and top width and depth for retardance "B" or "C", Appendix II.A-2, pgs. 77-86.

4. Elements of channel sections, Appendix II.A-2.

The use of these tables and graphs can best be shown by example problems, which are as follows:

Problem 1

Determine the non-erosive velocity and dimensions for stability and capacity for a waterway with parabolic cross section.

Given:	Run-off	Q = 55 cfs
	Grade	= 5.1 percent
	Vegetative cover	Kentucky bluegrass
	Condition of vegetation	
	Good stand-mowed (3"-4")	= "D" curve retardance
	Good stand-headed (6"-12")	= "C" curve retardance
	Permissible velocity	= 4 ft/sec

Solution: Horizontally opposite 55 cfs on the Parabolic Water Design Table for Grade = 5.0 percent (slope table that is nearest 5.1%) and the columns headed V = 4.0 ft/sec, find T = 33 feet and D = 0.8 feet.

Therefore, a waterway with a parabolic cross section, a top width of 33 feet, and a depth of 0.8 feet will carry 55 cfs at maximum velocity of 4 feet per second when the vegetative lining is short (3" to 4" in height). This complies with the requirement for non-erosive velocity when vegetation is short ("D" retardance) and for capacity when vegetation is tall ("C" retardance).

Problem 2

Determine the non-erosive velocity and dimensions for a waterway with trapezoidal cross section.

Given:	Run-off	Q = 55 cfs
	Grade	= 2 percent
	Side slopes	= 2:1
	Vegetative cover	Kentucky bluegrass
	Condition of vegetation	
	Good stand-headed (6"-12")	= "C" curve retardance
	Permissible velocity	= 5 ft/sec

Solution: Horizontally opposite 55 cfs on the Trapezoidal Channel Design Table for Grade = 2.0 percent, read across to the column for bottom width = 6 feet, and read the D = 1.3 feet and V = 4.9 ft/sec.

Therefore, a waterway with a trapezoidal cross section, 2:1 side slope, bottom width of 6 feet, and a depth of 1.3 feet will carry 55 cfs at maximum velocity of 4.9 feet per second "C" curve retardance).

Problem 3

Determine the safe velocity and dimensions for a waterway with trapezoidal cross section that does not fit the Trapezoidal Channel Design Tables.

Given:	Run-off	Q = 55 cfs
	Grade	= 3 percent
	Side slopes	= 3:1
	Vegetative cover	Kentucky bluegrass
	Condition of vegetation	
	Good stand-mowed (3"-4")	= "D" curve retardance
	Good stand-headed (6"-12")	= "C" curve retardance
	Permissible velocity	= 5 ft/sec

Solution: The solution is a trial and error process. The first step is to design for stability when the vegetation is short ("D" retardance), and the second step is to design for capacity when the vegetation is tall ("C" retardance).

Step 1 - Stability

$Q = 55$ cfs

$V_{max} = 5$ ft/sec

$$A = \frac{Q}{V_{max}} = \frac{55}{5} = \frac{11 \text{ sq. ft.}}{}$$

Try Bottom Width = 12 feet

$A = bd + zd^2$

$11 = 12d + 3d^2$

Note: Solve for d by use of the quadratic equation.

$ax^2 + bx + c = 0$

$$x = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$3d^2 + 12d - 11 = 0$

$$d = \frac{-12 \pm \sqrt{12^2 - 4(3)(-11)}}{2(3)}$$

$$d = \frac{-12 + 16.61}{6} = \frac{4.61}{6}$$

$d = 0.77$ feet

Hydraulic Radius

$$r = \frac{\text{area}}{\text{wetted perimeter}} = \frac{bd + zd^2}{b + 2d\sqrt{z^2 + 1}}$$

$$r = \frac{12(0.77) + 3(0.77^2)}{12 + 2(0.77)\sqrt{3^2 + 1}}$$

$$r = \frac{9.24 + 1.78}{12 + 4.87}$$

$$r = \frac{11.02}{16.87} = 0.65$$

$Vr = 5(0.65) = 3.25$

From graph, Figure II.A-1 (page 76), for Vr = 3.25 and "D" retardance, read n = 0.04.

$$V = \frac{1.486}{n} r^{2/3} s^{1/2}$$

$$= \frac{1.486}{0.04} (0.65^{2/3}) (0.03^{1/2}) = 4.83 \text{ ft/sec}$$

Okay, but less than V_{max} - try slightly smaller channel.

Try bottom width = 10 feet

$A = bd + zd^2$

$11 = 10d + 3d^2$

$$d = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = 0.87$$

$$r = \frac{bd + zd^2}{b + 2d\sqrt{z^2 + 1}} = 0.71$$

$Vr = 3.55$

$n = 0.040$ from page A-36.15

$V = \frac{1.486}{n} r^{2/3} s^{1/2} = 5.15$ which is greater than V_{max}

Therefore, select design bottom width = 12 feet

Velocity = 4.83 ft/sec for "D" retardance

$d = 0.8'$

Step 2 - Capacity check using "C" curve retardance. Determine additional depth needed to offset the increased retardance and decreased velocity.

Try $d = 0.9$ feet

$A = bd + zd^2 = (12)(0.9) + 3(.9^2) = 13.23$

$$r = \frac{A}{P} = \frac{13.23}{b+2d\sqrt{z^2 + 1}} = \frac{13.23}{12+2(.9)\sqrt{3^2 + 1}} = 0.75$$

Assume V = 4.4 ft/sec

$Vr = (4.4)(0.75) = 3.30$

From graph, Figure II.A-1 (page 76), for Vr = 3.30 and "C" retardance, read n = 0.046.

$V = \frac{1.486}{.046} (0.75^{2/3}) (.03^{1/2}) = 4.62$ ft/sec

which is greater than assumed value

Assume V = 4.6 ft/sec

Vr = (4.6) (0.75) = 3.45

From graph, n = 0.046

$$V = \frac{1.486}{.046} (0.75^{2/3}) (.03^{1/2}) = 4.62 \text{ ft/sec}$$

which is close enough

Therefore, dimensions and velocities are as follows:

Bottom width = 12 feet

Side slopes = 3:1

For "D" retardance - V = 4.83 ft/sec

d = 0.8 feet.

For "C" retardance - V = 4.62 ft/sec

d = 0.9 feet + freeboard.

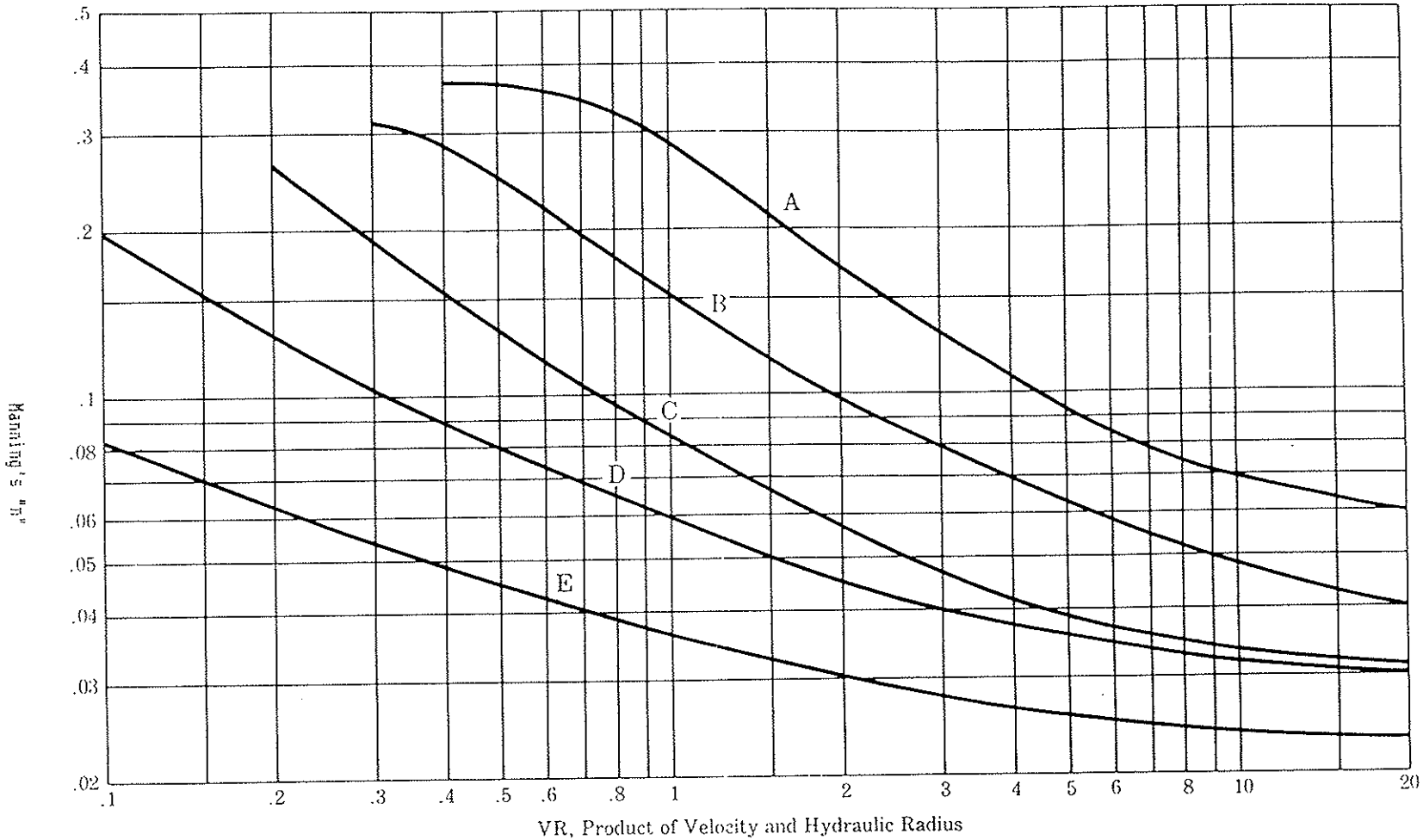


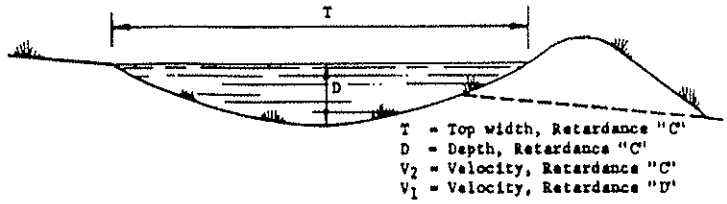
Figure II.A-1

Manning's "n" related to velocity, hydraulic radius, and vegetal retardance. (Ref: SCS-TP-61, Handbook of Channel Design for Soil and Water Conservation).

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, Retardance "C"
D = Depth, Retardance "C"
V_2 = Velocity, Retardance "C"
V_1 = Velocity, Retardance "D"

Note - Depth "D" does not include allowance for freeboard and settlement.

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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						

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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			

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "B"

GRADE 1.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5																											
10	9.7	1.6	1.0	6.2	2.0	1.2																					
15	14.8	1.5	1.0	10.2	1.7	1.3	6.5	2.2	1.5																		
20	20.2	1.5	1.0	13.8	1.7	1.3	9.6	1.9	1.6																		
25	25.1	1.5	1.0	17.4	1.7	1.3	12.2	1.9	1.6	8.5	2.2	2.0															
30	30.1	1.5	1.0	21.0	1.6	1.3	14.9	1.8	1.7	10.6	2.1	2.1															
35	35.1	1.5	1.0	24.7	1.6	1.3	17.5	1.8	1.7	12.6	2.0	2.1	8.9	2.4	2.5												
40	40.1	1.5	1.0	28.2	1.6	1.3	20.0	1.8	1.7	14.5	2.0	2.1	10.5	2.3	2.5												
45	45.1	1.5	1.0	31.7	1.6	1.3	22.5	1.8	1.7	16.4	2.0	2.1	12.1	2.2	2.5	9.2	2.8	2.9									
50	50.2	1.5	1.0	35.2	1.6	1.3	25.4	1.8	1.7	18.3	2.0	2.1	13.6	2.2	2.5	10.0	2.6	2.9									
55	55.2	1.5	1.0	38.8	1.6	1.3	27.9	1.8	1.7	20.3	1.9	2.1	15.1	2.2	2.5	11.2	2.5	3.0									
60	60.2	1.5	1.0	42.3	1.6	1.3	30.4	1.8	1.7	22.2	1.9	2.1	16.6	2.1	2.5	12.4	2.4	3.0									
65	65.2	1.5	1.0	45.8	1.6	1.3	32.9	1.8	1.7	24.0	1.9	2.1	18.0	2.1	2.5	13.6	2.4	3.0	8.9	3.1	3.5						
70	70.2	1.5	1.0	49.3	1.6	1.3	35.5	1.8	1.7	25.9	1.9	2.1	19.5	2.1	2.6	14.8	2.4	3.0	10.6	2.8	3.5						
75	75.2	1.5	1.0	52.8	1.6	1.3	38.0	1.8	1.7	28.2	1.9	2.1	20.9	2.1	2.6	16.0	2.3	3.0	11.5	2.8	3.5						
80	80.2	1.5	1.0	56.3	1.6	1.3	40.5	1.8	1.7	30.0	1.9	2.1	22.3	2.1	2.6	17.1	2.3	3.0	12.5	2.7	3.5						
85	85.2	1.5	1.0	59.8	1.6	1.3	43.0	1.8	1.7	31.9	1.9	2.1	23.7	2.1	2.6	18.3	2.3	3.0	13.5	2.7	3.6	9.8	3.3	3.9			
90	90.2	1.5	1.0	63.3	1.6	1.3	45.6	1.8	1.7	33.6	1.9	2.1	25.2	2.1	2.6	19.4	2.3	3.1	14.4	2.6	3.6	10.9	3.1	3.9			
95	95.2	1.5	1.0	66.9	1.6	1.3	48.1	1.8	1.7	35.5	1.9	2.1	26.6	2.1	2.6	20.5	2.3	3.1	15.3	2.6	3.6	12.0	3.0	3.9			
100	100.2	1.5	1.0	70.4	1.6	1.3	50.6	1.8	1.7	37.4	1.9	2.1	28.0	2.1	2.6	21.6	2.3	3.1	16.2	2.6	3.6	12.9	2.9	4.0			
105	105.3	1.5	1.0	73.9	1.6	1.3	53.1	1.8	1.7	39.2	1.9	2.1	29.8	2.1	2.6	22.8	2.3	3.1	17.1	2.6	3.6	13.7	2.9	4.0	10.8	3.4	4.3
110	110.3	1.5	1.0	77.4	1.6	1.3	55.7	1.8	1.7	41.1	1.9	2.1	31.3	2.1	2.6	23.9	2.3	3.1	18.0	2.6	3.6	14.4	2.9	4.0	12.0	3.2	4.3
115	115.3	1.5	1.0	80.9	1.6	1.3	58.2	1.8	1.7	42.9	1.9	2.1	32.7	2.1	2.6	25.0	2.3	3.1	18.9	2.5	3.6	15.2	2.8	4.0	12.7	3.2	4.3
120	120.3	1.5	1.0	84.4	1.6	1.3	60.7	1.8	1.7	44.8	1.9	2.1	34.1	2.1	2.6	26.1	2.2	3.1	19.7	2.5	3.6	16.0	2.8	4.0	13.4	3.1	4.3
125	125.3	1.5	1.0	88.0	1.6	1.3	63.2	1.8	1.7	46.7	1.9	2.1	35.5	2.1	2.6	27.2	2.2	3.1	20.6	2.5	3.6	16.8	2.8	4.0	14.1	3.1	4.3
130	130.3	1.5	1.0	91.5	1.6	1.3	65.8	1.8	1.7	48.5	1.9	2.1	36.9	2.1	2.6	28.4	2.2	3.1	21.5	2.5	3.6	17.4	2.8	4.0	14.8	3.1	4.3
135	135.3	1.5	1.0	95.0	1.6	1.3	68.3	1.8	1.7	50.4	1.9	2.1	38.3	2.1	2.6	29.5	2.2	3.1	22.4	2.5	3.6	18.2	2.8	4.0	15.5	3.0	4.3
140	140.3	1.5	1.0	98.5	1.6	1.3	70.8	1.8	1.7	52.2	1.9	2.1	39.7	2.0	2.6	30.6	2.2	3.1	23.2	2.5	3.6	18.9	2.7	4.0	16.1	3.0	4.4
145	145.3	1.5	1.0	102.0	1.6	1.3	73.3	1.8	1.7	54.1	1.9	2.1	41.1	2.0	2.6	32.1	2.2	3.0	24.1	2.5	3.6	19.7	2.7	4.0	16.8	3.0	4.4
150	150.3	1.5	1.0	105.5	1.6	1.3	75.9	1.8	1.7	56.0	1.9	2.1	42.5	2.0	2.6	33.2	2.2	3.0	25.0	2.5	3.6	20.4	2.7	4.1	17.5	2.9	4.4

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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	3.3	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	26.4	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	27.6	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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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	18.6	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	1.4	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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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	35.9	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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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	15.8	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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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	0.8	3.0	74.6	0.9	3.4

EXHIBIT 7-4 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "B")

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															

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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						

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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			

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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	25.4	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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

V1 FOR RETARDANCE "D", TOP WIDTH (T), DEPTH' (D) AND V2 FOR RETARDANCE "C"

GRADE 4.00 PERCENT

Q CFS	V1=2.0			V1=2.5			V1=3.0			V1=3.5			V1=4.0			V1=4.5			V1=5.0			V1=5.5			V1=6.0		
	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2	T	D	V2
5	8.5	0.6	1.4	5.9	0.7	1.8	4.1	0.8	2.3																		
10	17.2	0.6	1.4	12.1	0.7	1.8	8.8	0.7	2.3	6.7	0.8	2.8	5.2	0.9	3.3	3.8	1.0	3.9									
15	25.8	0.6	1.4	18.1	0.7	1.8	13.4	0.7	2.3	10.3	0.8	2.8	8.1	0.8	3.4	6.4	0.9	3.9	4.9	1.0	4.5						
20	34.4	0.6	1.4	24.2	0.7	1.8	17.8	0.7	2.3	13.9	0.8	2.8	10.9	0.8	3.4	9.7	0.9	3.9	6.9	1.0	4.5	5.5	1.1	5.0			
25	43.0	0.6	1.4	30.2	0.7	1.9	22.3	0.7	2.3	17.4	0.8	2.8	13.8	0.8	3.3	11.9	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	9.6	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	5.7
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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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									
15	28.5	0.6	1.4	20.5	0.6	1.8	14.6	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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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	3.3	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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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

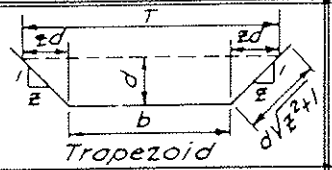
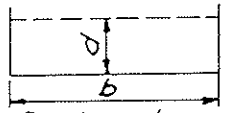
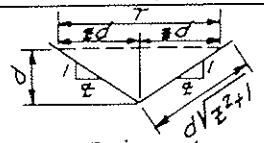
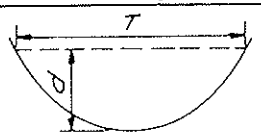
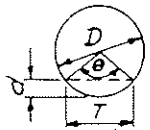
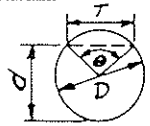
EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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	29.7	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

EXHIBIT 7-5 PARABOLIC WATERWAY DESIGN
(RETARDANCE "D" AND "C")

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

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

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

Figure II.A-2

II.B

STONE CENTER GRASSED WATERWAY

Definition: A permanent natural or man-made drainageway of parabolic, trapezoidal cross section, or a compound section, with a low flow channel that is below adjacent ground and is stabilized with suitable vegetation.

Purpose: The purpose of a stone center grassed waterway is to convey storm run-off without causing damage to the channel by erosion.

Applicability: Stone center grassed waterways are utilized where added channel capacity is required to control run-off. Control of erosion can be achieved by this practice singularly or in combination with other practices. This practice is not applicable where its construction would destroy riparian wildlife habitat.

Planning Criteria: The initial establishment period is the most critical time in successfully installing a grassed waterway. Special erosion control protection such as anchored erosion control blankets and straw bale dikes are often warranted during this period. Irrigation may also be needed during this period.

Depth of Flow - The maximum depth of flow excluding the low flow channel for this practice shall be 2 feet.

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm, or as specified by the permit issuing authority.

Outlet - A stable discharge outlet is required for all waterways.

Base Flow - A stone lined low flow channel shall be provided to convey the base flow. The capacity of the low flow channel area shall be at least 0.1 cubic feet per second per acre of drainage area. For natural channels the low flow channel capacity should be about the 1.5 year return interval event. For trapezoidal sections the minimum depth of the low flow channel shall be 1 foot below the grassed area, except when water tolerant vegetation such as reed canary grass is used.

Design Velocities - Design velocities, obtained by using the procedures and "n" values contained herein, shall not exceed the permissible velocities given in Table II.B-1.

Planning Criteria: Continued

Roughness Coefficients - The hydraulic roughness of grass lined channels depends on the length of mowing, the type of grass, and the depth of flow. Roughness coefficients are determined using Figure II.A-1, Appendix II.A-1.

Stone Size - The stone size for the low flow channel shall be based upon the design velocity for the composite channel and in accordance with the criteria for rock riprap contained in Section II.E.

Cutoff Walls - The use of cutoff walls at regular intervals to prevent the formation of blow outs and meander channels is recommended.

Protective Lining - For design velocities exceeding 3.5 and less than 5 feet per second a temporary erosion control blanket consisting of jute netting, coconut or straw and coconut fiber bound with nylon netting, shall be used.

For design velocities exceeding 5 feet per second an erosion control blanket or liner consisting of three-dimensional nylon filament blanket shall be used. Design velocities shall not exceed 8 feet per second.

Side Slopes - Side slopes shall not exceed 4:1 if the bank is to be mowed, or 2:1 for all other conditions.

Outlet Protection - The waterway shall discharge into a stable outlet such as a stabilized open channel or grade stabilization structure.

Seeding and Fertilization - The seed mix, seeding rates, and fertilization requirements, shall be determined from Part III.

Installation: Stone center grassed waterways shall be installed during periods of low flow. Temporary diversion of flows may be required to prevent detrimental effects on downstream water quality. Also temporary irrigation is required to insure establishment of the grass prior to high flows.

Operation and Maintenance: Periodic mowing and fertilization are required to maintain proper vegetative height and prevent intrusion of undesirable vegetation. Inspection and maintenance should be performed on a regular basis with accumulation of debris or sediments being removed as needed to preserve the channel capacity. After a period of time reseeding may be required.

Table II.B-1

Permissible Velocities for
Well Maintained Grass Channels

Cover <1>	Slope Percent	Permissible Velocity (fps) Erosion Resistant Soils	Easily Eroded Soils
Annual ryegrass Blando brome Zorro fescue Luna wheatgrass Topar wheatgrass Harding grass	0 - 5 5 - 10 over 10	4.0 NR<3> NR<3>	3.5 NR<3> NR<3>
Bermuda grass (Hybrid)	0 - 5 5 - 10 over 10	8.0<2> 7.0<2> 6.0<2>	6.0<2> 4.0<2> 3.0<2>
Alta or Fawn fescue	0 - 5 5 - 10 over 10	5.0 4.0 3.0	4.0 3.0 NR<3>
Reed canary grass <4>	0 - 5 5 - 10 over 10	5.0 4.0 NR<3>	4.0 3.0 NR<3>

<1> The permissible velocities are for dense stands of grasses. If flows exceeding the low flow channel are expected during the establishment period, temporary erosion control lining is recommended. The vegetative species chosen must be compatible with climatic and soil conditions. Check with the local Soil Conservation Service office for planting mix recommendations.

<2> For channels with flow velocities greater than 5 feet per second a nylon fiber blanket is required. Sodding may be used without blanket but requires irrigation.

<3> Not recommended. Use grade control structures or other types of lining.

<4> Requires irrigation and tolerates flooding and standing water.

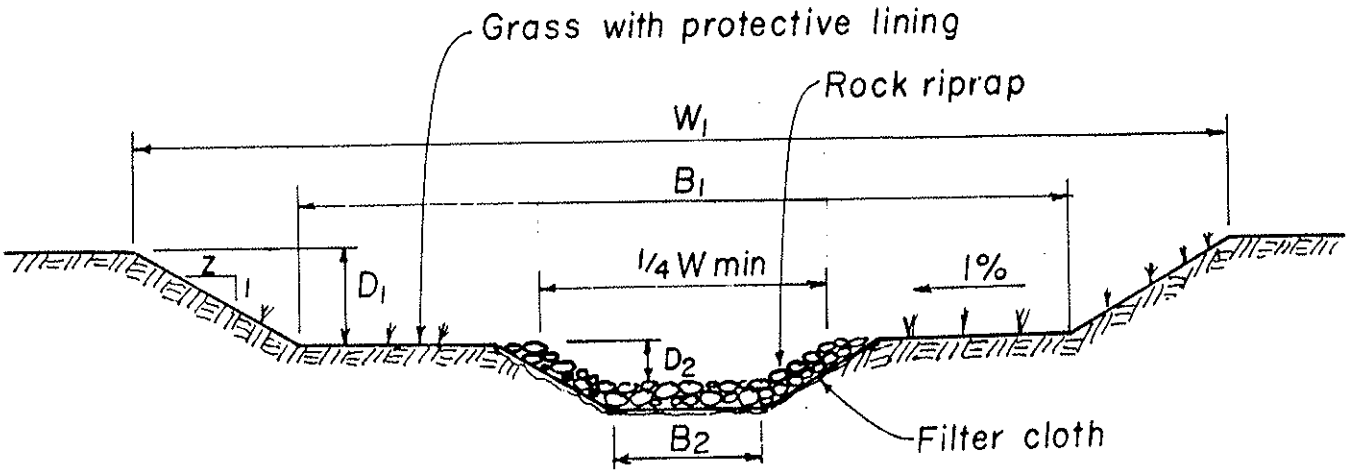
Table II.B-2

Degree of Flow Retardance by Vegetation Cover Type

Retardance	Cover type	Stand<1>	Condition
A	Reed canary grass	excellent	36" tall
B	Alta or Fawn fescue	good	uncut
	Reed canary grass	good	mowed 18"
C	Harding grass	good	uncut
	Luna or Topar wheatgrass	good	uncut
	Reed canary grass	good	mowed 12"
D	Annual ryegrass	good	uncut
	Blando brome	good	uncut
	Zorro fescue	good	uncut
	Bermuda grass	good	3"-6" tall
E	Bermuda grass (Hybrid)	good	mowed 1.5"
	Annual ryegrass	good	mowed 6"
	Blando brome	good	mowed 6"
	Zorro fescue	good	mowed 6"

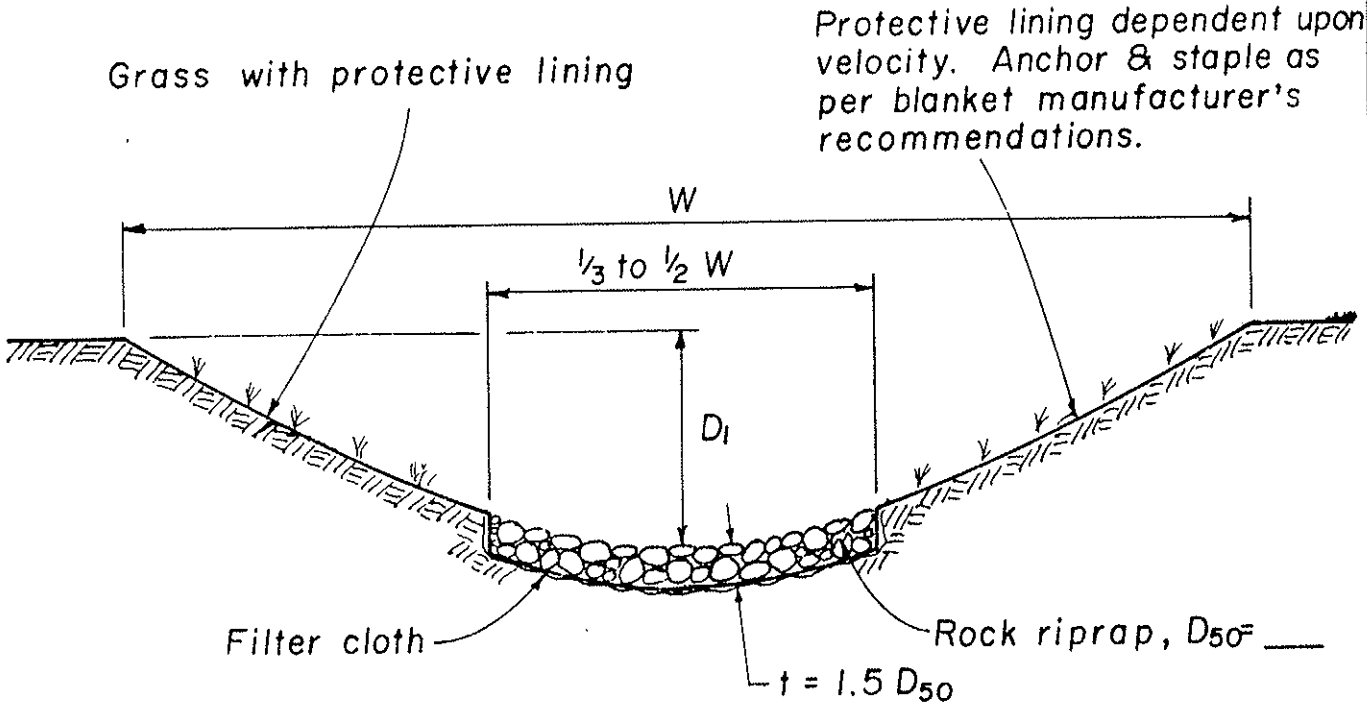
<1> A stand is considered "good" if 75 percent of the ground is covered by the plants. Reduce retardance one group for a stand with 50 percent ground cover.

D_1 = Design flow depth + Freeboard



TYPICAL TRAPEZOIDAL SECTION

no scale



TYPICAL PARABOLIC SECTION

no scale

High Sierra R. C. & D. Erosion & Sediment Control Guide	STONE CENTER GRASSED WATERWAY

II.C

LEVEL SPREADER

Definition: A level spreader is a stabilized outlet constructed at a zero percent grade across a slope.

Purpose: The purpose of a level spreader is to convert a concentrated flow of sediment free run-off into sheet flow and to outlet it onto stabilized areas without causing erosion.

Applicability: The level spreader is a permanent installation and is used only where a spreader can be constructed upon undisturbed soil with suitable vegetation. Other necessary conditions are that the drainage area be adequately treated against sheet and rill erosion to keep sediment from damaging the vegetation and where water will not be reconcentrated immediately below the point of discharge.

Planning Criteria: Level spreaders shall not be constructed on slopes greater than 15 percent. Applicable state drainage and water laws shall be observed.

Drainage Area - The maximum drainage area for this practice is 20 acres.

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm, or as specified by the permit issuing authority.

Level Spreader Length - A simplified design method is allowable for watersheds up to an area of 4 acres. The minimum length shall be 10 feet per acre of drainage area. For larger drainage areas the length is to be based on a maximum flow of 0.5 cubic feet per second per foot of length.

Methods and Materials:

Outlet - Discharge over the level lip shall be protected with fiberglass matting, nylon fiber blanket, and jute liners and stops. Discharge shall be onto an existing stabilized area.

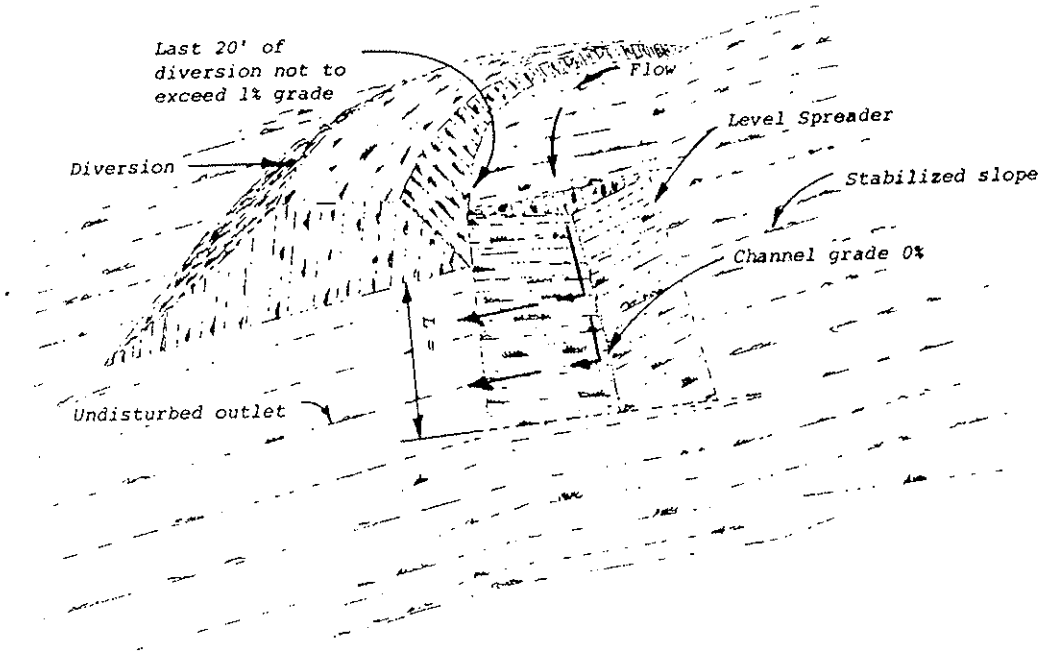
Methods and Materials: Continued

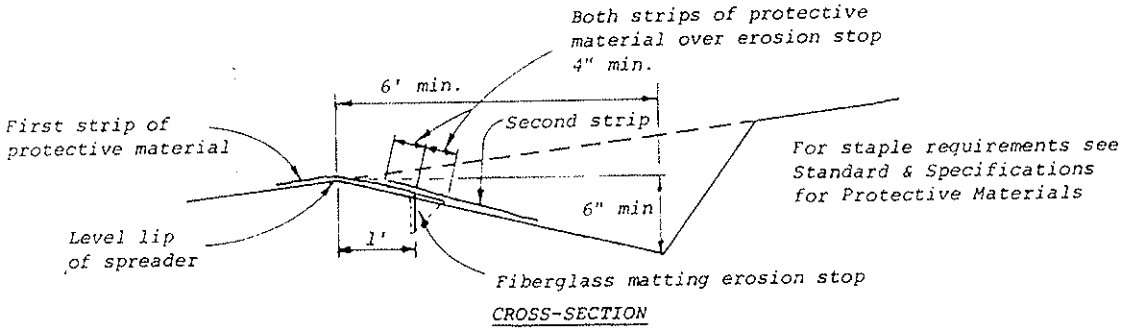
Erosion Stop - A fiberglass matting or nylon fiber blanket erosion stop shall be placed vertically, and at least 12 inches deep, in a slit trench 1 foot back of the level lip and parallel with the lip. This erosion stop shall extend the entire length of the level lip and shall be trimmed after backfilling with tamped soil so that the upper edge is even with the soil surface.

Protective Material - The entire level lip area shall be protected by placing two strips of jute or nylon fiber blanket material as shown in the standard drawing.

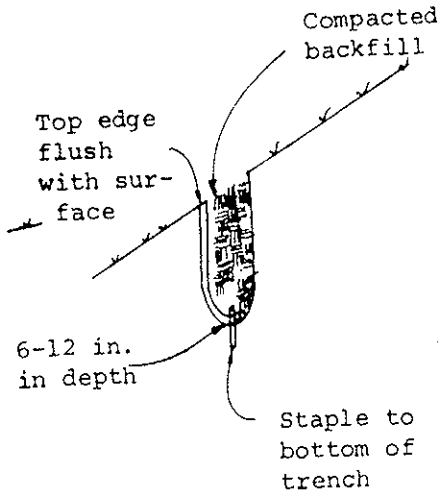
Entrance Channel - The entrance channel shall not exceed 1% grade for at least 20 feet before entering spreader.

Operation and Maintenance: Periodic inspection and maintenance shall be required. Inspect the level spreader following each storm period. Make repairs as necessary to ensure proper operation.





CROSS-SECTION



Erosion Stop Detail

LEVEL SPREADER

II.D

STORM DRAIN OUTLET PROTECTION

Definition: De-energizing devices and erosion resistant channel sections located between storm drain outlets and stable existing downstream channels.

Purpose: The purpose of outlet protection is to provide a transition between high velocity channelized flows and existing channels so that the concentrated energy will not erode downstream channels. Also to check the stability of the natural water course when flows are increased due to land use changes or diversions.

Applicability: Outlet protection is required at all storm drain outlets, road culverts, pipe slope drains, paved channel outlets, diversions, and grassed waterways that discharge into natural or constructed channels which in turn discharge into streams or drainage systems.

Planning Criteria: Analysis and appropriate treatment shall be provided the entire length of the flow path from the end of the pipe or channel to the point of entry into an existing stream or drainage system.

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm, or as specified by the permit issuing authority.

Channel Velocity - The velocity at the end of a structure or channel must not exceed the allowable velocity for the next downstream reach. Appropriate field surveys to determine cross sections, grades, vegetation, and channel conditions must be made. Maximum permissible velocities shall conform to those presented in Table II.D-1.

Roughness Coefficients - Each channel reach, whether natural, vegetated or riprap-paved bottom, shall have its velocity computed from Manning's equation using the Manning's "n" values in Table II.D-2 as a guide.

Planning Criteria: Continued

Details - Provide scaled plans showing plan and profile views, and cross section of each channel reach between outlet and stream or drainage system. A reach is defined as the length of channel throughout which the hydraulic characteristics, i.e. depth of flow, roughness, channel grade, side slopes, bottom width, discharge rate and velocity, do not change. On the plans indicate velocities at the outlet pipe, structure or channel; riprap or paved apron section; and each successive channel reach. Detail proposed method of stabilization of each channel reach.

Table II.D-1

Maximum Permissible Velocities for water containing colloidal silts

Channel Lining		Maximum Velocity (feet per second)
1)	Natural channels not completely lined with vegetation.	
	Sand and sandy loam	2.5
	Silt loam	3.0
	Sandy clay loam	3.5
	Clay loam	4.0
	Clay, fine gravel and graded loam to gravel	5.0
	Graded silt to cobbles	5.5
	Shale, hardpan and course gravels	6.0
2)	Riprap	Refer to Section II.E
3)	Vegetation	Refer to Section II.A, Diversion or II.B, Grassed Waterway

For the purpose of the Standard, the roughness coefficient "n" as in Manning's equation shall be presented in Table II.D-2.

Table II.D-2

Values of "n" to be used with the Manning's Equation

Channel Lining		"n" Value
Asphaltic Concrete:	Machine finish	0.018
	Hand finish	0.022
Concrete:	Float finish	0.015
	Unfinished	0.017
	Shotcrete	0.022
Natural channels with mixed vegetation		Refer to Open Channel textbook such as Chow (1959)
Gabion Mattress		0.028
Fabriform - Filter Point		0.025
Riprap		Refer to Section II.E, Riprap
Grass		Refer to Section II.B, Grassed Waterway

PIPE OUTLET

Apron: All pipe outlets shall have a structurally lined apron or other suitable de-energizing structure to convert pipe flow to channel flow conforming to the following criteria:

Bottom grade: 0.0%

Side slope: Maximum 2:1

Methods and Materials:

Sidewall: Top of sidewall shall extend a minimum of 1 foot above the maximum tail water elevation but no lower than 2/3 of the pipe diameter measured from the pipe invert.

PIPE OUTLET **Methods and Materials:** Continued

Invert Elevation: Outlet elevation shall be equal to or lower than the invert of downstream channel or drainage pipe.

Apron: Length of apron section shall be in determined accordance with the criteria in Appendix II.D-1, Design of Outlet Protection.

Width: Where there is no well defined channel immediately downstream from the apron, the end width of the apron shall be determined as follows:

1) Tail water elevation above the pipe centerline

   Width = pipe diameter + 0.4 La

2) Tail water elevation below the pipe centerline

   Width = diameter + La

Where La is the apron length as determined from Design of Outlet Protection, Appendix II.D-1.

Tail water elevation shall be determined from Manning's equation to calculate the depth of flow in the channel downstream from the apron.

Riprap: Riprap for energy dissipation at pipe outlets shall be in accordance with Design of Outlet Protection in Appendix II.D-1.

Horizontal Alignment: There shall be no bend or curves unless the structure is designed for excess capacity.

PAVED CHANNEL OUTLET

Methods and Materials:

Width: Equal to width of downstream channel side divergence of the transition shall be determined by the ration 1:3F where F is the Froude number and determined by:

$$F = V/(gd)^{1/2}$$

Where: V = velocity, in feet per second
d = depth of flow at transition in feet
g = acceleration due to gravity, 32.2 ft/sec^2

PAVED CHANNEL OUTLET **Methods and Materials:** Continued

Horizontal Alignment: No bends or curves unless F, Froude number, is less than 1.0.

Invert: Outlet channel invert elevation shall be equal to or lower than the invert of the downstream channel.

Site Preparation: All trees, brush, obstructions and other objectionable material shall be removed and disposed of so as not to interfere with the proper operation of the outlet protection. The apron shall be excavated and/or shaped to the line, grade and cross section as required to meet the criteria specified herein.

Compaction: Fills shall be compacted as needed to prevent unequal settlement that would cause structural damage to the completed apron.

Excess Soil Removal: All Soil removed and not needed shall be spread and compacted, or disposed of so that it will not interfere with the functioning of the apron and will not cause a sediment problem.

Concrete: Concrete or shotcrete shall be a 4 1/2 sack mix and have a 28 day compressive strength of 2500 psi. Curing shall be accomplished by soaked burlap or misting. A curing compound may be used in remote locations where water is unavailable during construction.

Grouted Rock Riprap: Rock shall be in accordance with the requirements for Riprap, Section II.E. Concrete for grout shall be a 5 1/2 sack mix. Grout shall be placed in such a manner that the upper 1/3 of the larger rocks project above the grout line so as to form a naturally rough surface.

Operation and Maintenance: Inspect outlet protection periodically, especially following storms. Note any defects or failures and repair according to the specifications herein. Remove deposited trash, debris or sediment.

Appendix II.D-1

DESIGN OF OUTLET PROTECTION

Outlet protection as presented here is a level apron of sufficient length and flare such that the expanding flow (from pipe or conduit to channel) loses sufficient velocity and energy that it will not erode the next downstream channel reach. The design curves are based on circular conduits flowing full. The curves provide the apron size and if riprap is to be used, the minimum d_{50} size for the riprap. There are two curves, one for a low or minimum tailwater condition and the other a high or maximum tailwater condition. The minimum condition applies to a tailwater surface elevation less than the center of the pipe whereas the maximum condition applies to a tailwater surface elevation equal to or higher than the center of the pipe.

The first requirement in using this procedure is to determine the tailwater condition as required in the Standard and Specifications. Then, for circular conduits, enter the appropriate chart with the discharge and the pipe diameter to find the riprap size and apron length. Then calculate apron width.

Example 1:

A circular conduit is flowing full
Q = 280 cfs, diam. = 66", and tailwater (surface) is 2 ft. above pipe invert.

This is a minimum tailwater condition.

Read d_{50} = 1.2', and apron length = 38'

Apron width = diam + L_a = 38 + 5.5 = 43.5'

Maximum stone size in the riprap mixture = 1.5 x d_{50} = 1.5 x 1.2 = 1.8'.

The curves may also be used for the design of outlet protection for rectangular conduits but the procedure is slightly different. Depth of flow and velocity are the two flow parameters to be used. Enter the lower set of curves with velocity and depth (using the diameter curves for depth), then read to the right to find d_{50} and up and left for the length of apron. To find the ap ron width substitute conduit width for diameter in the apron width equations.

Example 2:

A concrete box 5.5' x 10' is flowing 5.0' deep, Q = 600 cfs and tailwater surface 5' above invert (Max. tailwater condition).

$$V = \frac{Q}{A} = \frac{600}{5.0 \times 10} = 12 \text{ fps}$$

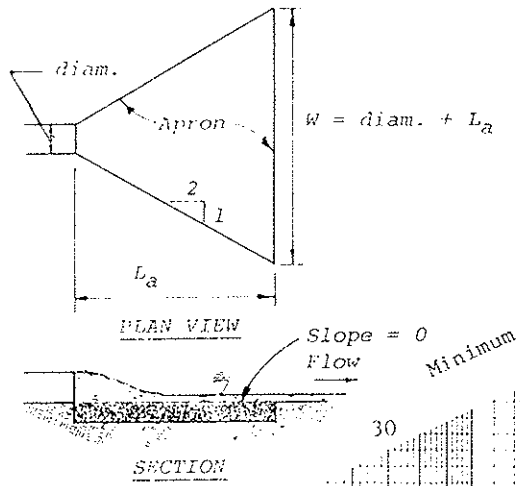
At the intersection of the curve d = 60" and V=12 fps, read d_{50} = 0.4'.

Then reading up to the d = 60" curve, read apron length = 40'.

Apron width, W = conduit width + 0.04 L_a = 10+(0.4) (40) = 26'.

Largest stone size = 0.4 x 1.5 = 0.6' or 7".

DESIGN OF OUTLET PROTECTION
MINIMUM TAILWATER CONDITION (Tw <0.5 diam.)



Median stone diameter, d_{50}, is the stone size which 50% of the riprap mixture, by weight, is larger than.

Velocities shown are for pipes flowing full.

Median Stone Diameter, d_{50}, in feet

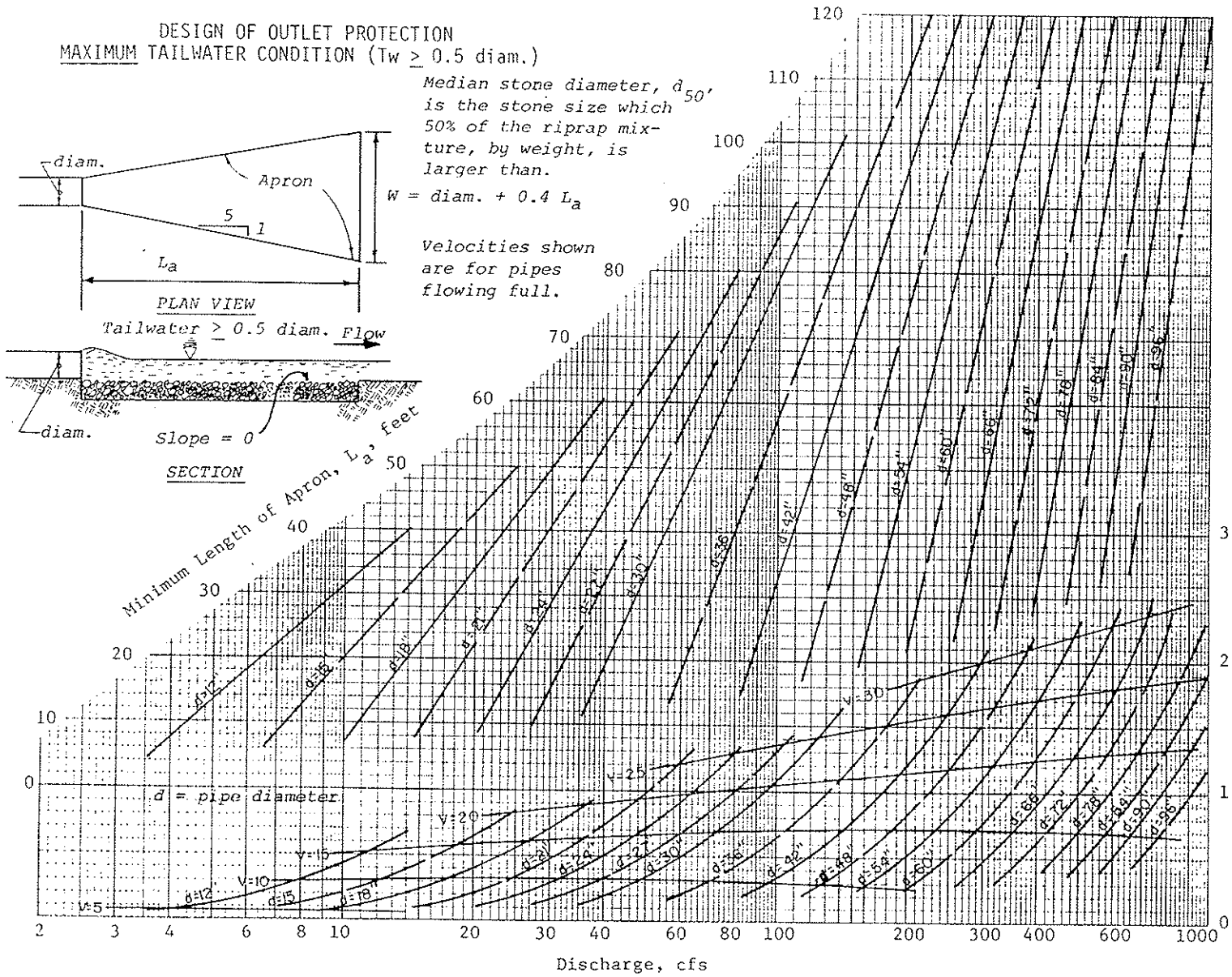
Minimum Length of Apron, L_a, feet

Discharge, cfs

a = pipe diameter

L_a = 38'

d_{50} = 1.2'


DESIGN OF OUTLET PROTECTION
MAXIMUM TAILWATER CONDITION (Tw ≥ 0.5 diam.)
Median stone diameter, d_{50}, is the stone size which 50% of the riprap mixture, by weight, is larger than.
W = diam. + 0.4 L_a
Velocities shown are for pipes flowing full.
diam.
Apron
5
1
L_a
PLAN VIEW
Tailwater ≥ 0.5 diam.
Flow
diam.
Slope = 0
SECTION
Minimum Length of Apron, L_a, feet
Median Stone Diameter, d_{50}, in feet
Discharge, cfs
d = pipe diameter
V=5
V=10
V=15
V=20
V=25
V=30
d=12"
d=15"
d=18"
d=21"
d=24"
d=27"
d=30"
d=33"
d=36"
d=42"
d=48"
d=54"
d=60"
d=66"
d=72"
d=78"
d=84"
d=90"
d=96"

II.E

RIPRAP

Definition: A layer of loose rock or aggregate placed over an erodible surface.

Purpose: The purpose of riprap is to protect the soil surface from the erosive forces of water.

Applicability: Riprap is placed at soil-water interfaces where soil conditions, water turbulence and velocity, expected vegetative cover, and groundwater conditions may cause erosion at design flow conditions. Locations that may require riprap are storm drain outlets, channel banks and/or bottoms, roadside ditches, drop structures and shorelines.

Planning Criteria: Riprap protection shall meet the following criteria:

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm, or as specified by the permit issuing authority.

Size - Refer to Appendix II.E-1 for the design of riprap lined channels. This procedure determines a design stone size that is stable under design flow conditions.

The minimum design stone size is the d_{50} or median stone diameter which is defined as the stone size that 50 percent of the mixture by weight is larger than. Diameter of the largest stone shall be 1.5 times the design stone size, d_{50}.

If the riprap size, d_{50}, computed for bends is less than 10 percent greater than the riprap size d_{50} for straight channels, use the straight channel size. If greater than 10 percent, use larger size riprap in the bends. Generally no more than two sizes should be used on any channel.

Limits of Riprap - Channel lining shall be started at a stabilized point or structure and ended at a point of stable bottom grade.

Bank protection at bends:

Upstream: From the point of curvature a distance equal to 3 times the channel bottom width.

Downstream: From the point of tangency a distance equal to 5 times the channel bottom width.

Planning Criteria: Continued

Toe Protection - Where there is no paving or riprap on the bottom of the channel provide toe protection by one of the following:

1) Extend riprap below anticipated depth of scour a minimum vertical distance of 3 feet below channel bottom for erodable bed materials.

2) Provide extra material at the toe by thickening the section to 3 times the normal rock layer thickness.

3) Provide riprap lining on the channel bottom for a distance of 10 feet out from the toe.

Top of Riprap - The top of the riprap shall extend to the design discharge elevation or to a point where suitable vegetation can be established. The minimum height of the riprap shall be the normal base flow level of the channel.

Thickness of Riprap - The minimum layer thickness shall be 1.5 times the maximum stone size but not less than 6 inches.

Methods and Materials:

Rock - Stone for riprap shall be field stone or uneven quarry stone of approximately rectangular shape. The stone shall be hard and angular. Individual stone shall have a specific gravity of at least 2.5. The stone will not disintegrate upon exposure to water or weathering. The rock shall conform to the grading limits given in the Cal-Trans Standard Specification, Section 72, Slope Protection.

Filter or Bedding - A filter or bedding layer shall be used under the riprap to prevent soil movement into and through the riprap. A filter shall be used when either of the following conditions exist:

1) Riprap is not well graded down to the 1 inch size particle.

2) Soil layer below riprap is sand-sized or finer with a plasticity index, PI, less than 10.

3) Excessive ground water or seepage from the banks.

Methods and Materials:
Filter or Bedding Continued

The filter shall be a layer of plastic filter cloth or properly graded layer of sand, gravel and stone. The plastic filter cloth shall be woven of polypropylene monofilament yarns, or equal cloth, manufactured expressly for this use. Aggregate filter shall conform to the following criteria:

$$\frac{\text{d15 riprap}}{\text{d85 filter}} \leq 5 \text{ and } \frac{\text{d15 filter}}{\text{d85 base}} \leq 5$$

d15 = size of particle which 15% is finer by weight

d85 = size of particle which 85% is finer by weight

base = soil under filter

Placement - Subgrade for riprap or filter shall be prepared to the lines and grades shown. Fills shall be compacted to the density of adjacent undisturbed material.

Stone for filter or riprap may be placed to the required thickness and limits by equipment or hand. Placement of riprap or filter shall be in one full operation to the full course thickness. Avoid displacement of underlying materials.

If a filter cloth is to be used, riprap that is 12 inches or larger shall not be dumped directly onto the cloth. A 4 inch minimum thickness of gravel shall be placed on the cloth prior to placement of the riprap. Any rips or holes in the cloth shall be repaired by placing another piece of cloth over the tear or hole and overlapping the ends of cloth a minimum of 1 foot.

Operation and Maintenance: Inspect riprap periodically, especially after heavy storms. Note loss or displacement of riprap and replace as necessary. Check for sediment buildup in riprap, indicating a tear in filter, and make all necessary repairs.

Appendix II.E-1

DESIGN PROCEDURE FOR RIPRAP-LINED CHANNELS

This design of riprap-lined channels is from the National Cooperative Highway Research Program Report No. 108, entitled "Tentative Design Procedure for Riprap-Lined Channels". It is based on the tractive force method and covers the design of riprap in two basic channel shapes, trapezoidal and triangular.

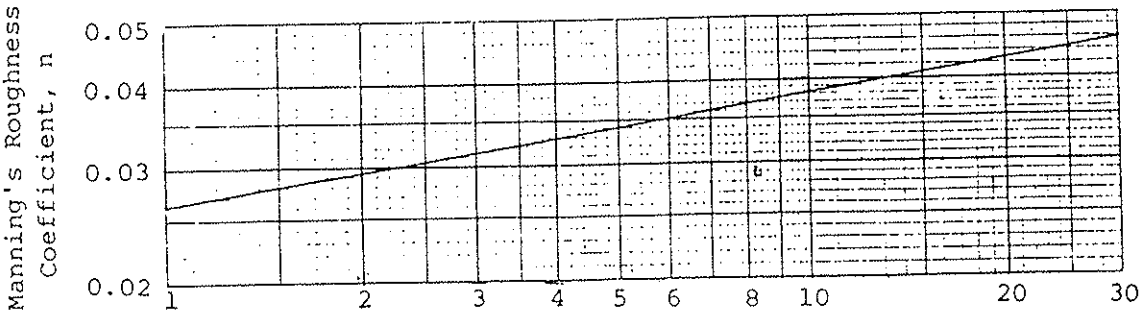
> NOTE: This procedure is for the uniform flow in channels and is not to be used for design of riprap de-energizing devices immediately downstream from such high velocity devices as pipes and culverts. See the Standard and Specification for Storm Drain Outlet Protection.

The method in Report No. 108 (design procedure beginning on pg. 18) gives a simple and direct solution to the design of trapezoidal channels including channel carrying capacity, channel geometry and the riprap lining. The publication is a very good reference and design aid.

The procedure presented in this appendix is based on the assumption that the channel is already designed and the remaining problem is to determine the riprap size that would be stable in the channel. The designer would first determine the channel dimensions by the use of Manning's equation. The n value for use in Manning's equation is estimated by estimating a riprap size and then determining the corresponding n value for the riprapped channel from Curve 1, below.

Curve 1 - Manning's "n" for Riprap-Lined Channels

$$n = 0.0395\ (d_{50})^{1/6}$$



When the channel dimensions are known the riprap can be designed (or an already completed design may be checked) as follows:

Trapezoidal Channels

1. Calculate the b/d ratio and enter curve 2 to find the P/R ratio.

2. Enter curve 3 with S_b, Q and P/R to find median riprap diameter, d_{50}, for straight channels.

3. Enter curve 1 to find the actual n value corresponding to the d_{50} from Step 2. If the estimated and actual n values are not in reasonable agreement another trial must be made.

4. For channels with bends, calculate the ration B_s/R_o, where B_s is the channel surface width and R_o is the radius of the bend. Enter curve 4 and find the bend factor, F_B. Multiply the d_{50} size to be used in bends. If the d_{50} for the bend is less than 1.1 times the d_{50} for the straight channel, then the size for straight channel may be used in the bend, otherwise the larger stone size calculated for the bend shall be used. The riprap shall extend across the full channel section and shall extend upstream and downstream from the end of the curve a distance equal to five times the bottom width.

5. Enter curve 5 to determine maximum stable side slope of riprap surface.

Triangular Channels

1. Enter curve 3A with S_b, Q and Z and find the median riprap diameter, d_{50}, for straight channels.

2. Enter curve 1 to find the actual n value. If the estimated and actual n values are not in reasonable agreement another trial must be made.

3. For channels with bends, see Step 4 under Trapezoidal channels.

The riprap size to be specified on the plans shall be the maximum stone size in the mixture which shall be 1.5 times the d_{50}. The thickness of the riprap layer is 1.5 times the maximum stone size, but not less than six inches. Freeboard shall be added to the channel depth and shall be not less than 0.2 times the depth of flow or 0.3 feet whichever is greater.

Example:

Given:

Trapezoidal channel

Q = 100 cfs
S = 0.01 ft/ft
Side slopes = 2.5:1
Mean bend radius, R_o = 25'
n = 0.33 (estimated and used to design the channel to find that b = 6' and d = 1.8')
Type of rock available is crushed stone.

Solution:

Straight channel reach

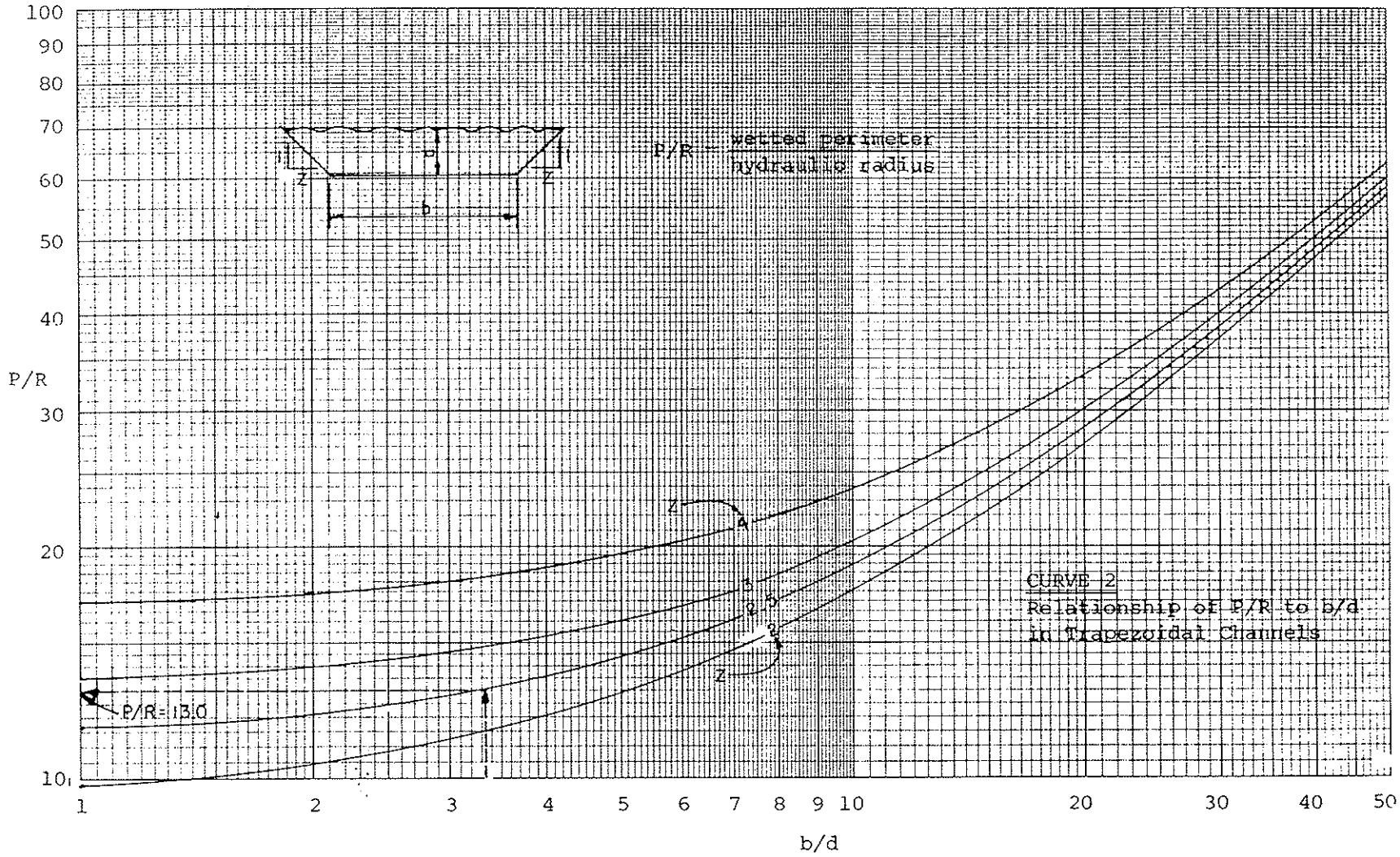
b/d = 6/1.8 = 3.33
from curve 2, P/R = 13.0
from curve 3, d_{50} = 3.4"
from curve 1, n (actual) = 0.032, which is reasonably close to the estimated n of 0.033.
Maximum riprap size = 1.5 x 5.1 = 7.7"
Riprap thickness = 1.5 x 5.1 = 7.7"
Use 5" as maximum riprap size and 8" as riprap layer thickness.

Channel bend

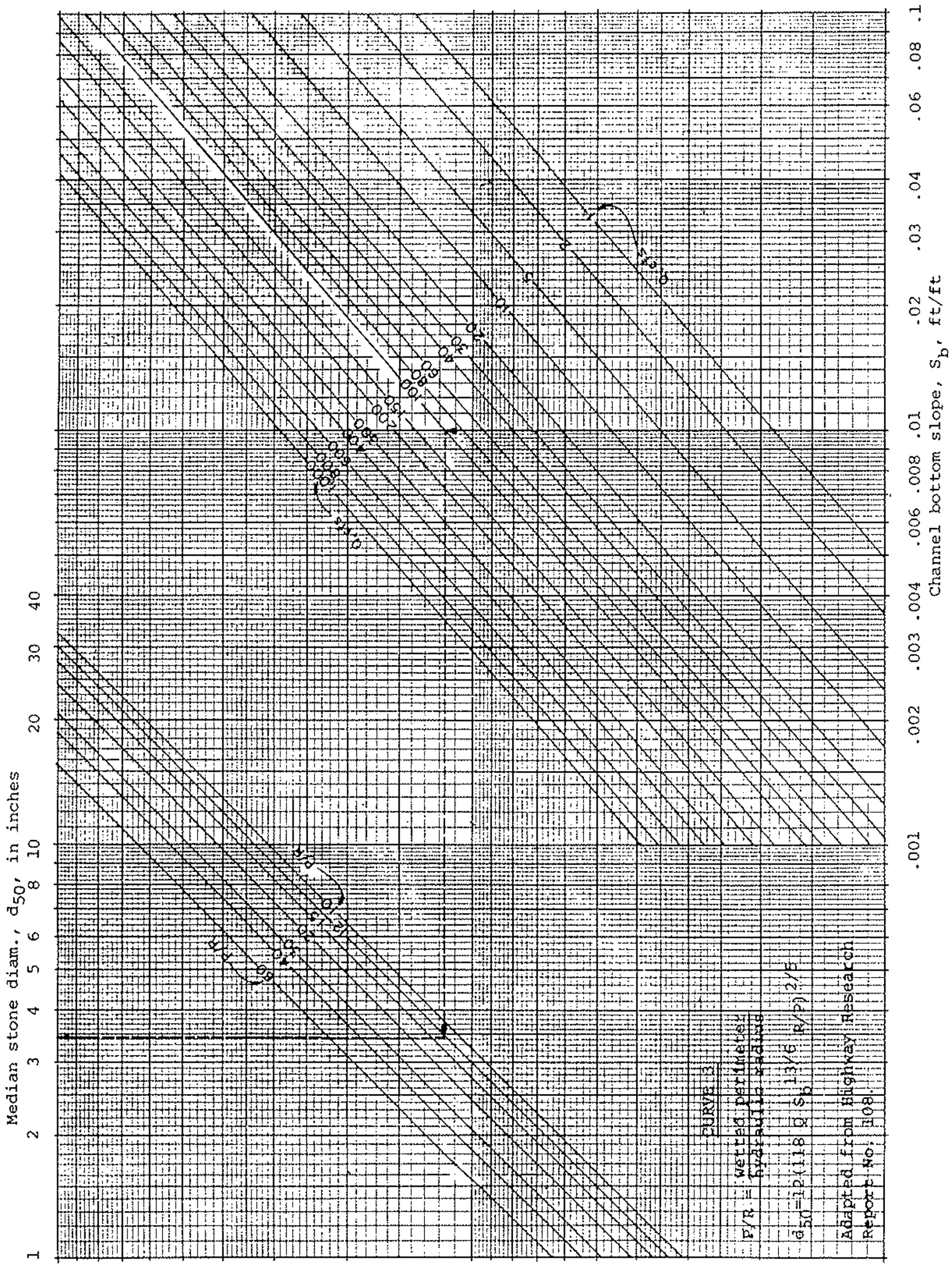
B_s = b + 2zd = 6 + (2) (2.5) (1.8) = 15'
B_s/R_o = 12/25 = 0.60
from curve 4, F_B = 1.33>1.1, therefore the bend factor must be used.
Riprap size in bend, d_{50} = 3.4 x 1.33 = 4.52"
Max. riprap size in bend = 4.52 x 1.5 = 6.78"
Riprap thickness = 10.2"
Use 7" for max. riprap size and 10" for riprap layer thickness.
The heavier riprap for the bend shall extend upstream and downstream from the ends of the bend a distance of (5) (6) = 30 feet.
From curve 5, it can be found that the riprap for d_{50} = 3.4" and 4.52" will both be stable on a 2.5:1 side slope.

Freeboard = (0.2) (1,8) = .36' but not less than 0.3'
Therefore, minimum freeboard is 0.36'. Use 0.4'

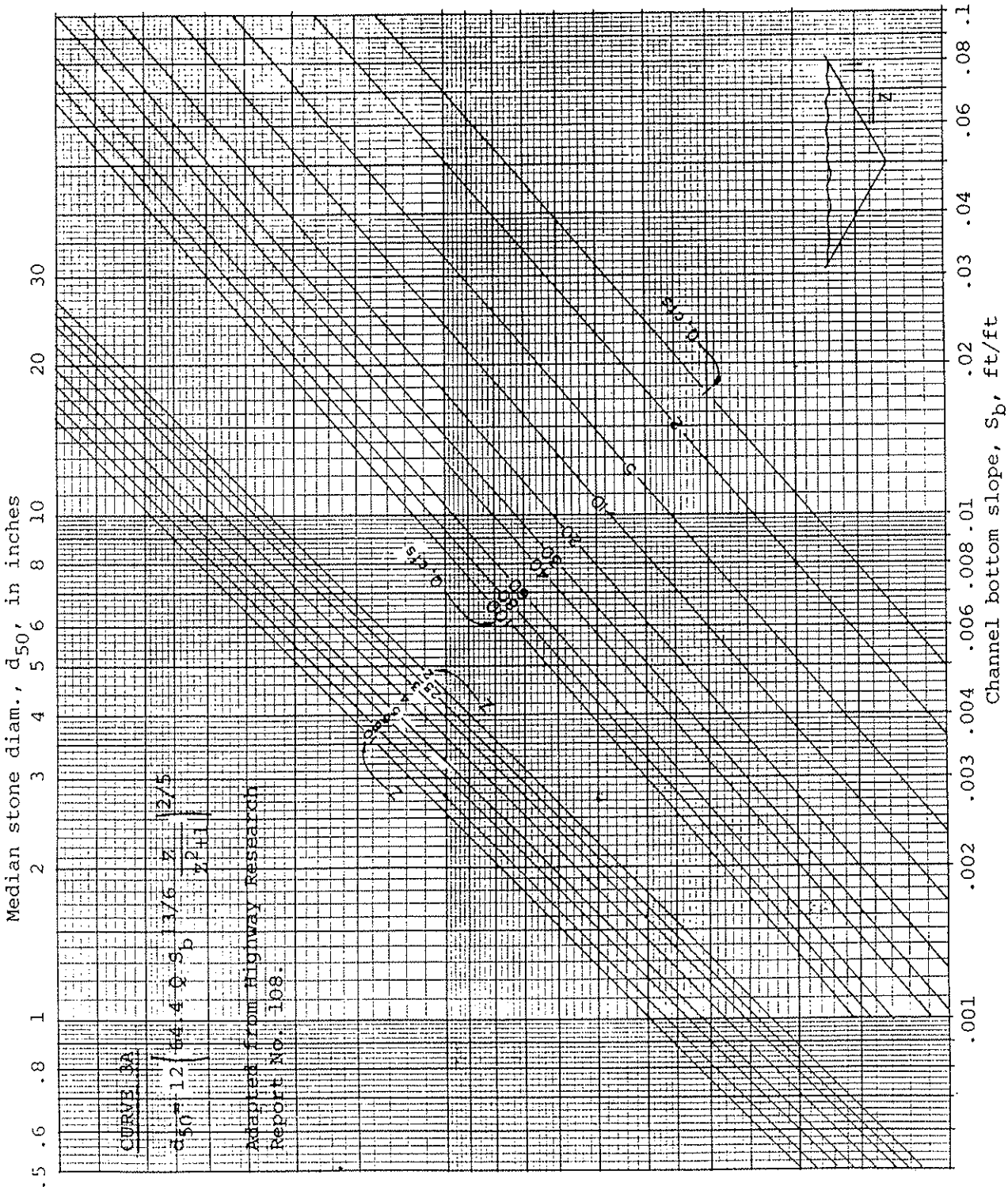
P/R FOR TRAPEZOIDAL CHANNELS



MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRAPEZOIDAL CHANNELS



MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRIANGULAR CHANNELS



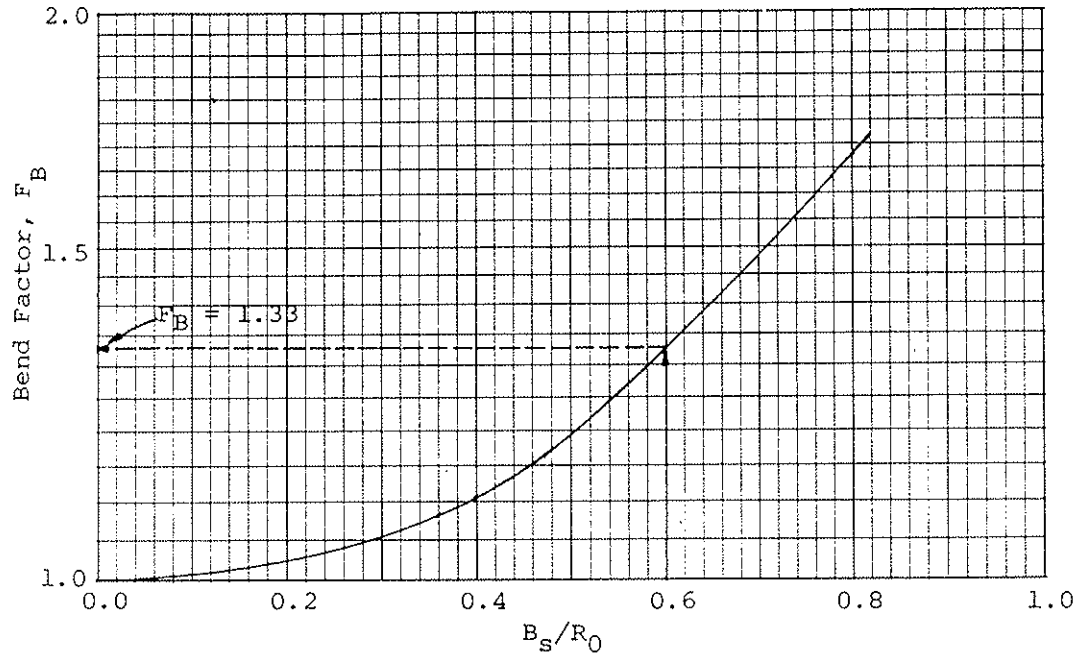
CURVE 4 - RIPRAP SIZE CORRECTION FACTOR FOR FLOW IN CHANNEL BENDS

d_{50}(for bend) = d_{50}(for straight) X F_B

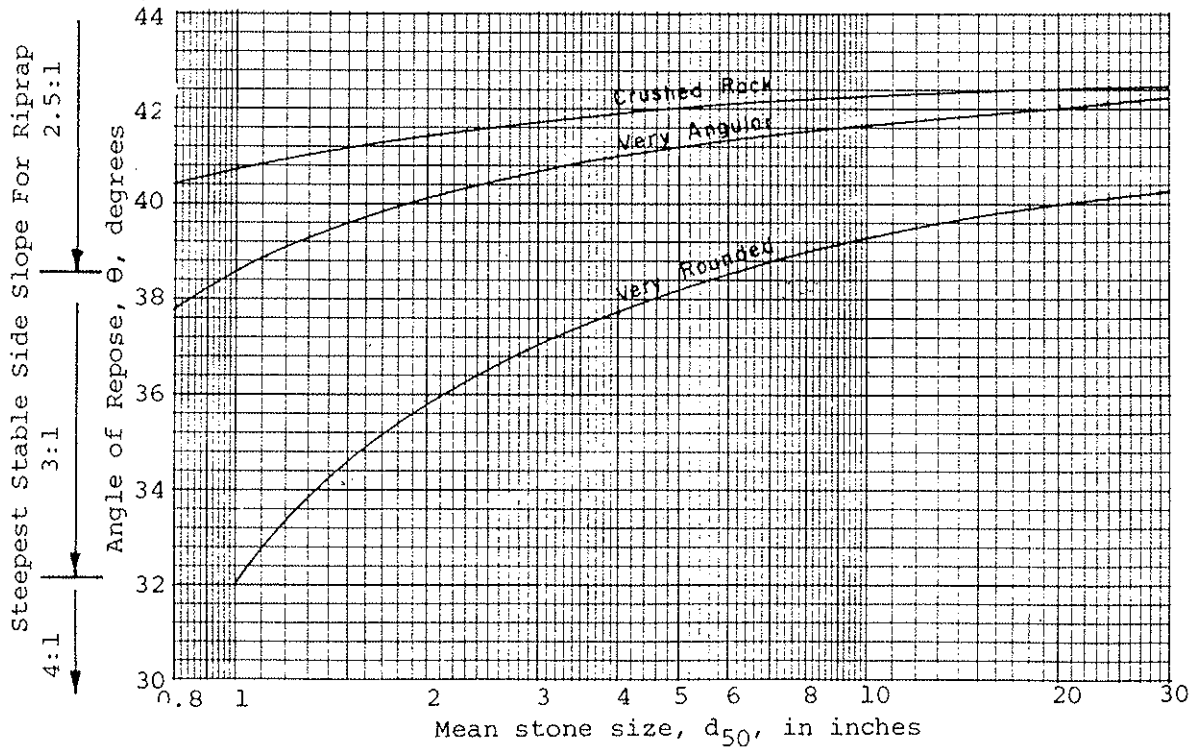
B_s = channel surface width

R_o = mean radius of bend

Adapted from Highway Research Report No. 108.



CURVE 5 - MAXIMUM RIPRAP SIDE SLOPE WITH RESPECT TO RIPRAP SIZE



II.F

SUBSURFACE DRAIN

Definition: A perforated conduit such as corrugated plastic tubing or corrugated metal pipe, installed beneath the ground surface which intercepts, collects and/or conveys drainage.

Purpose: The purpose of a subsurface drain is to:

1) Improve the soil environment by regulating the water table and groundwater flow or;

2) Intercept and prevent groundwater movement into undesirable areas and to handle base flow or;

3) Relieve artesian pressures or;

4) Remove surface run-off or;

5) Provide internal drainage of slopes, thereby improving stability and reducing erosion or;

6) Provide internal drainage behind structures or;

7) Replace existing subsurface drains that are not operating or;

8) Provide subsurface drainage for dry storm water management or;

9) Improve dewatering of sediment in sediment basins.

Applicability: Subsurface drains are used to lower or control groundwater or surface run-off. Subsurface drains do not include storm drainage systems or foundation drains.

Planning Criteria: The soil shall have sufficient depth and permeability to permit installation of an effective system. An outlet for the subsurface drain shall be available with the capacity to handle the quantity of water discharged without causing erosion above or below the point of discharge.

Capacity - Determine drain capacity by making flow measurements at the site or estimate as follows:

1) Uniform subsurface drainage system through systematic pattern of drains.

$$Q_{area} = 0.042 \text{ cfs/acre}$$
$$= 1 \text{ inch drained/24 hours}$$

Planning Criteria:
Capacity Continued

2) Random subsurface drainage system, minimum flows.

Qpipe = 1.5 cfs/1000 LF Pipe

For subsurface drains on sloping land, increase rate as follows:

Slope	Increase to Inflow Rate
2 - 5%	10%
5 -12%	20%
over 12%	30%

3) If surface water is to enter the subsurface drainage system, additional capacity to handle the increase to subsurface water must be provided. Refer to Appendix II.F-1 for subsurface drain sample calculations.

Conduit Size - The size shall be computed using Manning's formula assuming the conduit flowing partly full. The minimum pipe size shall be 4 inches.

Depth - Minimum coverage shall be 24 inches (reduction in minimum cover may be allowed on a case by case basis).

Spacing - Refer to Table II.F-1.

Table II.F-1

Spacing of Drains

Soil Classes	Soil Compaction			Drain Spacing (feet)			
	Percent Sand	Percent Silt	Percent Clay	3 Ft. Deep	4 Ft. Deep	5 Ft. Deep	6 Ft. Deep
Clean Sand	80-100	0-20	0-20	110-150	150-200		
Sandy Loam	50-80	0-50	0-20	50-100	100-150		
Loam	30-50	30-50	0-20	30-60	40-80	50-100	60-120
Clay Loam	20-50	20-50	20-30	20-40	25-50	30-60	40-80
Sandy Clay	50-70	0-20	30-50	15-30	20-40	25-50	30-60
Silty Clay	0-20	50-70	30-50	10-25	15-30	20-40	25-50
Clay	0-50	0-50	30-100	15 (max.)	20 (max.)	25 (max.)	40 (max.)

Note: Depth is measured to invert of pipe.

Planning Criteria: Continued

Velocity - The minimum velocity shall be 2 feet per second. The maximum velocity without protection shall be 3.5 feet per second for SW, SM, and ML soils, and 5 feet per second for all others. Protection measures shall include one or more of the following:

1) Enclose drain pipe in filter fabric material.

2) Use properly graded sand and gravel filter, or envelope material.

3) Use nonperforated pipe.

Grade - Minimum grade shall be 0.10 percent.

Methods and Materials:

Drain Tubing - Pipe shall be perforated, closed joint asbestos-cement, concrete, corrugated metal, corrugated polyethylene or polyvinyl chloride. Perforations shall be either circular or slots about equally spaced along the length and circumference of the conduit in not less than three rows. Circular perforations shall not exceed 3/16 inch in diameter, and slots shall not be more than 1/8 inch wide and 1-1/4 inch long for conduits less than 6 inches diameter, 1-1/2 inches long for conduits less than 10 inches diameter, and 1-3/4 inches long for 10 inches and larger. The total water inlet area shall be at least 1.0 square inches per foot of conduit length. Pipe under roadways shall be watertight.

Load - Based on trench and bedding conditions; use a safety factor of 1.5 to compute maximum depth of cover.

Bedding and Envelope Material - A sand-gravel envelope or filter shall be used to improve the flow of ground water and prevent the movement of soil materials into the conduit. A custom designed filter is needed for dispersives clays, low plasticity silts or fine sands (ML and SM with PI less than 7). For other stable soils, the gradation given in Table II.F-1 may be used. The specified filter or envelope material must completely encase the conduit so that all openings are covered with at least 3 inches of filter material. Envelope material shall be placed to the uppermost seepage strata. Behind bulkheads and retaining walls, envelope material shall be placed within 12 inches from the top of the structure.

Methods and Materials:
Bedding and Envelope Material Continued

Envelope material shall be a durable, clean mixture of sand and gravel, free of deleterious organic matter that will not cause sediment accumulation in the drain pipe. Filter cloth may be used to line the top of the sand-gravel envelope.

Table II.F-2

Gradation of Crushed Stone

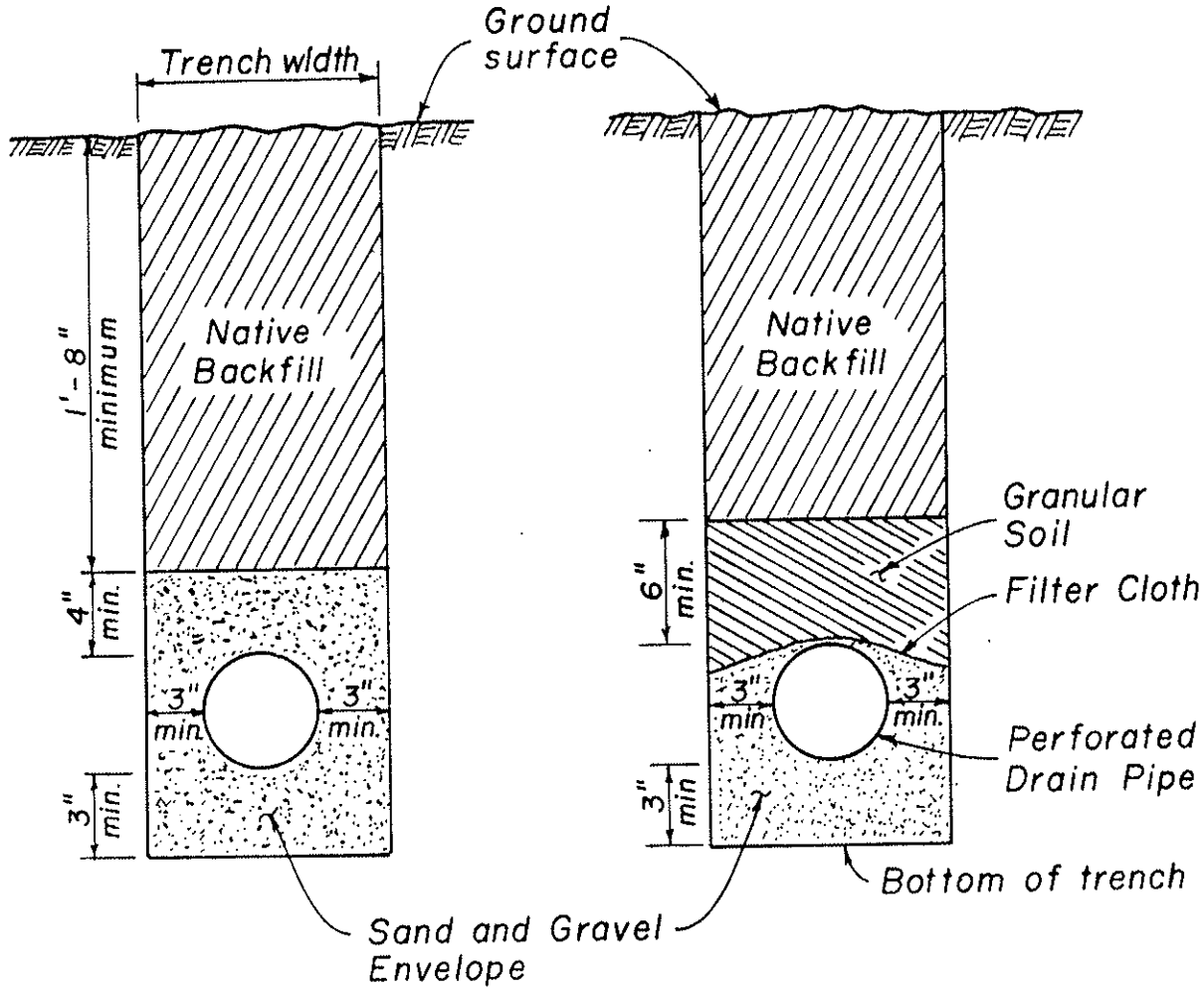
Sieve Size	Percent Passing by Weight
1"	100
3/8"	40-100
No. 4	25-40
No. 50	0-7
No. 200	0-3

Unstable soils shall be stabilized by over excavation and placement of additional envelope material.

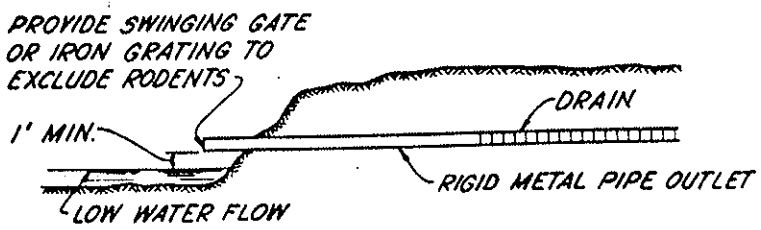
Outlet Pipe - A continuous 10 foot section of corrugated metal pipe, cast iron or steel pipe without perforations shall extend 3 feet from the ditch and shall be above the normal low flow elevation of the outlet ditch. No envelope material shall be used for the outlet pipe. The outlet ditch shall be protected from erosion by the appropriate applicable outlet structure. A suitable rodent guard shall be placed over the outlet.

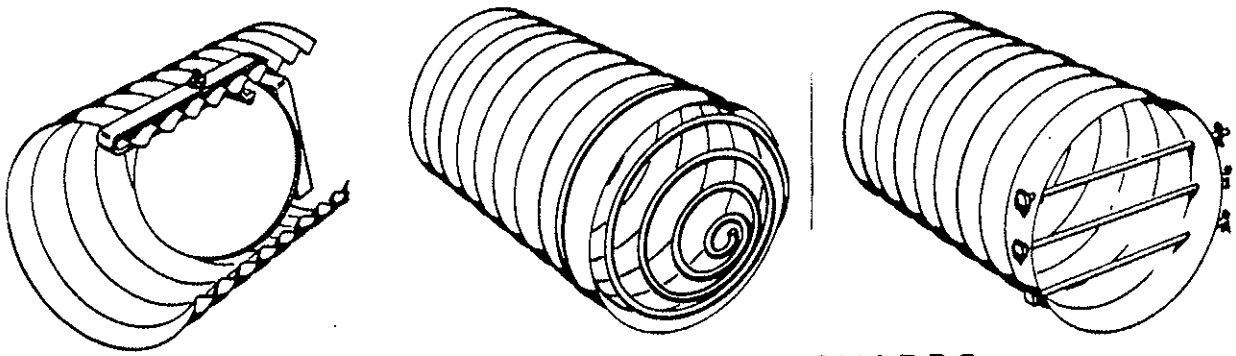
Installation - All pipes shall be placed to uniform line and grade. The pipe shall be laid with the perforations down. Pipe connections shall be closed joint and made according to the manufacturer's specifications.

Bedding and Backfill - Pipe bedding as specified herein shall be as shown on the plan. Native backfill, free of large boulders and/or other sharp objects, may be place in lifts, not to exceed 8 inches. Relative compaction shall be a minimum of 85% in native areas and 95% in roadways.



TYPICAL TRENCH DETAILS





OUTLET PIPE RODENT GUARDS

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Appendix II.F-1 for Subsurface Drains

DETERMINING SUBSURFACE DRAIN SIZES

Subsurface drains ordinarily are not designed to flow under pressure and the hydraulic gradient is considered to be parallel with the grade line. The flow in the subsurface drain is considered to be open-channel flow. The size of subsurface drain required for a give capacity is dependent on the hydraulic gradient and the roughness coefficient –"n" value – of the subsurface drain.

The "n" values for the different materials is as follows:

Description of Pipe or Tubing	"n" value
Plastic, smooth	0.011
Asbestos Cement	0.013
Bituminized Fiber	0.013
Concrete	0.015
Corrugated Plastic	0.015
Corrugated Metal	0.025

The Standard and Specifications for Subsurface Drain states that for a systematic pattern of drains, a drainage coefficient is equal to 0.042 cfs per acre of area to be drained.

Where subsurface drainage is to be by a random system, a minimum inflow rate of 1.5 cfs per 1,000 feet of line shall be used to determine the required capacity.

If surface water is allowed to enter the system, additional capacity must be provided for and the minimum design velocity shall be 2 feet per second.

The charts are set up for different "n" values. The abscissa of the chart is the hydraulic gradient in feet per foot and the ordinate is the capacity in cubic feet per second. On the chart are plotted the full flow capacity for different pipe diameters and a velocity line for 2 feet per second. The charts are used by going to the next higher pipe diameter line from the point of intersection of the hydraulic gradient and the capacity for the required pipe size since the design is for open-channel flow. Any point to the right or below the 2 feet per second line will have a velocity of less than 2 feet per second.

Examples using the charts are as follows:

Example 1

A random subsurface drain is to be installed. This drain will be 700 feet in length and will be installed at a grade of 0.20%. Bituminized fiber pipe will be used. Determine the size and capacity of the drain.

Solution

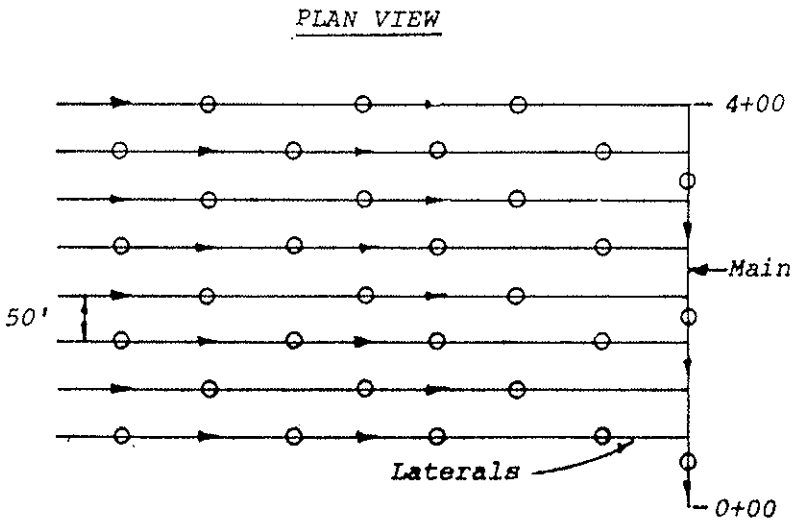
From the standard, capacity required = 1.5 cfs per 1000 feet of length.

Capacity = $\frac{700'}{1000'}$ x 1.5 cfs per 1000' = 1.05 cfs

Using Subsurface Drain Capacity Chart for n = 0.013,
capacity required = 1.05 cfs, and a gradient of 0.002 ft./ft.,
the size required is 12' and the actual capacity will be 1.58 cfs.

Example 2

A systematic pattern of subsurface drains is to be installed. There will be eight (8) laterals installed that will be spaced at fifty (50) feet center-to-center and each lateral will be 700 feet in length. The grade of the laterals will be 0.10%. The main will pick up these laterals and will be 400 feet in length. The grade of the main will be 0.10%. Determine the size and capacity of the laterals and the main at the outlet if corrugated plastic tubing is used.



Solution

a. Size and capacity of laterals.

Each lateral will drain for a distance of 25 feet on each side of the line since the spacing is at 50 feet center-to-center. Therefore, each lateral will drain.

$\frac{600' \text{ (length)} \times 50' \text{ (width)}}{43{,}560}$ = 0.69 acre

Capacity required = 0.69 acre x 0.042 cfs per acre = 0.029 cfs.
Using Subsurface Drain Capacity Chart for n = 0.015,
capacity required = 0.029 cfs, and a gradient of 0.001 ft./ft.,
the size required is 4" and the actual capacity will be 0.052 cfs.
(Note: Minimum size allowed is 4")

Solution

b. Size and capacity of the main at the outlet.

For the first 25 feet of the main from the outlet, the main will drain for a distance of 25 feet on each side. For the remaining 375 feet, the main will drain only 25 feet on the one side since the other side is included in the drainage area for the laterals. The main will also drain the laterals. Therefore:

Drainage area from laterals:

= 8 x 0.69 acre = 5.52 acres

Drainage area from main:

$$= \frac{25' \text{ (length)} \times 50' \text{ (width)}}{43{,}560} + \frac{375' \text{ (length)} \times 25' \text{ (width)}}{43{,}560} = 0.24 \text{ acre}$$

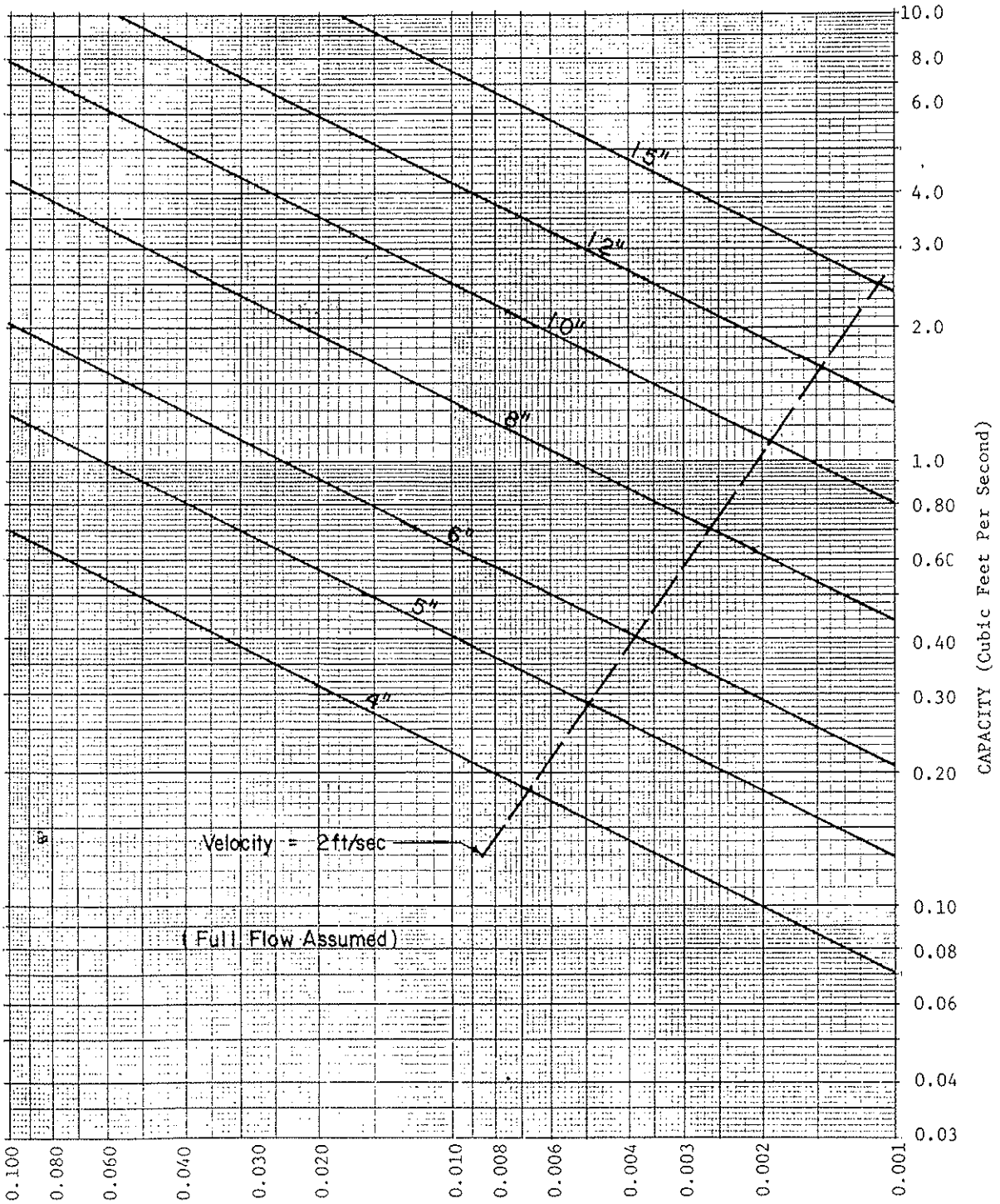
Total = 5.76 acres

Capacity required:

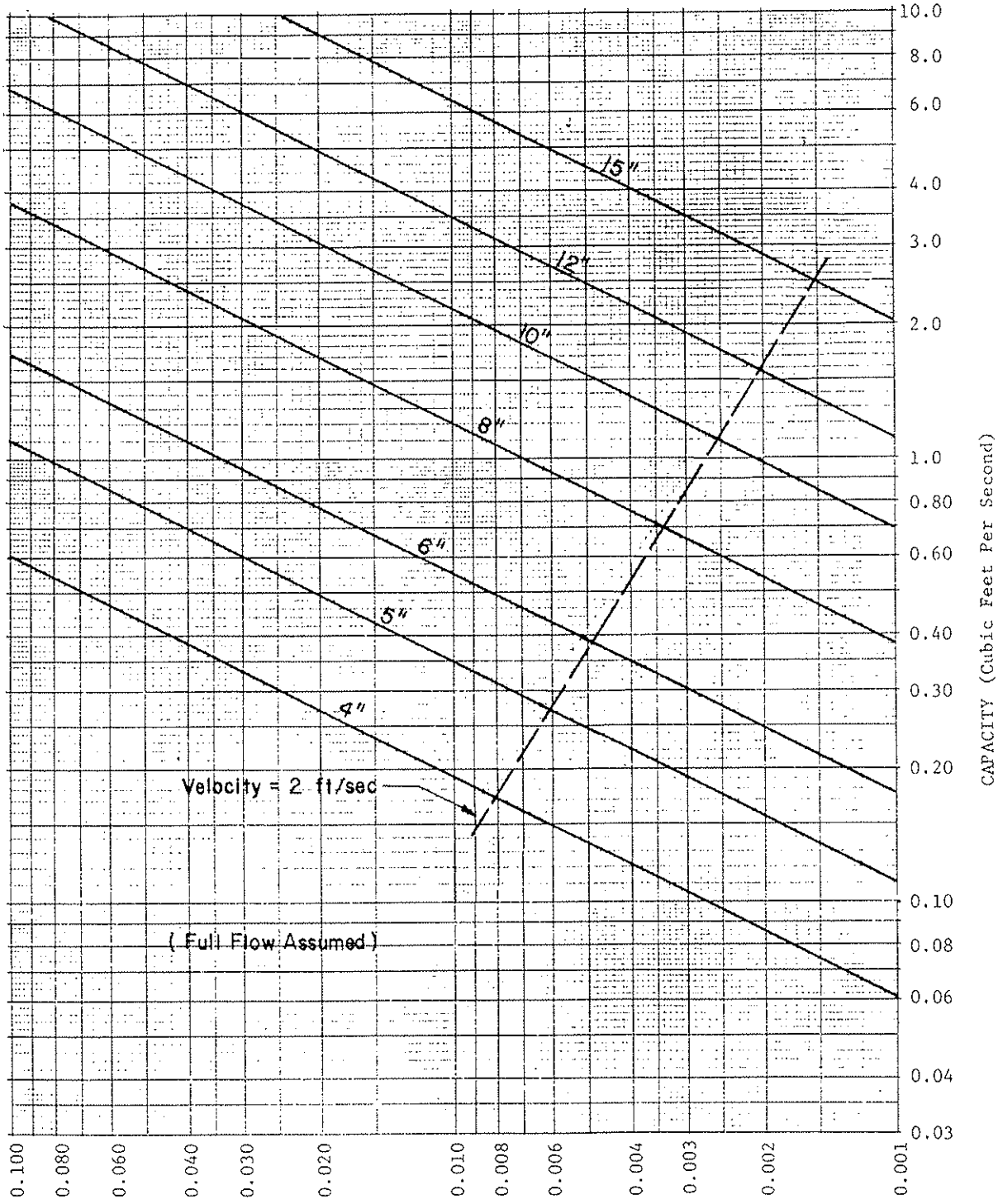
= 5.76 acres x 0.042 cfs/acre = 0.24 cfs.

Using Subsurface Drain Capacity Chart for n = 0.015,
capacity required = 0.24 cfs, and a gradient of 0.001 ft./ft.,
the size required at the outlet is 8" and the actual capacity
will be 0.33 cfs.

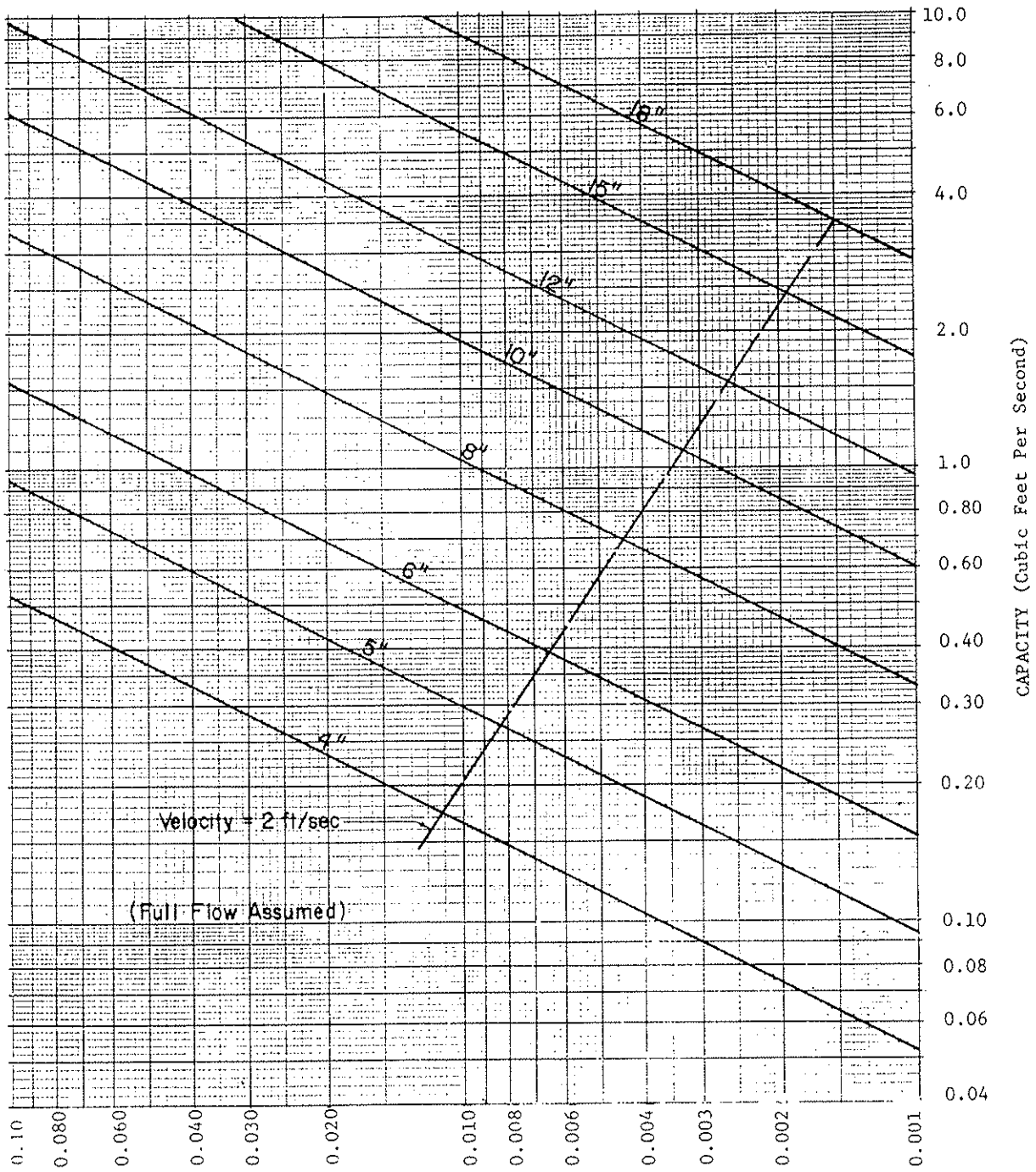
SUBSURFACE DRAIN CAPACITY CHART - n = 0.011 (14)



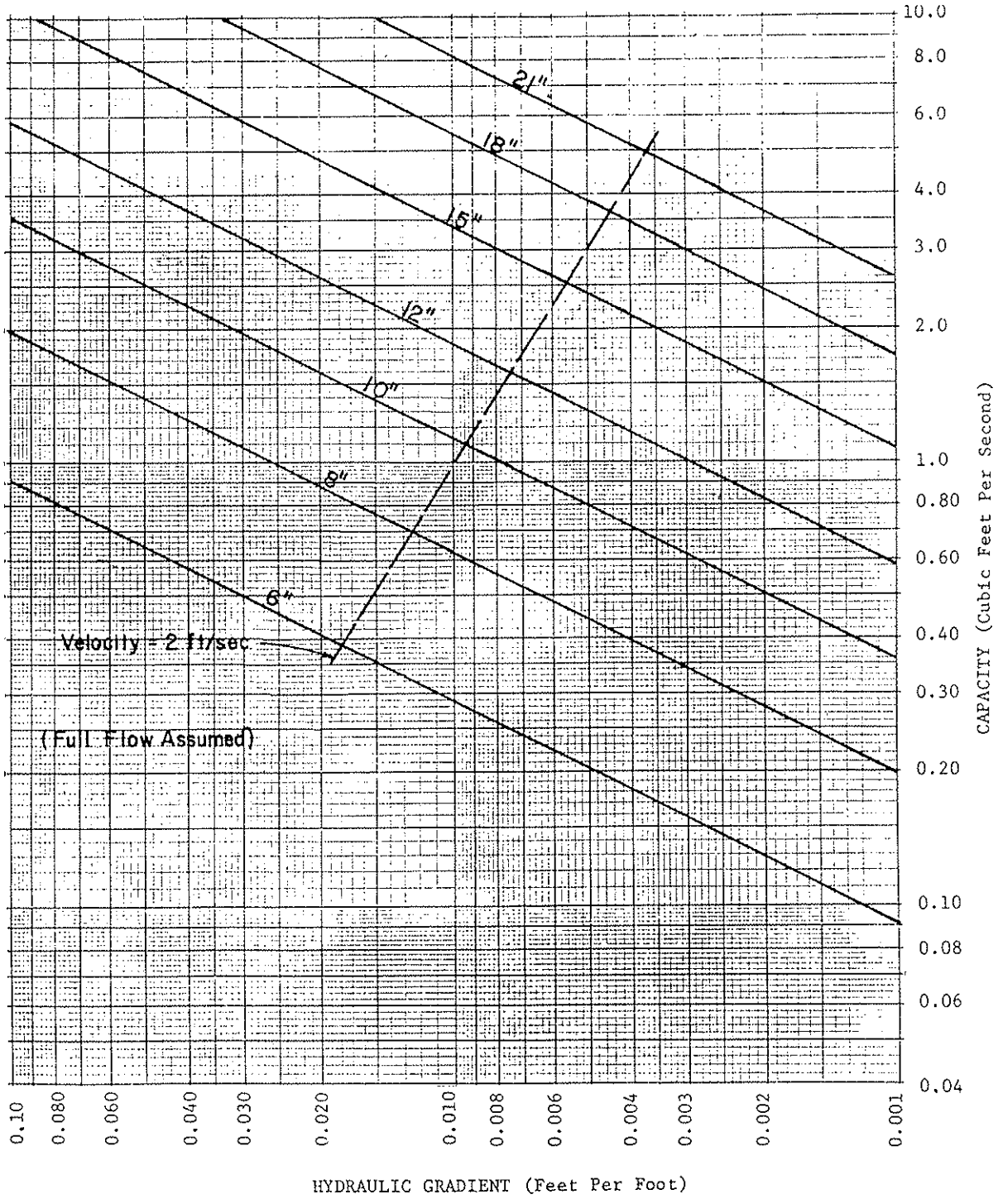
SUBSURFACE DRAIN CAPACITY CHART - n = 0.013



SUBSURFACE DRAIN CAPACITY CHART - n = 0.015



SUBSURFACE DRAIN CAPACITY CHART - n = 0.025



II.G

INFILTRATION TRENCH

Definition: A shallow, gravel filled trench located at the drip line of roofs, or adjacent to paved driveways, parking lots or other impervious surfaces.

Purpose: The purpose of the infiltration trench is to percolate run-off from impervious surfaces to compensate for increased peak discharges and to prevent erosion which would be caused by such run-off.

Applicability: Applicable to most sites with suitable soils and good subsurface drainage conditions. Run-off from parking lots and other areas that contain motor oil and other pollutants must be treated to prevent sealing of the trench soils.

Planning Criteria: Only clean water shall enter the trench to insure that oils, grease, and sediments do not seal the trench walls and reduce the effectiveness of the practice. At parking lots, and similar areas, vegetative filter strips or grease traps shall be installed to remove objectionable materials before the run-off reaches the infiltration trench.

Capacity - The minimum design capacity shall be adequate to contain the run-off from a 1-hour, 10-year return interval storm, or as specified by the permit issuing authority.

Soils - Soils at the infiltration trench site must be well drained.

Water Table - Trenches shall be located above the seasonally high water table.

Overflow - Emergency overflow outlets must be provided.

Storage - The minimum storage capacity of the infiltration trench is dependent upon the soil type, soil permeability, and the area of impervious surface.

Planning Criteria: Continued

Trench Requirements - Use the following relationship as a guideline for sizing the trenches:

$$L = \frac{A \times Q/12}{(W \times P) + .67\ (D \times P) + .33\ (D \times W)}$$

Where: A = area of impervious surface contributing run-off to infiltration trench (square feet)
L = length of the trench (feet)
W = width of the trench, usually 1.5 to 3 ft. (feet)
D = depth of the trench (feet)
P = percolation rate of the soil in which the trench is placed (ft./hr.)
Q = 1-hour, 10-year return interval storm (inches)

Where a vegetative filter strip is used the SCS run-off equation in TR-55 may be used to account for the losses due to the filter.

Trench Grade - A nearly level trench is ideal. Trenches constructed on slopes greater than 15 percent shall have baffles or headers.

Trench Excavation - Excavate to line and grade as shown on the plans. Scarify all smooth trench walls. Remove excess sediment from trench bottom.

Backfill - Utilize backfill that meets the following gradation:

Table II.G-1

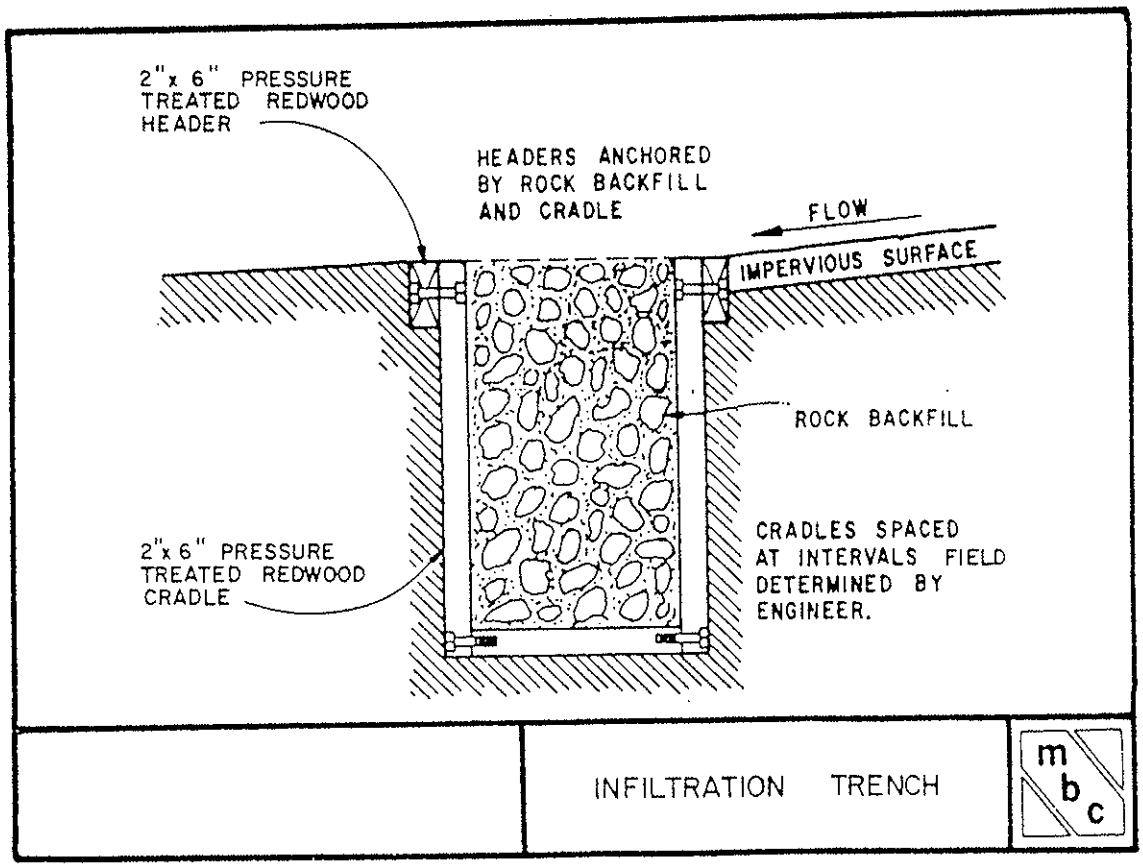
Gradation of Crushed Stone

Sieve Size	Percent Passing by Weight
1 1/2"	90-100
3/4"	45- 75
3/8"	35- 55
No. 4	30- 45
No. 8	23- 38
No. 50	0- 10
No. 200	0- 2

Planning Criteria: Continued

Trench Cradles - Trench cradles made from pressure treated redwood shall be utilized to ensure trench stability during normal operation and backfill removal. Cradles shall be placed flush with trench walls and bottom at locations determined in the field during trench construction.

Operation and Maintenance: Periodic inspections after storm periods. Removal and cleaning of backfill when trench overflows are caused by sediment buildup.



II.H

SLOPE TERRACING

Definition: A bench, terrace, or steps cut into a cut or fill slope to minimize the erosion potential of run-off originating on the slope.

Purpose: The purpose of slope terracing is to reduce the slope length of steep slopes, lengthen the overland flow path, and provide a more favorable site for plant establishment on difficult areas.

Applicability: Use on long or steep, disturbed or man-made slopes steeper than 5 horizontal to 1 vertical, and on cut or fill slopes greater than 15 feet vertical height, or when required by the soils or geotechnical engineering report, or as required by the permit issuing authority.

Planning Criteria: The type of terrace selected is dependent upon the soils and geologic formations. Benches or wide terraces should be established at 25 foot intervals for all cut or fill slopes exceeding 30 feet in height. Where only one bench is required it shall be at approximately mid-height. Suitable access shall be provided for cleaning and maintenance of the terrace drain.

In general, information necessary to prepare a slope benching plan shall include, but not be limited to, topographic features, classification of soils, geology of the site, evaluation of the stability of natural slopes and proposed cut and fill slopes, determination of storm run-off quantities, and recommendations regarding drainage and erosion control.

Methods and Materials:

1. **Benches** - A graded bench having a reverse slope of 1 foot or more and a minimum width of 8 feet. To assure proper drainage the minimum longitudinal grade of 2 percent, and a maximum of 12 percent is recommended.

   Length - 800 feet maximum.

   Capacity - The minimum design capacity of the terrace drain shall be adequate to carry the peak rate of run-off from a 10-year return interval storm, or as specified by the permit issuing authority.

   Velocity - The maximum channel velocity shall be nonerosive and shall not exceed the values given for Grassed Waterways and Lined Channel.

Methods and Materials:

1. **Benches** Continued

   Lining - Where seepage water would affect slope stability, a concrete lined channel shall be used.

2. **Steps** - Steps are applicable to rippable rock and are used to provide a planting base for vegetation and to increase moisture retention. They are 2 to 4 feet wide terraces cut at 2 to 4 foot vertical intervals. A level step grade is recommended, but terrace may be parallel to road if road grade is less than 2 percent. A diversion ditch must be provided at the toe of the slope.

3. **Serrated Slopes** - Serrations are the smallest form of terrace and consist of approximately 10 inch wide steps cut into soft rock with a special dozer wing blade. Weathered serrated slopes increase moisture, fertilizer and seed retention. Serrating should be provided on slopes with a gradient from 1 1/2:1 to 2:1.

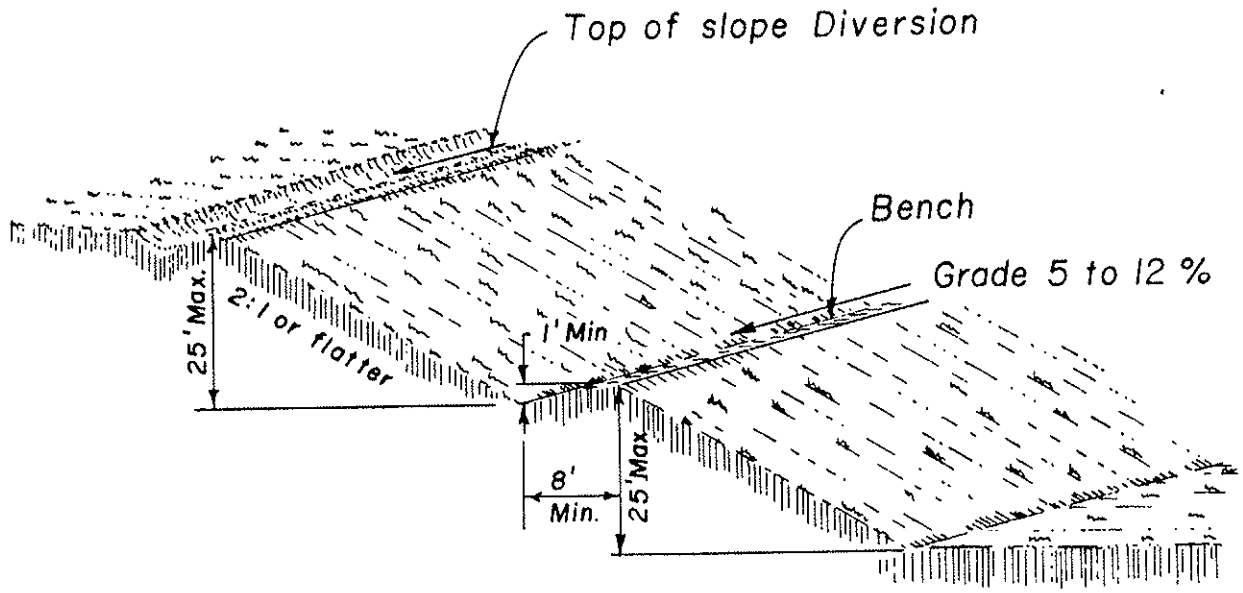
   Serrations should be horizontal, but may parallel to road if road grade is less than 2 percent. A diversion ditch must be provided at the toe of the slope.

4. **Subsurface Drainage** - Seeps or springs encountered during construction shall be handled with horizontal wells, or in accordance with the criteria for Subsurface Drains.

5. **Seeding and Mulching** - All graded or disturbed areas, including slopes, shall be protected during cleaning and construction with the appropriate temporary measures. All graded areas shall be permanently vegetated in accordance with the criteria for Vegetative Practices immediately following finished grading.

6. **Adjacent Property** - Slopes shall not be created so close to property lines as to endanger adjacent properties without adequately protecting such properties against erosion, slippage, settlement, or excessive run-off.

Operation and Maintenance: Periodic inspection during and after construction is required to ensure against erosion, sedimentation accumulation, and to verify adequacy of permanent vegetation. Check and repair lined channels as needed. Re-grade and seed as required.



BENCHED SLOPE

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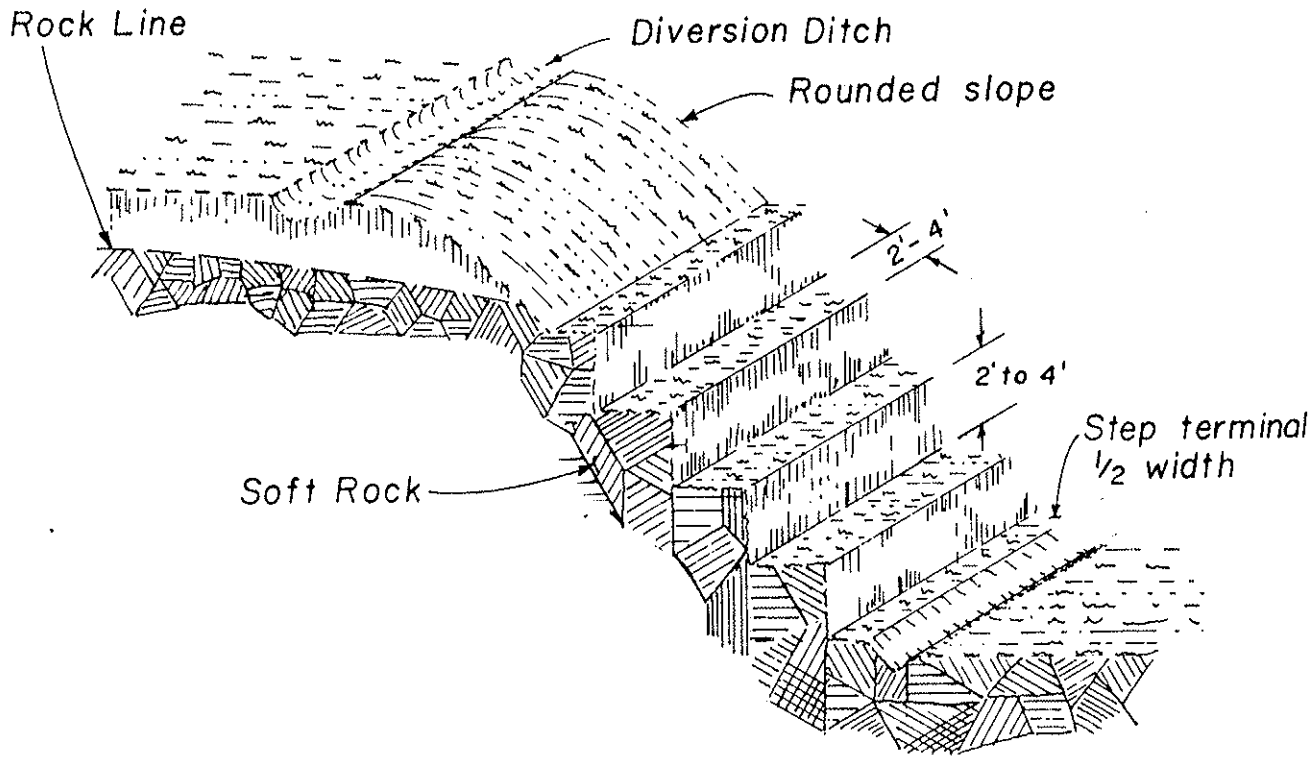

STEPPED SLOPE

No Scale

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II.I

ACCESS ROAD ROCK LINED DITCH

Definition: A roadside ditch having an erosion-resistant lining of stone with filter cloth or gravel bedding placed under the lining.

Purpose: To prevent erosion of the roadside ditch, provide drainage to the subgrade, and collect sheet flow run-off from paved areas.

Applicability: For private driveways, access roads and other low standard roads which do not require curbs and gutters. To be used where the grade of the road is greater than 5 percent or the anticipated flow velocity exceeds the allowable velocity. The typical details should not be used for slopes greater than 20 percent or where the spacing of crossroad culverts exceeds 300 feet.

Planning Criteria: A ditch, 6 inches deep by 4 feet wide, having a triangular section (see drawing) can be used for drainage areas up to 1/2 acre. Run-off and ditch size computations are needed when the drainage area is greater than 1/2 acre or the distance between cross road culverts exceeds 300 feet.

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 10-year return interval storm, or as specified by the permit issuing authority.

Methods and Materials:

Rock - Rock shall be sound and durable field stone or uneven quarry stone of angular shape with a blend of sizes. Semirounded river cobbles are not as good as quarry rock because of the tendency to roll out of place. Table II.I-1 may be used to estimate the rock size required from slope and design depth of flow.

Table II.I-1

Channel Slope (Percent)	Maximum Depth of Flow (ft)	Median Rock Size (Inches)
5	0.5	3
10	0.4	4
15	0.4	6
20	0.3	8

Methods and Materials: Continued

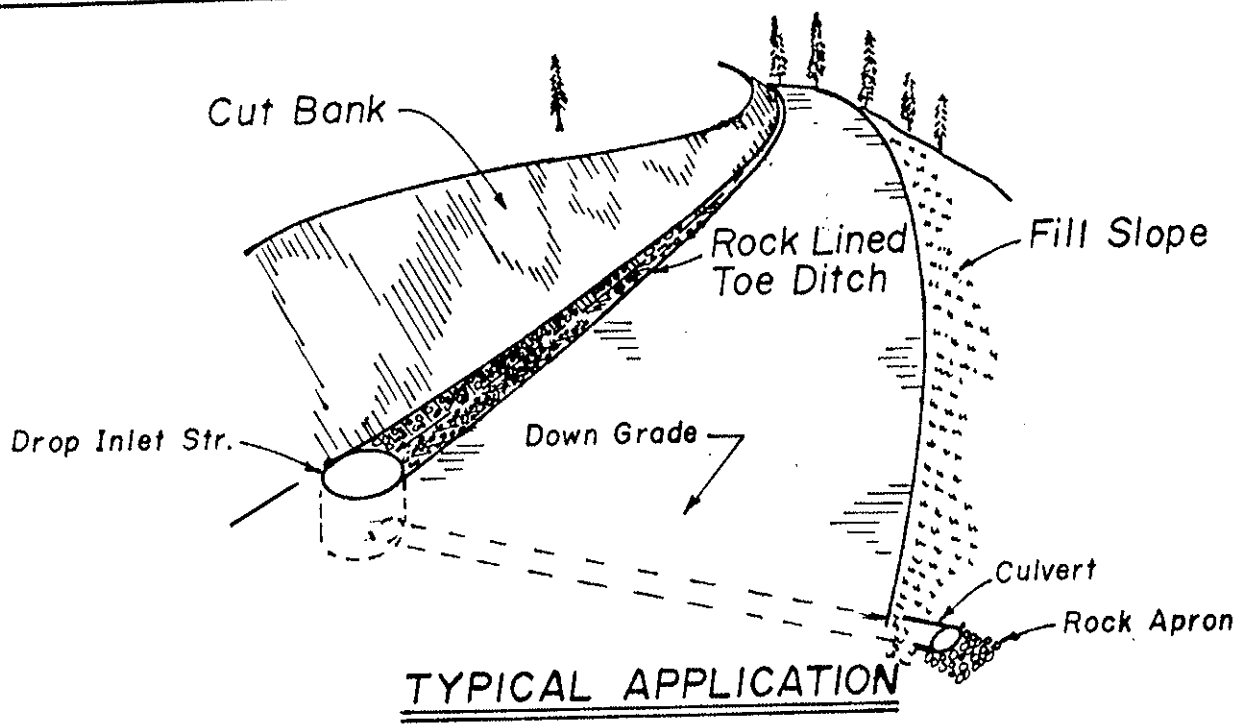
Filter or Bedding - A filter or bedding layer shall be used to prevent soil movement into or through the rock, which would result in the settling and failure of the lining.

Plastic filter cloth shall be black or grey, woven or non-woven polypropylene filter fabric, 8 ounces per square yard, and ultraviolet stabilized.

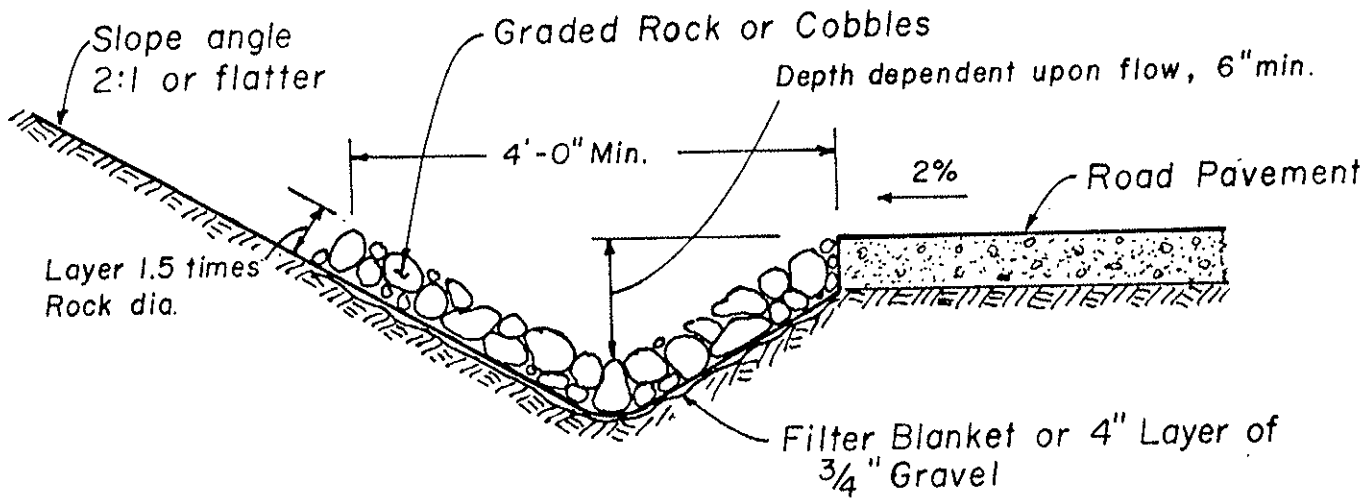
Bedding shall be a 4 inch layer of 3/4-inch crushed gravel.

Placement - Small ditches such as these usually require hand placement of the rock riprap. Larger rocks should be set in close contact with the spaces, and voids filled with smaller rocks and fragments.

Operation and Maintenance: Periodic inspections and repairs are recommended to assure proper operation of the ditch. Periodic mowing may be needed to control the growth of trees and shrubs which could obstruct the flow. Rock should be checked for displacement after large storms and any damaged sections repaired or replaced. Foreign debris and sediment, which reduce the ditch capacity, should also be removed.



TYPICAL APPLICATION



TYPICAL SECTION

no scale

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II.J

GRADE STABILIZATION STRUCTURE

(PIPE SLOPE DRAIN)

Definition: A permanent corrugated metal pipe or other rigid pipe conduit connected to a drainage inlet structure, placed to extend from the top of a slope to the bottom of a slope.

Purpose: The purpose of the pipe slope drain is to convey surface run-off safely down cut or fill slopes without causing erosion.

Applicability: Pipe slope drains are to be used where concentrated flows of surface run-off must be conveyed down a steep slope in order to prevent erosion. Not to be used for pond spillways or other sites where failure would damage buildings or other structures.

Planning Criteria: The maximum vertical drop for this practice is 35 feet. For steep slopes, when the slope of the pipe is equal to or greater than the critical slope, the inlet controls the flow. Thus, the capacity of the drain is a function of headwater depth and inlet geometry, and is entirely independent of the roughness, length, or slope of the pipe.

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm without ponding at the inlet, or as specified by the permit issuing authority.

Slopes - Pipe slopes shall be less than 70 percent of critical slope or more than 130 percent of critical slope at design flow.

Size - The size of the pipe shall be computed assuming the hydraulic grade line is 0.5 feet below the top of the grating. For sizing the inlet structure and grating, the maximum depth of ponding shall be 0.5 feet.

Methods and Materials: For drainage areas of 5 acres or less Table II.J-1 can be used to determine the size of the pipe in lieu of run-off and hydraulic computations.

Methods and Materials: Continued

Table II.J-1

Pipe/Tubing Diameter (inches)	Maximum Drainage Area (acres)
12	.5
18	1.5
21	2.5
24	3.5
30	5.0

Dike - The top of the earth dike directing flow to the entrance of the pipe slope drain shall be at least 12 inches higher than the inlet.

Outlet - The pipe slope drain shall outlet onto a grouted rock riprap basin and then to a stable water course. The riprap shall consist of 6 inch stone placed as shown on the standard drawing.

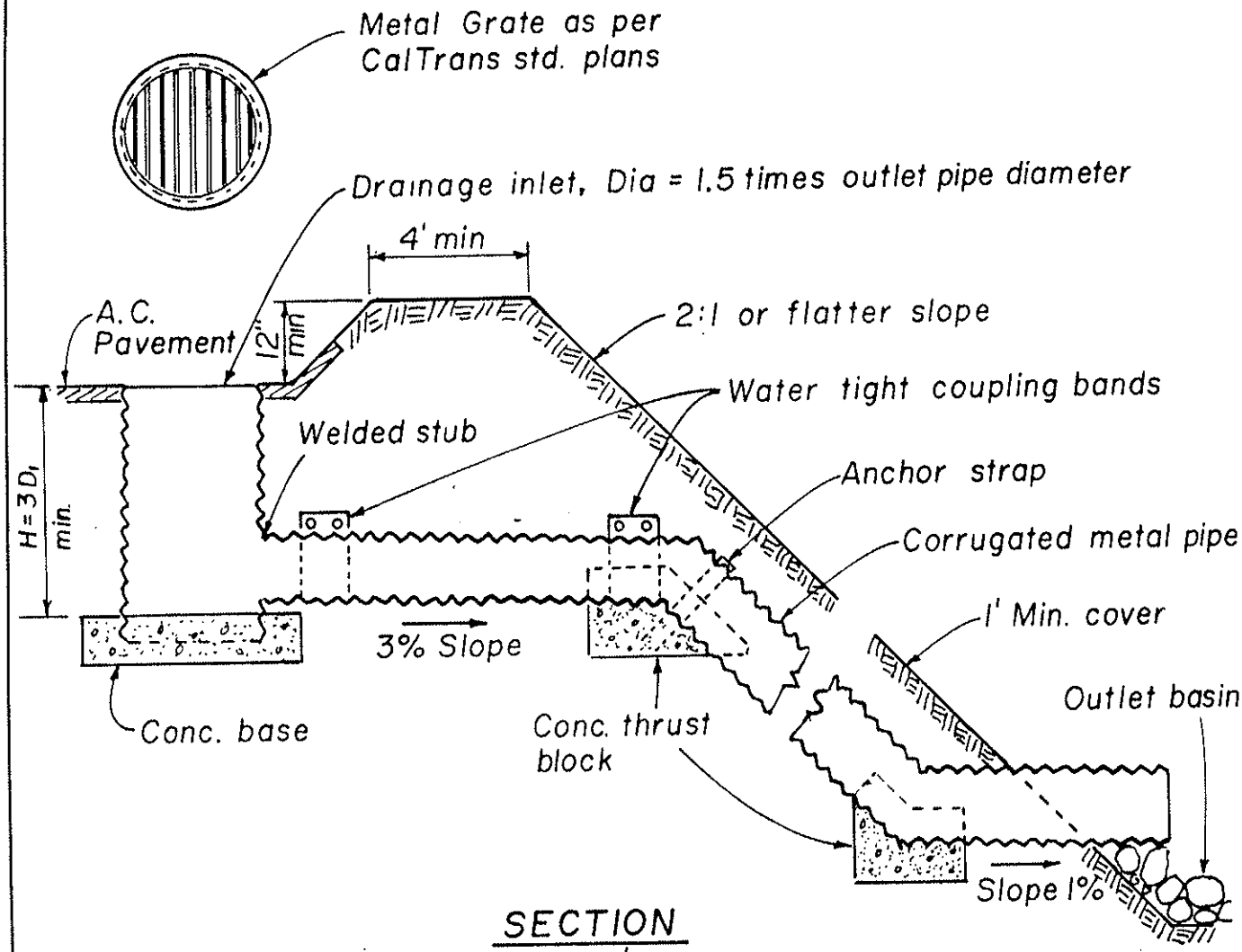
Pipe Entrance - The entrance section of the pipe shall have a slope of 3 percent or steeper toward the outlet.

Drainage Inlets - The drainage inlets shall be corrugated metal pipe, concrete boxes, or standard curb and gutter inlets designed according to California Department of Transportation (CalTrans) standard plans. All inlets shall have a metal grating suitable for wheel loads. The area around the inlet shall be paved or otherwise protected to prevent erosion at the drainage inlet.

Type of Pipe - Pipe material shall be corrugated steel, corrugated aluminum, or concrete. Rubber gaskets or water tight band couplings shall be used at all joints.

Soil Compaction - The soil around and under the inlet pipe and drainage inlets shall be hand compacted in 4 inch lifts. Consideration must be given to prevent piping along the underside of the conduit. Anti-seep collars may be needed to prevent failure of the slope drain.

Operation and Maintenance: Periodic inspections are recommended to assure proper operation of the pipe slope drain. Inspect the structure following major storms. Remove debris or sediment buildup and repair damaged structures.



SECTION
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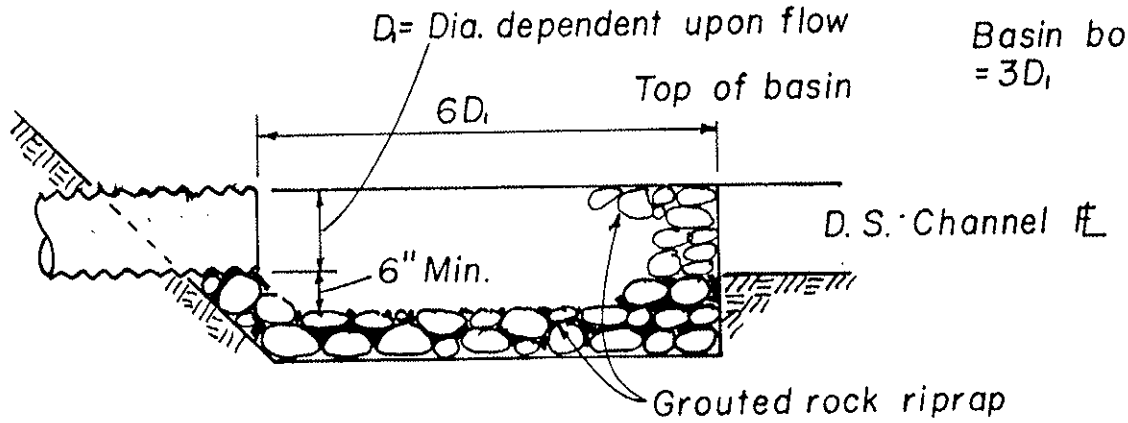

OUTLET BASIN DETAIL
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PIPE SLOPE DRAIN

II.K

GRADE STABILIZATION STRUCTURE

(GABION DROP STRUCTURE)

Definition: A weir or check dam constructed of wire mesh baskets filled with hand-sized stones.

Purpose: Used to stabilize the channel bottom and prevent the formation of gullies. Installed at intervals in channels to reduce the gradient of the channel and prevent erosive velocities.

Applicability: Gabion drop structures are applicable to sites where the volume of storm run-off exceeds the capacity of a pipe slope drain and the drop height is less than 10 feet.

Planning Criteria: Criteria given here is for minor structures where the design capacity is less than 100 cubic feet per second.

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm, or as specified by the permit issuing authority.

Spacing - The spacing between structures is determined by the following formula:

$$I = 100\ D\ /\ (S1 - S2)$$

Where:
- I is the distance between structures
- S1 is the original channel gradient.
- S2 is chosen so that the flow velocity does not exceed allowable for the soil.
- D is the drop over the weir, usually limited to 3 feet, so that the ditch will not be excessively deep.

Stability - The stability of the channel downstream of the structure must be checked to assure that the structure will not be undermined by head cutting.

Planning Criteria: Continued

Weir Dimensions - The bottom width of the weir shall be equal to or greater than the channel width. The depth of flow for weir without submergence is given by the weir equation:

$$Q = CLH^{3/2}$$

Where: Q = Design capacity, cfs
C = Discharge coefficient, varies 2.4 to 3.3
L = Weir length = channel bottom
H = Head at crest (feet)

Freeboard - A minimum of 0.5 feet is usually added to the design depth.

Grouting of the weir crest is recommended after the structure settles. The thickness of the grout layer must be added to the total weir depth.

Apron Protection - Approximate equations for proportioning the stilling basin are given in this section and are suitable for minor structures with intermittent flows. Where major structures or several structures are required use the procedures in the "Maccaferri Gabion Design Manual".

The minimum length of protection for a straight apron with downstream tailwater depth greater than critical depth is as follows:

$$L = 0.75\ (H + D + 1.5) + D$$

Where: L = Apron length (feet)
H = Head at crest (feet)
D = Drop height (feet)

When the above tailwater condition is not assured an end sill or counter weir is used to create the hydraulic jump. The height of the end sill should be 1/3 H and the minimum length of basin as follows:

$$L = D\ (2.28\ (H + 0.5)\ /\ D + 0.52)$$

Wing Walls - The structure must be solidly tied to both banks to prevent washout from overflow at the ends.

Installation and Materials:

Gabions - Gabions shall be made from galvanized steel wire, 12 gauge minimum, woven into a hexagonal pattern with 3" X 4" mesh openings. Wire selvage shall be 9 gauge minimum. Lacing wire shall be 13 gauge galvanized wire.

Geotextile Fabric - Filter cloth shall be woven or non-woven commercial grade polymeric fabric, resistant to soil chemicals, mildew, rodents, and ultraviolet light.

Stone - Stone or rock shall be sound, dense and durable with a specific gravity of not less than 2.5. Rock shall be graded from 4 to 12 inches with no more than 5 percent falling outside of these limits.

Grout - Grout shall consist of a 5.5 sack concrete mix, unless otherwise specified.

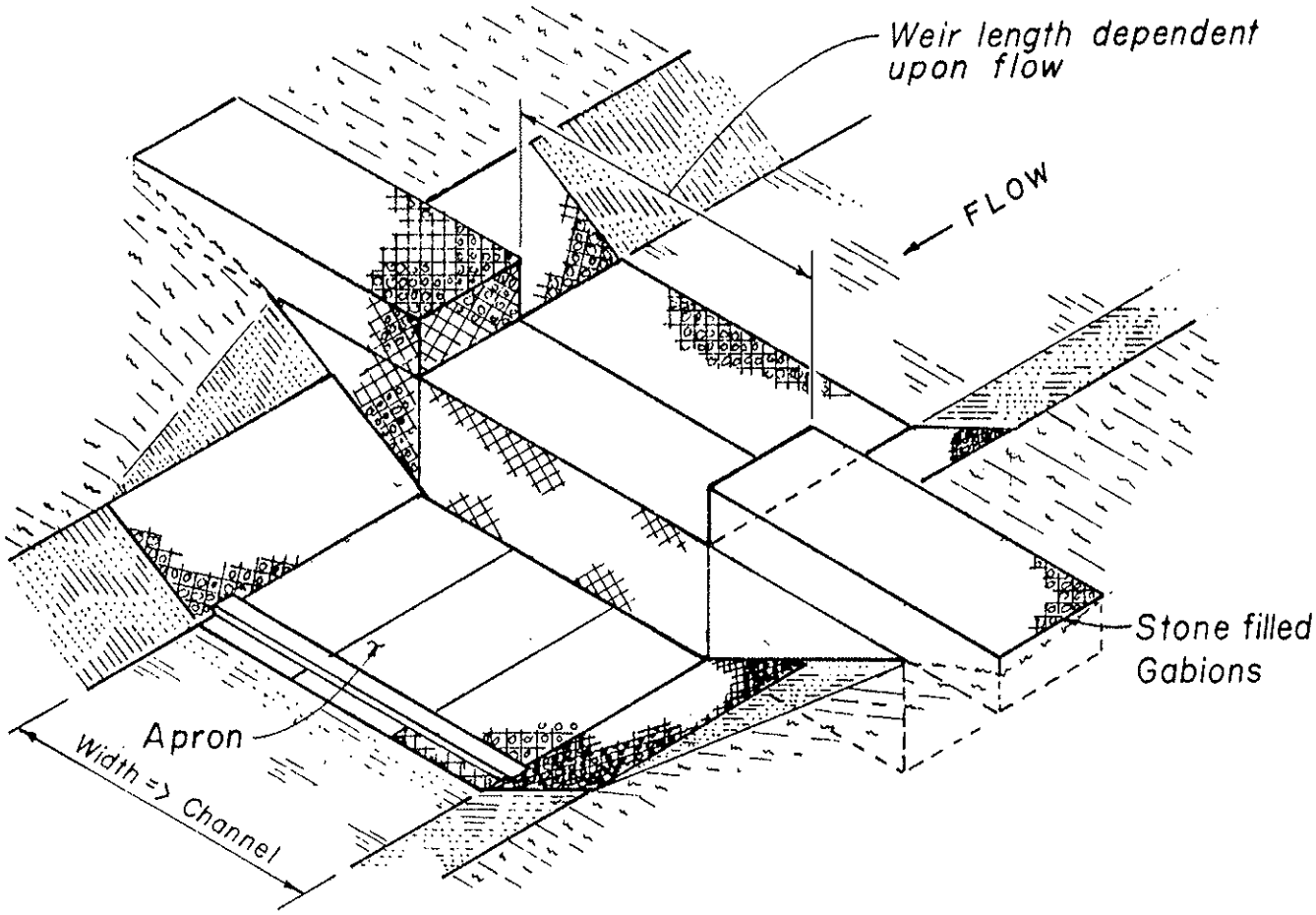
Excavation - Excavation shall be to the lines and grades as shown on the drawings or as staked in the field. Key wing walls and footings into banks.

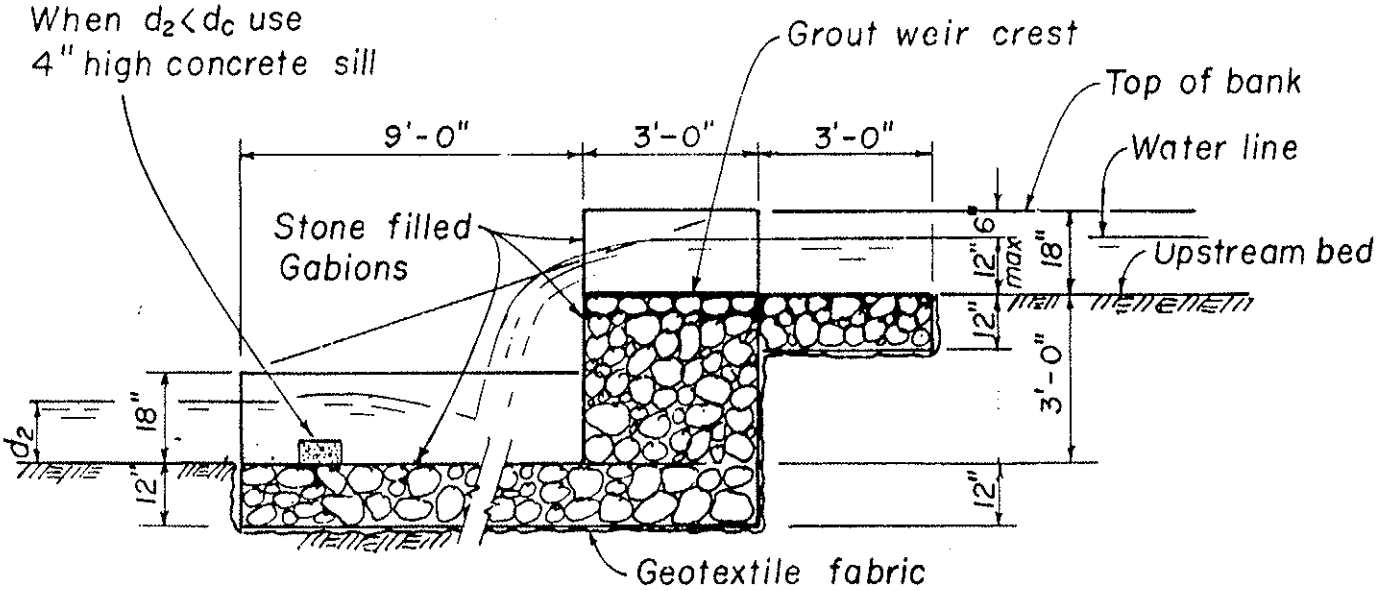
Assembly of Baskets - Each basket shall be assembled by tying all edges, including diaphragms, with lacing wire as recommended by the gabion manufacturer. Assembled baskets shall be tied together by lacing along the edges and corners of adjoining baskets.

Geotextile Fabric - The upstream face and floor of the structure has to be protected by filter cloth or gravel layer to prevent particles from moving through the gabion rocks.

Filling - For 3 foot deep gabions internal cross ties are required in each cell. Stones should be placed by hand or machine to 1/3 the depth, then cross ties installed to prevent spreading of the sides. Repeat the process at 2/3 depth.

Operation and Maintenance: Periodic inspections are recommended to assure proper operation of the drop structure. Undermining and damage to the gabion wire should be repaired to prevent failure of the structure.





SECTION ON ℄ WEIR

no scale

High Sierra R. C. & D. Erosion & Sediment Control Guide 3/90 Pg 141	GABION DROP STRUCTURE 3 FOOT VERTICAL DROP

II.L

LINED DITCH

Definition: A permanent man-made waterway or drainage channel designed, shaped, and lined to convey surface run-off.

Purpose: To convey concentrated run-off water at nonerosive velocities to a natural swale or other suitable outlet.

Applicability: To all drainage systems which collect and convey surface run-off. Used for sites where vegetated waterways are not adequate to prevent erosion.

Planning Criteria: The maximum flow depth shall be 2 feet and the maximum capacity limited to 200 cubic feet per second for this practice.

Lined ditches should be designed in accordance with the following criteria:

Capacity - The minimum design capacity shall be adequate to carry the peak rate of run-off from a 25-year return interval storm, or as specified by the permit issuing authority. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish	**.012 - .014**
Float finish	**.013 - .017**
Gunite	**.016 - .022**
Flagstone	**.020 - .025**
Nylon fiber blanket	**.020 - .024**
Rock riprap	**Curve 1, Appendix II.E**

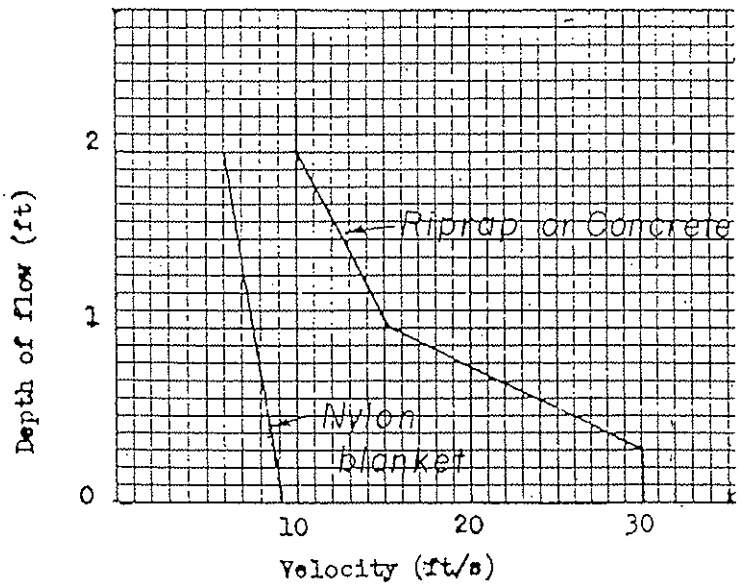
Resistance to Erosion - Both the capacity of the channel and the velocity of flow are functions of channel lining, cross-sectional area, shape, and slope of the channel.

Type of Lining - Both economic requirements and secondary functional requirements should be considered when selecting the lining type. Permeable lining materials should not be used on unstable cut or fill slopes. Nylon filament blankets are not designed to permanently control erosion on unvegetated channels and should only be used where conditions and soils are suitable for the establishment of vegetative cover.

Planning Criteria: Continued

Velocity - Maximum design velocity shall be as shown in Figure II.L-1. To avoid unstable surge flows, design velocities should not exceed 1.7 times critical velocity, or be in the range of 0.7 to 1.3 of critical slope, unless the channel is straight. Waterways with velocities exceeding critical shall discharge into an energy dissipator.

Figure II.L-1



Maximum velocity vs depth of flow.

Cross Section - Cross sections may be triangular, parabolic, or trapezoidal.

Freeboard - The minimum freeboard shall be 0.5 feet. Additional freeboard shall be added for supercritical channels at curves or bends.

Cutoff Trench - A transverse cutoff trench shall be placed at the beginning and end of the lined section. Trench shall extend a minimum of 12 inches below the bottom of the lining. For channel slopes greater than 5 percent additional cutoff trenches shall be placed at 100 foot intervals.

Methods and Materials:

Rock Riprap - Rock size should be determined in accordance with Riprap criteria contained in Section II.E.

The steepest permissible side slope shall be 2 horizontal to 1 vertical for materials.

The minimum lining thickness for rock riprap is 1.5 times the mean rock size (d_{50}).

Concrete - Concrete lining may be reinforced or nonreinforced depending upon the application. Nonreinforced concrete shall have construction joints placed at 15 foot intervals. Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation, and stiff enough to stay in place on side slopes. Specify a mix that can be certified to produce a minimum strength of 3000 psi at 28 days. Aggregate used shall have a maximum size of 1-1/2 inches.

The minimum thickness for nonreinforced concrete ditch lining is 2-1/2 inches for velocities less than 10 feet per second and 3-1/2 inches for greater than 10 feet per second.

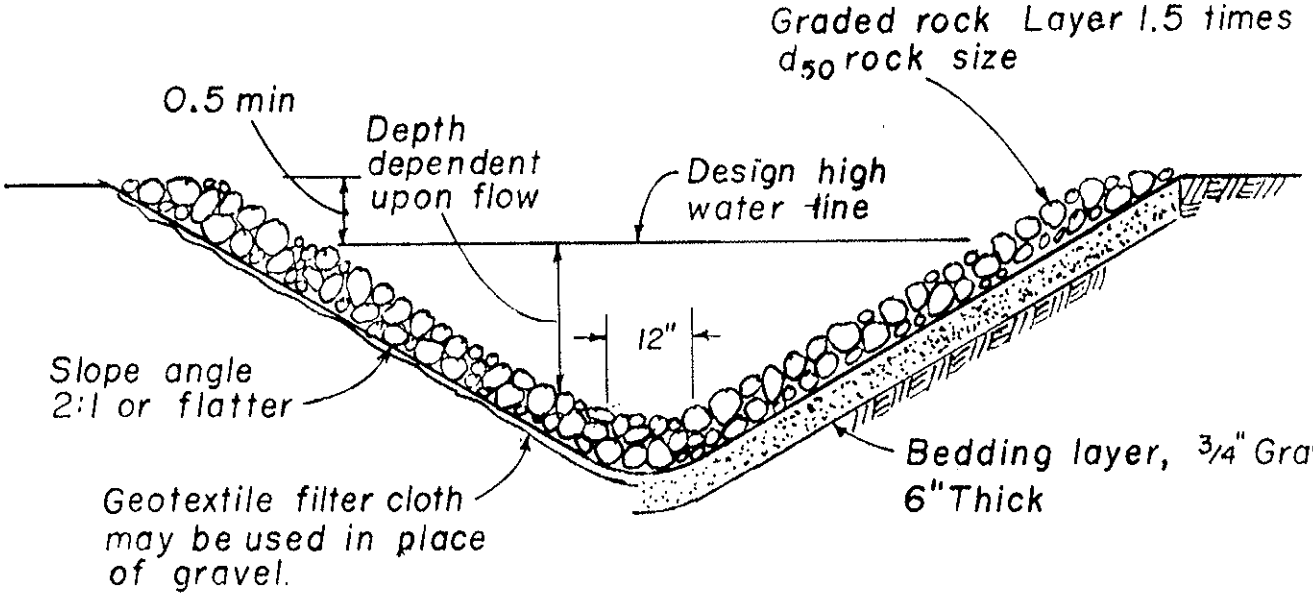
Nylon Fiber Blanket - A 100% nylon erosion control material recommended for ditch lining and having a weight or not less than 0.75 lbs per square yard. Subgrade shall be seeded with a suitable seed mix determined from Section II.B before installing lining. Lining shall be secured with anchors, staples, and trenches in accordance with the manufacturer's recommendations.

Installation: The finished ditch shall conform to the lines and grades shown on the drawings. For concrete and rock channels the subgrade should be excavated to the depth of the rock layer and bedding if specified.

When filter fabric is specified, the upstream end shall be anchored in a cutoff trench. Seams and joints should be overlapped in the downstream direction at least 4 feet.

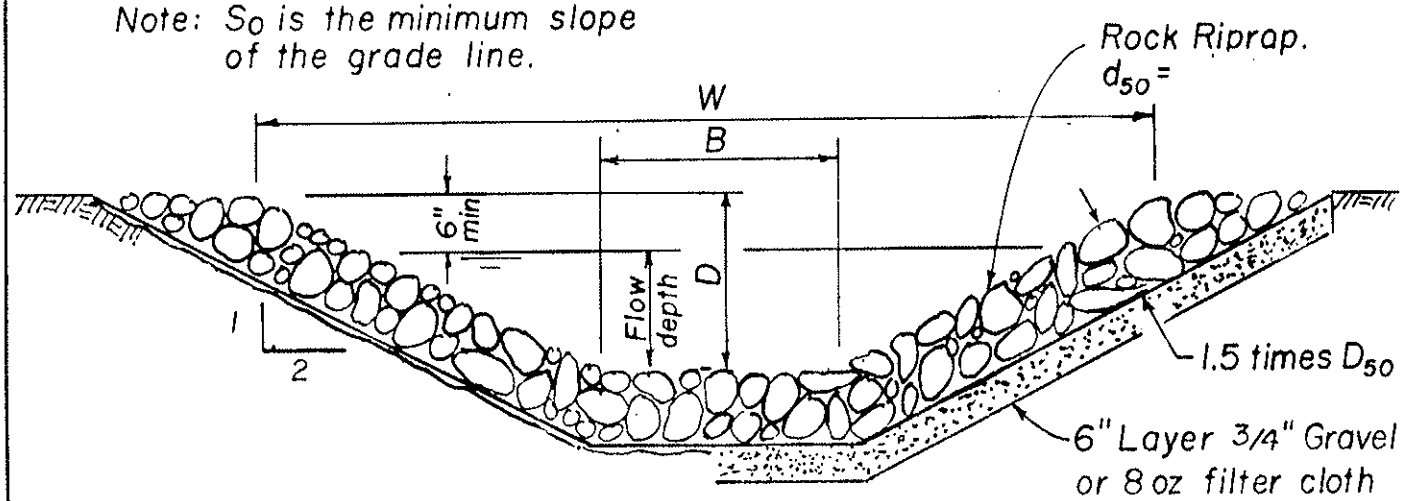
Rock riprap may be placed by hand or machine. Some hand placement is required to fill in the voids between larger rocks and even out the surface of the riprap.

Operation and Maintenance: Periodic inspection and repair are required to assure proper operation of the lined ditch. Periodic mowing may be needed to control the growth of trees and shrubs which would obstruct the flow. Accumulations of silt and sediment should be removed to preserve channel capacity. Cracks in concrete liners should be repaired.



TYPICAL TRIANGULAR SECTION

Note: S_o is the minimum slope of the grade line.



TRAPEZOIDAL SECTION

no scale

Location	Width W	Depth D	Bottom B	Rock D_{50}	Slope S_o	Remarks

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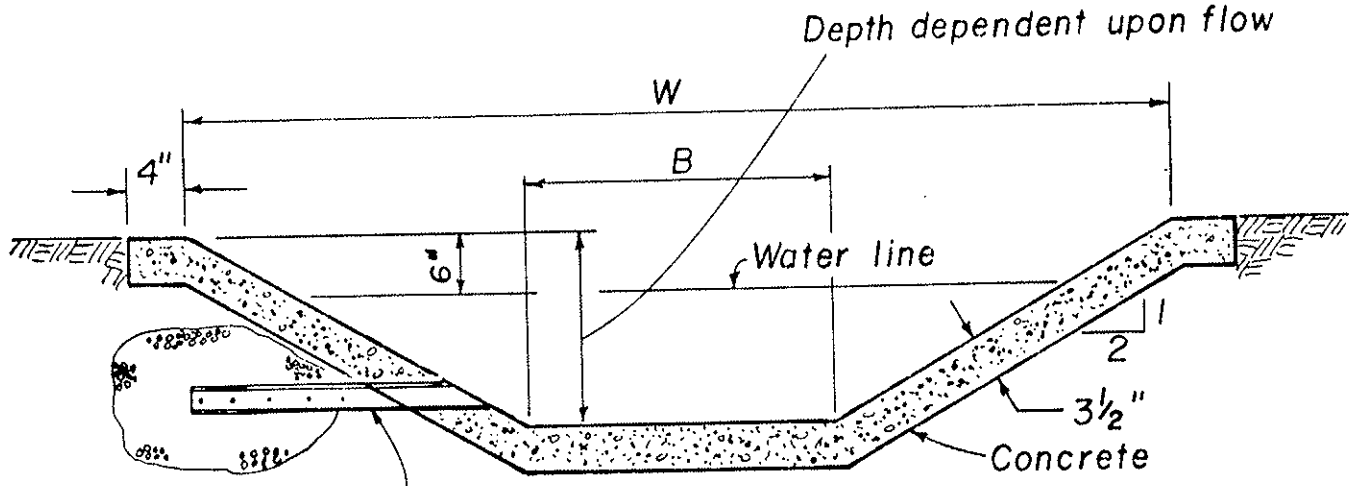
ROCK LINED DITCH



CONCRETE LINED DITCH

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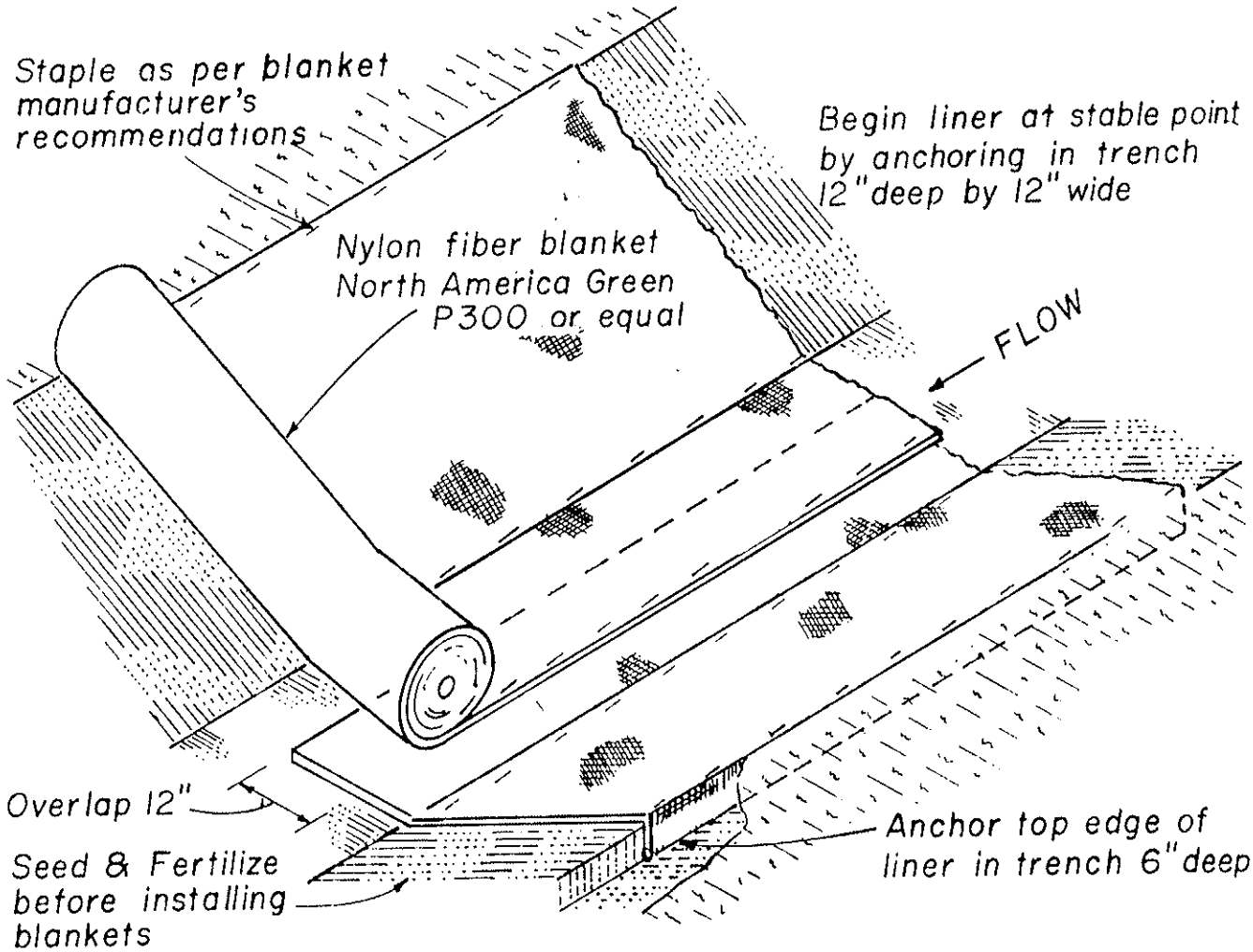


NYLON FIBER BLANKET LINED DITCH

no scale

II.M

LOT GRADING

Definition: The application of erosion control measures to individual lots or building sites.

Purpose: To assure that lot grading is in conformance with the subdivision drainage, erosion, and sediment control plans, and to protect permanent erosion and run-off control measures from damage.

Applicability: Applicable to all multi-lot subdivision development where mass lot grading is not planned concurrently with other grading activities.

Planning Criteria: Consideration shall be given to the impact of individual lot site development on the overall site development plan. A plan describing the erosion and sediment control measures needed to insure conformance with the Conditions of Approval for the subdivision shall be developed for lot owners.

This individual lot owner's plan shall be made part of the grading plans whenever a grading plan is required.

The developer, homeowners association, or other entity responsible for the operation and maintenance of the subdivision erosion and sediment control works, may find it appropriate to attach covenants or restrictions to the sale of the lot to assure that all planned erosion and sediment control measures are implemented and maintained. Such conditions may include:

> The requirement that a bond or other guarantee be posted at the beginning of construction. This bond should extend through the first winter season after construction to insure that erosion control measures are implemented and maintained.
>
> Provisions that the homeowners' association will enforce the implementation of erosion and sediment control measures and will collect fees from lot owners to cover the cost of enforcement.

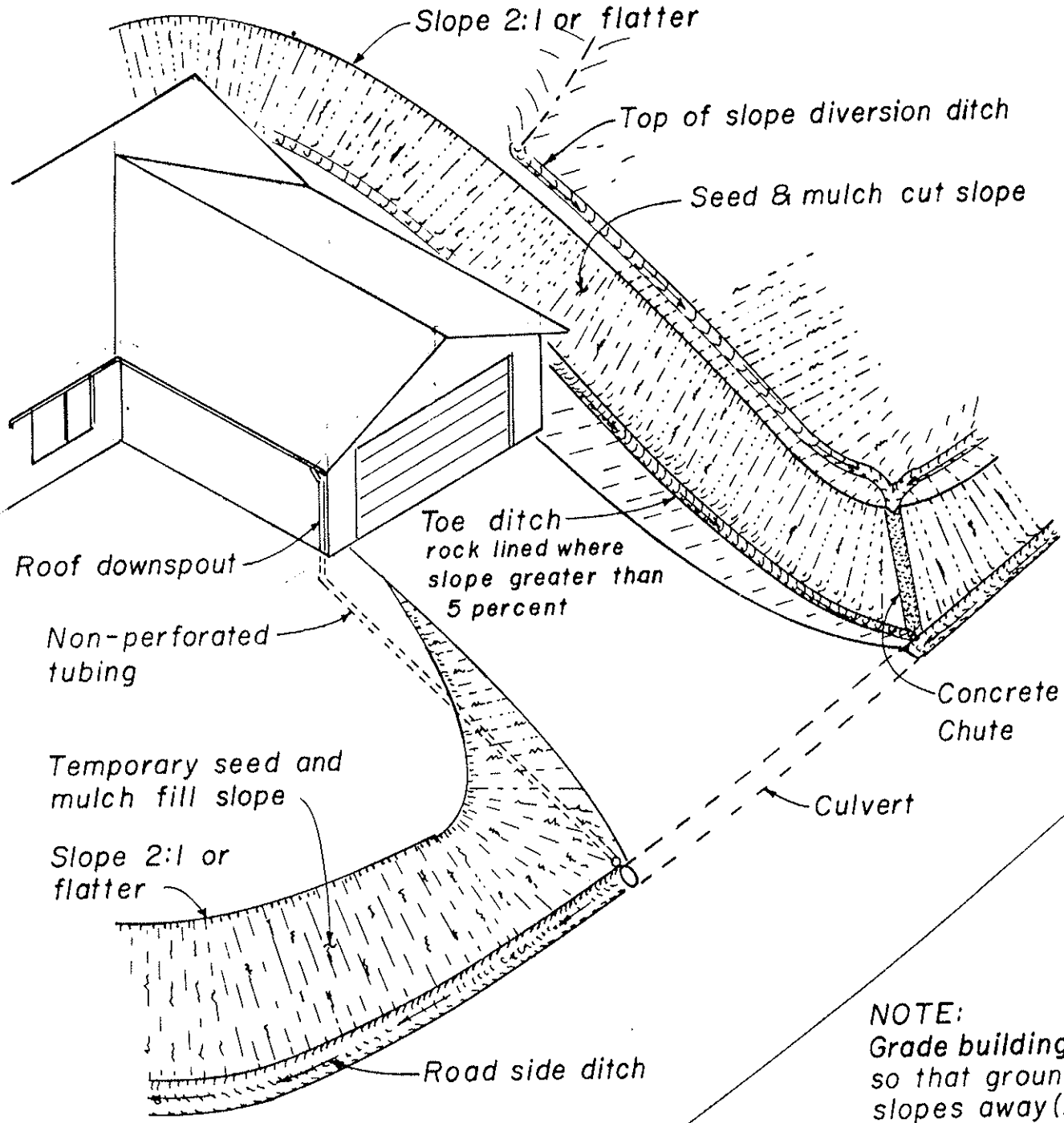
Methods and Materials:

Re-vegetation - Provide for the planting, seeding, fertilizing, and mulching of all disturbed sloping areas, cut or fill slopes.

Driveways - Provide for the relocation or replacement of sub-division drainage facilities, requiring culverts where driveways cross drainage swales and roadside ditches.

Roof Downspouts - Provide for the collection and disposal of run-off from roof downspouts and paved driveways to an area protected from erosion.

Rock Lined Ditches - Provide typical details for rock lined ditches for conveyance of lot drainage.



TYPICAL HOMESITE EROSION CONTROL PLAN

PART III

VEGETATIVE PRACTICES

CONTENTS

Vegetative Practices

This portion of the handbook is concerned with controlling erosion with vegetation. Vegetation by itself cannot control erosion from concentrated flows, however, it is the most cost effective means of controlling sheet and rill erosion on disturbed sites. Revegetation can take many forms, from establishing a natural ground cover to landscaping using exotic plants. In all cases the plantings must be compatible with the environment, mainly climate. The empha-sis in this handbook is revegetation using naturalized grasses and legumes. They are the most commonly used plants for revegetation and are most effective for long term erosion control. Local nurseries and landscape architects will provide the information on types of exotics to plant in disturbed areas.

With any revegetation project, a soil binding ground cover is needed to protect the site from erosion. Grasses are well suited to erosion control by virtue of being a low growing, dense vegetation with a fibrous root system. The grasses selected are expected to germinate and establish rapidly after fall rains, protecting the soil from rain and anchoring soil particles in place. Meeting these criteria in the Mediterranean type climate are Briggs barley, annual and 'Wimmera 62' rye grasses, Blando brome, and 'Zorro' fescue. Legumes are included to increase nitrogen and provide colorful flowers as well as cover. Native flowers such as California poppy or Lupine may also be used for color. At higher elevations, where most of the precipitation falls as snow, the situation is drastically different. There are no aggressive annual grasses except cheatgrass (Bromus tectorum) and cereal rye. Cheatgrass is undesirable and aggressive. Cereal rye does provide a vigorous fast cover but may become a problem when seeded near areas used as cropland. Perennial grasses require soil materials that will hold more moisture for plant growth than annuals grasses. They do not develop as rapidly as annuals but when established will provide a more dense, deeper rooting, later maturing, long-lived erosion control cover. Due to the longer period needed to become established, a portion of the seeding mixture may include some annual grasses to provide cover in the initial stages during the first year.

Shrubs and trees can be planted from seed but are difficult to establish in a natural environment. Also, seed availability varies widely from year to year. Planting of bare

root stock or potted plantings requires supplemental irrigation in the first year and a high degree of maintenance. They are also subject to damage by deer, rabbits and rodents.

Invasion of native vegetation and landscaping with exotic or introduced shrubs and trees will provide additional protection from erosion. Although, usually taking longer to establish and slower growing, the resulting deep rooting system and top growth will give additional permanent protection to the area seeded with grasses.

The climate, topography, soils and vegetation are very diversified in the Sierra foothill and mountain counties. Plant needs vary from one species or variety to another in relation to soils and climatic conditions. Planting dates are critical and related to soils, exposure, temperature and precipitation patterns and amounts.

It is for this reason that the area is divided into four areas called "Major Land Resources Areas" (MLRA). This system has been refined since its initial use in California by the U.S. Department of Agriculture, Soil Conservation Service.** It is important to know in which MLRA your project is located for the selection of seeding mixtures, seeding rates, dates of seeding, and fertilizer rates. The following narrative descriptions will be helpful in determining the area you are concerned with. These have been tailored to meet the conditions in the Sierra foothill counties. The local USDA Soil Conservation Service office has detailed maps showing these various MLRAs.

MLRA 17 is on the low terraces in the western part of Placer County in the Sacramento Valley. Vegetation is dominantly grass and scattered oak. Elevations are 50 to 300 feet. Rainfall is 18 to 25 inches. Slopes are undulating to rolling. The soils are predominantly shallow to moderately deep with dense clay subsoils. Some deeper soils occur adjacent to the streams but are not extensive.

MLRA 18 is the foothills of the Sierra Nevada Range. Vegetation is generally oak and grass. The area is rolling to steep. Elevations range from 300 to 1800 feet with an average annual rainfall of 25 to 50 inches. Soils are typically shallow (less than 20") to bedrock and have frequent out-croppings of bedrock.

** Austin, Morris L., 1965, "Land Resources and Major Land Resource Areas of the United States". U.S. Department of Agriculture, Handbook No. 296.

MLRA 22 is part of the Sierra Nevada Mountain Range. Vegetation is primarily conifer and hardwood. Although elevations are as low as 1000 feet on northern exposures and deep soils, elevation typically ranges from 1800 feet to the highest peaks on the summit. Precipitation ranges from 30 to 80 inches and generally increases with elevation . A large part of the precipitation falls as snow at the higher elevations. Soils range from shallow to very deep. Slopes are generally steep to very steep.

MLRA 22 has been divided into 22c and 22d. Most of the privately owned lands are within 22c where some snow falls but does not persist. The precipitation in MLRA 22d falls predominantly as snow, and ice crystals in the soil present a greater hazard to seedlings. Due to "frost heaving" seeding mortality increases. No aggressive desirable annual grasses are suitable within MLRA 22b. The divisions between 22c and 22d is approximately 4500 feet on southern exposures and 3000 feet on northern exposures.

MLRA 21 is the high plateau region on the eastern side of the Sierra Nevada. The high elevation and flat-basin characteristics result in a continental temperature regime. The Sierra Valley basin receives 15 to 20 inches of moisture. Most precipitation comes as snowfall. Vegetation is predominantly sagebrush, bitterbrush, and scattered perennial grasses with some conifers on footslopes. Elevations range from 4500 to 6000 feet. Soils range from the deep somewhat poorly drained soil of the valley to the shallow, excessively drained soils of the uplands.

STANDARDS AND SPECIFICATIONS FOR SEEDING OF GRASSES OR GRASSES AND LEGUMES

The revegetation of disturbed or cleared sites due to construction activities as defined in this handbook is restricted to grasses or grasses and legumes. All methods and procedures are listed in order of priority to be considered and completed.

Definition: Planting vegetation on critical areas.

Purpose: To stabilize soils and reduce or prevent erosion; to reduce damages from sediment and run-off to downstream areas; to enhance natural beauty.

Applicability: Graded or cleared areas subject to erosion. Building pads need not be revegetated if the following criteria is met:

1. Pad area is level (maximum slope of less than 0.2%);

and

2. Accumulated water on the pad is controlled thru the use of dikes or interceptor swales and discharged thru a slope drain to a stable area.

Planning Criteria: Revegetation of critical areas requires the following planning criteria for success:

1. Determination of the site by establishing in which MLRA the project is located.
2. Preparation of the seedbed for seeding.
3. Choosing the type of vegetation, seeding rate and seeding dates.
4. Determination of rate and type of fertilizer.
5. Determination of the most effective method of seeding the area.
6. Determination of mulching methods to protect the site until revegetation is established.

Methods and Materials:

Site Determination - The purpose of site determination is to select suitable grasses and legumes for the climate and soil conditions of the site to be revegetated. Also, site determination will determine fertilizer rates and seeding dates.

Determine elevation, average annual rainfall and soil conditions of the project area and refer to the guide for determining the project's MLRA. The local USDA-Soil Conservation Service office can provide additional information and assistance in identifying correct MLRA.

Seedbed Preparation - The area to be seeded shall be reasonably smooth and conform to the desired shape before actual seedbed preparation is begun. Any debris which would interfere with seeding operation, growth, or maintenance of the vegetative cover shall be removed.

The area to be seeded shall have a firm seedbed which has previously been roughened by scarifying, discing, harrowing, chiseling, or otherwise worked to a depth of 2 to 4

Methods and Materials:
Seedbed Preparation Continued

inches. Scarifying operations will be cross slope when possible. No implement shall be used that will create an excessive amount of downward movement of soil or clods. Seedbed may be prepared at time of completion of earth moving work, or immediately before seeding.

When soil conditions are adverse for plant growth establishment, as on soils developed on serpentine or droughty soil materials, 2 to 4 inches of topsoil, or other fairly good soil material, should be spread over the surface to provide a medium for plant growth.

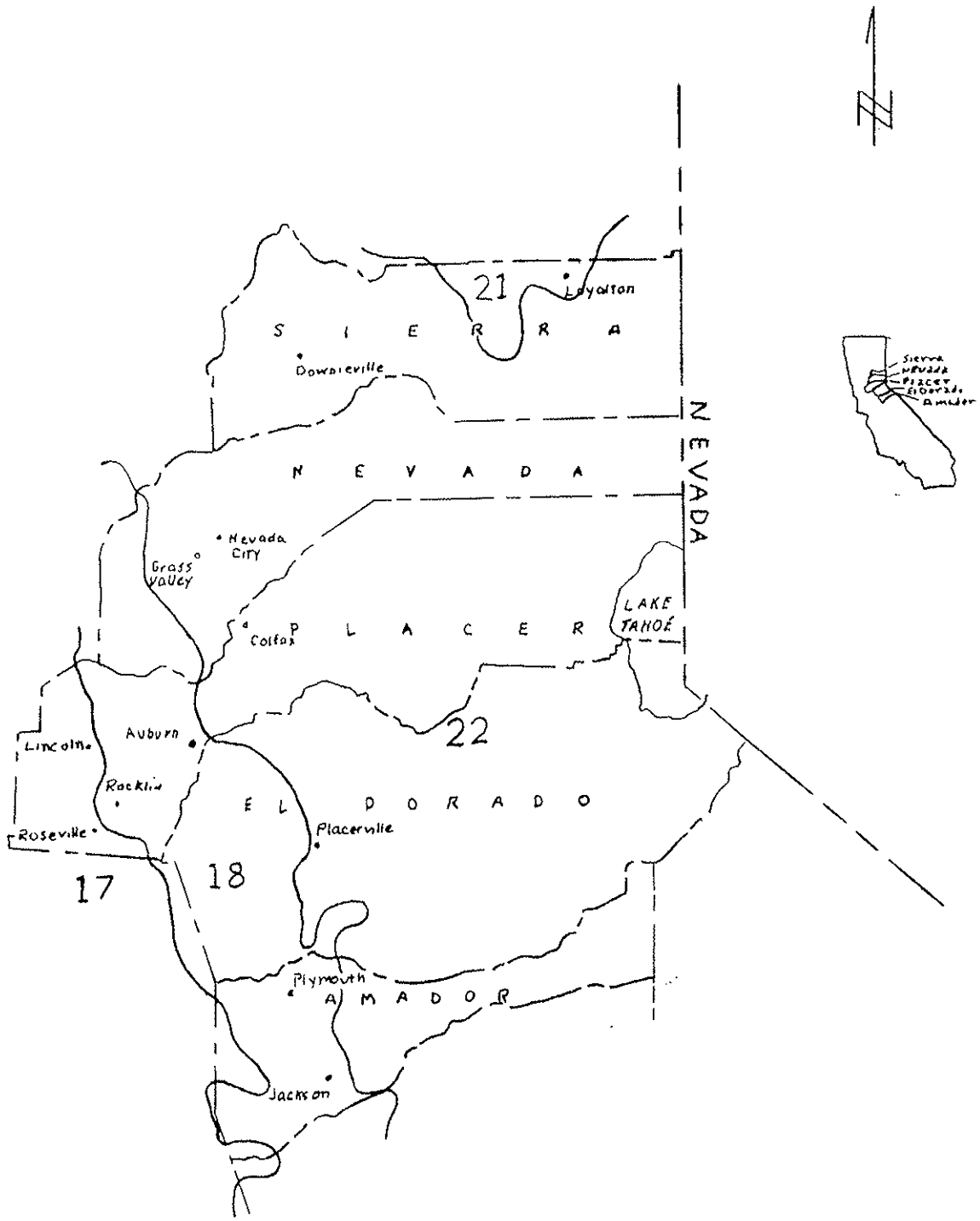
Stockpiling of topsoil should be the first phase of cut and fill operations when suitable topsoil is present. It should be free of gravels, cobbles, stones, roots, trash and other extraneous materials larger than 1 1/2 inches in diameter.

Topsoil should be applied after the subgrade is scarified to a depth of 2 inches. It will be uniformly distributed to prevent any irregularities that would cause formation of depressions and shall not be placed in a muddy condition or when the subgrade is excessively wet. Topsoil should be a minimum depth of 2 inches after compaction. Packing can be done by passing a bulldozer vertically over the area or by use of other suitable equipment. Care should be taken to avoid excessive downward movement of soil or clods. Bonding should be cross slope except when using a bulldozer for bonding and compacting.

Seeding Mixtures and Rates - Selecting the correct seeding mixture and rate is based upon the sites MLRA location and the purpose of the seeding.

All seed shall be delivered to the site tagged and labeled in accordance with California Agricultural Code and shall be acceptable to the County Agricultural Commissioner. Seed shall be of a quality which has a minimum pure live seed content of 80% (% purity X % germination) and weed seed shall not exceed 0.5% of the aggregate of pure live seed and other material. Legume seed shall be pellet inoculated with the appropriate bacteria.

Temporary seedings are used on those sites where the construction activities will not be completed by the start of the rainy season, October 1. Temporary seedings are of short duration, providing ground cover for one season.



U. S. DEPARTMENT OF AGRICULTURE ★ SOIL CONSERVATION SERVICE

Major Land Resource Area

1. SEEDING MIXTURES AND RATES WITH ANNUALS FOR TEMPORARY COVER.

MLRA 17, 18, 22C

	MIXTURE	LBS/ACRE	LBS/1000 SQ. FT.
1)	Briggs barley	180	4
2)	Annual ryegrass	30	1

MLRA 21, 22D

	MIXTURE	LBS/ACRE	LBS/1000 SQ. FT.
1)	Cereal rye	90	2
2)	Barley	180	4

Permanent seedings are used when the construction activities are completed and there is no more major soil moving activities. The area to be revegetated is at final grade. The recommended annual grasses and legumes are prolific reseeders. Although the plant dies in the spring, it provides soil protection into the next rainy season and a germinating environment for seed.

2. SEEDING MIXTURES AND RATES WITH ANNUALS FOR PERMANENT COVER.

MLRA 17, 18, 22C

	MIXTURE	LBS/ACRE	LBS/1000 SQ. FT.
1)	Zorro annual fescue Rose clover (shallow soils with south or west exposure)	6 9	.2 .2
2)	Blando brome Rose clover (Deeper soils or north exposure	12 9	.3 .2
3)	Blando brome Lana vetch	12 15	.3 .4

California poppy and/or lupine can be seeded in with any of these mixtures at the rate of 2 lbs/Acre.

3. **SEEDING MIXTURES AND RATES WITH PERENNIALS FOR PERMANENT COVER.**

MLRA 22C&D

	MIXTURE	LBS/ACRE	LBS/1000 SQ. FT.
1)	Luna pubescent wheatgrass	24	.6
	Palestine orchard grass	8	.2
	Sherman big bluegrass	6	.2
	Duara hard fescue	6	.2
2)	Luna pubescent wheatgrass	15	.4
	Tegmar intermediate wheatgrass	15	.4
	Potomac orchard grass	10	.3
	Lutana cicer milkvetch	15	.4

MLRA 21

	MIXTURE	LBS/ACRE	LBS/1000 SQ. FT.
1)	Luna pubescent wheatgrass	18	.4
	Norden desert wheatgrass	12	.3
	Sherman big bluegrass	8	.2
2)	Topar pubescent wheatgrass	18	.4
	Norden desert wheatgrass	12	.3
	Sherman big bluegrass	8	.2

Dates of seeding are critical. Seeding prior to recommended dates will cause seed to loose viability due to exposure and will be lost to insects and birds. If seeding is done after recommended dates it will not germinate because the weather is too cold and is subject to being washed away from concentrated rainfall. Recommended seeding dates are:

1) MLRA 17 - September 15 to October 15
2) MLRA 18 - September 15 to October 15
3) MLRA 22c - September 15 to October 15
4) MLRA 21, 22d - May 1 to June 30 (preferred) or after September 30 until such time as snow remains on the ground

Methods and Materials: Continued

Fertilizer - Seeded areas need to be fertilized for two reasons. First, during construction, especially where there are cuts and fills, the soils are mixed with subsoils. The resultant soil is rather infertile and to insure regrowth the area needs to be fertilized. Second, because construction sites do have the potential for high erosion rates fertilizing will insure rapid regrowth of vegetation.

Fertilizer rates of ammonium phosphate (16-20-0) are:

1) MLRA 17, 18, 19, & 22c
   500 lbs/Acre 12 lbs/1000 sq. ft.

2) MLRA 22d
   250 lbs/Acre 6 lbs/1000 sq. ft.

3) MLRA 21
   400 lbs/Acre 9 lbs/1000 sq. ft.

Fertilizer is applied to the site at the same time as the seed.

Seeding Methods - This criteria concerns the application of seed and fertilizer, in a uniform manner, to the disturbed area. Seed and fertilizer are applied at the same time and in the same manner. There are basically two methods of seeding.

Method 1: Broadcasting - This method of applying seed and fertilizer consists of uniformly distributing the material over the soil surface. Truck or tractor mounted automatic seeders are used on large sites. Breast seeders or "belly grinders" are used for small areas, or areas where trucks and tractors are impractical. Grass, legumes and fertilizer may be mixed together in the specified proportions prior to broadcasting. However, all seed and fertilizer grains must be approximately the same size. With different size seeds, several passes will be necessary, one for each size.

Broadcasted seed must be lightly raked and covered with about 1/4 to 1/2 inch of soil. This protects the seed and helps it take root. Raking should be done immediately following seeding. This can be done with agricultural rakes or spring toothed harrows set very lightly.

Seeding Methods Continued

Method 2: Hydroseeding - Hydroseeding is the application of seed, fertilizer, tacking agent, and water as a slurry. The slurry is then sprayed onto the site. Raking is needed to cover the seed and fertilizer.

Hydroseeding is acceptable if broadcast seeding is impossible. Hydroseeding can be applied to areas which are within approximately 200 feet of a road or other areas which can be reached by truck. It is suitable for large areas, steep slopes and/or sites that have excessive cobbles and stones.

Hydroseeding is applicable for a short period. Hydroseeding must be completed between October 1 and October 15. Hydroseed too early and the nitrogen escapes as a gas, the mulch drys out and blows away, and the seed is weakened. Seeding after October 15 is ineffective - weather is too cold for adequate establishment and slope protection before the heavy winter rains.

If the area is hydroseeded after October 15, the area shall be mulched with straw at the rate of 2 tons per acre (see specifications on mulch).

The hydroseeder shall be equipped with a gear-driven pump and a paddle agitator. Agitation by recirculation from the pump is not allowed. Agitation shall be sufficient to produce a homogeneous slurry of seed, fertilizer, and tacking agent in the designated proportions. Water shall be applied at a rate of 3,000 gallons per acre. Wood fiber which has been dyed with a non-toxic substance shall be added as an aid for uniform application at a rate of 150 pounds per acre.

Tacking agent shall be applied at 200 gallons of wet ingredients per acre, or 80 pounds of dry ingredients per acre. Fertilizer of the specified formulation shall be included at the specified rate. Both the hydroseeder manufacturer and the fertilizer manufacturer should be consulted regarding the appropriateness of the fertilizer for hydroseeder applications. If the fertilizer cannot be applied using the hydroseeder, broadcast using methods presented in Method 1: Broadcasting.

Method 2: Hydroseeding Continued

The time allowed between placement of seed in the hydroseeder and emptying of the hydroseeder tank shall not exceed 30 minutes. Legume seed shall be pellet inoculated with the appropriate bacteria. Inoculation rates shall be four times that required for dry seeding. Legume seed shall be placed in the mixing tank after all other ingredients have been included, as pellet inoculated legumes may have the coating washed off in the mixing tank.

Mulch - The use of mulch in this handbook means the application of nonerosive material over bare soil to: protect the soil from direct effects of rainfall; slow surface flows; reduce erosion; provide a favorable environment for revegetation. The most common mulch is grain straw, but this section will also apply to hydromulch and erosion control blankets.

Method 1: Straw Mulch - Straw mulch is used on slopes which have been seeded and are subject to erosion. It requires anchoring by crimping or punching, spraying with a tackifier, or covering with netting.

On small slopes straw mulch shall be applied by hand, broadcasting to a uniform depth of 2-3 inches. On larger slopes straw can be blown onto the slope to achieve a uniform cover of 1-2 inches. The straw should be applied in such a manner that 80-100% of the surface is covered. Application rate is 2 tons per acre. On soils subject to frost heaving 4 inches shall be applied to reduce seeding mortality. Straw mulch will be anchored by one of the following methods:

1. Hand Punching - used on small sites, or sites with much rock and stone on the surface. A spade or shovel shall be used to punch the straw into the slope until all areas have straw standing perpendicularly to the slope, and embedded at least 4 inches into the slope. The bunches of straw should resemble the tufts of a toothbrush.

2. Roller Punching - used on large or gently sloping sites without significant outcroppings of rock and stone. A roller equipped with straight studs not less than 6 inches long, from 4 to 6 inches wide, and approximately 7/8 inch thick, will best accomplish the desired effect. Studs should stand approximately 8 inches apart and should be staggered. All corners should be rounded to prevent withdrawing the straw from the soil.

Method 1: Straw Mulch Continued

3. Crimper Punching - specially designed straw crimping rollers are available for use wherever roller punching can be used. These crimpers consist of serrated disk blades set 4 to 8 inches apart which force straw mulch into the soil. Crimping should be done in two directions with the final pass conducted across the slope rather than up and down it.

4. Tacking Agent - can be sprayed on straw mulch to bind the straw together so it will not blow or wash away. It can be used on any type of site. There are a number of tackifying materials on the market. The instructions of the tackifier manufacturer shall be followed to insure success.

5. Netting - to be used on steep areas where straw mulch cannot be punched (usually slopes greater than 3 to 1). Netting is applied over unpunched straw and anchored using staples or anchor pins. The square mesh opening shall be no larger than 1 inch X 1 inch. Anchor pins shall be of rigid 0.12 inch diameter or heavier galvanized wire with a minimum length of 10 inches. Staples shall be "U" shaped, made of wire 0.09 inches in diameter or greater, have legs at least 6 inches in length and have a 1 inch crown. Placement and spacing of staples or anchor pins shall follow the recommendations of the netting manufacturer.

Method 2: Hydromulching - Hydromulching is the application of wood fiber mulch and a tacking agent in a slurry with water. Hydromulching can be combined with seed and fertilizer in one application. A portion of the seed is suspended in the mulch blanket requiring seed rates to be increased 25% to insure adequate seed germination. The hydromulching machine shall be equipped with a gear-driven pump and a paddle agitator. Agitation by recirculation from the pump will not be allowed. Agitation shall be sufficient to produce a homogeneous slurry of tacking agent, mulch, and seed and fertilizer. Tacking agent shall be applied at a rate of 200 gallons of wet ingredients per acre or 80 pounds of dry ingredients per acre. Wood fiber mulch shall be applied at a rate of 2,000 pounds per acre. When seeding is combined with hydroseeding, fertilizer of the

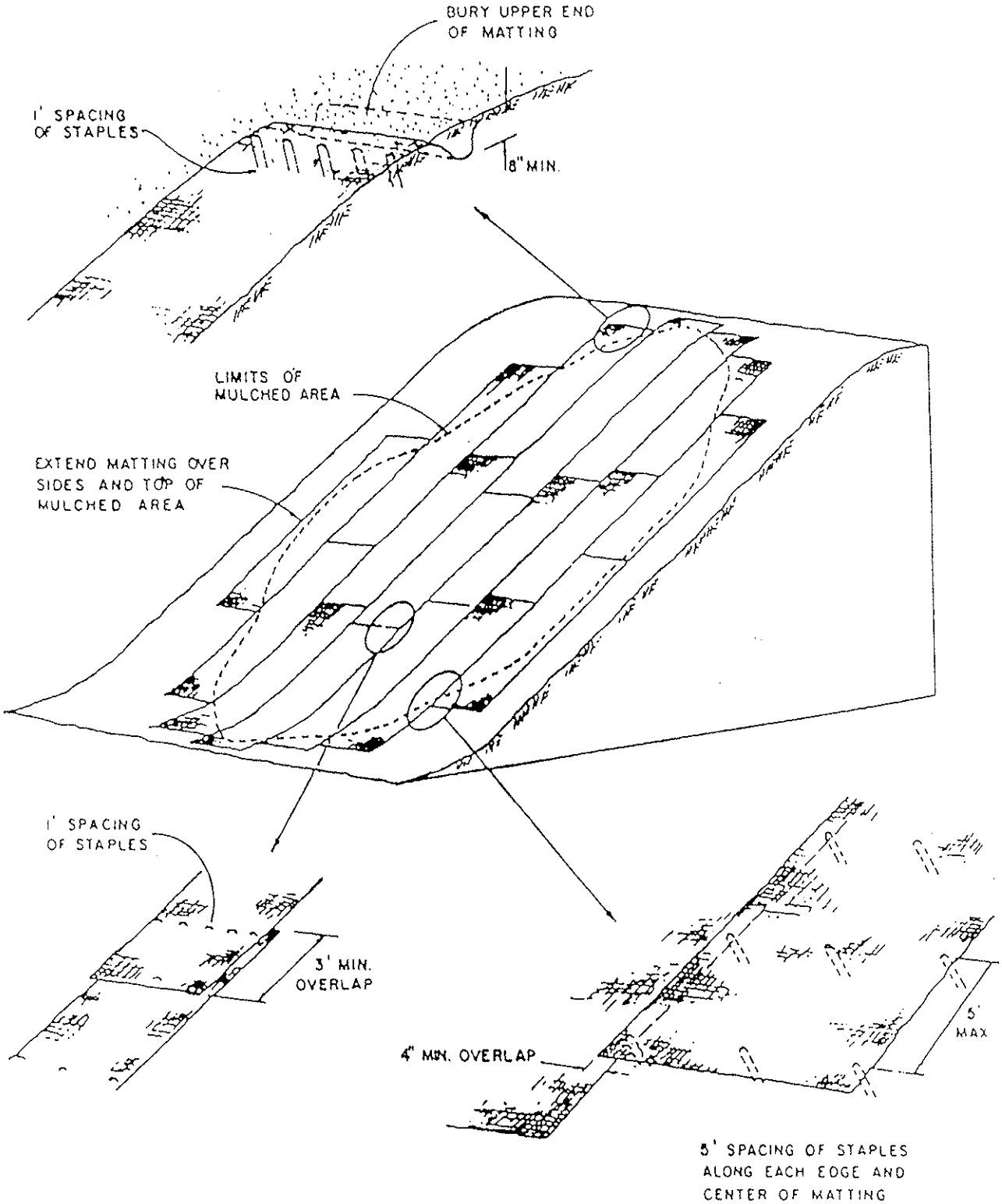
Method 2: Hydromulching Continued

specified formulation shall be included at the specified rate. Specified seeding mixtures shall be increased 25%. No seed shall be added to the slurry until immediately prior to beginning the seeding operation. Legume seeds shall be pellet inoculated with the appropriate bacteria. Inoculation rates shall be four times that required for dry seeding. The time allowed between placement of seed in the hydromulcher and the emptying of the hydromulcher tank shall not exceed 30 minutes. Wood fiber may be dyed to aid in uniform placement. Dye shall not stain concrete or painted surfaces nor injure plant or animal life when applied at the manufacturer's recommended rate. Application of the slurry shall proceed until a uniform cover is achieved. The applicator shall not be directed at one location for a period of time so as to cause applied water to create erosion.

Method 3: Erosion Control Blankets - Erosion Control Blankets are sheets of fibrous and biodegradable material which cover the seeded and fertilized area in place of using mulch. The newer blankets contain straw mulch bound together by netting and sewn into blankets. Erosion control blankets are most effective on steep slopes or critical sites (near water courses or sensitive areas).

Erosion control blankets come in rolls and are stapled to slopes to provide a uniform covering. The treated area must be reasonably smooth. Gullies and rills must be filled and compacted. Rocks and other obstructions which rise above the level of the soil must be removed.

Erosion control blankets come in various lengths, widths, and thickness. These blankets also are made of a variety of materials; straw, coconut fibers, wood fibers, jute and plastics (nylon). These materials are usually held together by netting and stitched with thread. The manufacturer's specifications will indicate which quality of blanket is to be used with various situations; i.e. percent slopes, length slope, etc. Manufacturer's instructions also dictate stapling patterns Figure 1 illustrates typical staple patterns for the top of slopes, along edges and splices down the slope.



TYPICAL STAPLE PATTERN
FOR NETTING AND BLANKETS

Operation and Maintenance: Maintenance is needed to insure germination and growth of grasses and legumes.

1. The site should be checked after first rains for areas of vegetative failure due to unfavorable weather conditions, localized site problems, or unforeseen damaging events. These areas should be reseeded to the original specifications to prevent them from becoming progressively larger.

2. Livestock and traffic (bikers, foot traffic, etc.) controls are required where needed.

3. Mowing of site should not be done before grass sets seed. Mowing should not be done lower than 4 inches If weeds become a problem mow to 4 inches before flowering stage of grasses.

4. 2-4-D must not be used before grasses reach a three leaf stage.

5. Applying fertilizer the second year before winter rains may be desirable for perennial grasses.

6. Where cover is sparse reseeding and fertilizing at the proper time could be necessary to increase the density of vegetative cover.

EXHIBIT I

GRASS AND LEGUME PLANT CHARACTERISTICS

ANNUALS

Common Name	Botanical Name	Droughty or Dry Sites	Reseeding	Plant Characteristics	Maintenance Mower[2]	Maintenance Fertilizer[3] Pounds/Acre/Year
Annual Ryegrass	Lolium multiflorum	fair	poor	slender	Not needed	-
Blando Brome	Bromus mollis	good	good	leafy	4-6" after seed set	20# N
Briggs Barley	Hordeum vulgare	fair	poor	leafy	Not needed	-
California Poppy	Eschscholzia Californica	good	poor	spindly	Not needed	-
Cereal Rye	Secale cereale	fair	fair	leafy	Mow before head sets seed if used for temporary cover	-
Lana Vetch	Vicia dasycarpa	fair	good[1]	robust & leafy	Mow after seed set	20-30# P_2O_5
Lupine	Lupinus spp.	good	fair	leafy	Not needed	-
Red Brome	Bromus rubens	good	fair	slender	Not needed	20# N
Rose Clover	Trifolium hirtum	good	good	spindly	After seed sets	20-30# P_2O_5
Wimmera 62 Ryegrass	Lolium rigidum	fair	fair	slender	After seed sets	20# N
Zorro Fescue	Vulpia myuros	excellent	excellent	short & slender	Not needed	20# N

1 Lana Vetch is good seed producer but many of the seed are "hard". These will remain in the ground for a number of years before germinating.
2 Mowing of annual may be desirable for ascethic value.
3 Fertilizer should be applied when soil is dry as specified in criteria for fertilizing.

EXHIBIT 2

PERENNIAL GRASSES AND LEGUMES

Common Name	Botanical Name	Dry site but not Droughty	Low Velocity Channels	Plant Velocity Channels	Sod Forming	Growing Season	Mowing[2]	Fertilization
Creeping Wildrye	Elymus triticoides	Poor	Good	R	Good	Summer	4-6"	20-30 N
Durar Hard Fescue	Festuca ovina var. duriuscula	Good	Poor	B	Poor	Spring-fall	as needed	20 N
Fairway Crested Wheatgrass	Agropyron cristatum	Fair	Poor	B	Poor	Spring-fall	as needed	20 N
Greener Intermediate Wheatgrass	Agropyron intermedium	Fair	Poor	B	Poor		as needed	20 N
Harding grass	Phalaris tuberosa var. stenoptera	Poor	Poor	B	Poor	Spring-fall	4-6"	20 N
Largo Tall Wheatgrass	Agropyron elongatum	Poor	Poor	B	Poor	Spring	4-6"	20 N
Luna Pubescent Wheatgrass	Agronpyron trichophorum	Good	Good	R	Good	Fall	4-6"	20 N
Lutana Cicer Milkvetch	Astragulus cicer	Poor	Poor	R	Poor	Early summer	4-6"	20-40 P_2O_5
Norden Desert Wheatgrass	Agropyron desertorus	Good	Poor	B	Poor	spring & summer	4-6"	20 N
Oshe Intermediate Wheatgrass	Agropyron intermedium	Fair	Poor	R	Poor	Spring & fall	4-6"	20 N
Palestine Orchardgrass	Dactylis glomerata	Fair	Poor	B	Poor	Spring & fall	4-6"	20 N
Perla Koleagrass	Phalaris tuberosa var. hirtiglumis	Fair	Poor	B	Poor	Spring & fall	4-6"	20 N
Patomac Orchardgrass	Dactylis glomerata	Fair	Poor	B	Poor	Spring & summer	4-6"	20 N
Reeds Canarygrass (Cana)	Phalaris arundinaces	Poor	Good	R	Good	Year round	4-6"	30-40 N
Sherman Big Bluegrass	Poa ampla	Poor	Good	B	Poor	Spring & fall	4-6"	20 N
Tegmar Intermediate Wheatgrass	Agropyron intermedium	Good	Good	R	Good	Spring & fall	4-6"	20 N
Topar Pubescent Wheatgrass	Agropyron trichophorum	Fair	Good	R	Good	Spring & fall	4-6"	20 N
Yellow Sweet Clover	Melilotus officinalis	Fair	Poor	-	Poor	Spring-midsummer		20-40 P_2O_5

B - bunch
R - rhizomatous
S - stoloniferous, streambank wheatgrass

1 Maximum growth after establishment
2 Mowing should not be done until plants are established for weed control; mowing should be done before flowering stage of grasses seeded.

EXHIBIT 3

SITE CONDITIONS AND ESTIMATED EFFECTIVENESS OF "MULCHES" FOR PRE-EMERGENCE EROSION CONTROL

Mulch (Pre-emergence erosion control)	Site [1] Conditions for use	Pre-Emergence Erosion Control effectiveness
1. Straw Mulch a) Hand punching	Small areas or areas with rock or stones preventing use of equipment. Site which has been wattled.	5-7
b) Roller punching	Large areas without significant outcrops of rock or stone - on slopes 2.5:1 or less - can be used with wattling if space between wattling is available.	6-8
c) Crimper punching	Large areas without significant outcrops of rock or stone on slopes 2.5:1 or less.	6-8
d) Tacking agent	Best suited on very stoney or rocky soils - all slopes up to 2:1.	5-7
2. Hydromulching	Can be used in all areas within 200 feet of road or otherwise accessible by truck.	2-5[2]
3. Jute Netting with Straw or Wood Fiber	Areas must be relatively free of outcrops of rock, stone have less than 35% by volume of coarse fragments.	8-10
4. Erosion Control Blankets	Same as for jute netting with straw or wood fiber.	7-10

1 Estimated rating of effectiveness of mulch or pre-emergence erosion control (1 = minimal - 10 = excellent).

2 Seeding success much greater if seed incorporated into soil and hydromulch then applied.

GUIDE TO DETERMINE MAJOR LAND RESOURCE AREAS (MLRA)

MLRA	Elevation	Average Annual Rainfall	Slopes	Soils	Vegetation	Climate
17	50-300 ft.	18-25"	0-15%	10"-40" deep frequently with dense clay subsoil	cropland some scattered oak	hot dry summers cool moist winters fog may persist for long periods from early December to late February
18	300-1800 ft.	25-50"	15-50%	10"-20" to bedrock with frequent outcrops	annual grasses, oak with pine on north exposure some areas or thick stands of brush	hot dry summers cool moist winters
22c	1800-3000 ft. on north exposure 3000-4500 ft. on south exposure	30-80"	30-75%	10"-60" deep	conifer hardwood	warm dry summers cool moist winters with occasional snow
22d	over 3000 ft. on north exposure over 4500 ft. on south exposure	30-80"	30-75%	10"-60" deep	conifer hardwood	warm summers with some showers, cold moist winters, most precipitation as snow, soil subject to frost heaving
21	4500-6000 ft.	8-20"	2-50%	40-60" valleys 10-20" uplands	sagebrush, bitterbrush, scattered perennial grasses with some pine	hot dry summers with some showers cold winters with most precipitation as snow

PART IV
SPECIAL PRACTICES

CONTENTS

PART IV

SPECIAL PRACTICES

PROTECTION OF TREES IN URBANIZING AREAS

Definition: Protection of desirable trees from mechanical and other injury while the land is being converted to urban use.

Purpose: To employ the necessary protective measures to insure the survival of desirable trees for shade, beautification and vegetative cover.

Applicability: On areas now occupied by single specimen trees and groups of trees.

A. Criteria for deciding upon the trees to leave:

1. Esthetic values: Consideration should be given to autumn foliage, foliage, flowering habits, bark and crown characteristics and type of fruit.

2. Freedom from disease and rot: Some trees may be saved if properly pruned of infected limbs by a licensed tree service.

3. Life span of trees: Some are considered short-lived trees.

4. Wind firmness: Trees may be susceptible to wind damage and blow over easily if they have been growing in a close stand. Thinning may stabilize the stand for better wind firmness in the future.

5. Wildlife values: Habitat for nesting, feeding, or shelter of birds. Habitat, food supply, or shelter for mammals.

6. Comfort index: Summer temperatures are generally ten degrees cooler under stands of hardwoods than pines or cedars.

7. Sudden exposure: To direct sunlight and ability to withstand radiated heat from proposed building and pavement.

8. Space needed: For future growth and relationship to structures, electric and telephone lines, water and sewer lines and driveways. Mark trees with bright paint or ribbon so there is no doubt as to which trees are to be left and protected from damage during construction.

B. Criteria for protecting remaining trees:

1. Where existing ground levels are raised, drainage tiles will be placed at the old soil level and open into a well built around the base of the tree. This well can be left open or can be filled with coarse stones or gravel. Tiles may be installed in a radiating pattern or laid in parallel lines. The size of the well should be in proportion to diameter of tree and diameter of the radiating tiles. (Figure 3).

2. Trees within 25 feet of a building site shall be boxed in to prevent mechanical injury. (Figure 4).

3. Boards will not be nailed to trees during building operations (Figure 4).

4. Heavy equipment operators will be cautioned to avoid damage to existing tree trunks and roots during land leveling operations. Tunnel under root system when installing utility lines if possible.

5. Tree trunks and exposed roots and limbs damages during equipment operations, will be painted immediately with good grade of tree "paint".

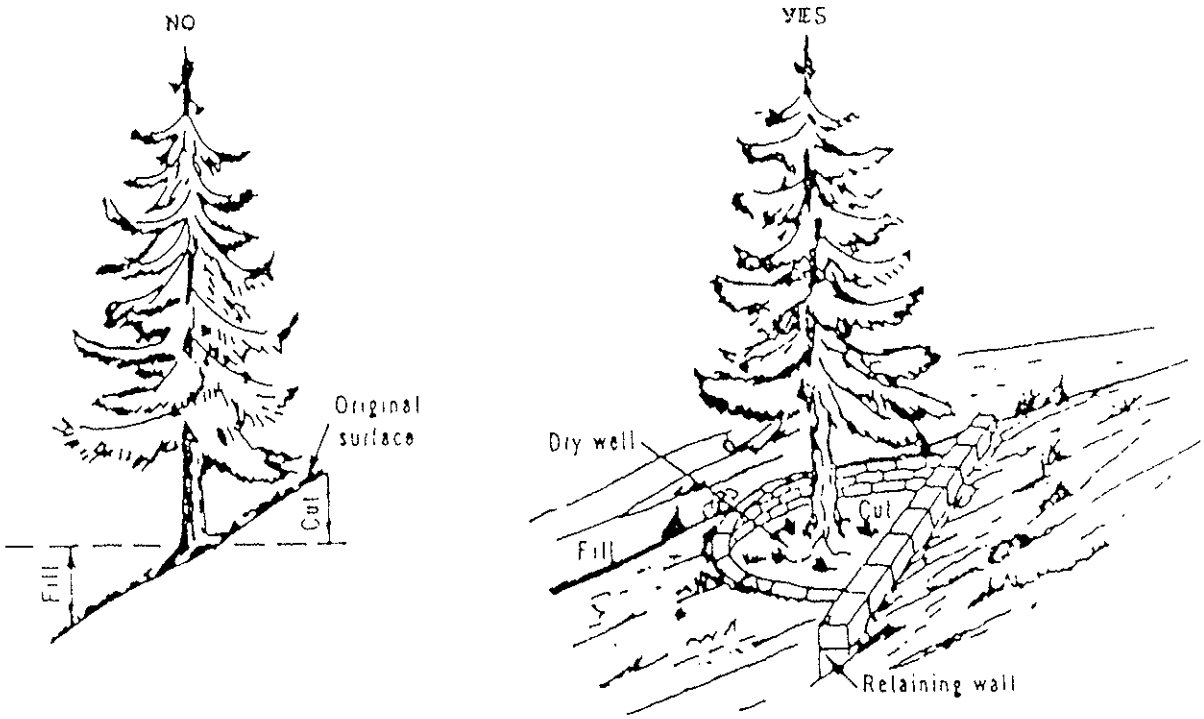
6. Wood chips when spread to a 6 inch depth can be used in wooded sites to help prevent soil compaction and damage to trees.

7. The use of heavy equipment on root systems of desirable trees should be avoided as much as possible to minimize soil compaction. All construction should be kept out of the drip line of protected trees.

8. During the first summer following construction, it is desirable that the trees receive adequate amounts of water. Excessive watering will cause disease infestations, combined with saturation of rooting area, and trees will become more susceptible to "wind throw".

CUTS AND FILLS

Excessive cuts or fills can kill a tree in a few weeks by destroying shallow feeder roots. Fertilizing, frequent watering and tree crown removal could be required to compensate for any damage to root system.



HANDLING EXCESSIVE FILL

Minor fills to 6 or 8 inches composed of noncompacted loamy topsoil material high in organic matter usually do not harm trees. Major fills will require drain tile on top of original surface and other treatment.

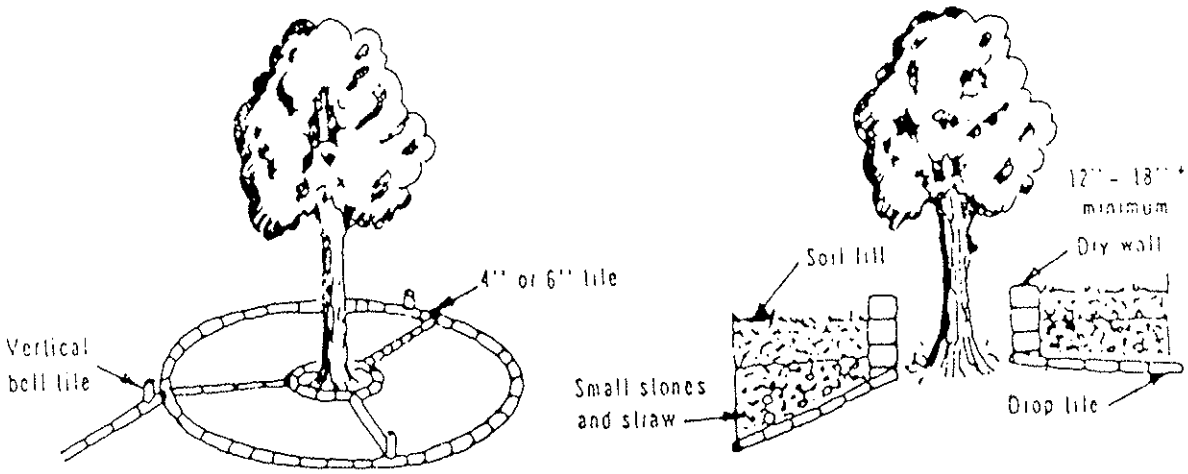
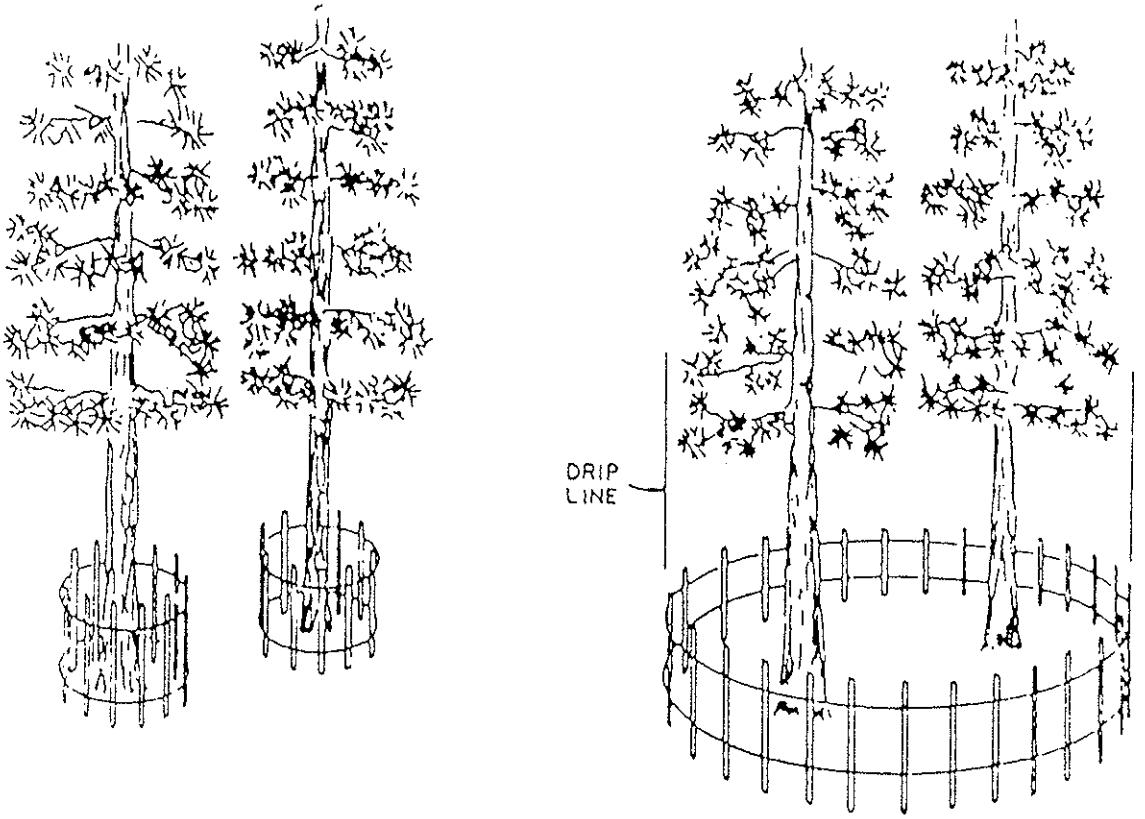
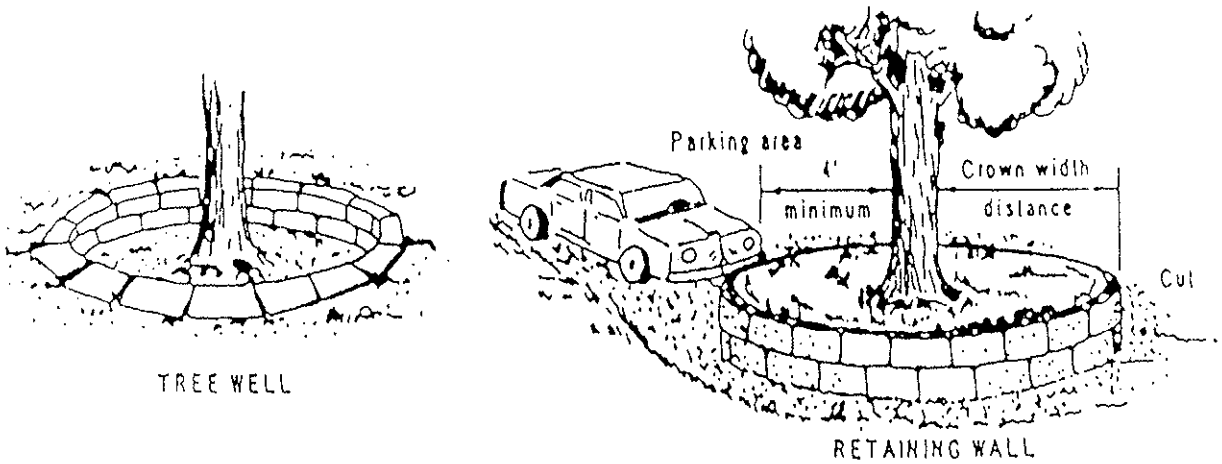


FIGURE 3



INCORRECT Temporary CORRECT

TREE PROTECTION FENCING



Permanent

WOODED AREAS

In densely wooded areas, tree removal should be done by experienced personnel to avoid damaging trees to be kept.

FIGURE 4

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GLOSSARY

AASHTO - American Association of State Highway and Transportation Officials (Formerly AASHO).

ACCEPTABLE OUTLET - That point where storm water run-off can be released into a watercourse or drainageway of adequate capacity without causing scour or erosion.

ACID SOIL - A soil giving an acid reaction throughout most or all of the portion occupied by roots. (Precisely, below a pH of 7.0; practically, below a pH of 6.6.)

ALLUVIAL FAN - A sloping, fan-shaped mass of sediment deposited by a stream where it emerges from an upland onto a plain.

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 - The angle between the horizontal and the maximum slope that a soil assumes through natural processes.

ANTI-SEEP COLLAR - An impermeable diaphragm usually of sheet metal or concrete constructed at intervals within the zone of saturation along the conduit of a principal spillway to increase the seepage length along the conduit and thereby prevent piping or seepage along the conduit.

ANTI-VORTEX DEVICE - A device, usually a vertical or horizontal plate, carefully designed and placed at the entrance of a pipe to prevent the formation of a vortex in the water at the pipe entrance.

APRON - A floor or lining to protect a surface from erosion. For example, the pavement below chutes, spillways, or at the toes of dams.

ASPECT - The direction a slope faces is a physiographic feature on steep slopes which influences plant growth and adaptation.

ASPHALT -
- Cutback - Asphalt thinned with lighter hydrocarbons such as kerosene or naphtha.
- Emulsion - An emulsion of water and asphalt.
- Liquid (in this application) - Asphalt which has a sufficiently low viscosity to be sprayed without thinning.

ATTERBERG LIMITS - Atterberg limits are soil properties measured for soil materials passing the No. 40 sieve.
Liquid Limit (LL) - The liquid limit is the water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil.
Plastic Limit (PL) - The plastic limit is the water content corresponding to an arbitrary limit between the plastic and semisolid states of consistency of a soil.
Plasticity Index (PI) - The plasticity index is the numerical difference between the liquid limit and plastic limit.

BAFFLES - Vanes, guides, grids, grating or similar devices placed in a conduit to deflect or regulate flow and effect a more uniform distribution of velocities

BARREL - The usually mildly sloping closed conduit used to convey water under or through a dam; part of a principal spillway.

BASE FLOW - The stream discharge from ground accretion.

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.

BERM - A shelf that breaks the continuity of a slope.

BIODEGRADABLE - Capable of being broken down (degraded) by common soil organisms.

BLIND DRAIN - A type of drain consisting of an excavated trench refilled with pervious material, such as coarse sand, gravel or crushed stone, through whose voids water percolates and flows to an outlet. Often referred to as a French drain because of its initial development and widespread use in France.

BLOOMY - Having a whitish, powdery, usually waxy coating on foliage.

BRACKISH (WATER) - Slightly to moderately salty water.

BULKHEAD - A wall made from wood, steel, concrete, etc. for protection of shoreline from waves or currents.

CALCIUM SULFATE - Gypsum. A hydrated form used to treat high sodium soils. $CaSO_4 \cdot 2H_2O$.

CHANNEL - A natural stream that conveys water; a ditch or channel excavated for the flow of water.

CHANNEL IMPROVEMENT - The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its water carrying capacity.

CHANNEL STABILIZATION - Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, structural linings, vegetation and other measures.

CHANNEL STORAGE - Water temporarily stored in channels while en route to an outlet.

CHECK DAM - A small dam constructed in a gully or other small watercourse to decrease the stream flow velocity (by reducing the channel gradient), minimize channel scour, and promote deposition of sediment.

CHUTE - A high velocity, open channel for conveying water to a lower level without erosion.

CLAY (SOILS) - 1: A mineral soil separate consisting of particles less than 0.002 millimeter in equivalent diameter. 2: A soil textural class. 3: (engineering) A fine grained soil (more than 50 percent passing the No. 200 sieve) that has a high plasticity index in relation to the liquid limit. (Unified Soil Classification System).

COMPACTION - To unite firmly. With respect to construction work with soils, engineering compaction is any process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per unit of volume, increasing the shear and bearing strength, and reducing permeability.

COMPOST - A mixture of vegetable refuse, manure or other organic matter which has gone through a decaying process.

CONDUIT - Any channel intended for the conveyance of water, whether open or closed.

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.

COOL (SLOPE, EXPOSURE) - A slope facing north or east, or a slope shaded during the hot part of the day.

CORDGRASS - Grasses of genus Spartina which are so named because of seed heads which have the appearance of coarse cord. These grasses are important soil binders along saltwater shorelines and marshes.

CORE TRENCH - See CUTOFF.

CRADLE (ENGINEERING) - A structure, usually of concrete, shaped to fit around the bottom and sides of a conduit to support the conduit, increase its strength, and in dams, to fill all voids between the underside of the conduit and the soil.

CREST - 1: The top of a dam, dike, spillway or weir, frequently restricted to the overflow portion. 2: The summit of a wave or peak of a flood.

CRITICAL AREA OR SITE - Sediment producing, highly erodible or severely eroded areas.

CRITICAL DEPTH (HYDRAULICS) - Depth of flow in a channel of specified dimensions at which specific energy is a minimum for a given discharge.

CRITICAL SLOPE (HYDRAULICS) - That slope which will sustain a given discharge at uniform critical depth in a given channel.

CROWN (OF SLOPE) - Top of slope; Apex.

CRUSHED STONE - Aggregate consisting of angular particles produced by mechanically crushing rock.

CULM - The stem of grasses, sedges and rushes which is jointed and usually hollow in grasses and usually solid in sedges and rushes.

CULTIPACKER - A corrugated roller used to crush clods, and eliminate coarse pores in soil by firming the seedbed.

CULTIPACKER SEEDER - In addition to being a cultipacker, this is a farm tool equipped with a seedbox which drops the seed between cultipacker rollers to place the seed on firm soil where they will be pressed into the soil by the second corrugated roller.

CUT - 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.

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 or other structure, such as a trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

CUTTINGS - A small shoot cut from a plant to start a new plant.

CYCLONE (SEEDER) - A hand turned or tractor drawn seeder that broadcasts seed onto the seedbed by a rotary motion that slings the seed outward from the seeder.

DAM - A barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion, or for retention of soil, sediment or other debris.

DEBRIS - Broken remains of plants, objects and rocks that form trash or remains.

DECIDUOUS - Plants that shed their leaves annually as opposed to evergreen.

DEPOSITION - The accumulation of material dropped because of a slackening movement of the transporting agent, water or wind.

DESICCATION - Drying out as of root systems of plants before they are planted.

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 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 stream flow or surface run-off which releases the stored water at controlled rates.

DIKE - (ENGINEERING) - An embankment to confine or control water. For example; one built along the banks of a river to prevent overflow of lowlands; a levee.

DISTINCT (BLOOM) - Blossoms of plants that are readily noticed.

DISTURBED AREA - An area in which the natural vegetative soil cover has been removed or altered, and therefore is susceptible to erosion.

DIVERSION - A channel with a supporting ridge on the lower side constructed across the slope to divert water from areas where it is in excess to sites where it can be used or disposed of safely. Diversions differ from terraces in that they are individually designed.

DOLOMITIC (LIMESTONE) - Liming materials that contain more than 6 percent magnesium (mg); High magnesium lime.

DRAIN (NOUN) - 1: A buried pipe or other conduit (subsurface drain). 2: A ditch or channel (open drain) for carrying off surplus surface water or groundwater.

DRAIN (VERB) - 1: To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or internal flow. 2: 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 AREA (WATERSHED) - All land and water area from which run-off may run to a common (design) point.

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. The drop may be vertical or inclined.

DROUGHTY (SOIL OR SLOPE) - Lacking medium to high moisture during part of the poor growing season during a typical year.

EMERGENCY SPILLWAY - A dam spillway designed and constructed to discharge flow in excess of the principal spillway design discharge.

ENERGY DISSIPATOR - A designed device, such as an apron of riprap or a concrete structure, placed at the end of a water transmitting apparatus such as a pipe, paved ditch or paved chute for the purpose of reducing the velocity, energy and turbulence of the discharged water.

ENTRANCE HEAD - The head required to cause flow into a conduit or other structure, including both entrance loss and velocity head.

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 happening much more rapidly than is normal, natural or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, other animals or natural catastrophes that expose base surfaces, for example, fires.

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 or 2 feet to as much as 75 to 100 feet. See GULLY.

Rill erosion - An erosion process in which numerous small channels only several inches deep are formed. See RILL.

Sheet erosion - The removal of a fairly uniform layer of soil from the land surface by run-off 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 run-off.

EROSION CONTROL BLANKET - A matting formed by binding a layer of straw, coconut fiber, or wood fiber with nylon netting. Usually biodegradable in one or two seasons. Used to protect seedings on steep slopes.

ESTHETIC (AESTHETIC) - Pleasing to look at.

EVERGREEN - Plants which have leaves or needles yearlong, as opposed to those that lose their leave during part of the year.

EXCELSIOR BLANKET - An erosion retardant material made from excelsior strands and held together with net-like strands of plastic or other material.

EXPOSURE (SLOPE) -

North - Slopes facing in any compass direction clockwise between N45W and S45E.

South - Those slopes which face in any compass direction clockwise between S45E and N45W.

FERRUGINOUS - Iron bearing: Usually refers to material of comparatively high iron oxide content.

FILTER CLOTH - A woven or non-woven geotextile fabric material used to separate layers of crushed stone or rock riprap and to prevent the erosion of soil particles through the rock layer. Also used to construct temporary filter fences.

FILTER STRIP - A strip of permanent vegetation above ponds, diversions and other structures to retard flow of run-off water, causing disposition of transported material, thereby reducing sediment flow.

FINES (SOIL) - Generally refers to the silt and clay size particles in soil.

FREEBOARD (HYDRAULICS) - The vertical distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures. Freeboard is provided to prevent overtopping due to unforeseen conditions.

FRONTAL DUNES - That row of dunes facing the ocean or other large body of water. Primary dunes.

GABION - A flexible woven-wire basket composed of two to six rectangular cells filled with small stones. Gabions may be assembled into many types of structures such as revetments, retaining walls, channel liners, drop structures and groins.

GABION MATTRESS - A thin gabion, usually six or nine inches thick, used to line channels for erosion control.

GEOTEXTILE FABRIC - A woven or non-woven polyester or polypropylene material designed for use with soils engineering, drainage and erosion control applications.

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 a canal bed, roadbed, top of embankment or bottom of excavation.

GRADE STABILIZATION - 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.

GRAFTING - A method of propagating plants by joining wood from one plant to another plant to get more desirable growth on the second plant.

GRASSED WATERWAY - A natural or constructed waterway, usually broad, shallow and covered with erosion resistant grasses, to convey surface water down the slope.

GRAVEL - 1: Aggregate consisting of mixed sizes of 1/4 inch to 3 inch particles which normally occur in or near old streambeds and have been worn smooth by the action of water. 2: A soil having particle sizes, according to the Unified Soil Classification System, ranging from the No. 4 sieve size (approximately 1/4 inch) to 3 inches. Particles may be natural gravel or angular in shape as produced by mechanical crushing.

GRAVEL ENVELOPE - Selected aggregate placed around the screened or perforated pipe section of a well casing, or a subsurface drain, to facilitate the entry of water into the well or drain.

GRAVEL FILTER - Washed and graded sand and gravel aggregate placed around a drain or well screen to prevent the movement of fine materials from the aquifer into the drain or well.

GROIN - A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shoreline.

GROUND COVER - Plants which are low-growing and provide a thick growth which protects the soil as well as providing some beautification of the area occupied.

GULLY - A channel or miniature valley cut by concentrated run-off through which water commonly flows only during and immediately after heavy rains or during the melting of snow. 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 lessor depth and would be smoothed by ordinary farm tillage.

GYPSUM - A hydrated form of calcium sulfate having a formula of $CaSO_4 \cdot 2H_2O$.

HARDEN OFF - Applying high phosphorous and potash fertilizer, in relation to nitrogen, causing plants to lose succulence; usually done before winter sets in to lessen winter kill of plants.

HEAD (HYDRAULICS) - 1: The height of water above any plane or 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 compounds terms such as pressure head, velocity head, and head loss.

HERBACEOUS PERENNIAL (PLANTS) - A plant whose stems die back to the ground each year.

HERBICIDE - Chemical formulations used to control weeds or brush.

HOT (REFERENCE TO SLOPE) - A slope facing in the direction from compass point S45E clockwise to N45W.

HULLED (SEED) - Hull-less seed, such as sericea lespedeza. Seed are usually processed after threshing to take off outer hull to facilitate scarification and quicken germination.

HYDRAULIC GRADE LINE - In a closed conduit a line joining the elevations to which water could stand in risers or vertical pipes connected to the conduit at their lower end and open at their upper end. In open channel flow, the hydraulic grade line is the free water surface.

HYDRAULIC GRADIENT - The slope of the hydraulic grade line. The slope of the free surface of water flowing in an open channel.

HYDRAULIC JUMP - The sudden turbulent rise in water level from a flow stage below critical depth to a flow stage above critical depth, during which the velocity passes from super critical to subcritical.

HYDRAULIC RADIUS - The cross sectional area of a channel divided by its wetted perimeter. The "r" in Manning's Formula.

HYDROGRAPH - A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

HYDROSEEDER - A machine designed to apply seed, fertilizer, lime and short fiber wood or paper mulch to the soil surface.

HYDROSEEDING - Seeding with a hydroseeder.

IMPACT BASIN - A type of energy dissipator that has a vertical impact wall inside a concrete structure, specifically the U.S. Bureau of Reclamation Type VI basin.

INDISTINCT - Blossoms are not readily noticed as opposed to large, showy blossoms.

INLET (HYDRAULICS) - 1: A surface connection to a closed drain. 2: A structure at the entrance end of a conduit. 3: The upstream end of any structure through which water may flow.

INTERCEPTOR DRAIN - A surface or subsurface drain, or a combination of both, designed and installed to intercept flowing water.

ISOBUTYLIDENE UREA - (IBDU) - A slowly soluble synthetic organic containing 31 percent nitrogen.

JUTE - A coarsely woven material of jute yarn which can be used to control soil erosion in waterways and on steep slopes.

LAYERING - A shoot or twig attached to the living stock for the purpose of propagation.

LIME - Basic calcareous materials used to raise pH of acid soils for benefit of plant being grown. May be either ground limestone or hydrated lime.

LITTORAL DRIFT - The sedimentary material moved in the littoral zone under the influence of waves and current.

MAJOR LAND RESOURCE AREAS (MLRA) - Consists of geographically associated land resource units (See below).

MAJOR LAND RESOURCE UNITS - Geographic areas of land, usually several thousand acres in extent, that are characterized by particular patterns of soil (including slope and erosion), climate, water resources, land use and type of farming.

MANNING'S FORMULA - A formula used to predict the velocity of water flow in an open channel or pipeline:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

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.

MULCH - Covering on surface of soil to protect and enhance certain characteristics, such as water retention qualities.

MULCH ANCHORING TOOL - A tool that looks like a dull disk designed to press straw and similar mulches into the soil to prevent loss due to wind, water or gravity.

NATIVE (GRASSES) - Naturally occurring; not introduced from other countries.

NATURAL GROUND - Ground surface which has not been disturbed by man.

NETTING (MULCH) - Plastic, paper or cotton material used to hold mulch material on the soil surface.

NITROGEN - FIXING (BACTERIA) - Bacteria having the ability to fix atmospheric nitrogen, making it available for use by plants. Inoculation of legume seeds is one way to insure a source of these bacteria for specified legumes.

NORMAL DEPTH - Depth of flow in an open conduit during uniform flow for the given conditions. See UNIFORM FLOW.

NOXIOUS WEEDS - Harmful; undesirable; hard to control.
Restricted - May be sold in the trade but are limited to very small amounts as undesirable contaminates.
Prohibited - Prohibited from sale.

NYLON FIBER BLANKET - A matting formed of a matrix of nylon fibers that is designed for ditch lining.

OUTFALL - The point where water flows from a conduit, stream or drain.

OUTLET - The point at which water discharges from such things as a stream, river, lake, tidal basin, pipe, channel or drainage area.

OUTLET CHANNEL - A waterway constructed or altered primarily to carry water from man-made structures such as terraces, subsurface drains, diversions and impoundments.

OVATE - Egg-shaped in outline and attached at the wide end.

OVERFALL - Abrupt change in stream channel elevation; the part of a dam or weir notch over which the water flows.

OVOID - A 3-dimensional solid, ovate in outline.

PADS - Individual pieces of sod cut to supplier's standard width and length.

PAPER FIBER - A short fiber mulch material usually applied by hydroseeder along with fertilizer and seed.

PARENT MATERIAL - The unconsolidated rock material from which the soil profile develops.

PENDULOUS - More or less hanging or inclined downward.

PERMANENT SEEDING - Results in establishing perennial vegetation which may remain on the area for many year.

PERMISSIBLE VELOCITY (HYDRAULICS) - The highest average velocity at which water may be carried safely in a channel or other conduit. The highest velocity that can exist through a substantial length of a conduit and not cause scour of the channel. Syn. safe, noneroding or allowable velocity.

pH - A number denoting the common logarithm of the reciprocal of the hydrogen ion concentration. A pH of 7.0 denotes neutrality, higher values indicate alkalinity, and lower values indicate acidity.

PHREATIC LINE - The upper surface of the zone of saturation in an embankment is the phreatic (zero pressure) surface; in cross section, this is called the phreatic line.

PIPING - Removal of soil material through subsurface flow channels or "pipes" developed by seepage water.

PLASTICITY INDEX - See ATTERBERG LIMITS.

PLASTIC LIMIT - See ATTERBERG LIMITS.

PLUGS - Pieces of turf or sod, usually cut with a round tube, which can be used to propagate the turf or sod by vegetative means.

PRESS WHEEL - A wheel which usually follows a seeding and presses seed into or on the surface of the seedbed.

PROCUMBENT - Lying down prone; trailing as a vine, usually not rooting at the nodes.

PROJECTION - In sediment basins or other dams the perpendicular distance that the anti-seep collar extends from the outside surface of the pipe or pipe cradle.

RAMPANT (GROWER) - Wild, unchecked climber; exceeding usual limits.

RESIDUES (PLANT) - Dead parts of plants which may be left on the soil surface following harvest, grazing or cutting.

RETENTION - The amount of precipitation on a drainage area that does not escape as run-off. It is the difference between total precipitation and total run-off.

REVETMENT - Facing of stone or other material, either permanent or temporary, placed along the edge of a stream or shoreline to stabilize the bank and protect it from the erosive action of water.

RHIZOME - Any prostrate, more or less elongated stem growing partly or completely beneath the surface of the ground; usually rooting at the nodes and becoming upcurved at the apex.

RIGHT-OF-WAY - Right of passage, as over another's property. A route that is lawful to use. A strip of land acquired for transport or utility construction.

RILL - A small channel cut by concentrated run-off but through which water commonly flows only during and immediately after rains or during the melting of snow. A rill is usually only a few inches deep (but no more than a foot) and, hence, no obstacle to tillage operations.

RIPPING - Pulling a chisel or subsoiling implement through the soil to reduce compaction and promote infiltration of water into the soil. Does not invert the soil.

RIPRAP - Broken rock, cobbles, or boulders placed 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 applies to brush or pole mattresses, or brush and stone, or similar materials used for soil erosion control.

ROUGHNESS COEFFICIENT (HYDRAULICS) - A factor in velocity and discharge formulas representing the effect of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.

RUN-OFF (HYDRAULICS) - That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include surface run-off, groundwater run-off or seepage.

SALINE SOIL - A non alkali soil containing sufficient soluble salts to impair plant growth.

SAND - 1: (Agronomy) A soil particle between 0.05 and 2.0 millimeters in diameter. 2: A soil textural class. 3: (Engineering) According to the Unified Soil Classification System, a soil particle larger than the No. 200 sieve (0.074mm) and passing the No. 4 sieve (approximately 1/4 inch).

SCRAMBLING (VINE) - Fast, disorganized growth.

SEDIMENT - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

SEDIMENTATION - Deposition of detached soil particles.

SEDIMENT DISCHARGE (SEDIMENT LOAD) - 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.

SEEPAGE - 1: Water escaping through or emerging from the ground. 2: The process by which water percolated through the soil.

SEEPAGE LENGTH - In sediment basins or ponds, the length along the pipe and around the anti-seep collars that is within the seepage zone through an embankment. See PHREATIC LINE.

SHEET FLOW - Water, usually storm run-off, flowing in a thin layer over the ground surface.

SIDE SLOPES (ENGINEERING) - The slope of the sides of a canal, dam or embankment. It is customary to name the horizontal distance first, as 1.5 to 1, or frequently, 1 1/2:1, meaning a horizontal distance of 1.5 feet to 1 foot vertical.

SILT - 1: (Agronomy) A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter. 2: A soil textural class. 3: (Engineering) According to the Unified Soil Classification System a fine grained soil (more than 50 percent passing the No. 200 sieve) that has a low plasticity index in relation to the liquid limit.

SLURRY - A thickened, aqueous mixture of such things as seed, fertilizer, short fiber mulch or soil.

SMALL GRAIN MULCH MATERIAL - Straw material from oats, barley, wheat, or rye.

SOD - A piece of earth containing grass plants with their matted roots. Turf.

SODDED WATERWAY - A grassed waterway vegetated by sodding with adapted species of grasses.

SOIL - 1: (Agronomy) 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.
2: (Engineering) Earth and rock particles resulting from the physical and chemical disintegration of rocks, and may or may not contain organic matter. It includes fine material (silts & clays), sand and gravel.

SOIL TEST - Chemical analysis of soil to determine needs for fertilizers or amendments for species of plants being grown.

SPECIFIC ENERGY - The energy of a stream referred to its bed, namely, depth plus velocity head of mean velocity.

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.

SPREADER (HYDRAULICS) - A device for distributing water uniformly in or from a channel.

SPRIG - A piece of rhizome or stolon without soil which may be used to vegetatively propagate plants such as Bermuda grass.

STABILIZATION - Providing adequate measures, vegetative and/or structural that will prevent erosion from occurring.

STABILIZED AREA - An area sufficiently covered by erosion resistant material such as a good cover of grass, or paving by asphalt, concrete or stone, in order that erosion of the underlying soil does not occur.

STABILIZED GRADE - The slope of a channel at which neither erosion nor deposition occurs.

STABLE (STREAM OR CHANNEL) - The condition of a stream, channel or other water course in which no erosion or deposition occurs; adequately protected from erosion.

STAGE (HYDRAULICS) - The variable water surface or the water surface elevation above any chosen datum.

STARVED (SHORELINES) - Shores which have receded or are receding due to losing more materials to waves and currents than is being deposited.

STATIC HEAD - Head resulting from elevation differences, for example, the difference in elevation in headwater and tailwater in a hydroelectric plant.

STILLING BASIN - An open structure or excavation at the foot of an overfall, conduit, chute, drop, or spillway to reduce the energy of the descending stream of water.

STOLON - A trailing or reclining above ground stem capable of rooting and/or sending up new shoots from the nodes.

STRAGGLING - Growing in a spread out or unplanned order.

STRUCTURAL - Relating to something constructed or built by man.

STRUCTURE (SOIL) - The combination or arrangement of primary soil particles into secondary particles, units or peds. (Dune sand is structureless).

SUBCRITICAL FLOW - Flow at velocities less than critical velocity.

SUBGRADE - The soil prepared and compacted to support a structure or a payment system.

SUBSOIL - Roughly that part of the soil below plow depth.

TAILWATER (HYDRAULICS) - Water, in a river or channel, immediately downstream from a structure.

TEMPORARY SEEDING - A seeding to provide temporary cover for the soil while waiting for further construction or other activity to take place.

TERRACE - An embankment or combination of an embankment and channel constructed across a slope at a suitable spacing to control erosion by diverting or storing surface run-off instead of permitting it to flow uninterrupted down the slope. Normally used only on cropland.

TEXTURE (SOIL) - The relative proportions of various soil separates in a soil material.

THATCH - A tightly intermingled layer of living and dead stems, leaves, and roots of grasses.

TIDAL BANKS - Vertical or sloping banks adjoining oceans, rivers, bays, estuaries, etc. which are affected by fluctuations of daily tides.

TIME OF CONCENTRATION - Time required for water to flow from the most remote point of a watershed, in a hydraulic sense, to the outlet.

TOE (OF SLOPE) - Where the slope stops or levels out. Bottom of the slope.

TOE WALL - Downstream wall of a structure, usually to prevent flowing water from eroding under the structure.

TOPSOIL - Presumably fertile or desirable soil material used to top-dress roadbanks, subsoils, parent material, etc.

TRAP EFFICIENCY - The capability of a reservoir to trap sediment. The ratio of sediment trapped to the sediment delivered, usually expressed in percent.

TRASH RACK - Grill, grate or other device at the intake of a channel, pipe, drain or spillway for the purpose of preventing oversize debris from entering the structure.

TUBERS - A thickened, short, usually subterranean stem having numerous buds called eyes; like a potato.

TUFTS - Having a cluster of hairs or other slender outgrowths; stems in a very close cluster.

TWIGGY - Having many fine branching stems; refers to wood shrubs or trees.

TWINING (VINE) - Ascending by coiling around a support.

UNHULLED (SEED) - Seed still encased with a hull. Example: Sericea lespedeza before it is rendered hull-less by mechanically removing the hull.

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 (USLE) - An equation used for the design of a water erosion control system:
A = RKLSCP wherein A is average annual soil loss in tons per acre per year; R is rainfall factor; K is soil erodibility factor; L is length of slope; S is percent of slope; C is cropping and management factor; and P is conservation practice factor.

UPLIFT (HYDRAULICS) - The upward force of water on the base or underside of a structure.

UREAFORM - URAMITE - UREAFORMALDEHYDE - A slowly soluble synthetic organic fertilizer containing 38 percent nitrogen which contains about 30 percent readily available nitrogen.

VARIETY - A variant within a species which reproduces true by seed or vegetative propagation as applicable.

VELOCITY HEAD (HYDRAULICS) - Head due to the velocity of a moving fluid, equal to the square of the mean velocity divided by twice the acceleration due to gravity (32.16 feet per second per second).

WATER SURFACE PROFILE (HYDRAULICS) - The longitudinal profile assumed by the surface of a stream flowing in an open channel; the hydraulic grade line.

WEEP-HOLES (ENGINEERING) - Openings left in retaining walls, aprons, linings or foundations to permit drainage and reduce pressure.

WETTED PERIMETER (HYDRAULICS) - The length of the line of intersection of the plane of the hydraulic cross section with the wetted surface of the channel.

WINDTHROW - State of being blown over by wind. Caused by shallow, pancake-like root systems in most cases.

WING WALL - Side wall extensions of a structure used to prevent sloughing of banks or channels and to direct and confine overfall.

WINTERKILL - Killed by low temperatures during winter months.

WOOD FIBER - A short fiber mulch material, usually applied with a hydroseeder in an aqueous mixture.