DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

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Pamphlet
No. 1110-1-16

28 February 1997

Engineering and Design
HANDBOOK FOR THE PREPARATION OF STORM WATER POLLUTION PREVENTION PLANS FOR CONSTRUCTION ACTIVITIES

1. **Purpose**. This pamphlet provides guidance for the preparation and development of plans for the prevention of storm water pollution at construction projects. Section 402 of the Federal Water Pollution Control Act (the Clean Water Act) requires that such plans be made.

2. **Applicability**. This pamphlet applies to HQUSACE elements and USACE commands having civil works and military construction responsibilities.

3. **Discussion**. In 1972, the CWA was amended to provide that the discharge of pollutants to waters of the United States from any point source is prohibited unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. In 1987, amendments to the CWA were added as Section 402(p) which established a framework for regulating municipal and industrial discharges of storm water under the NPDES. Regulations that established NPDES application requirements for these discharges were promulgated by the U.S. Environmental Protection Agency (EPA). In 1992, additional regulations broadened the classification for industrial discharges to include discharges associated with construction activities. EPA defined construction activities to include clearing, grading, or excavation that results in the disturbance of at least 5 acres of total land area. EPA regulations require that such activities disturbing 5 acres or more be regulated as an industrial activity and be covered by an NPDES permit. Construction activity on sites of less than 5 acres require an NPDES permit if the construction is part of a larger common plan of development or sale. Future revisions to the regulations are expected to require NPDES permits for construction activities at lest acres. Already some states are requiring an NPDES permit for construction sites less than 5 acres and for sites in environmentally sensitive areas.

4. **Intent**. The intent of this pamphlet is to provide the planner with guidance through the NPDES permitting process. It is not intended to be used as a directional or operations document.

FOR THE COMMANDER:

OTIS WILLIAMS
Colonel, Corps of Engineers
Chief of Staff

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1.0 INTRODUCTION

1.1 Purpose

This pamphlet provides guidance for the preparation and development of Storm Water Pollution Prevention Plans for construction projects. The requirement for such plans is regulated by Section 402 of the Federal Water Pollution Control Act (henceforth referred to as the Clean Water Act or the CWA).

1.2 Applicability

The pamphlet applies to HQUSACE elements and USACE commands having civil works and military construction responsibilities.

1.3 Explanation of Terms

Terms and abbreviations used in this pamphlet are defined in Appendix J.

1.4 Regulatory Background

In 1972, the CWA was amended to provide that the discharge of pollutants to waters of the United States from any point source is effectively prohibited unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Amendments to the CWA in 1987 added Section 402(p) to the Act, which established a framework for regulating municipal and industrial discharges of storm water under the NPDES. Regulations that established NPDES application requirements for regulated municipal and industrial storm water discharges were promulgated by the U.S. Environmental Protection Agency (EPA) and published in the Federal Register on 16 November 1990. Additional regulations promulgated by the EPA and published in the Federal Register on 9 September 1992 broadened the classification for industrial dischargers to include discharges associated with construction activities. EPA further defined construction activities to include any clearing, grading, or excavation which results in the disturbance of at least 2 hectares (5 acres) of total land area. The EPA regulations require that construction activities disturbing an area of 2 hectares or more be regulated as an industrial activity and covered by an NPDES permit. Construction activity on sites of less than 2 hectares requires a permit if the construction is part of a larger common plan of development or sale. Future revisions to the regulations are expected to require NPDES permits for construction activities at substantially less than 2 hectares. Presently, some states are requiring an NPDES permit for construction sites less than 2 hectares and for construction sites located in environmentally sensitive areas.

According to the Federal regulations, permit coverage for storm water discharges associated with construction activity can be obtained through *individual* permits or *general* permits. *Individual* permitting involves the submittal of specific data on a single construction project to the appropriate permitting agency who will issue a site-specific NPDES permit for the project. NPDES coverage under a *general* permit involves the submittal of a notice of intent (NOI) by the regulated construction project to comply with a *general* permit, to be developed by the EPA or a delegated State with general permitting authority.

The final Federal regulations (40 CFR 122.26[a][6]) require that storm water associated with industrial activity from point sources which discharge through a nonmunicipal storm sewer system be regulated either under a single NPDES permit issued to the system operator (the principal permittee) with each discharger to the system listed as a copermittee to the operator, or that each discharging entity to the nonmunicipal system obtain separate permit coverage. The sole permitting of the nonmunicipal system is not an available option according to the Federal regulations since the control of discharges into a private system is often beyond the control of the system operator. The selection of one of the two available options is at the discretion of the regulating authority.

1.5 Program Approach

In terms of implementing the final regulations, the states are divided into three basic categories: delegated NPDES states with general permitting authority; delegated NPDES states without general permitting authority; and states without NPDES delegated authority. Most states have moved toward implementation of the permitting process. However, not all state programs are in place at this time. Appendix A contains a list of contacts for each state, and readers are encouraged to contact the applicable regulatory representatives for up-to-date information early in the permitting process.

The first step in the NPDES permitting process is the development of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP has two major objectives: (1) to identify the source of pollutants that affect the quality of the industrial storm water discharge; and (2) to describe practices which shall be implemented to reduce the pollutants in the industrial storm water discharge. The SWPPP is a requirement of the storm water discharge permit and is considered by EPA to be a very important requirement of the NPDES permit. EPA requires the development of a SWPPP for each construction activity covered by a general permit. SWPPP's shall be prepared in accordance with good engineering practices emphasizing storm water Best Management Practices (BMP's) and complying with Best Available Technology Economically Achievable (BAT) and Best Conventional Pollutant Control Technology (BCT). The SWPPP shall identify potential sources of pollution which may reasonably be expected to affect storm water discharges associated with the construction activity. In addition, the SWPPP shall describe and ensure the implementation of practices which are to be used to reduce pollutants in storm water discharges associated with the construction activity and to assure compliance with the terms and conditions of this permit. Facilities must implement the provisions of the SWPPP required under this part as a condition of this permit.

This pamphlet is to be used as an environmental guidance manual for developing SWPPPs for construction activities. It is *not* designed or intended to be used as a *directional or operations document.* Any operations developed for construction activity must be in compliance with EPA and other Federal and state regulations. The storm water control measures and practices described herein should be used only when they meet or exceed all applicable EPA or other Federal and state regulations concerning the control of hazardous or toxic materials, erosion, sedimentation, storm water management, pollutants, and worker safety. Any pollution prevention measures used on a construction site, but not identified herein, should be included in the SWPPP.

Construction activities that are covered by the EPA baseline general permit (issued 3 September 1992) must have a completed SWPPP prior to mobilization. It must include the following:

1. Certifications required under Part IV.E of the general permit, prior to the submittal of a notice of intent (NOI) to be covered under the permit and updated as appropriate;

2. For construction activities that have begun on or before October 1, 1992, except for sediment basins required under Part IV.D.2.a(2) (structural practices) of the general permit, the plan shall provide for compliance with sediment basins required under Part IV.D.2.a(a) of the general permit by no later than December 1, 1992;

3. For construction activities that have begun after October 1, 1992, the SWPPP shall provide for compliance with the terms and schedule of the general permit beginning with the initiation of construction activities.

Other facilities that have filed an individual application must comply with the conditions of their individual permit, when issued. In most states, the SWPPP is not submitted to the permitting authority, but it must be retained onsite at the facility generating the discharge in accordance with Part V of the general permit. The SWPPP must be made available upon request to the Program Director; to a state or local agency approving erosion and sediment control plans, grading plans, or storm water management plans; or, in the case of discharge through a municipal separate storm sewer system with an NPDES permit, to the municipal operator of the system. The SWPPP must be available for review by the permit authority and the public. The permit authority may notify the construction activity representatives if the SWPPP for the construction activity does not meet the minimal requirements. Table 1-1 gives a brief description of each state's status, concerning SWPPP's, as of October 1993.

1.6 Statement of Policy for the Storm Water Pollution Prevention Plan

The U.S. Army Corps of Engineers (COE) intends to develop and implement the SWPPP (with the expressed cooperation of any tenants, contractors, or subcontractors (contractors)) for the purpose of minimizing the potential for the release of sediments and toxic or hazardous substances directly, or indirectly, to the storm drainage system. To achieve this objective, the responsibilities of both the COE and any contractors for the facilities they individually operate include:

- Implementing the policies and procedures presented in the SWPPP.
- Conducting periodic reviews of policies and procedures to evaluate the effectiveness of the current SWPPP.
- Updating the SWPPP and related materials whenever there is a significant physical change in a construction activity or a significant change in the operational procedures of a construction activity that could result in the discharge of pollutants to the storm water drainage system, or an increased risk of such discharge.

Table 1-1
Comparison of State General Permits for Industrial Storm Water Dischargers

Permits				SWPPPs					Monitoring		
State	No. of Permits	Expiration date	Fees	Completion deadline	Implementation deadline	Special rqts SARA Title III W.P.C.	Require PE cert.	Submit SWPPP	Monitoring required	Submit results	Rep. discharge allowed
EPA baseline permit	1	10/1/97	N	4/1/93	10/1/93	Y	Y(1)	N	Y;industry-specific, risk-based	Y(2)	Y
AL	15	mid to late 1997	Y	varies	varies	N	N	N*	varies	Y	Y(3)
AK**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
AZ**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
AR	1	9/30/97	Y	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
CA	1	1/15/97	Y	10/1/92	10/1/92	N	N	N	Y	Y	Y
CO	5	6/30/96	Y	5/1/93	11/1/93	Y*	N	Y(4)	Y*(4)	Y	Y
CT	1	10/1/97*	Y	4/1/93*	10/1/93*	N	Y	N*	Y(5)	N(6)	Y(7)
DE	1	8/6/98	Y	8/6/94	2/6/94	Y	N	N	Y(1)	N	Y*
FL**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
GA	1	5/31/98	N	12/31/93	5/31/94	N	N	N	Y	N	Y*
HI	1	10/29/97	Y	120 days after coverage	180 days after coverage	Y*	Y	Y	Y	Y	Y
ID**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
IL	1	10/1/97*	N	w/in 180 days of coverage	w/in 365 days of coverage	N	N	Y(8)	N	N	N
IN	permit by rule	none	Y	none	365 days after NOI	N	N	N	Y(5)	Y	Y

(Sheet 1 of 4)

Table 1-1 (Continued)

Permits				SWPPPs					Monitoring		
State	No. of Permits	Expiration date	Fees	Completion deadline	Implementation deadline	Special rqts SARA Title III W.P.C.	Require PE cert.	Submit SWPPP	Monitoring required	Submit results	Rep. discharge allowed
IA	1	10/1/97*	Y	4/1/93*	10/1/93*	Y*	N	N*	Y	Y(9)	Y*
KS	draft										
KY	7	10/1/97*	N	180 days after coverage	365 days after coverage	N	N	N*	Y(5)	N	Y
LA**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
ME**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y	N	Y
MD	1	9/28/97	Y	9/29/93	3/29/94	Y	N	N*	N	N	N
MA**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
MI	draft										
MN	1	9/30/97	Y	1 year from coverage	2 years from coverage	N	N	N	N	N	N
MS	98	7/13/97	N	4/1/93*	10/1/93*	Y	Y	Y	Y(10)	Y	Y
MO	many	varies	Y	varies	varies	varies	varies	varies	varies	varies	varies
MT	2	11/30/94	N(11)	6 months after coverage	12 months after coverage	N	N	Y	Y(5)	Y	Y
NE	1	varies	N	w/in 180 days of coverage	w/in 180 days of completion deadline	N	Y*	N	Y	Y	N
NV	3	5/14/98	Y	w/in 6 months of authorization	w/in 1 year of authorization	N	N	Y	Y(15)	Y(15)	N
NH**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
NJ	1	11/1/97	Y	5/2/93	11/2/94	N	N	N*	N	N	N
NM**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y(14)	Y	Y(13)

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Table 1-1 (Continued)

Permits				SWPPPs					Monitoring		
State	No. of Permits	Expiration date	Fees	Completion deadline	Implementation deadline	Special rqts SARA Title III W.P.C.	Require PE cert.	Submit SWPPP	Monitoring required	Submit results	Rep. discharge allowed
NY	1	8/1/98	Y	2/1/94	8/1/94	Y(14)	Y*	N*	Y	Y	Y*
NC	12	8/31/93	Y	12 months after coverage	12 months after coverage	Y(12)	N	N*(13)	Y(14)	Y	Y(13)
ND	2	3/31/95	N	w/in 90 days of coverage	w/in 180 days or 90 days of approval	Y*	Y*	Y(5)	Y	Y	Y(7)
OH	1	4/26/94	Y	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
OK**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
OR	12	9/30/96	Y	w/in 180 days of coverage	w/in 360 days of coverage	N	Y	N	Y(5)	Y	Y
PA	1	11/6/97	Y	before submitting NOI	before submitting NOI	Y	Y	N	Y	Y	Y*
RI	2		Y	4/1/93*	10/1/93*	Y*	Y*	N*	Y	Y*	Y*
SC	1	9/30/97	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
SD**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
TN	1	10/26/97	N	w/in 180 days of coverage	within 1 year of coverage	Y*	Y*	N*	Y	Y	Y
TX**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
UT	1	9/30/97	Y	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*(2)	Y*
VT**	1	10/1/97*	N	4/1/93*	10/1/93*	Y*	Y*	N*	Y*	Y*	Y*
VA	emergency permits										

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Table 1-1 (Concluded)

Permits				SWPPPs					Monitoring		
State	No. of Permits	Expiration date	Fees	Completion deadline	Implementation deadline	Special rqts SARA Title III W.P.C.	Require PE cert.	Submit SWPPP	Monitoring required	Submit results	Rep. discharge allowed
WA	1	11/18/95	Y	11/18/93	11/18/94	N	N	N*	N	N	N
WV	1	6/7/97	Y	w/in 180 days of coverage	w/in 365 days of coverage	Y*	Y*	N*	Y	Y	Y(13)
WI	draft										
WY	1	8/31/97	N	w/in 180 days of coverage	w/in 365 days of coverage				N	N	N

Note:

Abbreviations and footnotes:

SWPPP Storm Water Pollution Prevention Plan
SARA Superfund Amendments and Reauthorization Act
W.P.C. Water priority chemicals
* Same as EPA requirements
** EPA State
PE Professional Engineer
Y Yes
N No
(1) If SARA Title III water priority chemicals are involved
(2) Only for semiannual monitoring requirements
(3) Request-by-request basis
(4) Heavy industry only
(5) All permittees
(6) Unless acute toxicity exceeds minimum
(7) Subject to the 20-percent rule
(8) Annual reports submitted; not SWPPP
(9) Only those subject to effluent limitations
(10) SARA Title III, coal piles, wood treaters
(11) Anticipated later
(12) Semiannual inspections required
(13) Upon request and approval
(14) Must post onsite

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2.0 PLANNING, ORGANIZATION, AND SWPPP CERTIFICATION

2.1 Organization

The U.S. Army Corps of Engineers (COE) has developed a comprehensive approach to address the permitting of storm water discharges associated with construction activity. Due to the location and complexity of COE construction-related activities, the many contractors and subcontractors, and the number of projects related to COE operations and maintenance, the COE has elected to assume a role as a principal permittee with contractors who conduct construction activities at COE sites included as copermittees on the permit. Individual construction project operators (COE, tenants, and contractors) are responsible for the implementation of SWPPP provisions and the monitoring and reporting requirements of the general permit.

Many of the facilities under COE jurisdiction are comprised of numerous leaseholds and tenants which are part of a "larger common plan of development," (i.e., military installations). For this reason, COE will also require construction projects associated with these types of facilities which disturb less than 2 hectares (5 acres) to be included under permit coverage and thus subject to provisions of the SWPPP. COE will assemble a working list of proposed construction projects at each facility, and the list will be updated semiannually and incorporated into the SWPPP. COE will annually submit NOI's to cover construction activities at these types of installations.

This pamphlet is organized to function as a user's guide to meet SWPPP requirements. The step-by-step guidelines and checklists in the following sections are designed to assist in the organization of the required information. Using this information, the planner will develop and implement the SWPPP following the six basic phases listed below. Each phase is important and should be completed before advancing to the next one.

- Site Planning and Design Development Phase.
- Assessment Phase.
- Control Selection/Plan Design Phase.
- Notification/Approval Phase.
- Implementation/Construction Phase.
- Final Stabilization/Termination Phase.

Developing an SWPPP is basically a six-phase process. The first three phases are primarily the responsibility of the COE and any leasehold tenants planning construction activities. The final three phases are the joint responsibility of the COE and leasehold tenants and the construction site operators as co-permittees on a project-by-project basis. Because most aspects of the SWPPP take a significant amount of planning, its development must be closely connected to the development of the overall site plan for construction. Postconstruction storm water management controls must be considered in the planning stage.

The first phase in preparing an SWPPP for a construction project is to define the characteristics of the site and of the type of construction which will be occurring there. This phase is divided into three tasks: (1) Data collection, (2) Data Analysis, and (3) Site Plan Development. Section 3.0 describes these tasks in detail. The COE must address both project design considerations and the implementation of the SWPPP during construction and postconstruction phases of projects. Contractors will be primarily concerned with the implementation of the SWPPP during the construction and postconstruction phases of projects. The intent of this pamphlet is to place the various construction activities into perspective in terms of the intent of EPA with respect to storm water control of construction activities.

The reader should note the sections addressing special conditions, such as construction activities located on sites containing Title III, Section 313, water priority chemicals listed in the Superfund Amendments and Reauthorization Act of 1986 (SARA), and/or other priority pollutants. It is anticipated that most of the construction activities of the COE and leasehold tenants will not involve these special conditions, but some sites will—hence the inclusion of these sections. Appendix H lists the Section 313 water priority chemicals as published in the Federal Register on September 9, 1992. Since this list is subject to change, the designer should review 40 CFR 122 and 40 CFR 372 for the current list of priority pollutants.

In order to ensure that the plan is completely developed and adequately implemented, the regulations require that authorized representative(s) of the operator(s) sign and certify the plan. Section 2.4 details this requirement. Once the planning, design, and certification are completed, construction may commence. Section 6.0 details the requirements of implementation, documentation, and termination.

2.2 SWPPP Planning

The term planning could include the project as a whole as well as planning for the SWPPP. Design considerations for the project as a whole will affect the development of the SWPPP. Three tasks should be completed before developing the SWPPP document. These tasks are: (1) designating the person(s) responsible for developing and implementing the SWPPP, (2) reviewing existing pollution prevention plans for procedures which overlap the requirements and purpose of the SWPPP, such as state and local erosion and sedimentation regulations, and (3) reviewing and addressing specific permit regulations included in individual state NPDES Storm Water Permit requirements.

Designating a specific individual or team that will develop and implement the pollution prevention plan serves several purposes. Naming the individual or team members makes it clear that part of the job of the identified person(s) is to prevent storm water pollution. Identifying a specific individual(s) also provides a point of contact for those outside of the jobsite who may need to discuss aspects of the SWPPP.

Where setting up a pollution prevention team is appropriate, it is important to identify the key people onsite who know the construction activity and its operations well, and to provide adequate structure and direction for the construction activity's entire storm water management program. Specific activities of the pollution prevention team and the type and number of members vary for different sizes and types of projects.

Effective organization of the pollution prevention team is important in order for the team to accomplish the task of developing and implementing a comprehensive SWPPP. There are two important features in organizing a team of this nature: (1) selecting dedicated individuals to serve on the team and (2) establishing good channels of communication.

The formation and operation of any team involves decision-making and planning within a group environment. The team structure allows for people with different ideas and areas of expertise to share knowledge and collectively determine what works best for a particular construction activity. To broaden the base of involvement in the construction activity's storm water pollution prevention program, team members should represent all phases of the construction activity's operations.

It is advantageous to incorporate relevant provisions of best management practices (BMP's) or Spill Prevention and Control Countermeasure (SPCC) plans from other activities into the SWPPP. Many construction activities may already be subject to similar requirements under a number of different regulations. The following is a partial list of Federal regulations relevant to controlling potential releases to surface waters of hazardous wastes from the operations of construction activities (and their contractors):

- 29 CFR 1910 (Subparts G, H, I, J, and K) Hazardous Materials, Environmental Controls, and Personnel Protection.
- 29 CFR 1910.1200 OSHA Hazard Communication Standard.
- 40 CFR 112 Oil Pollution Prevention (SPCC Plans).
- 40 CFR 116,117 Hazardous Substances and Reportable Quantities.
- 40 CFR 122 NPDES Regulations (Storm Water Discharges).

- 40 CFR 260-262, 268, and 270-272 Hazardous Waste Management.
- 40 CFR 280-281 Underground Storage Tanks.
- 40 CFR 302 Designation, Reportable Quantities and Notification Requirements for Hazardous Substances Under CERCLA.
- 40 CFR 372 Toxic Chemical Release Reporting: Community Right-to-Know.
- 40 CFR 761 Toxic Substances.
- 49 CFR 171-173, 175, and 177 Department of Transportation Regulations.

It is the responsibility of the pollution prevention team to understand the NPDES Storm Water Permit requirements of the state where the construction activities are to take place and to determine which requirements of the SWPPP overlap with other plans or requirements and to so note them.

2.3 Storm Water Pollution Prevention Personnel

To ensure compliance with the NPDES permit regulations, it is necessary to establish a list of personnel who will be responsible for overseeing and coordinating and, when necessary, amending the policies, practices, and procedures of the SWPPP. These persons should be knowledgeable in construction operations and capable of understanding the technical aspects of the SWPPP. Trained personnel responsible for the execution of the SWPPP requirements should be available at the jobsite. Depending upon the size of the construction project and complexity of the SWPPP, it may be necessary to establish a team or committee of trained personnel to implement the SWPPP.

The personnel chosen should be identified by name and title. Exhibit D-1, in Appendix D, is provided to list names, titles, and phone numbers of the committee members. The storm water pollution prevention team concept is flexible and should be molded to conform to the resources and specific conditions of the construction activity. Specific activities of the storm water pollution prevention team and type and number of members vary for different projects.

The membership should be comprised of at least two responsible persons knowledgeable in the requirements of SWPPP.

For facilities leasing space to tenant operations, the SWPPP committee should include at least one representative from each tenant operation. The SWPPP committee will be responsible for overseeing the activities as outlined below and shall meet at least annually to address the implementation of these activities:

- Coordination of management in carrying out SWPPP objectives.
- Implementation of spill reporting procedures.
- Inspection programs for Stockpile Storage Areas.
- Identification of additional potential pollutant sources.
- Coordination of spill cleanup and containment activities.
- Reviewing the effectiveness of the SWPPP program.
- Updating the SWPPP program to comply with BMP policies and objectives.

2.4 SWPPP Certification

In order to ensure that the SWPPP is completely developed and adequately implemented, state-issued NPDES permits typically require that authorized representative(s) of the operator(s) sign and certify the plan. In signing the plan, the authorized representative certifies that the information is true and assumes liability for the plan.

Official signatures provide a basis for an enforcement action to be taken against the person signing the document. The permittee should be aware that Section 309 of the CWA provides for significant penalties where information is false or the permittee violates, either knowingly or negligently, the permit requirements. Specific signatory requirements for the SWPPP will be listed in the state-issued permits.

On the Federal level, the SWPPP certification must be signed in accordance with the provisions of Part VII. G of the baseline general permit. All reports, certifications, or other information required by the permit or requested by the permit authority shall be signed by a person described below:

1. For a corporation, by a responsible corporate officer. For the purposes of this section, a responsible corporate officer is a president, secretary, treasurer, or vice-president of the corporation in charge of principal business function, or any person who performs similar policy or decision-making functions for the construction activity; or the manager of the construction activity if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures;

2. For a partnership or sole proprietorship, by a general partner or the proprietor, respectively;

3. For a municipality, state, Federal, or other public agency, by either a principal executive officer or ranking elected official. For the purposes of this section, a principal executive officer of a Federal agency includes (1) the chief executive officer of the agency, or (2) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency.

The person who signs the document may also be a "duly authorized representative." A person is a duly authorized representative only if:

1. The authorization is made in writing by persons described above and retained as part of the SWPPP.

2. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated construction activity,

such as the position of manager, operator, superintendent, or position of equivalent responsibility for environmental matters for the company. A duly authorized representative may thus be either a named individual or any individual occupying a named position.

3. If an authorization is no longer accurate because a different individual or position has responsibility for the overall operation of the construction activity, a new authorization must be attached to the SWPPP prior to submittal of any reports, certifications, or information signed by the authorized representative.

The SWPPP must clearly identify the contractor(s) and/or subcontractor(s) who will be responsible for implementing the plan, and each must sign a copy of the certification located in Appendix F. A certification page must also be signed by a duly authorized representative of the COE and retained in the SWPPP document.

2.4.1 Notice of Intent

The NOI is essentially an application and contains important information about the site, including site location, owner information, operator (general contractor) information, receiving water(s), existing NPDES permit number, if any, an indication of existing quantitative data, and a brief description of the project. EPA has developed a one-page form to be used by industrial facilities and construction activities when they submit NOI's. A copy of the Federal NOI form is located in Appendix B.

There are different deadlines for submitting NOI's depending on the permitting authority responsible for issuing the NPDES permit. Time required to submit NOI's can vary from 2 days prior to construction for Federal regulated permits to over 120 days prior to construction for some states. The reader is referred to Appendix A for a list of state contacts to determine who and where the NOI is to be submitted. NOI's for the EPA general permit must be submitted directly to EPA's central processing center at the following address:

Storm Water Notice of Intent (4203)
401 M Street, S.W.
Washington, DC 20460

Each party or each of the parties who have day-to-day responsibilities for site operations and each party or each of the parties who have control over the designs and specifications necessary to ensure compliance with SWPPP requirements and permit conditions must be identified in the NOI. It is anticipated that there will be projects where more than one entity (e.g., the owner, developer, or general contractor) will need to submit an NOI so that both of the requirements for an operator are met. In this case, those persons will become co-permittees.

2.4.2 Plan Location and Public Access

Some NPDES-delegated states may require SWPPP's to be submitted to the Program Director for review and approval, whereas other permits may only require that plans be maintained onsite. Permitting authorities may prefer not to require plans to be submitted to reduce the administrative burden of reviewing a large number of SWPPP's. However, when the Director requests the plan, permittees should submit the plan in a timely manner. In addition, when requested, permittees should also submit their plan to state or local sediment and erosion or storm water management agencies, or to a municipal operator where the site discharges through an NPDES storm water permitted municipal separate storm sewer system. Readers are again urged to examine the issued permit carefully to determine what requirements apply to the SWPPP regarding plan submittal.

Regardless of whether or not the SWPPP is submitted to the permitting authority or other public agency, the SWPPP and supporting materials must be kept at the site of the construction activity at all times throughout the project. In maintaining plans onsite, the SWPPP committee should keep all records and supporting documents compiled together in an orderly fashion. The state-issued permit may require that all records be maintained for a certain period of time after the project is completed. The Federal regulations require permittees to keep the SWPPP and all reports and data for at least 3 years after the project is complete. This provision ensures that all records are available in case a legal situation arises for which documentation is necessary.

Despite the fact that plans and associated records are not necessarily required to be submitted to the Director, these documents are considered to be "reports" according to Section 308(b) of the CWA and, therefore, are available to the public. State-issued permits may require the submittal of copies of the SWPPP to the permitting authority, municipal operator, or state or local agency upon request. However, permittees may claim certain portions of their SWPPP as confidential according to the regulations at 40 CFR Part 2. Basically, these regulations state that records which contain trade secret information may be claimed as confidential.

2.5 Record of Revision

SWPPP elements will be modified as required (site inspections, additional BMPs, etc.) under the general permit by the appropriate COE SWPPP coordinator. Elements specific to tenant construction projects can be modified by the tenant project coordinator or duly authorized representative, as required under the general permit. Copies of any changes made by the tenant construction project coordinator must be immediately provided to the local COE SWPPP coordinator. The SWPPP will also be amended at any time it inadequately addresses conditions of the general permit or any amendments to the permit. The record of revision forms are located in Appendix G and are labeled Table G-1 and Exhibit G-1.

2.6 Special Requirements - SARA Title III, Section 313 Facilities

In addition to the minimum "baseline" requirements discussed previously, facilities may be subject to additional "special requirements." Not all facilities will have to include these special requirements in their SWPPP. Special permit requirements for all facilities regulated by SARA Title III, Section 313 [Emergency Planning and Community Right-to-Know Act (EPCRA)], include;

2.6.1 Control Measures

Control measures as listed below must be practiced in areas where Section 313 water priority chemicals are stored, handled, processed, or transferred: (A list of Section 313 water priority chemicals is located in Appendix H.)

- Provide containment, drainage control, and/or diversionary structures.
- Minimize discharges from liquid storage areas (install liquid materials in compatible storage containers and/or provide secondary containment or equivalent measures designed to hold the largest volume of the largest storage tank plus precipitation).
- Minimize discharges from material storage areas.
- Minimize discharges from loading/unloading areas (use drip pans and/or implement a strong spill contingency and integrity testing plan).
- Minimize discharges from handling/processing/transferring areas (use covers, guards, overhangs, door skirts and/or conduct visual inspections or leak tests for overhead piping).
- Minimize discharges from all the above-listed areas (use manually activated valves with drainage controls in all areas, and/or equip the plant with a drainage system to return spilled material to the storage facility).
- Introduce facility security programs to prevent spills (use fencing, lighting, traffic control, and/or secure equipment and buildings).

2.6.2 Preventative Maintenance

The SWPPP must include methods, controls, and procedures which will be incorporated to minimize, limit, and/or prevent leaks or spills of Section 313 water priority chemicals, as defined in the CWA, from occurring on the construction site. To prevent spills from occurring, these facilities are required to designate a person responsible for spill prevention, response, and reporting procedures. Any contaminated soil, material, or debris resulting from a spill of a priority chemical shall be removed promptly and disposed of in accordance with Federal, state, and local requirements and as described in the SWPPP. All areas of the construction activity must be inspected at appropriate intervals for the following as specified in the plan:

- Leaks or conditions that would lead to discharges of Section 313 water priority chemicals.
- Conditions that could lead to direct contact of storm water with raw materials, intermediate materials, waste materials or products thereof.
- Piping, pumps, storage tanks and bins, pressure vessels, process and material handling equipment, and material bulk storage areas for leaks, wind blowing loose material, corrosion, support or foundation failure, or other deterioration or noncontainment problems.

2.6.3 Training

Employees and contractor personnel must be trained in the following areas, at least once per year:

- Preventative measures, including spill prevention and response, construction activity inspections, and preventative maintenance.
- Pollution control laws and regulations.
- The construction activity's SWPPP.
- Features and operations of the construction activity that are designed to minimize discharges of Section 313 water priority chemicals, particularly spill prevention procedures.

2.6.4 Engineering Certification

Certain states require that SWPPP plans be reviewed and certified by a Registered Professional Engineer and recertified every 3 years or anytime the plan is significantly changed.

2.6.5 Monitoring Requirements

SARA Title III Section 313 facilities must monitor semiannually storm water discharges that come into contact with equipment, tanks, containers, or other vessels or areas used for storage of Section 313 water priority chemicals, or located at a truck or rail car loading or unloading area. Note that the permit provides an alternative to whole effluent toxicity (WET) testing. In lieu of monitoring for acute WET, the facility may monitor for pollutants that the facility "reasonably" believes are present onsite. Such determinations are to be based on reasonable best efforts to identify significant quantities of materials or chemicals present onsite. The pollutants are identified in Tables II and III of Appendix D of 40 CFR 122. Further, the permit provides that if the discharger certifies that industrial activities in a given drainage area are not exposed to storm water, monitoring is not required.

2.7 Special Requirements—Discharges to Municipal Separate Storm Sewer Systems

Additional requirements for storm water discharges associated with industrial activity discharging to municipal separate storm sewer systems serving a population of 100,000 or more include:

2.7.1 Compliance With Municipal Storm Water Management Programs

Activities must comply with applicable requirements in municipal storm water management programs developed under NPDES permits issued for the discharge of the municipal separate storm sewer system that receives the construction activity's discharge, provided the discharger has been notified of such conditions, in addition to complying with the permit requirements.

2.7.2 Availability of Plans

Permittees which discharge storm water associated with industrial activity through a municipal separate storm sewer system serving a population of 100,000 or more must make plans available to the municipal operator of the system upon request.

2.8 Special Requirements—Releases of Reportable Quantities

Due to the fact that construction activities may handle certain hazardous substances over the course of the project, spills of these substances in amounts that equal or exceed Reportable Quantity (RQ) levels are a possibility. EPA has issued regulations which define what reportable quantity levels are for oil and hazardous substances. These regulations are found at 40 CFR Part 110, 40 CFR Part 117, or 40 CFR Part 302. For oil, if an oily sheen is detectable in the storm water runoff, the reportable quantity level has been exceeded. For hazardous substances, the final RQ levels depend on the chemical. For example, for dieldrin, a pesticide, the level is 1 kilogram (kg). If there is a spill or other release of 1 kg or more, the RQ threshold has been exceeded. Spill events such as these can be avoided if the SWPPP addresses this possibility. Section 4 discusses spill prevention and control.

3.0 SITE DESCRIPTION

3.1 Data Collection/Data Analysis

An inventory of the existing site conditions which will be used in the development of the SWPPP will be required. The information obtained should be both plotted on a map and verbally explained in this portion of the plan. After all data are considered, an assessment of the site potentials and limitations should be made. The site planner or designer should be able to determine those areas which have critical pollutant generation potential. The following are some of the most important considerations in site analysis.

3.1.1 Topography

A small-scale topographic map of the site should be prepared to show the existing contour elevations at intervals of from 0.3 to 1.5 meters (1 to 5 feet) depending upon the slope of the terrain. Existing topographic maps (e.g., U.S. Geological Survey (USGS) or local government topos) can be a good starting point; however, the information should be verified by a field investigation. The primary topographic considerations are slope steepness and slope length. Because of the effect of accumulated runoff, erosion potential is greater on long, steep slopes. When the percent slope has been determined, areas of similar steepness should be outlined. Slope gradients can generally be grouped into three general ranges of soil erodability:

Slope	Erosion Hazard
0-7%	Low erosion hazard
7-15%	Moderate erosion hazard
>15%	High erosion hazard

Within these slope gradient ranges, the erosion hazard becomes greater as the slope length increases. Therefore, in determining potential critical areas, the site planner should be aware of excessively long slopes. As a general rule, the erosion hazard will become critical if the slope exceeds the following criteria:

Slope	Critical Length, meters (feet)
0-7%	91 (300)
7-15%	46 (150)
>15%	23 (75)

3.1.2 Drainage Patterns

All existing drainage swales and patterns on the site should be located and clearly marked on the topographic map. Perennial or intermittent streams, as well as wetland areas, should also be shown on the map. The existing drainage patterns, which consist of overland flow, swales and depressions, and natural watercourses, should be identified in order to plan around critical areas where water will concentrate. Where possible, natural drainageways should be used to convey runoff over and off the site to avoid the expense and problems of constructing an artificial drainage system. Man-made ditches and waterways can become part of the erosion problem if they are not properly designed and constructed. Care should also be taken to be sure that the increased runoff from the site will not erode or flood the existing natural drainage system. Possible sites for storm water detention should be located at this time.

3.1.3 Soils

Major soil type(s) on the site should be shown on the topographic map. Soils information can be obtained from a soil survey if one has been published for the county in which the project is proposed. If a soil survey is not available, a request can be made to a district Soil Conservation Service (SCS) office, a county extension service, or a state or Federal Department of Agriculture. Commercial soils evaluations may also be available. Soils information should be plotted directly onto the map or an overlay of the same scale for ease of interpretation. Such soils properties as natural drainage, depth to bedrock, depth to seasonal high water table, permeability, shrink-swell potential, texture, and erodibility should exert a strong influence on land development decisions.

3.1.4 Ground Cover

The existing vegetation such as tree clusters, grassy areas, and unique vegetation should be shown on the map. In addition, existing denuded or exposed soil areas should be indicated. Ground cover is the most important factor in terms of preventing erosion. Any existing vegetation which can be saved will help prevent erosion. Trees and other vegetation protect the soil, as well as beautify the site after construction. If the existing vegetation cannot be saved, the planner should consider staging construction and using temporary seeding or temporary mulching. Staging of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at one time. Temporary seeding and mulching involve seeding or mulching areas which would otherwise lie exposed for long periods of time. Thus, the time of exposure is shortened and the erosion hazard is reduced.

3.1.5 Adjacent Areas

Areas adjacent to the site should be delineated on the topographic map. Features such as streams, roads, houses or other buildings, and wooded or wetland areas should be shown. Streams which will receive runoff from the site should be surveyed to determine their carrying capacity. The analysis of adjacent properties should focus on areas downslope from the construction activity. Of major concern are watercourses which will receive direct runoff from the site. The potential for sediment pollution of these watercourses should be considered, as well as the potential for downstream channel erosion due to increased volume, velocity, and peak flow rate of storm water runoff from the site. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be analyzed so that appropriate sediment-trapping measures can be planned and installed prior to any land-disturbing activity. Drainage from large areas upstream from proposed active construction sites should be diverted around the sites wherever possible. Whenever possible, diversionary drainage channels should be established and stabilized before active site disturbance activities begin.

3.1.6 State/Local Requirements

Federal, state, and local agencies that undertake land-disturbing activities are generally regulated by the same authorities that regulate private land-disturbing activities. Readers are encouraged to contact local jurisdictional agencies such as the County Engineer regarding permits, fees, and plan submission, as well as any other requirements. Facilities which are already operating under approved state or local sediment and erosion plans, grading plans, or storm water management plans are required to submit copies of the NOI to the agency approving such plans in accordance with Part II.A of the general permit (or sooner where required by state or local rules), in addition to submitting the NOI to EPA or the NPDES-delegated authority in accordance with paragraph II.C of the general permit.

3.2 Site Plan Development

The permits issued by NPDES-delegated states will specify deadlines for plan development and implementation. The sequence of events, assumably, will be that the SWPPP's will be completed and implemented at the time the project breaks ground and revised, if necessary, as construction proceeds. The SWPPP should be in place before project initiation because construction operations pose environmental risks as soon as activity begins. The initial clearing and grubbing operation may contribute a significant amount of pollutants to storm water runoff. The reader is urged to read the applicable permit carefully to determine what dates and deadlines apply to the project.

The planning for pollution prevention measures should be done concurrently with the development of the construction plans. The best SWPPP's are developed at the same time as the design of the site plan. However, if the site design has already been completed, it is not necessary to start the process all over again. Much of the information needed for the

SWPPP should already be included in the design documents. An SWPPP can be prepared for most construction projects by using information from the existing design, and modifying the design to accommodate the controls.

After analyzing the data and determining the site limitations, the planner can develop a site plan. When designing the site plan, the planner should keep in mind that increases in runoff may require structural runoff control measures or channel improvements. Both items are expensive, and even more so when the site plan has to be redesigned to accommodate the runoff control measures. Therefore, the planner should minimize the increase in runoff or include runoff control measures in the initial design. The following are some issues to consider when developing the site plan.

3.2.1 Controlled Grading

The development of an area should be tailored to the existing site conditions. This tailoring will avoid unnecessary land disturbance, thereby minimizing the erosion hazards and costs. Excessive cutting and filling should be avoided, if possible. Slopes should be at a maximum of 2:1 or less, depending on soil type to provide for final stabilization.

3.2.2 Critical Areas

Land disturbance in critically erodible areas may necessitate the installation of more costly control measures. See criteria for critical areas in Section 3.1.1.

3.2.3 Cluster Development

Whenever possible, developments in which facilities are clustered together, or performance of construction is in a sequence of clusters, is a desired approach. The cluster concept minimizes the amount of disturbed area, concentrates utility lines and connections in one area, and provides more open natural space. The cluster concept not only lessens the erodible area, but it generally reduces runoff and generally reduces development costs.

3.2.4 Minimization of Imperviousness

Keep paved areas such as parking lots and roads to a minimum. This pavement minimization goes hand-in-hand with cluster development in eliminating the need for duplicating parking areas and access roads. The more land that is kept in vegetative cover, the more water will infiltrate, thus reducing runoff and erosion.

3.2.5 Utilization of Natural Drainage

If the natural drainage system of a site has been determined that it can properly handle runoff generated during and after construction activities without resulting in bank and bed erosion, the natural system should be preserved instead of being replaced with storm sewers or concrete channels.

3.3 Storm Water Runoff Calculations

The problems associated with storm water runoff in rapidly urbanizing watersheds have become well known. These problems relate both to the quantity and quality of storm water runoff. Major problems include increased flooding magnitude and frequency, accelerated stream channel erosion, and water quality degradation. The basic underlying cause of these problems is not difficult to understand. The hydrologic systems which have reached a natural equilibrium over centuries simply cannot adjust to the sudden impact of urban development. Flooding occurs because the increased volume and peak rate of runoff exceed the natural carrying capacity of the streams. Stream channel erosion accelerates due to suddenly increased flow velocities and flooding frequency. The water quality itself is degraded by sedimentation and numerous other pollutants associated with urbanization that become available to be washed off the land surface and into water resources.

Studies have shown that most natural stream channels are formed with a bankfull capacity to pass runoff from a storm with a 1.5- to 2-year recurrence interval. As upstream development occurs, the volume and velocity of flow from these relatively frequent storms increase. Consequently, even smaller storms with less than 1-year recurrence intervals begin to cause streams to flow full or flood. According to one study, stream channels are subject to a three- to five-fold increase in the frequency of bankfull flows in a typical urbanizing watershed. This increase in the flooding frequency places a stress on the channel to adjust its shape and alignment to accommodate the increased flow. Unfortunately, this adjustment takes place in a very short time in geologic terms, and the transition is usually not a smooth one. Meandering stream channels, which were once parabolic in shape and covered with vegetation, typically become straight, wide rectangular channels with barren vertical banks. This process of channel erosion often causes significant property damage, and the resulting sediment is transported downstream, further contributing to channel degradation.

One strategy for dealing with this problem is to increase the carrying capacity and stability of affected streams through channel modifications. This strategy may be employed most effectively on man-made channels or small, intermittent streams. Significant modifications to natural, continuous flowing streams, however, can be the subject of intense local controversy.

Wherever modifications to natural flowing streams are being considered, extreme care must be taken to weigh the benefits of such modifications against the cost and the concerns of the local citizens. Where channel modifications are necessary, an attempt should be made to incorporate conservation practices that will minimize adverse impacts to fish, wildlife, and the aesthetic quality of the stream. In general, erosion and sedimentation controls, and the overall SWPPP, are focused on preserving existing streamflow quantity and quality, whenever possible.

The following storm water runoff requirements were developed to provide guidance for designers and planners in the absence of state regulatory guidance or local storm water management programs. These criteria are considered "rule of thumb" minimums:

- Increased volumes of sheet flow that may cause erosion or sedimentation on adjacent property must be diverted to a stable outlet, *adequate* channel, or detention facility.

- Concentrated storm water runoff leaving a development site must be discharged directly into an *adequate* natural or man-made receiving channel, pipe, or storm sewer system.

- An adequate channel is defined as "a watercourse that will convey a chosen frequency storm event without overtopping its banks or causing erosive damage to the bed, banks, and overbank sections of the watercourse."

- A receiving channel may be considered *adequate* if the total drainage area to the point of analysis in the channel is 100 times greater than the contributing drainage area of the project site.

- For natural channels, the 2-year frequency storm is used to verify that storm water will not overtop the channel banks nor cause erosion of the channel bed or banks.

- For man-made channels, the 10-year frequency storm is used to verify that storm water will not overtop the channel banks and the 2-year storm is used to demonstrate that storm water will not cause erosion of the channel bed or banks.

- For pipes and storm sewer systems, the 10-year frequency storm is used to verify that storm water will be contained within the pipe or storm sewer.

If existing natural receiving channels or previously constructed man-made channels or pipes are not *adequate*, the applicant must choose one of the following options.

- Improve the channels to a condition where the 10-year frequency storm will not overtop the channel banks and the 2-year frequency storm will not cause erosion to the channel bed or banks. The applicant must provide evidence of permission to make the improvements.

- Improve the pipe or storm sewer system to a condition where the 10-year frequency storm is contained within the appurtenances. The applicant must provide evidence of permission to make the improvements.

- Develop a site design such that when runoff discharges directly to a natural channel, the postconstruction peak flow for the 2-year storm will be no greater than the predevelopment peak flow. When discharge is directed to a man-made channel, the postconstruction peak flow for the 10-year storm will be no greater than the predevelopment peak flow.

- Provide a combination of channel improvements, storm water detention, or other measures satisfactory to the plan-approving authority to prevent downstream erosion.

If the applicant chooses an option that includes storm water detention, the applicant must obtain approval from the locality for a plan for maintenance of the detention facility. The plan must establish the maintenance requirements for the facility and identify the person or entity responsible for performing the maintenance.

Each receiving channel must be tested for *adequacy*. A channel is considered adequate if any of the following conditions can be met:

- The bankfull capacity of the *natural* receiving channel is sufficient to pass the postdevelopment peak flow from the 2-year frequency storm *and* the channel velocity (2-year frequency storm) does not exceed the permissible (non-erodible) velocity of the channel lining.
- The bankfull capacity of the *man-made* receiving channel is sufficient to pass the postdevelopment peak flow from the 10-year frequency storm *and* the channel velocity (2-year frequency storm) does not exceed the permissible (nonerodible) velocity of the channel lining.
- The storm sewer conduits (pipes) must pass the 10-year frequency storm.
- The contributing drainage area of the development site is less than 1 percent of the total drainage area to the point of consideration in the channel.
- There is no increase in the peak runoff rate for the 2-year frequency storm (for natural receiving channels) or the 10-year frequency storm (for man-made channels) at the point of discharge after development.

If the receiving channel is found to be *inadequate*, the applicant should incorporate measures to either improve the receiving channel to an adequate condition, or detain runoff on the site so that the postdevelopment peak runoff rate for the 2-year storm will not exceed the predevelopment peak rate. The plan-approving authority may also approve a combination of channel improvements and detention or other measures deemed satisfactory to protect the channel

- If a channel-improvement option is chosen, the applicant must obtain necessary easements and comply with applicable regulations regarding channel modifications. Channel improvements must extend downstream until an adequate channel section is reached or until a point is reached where the total drainage area is at least 100 times greater than the drainage area of the development site.
- If a storm water detention option is chosen, the applicant must submit a plan for the continued maintenance requirements of the structure and designate someone, who has consented to be responsible, to carry out the maintenance. The local government may choose to accept the maintenance responsibility for detention structures. However, where the local government does not accept responsibility, the responsibility must be borne by the COE, other Federal agency, landowner, a homeowners' association, or other legal entity.

3.3.1 Calculation Method

Selection of the appropriate method of calculating runoff should be based upon the size of the drainage area and the output information required. Table 3-1 lists the acceptable calculation methods for different drainage areas and output requirements. The plan-approving authority may require or accept other calculation methods deemed more appropriate for local conditions.

3.4 Erosion and Sediment Control Plan

Simply stated, an erosion and sediment (E&S) control plan is a document that describes the measures to be taken to control the potential for erosion and sedimentation on a construction project.

Table 3-1
Runoff Calculation Methods: Selection Criteria

Calculation Methods*

1. Rational Method
2. Peak Discharge Method
3. Tabular Method (TR-55)
4. Unit Hydrograph Method

Output Requirements	Drainage Area	Appropriate Calculation Methods
Peak discharge only	Up to 81 hectares (200 acres) Up to 809 hectares (2,000 acres) Up to 52 sq km (20 square miles)	1,2,3,4 2,3,4 3,4
Peak discharge and total runoff volume	Up to 809 hectares (2,000 acres) Up to 52 sq km (20 square miles)	2,3,4 3,4
Runoff hydrograph	Up to 52 sq km (20 square miles)	3,4

* There are numerous publications that describe the four methods listed in Table 3-1. A comprehensive discussion of each of these methods is beyond the scope of this pamphlet; readers are encouraged to consult other sources. One such source is McCuen, Richard H., *Hydrologic Analysis and Design*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1989.

The E&S control plan should be an independent entity from the construction drawings of a project. While it is a good idea to include E&S control standards and specifications in contract documents, the E&S control plan itself should contain measures to ensure that the controls are installed, inspected, and maintained properly.

The plan narrative should explain the E&S control decisions made for a particular project and the justification for those decisions. The narrative is especially important to the plan-approving authority because it contains concise information concerning existing site conditions, construction schedules, and other pertinent items which are not apparent in a typical site plan. Since a plan reviewer cannot always visit the site or discuss the project at length with the site planner, it is essential that the necessary information be provided for the plan review.

The narrative is also important to the construction superintendent and inspector who are responsible for seeing that the plan is implemented properly. The narrative provides them with a single report that describes where and when the various erosion and sediment control practices should be installed.

An E&S control plan must contain sufficient information to satisfy the plan-approving authority that the problems of erosion and sedimentation have been adequately addressed for a proposed project. The length and complexity of the plan should be commensurate with the size of the project, the severity of site conditions, and the potential for offsite damage. Obviously, a plan for constructing a small structure on smaller area does not need to be as complex as a plan for a large multistructure project involving many acres. Also, plans for projects undertaken on flat terrain will generally be less complicated than plans for projects constructed on steep slopes where erosion potential is greater. The greatest level of planning and detail should be evident on plans for projects which are directly adjacent to flowing streams, dense population centers, or high value properties where damage may be particularly costly or detrimental to the environment. As a guide to E&S plan content, the site planners should use the checklists located on the following pages.

CHECKLIST

FOR EROSION AND SEDIMENT CONTROL PLANS

NARRATIVE

_____ Project description - Briefly describe the nature and purpose of the land-disturbing activity and the area (hectares or acres) to be disturbed.

_____ Existing site conditions - Describe the existing topography, vegetation, ground cover, and drainage.

_____ Adjacent areas - Describe neighboring areas such as streams, lakes, residential areas, and roads which might be affected by the land disturbance.

_____ Offsite areas - Describe any offsite land-disturbing activities that will occur (including borrow sites, waste or surplus areas, etc.). Will any other areas be disturbed?

_____ Soils - Describe the soils on the site giving such information as soil name, mapping unit, erodibility, permeability, depth, texture, and soil structure.

_____ Critical areas - Describe areas on the site which have potentially serious erosion problems (e.g., steep slopes, channels, and wet weather/underground springs).

_____ Erosion and sediment control measures - Describe methods which will be used to control erosion and sedimentation on the site.

_____ Permanent stabilization - Provide a brief description, including specifications, of how the site will be established after construction is completed.

_____ Storm water runoff considerations - Will the development site cause an increase in peak runoff rates? Will the increase in runoff cause flooding or channel degradation downstream? Describe the strategy to control storm water runoff.

_____ Calculations - Present detailed calculations for the design of temporary sediment basins, permanent storm water detention basins, diversions, channels, etc. Include calculations for pre- and postdevelopment runoff.

CHECKLIST
FOR EROSION AND SEDIMENT CONTROL PLANS
(continued)

SITE PLAN

_____ Vicinity map - Provide a small map locating the site in relation to the surrounding area. Include any landmarks which might assist in locating the site.

_____ North arrow - Indicate the direction of north in relation to the site.

_____ Limits of clearing and grading - Show areas which are to be cleared and graded.

_____ Existing contours - Show the existing contours of the site.

_____ Final contours - Indicate changes to the existing contours, including final drainage patterns.

_____ Existing vegetation - Show the existing tree lines, grassed areas, or unique vegetation.

_____ Soils - Show the boundaries of different soil types.

_____ Existing drainage patterns - Indicate the dividing lines and the direction of flow for the different drainage areas. Include the size (area in hectares or acres) of each drainage area.

_____ Critical erosion areas - Show areas with potentially serious erosion problems.

_____ Site development - Show all improvements such as buildings, parking lots, access roads, and utility construction.

_____ Location of practices - Show the locations of erosion and sediment controls and storm water management practices used on the site.

_____ Offsite areas - Identify any offsite land-disturbing activities (e.g., borrow sites and waste areas). Show location of erosion controls. (Is there sufficient information to assure adequate protection and stabilization?)

_____ Detail drawings - Note that any structural practices used that are not referenced to an erosion and sedimentation handbook or local handbooks should be explained and illustrated with detail drawings.

_____ Maintenance - Furnish a schedule of regular inspections and repair of erosion and sediment control structures.

Erosion and sediment control planning should be an integral part of the site planning process, not an afterthought. The potential for soil erosion should be a significant consideration when deciding upon the layout of buildings, parking lots, roads, and other facilities. Costly erosion and sediment control measures can be minimized if the site design can be adapted to existing site conditions and if good conservation principles are used. Note that sedimentation ponds, often used for erosion and sedimentation control during construction, can be adapted to site amenities, if properly preplanned. The owner or lessee of the land being developed has the responsibility for plan preparation and submission. The owner or lessee may designate someone (e.g., an engineer, architect, or contractor) to prepare the plan, but the owner or lessee retains the ultimate responsibility.

3.4.1 Technical Assistance

There are a number of possible sources of erosion and sediment control planning assistance within most states.

1. Soil and Water Conservation Districts: These districts usually have elected representatives (directors) from different localities throughout the state. One of the primary functions of these districts is to provide assistance to landowners for soil conservation planning and implementation. Requests for assistance in preparing an erosion and sediment control plan for a construction site can be made through the local district.

2. Natural Resource Conservation Service (NRCS): The NRCS is formerly the Soil Conservation Service. The NRCS provides technical assistance on conservation planning through local soil and water conservation districts to landowners throughout the country. In addition, the NRCS, in conjunction with many state universities, is involved with soil surveys throughout many states. Many localities have existing published soil surveys. Requests can be made through an NRCS field office or a university soil survey field office for a soil survey on a specific site. Requests will generally be acted upon according to local priorities.

3. State Cooperative Extension Service: The Extension Service can provide valuable information on site planning and establishment of lawns and plant materials. The extension service has a number of useful publications and in

addition will have soil samples analyzed upon request to determine fertilization and liming needs for establishing vegetation on a particular site.

4. Local Government Offices: Many localities have a separate department that is responsible for administering the local erosion and sediment control program. Local staff can be a valuable resource for technical assistance and information concerning local requirements. Often, the County Engineer's office is a good place to start in the development of the basic information needed to prepare an SWPPP.

3.4.2 Limits of Disturbance

After the layout of the site has been determined, a plan to control erosion and sedimentation from the disturbed areas must be formulated. Decision concerning which areas must be disturbed in order to accommodate the proposed construction must be made. Special attention is directed to critical areas that may be disturbed.

3.4.3 Drainage Map

The site should be divided into drainage areas. Potential runoff flow paths over the developed site should be determined. Considerations concerning how erosion and sedimentation can be controlled in each small drainage area should be made before considering the entire site. The guiding principle is that it is easier to control erosion than to contend with sediment after it has been carried downstream.

3.4.4 Erosion and Sediment Control Best Management Practices

Erosion and sediment control practices can be divided into three broad categories: vegetative controls, structural controls, and management measures. Each of these categories have temporary and permanent control measures to be considered. Vegetative and structural practices should be selected and designed in accordance with Federal, state, and/or local specifications if they exist. In lieu of any local standards and specifications, the best management practices described in Appendix C should be utilized. The Best Management Practices (BMP) listed in Appendix C were obtained from the following sources:

(1) Virginia Department of Conservation and Recreation Division of Soil and Water Conservation's *Virginia Erosion and Sediment Control Handbook*, 1992 Third Edition.

(2) Washington State Department of Ecology's "Stormwater Management Manual For Puget Sound Basin," 1992.

(3) United States Department of Agriculture, Soil Conservation Service's Guidelines for the Control of Erosion and Sediment in Urbanizing Areas Within Mississippi, 1975.

(4) United States Environmental Protection Agency's *Summary Guidance For Storm Water Management For Construction Activities - Developing Pollution Prevention Plans and Best Management Practices,* 1992.

In the event of overlap or conflicting specifications (i.e., riprap gradations or filter fabric design specs), the appropriate geographic district should be contacted to resolve any discrepancy. The following are summary overviews of the erosion and sediment control practices recommended for use. Management measures are construction management techniques which, if properly utilized, can minimize the need for physical controls and possibly reduce costs.

3.4.4.1 Vegetative Controls

Planners should keep in mind that the first line of defense is to prevent erosion. Erosion prevention is accomplished by protecting the soil surface from raindrop impact and overland flow of runoff. The best way to protect the soil surface is to preserve the existing ground cover. Where land disturbance is necessary, temporary seeding or mulching should be used on areas which will be exposed for long periods of time. Erosion and sediment control plans must contain provisions for permanent stabilization of denuded areas. Selection of permanent vegetation should include the following considerations:

- Applicability to site conditions.
- Establishment requirements.
- Maintenance requirements.
- Aesthetics.

The vegetative BMP's in Appendix C are numbered according to the following categories of use:

BMP No.	Description
29-30	Site Preparation for Vegetation Establishment
31-34	Grass Establishment
35-36	Mulches
37-38	Other Vegetative Controls
39	Dust Control

The local agricultural extension service should be consulted concerning suitable vegetation and vegetative treatments.

3.4.4.2 Structural Controls

Structural control practices are generally more costly than vegetative controls. However, they are usually necessary since not all disturbed areas can be protected with vegetation. Structural controls are often used as a second or third line of defense to capture sediment before it leaves the site. It is very important that structural practices be selected, designed, and constructed according to BMP's of which many are listed in Appendix C. Improper use or inadequate installation can result in failure of the control and subsequent release of any trapped sediment.

The structural BMP's in Appendix C are numbered according to the following categories of use:

BMP No.	Description
1	Safety
2-3	Road Stabilization
4-8	Sediment Barriers
9-12	Dikes and Diversions
13-14	Sediment Traps and Basins
15-16	Flumes
17-21	Waterway and Outlet Protection
22-27	Stream Protection
28	Subsurface Drainage

3.4.4.3 Management Measures

Good construction management is as important as structural and vegetative practices for erosion and sediment control, and there is generally little or no cost involved. Management measures must be properly addressed in the SWPPP to identify responsible parties and duties required for implementing these measures. Following are some management considerations which can be employed:

- Include erosion and sediment control as an agenda item for the pre-construction meeting.
- Sequence construction so that no area remains exposed for unnecessarily long periods of time.
  - Work in a logical sequence, especially for drainage items.
  - Anticipate the site conditions that will exist as the construction progresses toward the final product.
  - Have the materials on-hand to complete the work without delay.
  - Apply temporary stabilization immediately after grading.
- On large projects, stage the construction, if possible, so that one area can be stabilized before another is disturbed, whenever possible.

- Consider the time of year.

  - Be prepared for sudden thunderstorms.
  - Install erosion and sediment controls immediately.
  - Use straw mulch for grass seed, especially during poor germination periods.

- Physically mark off limits of disturbance on the site with tape, signs, or other methods, so that workers can see areas to be protected.

- Develop and carry out a regular maintenance schedule for erosion and sediment control practices.

- Designate one individual (preferably the job superintendent or Quality Control Chief) responsible for implementing the erosion and sediment control plan. Make sure that all workers understand the major provisions of the erosion and sediment control plan. Establish reporting procedures for problems identified by workers.

4.0 SOURCE IDENTIFICATION

4.1 The Erosion Process

The principal source of pollutant export associated with construction activities is erosion. Soil erosion is the process by which the land's surface is worn away by the action of wind, water, ice, and gravity. Natural, or geologic erosion, has been occurring at a relatively slow rate since the earth was formed and is a tremendous factor in creating the earth as we know it today. Except for some cases of shoreline and stream channel erosion, natural erosion occurs at a very slow and uniform rate and is a vital factor in maintaining environmental balance.

4.1.1 Types of Erosion

Water-generated erosion is unquestionably the most severe type of erosion, particularly in areas of development. Consider the erosive action of water as the effects of the energy developed by rain as it falls, or as the energy derived from its motion as it runs off the land surface. The force of falling raindrops is applied vertically, and the force of flowing water is applied horizontally. Although the direction of the forces created is different, they both perform work in detaching and moving soil particles. Water-generated erosion can be classified into the following types:

- Raindrop erosion is the first effect of a rainstorm on the soil. Raindrop impact dislodges soil particles and splashes them into the air. These detached particles are then vulnerable to the next type of erosion.
- Sheet erosion is the erosion caused by the shallow flow of water as it runs off the land. These very shallow moving sheets of water are seldom the detaching agent, but the flow transports soil particles which are detached by raindrop impact and splash. The shallow surface flow rarely moves as a uniform sheet for more than a meter (3 feet) on land surfaces before concentrating in the surface irregularities.

- Rill erosion is the erosion which develops as the shallow surface flow begins to concentrate in the low spots of the irregular contours of the surface. As the flow changes from the shallow sheet flow in these low areas, the velocity and turbulence of flow increase. The energy of this concentrated flow is able to both detach and transport soil materials. This action begins to cut small channels of its own. Rills are small but well-defined channels which are normally less than 100 mm (4 inches) deep. The rills are easily obliterated by harrowing or other surface treatment.

- Gully erosion occurs as the flow in rills comes together in larger and larger channels. The major difference between gully and rill erosion is in magnitude. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy equipment and special techniques for stabilization.

- Channel erosion occurs as the volume and velocity of flow causes movement of the streambed and bank materials.

4.1.2 Factors Influencing Erosion

The erosion potential of any area is determined by four principal factors: the characteristics of the soil, vegetative cover, topography, and climate. Although each of these factors is discussed separately herein, they are interrelated in determining erosion potential.

Soil characteristics which influence the potential for erosion by rainfall and runoff are those properties which affect the infiltration capacity of a soil and those which affect the resistance of the soil to detachment and being carried away by falling or flowing water. The following four factors are important in determining soil erodibility:

1. Soil texture (particle size and gradation).
2. Percentage of organic content.
3. Soil structure.
4. Soil permeability.

Soils containing high percentages of fine sands and silt are normally the most erodible. As the clay and organic matter content of these soils increases, the erodibility decreases. Clays act as a binder to soil particles, thus reducing erodibility. However, while clays have a tendency to resist erosion, once eroded, they are easily transported by water. Soils high in organic matter have a more stable structure which improves their permeability. Such soils resist raindrop detachment and infiltrate more rainwater. Clean, well-drained and well-graded gravel and gravel-sand mixtures are usually the least erodible soils. Soils with high infiltration rates and permeabilities either prevent or delay and reduce the amount of runoff.

Vegetative cover has an extremely important role in controlling erosion as it provides the following five benefits:

1. Shields the soil surface from raindrop impact.
2. Protects root systems by holding soil particles in place.
3. Maintains the soil's capacity to absorb water.
4. Slows the velocity of runoff.
5. Removes subsurface water between rainfalls through the process of evapotranspiration.

By limiting and staging the removal of existing vegetation and by decreasing the area and duration of exposure, soil erosion and sedimentation can be significantly reduced. Special consideration should be given to the maintenance of existing vegetative cover on areas of high erosion potential such as moderately to highly erodible soils, steep slopes, drainageways, and the banks of streams.

Topography. The size, shape, and slope characteristics of a watershed influence the amount and rate of runoff. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified. Slope orientation can also be a factor in determining erosion potential. For example, a slope that faces south and contains droughty soils may have such poor growing conditions that vegetative cover will be difficult to re-establish.

Climate. The frequency, intensity, and duration of rainfall are fundamental factors in determining the amounts of runoff produced in a given area. As both the volume and velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are increased. Seasonal changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year. When precipitation falls as dry snow, no erosion will take place. However, when the temperature rises, melting snow adds to runoff, and erosion hazards are high. Because the ground may still be partially frozen, its absorptive capacity is reduced. Frozen soils are relatively erosion-resistant. However, soils with high moisture content are subject to uplift by freezing action and are usually very easily eroded upon thawing.

4.2 Sedimentation

Normally, runoff builds up rapidly to a peak and then diminishes. Excessive quantities of sediment are derived by erosion, principally during the higher flows. During lower flows, as the velocity of runoff decreases, the transported materials are deposited to be picked up by later peak flows. In this way, sediments are carried downslope, or downstream, intermittently and progressively from their source or point of origin.

4.2.1 Sediment Pollution and Damage

Sediment pollution is soil out of place. It is a product accentuated by the activities of man which leads to severe soil loss. When these large quantities of soil enter our waters, then sediment pollution occurs.

Over four billion tons of sediment are estimated to reach the ponds, rivers, and lakes of our country each year, and approximately one billion tons of this sediment are carried all the way to the ocean. Approximately 10 percent of this amount is contributed by erosion from land undergoing highway construction or land development. Although these latter quantities may appear to be small compared to the total, they could represent more than one-half of the sediment load carried by many streams draining small subwatersheds which are undergoing development.

Excessive quantities of sediment cause costly damage to waters and to private and public lands. Obstruction of stream channels and navigable rivers by masses of deposited sediment reduces their hydraulic capacity which, in turn, causes an increase in subsequent flood crests and a consequent increase in the frequency of damaging storm events.

Sediment may fill drainage channels, especially along highways and railroads, and plug culverts and storm drainage systems, thus necessitating frequent and costly maintenance. Municipal and industrial water supply reservoirs lose storage capacity, the usefulness of recreational impoundments is impaired or destroyed, navigable channels must be continually dredged, and the cost of filtering muddy water preparatory to domestic or industrial use may become excessive. The added expense of water purification in the United States, because of sedimentation, amounts to hundreds of millions of dollars each year.

In an aquatic environment, the general effect of fine-graded sediments such as clays, silts, and fine sands is to reduce drastically both the kinds and the amounts of organisms present. Sediments alter the existing aquatic environment by screening out sunlight and by changing the rate and the amount of heat radiation. Particles of silt settling on stream and lake bottoms form a blanket which creates a hostile environment for the organisms living there and literally smothers many of them and their eggs.

Coarser-grained materials also blanket bottom areas to suppress aquatic life found in these areas. Where currents are sufficiently strong to move the bedload, the abrasive action of these materials in motion accelerates channel scour and has an even more severely deleterious effect upon aquatic life. The aesthetic attraction of many streams, lakes, and reservoirs used for swimming, boating, fishing, and other water-related recreational activities has been seriously impaired or destroyed by bank cutting and channel scour, accelerated by a higher flood stage induced by sedimentation.

4.2.2 Costs

Many state and local jurisdictional agencies require that land-disturbing activities have an approved E&S control plan prior to commencement of work. The owner is responsible for the development of E&S control plans. Once a plan is approved, generally a contractor will be responsible for implementing, installing, and maintaining the E&S control plan. However, the owner is ultimately responsible and in many instances must certify that the plan will be carried out. Once the project has moved through the bid process, the cost of implementation becomes the primary concern. Proper implementation of the E&S plan can save the developer and the contractor money in excavation costs. If denuded areas are stabilized initially, little or no additional work will be required later. This can speed up completion dates, and overall savings will be realized. This strategy requires that planning take on a more important role in the management of a project. Good management throughout the life of a project will lead to increased savings.

On the other hand, failure to implement an E&S plan or failure to maintain controls during construction of a project can mean additional costs to the developer and the contractor. These additional costs exist at three levels. The primary level is the cost of work being stopped for noncompliance with an approved plan; the secondary level is the cost of repairing damage to adjacent properties; the tertiary level would be the costs associated with missed deadlines, litigation with damaged parties, and extra charges by the contractor for additional work. The perception by the public that the developer and the contractor were negligent in performing their responsibilities may also pose a negative cost, if not immediately, sometime in the future.

4.3 Other Potential Nonsediment Pollutants

The general permit requires the listing of potential nonsediment pollutants likely to be present in storm water in significant quantities. The sections below discuss potential pollutants which are commonly associated with construction activities.

4.3.1 Nutrients

Nitrogen, phosphorus, and potassium are the major plant nutrients used for the fertilizing of new landscape at construction sites. Heavy use of fertilizers can result in the discharge of nutrients to water bodies resulting in excessive algal growth and eutrophication, and in some states a violation of water quality standards.

4.3.2 Trace Metals

Galvanized metal, painted surfaces, and pressure-treated lumber comprise many of the surfaces exposed to storm water as a result of construction activity. These coatings and treatments contain metals which enter storm water as the surfaces corrode, flake, dissolve, decay, or leach. Acid rain can accelerate these processes.

4.3.3 Pesticides

Herbicides, insecticides, and rodenticides are commonly used at construction sites. The unnecessary or improper application of these pesticides may result in direct contamination, indirect pollution through drift, or the transport of soil surfaces into water.

4.3.4 Spills and Illegal Dumping of Construction Materials

Petroleum products, pesticides, and other synthetic organic compounds (glues, sealants, solvents, etc.) are used widely at construction sites and may be improperly stored and disposed. Deliberate dumping of these materials, which can migrate into surface or groundwater resources, is a direct violation of the CWA. On parking lot or highway construction projects, the application of diesel fuel to the contact surfaces of the "hot mix asphalt" application and transport vehicles is a common practice that should be discontinued immediately.

4.3.5 Miscellaneous Wastes

Miscellaneous wastes include wash from concrete mixers; solid wastes resulting from the clearing and grubbing of vegetation; wood and paper materials derived from packaging of building products; food containers such as paper, aluminum, and steel beverage cans; and sanitary wastes. In addition to erosion and sediment controls, the SWPPP must address the other potential pollutant sources that may exist on a construction site. These controls include proper disposal of construction site waste; compliance with applicable state or local waste disposal, sanitary sewer, or septic system regulations; control of offsite vehicle tracking; and control of allowable nonstorm water discharges which are discussed in Section 6.5.

4.4 Allowable Nonstorm Water Discharges

The following discharges are generally allowed if they do not commingle with contaminated material or other discharges associated with industrial activity:

- Uncontaminated flows from fire fighting.
- Fire hydrant flushing.
- Potable water sources including water line flushing.
- Uncontaminated groundwater resulting from dewatering activities.
- Uncontaminated flows from foundation or footing drains.
- Naturally occurring flows such as springs, wetlands, and riparian habitats.

- Irrigation water discharged during seeding, planting, and maintenance, provided fertilizers and pesticides are applied correctly.
- Pavement wash waters for dust control and general housekeeping practices providing that spills or leaks of toxic or hazardous materials have not occurred and where detergents are not used.

It must be emphasized that the flows described above are uncontaminated flows. For example, if the discharge from potable water line flushing were to collect significant amounts of sediment or contaminants while flowing over soil or pavement, it would be considered contaminated and, therefore, could not be discharged directly to the storm drain system.

4.5 Pollutant Lists

The construction activity should list any pollutants that have a reasonable potential to be present in the storm water discharge in significant quantities. The definition of significant quantities varies from item to item. In general, a significant quantity is taken to be any quantity that is not consumed within a normal day's operations or would result in spills beyond the immediate cleanup capabilities of the individual charged with the use of the materials. A significant quantity also relates to a "reportable" quantity for those substances that are regulated under SARA Title III Section 313, or any of the programs mentioned in Section 2.6. Table E-1 in Appendix E has been provided to inventory materials found onsite.

Some of the primary contaminants associated with construction activities are as follows:

- CCA treated lumber
- AZCA treated lumber
- Boiler treatment chemicals
- Creosote
- Tribucide
- Diesel fuel
- Fire retardant
- White wood
- Fuel oil
- Detergents
- Gasoline
- Hydrogen peroxide
- Maintenance and motor lubricants and coolants
- Paints, thinners, and sealants
- Pentachlorophenol treated lumber
- Metal studs
- Propane
- Solvents
- Sulfuric acid
- Timbor
- Mold inhibitor
- Water repellant
- Refrigerant
- Concrete
- Tar

- Fertilizers
- Hydraulic fluid
- Masonry block
- Roofing shingles

4.6 Significant Spills or Leaks

Because construction activities may handle certain hazardous substances over the course of the project, spills of these substances in amounts that equal or exceed Reportable Quantity (RQ) levels are a possibility. EPA has issued regulations that define the reportable quantities for oil and hazardous substances. These regulations are found at 40 CFR Part 110, 40 CFR Part 117, and 40 CFR Part 302. If a release occurs, a contingency plan should be put into effect. The single most important action required in the contingency plan should be to minimize environmental impacts or health threats. If there is a RQ release during the construction period, the following actions must be taken:

- Notify the National Response Center immediately at (800) 424-8802; in Washington, DC, call (202) 426-2675.
- Within 14 days, submit a written description of the release to the EPA Regional office providing the date and circumstances of the release and the steps to be taken to prevent another release.
- Modify the SWPPP to include the information listed above.

If a spill occurs and the above actions are taken, the single most important action is to document all calls, correspondence, and any other communications relative to the spill. Record names, titles, phone numbers, dates, times, and any other information that may be used to prove that the actions were taken.

The construction activity must list all historical spills or leaks of toxic or hazardous pollutants to the storm water system that have occurred in the last 3 years. This list must include: toxic chemicals listed in 40 CFR Part 372 that have been discharged to storm water as reported on EPA Form R, and oil or hazardous substances in excess of reportable quantities, 40 CFR

Part 110, 117, or 302. Table E-2, in Appendix E may be used to record the lists described previously.

The SWPPP should designate a person who is accountable for spill response at the construction site. The designated person will be responsible for emergency procedure action and documentation. The responsible person should be thoroughly trained and familiar with all aspects of the response plan as well as the operations and daily activities of the construction activity. In addition this person must have the authority to commit the resources needed to accomplish the spill plan response.

Contingency plans are required by law for proper response to a hazardous waste, chemical, or oil spill. The plans are designated Exhibit E-1, -2, and -3, in Appendix E. These plans are provided as a guideline only and should be customized by the construction activity. These plans and lists of contacts should be posted in obvious locations to facilitate a quick response to any spill.

The key to a successful SWPPP is that no matter what quantities of materials are dispensed and stored, proper and safe management can reduce the risk of spills and leaks substantially. The following sections highlight the most common activities with a reasonable potential for spill or releases of hazardous materials to ground or surface water resources.

4.6.1 Bulk Chemical and Fuel Storage or Transfer Areas

Underground fuel storage has been addressed in other EPA programs. The use of double containment tanks, monitoring wells, and other controls has been established and all facilities should be in compliance. (The construction activity management should assure itself that all regulated underground storage tanks meet requirements.) Not all tanks fall under existing programs. The objective is to assure that tank contents do not leak into the storm sewer system or into the groundwater.

Aboveground storage tanks are not regulated in the same way that underground tanks are regulated. Areas containing fuel, lubricants, chemicals, waste oil, waste solvent, and other such tanks or storage barrels should be covered (preferably under roof) wherever possible. Storm water flows should be directed around the storage locations. Protective dikes around the sites which can provide containment are also in order, particularly if the potential spill volume exceeds the sump volume or what can be contained using absorbent "pillows" or other material and containment booms.

The construction activity should identify areas in which a leak or a spill of significant materials could result in contact with storm water runoff and enter the storm water drainage system. These areas will coincide with areas of material handling, transfer, and storage. After areas of concern are identified, specific material handling procedures, storage requirements, and cleanup equipment and procedures should be established. Table E-4, in Appendix E, will be used to record the spill control and countermeasures established by the construction activity. Additional documentation relating to spill prevention countermeasures and control must be added to the SWPPP document.

Aboveground tanks are primarily used for the bulk storage of chemicals, diesel, gasoline, coolants, and lubricants. These tanks may be serviced by any combination of below ground or aboveground piping systems. Bulk shipments are generally received from tank trucks. The products are off-loaded adjacent to the storage tanks and are dispensed to equipment as needed. Hazardous wastes generated from construction activity operations primarily consist of contaminated sediments from the fueling or maintenance areas.

Waste oils are stored in both aboveground and underground tanks. Generally, the tanks are less than 1,900 liters (500 gallons) in capacity. All outdoor, aboveground tanks should be contained by dikes having adequate volume to hold a spill and, depending upon the region, an appropriate precipitation event. Underground storage tanks (UST's) must conform to their own set of regulations. The SWPPP should contain appropriate references to UST management.

Outdoor storage of chemicals, including petroleum substances, is a major environmental concern at construction sites. Aboveground tanks are subject to solar heating resulting in potential explosive gases near vents, collisions from moving equipment, acts of vandalism, acts of disgruntled employees, etc. UST's may be a source of leaks. Storm water discharges have a potential of being contaminated during excavation, backfilling, maintenance, and remediation activities involving fuel storage tanks. Construction activities may have outdoor collection tanks for waste oil. These tanks may leak or overflow if they are not properly maintained.

4.6.2 Vehicle and Equipment Fueling Areas

Fuel is usually delivered to construction activities by tank truck. The bulk storage area should be contained by dikes and loading/unloading areas should be served by oil/water separators. Dispensing to vehicles and equipment is usually accomplished through standard fuel dispensers. Most spills are relatively minor. Spills are usually cleaned up by construction activity personnel and/or private contractors under the supervision of the local fire department. In the event a spill does reach the storm sewer system, a licensed cleanup contractor should be immediately dispatched to clean out the storm lines and recover spilled fuel.

4.6.3 Vehicle and Equipment Maintenance Areas

Most construction activity vehicles and equipment are maintained by construction activity personnel and are frequently repaired and serviced on the jobsite. Substantial volumes of petroleum oils, including engine oil, transmission fluid, brake fluid, and other lubricants, are used in vehicle maintenance operations. As a result, there is a potential for illicit discharges or storm water discharge contamination by oils, solvent, lubricants, fuel, and coolants.

Equipment maintenance typically takes place in one of two locations: (1) the construction activity maintenance area or garage; or (2) wherever the equipment breaks down. The potential for storm water contamination where the equipment is serviced must be considered.

The following fluids have the potential to enter the storm water system from spillage: diesel fuel, gasoline, engine oil, hydraulic fluid, transmission fluid, lubricants, refrigerants, and solvents. All spillage other than potable water should be prevented from entering the storm water system. Engine oil and hydraulic fluids are used in relatively small quantities but may enter the storm drain system during precipitation events. If the garage area has unsealed cracks, spillage may result in groundwater contamination. Maintenance activities which occur inside garages may result in storm water contamination through floor drains connected to the storm sewer system. Hydrocarbon spillage should be minimized and cleaned up when it occurs. Residual cleanup waters should be passed through an oil/water separator into a sanitary sewer system if available or transported to a permitted treatment facility.

4.6.4 Vehicle and Equipment Cleaning Areas

The spent wash water from vehicle and equipment cleaning may be contaminated with surface dirt, rust, flash metal, or paint from the surface of the equipment and fluids (fuel, hydraulic fluid, oil, lubricants, etc.). Most construction activity vehicles and equipment are maintained by construction activity personnel and are frequently repaired and serviced on the jobsite. As a result, there is a potential for illicit discharges or storm water discharge contamination by oils, solvents, lubricants, fuel, and coolants.

EPA regulations prohibit the discharge of wash water from car and truck cleaning facilities without a permit. The potential for storm water runoff contamination and the presence of illicit discharges from these facilities must be considered. The discharge should be treated for the removal of oil, grease, solvents, soaps, and solids prior to discharge to receiving waters. Although some vehicle-cleaning activities are not currently covered separately by the EPA storm water regulations, these activities must be addressed under the SWPPP wherever storm water may come into contact with the results of activities that are covered.

4.6.5 Combined Sewer Overflow (CSO)

Many of our nation's older and more-established cities are coping with problems related to a deteriorated infrastructure stressed beyond capacity. Chronic flooding occurs in some areas where storm sewer trunk lines were not designed to convey the extent of development that has occurred. As a result of this flooding, deteriorated sanitary sewers are overloaded by infiltration and inflow (I & I). This I & I laden sewage often overflows during high intensity or long duration storms washing pollutants into surface waters. Several older cities combined sanitary and storm sewers into a single combined sewer system, These also overflow during larger storm events as combined sewer overflows. These discharges containing raw sewage threaten the health of all who come into contact with them. In addition to being a threat to public health, CSO's jeopardize the beneficial use of surface waters. High bacterial counts result in beach closings and shellfish contamination. Low dissolved oxygen levels affect the health of fish and other aquatic life. Toxic pollutants tend to settle out and increase the level of contamination in the sediments. Floating debris, containing materials commonly associated with sewage, is offensive and greatly reduces the enjoyment of streams, rivers, and coastal zones.

Federal and state regulatory agencies are currently struggling to develop the proper program for monitoring and controlling CSO's. They are struggling because each system varies from one community to the next, and each CSO solution is inherently complex and potentially expensive. Programs are in place to attempt to control I & I problems with sanitary sewer systems. The required level of control for the CSO discharges is not clearly specified in current NPDES discharge permits, nor are CSO control requirements defined in most state water quality standards. Construction designers and managers should be aware of the state and local trends concerning CSO's. Impacts concerning problems could conceivably result in sanitary sewer user fees, moratoriums on expansion, or even requiring onsite sewage disposal.

4.6.6 Onsite Sewage Disposal Systems

Onsite sewage disposal systems (OSDS) include conventional septic systems, large-scale conventional systems, alternative and innovative designs, and private sewage treatment facilities. The term applies to any residential or industrial sewage that is not treated or planned for treatment in a centralized public sewer system.

Proper treatment of wastewater effluent with onsite disposal systems is an essential component of surface water quality protection. When properly sited, designed, permitted by state or local health authority, installed, and maintained, individual sewage disposal systems can be used to treat most pollutants found in construction activity wastewater simply and effectively. Treated wastewater usually reaches surface waters by ground water recharge or by ground/surface water interfaces.

4.7 Summary of Sampling Data/Existing Water Quality

If storm water runoff from the proposed construction site has been sampled and analyzed for the presence of any pollutant (e.g., total suspended solids), then the results of the analyses must be included in the SWPPP. In most cases, existing runoff water quality data are not available for a specific site, particularly an undeveloped site. However, if the construction is on or adjacent to an existing industrial facility, that facility may have collected runoff water quality data to satisfy another permit. If there are no existing data on the quality of runoff from the site, then it is not necessary to collect samples for the general permit. Runoff water quality data may sometimes be available from your state or local government. You may also be able to obtain runoff water quality information from the USGS or state or local watershed protection agencies. The sampling event(s) information should be recorded in Table E-3, in Appendix E, and a one-page summary included from the sampling data report package. Previous sampling data will be useful in determining the source of pollutants and in initiating controls.

5.0 STORM WATER MANAGEMENT CONTROLS

This section of the SWPPP describes storm water management measures to control and abate water quality impairment associated with the activities described in the preceding sections.

Land conversion associated with development has resulted in the loss of vegetation and sensitive wetlands, alteration of natural drainage patterns, and the creation of expanded areas of imperviousness. This loss of infiltration capacity has correlated with increases in the velocity, volume, and frequency of storm water runoff. Mitigation of this process is inherently complex in that sources are somewhat diverse, changes in water quality tend to be gradual and cumulative, and the site-specific physical and safety constraints associated with the configuration of the different facilities tend to limit the number of viable measures for implementation at each site. However, since pollutants have a limited number of pathways by which they reach water resources, the practices that constitute management measures for the various source categories tend to be somewhat similar for each construction activity.

The design and implementation of effective source control measures is achieved from a management systems approach as opposed to an approach that focuses on individual practices. That is, the pollutant control achievable from any given management system is viewed as the sum of the parts, taking into account the range of effectiveness associated with each single practice, the costs of each practice, and the resulting overall cost and effectiveness of the system. Some individual practices may not be effective alone but, in combination with others, may provide a key function in a highly effective system. This is analogous to the use of "treatment trains" or a series of treatment steps.

This guidance adopts the approach of specifying management measures as systems of management practices. This approach is primarily reflected in two ways: (1) the management measures are usually presented as systems, and (2) for those sources that generate pollutants from a number of discrete activities, or unit areas, the guidance includes management measures for each activity, or area.

It is generally not possible to prescribe a highly specific management measure that will be uniformly applicable over an expanded region. For example, when designing erosion and sediment control systems, one considers soil types, antecedent moisture conditions, land use, precipitation patterns, and slopes to determine the proper set of practices. The multitude of combinations of site-specific factors that arise within a state, region, and even within a watershed, makes it difficult to develop a list of specific management measures to be used.

Congress has defined management measures as "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operation methods, or other alternatives." Congress has not defined the term "economically achievable," nor has it explained the term in legislative history. This distinction relates to the extensive flexibility inherent in implementing pollution prevention management measures. The ability of a particular management measure to deal with nonpoint source pollution from a particular site is subject to a variety of factors (e.g., geography, geology, soils, hydrology, and production methods) too complex to address in a single set of simple, mechanical prescriptions at the state or regional level, so this guidance provides considerable flexibility for local selection. These considerations make it difficult to predict the costs and economic impacts of measures that will ultimately be developed, applied, and implemented on a localized basis. Many of the proposed management measures are regarded as low-cost, yet highly effective. Examples include source control measures such as spill prevention or pesticide management. Others are more expensive, yet widely practiced (e.g., construction management measures such as erosion and sediment control practices, storm water management measures such as constructed wetlands or pond systems). This guidance provides a set of management practices for each source category. The number and type of systems identified per source category are based upon the range and diversity of substantively different subcategories and pollutants. Pollution prevention is generally considered as the first component of management measures. Pollutant delivery reduction measures are typically added only after it is determined that additional control is necessary to reach the greatest degree of pollutant reduction economically achievable.

For each management measure, a list of management practices that can be used in designing an equivalent or better system is provided. The list of practices reflects the best available set of practices, or components of best available systems, but is not all-inclusive of those practices that could be used to develop systems that are equivalent to or better than specified management measures.

The pollutant reduction estimates that can be achieved using the specified management practices are also described in this guidance, quantitatively wherever possible. These reductions serve as the benchmarks for equivalent or better management measures. All estimates provided are based upon the best available data currently available, but are somewhat empirical. Further monitoring will provide data to support the effectiveness of this portion of the SWPPP.

The controls to be implemented at each construction activity will reflect the identified potential sources of pollutants at each construction site. This list of sources will be different for each construction activity. It is recommended that the SWPPP personnel or committee be responsible for implementing the appropriate control measures for the construction activity. Each construction activity will find some solutions more appropriate or feasible than others.

5.1 The Nonpoint Source Pollution Process

Nonpoint source pollutants are transported to surface water by a variety of means, including runoff and ground water infiltration. Ground water and surface water are both considered part of the same hydrologic cycle when designing management measures. Ground water contributions of pollutant loadings on surface waters are often very significant. The transport of nonpoint source pollutants to surface waters through ground water discharge is governed by physical and chemical properties of the water, pollutant, soil, and aquifer.

The combination of source control and delivery reduction measures and the application of those measures as components of management systems are dependent upon site-specific conditions. Technical factors that may affect the suitability of management measures include, but are not limited to, land use, climate, size of drainage area, soil permeability, slopes, depth to water table, space requirements, the type and condition of the receiving waters, depth to bedrock, and the pollutants to be addressed.

5.2 Source Control Measures

Source control is the first opportunity in any nonpoint source control effort. Source control methods vary for different types of nonpoint source problems. Examples of source control include:

(1) Reducing or eliminating the introduction of pollutants to a land area.

(2) Preventing nonintroduced pollutants (such as loose dirt and sediments) from leaving the site during land-disturbing activities.

(3) Preventing interaction between precipitation and introduced pollutants.

(4) Protecting wetlands or riparian habitat and other sensitive areas.

(5) Protecting natural hydrology.

5.2.1 Preventive Maintenance (PM)

A Preventive Maintenance (PM) program is an effective and cost-efficient measure in pollution prevention. It is easily performed at a relatively low cost and may yield great savings in the long run. Preventive maintenance includes inspection of construction activity/contractor equipment and systems, such as equipment cleaning facilities, all vehicular and maintenance facilities, and any structural source controls already in place, such as drip pads, sumps, and tank containment. Each contractor should be directly responsible for inspection, testing, adjustment, and repair of their contractor-owned facilities and equipment, subject to the supervision and review by the SWPPP committee. Contractor-owned facilities, equipment, and maintenance records will be reviewed by construction activity SWPPP personnel on a regular scheduled basis.

5.2.2 Requirements in PM Program

The preventive maintenance program should include the following:

- Identification of the equipment and systems to which the preventive maintenance program should apply.
- Periodic inspections of identified equipment and systems.
- Periodic testing of equipment and systems.
- Appropriate adjustments, repair, or replacement of parts.
- Maintenance of all records of inspections and follow-up actions.

Preventive maintenance inspections should be carried out by trained personnel or the designated SWPPP committee. It is important that the personnel be familiar with the systems and equipment to be monitored and tested. The inspection schedules should be established by the committee, in conjunction with the construction activity manager, and brought to the attention of all employees. Inspection frequencies can be established in part by reviewing any "Risk Identification and Assessment" studies that may have been completed for the construction activity, equipment, facilities, or contractor activity. In some cases, monthly inspections will be appropriate. A testing schedule can be developed in the same manner; however, testing frequencies will not need to be as often as inspection frequencies. Adjustments or repairs of any type to the equipment or systems must be completed by trained personnel.

Documentation and retention of records is a critical element of a good preventative maintenance and inspection program. A tracking or follow-up procedure will be used to ensure that the appropriate response to the inspection findings has been made. All inspection documentation and records must be maintained with the SWPPP documentation for a period of 3 years following final stabilization. The tables and exhibits located in Appendix D should be used to record inspection and maintenance activities and any corrective actions implemented.

Inspection and maintenance guidelines for construction equipment should follow the manufacturer's specifications. The equipment itself should be serviced in designated areas as indicated above. Special attention must be given to those portions of the equipment that come into contact with any suspected pollutant. These portions include, among others: trams or conveyor mechanisms, pipes for liquid conveyance (including vacuum hoses for liquid extraction), tanks and associated valves, fittings, nozzles, and tank seams. Particular attention should be given to remedying leaks and replacement of deteriorated rubber or plastic hoses, pipes, washers, and gaskets.

Good housekeeping refers to the cleaning and maintenance practices conducted at the construction activity. Good housekeeping is an important component of the pollution prevention plan. Periodic training of employees in housekeeping techniques for those areas of the construction activity where pollutant sources are found reduces the significant material contamination of storm water. Housekeeping practices include:

- Maintenance of material loading/unloading areas.
- Safe and orderly storage of construction debris, chemicals, and other significant materials.
- Stimulating employee interest in good housekeeping.

Maintenance areas should be kept clean. Chemicals, grease, oil, solvent, and fuel spills should be collected by use of absorbents and booms where necessary. Disposal of these materials should be by qualified hazardous materials handling contractors. Material loading and unloading areas should be cleaned manually or with heavy equipment. Liquids should be removed using absorbent materials or with vacuum machinery.

Cleaning protocols should be site-specific. The protocols should fit the nature of construction activity (and tenant organizations). The protocols should be developed to meet the site-specific requirements of the construction activity. The protocols should cover:

- Areas, operations, and equipment to be inspected.
- Frequency of inspection.
- Checklists and procedures to be used.
- Records of inspection and filing requirements.
- Records of resulting maintenance and filing requirements.
- Mechanism for revising protocols.

5.3 Delivery Reduction Measures

Pollution prevention often involves delivery reduction (intercepting pollutants prior to delivery to the receiving waters) in addition to appropriate source control measures. Management measures include delivery reduction practices to achieve the greatest degree of pollutant reduction economically achievable, as required by NPDES regulations.

Delivery reduction practices intercept pollutants leaving the source by capturing the runoff or infiltrate, followed either by treating and releasing the effluent or by permanently keeping the effluent from reaching a surface or ground water resource. By their nature, delivery reduction practices often bring with them side effects that must be accounted for. For example, management practices that intercept pollutants leaving the source may reduce runoff, but also increase infiltration to ground water. These devices, although highly successful at controlling suspended solids, may not, because of their infiltration properties, be suitable for use in areas with high ground water tables and nitrate or petroleum residue problems. The performance of delivery reduction practices is to a large extent dependent on suitable designs, operational conditions, and proper maintenance. For example, filter strips may be effective for controlling particulate and soluble pollutants where sedimentation is not excessive, but may be overwhelmed by high sediment input. In many cases, filter strips are used as pretreatment or supplemental treatment for other practices within a management system.

5.3.1 Storm Water Management BMP's

The evolution of the need to manage or control storm water runoff has directly paralleled the evolution of land development and its impact on the environment. In the past, control of storm water was attempted by maximizing conveyance with rapid downstream disposal of surface water. The cumulative effects of this practice have created frequent downstream flooding and depletion of underground water supplies. Until the early 1970's little or no consideration was given to the downstream impacts of such activity. Current practices dictate the attenuation of design peak flows to predevelopment rates. While this approach has proven reasonably effective in curtailing flooding problems, it does not mitigate the adverse impacts of pollutant export. The first flush of pollutants refers to the higher concentrations of storm water pollutants that characteristically occur during the early part of a storm with concentrations decaying as the runoff continues. Concentration peaks and decay functions vary from site to site and from region to region, depending on contributing land use, the pollutants of interest, and the characteristics of the drainage basin. Studies have indicated that for a variety of land uses the first 1.25 cm (0.5 in.) of each runoff contains 80 to 95 percent of the total annual loading of most storm water pollutants. The best available procedures for storm water management include both structural and nonstructural components and involve a combination of detention, infiltration, and filtering devices. Treatment systems, rather than individual practices, will tend to achieve the greatest pollutant reduction goal. Treatment systems should include source control, storm water management, and riparian protection to achieve the highest level of effectiveness.

Storm water treatment systems are site-specific and their effectiveness is highly variable and dependent on many factors. Practices or combinations of practices that are considered to be "best available" in some or in many situations, nevertheless, may not be the most effective or economically achievable for a particular site, and may even be entirely ineffective for the site. A system of practices should be tailored to a particular site to avoid selection of unsuitable practices, maintenance problems, or failure to achieve desired pollutant reduction.

Storm water management controls are constructed to prevent or control pollution of storm water after the construction is completed. The general permit requires that the pollution prevention plan include a description of the measures that will be installed to control pollutants in storm water after construction is complete. For sites in which the development results in runoff flows that are higher than preconstruction levels, the SWPPP must include a technical explanation of why a particular storm water management measure was selected.

Selection of the most appropriate BMP depends upon a number of factors associated with site conditions. EPA expects that most sites can employ measures to remove 80 percent of the total suspended solids from postconstruction runoff. When selecting BMP's for a development project, consider the impacts of these measures on other environmental media (e.g., land, air, and ground water).

In addition to pollutant removal, the SWPPP must address velocity dissipation at discharge locations. Development usually means an increase in speed with which the site will drain because of the addition of paved areas, storm sewers, curbs, gutters, etc. The general permit requires that the velocity dissipation devices be placed along the length of any outfall where the discharge from the developed area may erode the channel. See Section 3.3 for further information on runoff calculations.

5.3.2 Storm Water Retrofit

Retrofit projects must take into account a number of site-specific factors. Nature of pollutants, loading rates, classification of receiving waters, location and condition of existing storm drains, existing and proposed land uses, location of existing utilities, soil characteristics, and floodplain location are but a few. A brief discussion of these practices follows:

Pond Systems

The ponds described in the following paragraphs range from completely dry structures to permanently wet structures with various combinations included. In addition, wetland components are discussed for their ability to enhance pollutant removal, create habitat diversity, and provide visual interest.

<u>Wet Extended Detention Pond</u> - A permanent pool system containing a forebay near the inlet to trap sediments and a deeper pool near the riser. This pond system provides an optimal combination of downstream channel protection and pollutant removal. Extended detention wet ponds are generally the most cost-effective urban/coastal practices available for pollutant removal and storm water control.

<u>Wet Pond</u> - A pond system with all of its storage utilized as a permanent pool. This system traps sediments and may provide pollutant removal through biological uptake from aquatic wetland plant species. In addition, a wet pond can be an attractive aesthetic feature.

<u>Extended Detention (ED) Micro-Pool</u> - A dry ED system containing one or two small permanent pools for pollutant removal. One micro-pool located near the inlet acts as a sediment forebay. The micro-pool system has a much lower maintenance burden than conventional dry ED pond systems and is a particularly useful design for fingerprinting a pond into a sensitive woodland or wetland area.

Extended Detention Shallow Marsh - A system utilizing emergent aquatic wetland plant species as its principal pollutant removal mechanism. The ED shallow marsh typically consists of a 0- to 1-meter- (0-3 feet) deep irregularly shaped permanent pool, creating diverse wetland habitats in a relatively small space, while providing moderate levels of soluble pollutant removal.

Shallow Marsh - A system with much of its storage devoted to a shallow marsh, this pond design can consume a great deal of land area. However, with proper grading, design, and propagation techniques, this system can result in the creation of an extensive, high quality emergent wetland habitat. The shallow marsh can achieve high removal rates of soluble and particulate pollutants through the biological uptake mechanism of emergent aquatic plants.

In-Filter Dry Pond - An innovative dry pond system for sites having permeable soils that promote infiltration. Design includes storm water detention, pretreatment via plunge pools and grassed swales, and a series of infiltration trenches and basins.

Dry Extended Detention Pond - A pond system typically comprised of two stages: The upper stage is graded to remain dry except for infrequent storms; whereas the lower stage is designed for regular inundation. Runoff pretreatment is difficult to achieve with this pond system, and it is equally difficult to prevent clogging of the ED control device.

Wet Ponds and Wet Extended Detention Ponds are extremely effective water quality practices. When properly sized and maintained, Wet Ponds and Wet Extended Detention Ponds can achieve high removal rates for sediment, biochemical oxygen demand (BOD), nutrients, and trace metals. Biological processes within the pond also remove the soluble nutrients (nitrate and ortho-phosphorus) that contribute to nutrient enrichment (eutrophication). Soluble nutrient removal is achieved through a process known as biological uptake where algae and other aquatic plants convert the soluble nutrients into biomass which eventually settles into pond sediments and is later consumed by bacteria. Some of the nutrients are recycled to the water column, but most nutrients remain in the consolidated sediments.

Wet Extended Detention Ponds are most cost effective in larger, more intensely developed sites. Pond practices normally require a significant contributing watershed area (greater than 4 hectares or 10 acres) to ensure proper operation. Positive impacts associated with wet pond systems can include: creation of local wildlife habitat, increased property values, recreation, and landscape amenities.

Extended Detention Ponds are effective in controlling postdevelopment peak storm water discharge rates to a desired predevelopment level for the design storm(s) specified. If storm water is detained for 24 hours or more, as much as 90-percent removal of particulates or suspended solid pollutants is possible. It should be noted, however, that extended detention ponds have the disadvantage of elevating water temperatures, thus potentially contributing to thermal pollution. Their use may be inappropriate in some locations, such as, adjacent to trout streams. In addition, care should be taken not to reduce base flows below those necessary to sustain the resident aquatic habitat.

Infiltration Systems

The infiltration systems described below range in design from stone-filled trenches and basins to permeable asphalt pavement. All utilize differing methods for removing soluble and fine particulate pollutants found in storm water runoff. To prevent infiltration systems from becoming clogged with fine sediment, it is essential to pretreat the incoming runoff. Methods of pretreatment range from filter cloth to vegetated filter strips. With pretreatment, infiltration systems can be an effective component of a water quality management measure.

It is important to recognize that infiltration systems create a risk of transferring pollutants from surface water to ground water. Therefore, infiltration systems should not be used near wells, in wellhead protection areas, in areas with high ground water, or in karstic terrain or in settings in which drinking water supplies may become contaminated. Furthermore, concentrations of toxic materials leached into the substrate could result in a hazardous waste designation for the area subject to regulations under CERCLA.

Infiltration Trench #1 - An infiltration trench works by diverting storm water into a shallow (1 to 2.5 meter or 3 to 8 feet) excavated trench which has been backfilled with stone to form an underground reservoir. Runoff is then either exfiltrated into the substrate or collected in underdrain pipes and conveyed to an outfall. Infiltration trenches are an adaptable practice that adequately removes both soluble and particulate pollutants. They are primarily an onsite control and are seldom practical or economical for drainage areas larger than 2 to 4 hectares (5 to 10 acres). Infiltration trenches are one of the few practices that adequately provide pollutant removal on small sites of infill development. They preserve the natural ground water recharge capabilities of a site and can often fit into margins, perimeters, and other unused areas of the site. A disadvantage is that infiltration trenches require careful construction, pretreatment, and regular maintenance to prevent premature clogging. Infiltration trenches can be used effectively in sandy or sandy loam soil areas but are much less effective for clayey or silty soils.

Infiltration Trench #2 - Similar to the trench system described above, this design accepts sheet flow from the lower end of a parking lot or paved surface. Runoff is diverted off the paved parking lot through slotted curbs. The slotted curbs function as a level spreader for storm water. A grass filter strip separates the trench from the paved surface for capture of sediments. This trench includes a perforated PVC-type pipe for passage of large design storm events. At the end of the trench is a grassed berm to ensure that runoff does not escape.

Infiltration Basin - Infiltration basins are an effective means for removal of soluble and fine particulate pollutants. Unlike other infiltration systems, basins are easily adaptable to provide full control for peak storm events. Basins can also serve large drainage areas (up to 20 hectares or 50 acres). Basins are a feasible option where soils are permeable. Basins are advantageous in that they can preserve the natural water table of a site, serve larger developed areas, be used as a construction sediment basin during construction and converted later to a long-term BMP, and are reasonably cost-effective in comparison to other practices.

One disadvantage is the need for frequent maintenance. In addition, infiltration basins have sometimes failed because they were installed in unsuitable locations or soils.

Dry Well - A small infiltration system designed to accept storm water from a roof-drain downspout. Rather than dispersing its storm water across a paved surface or grassed area, the downspout pipe connects directly into the dry well which filters rooftop runoff into soils. This system should not be used near foundations where expansive soils are found, as foundations may be damaged.

Porous Pavement - Porous pavement is a permeable pavement having the capability to remove both soluble and fine particulate pollutants in runoff and provide ground water recharge. Use is generally restricted to low-traffic-volume parking areas. Porous pavement systems can receive runoff from adjacent rooftops. This reasonably cost-effective practice is only feasible on sites with gentle slopes, permeable soils, deep water tables, and bedrock levels. It also requires careful design, installation, and maintenance. Although porous pavement has the high capability to remove both soluble and fine particulate pollutants from storm water runoff, it can become clogged easily and is difficult and costly to rehabilitate.

From a pollutant removal standpoint, Infiltration Trenches, Basins, and Porous Pavement have a moderate to high removal capability for both particulate and soluble pollutants, depending upon how much of the annual runoff volume is effectively exfiltrated through the soil layer. It should be noted that infiltration practices should *not* be entirely relied upon to achieve high levels of particulate pollutant removal (particularly sediments), because these particles can rapidly clog the device. For these systems to be effective, particulate pollutants must be removed before they enter the structure by means of a filter strip, sediment trap, or other pretreatment devices, and these devices must be regularly maintained.

Filter Strips

The filter systems described below rely on various forms of erosion-resistant vegetation to amplify particulate pollutant removal, improve terrestrial habitat, and enhance the appearance of a site. In addition, filter systems can improve both the performance and amenity value of pond and infiltration practices via storm water pretreatment.

Grass Filter Strip - These are similar to a grassed swale, but they can only accept overland flow. Filter strips are effective when used to protect surface infiltration trenches from clogging by sediment. They are effective in removal of sediment, organic material, and trace metals. They should be used as a component in an integrated storm water management system. Filter strips are inexpensive to establish if preserved prior to site development. As with all filter systems, long-term maintenance (mowing, inspection for short circuiting, etc.), should be included in overall costs.

Riparian Buffer Strip - Riparian buffer strips improve water quality by removing nutrients, sediment and suspended solids, and pesticides and other toxins from surface runoff as well as from subsurface and ground water flows. The pollutant removal mechanism associated with riparian vegetation combines the physical process of filtering and the biological processes of nutrient uptake and denitrification.

Grassed Swale - This is a grassed, low gradient conveyance channel that provides some water quality improvements for storm water via natural filtration, settling, and nutrient uptake of the grass cover. Often used as an alternative to curb-and-gutter drainage conveyance, grassed swales affect peak discharges by lengthening the time of concentration. They can also be fitted with low check dams to increase removal efficiency via temporary ponding.

Sand Filters - Sand filters are a water quality control filtration system used to remove large particulates from runoff and protect filter media from excessive sediment loading at storm water quality control basins. Sand filters can be used independently or with a dry pond basin element.

Peat/Sand Filters - This is a man-made soil filter system utilizing the natural absorptive features of peat. The system features a grass cover crop and alternating sublayers of peat, sand, and a perforated pipe underdrain system. Systems are presently used for municipal waste effluent treatment and are being adapted for use in storm water management.

Filter strips have a low-to-moderate capability of removing pollutants in urban runoff and exhibit higher removal rates for particulates rather than soluble pollutants. Pollutant removal techniques include filtering through vegetation and soil, settling and deposition, and uptake by vegetation. Riparian buffer strips appear to have a higher pollutant removal capability than grass filter strips. However, length, slope, and soil permeability are critical factors that influence the effectiveness of any strip. Another practical design problem is prevention of storm water from concentrating and thereby "short-circuiting" the strip.

Filter systems are an essential component of a comprehensive nonpoint source control strategy but should generally be used in conjunction with infiltration systems and pond systems as a pretreatment for runoff.

Oil/Water Separators

There are several types of oil-water separators. The basic separators that could be utilized at a construction activity are listed as follows:

SC Separator - An SC separator consists of an underground vault or manhole with an inlet pipe and "T" outlet. The structure of the separator allows for separation of floating oil only and has a capacity for small spills.

API Separator - The API separator consists of a rectangular vault with a series of baffles. Some systems have sophisticated equipment for skimming and removal of oil and other materials.

CPI Separator - The CPI separator consists of a vault that contains a series of closely aligned parallel plates made of fiberglass. The plates are positioned at an angle to the direction of inflow from 0 to 60 degrees.

Oil/water separators may be used within a storm drainage system or as a pretreatment for discharge into the sanitary system or hold tank for removal. An SC separator is effective for retaining small fuel or oil spills. The API and CPI separators are effective in removing diluted oil droplets from storm water. Maintenance must be performed regularly. Oil/water separators must be cleaned frequently to keep accumulated oil from escaping during larger storm events.

6.0 Mobilization, Implementation, Monitoring, and Documentation

6.1 Mobilization/Implementation

The first step of mobilization should be the implementation of controls. The controls should be constructed or applied in accordance with state or local standard specifications. If there are no state or local specifications for control measures then the controls should be constructed in accordance with Appendix C. In any event the controls must be constructed in accordance with good engineering practices and in compliance with NPDES regulations. Appendix C lists typical design standards for structural control measures. The controls should be constructed and the stabilization measures applied in the order indicated by the sequence of major activities.

To ensure that controls are adequately implemented, it is important that the work crews installing the measures are experienced and/or adequately trained. Improperly installed controls can have little or no effect and may actually increase pollutant export. It is also important that all other workers on the construction site be made aware of the controls so that they do not inadvertently disturb or remove them.

6.2 Site Inspections

Inspection and maintenance of the control measures are as important to pollution prevention as proper planning and design. Inspection should be performed at the frequency specified in the SWPPP and/or the issued permit. **Each state has different inspection and reporting requirements, the reader is encouraged to contact the permit authority for the states in question.** The inspector should note any damage or deficiencies in the control measures in an inspection report. An example of an inspection report can be found in Appendix D, as Exhibit D-2. The operator should correct damages or deficiencies as soon as practicable after the inspection, and any changes that may be required to correct deficiencies in the SWPPP should be made as soon as practicable after the inspection. In addition to the inspection and maintenance reports, the operator should keep records of the construction activity on the site. In particular, the operator should keep a record of dates when each activity starts and is completed. Exhibits D-2 through D-4, in Appendix D may be used to record this information. The Inspection and Maintenance Report Forms are organized into three basic management measures: (1) Structural Controls, (2) Vegetative Controls, and (3) Management Measures. The particular practices associated with these measures are located in Appendix C, and are categorized in Section 3.4.4. The general permit requires inspection every 7 days or within 24 hours of a storm event of 12.5 mm (0.5 inch) or more. All disturbed areas of the site, areas for material storage, locations where vehicles enter or exit the site, and all of the erosion and sediment controls that were identified as part of the plan must be inspected. Controls must be in good operating condition until the area they protect has been completely stabilized and the construction activity is complete. The construction project manager will designate an inspector for monitoring BMP's (these inspections can be performed as part of a regular construction inspection program). As the principal permittee, COE will also regularly inspect each construction site to determine compliance with provisions of the SWPPP. Construction sites which do not comply with provisions of the SWPPP will be shut down by COE until compliance is achieved.

6.3 Personnel Designation

Designated personnel for each contractor/tenant construction project should be listed in the Pollution Prevention Committee Members form, Exhibit D-1, in Appendix D.

6.4 Training

Personnel performing site inspections (COE and tenant projects) are required to be experienced in construction practices and erosion and sediment control practices. Many states and organizations offer general training programs in sediment and erosion control. Training as a whole should address:

- The location and type of control measures.
- The construction requirements for the control measures.
- Spill response.
- Inspection and maintenance record-keeping requirements.
- Pollution control laws and regulations.
- Good housekeeping and material management practices.
- Particular construction activity features and operations designed to minimize storm water pollution.

COE will review SWPPP requirements with each tenant or contractor before approving construction activities.

A large part of the success of an SWPPP is the capability and interest of the employees responsible for implementing and maintaining the program. Personnel must understand the importance of the program and the goals of the SWPPP. Personnel must be trained in the techniques of response, removal, and documentation. The permit authority representatives will be inspecting the general permit participants, and it is important that they are received by trained, knowledgeable personnel who have access to the SWPPP, environmental files, and other documentation. The SWPPP documentation must be current and complete when inspected.

Annual training workshops and meetings should be established, at which time employee participation and input should be encouraged. Training schedules should be recorded (see Table E-5, Appendix E). New techniques of storm water management controls as well as changes in permit compliance or limits should be explained to the employees.

6.5 Nonstorm water discharges

6.5.1 Certification

The general permit requires nonstorm water discharges to be eliminated prior to the implementation of the SWPPP. Existing industrial facilities must certify that there are no nonstorm water discharges present in the storm water drainage system. All facilities must certify and monitor outfalls for dry weather discharges.

The certification page for nonstorm water certification is shown in Appendix F. A certification page should be signed and retained as part of the SWPPP documentation. All forms filled out while surveying and evaluating outfalls should also be inserted into the nonstorm water discharge section of the SWPPP. A record of methods used, dates, and time conducted should be listed on the form.

If certification is not feasible because of the inability to eliminate the nonstorm water discharge because of the need for significant structural changes, the construction activity must notify the permit authority. This notification should include a summary of why the extension in eliminating nonstorm water discharges is required and a schedule indicating when nonstorm water discharges will be eliminated. The schedule is subject to modification by the permit authority.

6.5.2 Nonstorm Water Inspection

The inspection for nonstorm water discharges should take place concurrently with the inspection of the drainage system (Section 6.5.3).

6.5.3 Drainage System

There may be several drainage systems serving the construction activity depending on topography. The inspection for each drainage system should begin at the farthest discharge point from the center of construction activity operations. The farthest discharge point may be at the property boundary, or it may be at the point where the "waters of the United States" cross the construction activity property and intersect with a drainage system.

Physical inspection of the outfalls should include (principal issues identified):

- Flow — If flow is present, and precipitation has not occurred within the past 3 days, there may be a problem requiring further investigation unless the source is positively known and is nonpolluting.
- Odor — The presence of any odor from the drainage system may indicate an unnatural occurrence.
- Clarity — If water is present, standing or flowing, and it is not clear, pollution should be suspected.
- Floatables — If there is floating debris, garbage, sewage, or an oily sheen, the source of the material should be identified.
- Stains, etc. — If stains are present on lined channels/pipes, or other than the normal vegetation or soil color, this may be an indicator requiring further investigation.
- Vegetation — If vegetation in the discharge channel is more luxurious or, conversely, appears stressed in comparison to adjacent vegetation, this is likely an indicator of excess nutrients or other problems and requires further investigation.

In addition, inspection should note siltation or scour problems below outfalls, or at system confluences, for referral to construction activity maintenance officials.

Chemical inspection of outfalls may make use of dry weather monitoring kits if dry weather flow is observed from the discharge points(s) or stagnant pools are observed at the discharge point(s). The results of the tests using these kits can assist in identifying possible problem sources upstream in the system.

From the discharge point(s), the inspection should proceed upstream. Similar inspections should be made of each intervening discharge point, if the storm drain is not continuous to its final outfall. If the storm drain is continuous, inspections should be made at each manhole upstream to the inlets of the storm water drainage system. **(Inspectors shall not enter manholes unless OSHA-approved confined space entry procedures are followed.)** The inspectors should make note of any of the items listed above. Particular attention should be given to connections in the storm water drain lines or any inlet lines not shown on the plans. Patched pavements may be indicators of postdesign connections.

Attention should be given to determine the discharge destination of floor drains. These drains must be connected to the sanitary sewer system.

The flow paths to each of the inlets must be inspected, as well as the inlets themselves. Particular attention should be given to the presence of grease, oil, fuel, chemical, or solvent residues along these flow paths, as well as any other staining that could indicate a pollutant that could be washed down the storm drain. Inlet sumps should be inspected. Debris collected in inlet sumps should be removed regularly and before any substantial buildup occurs.

The physical condition and cleanliness of the components of the drainage system must be inspected as well. The inspector should make sure that the drainage areas are clean and free of debris. The physical integrity of all conveyances and discharge points should be inspected for corrosion, seam and joint connections, erosion, silting, leaks, and condition of dikes, berms, and other structures of the storm water controls.

These inspections, related to the construction activity SWPPP's, are important to ensure that pollutants arising from other industrial activities are not incorrectly ascribed to the construction activity.

Table D-6, Appendix D, will be used to record drainage system maintenance and inspection observations.

Inspection of paved areas is not a difficult task, because all surfaces can be easily seen. With respect to storm water pollution, if the paved areas are free of visible pollutants, storm water contamination is less likely.

Inspections will focus on maintenance activities that assure that paved surfaces are clean of chemicals, grease, oil, solvents, and fuels, and that other potential pollutants are kept off the paved areas, or that they are kept covered and out of storm water flow paths.

Paved areas will also be inspected for cracks. Where there is a significant potential for a spill, such as drip pads or fueling stations, cracks may allow pollutants to seep into the soil where ground water contamination could occur. Maintenance activities could include proper grouting of all pavement joints.

Herbicides and petroleum products are sometimes applied to pavement cracks and at joints to control vegetation growth. The use of herbicides or other chemicals should be reviewed, as these materials may combine with storm water runoff or infiltrate into the underlying soil. If herbicides must be used, those with low toxicity and persistence should be considered. The frequency of application should be reduced to the minimum required. Grouting of joints and cracks may offer an alternative to herbicide application.

6.6 Final Stabilization/Termination

As soon as practicable after construction activities have been completed in a disturbed area, permanent stabilization should be started to prevent further erosion of soil from that area. All disturbed areas of a site, except those portions which are covered by pavement or a structure, should be finally stabilized once all construction activities are completed. Final stabilization requirements may vary from permit to permit. Final stabilization is defined by the EPA General Permit as meaning that all soil-disturbing activities at the site have been completed, and that a uniform perennial vegetative cover with a density of 70 percent of the cover for the unpaved areas has been established or equivalent stabilization measures, such as the use of riprap, gabions, or geotextiles, have been employed.

Operators of a construction site must continue to comply with permit conditions until: (1) they no longer meet the definition of an operator of a construction site; or (2) the construction activity is complete, all disturbed soils have been finally stabilized, and temporary erosion and sediment controls have been or will be removed. A permittee should submit a Notice of Termination (NOT) to inform EPA that they are no longer an operator of a construction activity. The NOT is a one-page form (see Appendix F) which should be completed and submitted to the permitting authority when a site has been finally stabilized or when an operator of a construction activity changes. The NOT is typically the final task required to comply with the requirements of an NPDES storm water permit for a construction activity. The NOT communicates to the permitting authority that the construction activity has ceased and the area is stabilized.

Note that when there is a change in operators of a construction activity, then the new operator must submit an NOI to be covered by the permit at least 2 days before the change in operator.

Where the NOT's are submitted depends on the permitting authority. Some state agencies do not require submittal of NOT's. Federally regulated NPDES permits require NOTs to be submitted to the following address:

Storm Water Notice of Termination
P.O. Box 1185
Newington, Virginia 22122

Following the termination of construction activities, the permittees must keep a copy of the SWPPP and records of all the data used to complete the NOI for a period of at least 3 years following final stabilization. The record retention period may be extended by the permitting authority's request.

FOR THE COMMANDER:

10 Appendices
(See Table of Contents)

ROBERT H. GRIFFIN
Colonel, Corps of Engineers
Chief of Staff

APPENDIX A

List of State Contacts

Alabama
(205) 271-7852
Department of Environmental
Management- Water Quality Division
1751 Congressman W.L. Dickson Drive
Montgomery, Ala. 36130

Alaska*
(206) 553-8399
U.S. EPA, Region 10
1200 Sixth Ave.
Mailcode: WD-234
Seattle, Wash. 98101

(907) 271-3689
U.S. EPA-Alaska Operations Office
222 West 7th Ave., No. 19
Anchorage, Alaska 99513-7588

Arizona*
(415) 744-1906
U.S. EPA, Region 9
75 Hawthorne St.
Mailcode: W-5-1
San Francisco, Calif. 94105

Arkansas
(501) 682-0627
Department of Pollution Control
and Ecology-Water Division
8001 National Drive
P.O. Box 8913
Little Rock, Ark. 72219-8913

California
(916) 657-1110
State Water Resources Control Board-
Water Quality Division
P.O. Box 100
901 P St.
Sacramento, Calif. 95801

Colorado
(303) 331-4590
Colorado Department of Health
Water Quality Control Division
4300 Cherry Creek Dr. South
Denver, Colo. 80222-1530

Connecticut
(203) 566-7167
Department of Envir. Protection
Water Management Bureau-Water
Discharge Management
165 Capitol Ave.
Hartford, Conn. 06106

Delaware
(302) 739-5731
Department of Natural Resources and
Environmental Control-Division of
Water Resources
Water Pollution Control Branch
NPDES Stormwater Program
89 Kings Highway
P.O. Box 1401
Dover, Del. 19903

** As of February 1995, for non-NPDES states and territories, EPA regional office contacts are listed.*

District of Columbia*
(215) 597-1651
U.S. EPA, Region 3
841 Chestnut St. Building
Mailcode: 3HW31
Philadelphia, Pa. 19107

Florida*
(404) 347-3633
U.S. EPA, Region 4
345 Courtland St. N.W.
Mailcode: 4WM-WPEB
Atlanta, Ga. 30365

(904) 488-0782
Department of Envir. Regulation
Stormwater/Nonpoint Source Mgmt.
Section
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Fla. 32399-2400

Georgia
(404) 656-4887
Industrial Wastewater Program
(404) 362-2680
Municipal Permitting Program
Department of Natural Resources
Environmental Protection Division
205 Butler St. S.E.
Atlanta, Ga. 30334

Hawaii
(808) 586-4309
Department of Health
Clean Water Branch
P.O. Box 3378
Honolulu, Hawaii 96801

Idaho*
(206) 553-8399
U.S. EPA, Region 10
1200 Sixth Ave.
Mailcode: WD-134
Seattle, Wash. 98101

(208) 334-9498
U.S. EPA
422 West Washington
Boise, Idaho 83702

Illinois
(217) 782-0610
Environmental Protection Agency
Water Pollution Control Division
2200 Churchill Road
P.O. Box 19276
Springfield, Ill. 67294-9276

Indiana
(317) 233-6725
Department of Environmental Mgmt.
Water Management Office
NPDES Permits Group
100 N. Senate Avenue
P.O. Box 6015
Indianapolis, Ind. 46206

** As of February 1995, for non-NPDES states and territories, EPA regional office contacts are listed.*

Iowa
(515) 281-7017
Department of Natural Resources
Surface and Groundwater Protection Bureau
Wallace State Office Building
900 E. Grand Ave.
Des Moines, Iowa 50319-0034

Kansas
(913) 296-5547
Department of Health and Envir.
Water Bureau
Forbes Field, Building 740
Topeka, Kan. 66620

Kentucky
(502) 564-3410
NPDES Branch
Department of Envir. Protection
Water Division
18 Reilly Road
Frankfort, Ky. 40601

Louisiana*
(214) 665-7523
U.S. EPA, Region 6
1445 Ross Ave.
Mailcode: 6W-PM
Dallas, Texas 75202

(504) 765-0525
Department of Envir. Quality
Office of Water Resources
Water Pollution Control Division
P.O. Box 82215
Baton Rouge, La. 70884-2215

Maine*
(617) 565-3590
U.S. EPA, Region 1
Compliance Branch-WPC
JFK Federal Building
Boston, Mass. 02203

(207) 289-7693
Department of Envir. Protection
Water Bureau
State House, Station 17
Augusta, Maine 04333

Maryland
(410) 631-3323
Hazardous & Solid Waste Mangment Administration-Sediment & Stormwater Management Administration
Department of the Environment
2500 Broening Highway
Baltimore, Md. 21224

Massachusetts*
(617) 565-3590
U.S. EPA, Region 1
Special Permits Section, Wastewater Management Branch
JFK Building
Mailcode: HPU-1
Boston, Mass. 02203

** As of February 1995, for non-NPDES states and territories, EPA regional office contacts are listed.*

Michigan
(517) 373-8088
Department of Natural Resources
Surface Water Division
P.O. Box 30338
Lansing, Mich. 48909

Minnesota
(612) 296-7203
General Program and Industrial Permits
(612) 296-8722
Municipal dischargers
(612) 296-7219
Construction activity dischargers
Pollution Control Agency
Water Quality Division
520 Lafayette Road
St. Paul, Minn. 55155

Mississippi
(601) 961-5074
Office of Pollution Control,
Industrial Wastewater Branch
Mississippi Department of Envir. Quality
2380 Highway 80 W
Jackson, Miss. 39289-0385

Missouri
(314) 751-6825
Department of Natural Resources
Water Pollution Control Program
P.O. Box 176
Jefferson City, Mo. 65102

Montana
(406) 444-2406
Department of Health and Envir. Sciences-Water Quality Division
P.O. Box 200901
Helena, Mont. 59620-0901

Nebraska
(402) 471-4239
Department of Environmental Ctrl
Water Quality Division
P.O. Box 98922
Lincoln, Neb. 68509

Nevada
(702) 687-4670
Department of Conservation and Natural Resources
Environmental Protection Division
123 W. Nye Lane
Carson City, Nev. 89710

New Hampshire*
(617) 565-3590
U.S. EPA, Region 1
Compliance Branch--WPC
JFK Federal Building
Boston, Mass. 02203

(603) 271-2457
Department of Environmental Services
Water Supply and Pollution Ctrl Div
Water Quality Permits and Compliance Bureau
P.O. Box 95
6 Hazen Drive
Concord, N.H. 03301

** As of February 1995, for non-NPDES states and territories, EPA regional office contacts are listed.*

New Jersey
(609) 633-7026
Department of Environmental
Protection and Energy
Water Resources Division
Water Quality Planning Bureau
401E. State St.
Trenton, N.J. 08265-0029

New Mexico*
(214) 665-7523
U.S. EPA, Region 6
1445 Ross Ave.
Mailcode: 6W-PM
Dallas, Texas 75202

(505) 827-2798
Water Quality Control Commission
1190 St. Francis Dr.
Harold Runnels Building
P.O. Box 26110
Santa Fe, N.M. 87502

New York
(518) 457-1157
Department of Environmental Conserv
Wastewater Facilities Design
50 Wolf Rd.
Albany, N.Y. 12233

North Carolina
(919) 733-5083
Department of Envir., Health and
Natural Resources
Division of Environmental Mgmt.
Water Quality Planning
P.O. Box 29535
Raleigh, N.C. 27626-0535

North Dakota
(701) 221-5242
Department of Labor and Consolidate
Laboratories-Water Quality Division
1200 Missouri Ave.
P.O. Box 5520
Bismark, N.D. 58502-5520

Ohio
(614) 664-2001
Environmental Protection Agency
Water Pollution Control Division
P.O. Box 163669
1800 Watermark Drive
Columbus, Ohio 43266-3669
Hotline: (614) 644-2053

Oklahoma*
(214) 665-7523
U.S. EPA, Region 6
1445 Ross Ave.
Mailcode: 6W-PM
Dallas, Texas 75202

Oregon
(503) 229-5256
Department of Environmental Quality
Water Quality Division
811 S.W. Sixth Ave.
Portland, Ore. 97204

Pennsylvania
(717) 787-8184
Department of Envir. Resources
Water Quality Management Bureau
P.O. Box 2063
Harrisburg, Pa. 17120

** As of February 1995, for non-NPDES states and territories, EPA regional office contacts are listed.*

Rhode Island
(401) 277-6519
Department of Environmental Mgmt.
Division of Water Resources
291 Promenade Street
Providence, R.I. 02908

South Carolina
(803) 734-5300
Bureau of Water Pollution Control
Department of Health and
Environmental Control
2600 Bull St.
Columbia, S.C. 29201

South Dakota*
(303) 293-1647
U.S. EPA, Region 8
999 18th St., Suite 500
Denver, Colorado 80202-2466

(605) 773-3351
Department of Envir. and Natural
Resources-Division of Envir.
Regulation
Joe Foss Building
523 East Capitol
Pierre, S.D. 57501-3181

Tennessee
(615) 741-7833
Division of Water Pollution Control
150 Ninth Ave. N.
Fourth Floor
Department of Environment and
Conservation
Nashville, Tenn. 37243-1534

Texas*
(214) 665-7523
U.S. EPA, Region 6
1445 Ross Ave.
Mailcode: 6W-PM
Dallas, Texas 75202

Utah
(801) 538-6146
Department of Environmental Quality
Division of Water Quality
Salt Lake City, Utah 84114-4870

Vermont
(802) 241-3822
Department of Envir. Conservation
Permits, Compliance and Protection
Division
103 S. Main St.
Waterbury, Vt. 05676

Virginia
(804) 527-5083
Virginia Department of Environmental
Quality-Water Control Board
P.O. Box 11143
Richmond, Va. 23230-1143

Washington
(206) 438-7614
Industrial permits
(206) 438-7529
Municipal permits
Department of Ecology-Office of
Water Programs
Mail Stop PV-11
Olympia, Wash. 98504-7696

** As of February 1995, for non-NPDES states and territories, EPA regional office contacts are listed.*

West Virginia
(304) 558-8855
Department of Commerce, Labor and Natural Resources-Office of Water Resources-Industrial Branch
State Capitol Building
1201 Greenbrier St.
Charleston, W. Va. 25311

Wisconsin
(608) 267-7634
Department of Natural Resources
Bureau of Wastewater Management
P.O. Box 7921
Madison, Wis. 53707

Wyoming
(307) 777-7082
Department of Environmental Quality
Herschler Building, 4th Floor
Cheyenne, Wyo. 82002

American Samoa*
(415) 744-1906
U.S. EPA, Region 9
75 Hawthorne St.
Mailcode: W-5-1
San Francisco, Calif. 94103

Guam*
(415) 744-1906
U.S. EPA, Region 9
75 Hawthorne St.
Mailcode: W-5-1
San Francisco, Calif. 94103

Northern Mariana Islands*
(415) 744-1906
U.S. EPA, Region 9
75 Hawthorne St.
Mailcode: W-5-1
San Francisco, Calif. 94013

Puerto Rico*
(212) 264-8611
U.S. EPA, Region 2
26 Federal Plaza, Room 845
Mailcode: WMD-WPCB
New York, N.Y. 10278

(809) 767-8181
Director of Water Quality Area
Environmental Quality Board
P.O. Box 11488
Santurce, Puerto Rico 00910

Virgin Islands
(809) 773-0565
Department of Planning and Natural Resources-Environmental Protection Division
Government House
Charlotte Amalie
St. Thomas, Virgin Islands 00801

(809) 774-3320
Director, Coastal Zone Management Office-Department of Planning and Natural Resources
6003 Annas Hope
Christiansted
St Croix, Virgin Islands 00820-4433

** As of February 1995, for non-NPDES states and territories, EPA regional office contacts are listed.*

APPENDIX B

Federal Notice of Intent

THIS FORM REPLACES PREVIOUS FORM 3510-6 (8-92)
See Reverse for Instructions

Form Approved. OMB No. 2040-0086 Approval expires: 8-31-98

NPDES FORM

EPA

United States Environmental Protection Agency
Washington, DC 20460

Notice of Intent (NOI) for Storm Water Discharges Associated with Industrial Activity Under a NPDES General Permit

Submission of this Notice of Intent constitutes notice that the party identified in Section II of this form intends to be authorized by a NPDES permit issued for storm water discharges associated with industrial activity in the State identified in Section III of this form. Becoming a permittee obligates such discharger to comply with the terms and conditions of the permit. ALL NECESSARY INFORMATION MUST BE PROVIDED ON THIS FORM.

I. Permit Selection: You **must** indicate the NPDES Storm Water general permit under which you are applying for coverage. Check one of these. following:

Baseline Industrial ☐ Baseline Construction ☐ Multi-Sector (Group Permit) ☐

II. Facility Operator Information

Name: ______ Phone: ______

Address: ______ Status of Owner/Operator: ☐

City: ______ State: ______ ZIP Code: ______

III. Facility/Site Location Information

Name: ______

Is the facility located on Indian Lands? (Y or N) ☐

Address: ______

City: ______ State: ______ ZIP Code: ______

Latitude: ______ Longitude: ______ Quarter: ______ Section: ______ Township: ______ Range: ______

IV. Site Activity Information

MS4 Operator Name: ______

Receiving Water Body: ______

If you are filing as a co-permittee, enter storm water general permit number: ______

SIC or Designated Activity Code: Primary: ______ 2nd: ______

Is the facility required to submit monitoring data? (1, 2, 3, or 4) ☐

If You Have Another Existing NPDES Permit, Enter Permit Number: ______

Multi-Sector Permit Applicants Only:

Based on the instructions provided in Addendum H of the Multi-Sector permit, are species identified in Addendum H in proximity to the storm water discharges to be covered under this permit, or the areas of BMP construction to control those storm water discharges? (Y or N) ☐

Will construction (land disturbing activities) be conducted for storm water controls? (Y or N) ☐

Is applicant subject to and in compliance with a written historic preservation agreement? (Y or N) ☐

V. Additional Information Required for Construction Activities Only

Project Start Date: ______ Completion Date: ______

Estimated Area to be Disturbed (in Acres): ______

Is the Storm Water Pollution Prevention Plan in compliance with State and/or Local sediment and erosion plans? (Y or N) ☐

VI. Certification: The certification statement in Box 1 applies to all applicants.
The certification statement in Box 2 applies only to facilities applying for the Multi-Sector storm water general permit.

BOX 1

ALL APPLICANTS:

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

BOX 2

MULTI-SECTOR STORM WATER GENERAL PERMIT APPLICANTS ONLY:

I certify under penalty of law that I have read and understand the Part I.B. eligibility requirements for coverage under the Multi-Sector storm water general permit, including those requirements relating to the protection of species identified in Addendum H.

To the best of my knowledge, the discharges covered under this permit, and construction of BMPs to control storm water run-off, are not likely to and will not likely adversely affect any species identified in Addendum H of the Multi-Sector storm water general permit or are otherwise eligible for coverage due to previous authorization under the Endangered Species Act.

To the best of my knowledge, I further certify that such discharges, and construction of BMPs to control storm water run-off, do not have an effect on properties listed or eligible for listing on the National Register of Historic Places under the National Historic Preservation Act, or are otherwise eligible for coverage due to a previous agreement under the National Historic Preservation Act.

I understand that continued coverage under the Multi-Sector general permit is contingent upon maintaining eligibility as provided for in Part I.B.

Print Name: ______ Date: ______

Signature: ______

EPA Form 3510-6 (8-98)

Instructions - EPA Form 3510-6
Notice Of Intent (NOI) For Storm Water Discharges Associated With Industrial Activity
To Be Covered Under a NPDES General Permit

Who Must File A Notice Of Intent (NOI) Form

Federal law at 40 CFR Part 122 prohibits point source discharges of storm water associated with industrial activity to a water body(ies) of the U.S. without a National Pollutant Discharge Elimination System (NPDES) permit. The operator of an industrial activity that has such a storm water discharge must submit a NOI to obtain coverage under a NPDES Storm Water General Permit. If you have questions about whether you need a permit under the NPDES Storm Water program, or if you need information as to whether a particular program is administered by EPA or a state agency, telephone or write to the Notice of Intent Processing Center at (703) 931-3230.

Where To File NOI Form

NOIs must be sent to the following address: Storm Water Notice of Intent (4203)
401 M Street, S.W.
Washington, DC 20460

Completing The Form

You must type or print, using upper-case letters, in the appropriate areas only. Please place each character between the marks. Abbreviate if necessary to stay within the number of characters allowed for each item. Use one space for breaks between words, but not for punctuation marks unless they are needed to clarify your response. If you have any questions on this form, call the Notice of Intent Processing Center at (703) 931-3230.

Section I Permit Selection

You must indicate the NPDES storm water general permit under which you are applying for coverage. Check one box only. The Baseline Industrial and Baseline Construction permits were issued in September 1992. The Multi-Sector Permit became effective October 1, 1995.

Section II Facility Operator Information

Provide the legal name of the person, firm, public organization, or any other entity that operates the facility or site described in this application. The name of the operator may or may not be the same as the name of the facility. The responsible party is the legal entity that controls the facility's operation, rather than the plant or site manager. Do not use a colloquial name. Enter the complete address and telephone number of the operator.

Enter the appropriate letter to indicate the legal status of the operator of the facility: F = Federal; S = State; M = Public (other than federal or state); P = Private.

Section III Facility/Site Location Information

Enter the facility's or site's official or legal name and complete street address, including city, state, and ZIP code. If the facility or site lacks a street address, indicate the state and either the latitude and longitude of the facility to the nearest 15 seconds or the quarter, section, township, and range (to the nearest quarter section) of the approximate center of the site. Do not provide a P.O. Box number as the street address.

Indicate whether the facility is located on Indian lands.

Section IV Site Activity Information

If the storm water discharges to a municipal separate storm sewer system (MS4), enter the name of the operator of the MS4 (e.g., municipality name, county name) and the receiving water of the discharge from the MS4. (A MS4 is defined as a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) that is owned or operated by a state, city, town, borough, county, parish, district, association, or other public body which is designed or used for collecting or conveying storm water.)

If the facility discharges storm water directly to receiving water(s), enter the name of the receiving water(s).

If you are filing as a co-permittee and a storm water general permit number has been issued, enter that number in the space provided.

Indicate the monitoring status of the facility. Refer to the permit for information on monitoring requirements. Indicate the monitoring status by entering one of the following:

1 = Not subject to monitoring requirements under the conditions of the permit.
2 = Subject to monitoring requirements and required to submit data.
3 = Subject to monitoring requirements but not required to submit data.
4 = Subject to monitoring requirements but submitting certification for monitoring exclusion.

List, in descending order of significance, up to two 4-digit standard industrial classification (SIC) codes that best describe the principal products or services provided at the facility or site identified in Section III of this application. If you are applying for coverage under the construction general permit, enter "CO" (which represents SIC codes 1500 - 1799).

For industrial activities defined in 40 CFR 122.26(b)(14)(i)-(xi) that do not have SIC codes that accurately describe the principal products produced or services provided, use the following 2-character codes.

HZ = Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA [40 CFR 122.26 (b)(14)(iv)];
LF = Landfills, land application sites, and open dumps that receive or have received any industrial wastes, including those that are subject to regulation under subtitle D of RCRA [40 CFR 122.26 (b)(14)(v)];
SE = Steam electric power generating facilities, including coal handling sites [40 CFR 122.26 (b)(14)(vii)];
TW = Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage [40 CFR 122.26 (b)(14)(ix)]; or,
CO = Construction activities [40 CFR 122.26 (b)(14)(x)].

If there is another NPDES permit presently issued for the facility or site listed in Section III, enter the permit number. If an application for the facility has been submitted but no permit number has been assigned, enter the application number.

Facilities applying for coverage under the Multi-Sector storm water general permit must answer the last three questions in Section IV. Refer to Addendum H of the Multi-Sector general permit for a list of species that are either proposed or listed as threatened or endangered. "BMP" means "Best Management Practices" that are used to control storm water discharges.

Indicate whether any construction will be conducted to install or develop storm water runoff controls.

Section V Additional Information Required for Construction Activities Only

Construction activities must complete Section V in addition to Sections I through IV. Only construction activities need to complete Section V.

Enter the project start date and the estimated completion date for the entire development plan.

Provide an estimate of the total number of acres of the site on which soil will be disturbed (round to the nearest acre).

Indicate whether the storm water pollution prevention plan for the site is in compliance with approved state and/or local sediment and erosion plans, permits, or storm water management plans.

Section VI Certification

Federal statutes provide for severe penalties for submitting false information on this application form. Federal regulations require this application to be signed as follows:

For a corporation: by a responsible corporate officer, which means: (i) president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions, or (ii) the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25 million (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures;

For a partnership or sole proprietorship: by a general partner or the proprietor; or

For a municipality, state, Federal, or other public facility: by either a principal executive officer or ranking elected official.

Paperwork Reduction Act Notice

Public reporting burden for this application is estimated to average 0.5 hours per application, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate, any other aspect of the collection of information, or suggestions for improving this form, including any suggestions which may increase or reduce this burden to: Chief, Information Policy Branch, 2136, U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, or Director, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

APPENDIX C
BEST MANAGEMENT PRACTICES FOR CONSTRUCTION
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BEST MANAGEMENT PRACTICES FOR CONSTRUCTION
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PREFACE

This appendix provides best management practices (BMP) which will aid the designer in the preparation of a Storm Water Pollution Prevention Plan. The BMP listed in this appendix were taken primarily from the following sources;

1. Virginia Department of Conservation and Recreation Division of Soil and Water Conservation, Virginia Erosion and Sediment Control Handbook, third edition, 1992.

2. Washington State Department of Ecology, Stormwater Management Manual for Pugent Sound Basin, 1992.

3. United States Department of Agriculture, Soil Conservation Service, Guidelines for the Control of Erosion and Sediment in Urbanizing Areas Within Mississippi, 1975.

4. United States Environmental Protection Agency, Summary Guidance for Stormwater Management for Construction Activities-Developing Pollution PreventionPlans and Best Management Practices, 1992.

Since the BMP were developed with various regional controls, not all specifications and practices will be appropriate in all cases. The designer shall ensure that the selection, design and use of each BMP used in the SWPPP is appropriate and acceptable to the specific needs, location and acceptable to any approval agency for each plan developed.

Metric conversion of these BMP have been converted as required by Executive Order 12770 with the exception of BMP that use United States Department of Agriculture, Agricultural Research Service's (ARS) hydrological nomographs and charts. Conversion of these BMP will be conducted after the ARS has developed metric equivalents to these graphs. General metric conversion tables are used in these BMP for conversion to metric units once the final design has been completed.

BMP: SAFETY FENCE

Definition

A protective barrier installed to prevent access to an erosion control measure.

Purpose

To prohibit the undesirable use of an erosion control measure by the public.

Conditions Where Practice Applies

Applicable to any control measure or series of measures that can be considered unsafe by virtue of potential for access by the public.

Planning Considerations

The safety of the public must always be considered at both the planning and implementation phases of a land-disturbing activity. If there is any question concerning the risk of a particular erosion control measure to the general public, the measure should be relocated to a safer area, or an appropriate safety fence should be installed to prevent undesired access. Many times, the danger posed by a control may not be easily seen by plan designers and reviewers - that is when the on-site contractor or inspector must correct such situations in the field. Properly designed and installed safety fences prevent the trespassing of people into potentially dangerous areas, such as children using a sediment basin or a stormwater retention structure as play areas. The installation of these fences will protect people from hazards and the owner from possible litigation.

Two different types of fence will be discussed in this specification. The designer, developer, and contractor should always be sure that the most appropriate type of fence is utilized for a particular need.

Design Criteria

1. Safety fences should be located so as to create a formidable barrier to undesired access, while allowing for the continuation of necessary construction operations.

2. Safety fences are most applicable to the construction of berms, traps, and dams. In use with those structures, safety fences should be located far enough beyond the outer toe of the embankment to allow for the passage of maintenance vehicles. Fences should not be installed across the slope of a dam or dike.

3. The height of the fence shall be a minimum of 1.5 meters (5 feet) for plastic fence and 2 meters (6 feet) for metal fence. A fence must never be so short as to become an attraction for children to climb on or over.

4. Signs noting potential hazards such as "DANGER-QUICKSAND" or "HAZARDOUS AREA - KEEP OUT" should be posted and easily seen by anyone approaching the protected area.

5. Plastic (polyethylene) fence may be used as safety fencing, primarily in situations where the need is for a temporary barrier.

6. Metal or "chain-link" fence should be used when a potentially dangerous control measure will remain in place permanently, such as a stormwater detention or retention basin. However, they may also be used for measures which will only serve a temporary function, at the discretion of those responsible for project safety. The metal fence must meet the following physical requirements:

   a. Fabric shall be zinc-coated steel, 50 millimeter (2-inch) mesh, 9-gauge, minimum.

   b. Zinc coating shall have a minimum weight of 550 grams per square meter (1.8 ounces per square foot).

   c. Posts shall be steel pipe, zinc-coated.

   d. Top rails shall be steel pipe, zinc-coated.

   e. Braces shall be made of zinc-coated steel.

   f. Gates shall be single or double swing, zinc-coated steel. They shall be a minimum of 3.7 meters (12-feet) wide.

Construction Specifications

1. Safety fences must be installed prior to the construction of erosion control measures.

2. The polyethylene web of the plastic safety fence shall be secured to a conventional metal "T" or "U" post driven into the ground to a minimum depth of 450 millimeters (18 inches); posts should be spaced at 2 meter (6-foot) centers.

3. The metal safety fence shall be installed as per the following procedure:

   a. Line posts shall be placed at intervals of 3 meters (10 feet) measured from center to center of adjacent posts. In determining the post spacing, measurement will be made parallel with the ground surface.

   b. Posts will be set in concrete and backfilled or anchored by other acceptable means.

   c. Posts set in the tops of concrete walls shall be grouted into preformed holes to a minimum depth of 300 millimeters (12 inches).

   d. All corner posts, end posts, gate posts, and pull posts shall be embedded, braced, and trussed.

   e. Fencing fabric shall not be stretched until at least 4 days after the posts are grouted into walls or 14 days after the posts are set into concrete.

   f. The fabric shall be stretched taut and securely fastened, by means of tie clips, to the posts at intervals not exceeding 400 millimeters (15 inches) and to the top rails or tension wires at intervals not exceeding 600 mm (24 in.). Care shall be taken to equalize the tension on each side of each post.

4. Applicable warning signs noting hazardous conditions must be installed immediately upon installation of safety fence.

Maintenance

1. Safety fence shall be checked regularly for weather-related or other damage. Any necessary repairs must be made immediately.

2. Care should be taken to secure all access points (gates) at the end of each working day. All locking devices must be repaired or replaced as necessary.

BMP-2

BMP: TEMPORARY STONE CONSTRUCTION ENTRANCE

Definition

A stabilized stone pad with a filter fabric underliner located at points of vehicular ingress and egress on a construction site.

Purpose

To reduce the amount of mud transported onto paved public roads by motor vehicles or runoff.

Conditions Where Practice Applies

Wherever traffic will be leaving a construction site and move directly onto a public road or other paved area.

Planning Considerations

Accepted engineering standards require that provisions be made to minimize the transport of sediment by vehicular traffic onto a paved surface. Construction entrances provide an area where a significant amount of mud can be removed from construction vehicle tires before they enter a public road and, just as important, the soil adjacent to the paved surface can be kept intact. A filter fabric liner is used as a "separator" to minimize the dissipation of aggregate into the underlying soil due to construction traffic loads. If the action of the vehicles traveling over the gravel pad is not sufficient to remove the majority of the mud or there exists an especially sensitive traffic situation on the adjacent paved road, the tires must be washed before the vehicle enters the public road. If washing is necessary, provisions must be made to intercept the wash water and trap the sediment so it can be collected and stabilized. Construction entrances should be used in conjunction with the stabilization of construction roads (see BMP-3, CONSTRUCTION ROAD STABILIZATION) to reduce the amount of mud picked up by construction vehicles and to do a better job of mud removal. Other innovative techniques for accomplishing the same purpose (such as a bituminous entrance) can be utilized, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

Design Criteria

Aggregate Size: Coarse Aggregate size of 50 to 75 millimeters (2 to 3 inches) stone should be used.

Entrance Dimensions: The aggregate layer must be at least 150 millimeters (6 inches) thick; a minimum of 75 millimeters (3 inches) of aggregate should be placed in a cut section to give the entrance added stability and to help secure filter cloth separator. It must extend the full width of the vehicular ingress and egress area and have a minimum width of 4 meters (12-feet). The length of the entrance should not be less than 15 meters (50 feet).

Washing: If conditions on the site are such that the majority of the mud is not removed by the vehicles traveling over the stone, then the tires of the vehicles must be washed before entering the public road. Wash water must be carried away from the entrance to an approved settling area to remove sediment. All sediment shall be prevented from entering storm drains, ditches, or watercourses. A wash rack may also be used to make washing more convenient and effective.

Location: The entrance should be located to provide for maximum utilization by all construction vehicles.

Construction Specifications

The area of the entrance must be excavated a minimum of 75 millimeters (3 inches) and must be cleared of all vegetation, roots, and other objectionable material. The filter fabric underliner will then be placed the full width and length of the entrance.

Following the installation of the filter cloth, the stone shall be placed to the specified dimensions. If wash racks are used, they should be installed according to manufacturer's specifications. Any drainage facilities required because of washing should be constructed according to specifications. Conveyance of surface water under entrance, through culverts, shall be provided as required. If such conveyance is impossible, the construction of a "mountable" berm with 5:1 slopes will be permitted.

The filter cloth utilized shall be a woven or non-woven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The fabric shall be inert to commonly encountered chemicals and hydrocarbons and be mildew and rot resistant.

Maintenance

The entrance shall be maintained in a condition which will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with additional stone or the washing and reworking of existing stone as conditions demand and repair and/or cleanout of any structures used to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately. The use of water trucks to remove materials dropped, washed, or tracked onto roadways will not be permitted under any circumstances.

BMP: CONSTRUCTION ROAD STABILIZATION

Definition

The temporary stabilization of access roads, subdivision roads, parking areas, and other onsite vehicle transportation routes with stone immediately after grading.

Purposes

1. To reduce the erosion of temporary roadbeds by construction traffic during wet weather.

2. To reduce the erosion and subsequent regrading of permanent roadbeds between the time of initial grading and final stabilization.

Conditions Where Practice Applies

Wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

Planning Considerations

Areas which are graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy quagmires which generate significant quantities of sediment that may pollute nearby streams or be transported off site on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable.

Immediate stabilization of such areas with stone may cost money at the outset, but it may actually save money in the long run by increasing the usefulness of the road during wet weather.

Permanent roads and parking areas should be paved as soon as possible after grading. However, it is understandable that weather conditions or the potential for damage may not make paving feasible in the early phases of the development project. As an alternative, the early application of stone may solve potential erosion and stability problems and eliminate later regrading costs. Some of the stone will also probably remain in place for use as part of the final base course in the construction of the road.

Construction Specifications

Temporary Access Roads and Parking Areas

1. Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes should not exceed 10 percent.

2. Temporary parking areas should be located on naturally flat areas to minimize grading. Grades should be sufficient to provide drainage but should not exceed 4 percent.

3. Roadbeds shall be at least 4.25 meters (14 feet) wide for one-way traffic and 6.25 meters (20 feet) wide for two-way traffic.

4. All cuts and fills shall be 2:1 or flatter to the extent possible.

5. Drainage ditches shall be provided as needed and shall be designed and constructed in accordance with STORMWATER CONVEYANCE CHANNEL, BMP-17.

6. The roadbed or parking surface shall be cleared of all vegetation, roots and other objectionable material.

7. A 150 millimeter (6-inch) course of coarse aggregate, 50 to 75 millimeter (2 to 3 inch) stone, shall be applied immediately after grading or the completion of utility installation within the right-of-way. Filter fabric may be applied to the roadbed for additional stability. Design specifications for filter fabric can be found within BMP-2, TEMPORARY STONE CONSTRUCTION ENTRANCE. In "heavy duty" traffic situations, stone should be placed at a minimum depth of 200 millimeters (8 inches) to avoid excessive dissipation or maintenance needs.

Permanent Roads and Parking Areas

Permanent roads and parking areas shall be designed and constructed in accordance with applicable local criteria except that an initial base course of gravel of at least 150 millimeters (6 inches) shall be applied immediately following grading.

Vegetation

All roadside ditches, cuts, fills and disturbed areas adjacent to parking areas and roads shall be stabilized with appropriate temporary or permanent vegetation according to the applicable standards and specifications contained in this handbook.

Maintenance

Both temporary and permanent roads and parking areas may require periodic top dressing with new gravel. Seeded areas adjacent to the roads and parking areas should be checked periodically to ensure that a vigorous stand of vegetation is maintained. Roadside ditches and other drainage structures should be checked regularly to ensure that they do not become clogged with silt or other debris.

BMP-4

BMP: STRAW BALE BARRIER

Definition

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas of limited extent in order to prevent sediment from leaving the construction site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion.

2. Where the size of the drainage area is no greater than 0.3 hectares per 100 meters of barrier length (0.25 acres per 100 feet); the maximum slope length behind the barrier is 30 meters (100 feet); and the maximum slope gradient behind the barrier is 50 percent (2:1).

3. In minor swales or ditch lines where the maximum contributing drainage area is no greater than 0.8 hectares (2 acres).

4. Where effectiveness is required for less than 3 months.

5. Under no circumstances should straw bale barriers be constructed in live streams or in swales where there is the possibility of a washout.

6. Straw bale barriers shall not be used on areas where rock or another hard surface prevents the full and uniform anchoring of the barrier.

Planning Considerations

Based on observations made in Virginia, Pennsylvania, Maryland and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be - especially when used to slow down and filter concentrated flows. They should be used judiciously and with caution as erosion control measures. There are three major reasons for such ineffectiveness.

First, improper utilization of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water depth and velocities have destroyed or damaged the control. Secondly, improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions of, rather than removal of, sediment from runoff waters. Finally, inadequate maintenance lowers the effectiveness of these barriers. Trapping efficiencies of **carefully** installed straw bale barriers on one project in Virginia dropped from 57% to 16% in one month due to lack of maintenance.

Design Criteria

A formal design is not required. However, an effort should be made to locate the straw bale barrier, as well as other perimeter controls, at least 1.5 to 2 meters (5 to 7 feet) from the base of disturbed slopes with grades greater than 7%. This will help prevent the measure from being rendered useless following the initial movement of soil.

Construction Specifications

Sheet Flow Application

1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

2. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that bindings are oriented around the sides rather than along the tops and bottoms of the bales in order to prevent deterioration of the bindings.

3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 100 millimeters (4 inches). After the bales are staked and chinked (gaps filled by wedging), the excavated soil shall be backfilled against the barrier.

Backfill soil shall conform to the ground level on the downhill side and shall be built up to 100 millimeters (4 inches) against the uphill side of the barrier.

4. Each bale shall be securely anchored by at least two stakes each having minimum dimensions of 50 millimeters x 50 millimeters x 900 millimeters (2 inches x 2 inches x 36 inches) or standard "T" or "U" steel posts (minimum weight of 2 kilograms per meter (1.33 pounds per linear foot) driven through the bale. The first stake or steel post in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or steel pickets shall be driven a minimum 450 millimeters (18 inches) deep into the ground to securely anchor the bales.

5. The gaps between bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency.

6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

Maintenance

1. Straw bale barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall.

2. Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales.

3. Necessary repairs to barriers or replacement of bales shall be accomplished promptly.

4. Sediment deposits should be removed after each rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.

5. Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.

BMP-5

BMP: SILT FENCE

Definition

A temporary sediment barrier consisting of a synthetic filter fabric stretched across and attached to supporting posts and entrenched.

Purposes

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate **level** channel flows.

Conditions Where Practice Applies

1. Below disturbed areas where erosion would occur in the form of sheet and rill erosion.

2. Where the size of the drainage area is no more than 0.3 hectares per 100 meters of silt fence length (0.25 acres per 100 feet); the maximum slope length behind the barrier is 30 meters (100 feet); and the maximum gradient behind the barrier is 50 percent (2:1).

3. In minor swales or ditch lines where the maximum contributing drainage area is no greater than 0.8 hectares (2 acres).

4. Under no circumstances should silt fences be constructed in live streams or in swales or ditch lines where flows are likely to exceed 0.03 cubic meters per second (1 cfs).

5. Silt fence will not be used in areas where rock or some other hard surface prevents the full and uniform depth anchoring of the barrier.

Planning Considerations

Research has shown that silt fences can trap a much higher percentage of suspended sediments than straw bales, though silt fences pass the sediment-laden water slower. Silt fences are preferable to straw barriers in many cases because of their durability and potential cost savings. While the failure rate of silt fences is lower than that of straw barriers, many instances have been observed where silt fences are improperly installed, inviting failure and sediment loss. The installation methods outlined here can improve performance and reduce failures.

As noted, flow rate through silt fence is significantly lower than the flow rate for straw bale barriers. This creates more ponding and hence more time for sediment to fall out.

Both woven and non-woven synthetic fabrics are commercially available. The woven fabrics generally display higher strength than the non-woven fabrics and, in most cases, do not require any additional reinforcement. When tested under acid and alkaline water conditions, most of the woven fabrics increase in strength, while the reactions of non-woven fabrics to these conditions are variable. The same is true of testing under extensive ultraviolet radiation. Permeability rates vary regardless of fabric type. While all of the fabrics demonstrate very high filtering efficiencies for sandy sediments, there is considerable variation among both woven and non-woven fabrics when filtering the finer silt and clay particles.

Design Criteria

1. No formal design is required. As with straw bale barriers, an effort should be made to locate silt fence at least 1.5 to 2 meters (5 to 7 feet) beyond the base of disturbed slopes with grades greater than 7%.

2. The use of silt fences, because they have such a low permeability, is limited to situations in which only sheet or overland flows are expected and where concentrated flows originate from drainage areas of 0.4 hectares (1 acres) or less.

3. Field experience has demonstrated that, in many instances, silt fence is installed too short, less than 0.4 meters (16 inches) above ground elevation. The short fence is subject to breaching during even small storm events and will require maintenance "clean outs" more often. Properly supported silt fence which stands 0.6 to 0.8 meters (24 to 34 inches) above the existing grade tends to promote more effective sediment control.

Construction Specifications

Materials

1. Synthetic filter fabric shall be a pervious sheet of propylene, nylon, polyester or ethylene yarn and shall be certified by the manufacturer or supplier.

2. Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of -18° C to 50° C (O° F to 120° F).

3. If wooden stakes are utilized for silt fence construction, they must have a diameter of 50 millimeters (2 inches) when oak is used and 100 millimeters (4 inches) when pine is used. Wooden stakes must have a minimum length of 1.5 meters (5 feet).

4. If steel posts (standard "U" or "T" section) are utilized for silt fence construction, they must have a minimum weight of 2 kilograms per meter (1.33 pounds per linear foot) and shall have a minimum length of 1.5 meters (5 feet).

5. Wire fence reinforcement for silt fences using standard-strength filter cloth shall be a minimum of 14 gauge and shall have a maximum mesh spacing of 150 millimeters (6 inches).

Installation

1. The height of a silt fence shall be a minimum of 400 millimeters (16 inches) above the original ground surface and shall not exceed 865 millimeters (34 inches) above ground elevation.

2. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are unavoidable, filter cloth shall be spliced together only at a support post, with a minimum 150 millimeter (6-inch) overlap, and securely sealed.

3. A trench shall be excavated approximately 100 millimeters (4-inches) wide and 100 millimeters (4-inches) deep on the upslope side of the proposed location of the measure.

4. When wire support is used, standard-strength filter cloth may be used. Posts for this type of installation shall be placed a maximum of 3 meters (10-feet apart). The wire mesh fence must be fastened securely to the upslope side

of the posts using heavy duty wire staples at least 25 millimeters long (1 inch), tie wires or hog rings. The wire shall extend into the trench a minimum of 50 millimeters (2 inches) and shall not extend more than 865 millimeters (34 inches) above the original ground surface. The standard-strength fabric shall be stapled or wired to the wire fence, and 200 millimeters (8 inches) of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees.

5. When wire support is not used, extra-strength filter cloth shall be used. Posts for this type of fabric shall be placed a maximum of 2 meters (6-feet) apart. The filter fabric shall be fastened securely to the upslope side of the posts using one 25 millimeter (1 inch) long (minimum) heavy-duty wire staples or tie wires and 200 millimeters (8 inches) of the fabric shall be extended into the trench. The fabric shall not be stapled to existing trees. This method of installation has been found to be more commonplace than #4.

6. If a silt fence is to be constructed across a ditch line or swale, the measure must be of sufficient length to eliminate endflow, and the plan configuration shall resemble an arc or horseshoe with the ends oriented upslope. Extra-strength filter fabric shall be used for this application with a maximum 1 meter (3-foot) spacing of posts.

   All other installation requirements noted in #5 apply.

7. The 100 millimeter by 100 millimeter (4-inch by 4-inch) trench shall be backfilled and the soil compacted over the filter fabric.

8. Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

Maintenance

1. Silt fences shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately.

2. Close attention shall be paid to the repair of damaged silt fence resulting from end runs and undercutting.

3. Should the fabric on a silt fence decompose or become ineffective prior to the end of the expected usable life and the barrier still be necessary, the fabric shall be replaced promptly.

4. Sediment deposits should be removed after each storm event. They must be removed when deposits reach approximately one-half the height of the barrier.

5. Any sediment deposits remaining in place after the silt fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

BMP: BRUSH BARRIER

Definition

A temporary sediment barrier constructed at the perimeter of a disturbed area from the residue materials available from clearing and grubbing the site.

Purpose

To intercept and retain sediment from disturbed areas of limited extent, preventing sediment from leaving the site.

Conditions Where Practice Applies

1. Below disturbed areas subject to sheet and rill erosion, where enough residue material is available for construction of such a barrier.

2. Where the size of the drainage area is no more than 0.3 hectares per 100 meters of barrier length (0.25 acres per 100 feet); the maximum slope length behind the barrier is 30 meters (100 feet); and the maximum gradient behind the barrier is 50 percent (2:1).

Planning Considerations

Organic litter and spoil material from site clearing operations is usually burned or hauled away to be dumped elsewhere. Much of this material can be used effectively on the construction site itself. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation and root mat along with minor amounts of rock into windrows along the toe of a slope where erosion and accelerated runoff are expected. Because brush barriers are fairly stable and composed of natural materials, maintenance requirements are small. Field experience has shown; however, that many brush barrier installations are not effective when there are large voids created by the use of material which is too large (such as tree stumps) to provide a compact, dense barrier. Therefore, it is necessary to use residual material under 150 millimeters (6 inches) in diameter which will create a more uniform barrier <u>or</u> utilize a filter fabric overlay to promote enhanced filtration of sediment laden runoff.

Design Criteria

A formal design is not required.

Construction Specifications

Without Filter Cloth

1. The height of a brush barrier shall be a minimum of 1 meter (3 feet).

2. The width of a brush barrier shall be a minimum of 1.5 meters (5 feet) at its base (the sizes of brush barriers may vary considerably based upon the amount of material available and the judgement of the design engineer).

3. The barrier shall be constructed by piling brush, stone, root mat and other material from the clearing process into a mounded row on the contour. Material larger than 150 millimeters (6 inches) in diameter should not be used to create the mound as the non-homogeneity of the mixture can lead to voids where sediment-laden flows can easily pass.

If a Filter is Used

1. Filter fabric must meet the minimum physical requirements.

2. The filter fabric shall be cut into lengths sufficient to lay across the barrier from its up-slope base to just beyond its peak. Where joints are necessary, the fabric shall be spliced together with a 150 millimeter (6-inch) minimum overlap and securely sealed.

3. A trench shall be excavated 150 millimeters (6-inches) wide and 100 millimeters (4-inches) deep along the length of the barrier and immediately uphill from the barrier.

4. The lengths of filter fabric shall be draped across the width of the barrier with the uphill edge placed in the trench and the edges of adjacent pieces overlapping each other.

5. The filter fabric shall be secured in the trench with stakes set approximately 1 meter (3 foot) on center.

6. The trench shall be backfilled and the soil compacted over the filter fabric.

7. Set stakes into the ground along the downhill edge of the brush barrier, and anchor the fabric by tying twine from the fabric to the stakes.

Maintenance

1. Brush barriers shall be inspected after each rainfall and necessary repairs shall be made promptly.

2. Sediment deposits must be removed when they reach approximately one-half the height of the barrier.

BMP: STORM DRAIN INLET PROTECTION

Definition

A sediment filter or an excavated impounding area around a storm drain drop inlet or curb inlet.

Purpose

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

Conditions Where Practice Applies

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

Planning Considerations

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

This practice contains several types of inlet filters and traps which have different applications dependent upon site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the appropriate Plan-Approving Authority.

Care should be taken when choosing a specific type of inlet protection. Field experience has shown that inlet protection which causes excessive ponding in an area of high construction activity may become so inconvenient that it is removed or bypassed, thus transmitting sediment-laden flows unchecked. In such situations, a structure with an adequate overflow mechanism should be utilized.

The following inlet protection devices are for drainage areas of 4,000 square meters (1 acre) or less. Runoff from larger disturbed areas should be routed to a TEMPORARY SEDIMENT TRAP (BMP-13) or a TEMPORARY SEDIMENT BASIN (BMP-14).

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

Stone is utilized as the chief ponding/filtering agent in most of the inlet protection types described in this specification. The various types of "coarse aggregates" which are depicted are able to filter out sediment mainly through slowing down flows directed to the inlet by creating an increased flow path for the stormwater (through void space in the respective stone). The stone filtering medium by no means slows stormwater flow rate as does filter cloth and therefore cannot provide the same degree of filter efficiency when smaller silt and clay particles are introduced into stormwater flows. However, as mentioned earlier, excessive ponding in busy areas adjacent to stormwater inlets is in many cases unacceptable - that is why stone must be utilized with many installations.

Fortunately, in most instances, inlet protection utilizing stone should not be the sole control measure. At the time that storm sewer inlet and associated appurtenances become operational, areas adjacent to the structures are most likely at final grade or will not be altered for extended periods; this is the time when TEMPORARY SEEDING (BMP-31) and other appropriate controls should be implemented to enhance sediment-loss mitigation. In addition, by varying stone sizes used in the construction of inlet protection, a greater degree of sediment removal can be obtained. As an option, filter cloth can be used with the stone in these devices to further enhance sediment removal. Notably, the potential inconvenience of excessive ponding must be examined with these choices, especially the latter.

Design Criteria

1. The drainage area shall be no greater than 4,000 square meters (1 acre).

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

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

4. For the inlet protection devices which utilize stone as the chief ponding/filtering medium, a range of stone sizes can be used. The designer/plan reviewer should attempt to get the greatest amount of filtering action possible (by using smaller-sized stone), while not creating significant ponding problems.

6. In all designs which utilize stone with a wire-mesh. support as a filtering mechanism, the stone can be <u>completely wrapped</u> with the wire mesh to improve stability and provide easier cleaning.

7. <u>Filter Fabric</u> may be added to any of the devices which utilize "coarse aggregate" stone to significantly enhance sediment removal. The fabric, which must meet the physical requirements noted for "extra strength", should be secured between the stone and the inlet (on wire-mesh if it is present). As a result of the significant increase in filter efficiency provided by the fabric, a <u>larger</u> range of stone sizes may be utilized with such a configuration. The larger stone will help keep larger sediment masses from clogging the cloth. Notably, significant ponding may <u>occur at the inlet if filter cloth is utilized in this manner</u>.

<u>Construction</u>

1. Silt Fence Drop Inlet Protection

    a. Silt Fence shall conform to the construction specifications for "extra strength" and shall be cut from a continuous roll to avoid joints.

    b. <u>For stakes, use 50 x 100 millimeter (2 x 4-inch) wood</u> (preferred) or equivalent metal with a minimum length of 1 meter (3 feet).

    c. Space stakes evenly around the perimeter of the inlet a <u>maximum of 1 meter (3-feet) apart</u>, and securely drive them into the ground, approximately 450 millimeters (18-inches) deep.

    d. To provide needed stability to the installation, frame with 50 x 100 millimeter (2 x 4-inch) wood strips around the crest of the overflow area at a maximum of 450 millimeters (18 inches) above the drop inlet crest.

    e. Place the bottom 300 millimeters (12 inches) of the fabric in a trench and backfill the trench with 300 millimeters of compacted soil.

    f. Fasten fabric securely by staples or wire to the stakes and frame. Joints must be overlapped to the next stake.

g. It may be necessary to build a temporary dike on the downslope side of the structure to prevent bypass flow.

2. Gravel and Wire Mesh Drop Inlet Sediment Filter

   a. Wire mesh shall be laid over the drop inlet so that the wire extends a minimum of 300 millimeters (12 inches) beyond each side of the inlet structure. Wire mesh with 13 millimeter (0.5 inch) openings shall be used. If more than one strip of mesh is necessary, the strips shall be overlapped.

   b. Coarse aggregate shall be placed over the wire mesh. The depth of stone shall be at least 300 millimeters (12 inches) over the entire inlet opening. The stone shall extend beyond the inlet opening at least 450 millimeters (18 inches) on all sides.

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

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

3. Block and Gravel Drop Inlet Sediment Filter

   a. Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, with the ends of adjacent blocks abutting. The height of the barrier can be varied, depending on design needs, by stacking combinations of 100, 200, and 300 millimeter (4, 8, and 12 inch) wide blocks. The barrier of blocks shall be at least 300 millimeters (12-inches) high and no greater than 600 millimeters (24-inches) high.

   b. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 13 millimeter (0.5-inch) openings shall be used.

c. Stone shall be piled against the wire to the top of the block barrier.

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

4. Excavated Drop Inlet Sediment Trap

a. The excavated trap shall be sized to provide a minimum storage capacity calculated at the rate of 255 cubic meters per hectare (134 cubic yards per acre) of drainage area. A trap shall be no less than 300 millimeters (1-foot) nor more than 600 millimeters (2-feet) deep measured from the top of the inlet structure. Side slopes shall not be steeper than 2:1.

b. The slope of the basin may vary to fit the drainage area and terrain. Observations must be made to check trap efficiency and modifications shall be made as necessary to ensure satisfactory trapping of sediment. Where an inlet is located so as to receive concentrated flows, such as in a highway median, it is recommended that the basin have a rectangular shape in a 2:1 (length/width) ratio, with the length oriented in the direction of the flow.

c. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in a manner such that it will not erode.

5. Sod Drop Inlet Sediment Filter

a. Soil shall be prepared and sod installed according to the specifications in BMP-33, SODDING.

b. Sod shall be placed to form a turf mat covering the soil for a distance of 1.2 meters (4 feet) from each side of the inlet structure.

6. Gravel Curb Inlet Sediment Filter

a. Wire mesh with 13 millimeter (0.5 inch) openings shall be placed over the curb inlet opening so that at least 300 millimeters (12 inches) of wire extends across the inlet cover and at least 300 millimeters of wire extends across the concrete gutter from the inlet opening.

b. Stone shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely.

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

7. Curb Inlet Protection with 50 x 100 millimeter (2 x 4-inch) Wooden Weir

   a. Attach a continuous piece of wire mesh 750 millimeters (30 inches) minimum width x inlet throat length, plus 1.2 meters (4 feet) to the 50 x 100 millimeter (2 inch by 4 inch) wooden weir with a total length of throat length plus 0.6 meters (2 feet). Wood should be of "construction grade" lumber.

   b. Place a piece of approved "extra-strength" filter cloth of the same dimensions as the wire mesh over the wire mesh and securely attach to the 50 x 100 millimeter weir.

   c. Securely nail the 50 x 100 millimeter weir to the 225 millimeter (9-inch) long vertical spacers which are to be located between the weir and inlet face at a maximum 2 meter (6-foot) spacing.

   d. Place the assembly against the inlet throat and nail 0.5 meters (2-foot) (minimum) lengths of 50 x 100 millimeter (2-inch x 4-inch) board to the top of the weir at spacer locations. These 50 x 100 millimeter anchors shall extend across the inlet tops and be held in place by sandbags or alternate weight.

   e. The assembly shall be placed so that the end spacers are a minimum 300 millimeters (1 foot) beyond both ends of the throat opening.

   f. Form the wire mesh and filter cloth to the concrete gutter and against the face of curb on both sides of the inlet. Place coarse aggregate over the wire mesh and filter fabric in such a manner as to prevent water from entering the inlet under or around the filter cloth.

   g. This type of protection must be inspected frequently and the filter cloth and stone replaced when clogged with sediment.

   h. Assure that storm flow does not bypass inlet by installing temporary earth or asphalt dikes directing flow into inlet.

8. Block and Gravel Curb Inlet Sediment Filter

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

   b. A 50 x 100 millimeter (2-inch x 4-inch) stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.

   c. Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks.

   d. Wire mesh shall be placed over the outside vertical face (webbing) of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire mesh with 13 millimeter (0.5 inch) openings shall be used.

   e. Coarse aggregate shall be piled against the wire to the top of the barrier.

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

Maintenance

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

2. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

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

BMP-8

BMP: CULVERT INLET PROTECTION

Definition

A sediment filter located at the inlet to storm sewer culverts.

Purposes

1. To prevent sediment from entering, accumulating in and being transferred by a culvert and associated drainage system prior to permanent stabilization of a disturbed project area.

2. To provide erosion control at culvert inlets during the phase of a project where elevation and drainage patterns change, causing original control measures to be ineffective or in need of removal.

Conditions Where Practice Applies

Where culvert and associated drainage system is to be made operational prior to permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions.

Planning Considerations

When construction on a project reaches a stage where culverts and other storm sewer appurtenances are installed and many areas are brought to a desired grade, the erosion control measures used in the early stages normally need to be modified or may need to be removed altogether. At that time, there is a need to provide protection at the points where runoff will leave the area via culverts and drop or curb inlets.

Similar to drop and curb inlets, culverts which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In case of extreme sediment loading, the pipe or pipe system itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the culvert by using one of the methods noted in this section.

General Guidelines (All Types)

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

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

Design Criteria

1. Silt Fence Culvert Inlet Protection

    a. No formal design is required.

    b. Silt fence culvert inlet protection has an expected maximum usable life of three months.

    c. The maximum area draining to this practice shall not exceed 4,000 square meters (1 acre).

2. Culvert Inlet Sediment Trap

    a. Runoff storage requirements shall be in accordance with information outlined under BMP-13, TEMPORARY SEDIMENT TRAP.

    b. Culvert inlet sediment traps have a maximum expected useful life of 18 months.

    c. The maximum area draining to this practice shall not exceed 1,200 square meters (3 acres).

Construction Specifications

1. Silt Fence Culvert Inlet Protection

    a. The height of the silt fence (in front of the culvert opening) shall be a minimum of 400 millimeters (16 inches) and shall not exceed 1 meter (3 feet).

b. Extra strength filter fabric with a maximum spacing of stakes of 1 meter shall be used to construct the measure.

c. The placement of silt fence should be approximately 2 meters (6 feet) from the culvert in the direction of incoming flow, creating a "horseshoe" shape.

d. If silt fence cannot be installed properly or the flow and/or velocity of flow to the culvert protection is excessive and may breach the structure, stone protection should be incorporated with fence installation.

2. Culvert Inlet Sediment Trap

a. Geometry of the design will be a "horseshoe" shape around the culvert inlet.

b. The toe of riprap (composing the sediment filter dam) shall be no closer than 600 millimeters (24 inches) from the culvert opening in order to provide an acceptable emergency outlet for flows from larger storm events.

c. All other "Construction Specifications" found within BMP-13, TEMPORARY SEDIMENT TRAP, also apply to this practice.

e. The proper installation of the culvert inlet sediment trap is a viable substitute for the installation of the TEMPORARY SEDIMENT TRAP.

Maintenance

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

2. Aggregate shall be replaced or cleaned when inspection reveals that clogged voids are causing ponding problems which interfere with on-site construction.

3. Sediment shall be removed and the impoundment restored to its original dimensions when sediment has accumulated to one-half the design depth. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

4. Temporary structures shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

BMP: TEMPORARY DIVERSION DIKE

Definition

A temporary ridge of compacted soil constructed at the top or base of a sloping disturbed area.

Purposes

1. To divert storm runoff from upslope drainage areas away from unprotected disturbed areas and slopes to a stabilized outlet.

2. To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a sediment trap or sediment basin.

Conditions Where Practice Applies

Wherever stormwater runoff must be temporarily diverted to protect disturbed areas and slopes or retain sediment -on site during construction. These structures generally have a life expectancy of 18 months or less, which can be prolonged with proper maintenance.

Planning Considerations

A temporary diversion dike is intended to divert overland sheet flow to a stabilized outlet or a sediment-trapping facility during establishment of permanent stabilization on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

It is very important that a temporary diversion dike be stabilized immediately following installation with temporary or permanent vegetation to prevent erosion of the dike itself. The gradient of the channel behind the dike is also an important consideration. The dike must have a positive grade to assure drainage, but if the gradient is too great, precautions must be taken to prevent erosion due to high-velocity channel flow behind the dike. The cross-section of the channel which runs behind the dike should be of a parabolic or trapezoidal shape to help inhibit a high velocity of flow which could arise in a vee ditch.

This practice is considered an economical one because it uses material available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the dike with vegetation. Diversion dikes are preferable to silt fence because they are more durable, less expensive, and require much less maintenance when constructed properly. Along with a TEMPORARY SEDIMENT TRAP (BMP-13), they become a logical choice for a control measure once the control limits of the silt fence or-straw bale barrier have been exceeded.

Temporary diversion dikes are often used as a perimeter control in association with a sediment trap or a sediment basin, or a series of sediment-trapping facilities, on moderate to large construction sites. If installed properly and in the first phase of grading, maintenance costs are very low. Often, cleaning of sediment-trapping facilities is the only associated maintenance requirement.

As specified herein, this practice is intended to be temporary. However, with more stringent design criteria, it can be made permanent in accordance with DIVERSIONS (BMP-12).

Design Criteria

No formal design is required. The following criteria shall be met:

Drainage Area-

The maximum allowable drainage area is 2 hectares (5 acres).

Height-

The minimum allowable height measured from the upslope side of the dike is 450 millimeters (18 inches).

Side Slopes-

1.5:1 or flatter, along with a minimum base width of 1.5 meters (4.5 feet).

Grade-

The channel behind the dike shall have a positive grade to a stabilized outlet. If the channel slope is less than or equal to 2%, no stabilization is required. If the slope is greater than 2%, the channel shall be stabilized in accordance with BMP-17, STORMWATER CONVEYANCE CHANNEL.

Outlet-

1. The diverted runoff, if free of sediment, must be released through a stabilized outlet or channel.

2. Sediment-laden runoff must be diverted and released through a sediment-trapping facility such as a TEMPORARY SEDIMENT TRAP (BMP-13) or TEMPORARY SEDIMENT BASIN (BMP-14).

Construction Specifications

1. Temporary diversion dikes must be installed as a first step in the land-disturbing activity and must be functional prior to upslope land disturbance.

2. The dike should be adequately compacted to prevent failure.

3. Temporary or permanent seeding and mulch shall be applied to the dike immediately following its construction.

4. The dike should be located to minimize damages by construction operations and traffic.

Maintenance

The measure shall be inspected after every storm and repairs made to the dike, flow channel, outlet or sediment trapping facility, as necessary. Once every two weeks, whether a storm event has occurred or not, the measure shall be inspected and repairs made if needed. Damages caused by construction traffic or other activity must be repaired before the end of each working day.

BMP-10

BMP: TEMPORARY FILL DIVERSION

Definition

A channel with a supporting ridge of soil on the lower side, constructed along the top of an active earth fill.

Purpose

To divert storm runoff away from the unprotected slope of the fill to a stabilized outlet or sediment-trapping facility.

Conditions Where Practice Applies

Where the drainage area at the top of an active earth fill slopes toward the exposed slope and where continuous fill operations make the use of a DIVERSION (BMP-12) unfeasible. This temporary structure should remain in place for less than one week.

Planning Considerations

One important principle of erosion and sediment control is to keep stormwater runoff away from exposed slopes. This is often accomplished by installing a dike, diversion, temporary slope drain or paved ditch at the top of a slope to carry the runoff away from the slope to a stabilized outlet. In general, these measures are installed after the final grade has been reached. On cuts, the measures may be installed at the beginning since the work proceeds from the top to the bottom of the slope, and the measures have little chance of being covered or damaged. On fill, the work proceeds from the bottom to the top and the elevation changes daily. It is; therefore, not feasible to construct a compacted dike or permanent diversion which may be covered by the next day's activity.

The temporary fill diversion is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed. This practice can be constructed by the use of a motor grader or a small dozer. To shape the diversion, the piece of machinery used may run near the top edge of the fill with its blade tilted to form a channel. This work would be done at the end of the working day and provide a channel with a berm to protect the slope.

Wherever possible, the temporary diversion should be sloped to direct water to a stabilized outlet. If the runoff is diverted over the fill itself, the practice may cause erosion by concentrating water at a single point.

Good timing is essential to fill construction. The filling operation should be completed as quickly as possible and the permanent slope protection measures and slope stabilization measures installed as soon after completion as possible. With prompt and proper construction, the landowner or contractor will save both time and money in building, repairing and stabilizing the fill area. The longer the time period for construction and stabilization "tends, the more prone the fill operation is to be damaged by erosion. Repairing the damages adds additional time and expense to the project.

Design Criteria

No formal design is required. The following criteria shall be met:

Drainage Area-

The maximum allowable drainage area is 2 hectares (5 acres).

Height-

The minimum height of the supporting ridge shall be 225 millimeters (9 inches).

Grade-

The channel shall have a positive grade to a stabilized outlet.

Outlet-

The diverted runoff should be released through a stabilized outlet, slope drain or sediment trapping measure.

Construction Specifications

1. The diversion shall be constructed at the top of the fill at the end of each work day as needed.

2. The diversion shall be located at least 600 millimeters (2 feet) inside the top edge of the fill.

3. The supporting ridge shall be constructed at a uniform height along its entire length. Without uniform height, the fill diversion may be susceptible to breaching.

Maintenance

Since the practice is temporary and under most situations will be covered the next work day, the maintenance required should be low. If the practice is to remain in use for more than one day, an inspection will be made a the end of each work day and repairs made to the measure if needed. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the diversion.

BMP: TEMPORARY RIGHT-OF-WAY DIVERSION

Definition

A ridge of compacted soil or loose rock or gravel constructed across disturbed rights-of-way and similar sloping areas.

Purpose

To shorten the flow length within a sloping right-of-way, thereby reducing the erosion potential by diverting storm runoff to a stabilized outlet.

Conditions Where Practice Applies

Generally, earthen diversions are applicable where there will be little or no construction traffic within the right-of-way. Gravel structures are more applicable to roads and other rights-of-way which accommodate vehicular traffic.

Planning Considerations

Construction of utility lines and roads often requires the clearing of long strips of right-of-way over sloping terrain. The volume and velocity of stormwater runoff tend to increase in these cleared strips and the potential for erosion is much greater since the vegetative cover is diminished or removed. To compensate for the loss of vegetation, it is usually a good practice to break up the flow length within the cleared strip so that runoff does not have a chance to concentrate and cause erosion. At proper intervals, temporary right-of-way diversions can significantly reduce the amount of erosion which will occur until the area is permanently stabilized. Since many right-of-ways are constructed through heavily vegetated areas, runoff can often be diverted into a vegetative buffer strip, if it provides a minimum flow length of 23 meters (75 feet).

Design Criteria

No formal design is required. The following criteria shall be met:

Height-

The minimum allowable height of the diversion is 450 millimeters (18 inches).

Side Slopes-

Side slopes should be 2:1 or flatter to allow the passage of construction traffic, along with a minimum base width of 2 meters (6 feet).

Width-

The measure should be constructed completely across the disturbed portion of the right-of-way.

Spacing-

Table 11-A will be used to determine the spacing of right-of-way diversions.

TABLE 11-A
SPACING OF RIGHT-OF-WAY DIVERSIONS

	SPACING	
%SLOPE	Meters	(Feet)
Less than 7%	30	100
Between 7% and 25%	23	75
Between 25% and 40%	15	50
Greater than 40%	8	25

Grade-

Positive drainage (with less than 2% slope) should be provided to a stabilized outlet,

Outlet-

Interceptor dikes must have an outlet which is not subject to erosion.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet. Concentrated flows should spread over the widest possible area after release. Flows with high sediment concentrations should pass through an appropriate sediment-trapping measure.

Construction Specifications

1. The diversion shall be installed as soon as the right-of-way has been cleared and/or graded.

2. All earthen diversions shall be machine- or hand-compacted in 200 millimeter (8-inch) lifts.

3. The outlet of the diversion shall be located on an undisturbed and stabilized area when at all possible. The field location should be adjusted as needed to utilize a stabilized outlet.

4. Earthen diversions which will not be subject to construction traffic should be stabilized in accordance with TEMPORARY SEEDING (BMP-31).

Maintenance

The practice shall be inspected after every rainfall and repairs made if necessary. At least once every two weeks, whether a storm has occurred or not, the measure shall be inspected and repairs made if needed. Right-of-way diversions, which are subject to damage by vehicular traffic, should be reshaped at the end of each working day.

BMP: DIVERSION

Definition

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

Purpose

To reduce slope length and to intercept and divert stormwater runoff to stabilized outlets at non-erosive velocities.

Conditions Where Practice Applies

1. Where runoff from areas of higher elevation may damage property, cause erosion, or interfere with the establishment of vegetation on lower areas.
2. Where surface and/or shallow subsurface flow is damaging sloping upland.
3. Where the slope length needs to be reduced to minimize soil loss.

Planning Considerations

Diversions can be useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion. They may be placed at the top of cut or fill slopes to keep runoff from upland drainage areas off the slope. They can also be used to protect structures, parking lots, adjacent properties, and other special areas from flooding.

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

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

Design Criteria

Location-

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope, seepage planes (where seepage is a problem) and the development layout.

Capacity-

1. The diversion channel must have a minimum capacity to carry the runoff expected from a 10-year frequency storm with a freeboard of at least 90 millimeters (4 inches).

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

Channel Design-

The diversion channel may be parabolic, trapezoidal or vee-shaped and shall be designed and constructed according to BMP-17, STORMWATER CONVEYANCE CHANNELS.

Ridge Design-

The supporting ridge cross-section shall meet the following criteria:

1. The side slopes shall be no steeper than 2:1.
2. The width at the design water elevation shall be a minimum of 1.2 meters (4 feet).
3. The minimum freeboard shall be 90 millimeters (3.6 inches).
4. The design shall include a 10 percent settlement factor.

Outlet-

Diversions shall have adequate outlets which will convey concentrated runoff without erosion. Acceptable outlets include STORMWATER CONVEYANCE CHANNEL

(BMP-17); LEVEL SPREADER (BMP-21); OUTLET PROTECTION (BMP-18); and PAVED FLUME (BMP-16).

Stabilization

1. The ridge and channel shall be seeded and mulched immediately following their construction in accordance with BMP-32, PERMANENT SEEDING.

2. Disturbed areas draining into the diversion should normally be seeded and mulched prior to the time the diversion is constructed. Sediment trapping measures must remain in place to prevent soil movement into the diversion if upslope area is not stabilized.

Construction Specifications

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

2. The diversion shall be excavated or shaped to line, grade, and cross-section as required to meet the criteria specified herein, free of irregularities which will impede flow.

3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed diversion. Fill shall be composed of soil which is free from excessive organic debris, rocks or other objectionable materials.

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

5. Permanent stabilization of disturbed areas shall be done in accordance with the applicable standard and specification contained in this handbook. Permanent stabilization techniques include PERMANENT SEEDING (BMP-32).

Maintenance

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

BMP: TEMPORARY SEDIMENT TRAP

Definition

A temporary ponding area formed by constructing an earthen embankment with a stone outlet.

Purpose

To detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out.

Conditions Where Practice Applies

1. Below disturbed areas where the total contributing- drainage area is less than 1.2 hectares (3 acres).

2. Where the sediment trap will be used no longer than 18 months (the maximum useful life is 18 months).

3. The sediment trap may be constructed either independently or in conjunction with a TEMPORARY DIVERSION DIKE (BMP-9).

Planning Considerations

Sediment traps should be used only for small drainage areas. If the contributing drainage area is 1.2 hectares (3 acres) or greater, refer to SEDIMENT BASIN (BMP-14).

Sediment traps, along with other perimeter controls intended to trap sediment, shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

Recent studies have been conducted on the performance of sediment traps (and basins) which indicate the control measures only achieved a 46% removal of sediment which flowed into them during storm events which caused measurable outflow. To achieve a more acceptable removal rate (60%), it was necessary to revise the design of these measures. The total initial storage volume for both the sediment trap and the TEMPORARY SEDIMENT BASIN (BMP-14) has been doubled. There are both a "wet" storage volume and a drawdown or "dry" storage volume which help to enhance sediment fall-out and prevent excessive sediment losses during large storm events which occur during the advanced stages of land disturbance.

In most cases excavation will be required to attain the necessary storage volume. Also, sediment must be periodically removed from the trap to maintain the required volume. Plans should detail how excavated sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site location.

As noted previously in this handbook, there are numerous other acceptable ways to design many of the erosion control practices within. This is certainly true in the case of the sediment trap. However, variations in its design should be considered judiciously by plan reviewers to ensure that the minimum storage requirements and structural integrity noted in this specification are maintained.

Design Criteria

Trap Capacity-

The sediment trap must have an initial storage volume of 254 cubic meters per hectare (134 cubic yards per acre) of drainage area, half of which shall be in the form of a permanent pool or wet storage to provide a stable settling medium. The remaining half shall be in the form of a drawdown or dry storage which will provide extended settling time during less frequent, larger storm events. The volume of the wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure. The volume of the dry storage shall be measured from the base of the stone outlet to the crest of the stone outlet (overflow mechanism). Sediment should be removed from the basin when the volume of the wet storage is reduced by one-half.

For a sediment trap, the wet storage volume may be approximated as follows:

$$V_1 = 0.85 \times A_1 \times D_1$$

where,

V_1	=	the wet storage volume in cubic meters (cubic feet).
A_1	=	the surface area of the flooded area at the base of the stone outlet in square meters (square feet).
D_1	=	the maximum depth in meters (feet), measured from the low point in the trap to the base of the stone outlet.

The dry storage volume may be approximated as follows:

$$V_2 = (A_1 + A_2) / 2 \times D_2$$

where,

V_2	=	the dry storage volume in cubic meters (cubic feet)
A_1	=	the surface area of the flooded area at the base of the stone outlet in square meters (square feet)
A_2	=	the surface area of the flooded area at the crest of the stone outlet (overflow mechanism), in square meters (square feet)
D_2	=	the depth in meters (feet), measured from the base of the stone outlet to the crest of the stone outlet

The designer should seek to provide a storage area which has a minimum 2:1 length to width ratio (measured from point of maximum runoff introduction to outlet).

Note: Conversion between cubic meters to cubic feet and cubic yards is as follows:

Cubic feet = cubic meters x 35.31
Cubic yards = cubic feet x 0.037

Excavation

Side slopes of excavated areas should be no steeper than 1:1. The maximum depth of excavation within the wet storage area should be 1 meter (4 feet) to facilitate clean-out and for site safety considerations.

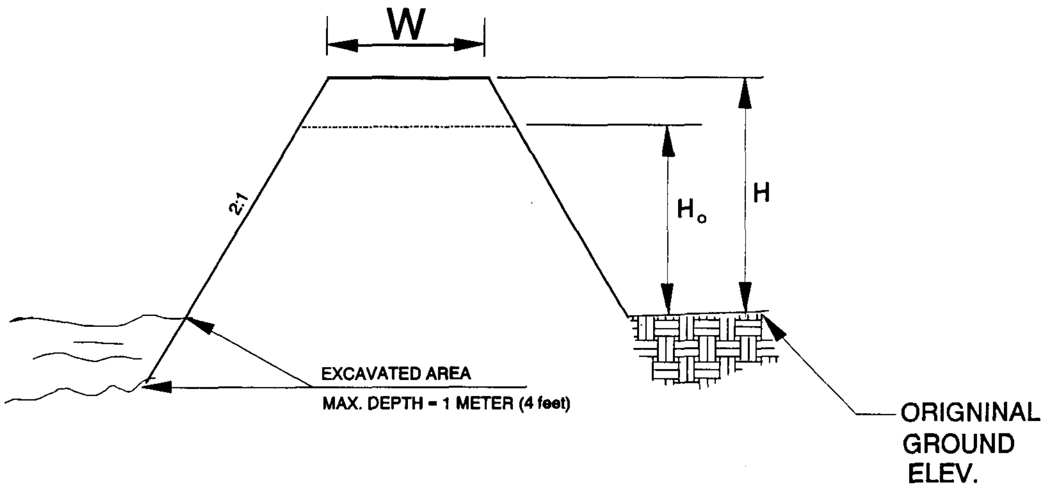
Outlet

The outlet for the sediment trap shall consist of a stone section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap shall be used to provide for filtering/detention as well as outlet stability. The smaller stone shall be coarse aggregate (smaller stone sizes will enhance filter efficiency) and riprap shall be "Class I." Filter cloth which meets the physical requirements noted in BMP-19, RIPRAP shall be placed at the stone-soil interface to act as a "separator." The minimum length of the outlet shall be 4.5 meters times the number of hectares comprising the total area draining to the trap (6 feet times the number of acres). The crest of the stone outlet must be at least 300 millimeters (1.0 foot) below the top of the embankment to ensure that the flow will travel over the stone and not the embankment.

Embankment Cross-Section

The maximum height of the sediment trap embankment shall be 1.5 meters (5 feet) as measured from the base of the stone outlet. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in Figure 13-1. Side slopes of the embankment shall be 2:1 or flatter.

FIGURE 13-1: MINIMUM TOP WIDTH (W) REQUIRED FOR SEDIMENT TRAP EMBANKMENTS ACCORDING TO HEIGHT OF EMBANKMENT (METERS)



Meters

H	H_o	W
0.5	0.2	0.6
0.6	0.3	0.6
0.8	0.5	0.8
0.9	0.6	0.8
1.0	0.8	0.9
1.2	0.9	0.9
1.4	1.1	1.2
1.5	1.2	1.4

Feet

H	H_o	W
1.5	0.5	2.0
2.0	1.0	2.0
2.5	1.5	2.5
3.0	2.0	2.5
3.5	2.5	3.0
4.0	3.0	3.0
4.5	3.5	4.0
5.0	4.0	4.5

Removal

Sediment traps must be removed after the contributing drainage area is stabilized. Plans should show how the site of the sediment trap is to be graded and stabilized after removal.

Construction Specifications

1. The area under the embankment shall be cleared, grubbed, and stripped of any vegetation and root mat.

2. Fill material for the embankment shall be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 150 millimeter (6-inch) layers by traversing with construction equipment.

3. The earthen embankment shall be seeded with temporary or permanent vegetation (BMP-31 and 32) immediately after installation.

4. Construction operations shall be carried out in such a manner that erosion and water pollution are minimized.

5. The structure shall be removed and the area stabilized when the upslope drainage area has been stabilized.

6. All cut and fill slopes shall be 2:1 or flatter (except for excavated, wet storage area which may be at a maximum 1:1 grade).

Maintenance

1. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design volume of the wet storage. Sediment removal from the basin shall be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

2. Filter stone shall be regularly checked to ensure that filtration performance is maintained. Stone choked with sediment shall be removed and cleaned or replaced.

3. The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be checked to ensure that its center is at least 300 millimeters (1 foot) below the top of the embankment.

BMP: TEMPORARY SEDIMENT BASIN

Definition

A temporary barrier or dam with a controlled stormwater release structure formed by constructing an embankment of compacted soil across a drainageway.

Purpose

To detain sediment-laden runoff from disturbed areas in "wet" and "dry" storage long enough for the majority of the sediment to settle out.

Conditions Where Practice Applies

Below disturbed areas where the total contributing drainage area is equal to or greater than 1.2 hectares (3 acres). There must be sufficient space and appropriate topography for the construction of a temporary impoundment. These structures are limited to a useful life of 18 months unless they are designed as permanent impoundments. It is required that these measures, by virtue of their potential to impound large volumes of water, be designed by a qualified professional.

Planning Considerations

Effectiveness-

Sediment basins constructed as per this specification are, at best, 60% effective in trapping sediment which flows into them during large storm events (those which cause flow from the outfall pipe) or during periods of minimal vegetative cover at a construction site. Therefore, they should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, etc., to reduce the amount of sediment flowing into the basin.

The sediment removal efficiency problems noted for previous designs of the TEMPORARY SEDIMENT TRAP (BMP-13) are also applicable to the sediment basin. In order to contain the majority of sediment which flows to the structure, the basin should have a permanent pool, or wet storage area and a dry storage area which dewaters over time. The volume of the permanent pool (needed to protect against re-suspension of sediment and promote better settling conditions) must be 127 cubic meters per hectare (67 cubic yards per acre) of drainage area and the volume of dry storage above the permanent pool (needed to prevent "short-circuiting" of basin during larger storm events) must be an additional 127 cubic meters per hectare (67 cubic yards per acre) of drainage area. The total storage volume of the basin at the principal spillway riser crest will therefore be 254 cubic meters per hectare (134 cubic yards per acre) of drainage area.

Sediment basins, along with other perimeter controls which are intended to trap sediment, shall be constructed as a first step in any land disturbing activity and shall be made functional before upslope land disturbance takes place.

Location-

To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas and natural drainageways below disturbed areas. Drainage into the basin can be improved by the use of diversion dikes and ditches. The basin must not be located in a live stream but should be located to trap sediment-laden runoff before it enters a stream. The basin should not be located where its failure would result in the loss of life or interruption of the use or service of public utilities or roads.

Multiple Use-

Sediment basins may remain in place after construction and final site stabilization are completed to serve as permanent stormwater management structures. Because the most practical location for a sediment basin is often the most practical location for a stormwater management basin, it is often desirable to utilize these structures for permanent stormwater management purposes. It should be noted, however, that in most cases, a typical structure's outfall system will vary during the construction and post-construction periods. Care must be taken to avoid constructing an outfall system which will achieve the desired post. construction quantity or quality control but will not provide the necessary medium for the containment and settling of sediment-laden <u>construction</u> runoff. Notably, the design for permanent ponds is beyond the scope of these standards and specifications.

<u>Design Criteria</u>

Maximum Drainage Area-

The maximum allowable drainage area into a temporary sediment basin shall be 40 hectares (100 acres). It is recommended that when the drainage area to any one temporary basin exceeds 20 hectares (50 acres), an alterative design procedure which more accurately defines the specific hydrology and hydraulics of the site and the control measure be used. The design procedures in this standard and specification do not generate hydrographs, utilize storage volumes or provide a routing of the design storms; for a large drainage area, this may result in an excessively large diameter riser or an oversized basin. Notably, design considerations which are more accurate and project-specific than those in this specification are acceptable and encouraged with any size basin.

Basin Capacity-

The design storage capacity of the basin must be at least 254 cubic meters per hectare (134 cubic yards per acre) of total contributing drainage area. One half of the design volume shall be in the form of a permanent pool, and the remaining half as drawdown volume. The volume of the permanent pool shall be measured from the low point of the basin to the elevation corresponding to one half the total storage volume. The volume of the drawdown area shall be measured from the elevation of the permanent pool to the crest of the principal spillway (riser pipe). Sediment should be removed from the basin when the volume of the permanent pool has been reduced by one half. In no case shall the sediment cleanout level be higher than 300 millimeters (1 foot) below the bottom of the dewatering device. The elevation of the sediment cleanout level should be calculated and clearly marked on the plans and riser (since this part of the riser normally will be under water, a mark should appear above the permanent pool a measured distance above the cleanout elevation).

While attempting to attain the desired storage capacities, efforts should be made to keep embankment heights to a minimum. This precaution takes on added significance when the basin will only serve as a temporary measure or will need substantial retrofitting prior to functioning as a permanent measure. When site topography permits, the designer should give strong consideration to the use of excavation to obtain the required capacity and to possibly reduce the height of the embankment. This excavation can be performed in a manner which creates a wet storage forebay area or which increases the storage capacity over the entire length of the basin.

Basin Shape-

To improve sediment trapping efficiency of the basin, the effective flow length must be twice the effective flow width. This basin shape may be attained by properly selecting the site of the basin, by excavation, or by the use of baffles. See Appendix BMP-14a for pertinent design details.

Embankment Cross-Section-

For embankments of less than 3 meters (10 feet), the embankment must have a minimum top width of 2 meters (6 feet), and the side slopes must be 2:1 or flatter. In the case of an embankment 3 to 4 meters (10 to 14 feet) in height, the minimum top width shall be 2.5 meters (8 feet) and the side slopes shall be 2.5:1 or flatter. For 4.5 meter (15-foot) embankments (maximum allowed under these specifications), the top width must be 3 meters (10 feet) with maximum 2.5:1 side slopes.

Spillway Design-

The outlets for the basin shall consist of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 25-year storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 25-year storm. However, an attempt to provide a separate emergency spillway should always be made (refer to "Emergency Spillway" later on in this section). Runoff computations shall be based upon the soil cover conditions which are expected to prevail during the life of the basin. Notably, the flow through the dewatering orifice cannot be utilized when calculating the 25 year storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.

The spillways designed by the procedures contained in the standard and specification <u>will not necessarily result in any reduction in the peak rate of runoff</u>. If a reduction in peak runoff is desired, the appropriate hydrographs/storm routings should be generated to choose the basin and outlet sizes.

Principle Spillway-

For maximum effectiveness, the principal spillway should consist of a vertical pipe or box of corrugated metal or reinforced concrete, with a minimum diameter of 380 millimeters (15 inches), joined by a watertight connection to a horizontal pipe (barrel) extending through the embankment and outletting beyond the downstream toe of the fill. If the principal spillway is used in conjunction with a separate emergency spillway, the principal spillway must be designed to pass at least the peak flow expected from of 2-year storm. If no emergency spillway is used, the principal spillway must be designed to pass the entire peak flow expected from a 25-year storm (see Appendix BMP-14a for design details).

Design Elevations-

The crest of the principal spillway shall be set at the elevation corresponding to the storage volume required - 127 cubic meters per hectare wet storage plus 127 cubic meters per hectare dry storage for a total of 254 cubic meters per hectare (134 cubic yards per acre). If the principal spillway is used in conjunction with an emergency spillway, this elevation shall be a minimum of 300 millimeters (1.0 foot) below the crest of the emergency spillway. In addition, a minimum freeboard of 300 millimeters shall be provided between the design high water (25-year) and the top of the embankment. If no emergency spillway is used, the crest of the principal spillway shall be a minimum of 1 meter (3 feet) below the top of the embankment; also, a minimum freeboard of 600 millimeters (2.0 feet) shall be provided between the design high water and the top of the embankment.

Anti-Vortex Device and Trash Rack-

An anti-vortex device and trash rack shall be attached to the top of the principal spillway to improve the flow characteristics of water into the spillway and prevent floating debris from blocking the principal spillway. The anti-vortex device shall be of the concentric type. See Appendix BMP-14a for design procedures for the anti-vortex device and trash rack.

Dewatering-

Provisions shall be made to dewater the basin down to the permanent pool elevation. Recent studies by the Washington Metropolitan Council of Governments have shown that it is necessary to provide at least a <u>6-hour drawdown time</u> in the dry storage area in order to achieve up to 60% removal of sediment.

Dewatering of the dry storage should be done in a manner which removes the "cleaner" water without removing the potentially sediment-laden water found in the wet storage area or any appreciable quantities of floating debris. An economical and efficient device for performing the drawdown is a section of perforated vertical tubing which is connected to the principal spillway at two locations. By virtue of the potential for the dewatering device or orifice becoming clogged, no credit is given for drawdown by the device in the calculation of the principal or emergency spillway locations. The method for sizing the dewatering orifice and the associated flexible conduit is located in Appendix 14-a.

Base-

The base of the principal spillway must be firmly anchored to prevent its floating. If the riser of the spillway is greater than 3 meters (10 feet) in height, computations must be made to determine the anchoring requirements. A minimum factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces).

For risers 3 meters (10 feet) or less in height, the anchoring may be done in one of the two following ways:

1. A concrete base 450 millimeters (18 inches) thick and twice the width of riser diameter shall be used and the riser embedded 150 millimeters (6 inches) into the concrete. See Appendix BMP-14a for design details.

2. A square steel plate, a minimum of 6 millimeters (0.25 inches) thick and having a width equal to twice the diameter of the riser shall be used; it shall be covered with 750 millimeters (2.5 feet) of stone, gravel, or compacted soil to prevent flotation. See Appendix BMP-14a for design details.

   Note: If the steel base is used, special attention should be given to compaction so that 95% compaction is achieved over the plate. Also, added precautions should be taken to ensure that material over the plate is not removed accidently during removal of sediment from basin.

Barrel-

The barrel of the principal spillway, which extends through the embankment, shall be designed to carry the flow provided by the riser of the principal spillway with the water level at the crest of the emergency spillway. The connection between the riser and the barrel must be watertight. The outlet of the barrel must be protected to prevent erosion or scour of downstream area. See Appendix BMP-14a for design details.

Anti-Seep Collars-

Anti-seep collars shall be used on the barrel of the principal spillway within the normal saturation zone of the embankment to increase the seepage length by at least 10%, if either of the following two conditions is met:

1. The settled height of the embankment exceeds 3 meters (10 feet).

2. The embankment has a low silt-clay content (Unified Soil Classes SM or GM) and the barrel is greater than 250 millimeters (10 inches) in diameter.

The anti-seep collars shall be installed within the saturated zone. The maximum spacing between collars shall be 14 times the projection of the collars above the barrel. Collars shall not be closer than 600 millimeters (2 feet) to a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. <u>Precautions should be taken to ensure that 95% compaction is achieved around the collars</u>. Connections between the collars and the barrel shall be watertight. See Appendix BMP-14a for details and design procedure.

Alternatives to Anti-Seepage Collars-

Anti-seep collars are designed to control seepage and piping along the barrel by increasing the flow length and thus making any flow along the barrel travel a longer distance. However, due to the constraints that collars impose on embankment fill placement and compaction, collars may sometimes be ineffective or actually result in an increase in seepage and piping.

Alternative measures have been developed and are being incorporated into embankment designs. These measures include a structure known as a "filter diaphragm." A filter diaphragm consists of a layer of sand and fine gravel which runs through the dam embankment perpendicular to the barrel. Typically, the structure is 100 to 125 millimeters (4 to 5 inches) in width, approximately 300 millimeters (1 foot) in height and is located at the barrel elevation at its intersection with the upper bounds of the seepage zone. The measure controls the transport of embankment fines, which is the major concern with piping and seepage. The diaphragm channels any undesirable flow through the fine-graded material, which traps any embankment material being transported. The flow is then conveyed out of the embankment through a perforated toe drain.

The critical design element of the filter diaphragm is the grain-size distribution of the filter material which is determined by the grain-size distribution of the embankment fill material. The use and design of these measures must be based on site-specific geotechnical information and should be supervised by a qualified professional.

Emergency Spillway

The emergency spillway acts as a safety release for a sediment basin, or any impoundment type structure, by conveying the larger, less frequent storms through the basin without damage to the embankment. The emergency spillway also acts as its name implies - in case of an emergency such as excessive sedimentation or damage to the riser which prevents flow through the principal spillway. The emergency spillway shall consist of an open channel (earthen and vegetated) constructed adjacent to the embankment over undisturbed material (not fill). Where conditions will not allow the construction of an emergency spillway on undisturbed material, a spillway may be constructed of a non-erodible material such as riprap. The spillway shall have a control section at least 6 meters (20 feet) in length. The control section is a level portion of the spillway channel at the highest elevation in the channel. See Appendix BMP-14a for details and design procedure.

An evaluation of site and downstream conditions must be made to determine the feasibility and justification for the incorporation of an emergency spillway. In some cases, the site topography does not allow a spillway to be constructed in undisturbed material, and the temporary nature of the facility may not warrant the cost of disturbing more acreage to construct and armor a spillway. The principal spillway should then be sized to convey all the design storms. If the facility is designed as a permanent facility with downstream restrictions, the added expense of constructing and armoring an emergency spillway may be justified.

Capacity-

The emergency spillway shall be designed to carry the portion of the peak rate of runoff expected from a 25-year storm which is not carried by the principal spillway. See Appendix BMP-14a for design procedure and details.

Design Elevations-

The 25-year storm elevation through the emergency spillway shall be at least 300 millimeters (1 foot) below the top of the embankment. The crest of the emergency spillway channel shall be above the 2-year storm water surface elevation.

Location-

The emergency spillway channel shall be located so that it will not be constructed over fill material. The channel shall be located so as to avoid sharp turns or bends. The channel shall return the flow of water to a defined channel downstream from the embankment.

Maximum Velocities-

The maximum allowable velocity in the emergency spillway channel will depend upon the type of lining used. For vegetated linings, allowable velocities are listed in Table 17-1 (BMP-17, STORMWATER CONVEYANCE CHANNELS). For non-erodible linings, such as concrete or riprap, design velocities may be increased. However, the emergency spillway channel shall return the flow to the receiving channel at a non-eroding velocity. See Appendix BMP-14a for design procedure and details.

Stabilization-

The embankment of the sediment basin shall receive temporary or permanent seeding <u>immediately after installation</u> (see TEMPORARY SEEDING, BMP-31 or PERMANENT SEEDING, BMP-32). If excavation is required in the basin, side slopes should not be steeper than 1.5:1.

Disposal-

Sediment shall be removed from the basin when the sediment level is no higher than 300 millimeters (1 foot) below the bottom of the dewatering orifice, or one-half of the permanent pool volume, whichever is lower. Plans for the sediment basin shall indicate the methods for disposing of sediment removed from the basin. Possible alternatives are the use of the material in fill areas on-site or removal to an approved off-site location.

Sediment basin plans shall indicate the final disposition of the sediment basin after the upstream drainage area is stabilized. The plans shall include methods for the removal of excess water lying over the sediment, stabilization of the basin site, and the disposal of any excess material. Where the sediment basin has been designed as a permanent stormwater management basin, plans should also address the steps necessary for the conversion from sediment basin to a permanent detention or retention facility.

Safety-

Sediment basins can be attractive to children and can be dangerous. They should; therefore, be fenced or otherwise made inaccessible to persons or animals unless this is deemed unnecessary by the plan approving authority due to the remoteness of the site or other circumstances. Strategically placed signs around the impoundment reading "DANGER-QUICKSAND" should also be installed. In any case, local ordinances and regulations regarding health and safety must be adhered to (see BMP-1, SAFETY FENCE).

Construction Specifications

Site Preparation-

Areas under the embankment or any structural works related to the basin shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material. In order to facilitate cleanout and restoration, the area of most frequent inundation (measured from the top of the principal spillway) will be cleared of all brush and trees.

Cutoff Trench-

For earth-fill embankments, a cutoff trench shall be excavated along the centerline of the dam. The trench must extend at least 300 millimeters (1 foot) into a stable, impervious layer of soil and have a minimum depth of 600 millimeters (2 feet). The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 1.2 meters (4 feet), but also must be wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1.

Compaction requirements shall be the same as those for the embankment. The trench shall be drained during the backfilling/compacting operations.

Embankment-

The fill material shall be taken from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized stones, rocks, or other perishable or objectionable material. The material selected must have enough strength for the dam to remain stable and be tight enough, when properly compacted, to prevent excessive percolation of water through the dam. Fill containing particles ranging from small gravel or coarse sand to fine sand and clay in desired proportion is appropriate. Any embankment material should contain approximately 20% clay particles by weight. Using the Unified Soil Classification System, SC (clayey sand), GC (clayey gravel) and CL ("low liquid limit" clay) are among the preferred types of embankment soils. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain the proper amount of moisture to ensure that 95% compaction will be achieved. Fill material will be placed in 150 millimeter (6-inch) continuous layers over the entire length of the fill. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is transversed by at least one wheel or tread track of the equipment, or by using a compactor. Special care shall be taken in compacting around the anti-seep collars (compact by hand, if necessary) to avoid damage and achieve desired compaction. The embankment shall be constructed to an elevation 10% higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to not less than 5%.

Principal Spillway-

The riser of the principal spillway shall be securely attached to the barrel by a watertight connection. The barrel and riser shall be placed on a firmly compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent its floating. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the barrel or anti-seep collars. Special care shall be taken in compacting around the anti-seep collars (compact by hand, if necessary). Fill material shall be placed around the pipe in 100 millimeter (4-inch) layers and compacted until 95% compaction is achieved. A minimum of 600 millimeters (2 feet) of fill shall be hand-compacted over the barrel before crossing it with construction equipment.

Emergency Spillway-

Vegetative emergency spillways shall not be constructed over fill material. Design elevations, widths, entrance and exit channel slopes are critical to the successful operation of the spillway and should be adhered to closely during construction.

Vegetative Stabilization-

The embankment and emergency spillway of the sediment basin shall be stabilized with temporary or permanent vegetation immediately after installation of the basin (see TEMPORARY SEEDING, BMP-31 or PERMANENT SEEDING, BMP-32).

Erosion and Sediment Control-

The construction of the sediment basin shall be carried out in a manner such that it does not result in sediment problems downstream.

Safety-

All state and local requirements shall be met concerning fencing and signs warning the public of the hazards of soft, saturated sediment and flood waters (refer to BMP-1, SAFETY FENCE).

Maintenance

The basin embankment should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment.

The emergency spillway should be checked regularly to ensure that its lining is well established and erosion-resistant.

The basin should be checked after each runoff-producing rainfall for sediment cleanout. When the sediment reaches the clean-out level, it shall be removed and properly disposed.

APPENDIX BMP-14a

Design Procedure for Temporary Sediment Basins

The following design procedure provides a step-by-step method for the design of a temporary sediment basin. The data sheet found in the back of this Appendix should be used in the erosion and sediment control plan to outline design values calculated.

I. Basin Volume

A. Determine the required basin volume. The design capacity of the basin must be at least 254 cubic meters per hectare (134 cubic yards per acre of total contributing drainage area, half of which shall be in the form of a permanent pool or wet storage, and the remaining half as a "drawdown" area or dry storage.

1. For a natural basin, the wet storage volume may be approximated as follows:

$$V_1 = 0.4 \times A_1 \times D_1$$

where,

V_1 = the wet storage volume in cubic meters (cubic feet)

A_1 = the surface area of the flooded area at the invert of the dewatering outlet, in square meters (square feet)

D_1 = the maximum depth in meters (feet), measured from the low point in the basin to the invert of the dewatering outlet

2. For a natural basin, the dry storage volume may be approximated as follows:

$$V_2 = (A_1 + A_2) / 2 \times D_2$$

where,

V_2 = the dry storage volume in cubic meters (cubic feet)

A_1 = the surface area of the flooded area at the invert of the dewatering outlet, in square meters (square feet) - see #1 above

A_2 = the surface area of the flooded area at the crest of the principal spillway

D_2 = the depth, in meters (feet), measured from the invert of the dewatering outlet to the crest of the principal spillway

Note 1: The volumes may be computed from more precise contour information or other suitable methods.

Note 2: Conversion between acres to hectares and cubic meters to cubic feet and cubic yards is as follows:

acres = number of hectares x 2.47
cubic feet = number of cubic meters x 35.31
number of cubic yards = number of cubic meters x 1.308

B. If the volume of the basin is inadequate or embankment height becomes excessive, pursue the use of excavation to obtain the required volume.

II. Basin Shape

A. The shape of the basin must be such that the length-to-width ratio is at least 2 to 1 according to the following equation:

$$\text{Length-to-width Ratio} = L / We$$

where,

We = A/L = the effective width

A = the surface area of the normal pool

L = the length of the flow path from the inflow to the outflow. If there is more than one inflow point, any inflow which carries more than 30% of the peak rate of inflow must meet these criteria.

B. The correct basin shape can be obtained by proper site selection, excavation, or the use of baffles. Baffles increase the flow length by deflecting the flow. The baffles should be placed halfway between the inflow point and the outflow. Figure 14-1 shows the detail for baffle construction and three situations where baffles might be used.

III. Determine whether the basin will have a separate emergency spillway.

IV. Determine the elevation of the crest of the principal spillway for the required volume - dewatering orifice at 127 cubic meters per hectare (67 cubic yards per acre) and crest of principal spillway - 254 cubic meters per hectare (134 cubic yards per acre).

V. Estimate the elevation of the design high water and the required height of the dam.

A. If an emergency spillway is included, the crest of the principal spillway must be at least 300 millimeters (1.0 foot) below the crest of the emergency spillway.

B. If an emergency spillway is included, the elevation of the peak flow through the emergency spillway (which will be the design high water for the 25-year storm) must be at least 300 millimeters below the top of embankment.

C. If an emergency spillway is <u>not</u> included, the crest of the principal spillway must be at least 1 meter (3 feet) below the top of the embankment.

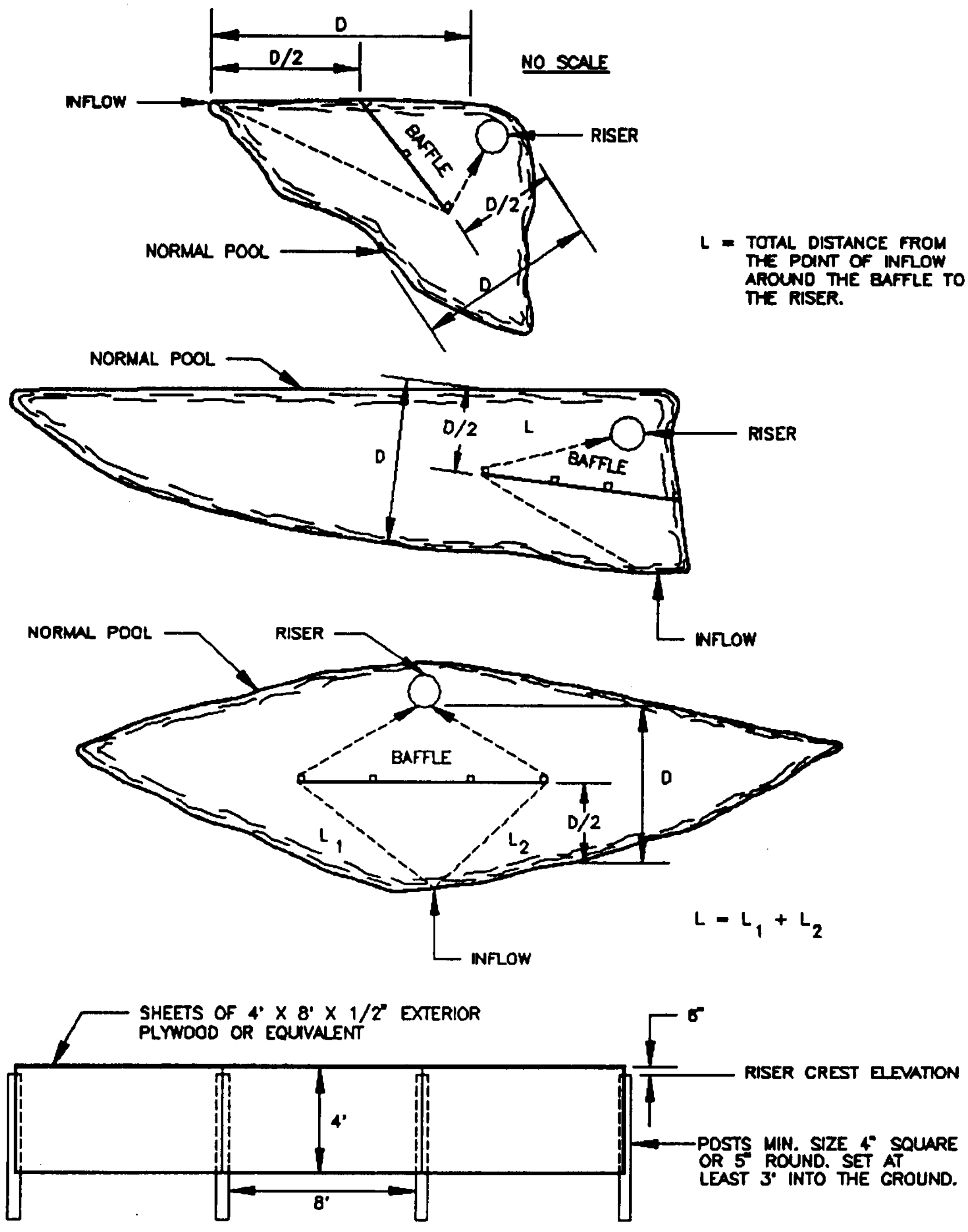
D. If an emergency spillway is <u>not</u> included, the elevation of the design high water for the 25-year storm must be 600 millimeters (2.0 feet) below the top of the embankment.

VI. Principal Spillway Design

A. If an emergency spillway is included, the principal spillway must at least pass the peak rate of runoff from the basin drainage area for a 2-year storm. Therefore,

$$Q_p = \text{the 2-year peak rate of runoff.}$$

FIGURE 14-1: EXAMPLE PLAN VIEWS OF BAFFLE LOCATIONS IN SEDIMENT BASINS



B. If an emergency spillway is <u>not</u> included, the principal spillway must pass the peak rate of runoff from the basin drainage area for a 25-year storm. Therefore,

$$Q_p = \text{the 25-year peak rate of runoff.}$$

C. Refer to Figure 14-2, where h is the difference between the elevation of the crest of the principal spillway and the elevation of the crest of the emergency spillway.

D. Enter Figure 14-3 with Q_p. Choose the smallest riser which will pass the required flow with the available head, h.

E. Refer to Figure 14-2, where H is the difference in elevation of the centerline of the outlet of the barrel and the crest of the emergency spillway. L is the length of the barrel through the embankment.

F. Enter Table 14-1 or Table 14-2 with H. Choose the smallest size barrel which will pass the flow provided by the riser. If L is other than 21 meters (70 feet), make the necessary correction.

VII. Emergency Spillway Design

A. The emergency spillway must pass the remainder of the 25-year peak rate of runoff not carried by the principal spillway.

B. Compute, $Q_e = Q_{25} - Q_p$

C. Refer to Table 14-3 and Figure 14-4.

D. Determine approximate permissible values for b, the bottom width; s, the slope of the exit channel; and x, minimum length of the exit channel.

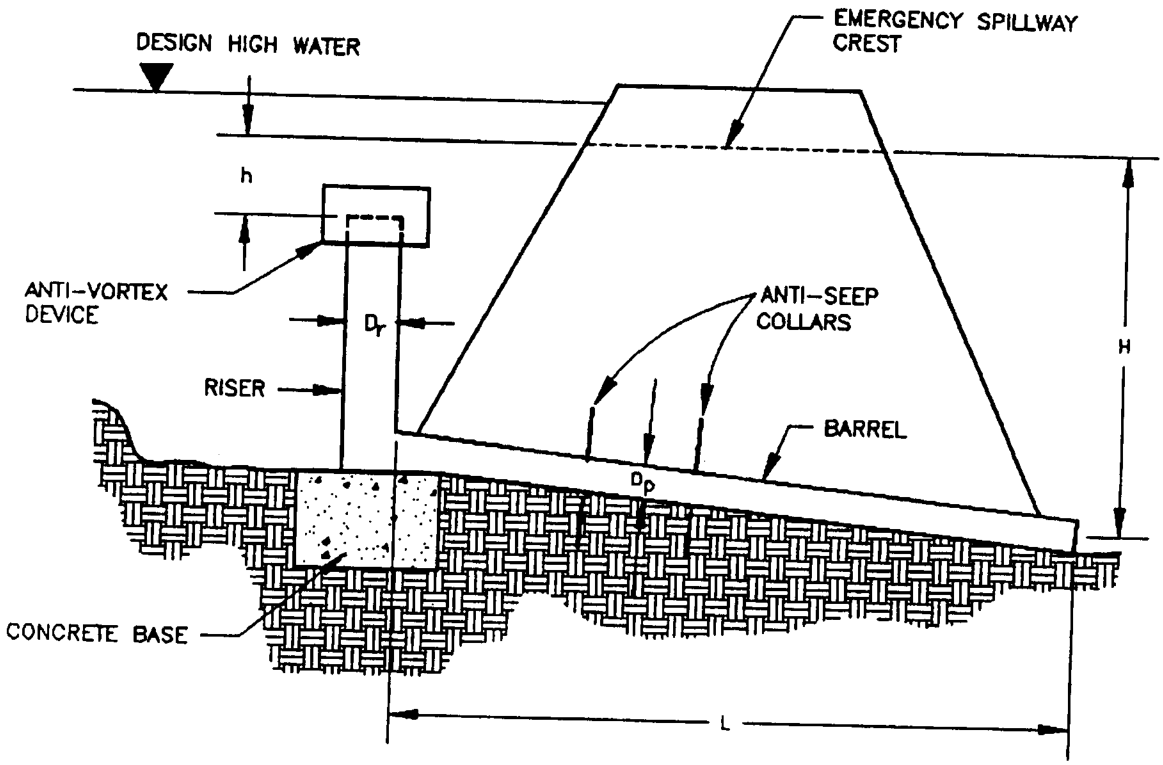
E. Enter Table 14-3 and choose an exit channel cross-section which passes the required flow and meets the other constraints of the site.

F. Note:

1. The maximum permissible velocity for vegetated waterways must be considered when designing an exit channel.

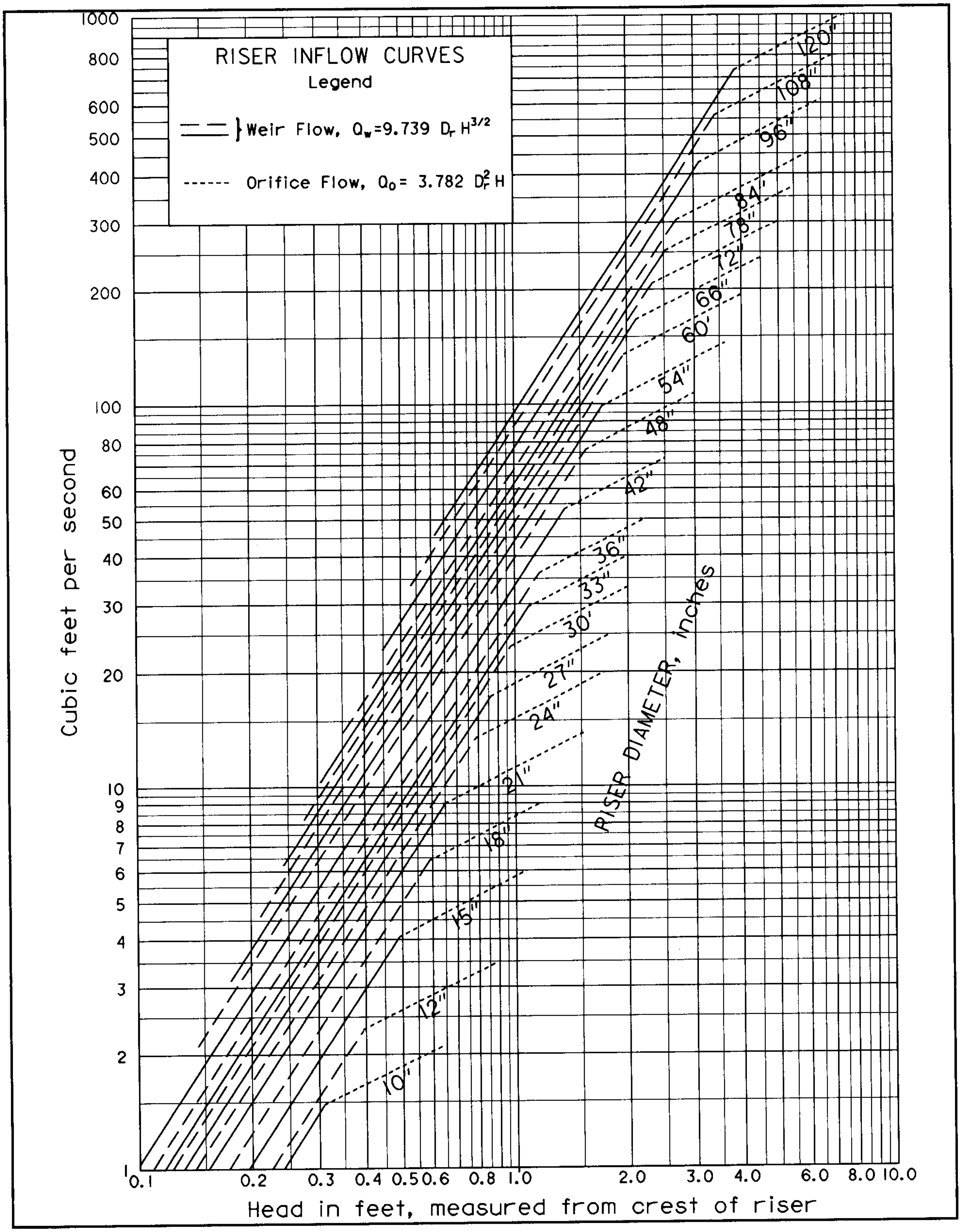
2. For a given Hp, a decrease in the exit slope from S as given in the table decreases spillway discharge, but increasing the exit

FIGURE 14-2: PRINCIPAL SPILLWAY DESIGN



H = HEAD ON PIPE THROUGH EMBANKMENT
h = HEAD OVER RISER CREST
L = LENGTH OF PIPE THROUGH EMBANKMENT
D_p = DIAMETER OF PIPE THROUGH EMBANKMENT
D_r = DIAMETER OF RISER

FIGURE 14-3



SOURCE: USDA-SCS

METRIC CONVERSIONS:

CUBIC METERS PER SECOND = CUBIC FEET PER SECOND x 0.0283

MILLIMETERS = INCHES x 25.4

TABLE 14-1: 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

H, in feet	diameter of pipe in inches: 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	

Typical Metric Conversions:
Meters = 0.3048 x feet
millimeters = 25.4 x inches

TABLE 14-2: 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

Typical Metric Conversions:
Meters = 0.3048 x feet
millimeters = 25.4 x inches

TABLE 14-3: DESIGN DATA FOR SPILLWAYS[1]

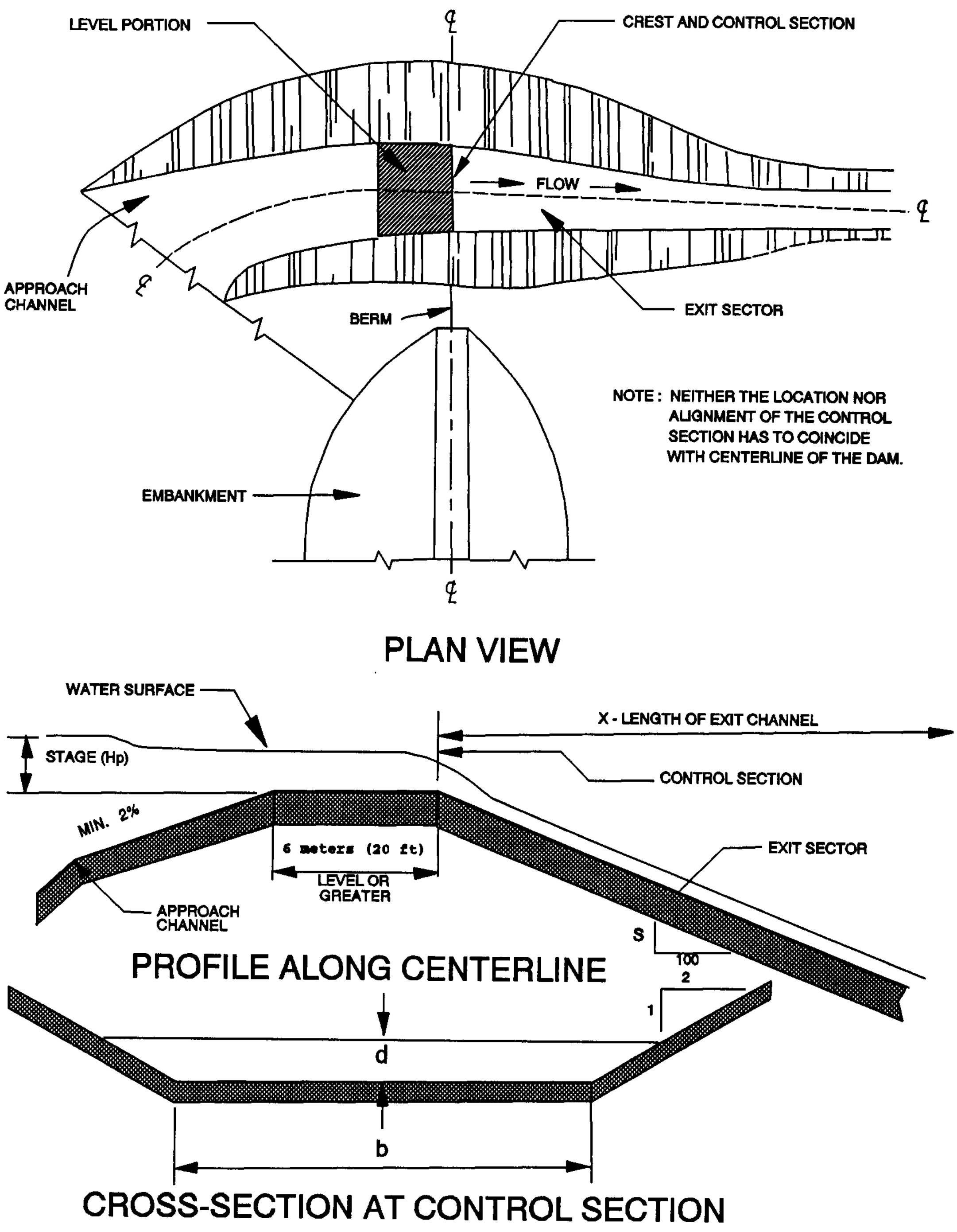
Stage (Hp) (feet)	Spillway Variables	Bottom Width (b) in Feet																
		8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
0.5	Q	6	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
	V	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	X	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
0.6	Q	8	10	12	14	16	18	20	22	24	26	28	30	32	34	35	37	39
	V	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.6	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	X	36	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37
0.7	Q	11	13	16	18	20	23	25	28	30	33	35	38	41	43	44	46	48
	V	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	X	39	40	40	40	41	41	41	41	41	41	41	41	41	41	41	41	41
0.8	Q	13	16	19	22	26	29	32	35	38	42	45	46	48	51	54	57	60
	V	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	S	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	X	44	44	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45
0.9	Q	17	20	24	28	32	35	39	43	47	51	53	57	60	64	68	71	75
	V	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.2	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	X	47	47	48	48	48	48	48	48	48	48	49	49	49	49	49	49	49
1.0	Q	20	24	29	33	38	42	47	51	56	61	63	68	72	77	81	86	90
	V	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	X	51	51	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52
1.1	Q	23	28	34	39	44	49	54	60	65	70	74	79	84	89	95	100	105
	V	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	S	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	55	55	55	55	55	55	55	56	56	56	56	56	56	56	56	56	56
1.2	Q	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	S	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	58	58	59	59	59	59	59	59	60	60	60	60	60	60	60	60	60
1.3	Q	32	38	46	53	58	65	73	80	86	91	99	106	112	119	125	133	140
	V	4.5	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	X	62	62	62	63	63	63	63	63	63	63	63	64	64	64	64	64	64
1.4	Q	37	44	51	59	66	74	82	90	96	103	111	119	127	134	142	150	158
	V	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
	S	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	X	65	66	66	66	66	67	67	67	67	67	67	68	68	68	68	68	69

TABLE 14-3: DESIGN DATA FOR SPILLWAYS Continued

Stage (Hp) (feet)	Spillway Variables	Bottom Width (b) in Feet																
		8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
1.5	Q	41	50	58	66	75	85	92	101	108	116	125	133	142	150	160	169	175
	V	4.8	4.9	4.9	5	5	5	5	5	5	5	5	5	5	5	5.1	5.1	5.1
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5
	X	69	69	70	70	71	71	71	71	71	71	71	72	72	72	72	72	72
1.6	Q	46	56	65	75	84	94	104	112	122	132	142	149	158	168	178	187	197
	V	5.0	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	72	74	74	75	75	76	76	76	76	76	76	76	76	76	76	76	76
1.7	Q	52	62	72	83	94	105	115	126	135	145	156	167	175	187	196	206	217
	V	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	S	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	76	78	79	80	80	80	80	80	80	80	80	80	80	80	80	80	80
1.8	Q	58	69	81	93	104	116	127	138	150	160	171	182	194	204	214	226	233
	V	5.3	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.6	5.6	5.6
	S	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	80	82	83	84	84	84	84	84	84	84	84	84	84	84	84	84	84
1.9	Q	64	76	88	102	114	127	140	152	164	175	188	201	213	225	235	248	260
	V	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	S	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	84	85	86	87	88	88	88	88	88	88	88	88	88	88	88	88	88
2.0	Q	71	83	97	111	125	138	153	164	178	193	204	218	232	245	256	269	283
	V	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	88	90	91	91	91	91	92	92	92	92	92	92	92	92	92	92	92
2.1	Q	77	91	107	122	135	149	162	177	192	207	220	234	250	267	276	291	305
	V	5.7	5.8	5.9	5.9	5.9	5.9	5.9	6	6	6	6	6	6	6	6	6	6
	S	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	92	93	95	95	95	95	95	95	95	96	96	96	96	96	96	96	96
2.2	Q	84	100	116	131	146	163	177	194	210	224	238	253	269	288	301	314	330
	V	5.9	5.9	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2
	S	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	96	98	99	99	99	99	99	100	100	100	100	100	100	100	100	100	100
2.3	Q	90	108	124	140	158	175	193	208	226	243	258	275	292	306	323	341	354
	V	6.0	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	S	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	100	102	102	103	103	103	104	104	104	105	105	105	105	105	105	105	105
2.4	Q	99	116	136	152	170	189	206	224	241	260	275	294	312	327	346	364	378
	V	6.1	6.2	6.2	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
	S	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	105	105	106	107	107	108	108	108	108	109	109	109	109	109	109	109	109

Typical Metric Conversions
cubic meters per second = cubic feet per second x 0.0283
meters = feet x 0.3048
millimeters = inches x 25.4

FIGURE 14-4: EXCAVATED EARTH SPILLWAY



slope from S does not increase discharge. If an exit slope (Se) steeper than S is used, then design procedures should be used to verify the adequacy of the exit channel.

3. Data to the right of heavy vertical lines should be used with caution, as the resulting sections will be either poorly proportioned or have excessive velocities.

VIII. Re-estimate the elevation of the design high water and the top of the dam based upon the design of the principal spillway and the emergency spillway.

IX. Anti-Vortex Device and Trash Rack

A. This design procedure for the anti-vortex device and trash rack refer only to riser pipes of corrugated metal. There are numerous ways to provide protection for concrete pipe; these include various hoods and grates and rebar configurations which should be a part of project-specific design and will frequently be a part of a permanent structure.

B. Refer to Figure 14-5 and Table 14-4. Choose cylinder size, support bars, and top requirements from Table 14-4 based on the diameter of the riser pipe.

X. Anti-Seep Collars

A. Anti-seep collars must be used under the conditions specified in the Design Criteria.

B. Anti-seep collars are used to increase the seepage length along the barrel by 10%.

C. Determine the length of the barrel within the saturated zone. This may be done by solving the following equation:

$$Ls = Y (Z + 4) (1 + (S / (0.25 - S))$$

where:

Ls	=	length of barrel in the saturated zone, meters (feet).
Y	=	the depth of water at the principal spillway crest, meters (feet).
Z	=	slope of the upstream face of embankment in Z meters (feet) horizontal to one vertical.
S	=	slope of the barrel in meters per meter (feet per feet).

FIGURE 14-5: ANTI-VORTEX DEVICE DESIGN

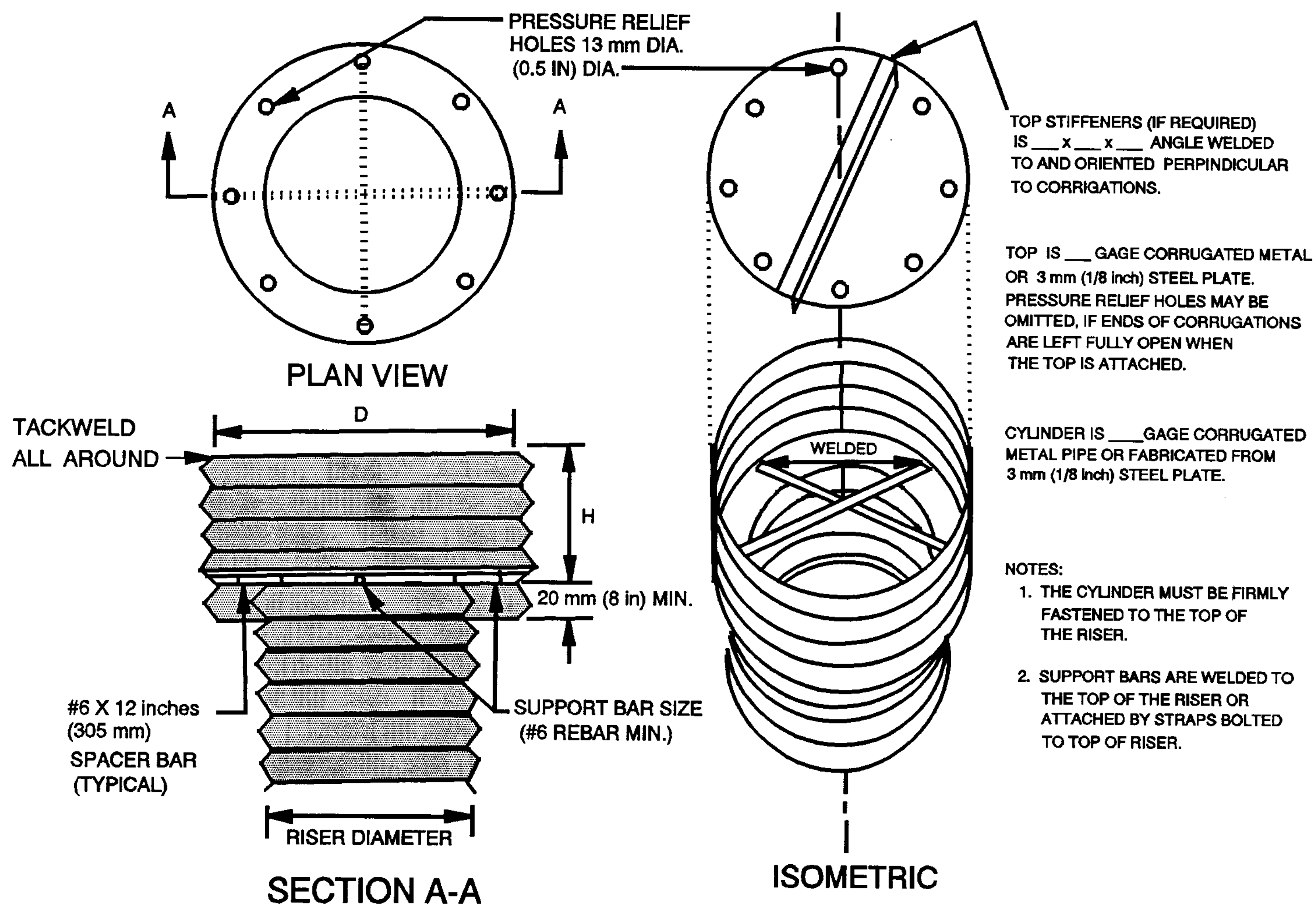


TABLE 14-4
CONCENTRIC TRASH RACK AND ANTI-VORTEX DESIGN TABLE

Riser Diameter, inches	Cylinder		Height, inches	Minimum Size Support Bar	Minimum Top	
	Diameter	Thickness, gage			Thickness	Stiffener
12	18	16	6	#6 Rebar or 1.5 x 1.5 x 3/16 angle	16 ga. (F&C)	-
15	21	16	7	" "	" "	-
18	27	16	8	" "	" "	-
21	30	16	11	" "	16 ga.(C), 14 ga. (F)	-
24	36	16	13	" "	" "	-
27	42	16	15	" "	" "	-
36	54	14	17	#8 Rebar	14 ga.(C), 12 ga. (F)	-
42	60	16	19	" "	" "	-
48	72	16	21	1.25" pipe or 1.25 x 1.25 x 0.25 angle	14 ga.(C), 10 ga. (F)	-
54	78	16	25	" "	" "	-
60	90	14	29	1.5" pipe or 1.5 x 1.5 x 0.25 angle	12 ga.(C), 8 ga. (F)	-
66	96	14	33	2" pipe or 2 x 2 x 3/16 angle	12 ga.(C), 8 ga. (F) w/stiffener	2 x 2 x 0.25 angle
72	102	14	36	" "	" "	2.5 x 2.5 x 0.25 angle
78	114	14	39	2.5" pipe or 2 x 2 x 0.25 angle	" "	" "
84	120	12	42	2.5" pipe or 2.5 x 2.5 x 0.25 angle	" "	2.5 x 2.5 x 5/16 angle

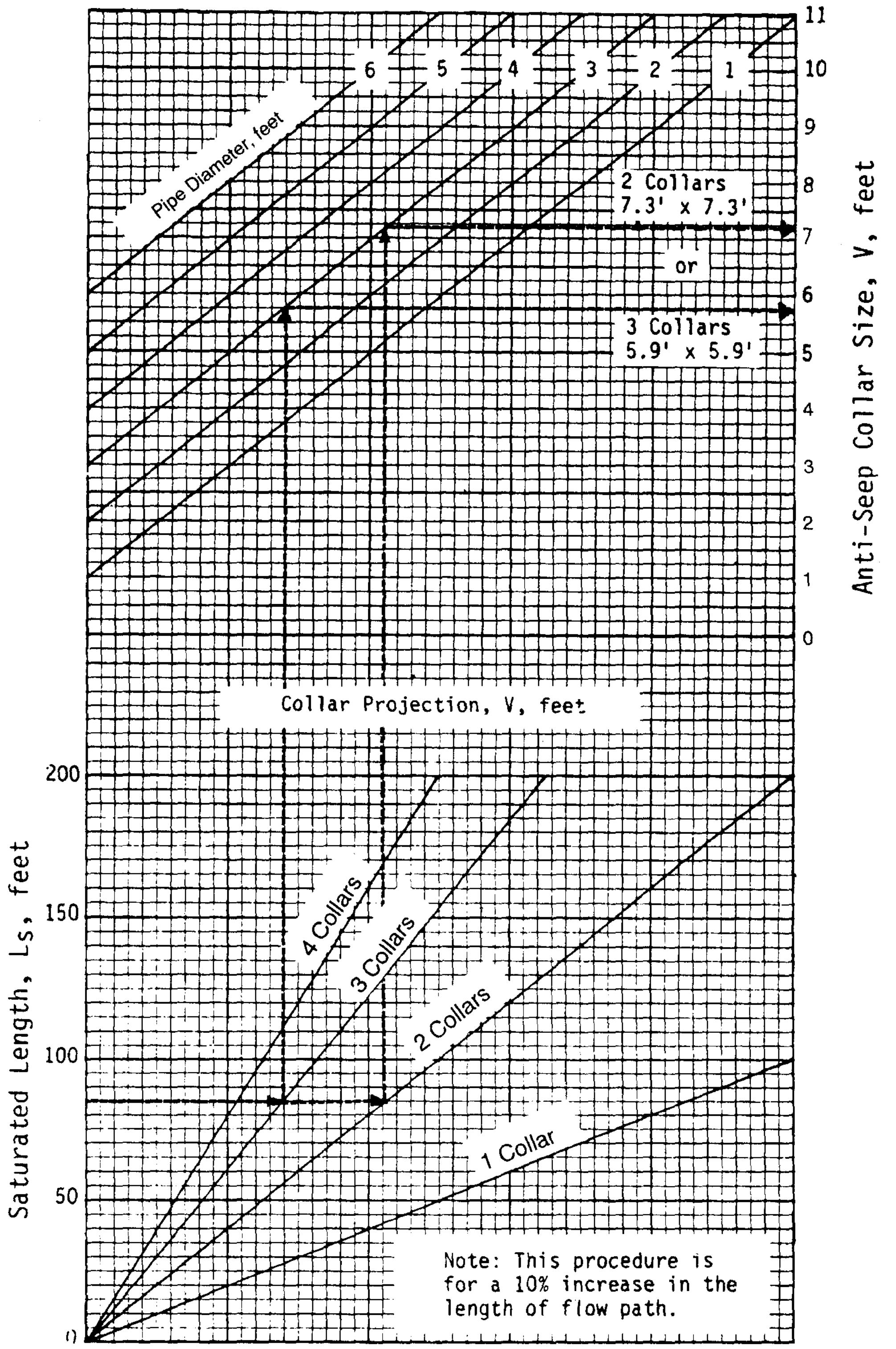
Note 1: The criterion for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.

Note 2: Corrugation for 12"-36" pipe measures 2 2/3" x 1/2"; for 42"-84" the corrugation measures 5" x 1" or 8" x 1".

Note 3: C = corrugated; F = flat.

Conversion Units: Millimeters = inches x 25.4

FIGURE 14-6: NUMBER OF ANTI-SEEP COLLARS REQUIRED



* - Metric Conversion : meters = feet x 0.3048

NUMBER OF ANTI-SEEP COLLARS REQUIRED

D. Enter Table 14-6 with Ls. Move horizontally right until one of the lines is intersected. Move vertically until the correct line for barrel diameter is intersected. Move horizontally right to read P, the size of the anti-seep collar.

E. If more than one collar is used, the spacing between collars should be 14 times the projection of the collar above the barrel.

F. Collars should not be located closer than 600 millimeters (2 feet) to a pipe joint.

XI. Anchoring the Principal Spillway

A. The principal spillway must be firmly anchored to prevent its floating.

B. If the riser is over 3 meters (10 feet) high, the forces acting on the spillway must be calculated. A method of anchoring the spillway which provides a safety factor of 1.25 must be used (downward forces = 1.25 x upward forces).

C. If the riser is 3 meters (10 feet) or less in height, choose one of the two methods in Figure 14-7 to anchor the principal spillway.

XII. Dewatering

A. Refer to Figure 14-8 for details and orientation.

B. Calculation of the diameter of the dewatering orifice:

Use a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice.

Naming the variables:

A	=	flow area of orifice, in square meters (square feet).
d	=	diameter of circular orifice, in millimeters (inches).
h	=	average driving head (maximum possible head measured from radius of orifice to crest of principal spillway divided by 2), in meters (feet)
Q	=	volumetric flowrate through orifice needed to achieve approximate 6-hour drawdown, cubic meters per second (cubic feet per second).

S	=	total storage available in dry storage area, cubic meters (cubic feet).
Q	=	S / 21,600 seconds

Use S for basin and find Q. Then substitute in calculated Q and find A:

$$A=\frac{Q}{(64.32*\frac{h}{2})^{\frac{1}{2}}(0.6)}$$

Then, substitute in calculated A and find d:

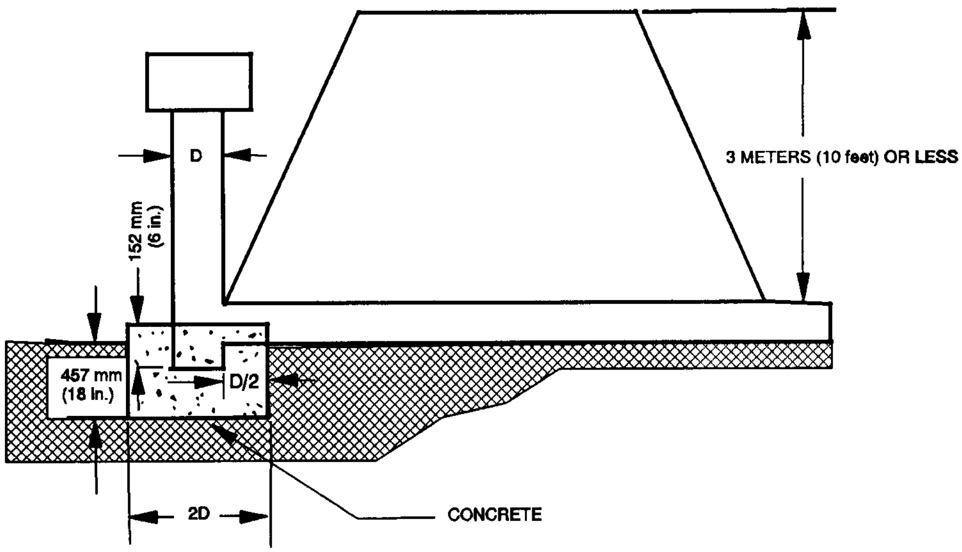
$$d^{*}=2*(\frac{A}{3.14})^{\frac{1}{2}}$$

* Diameter of dewatering orifice should never be less than 75 millimeters (3 inches) in order to help prevent clogging by soil or debris.

<u>Note:</u> Flexible tubing used should be at least 50 millimeters (2 inches) larger in diameter than the calculated orifice to promote improved flow characteristics.

FIGURE 14-7: RISER PIPE BASE CONDITIONS FOR EMBANKMENTS LESS THAN 3 METERS (10 FEET) HIGH

CONCRETE BASE FOR EMBANKMENT 3 METERS (10 feet) OR LESS IN HEIGHT



STEEL BASE FOR EMBANKMENT 3 METERS (10 feet) OR LESS IN HEIGH

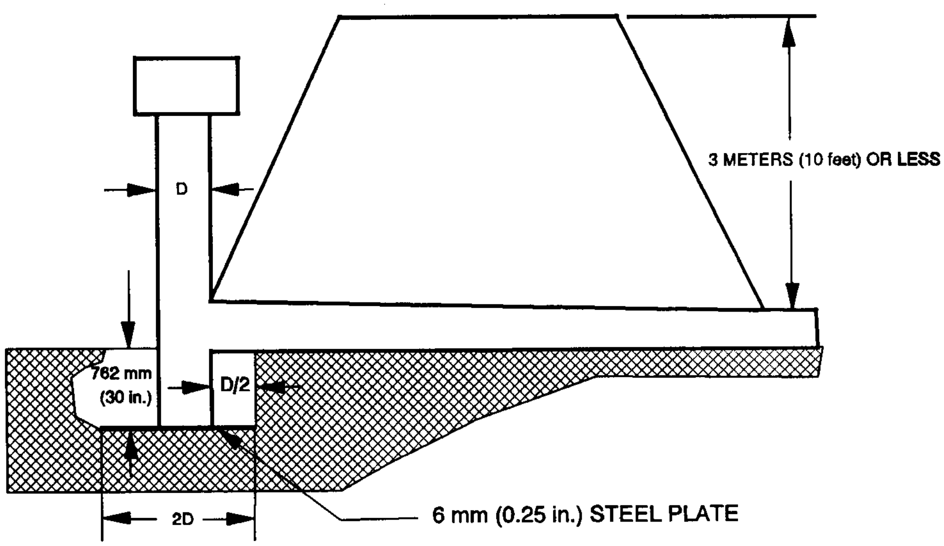
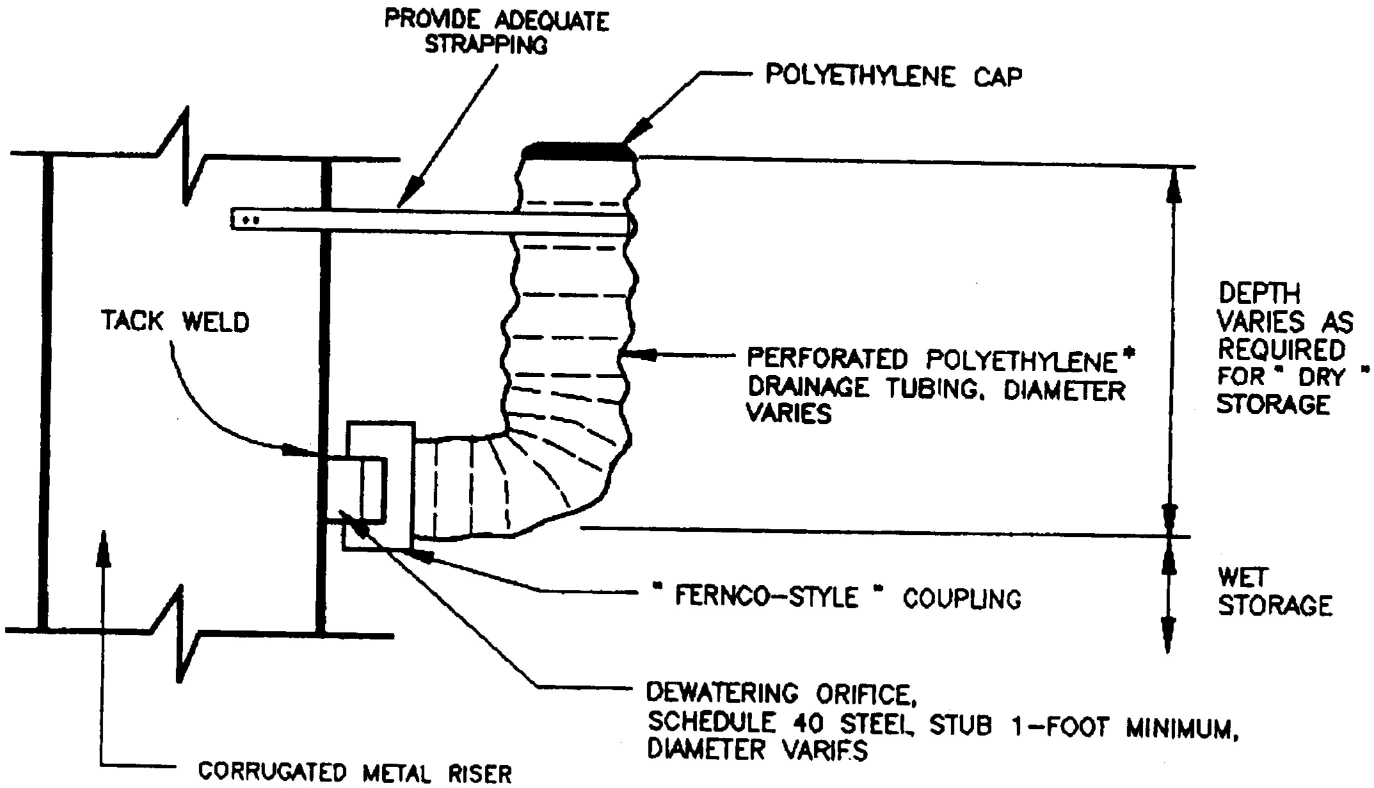


FIGURE 14-8: RECOMMENDED DEWATERING SYSTEM FOR SEDIMENT BASINS



NOTE: WITH CONCRETE RISER, USE PVC SCHEDULE 40 STUB FOR DEWATERING ORIFICE

*DRAINAGE TUBING SHALL COMPLY WITH ASTM F667 AND AASHTO M294

TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

(with or without an emergency spillway)

Project ____

Basin #____________________ Location ____________________

Total area draining to basin:________ hectares (acres).

<u>Basin Volume Design</u>

Wet Storage:

1. Minimum required volume = 127 cubic meters per hectare x Total Drainage Area (hectares).

   127 m^3/hectare x _______ hectares = _______ m^3

   (67 cubic yards per acre x _______ acres = _______ cubic yards)

2. Available basin volume = _______ m^3 at elevation _______.
   (From storage - elevation curve)

3. Excavate _______ m^3 to obtain required volume*.

   * Elevation corresponding to required volume = invert of the dewatering orifice.

4. Available volume before cleanout required.

   63 m^3 per hectare x _______ hectares = _______ m^3

   (33 cubic yards per acre x _______ acres = _______ cubic yards)

5. Elevation corresponding to cleanout level = _________.
   (From Storage - Elevation Curve)

6. Distance from invert of the dewatering orifice to cleanout level = _______ ft.
   Min. = 0.3 meters (1.0 ft.)

Dry Storage:

7. Minimum required volume = 127 cubic meters per hectare x Total Drainage Area (hectares).

$127\ m^3$/hectare x _______ hectares = _______ m^3

(67 cubic yards per acre x _______ acres = _______ cubic yards)

8. Total available basin volume at crest of riser* = _______ m^3 at elevation _______. (From Storage - Elevation Curve)

* Minimum = 254 cubic meters per hectare of total drainage area.
* Minimum = 134 cubic yards per acre of total drainage area.

9. Diameter of dewatering orifice = __________ millimeters (mm).

10. Diameter of flexible tubing = ________ mm (diameter of dewatering orifice plus 50 mm).

Preliminary Design Elevations

11. Crest of Riser = ___________

Top of Dam = __________

Design High Water = __________

Upstream Toe of Dam = ___________

Basin Shape

12. $\frac{\text{Length of Flow}}{\text{Effective Width}} \quad \frac{L}{We} =$ ________

If > 2, baffles are not required __________

If < 2, baffles are required __________

Runoff

13. Q_2 = _______ cubic meters per second (cms)

14. Q_{25} = _______ cms

Principal Spillwav Design

15. With emergency spillway, required spillway capacity $Q_p = Q_2$ = _______ cms. (riser and barrel)

    Without emergency spillway, required spillway capacity Q_p = Q_{25} = _______*cms.* (riser and barrel)

16. With emergency spillway:

    Assumed available head (h) = _______ m. (Using Q_2)

    h = Crest of Emergency Spillway Elevation - Crest of Riser Elevation

    Without emergency spillway:

    Assumed available head (h) = ________ m. (Using Q_{25})

    h = Design High Water Elevation - Crest of Riser Elevation

17. Riser diameter (D_r) = _______ mm Actual head (h) = ________ m
    (From Figure 14-3)
    Note: Avoid orifice flow conditions.

18. Barrel length (l) = _______ m

    Head (H) on barrel through embankment = _______ m
    (From Table 14-1).

19. Barrel diameter = _______ mm
    (From Table 14-2 [concrete pipe] or Table 14-1 [corrugated pipe]).

20. Trash rack and anti-vortex device
    Diameter = _______ mm
    Height = _______ mm
    (From Table 14-4).

Emergency Spillway Design

21. Required spillway capacity Q_e = Q_{25} - Q_p = _______ cms.

22. Bottom width (b) = m; the slope of the exit channel (s) = ________ m/meter; and the minimum length of the exit channel (x) = ________ m (From Table 14-3).

Anti-Seep Collar Design

23. Depth of water at principal spillway crest (Y) = _______ m

Slope of upstream face of embankment (Z) = _______ : 1.

Slope of principal spillway barrel (S_b) = _______ %

Length of barrel in saturated zone (L_s) = _______ m

24. Number of collars required = _______ dimensions = _______
(from Figure 14-6).

Final Design Elevations

25. Top of Dam = _______

Design High Water = ________

Emergency Spillway Crest = _______

Principal Spillway Crest = _______

Dewatering Orifice Invert = _______

Cleanout Elevation = _______

Elevation of Upstream Toe of Dam
or Excavated Bottom of "Wet Storage
Area" (if excavation was performed) = ________

BMP: TEMPORARY SLOPE DRAIN

Definition

A flexible tubing or conduit extending from the top to the bottom of a cut or fill slope.

Purpose

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

Conditions Where Practice Applies

On cut or fill slopes where there is a potential for upslope flows to move over the face of the slope causing erosion and preventing adequate stabilization.

Planning Considerations

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

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

Design Criteria

Drainage Area-

The maximum allowable drainage area per slope drain is 2 hectares (5 acres).

Flexible Conduit-

The slope drain shall consist of heavy-duty, flexible material designed for this purpose. The diameter of the slope drain shall be equal over its entire length. Reinforced hold-down grommets shall be spaced at 3 meter (10-foot) or less intervals. Slope drains shall be sized as listed in Table 15-1.

TABLE 15-1
SIZE OF SLOPE DRAIN

Maximum Drainage Area		Pipe Diameters	
Hectares	Acres	millimeters	inches
0.2	0.5	305	12
0.6	1.5	457	18
1.0	2.5	533	21
1.4	3.5	610	24
2.0	5.0	762	30

Entrance Sections-

The entrance to the slope drain shall consist of a standard flared end-section for metal pipe culverts with appropriate inlet protection as set forth in CULVERT INLET PROTECTION, BMP-8. If ponding will cause a problem at the entrance and make such protection impractical, appropriate sediment removing measures shall be taken at the outlet of the pipe. Extension collars shall consist of 300 millimeter (12-inch) long corrugated metal pipe. Watertight fittings shall be provided (See Figure 15-1).

Note: End-sections made of heavy-duty, flexible material may be utilized if determined by the Plan-Approving Authority to provide a stable inlet or outlet section.

Dike Design-

An earthen dike shall be used to direct stormwater runoff into the temporary slope drain and shall be constructed as set forth in DIVERSION, BMP-12. See Figure 15-1 for placement of dike in relation to the slope drain.

The height of the dike at the centerline of the inlet shall be equal to the diameter of the pipe plus 150 millimeters (6 inches). Where the dike height is greater than 450 millimeters (18 inches) at the inlet, it shall be sloped at the rate of 3:1 or flatter to connect with the remainder of the dike (see Figure 15-1).

Outlet Protection-

The outlet of the slope drain must be protected from erosion as set forth in OUTLET PROTECTION, BMP-18.

Construction Specifications-

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

2. The entrance section shall slope toward the slope drain at the minimum rate of 42 millimeters per meter (0.5 inches per foot).

3. The soil around and under the entrance section shall be hand-tamped in 200 millimeter (8-inch) lifts to the top of the dike to prevent piping failure around the inlet.

4. The slope drain shall be securely staked to the slope at the grommets provided.

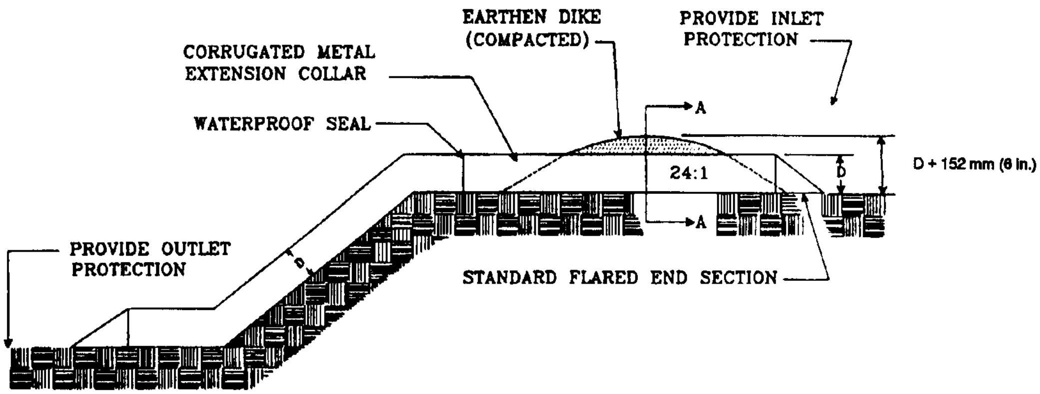
5. The slope drain sections shall be securely fastened together and have watertight fittings.

6. Install CULVERT INLET PROTECTION and OUTLET PROTECTION as per BMP-8 and BMP-18, respectively.

Maintenance

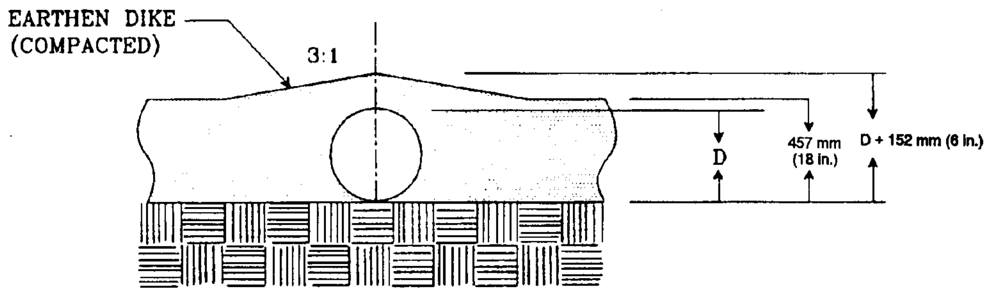
The slope drain structure shall be inspected weekly and after every storm, and repairs made if necessary. The contractor should avoid the placement of any material on and prevent construction traffic across the slope drain.

FIGURE 15-1: TEMPORARY SLOPE DRAIN



SECTION VIEW

NOTE: SEDIMENT MAY BE CONTROLLED AT OUTLET IF UPLAND PONDING WILL CREATE PROBLEMS



SECTION A – A

BMP: PAVED FLUME

Definition

A permanent paved channel constructed on a slope.

Purpose

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

Conditions Where Practice Applies

Wherever concentrated stormwater runoff must be conveyed from the top to the bottom of cut or fill slopes on a permanent basis and a riprap-lined channel is not capable of conveying the runoff without erosion.

Planning-Considerations

Paved flumes are used routinely on highway cuts and fills to convey concentrated stormwater runoff from the top to the bottom of the slope without erosion. Standards and specifications have been developed for these structures which apply to all secondary and primary highway construction projects.

Consideration must be given to protecting structures against buoyancy failures. The potential for buoyancy failures due to hydrostatic uplift forces exists in channels constructed in periodically saturated areas (basically all channels will experience saturation of the subgrade by virtue of the function of the channel) and especially if a submerged outfall condition exists.

Paved flumes should be utilized and constructed carefully. Field experience has shown a significant amount of post-construction problems with these controls. If the base contains some unsuitable material or is too "soft," the flume will be subject to undermining and fracturing. There are also many cases where the outlet velocities and flow rates of stormwater which travels in a paved flume are so great that erosion and flooding at the end of the structure are inevitable, no matter what type of treatment is installed at the outlet. In these cases, strong consideration should be given to a riprapped channel or to a system of inlets, manholes, and pipe to safely convey the stormwater to the receiving channel or drainage structure.

Design Criteria

Capacity-

Paved flumes shall be capable of passing the peak flow expected from a 10-year frequency storm.

Cross-Sections-

Figure 16-1 illustrates a typical trapezoidal cross-section of a standard paved flume. Where additional flow capacity is required, larger trapezoidal cross-sections may be designed. The following criteria apply to all trapezoidal flume designs:

1. The maximum slope of the structure shall be 1.5:1 (67%).

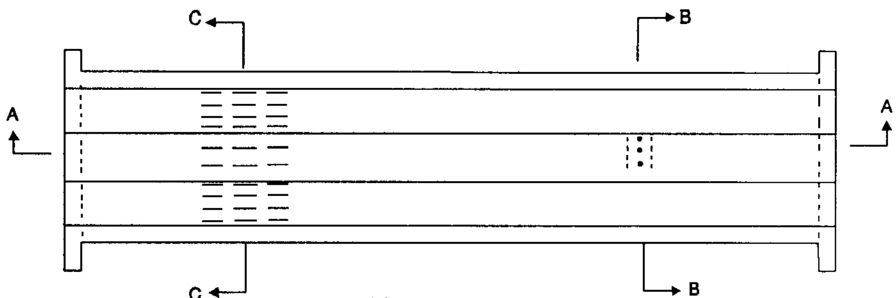
2. Curtain Walls shall be provided at the beginning and end of all paved flumes not abutted to another structure. The curtain wall shall be as wide as the flume channel, extend at least 450 millimeters (18 inches) into the soil below the channel, and have a thickness of 150 millimeters (6 inches). Curtain walls shall be reinforced with #4 reinforcing steel bars placed on 100 millimeter (4-inch) centers.

3. Anchor Lugs shall be spaced at a maximum of 3 meters (10 feet) on center for the length of the flume. Where no curtain wall is required, an anchor lug shall be installed within 600 millimeters (2 feet) of the end of the flume. Anchor lugs are to be as wide as the bottom of the flume channel, extend at least 300 millimeters (1 foot) into the soil below the channel, and have a thickness of 150 millmeters (6 inches). Anchor lugs shall be reinforced with #4 reinforcing steel bars placed on 100 millimeter (4-inch) centers.

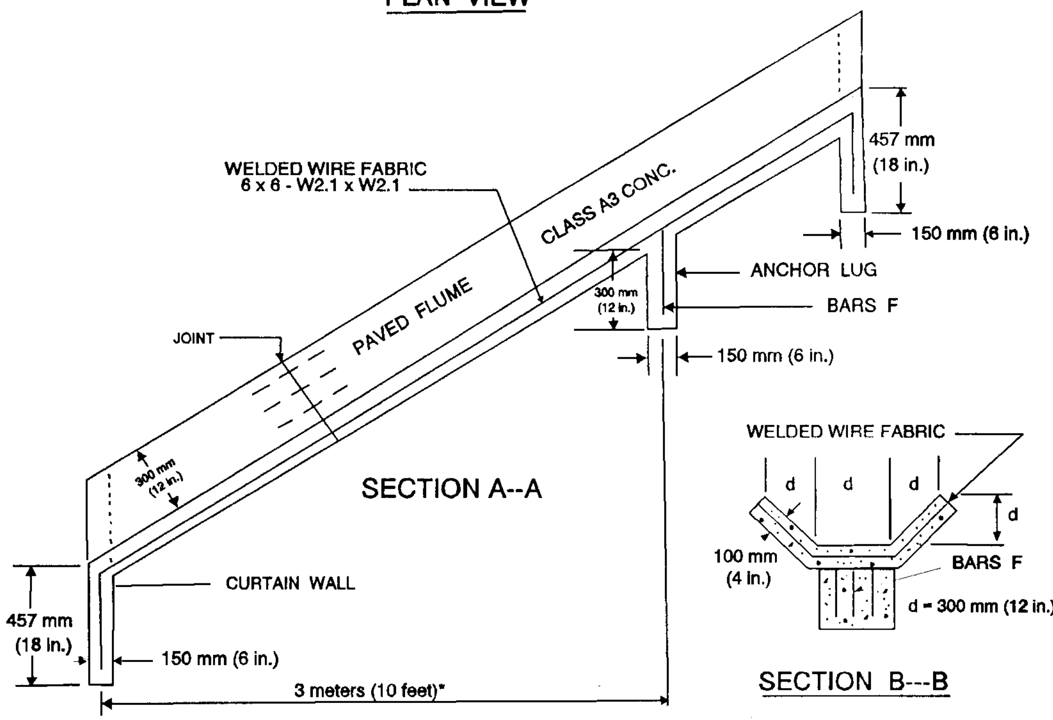
4. The flume channel shall have at least a 100 millimeter (4-inch) thickness of class A-3 concrete with welded wire fabric 150 mm X 150 mm (6 in X 6 in) - (W2.1 x W2.1) in the center for reinforcement.

5. Expansion Joints shall be provided approximately every 30 meters (90 feet). At least 500 millimeter (18-inch) dowels of #4 reinforcing steel placed on 125 millimeter (5-inch) centers shall be located at all required joints.

FIGURE 16-1: PAVED FLUME

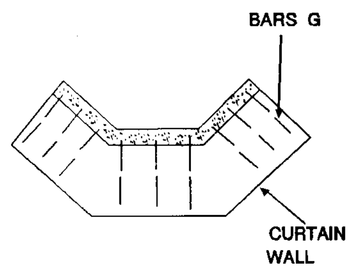


PLAN VIEW



SECTION B---B

* 3 meters (10 feet) C-C MAXIMUM TYPICAL SPACING BETWEEN ANCHOR LUGS. WHERE CURTAIN WALL IS NOT REQUIRED ANCHOR LUG IS TO BE A MAXIMUM OF 600 mm (2ft.) FROM END OF CHANNEL.



SECTION C---C

SCHEDULE OF REINFORCING STEEL

MARK	NO.	LENGTH 2 : 1	LENGTH 1.5 : 1	SIZE	SPACING C-C	SHAPE
F	3	355 mm (14 in.)	355 mm (14 in.)	4	100 mm (4 in.)	STRAIGHT
G	9	432 mm (17 in.)	432 mm (17 in.)	4	152 mm (6 in.)	STRAIGHT
DOWELS	10	457 mm (18 in.)	457 mm (18 in.)	4	127 mm (5 in.)	STRAIGHT

NO. SHOWN ARE FOR ONE ANCHOR LUG, CURTAIN WALL AND JOINT

Outlet-

Outlets of paved flumes should be protected from erosion. The use of an energy dissipator with OUTLET PROTECTION (BMP-18) is recommended in order to temporarily reduce the existing velocity of the flow, thus preventing undermining of the structure and providing a stable transition zone between the flume and the receiving channel or drainage structure at the base of the slope. OUTLET PROTECTION should still be utilized with the use of a standard energy dissipating structure to further dissipate flow energy and to provide a smooth transition into the receiving channel. Larger energy dissipator systems may be similarly designed for larger flume cross-sections.

Construction Specifications

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

2. Anchor lugs and curtain walls shall be formed to be continuous with the channel lining.

3. Traverse joints for crack control should be provided at approximately 6 meter (20-foot) intervals and when more than 45 minutes elapses between consecutive concrete placements. All sections should be at least 2 meters (6 feet) long. Crack control joints may be formed by using a 3 millimeter (1/8-inch) thick removable template, by scoring or sawing to a depth of at least 20 millimeters (3/4 inch) or by an approved "leave-in" type insert.

Maintenance

Prior to permanent stabilization of the slope, the structure should be inspected after each rainfall. Damages to the slope, flume or outlet area must be repaired immediately. After the slope is stabilized, the structure should be inspected to ensure continued adequate functioning (see potential problems noted in Planning Considerations).

BMP: STORMWATER CONVEYANCE CHANNEL

Definition

A permanent, designed waterway, shaped, sized, and lined with appropriate vegetation or structural material used to safely convey stormwater runoff within or away from a developing area.

Purpose

To provide for the conveyance of concentrated surface runoff water to a receiving channel or system without damage from erosion.

Conditions Where Practice Applies

Generally applicable to man-made channels, including roadside ditches and intermittent natural channels, that are constructed or are modified to accommodate flows generated by land development. The implementation of this control should come only after a channel adequacy analysis for capacity and velocity has been performed. The measure should be installed and stabilized prior to the introduction of post-development flows. This practice is not generally applicable to continuous flowing natural streams. Major streams need full design considerations and calculations. Provisions for protecting the banks of such streams are described in VEGETATIVE STREAMBANK STABILIZATION, BMP-22 and STRUCTURAL STREAMBANK STABILIZATION, BMP-23.

Planning Considerations

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

Besides the primary design considerations of capacity and velocity, a number of other important factors should be taken into account when selecting a cross-section and lining. These factors include land availability, compatibility with land use and surrounding environment, safety, maintenance requirements, outlet conditions, and soil erodibility factor. If the riprap design is chosen, filter fabric must be used to act as a separator and stabilizer between the stone and the earth.

Cross-section design-

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

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

Trapezoidal channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity. Trapezoidal ditches are generally lined with concrete or riprap.

Outlet design-

Outlet conditions for all channels must be considered. This is particularly important for the transition from a man-made lining, such as concrete and riprap, to a vegetated or nonvegetated lining. Appropriate measures must be taken to dissipate the energy of the flow to prevent scour of the receiving channel. (See OUTLET PROTECTION, BMP-18).

Capacity-

All channels shall be designed in accordance with accepted engineering practices. If channel modifications are necessary, the capacity of the channel must be sufficient to convey the 10-year frequency design storm (24-hour duration) without overtopping the banks. If predevelopment flooding problems exist, the consequences of flooding are severe, or drainage systems which convey larger storms converge with the channel in question, consideration should be given to increasing the capacity beyond the 10-year frequency storm capacity.

Velocity-

Channels should be designed so that the velocity of flow expected from a 2-year frequency storm shall not exceed the permissible velocity for the type of lining used.

While concrete-lined channels can usually be smaller than grass-lined channels, the increased velocity will produce more erosion and flooding downstream.

Grass-lined channels provide good protection against erosion, while they provide an aesthetic setting for conveyance of runoff. However, the velocities that grass linings can handle are much lower than those which can be withstood by riprap or concrete-lined channels. For grass linings, the type of vegetation chosen shall be appropriate for the site conditions: i.e., drainage tolerance, shade tolerance, maintenance requirements, etc. (See PERMANENT SEEDING, BMP-32 and SODDING, BMP-33). Where there will be a base flow in grass-lined channels, a stone center, a subsurface drain, or other suitable means to handle the base flow shall be provided. Refer to RIPRAP, BMP-19 to choose the correct stone size and for filter fabric specifications. Permissible velocities for grass-lined channels are shown in Table 17-1.

Riprap-lined channels can be designed to withstand most flow velocities by choosing a stable stone size. The procedures for selecting a stable stone size for channels and installation is contained in BMP-19, RIPRAP. All riprap must be installed with a <u>filter fabric or gravel (granular) underlining</u>. Transition from a riprap lining to grass and earth linings must be carefully designed to meet the allowable velocities of each type of lining.

Concrete-lined channels are not usually limited in the velocity they can carry; however, it should be kept in mind that the flow velocity at the outlet of the paved section must not exceed the permissible velocity of the receiving channel. See OUTLET PROTECTION, BMP-18.

Depth-

The design water surface elevation of a channel receiving water from diversions or other tributary channels shall be equal to or less than the design water surface elevation of the diversion or other tributary channel at the point of intersection.

The top width of parabolic and vee-shaped, grass-lined channels shall not exceed 9 meters (30 feet), and the bottom width of trapezoidal, grass-lined channels shall not exceed 5 meters (15 feet) unless multiple or divided waterways, riprap center, or other means are provided to control meandering of low flows.

TABLE 17-1: PERMISSIBLE VELOCITIES FOR GRASS LINED CHANNELS

CHANNEL SLOPE	LINING	PERMISSIBLE VELOCITY*
0 - 5%	Bermudagrass	2 meters/sec (6 ft./sec)
	Reed canarygrass Tall fescue Kentucky bluegrass	1.5 meters/sec (5 ft./sec)
	Grass-legume mixture	1.2 meters/sec (4 ft./sec)
	Red fescue Redtop Sericea lespedeza Annual lespedeza Small grains (temporary)	0.75 meters/sec (2.5 ft./sec)
5 - 10 %	Bermudagrass	1.5 meters/sec (5 ft./sec)
	Reed canarygrass Tall fescue Kentucky bluegrass	1.2 meters/sec (4 ft./sec)
	Grass-legume misture	1 meter/sec (3 ft./sec)
Greater than 10%	Bermudagrass	1.2 meters/sec (4 ft./sec)
	Reed canarygrass Tall fescue Kentucky bluegrass	1 meter/sec (3 ft./sec)

* for highly erodible soils, permissible velocities should be decreased by 25%. An erodibility factor (K) greater than 0.35 would indicate a highly erodible soil.

Outlet-

The outlets of all channels shall be protected from erosion (see OUTLET PROTECTION, BMP-18).

Construction Specifications

General-

1. All trees, brush, stumps, roots, obstructions and other unsuitable material shall be removed and disposed of properly.

2. The channel shall be excavated or shaped to the proper grade and cross-section.

3. Any fills shall be well compacted to prevent unequal settlement.

4. Any excess soil shall be removed and disposed of properly.

Grass-lined Channels-

The method used to establish grass in the ditch or channel will depend upon the severity of the conditions encountered. The methods available for grass establishment are set forth in PERMANENT SEEDINGS, BMP-32 and SODDING, BMP-33.

Riprap-lined Channels-

Riprap shall be installed in accordance with RIPRAP, BMP-19.

Concrete-lined Channels-

Concrete-lined channels must be constructed in accordance with all acceptable engineering specifications. The following items highlight those specifications:

1. The subgrade should be moist at the time the concrete is poured.

2. Traverse joints for crack control should be provided at approximately 6 meter (20-foot) intervals and when more than 45 minutes elapses between consecutive concrete placements. All sections should be at least 2 meters (6 feet) long. Crack control joints may be formed by using a 3 millimeter (1/8-inch) thick removable template, by scoring or sawing to a depth of at least 20 millimeters (3/4 inch) or by an approved "leave-in" type insert.

3. Expansion joints shall be installed every 30 meters (100 feet).

Maintenance

Grass-lined Channels-

During the initial establishment, grass-lined channels should be repaired immediately and grass re-established if necessary. After grass has become established, the channel should be checked periodically to determine if the grass is withstanding flow velocities without damage. If the channel is to be mowed, it should be done in a manner that will not damage the grass.

Riprap-lined Channels-

Riprap-lined channels should be checked periodically to ensure that scour is not occurring beneath fabric underlining of the riprap layer. The channel should also be checked to determine that the stones are not dislodged by large flows.

Concrete-lined Channels-

Concrete-lined channels should be checked periodically to ensure that there is no undermining of the channel. Particular attention should be paid to the outlet of the channel. If scour is occurring at the outlet, appropriate outlet protection shall be installed. See OUTLET PROTECTION, BMP-18.

Sediment Deposition-

If the channel is below a high sediment-producing area, sediment should be trapped before it enters the channel. Field experience has demonstrated that many newly constructed conveyance channels become damaged and require costly repairs as a result of improper upslope controls. If sediment is deposited in a grass-lined channel, it should be removed promptly to prevent damage to the grass. Sediment deposited in riprap and concrete-lined channels should be removed when it reduces the capacity of the channel.

BMP: OUTLET PROTECTION

Definition

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

Purpose

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

Conditions Where Practice Applies

Applicable to the outlets of all pipes and engineered channel sections.

Planning Considerations

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

The most commonly used device for outlet protection is a structurally lined apron. These aprons are generally lined with riprap, grouted riprap or concrete. They are constructed at a zero grade for a distance which is related to the outlet flow rate and the tailwater level.

Where flow is excessive for the economical use of an apron, excavated stilling basins may be used.

Design Criteria

The design of structurally lined aprons at the outlets of pipes and paved channel sections applies to the immediate area or reach below the pipe or channel and does not apply to continuous rock linings of channels or streams (See STORMWATER CONVEYANCE CHANNEL, BMP-17). Notably, pipe or channel outlets at the top of cut slopes or on slopes steeper than 10% should not be protected using just outlet protection as a result of the reconcentration and large velocity of flow encountered as the flow leaves the structural apron. Outlet protection shall be designed according to the following criteria:

Pipe Outlets (See Figure 18-1)-

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

2. Apron length: The apron length shall be determined from the curves according to the tailwater condition:

   Minimum Tailwater - Use Figure 18-2
   Maximum Tailwater - Use Figure 18-3

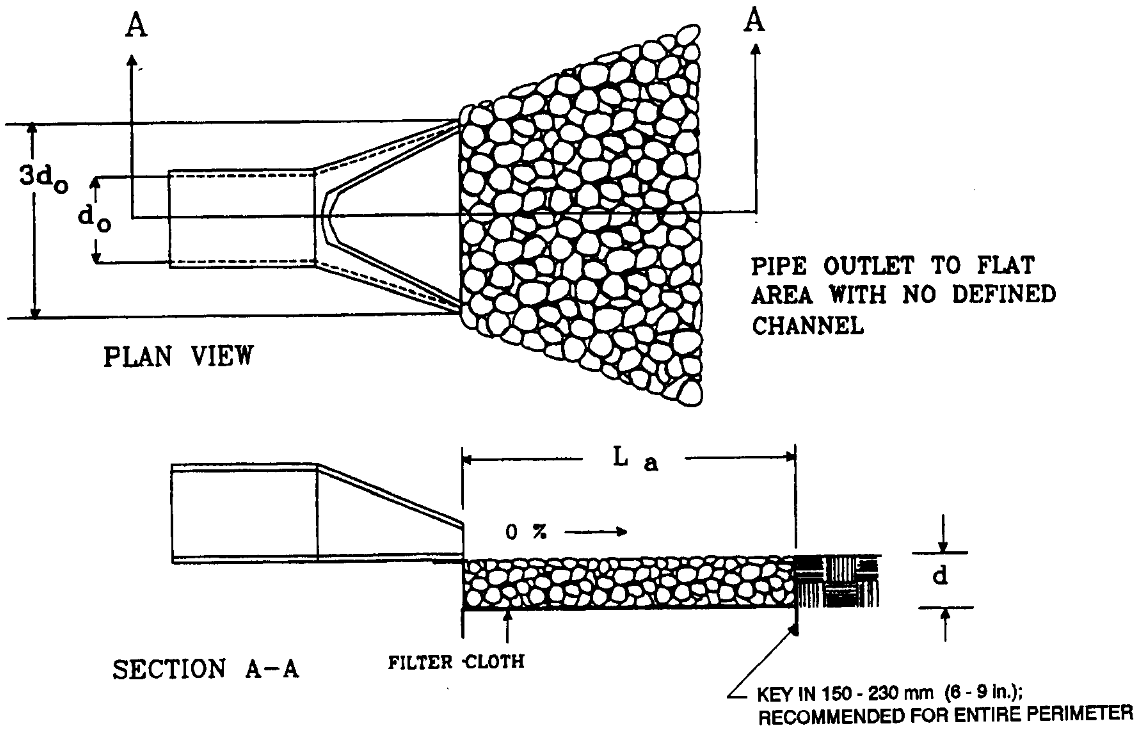
3. Apron width: When the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation 0.3 meters (1 foot) above the maximum tailwater depth or to the top of the bank (whichever is less).

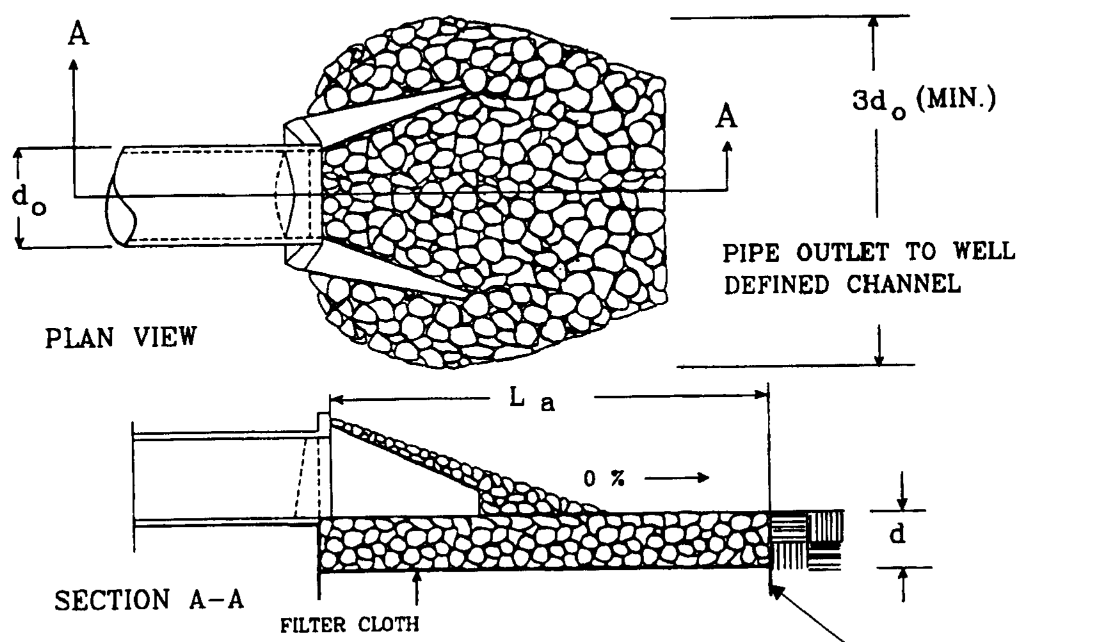
   If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

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

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

FIGURE 18-1: PIPE OUTLET CONDITIONS

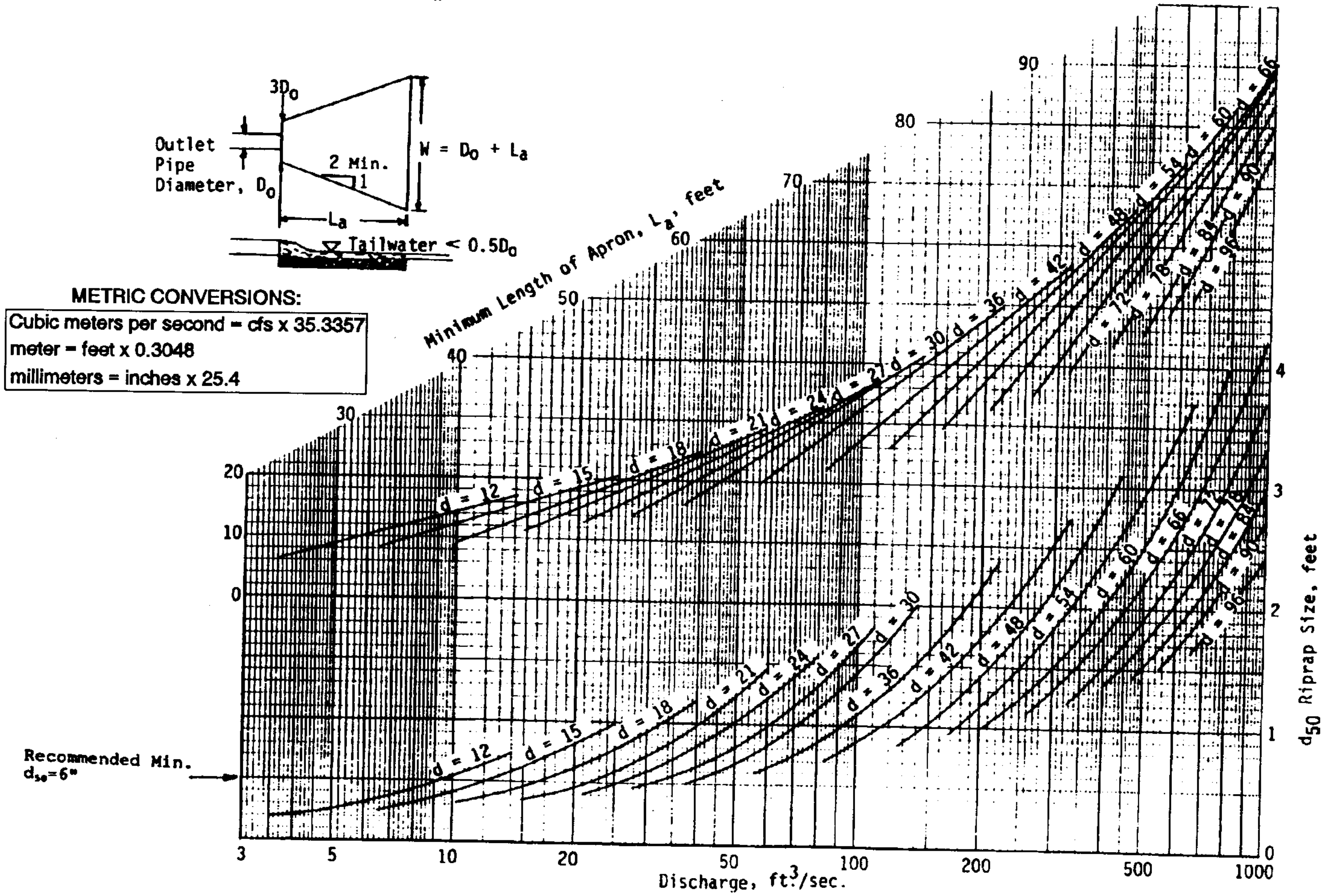




NOTES:
1. APRON LINING MAY BE RIPRAP, GROUTED RIPRAP, GABION BASKET, OR CONCRETE.
2. La IS THE LENGTH OF THE RIPRAP APRON AS CALCULATED USING PLATES 3.18–3 AND 3.18–4.
3. d = 1.5 TIMES THE MAXIMUM STONE DIAMETER, BUT NOT LESS THAN 150 mm (6 in.).

FIGURE 18-2

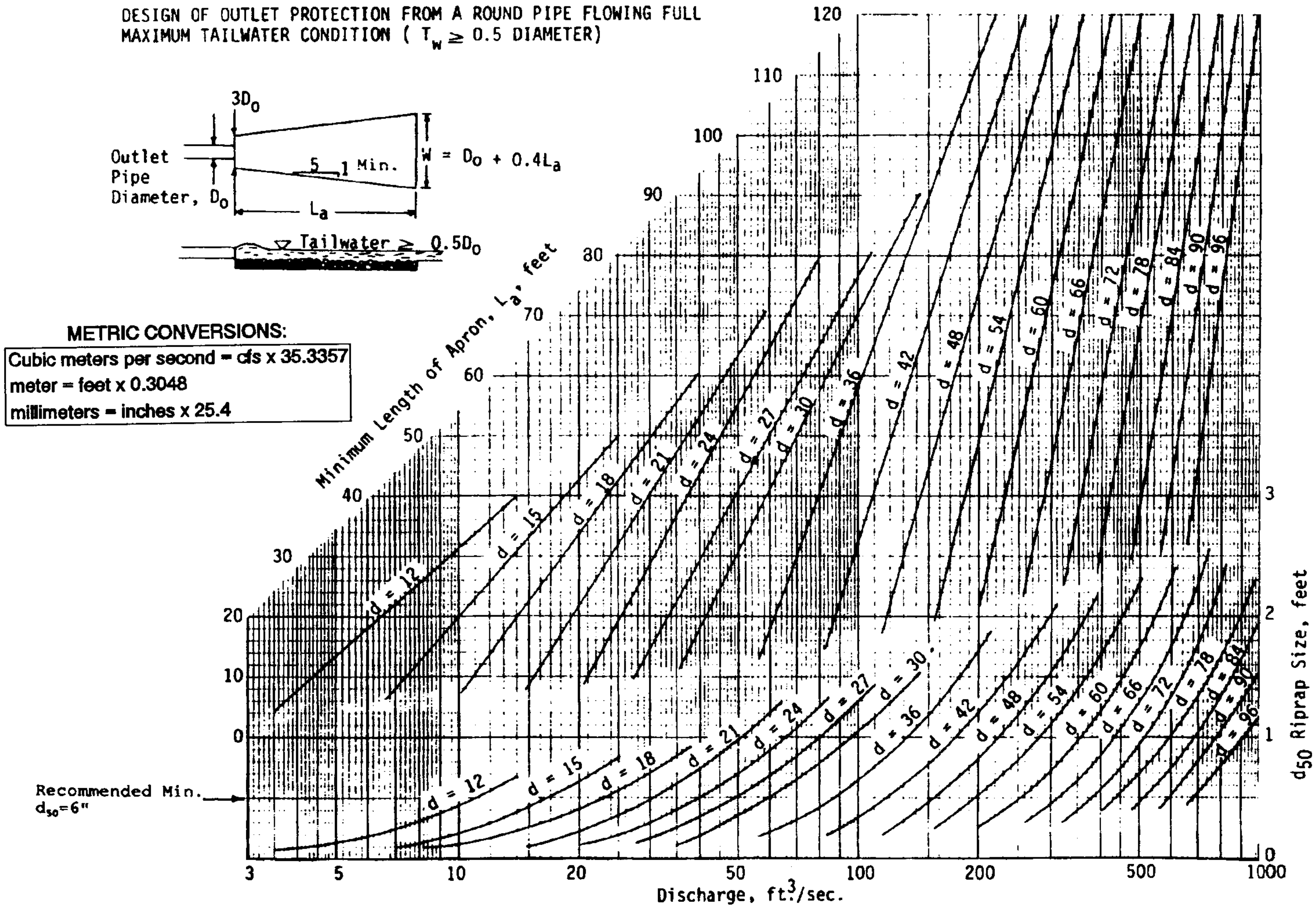
DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL
MINIMUM TAILWATER CONDITION (T_w < 0.5 DIAMETER)



METRIC CONVERSIONS:

Cubic meters per second = cfs x 35.3357
meter = feet x 0.3048
millimeters = inches x 25.4

FIGURE 18-3



DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL
MAXIMUM TAILWATER CONDITION ($T_w \geq 0.5$ DIAMETER)
$3D_o$
Outlet Pipe Diameter, D_o
5 1 Min.
$W = D_o + 0.4L_a$
L_a
Tailwater $\geq 0.5D_o$
METRIC CONVERSIONS:
Cubic meters per second = cfs x 35.3357
meter = feet x 0.3048
millimeters = inches x 25.4
Minimum Length of Apron, L_a, feet
Recommended Min. d_{50}=6"
Discharge, ft^3/sec.
d_{50} Riprap Size, feet
d = 12
d = 15
d = 18
d = 21
d = 24
d = 27
d = 30
d = 36
d = 42
d = 48
d = 54
d = 60
d = 66
d = 72
d = 78
d = 84
d = 90
d = 96

c. For a Maximum Tailwater Condition, the downstream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron.

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

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

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

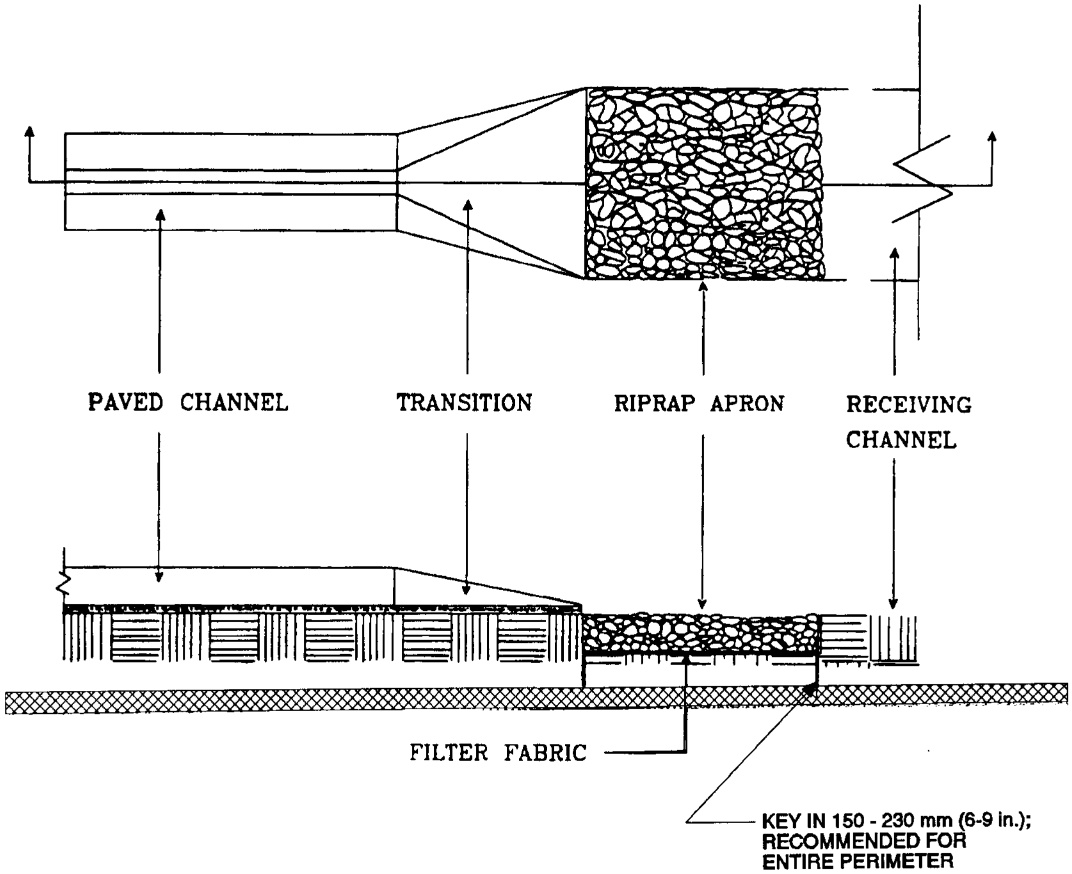
7. Materials: The apron may be lined with riprap, grouted riprap, concrete, or gabion baskets. The median sized stone for riprap shall be determined from the curves in Figures 18-3 and 18-4, according to the tailwater condition. The gradation, quality and placement of riprap shall conform to BMP-19, RIPRAP.

8. Filter cloth: In all cases, filter cloth shall be placed between the riprap and the underlying soil to prevent soil movement into and through the riprap. The material must meet or exceed the physical properties for filter cloth found in BMP-19, RIPRAP. See Figure 18-1 for orientation details.

Paved Channel Outlets (See Figure 18-4) -

1. The flow velocity at the outlet of paved channels flowing at design capacity must not exceed the permissible velocity of the receiving channel (see Tables 18-1 and 18-2).

FIGURE 18-4: PAVED CHANNEL OUTLET



NOTES:

1. RIPRAP APRON REDUCES THE FLOW VELOCITY BELOW THE PERMISSIBLE VELOCITY OF THE NATURAL RECEIVING CHANNEL.
2. TRANSITION SIDE DIVERGENCE IS 1 IN 3F, WHERE

$$F = \text{FROUDE NUMBER} = \frac{V}{\sqrt{gd}} \quad \text{WHERE}$$

V = VELOCITY AT THE BEGINING OF THE TRANSITION

d = DEPTH OF FLOW AT THE BEGINING OF THE TRANSITION

g = 9.82 m/sec^2 (32.2 ft/sec^2)

2. The end of the paved channel shall merge smoothly with the receiving channel section. There shall be no overfall at the end of the paved section. Where the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a transition section shall be provided. The maximum side divergence of the transition shall be 1 in 3F where;

$$F=\frac{V}{\sqrt{gd}}$$

where,

F	=	Froude number
V	=	Velocity at beginning of transition, meters/sec (feet/sec)
d	=	depth of flow at beginning of transition, meters (feet)
9	=	9.82 meters/sec.^{2} (32.2 feet/sec.^{2})

3. Bends or curves in the horizontal alignment at the transition are not allowed unless the Froude number (F) is 1.0 or less, or the section is specifically designed for turbulent flow.

BMP: RIPRAP

Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone with filter fabric or granular underlining.

Purposes

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

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

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

Conditions Where Practice Applies

Wherever soil and water interface and the soil conditions, water turbulence and velocity, expected vegetative cover, etc., are such that the soil may erode under the design flow conditions. Riprap may be used, as appropriate, at stormdrain outlets, on channel banks and/or bottoms, roadside ditches, drop structures, at the toe of slopes, as transition from concrete channels to vegetated channels, etc.

Planning

Graded vs. Uniform Riprap-

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

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

Riprap sizes can be designed by either the diameter or the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be angular instead of spherical. However, it is simpler to specify the diameter of an equivalent size of spherical stone. Table 19-1 lists some typical stones by weight, spherical diameter and the corresponding rectangular dimensions. These stone sizes are based upon an assumed specific weight of 2,645 kg/m^3 (165 lbs./ft^3).

Since graded riprap consists of a variety of stone sizes, a method is needed to specify the size range of the mixture of stone. This is done by specifying a diameter of stone in the mixture for which some percentage, by weight, will be smaller. For example, d_{85} refers to a mixture of stones in which 85% of the stone by weight would be smaller than the diameter specified. Most designs are based on d_{50}. In other words, the design is based on the average size of stone in the mixture. Table 19-2 lists classes of standard graded riprap sizes by diameter and weight of the stone.

TABLE 19-1
SIZE OF RIPRAP STONES

Weight		Mean Spherical Diameter		Angular Length		Shape: Width, Height	
Kg	lbs	m	ft	m	ft	m	ft
20	50	0.2	0.8	0.4	1.4	0.1	0.5
45	100	0.3	1.1	0.5	1.8	0.2	0.6
70	150	0.4	1.3	0.6	2.0	0.2	0.7
135	300	0.5	1.6	0.8	2.6	0.3	0.9
225	500	0.6	1.9	0.9	3.0	0.3	1.0
455	1000	0.7	2.2	1.1	3.7	0.4	1.2
680	1500	0.8	2.6	1.4	4.7	0.5	1.5
910	2000	0.9	2.8	1.6	5.4	0.5	1.8
1815	4000	1.1	3.6	1.8	6.0	0.6	2.0
2725	6000	1.2	4.0	2.1	6.9	0.7	2.3
3630	8000	1.4	4.5	2.3	7.6	0.8	2.5
9080	20000	1.8	6.1	3.0	10.0	1.0	3.3

To ensure that stone of substantial <u>weight</u> is used when implementing riprap structures, specified weight ranges for individual stones and composition requirements should be followed. Such guidelines will help to prevent inadequate stone from being used in construction of the measures and will promote more consistent stone classification statewide. Table 19-3 notes these requirements.

Sequence of Construction-

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

Design Criteria

Gradation-

The riprap shall be composed of a well-graded mixture down to the 25 millimeter (1-inch) size particle such that 50% of the mixture by weight shall be larger than the d_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size.

TABLE 19-2
GRADED RIPRAP - DESIGN VALUES

Riprap Class	D_{15} Weight		Mean D_{15} Spherical Diameter		Mean D_{50} Spherical Diameter	
	Kg	lbs	m	ft	m	ft
Class AI	11	25	0.2	0.7	0.3	0.9
Class I	23	50	0.2	0.8	0.3	1.1
Class II	68	150	0.4	1.3	0.5	1.6
Class III	227	500	0.6	1.9	0.7	2.2
Type I	680	1,500	0.8	2.6	0.9	2.8
Type II	2,725	6,000	1.2	4.0	1.4	4.5

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

Thickness-

The minimum thickness of the riprap layer shall be 2 times the maximum stone diameter, but not less than 150 millimeters (6 inches).

Quality of Stone-

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

Rubble concrete may be used provided it has a density of at least 2,400 kilograms per cubic meter (150 pounds per cubic foot), and otherwise meets the requirement of this Best Management Practice.

TABLE 19-3
GRADED RIPRAP - WEIGHT ANALYSIS

Riprap Class/Type	Weight Range*	Requirements for Stone Mixture
Class AI	11-34 kg (25-75 lbs)	Max. 10% > 34 kg (Max. 10% > 75 lbs)
Class I	23-68 kg (50-150 lbs)	60% > 45 kg (60% > 100 lbs)
Class II	68-227 kg (150-500 lbs)	50% > 136 kg (50% > 300 lbs)
Class III	227- 681 kg (500-1,500 lbs)	50% > 409 kg (50% > 900 lbs)
Type I	681-1,816 kg (1,500-4,000 lbs)	Av. wt. = 908 kg (Av. wt. = 2,000 lbs.)
Type II	2,724- 9,080 kg (6,000-20,000 lbs)	Av. wt. = 3,632 kg (Av. wt. = 8,000 lbs.)
*In all classes/types of riprap, a maximum 10% of the stone in the mixture may weigh less than the lower end of the range.		

Filter Fabric Underlining-

A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. Table 19-4 notes the minimum physical properties of the filter fabric.

Filter fabric shall not be used on slopes greater than 1.5:1 as slippage may occur and should be used in conjunction with a layer of course aggregate (granular filter blanket is described below) when the riprap to be placed is Class II or larger.

Granular Filter-

Although the filter cloth underlining or bedding is the preferred method of installation, a granular (stone) bedding is a viable option when the following relationship exists:

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

and,

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

In these relationships, filter refers to the overlying material and base refers to the underlying material. The relationships must hold between the filter material and the base material and between the riprap and the filter material. In some cases, more than one layer of filter material may be needed. Each layer of filter material should be approximately 150 millimeters (6-inches) thick.

Riprap at Outlets-

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structure are contained in OUTLET PROTECTION (BMP-18). A filter fabric underlining is required for riprap used as outlet protection.

TABLE 19-4
REQUIREMENTS FOR FILTER FABRIC USED WITH RIPRAP

Physical Property	Test Method	Requirements
Equivalent Opening Size	Corps of Engineers CWO 2215-77	Equal or greater than U.S. No. 50 sieve
Tensile Strength* @ 20% (maximum) in.)	VTM-52	0.5 kg/linear millimeter (30 lbs./linear minimum
Puncture Strength	ASTM D751*	36 kg (80 lbs) (minimum)

* Tension testing machine with ring clamp, steel ball replaced with 7.9 millimeter (5/16 inch) diameter solid steel cylinder with hemispherical tip centered within the ring clamp.

Seams shall be equal in strength to basic material.

Additional fabric material or non-corrosive steel wire may be incorporated into the fabric to increase overall strength.

Riprap for Channel Stabilization-

Riprap for channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized. This method establishes the stability of the rock material relative to the forces exerted upon it.

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

The riprap size to be used in a channel bend shall extend upstream from the point of curvature and downstream from the bottom of the channel to a minimum depth equal to the thickness of the blanket and shall extend across the bottom of the channel the same distance (see Figure 19-1).

Freeboard and Height of Bank-

For riprapped and other lined channels, the height of channel lining above the water surface should be based on the size of the channel, the flow velocity, the curvature, inflows, wind action, flow regulation, etc.

The height of the bank above the water surface varies in a similar manner, depending on the above factors plus the type of soil.

Figure 19-2 is based on information developed by the U.S. Bureau of Reclamation for average freeboard and bank height in relation to channel capacity. This chart should be used by the designer to obtain a minimum freeboard for placement of riprap and top of bank.

Riprap for Slope Stabilization-

Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is greater than the gradient of the slope being stabilized (see Figure 19-3).

Riprap for Lakes and Ponds Subject to Wave Action-

Riprap used for shoreline protection on lakes and ponds may be subject to wave action. The waves affecting the shoreline may be wind-driven or created by boat wakes.

Riprap for Installations Subject to Tidal and Wave Action-

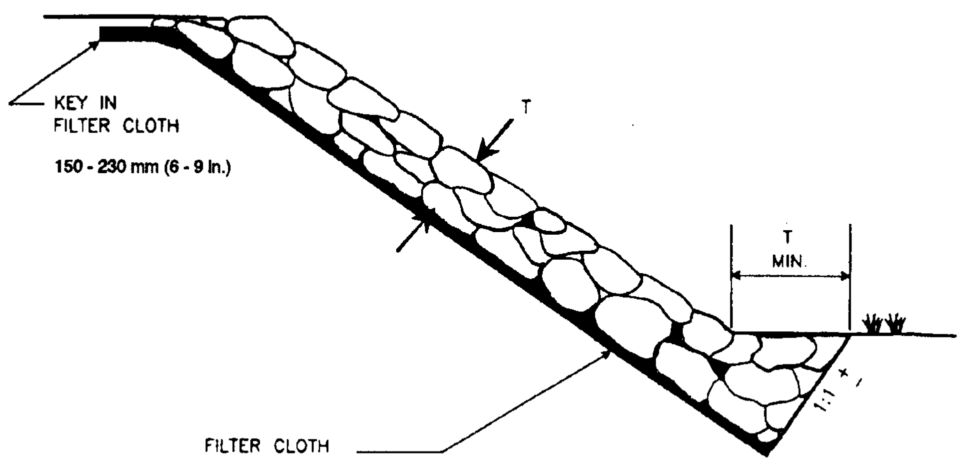
A riprap design for shoreline protection in tidal areas must meet all applicable state and federal requirements and should be carried out by a qualified professional.

Construction Specifications

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

FIGURE 19-1: TOE REQUIREMENTS FOR BANK STABILIZATION

FILTER CLOTH UNDERLINER (PREFERRED)



GRANULAR FILTER

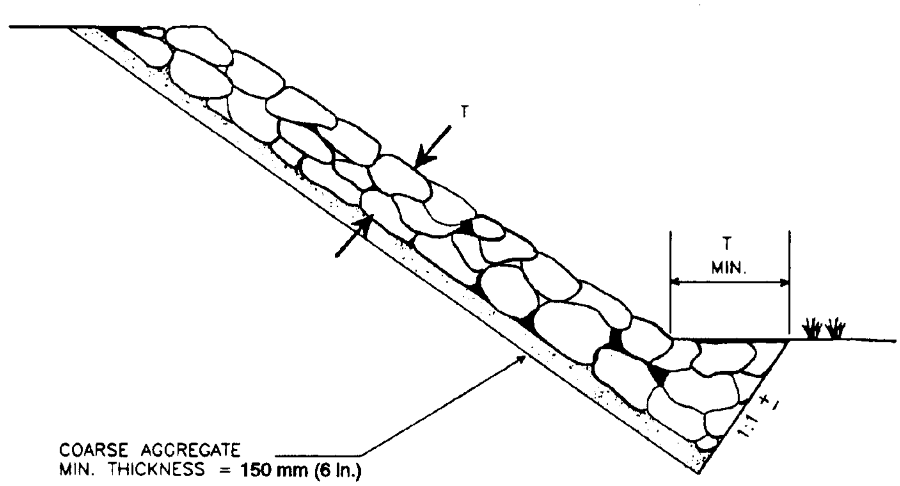
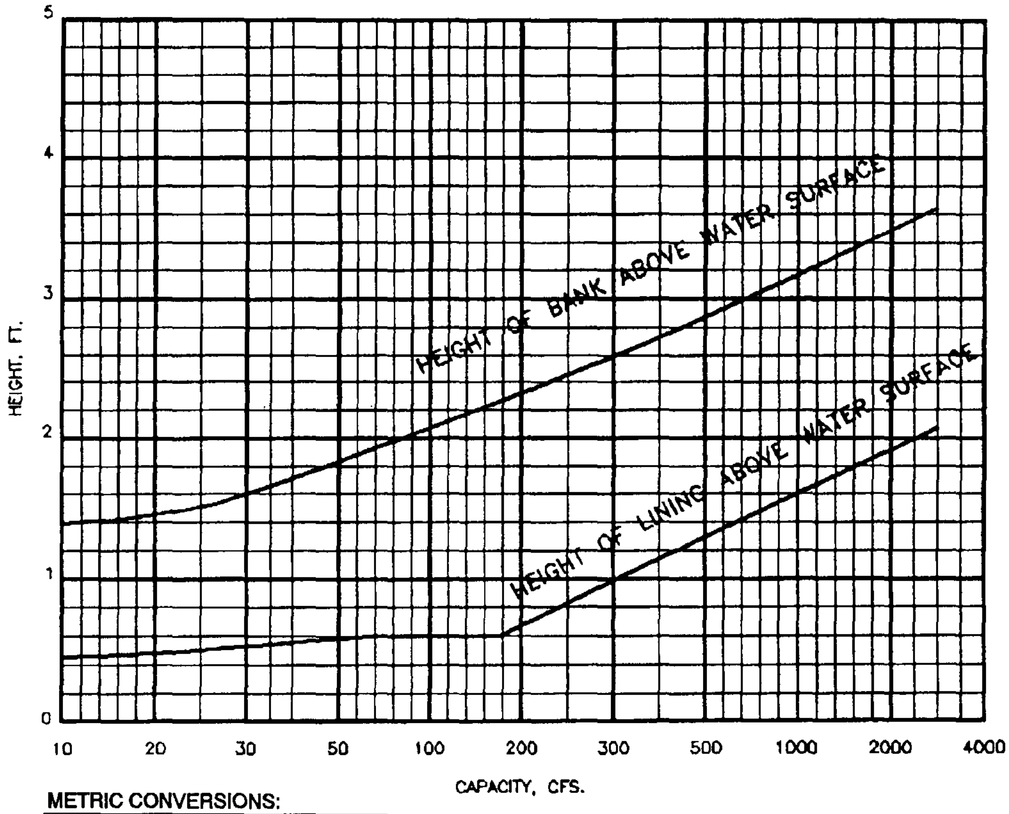


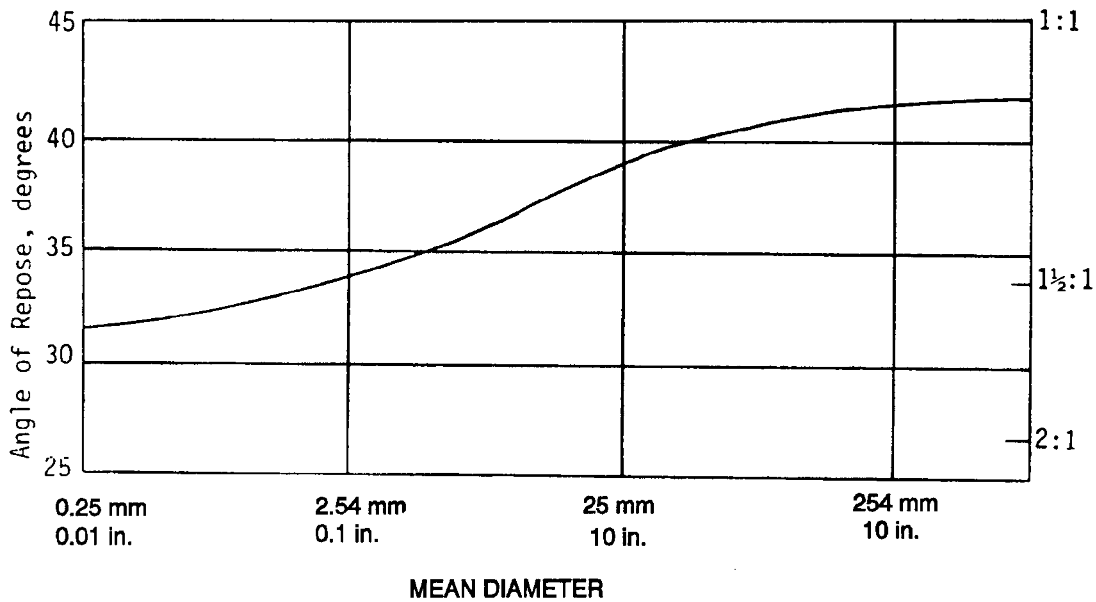
FIGURE 19-2: RECOMMENDED FREEBOARD AND HEIGHT OF BANK OF LINED CHANNELS



METRIC CONVERSIONS:

Cubic meters per second = cfs x 35.3357
meter = feet x 0.3048
millimeters = inches x 25.4

FIGURE 19-3: ANGLE OF REPOSE FOR RIPRAP STONES



Filter Fabric or Granular Filter: Placement of the filter fabric should be done immediately after slope preparation. For granular filters, the stone should be spread in a uniform layer to the specified depth, normally 150 millimeters (6 inches). Where more than one layer of filter material is used, the layer should be spread so that there is minimal mixing of the layers.

When installing geotextile filter cloths, the cloth should be placed directly on the prepared slope. The edges of the sheets should overlap by at least 300 millimeters (12 inches). Anchor pins, 400 millimeters (15 inches) long, should be spaced every meter (3 feet) along the overlap. The upper and lower ends of the cloth should be buried at least 300 millimeters. Care should be taken not to damage the cloth when placing the riprap. If damage occurs, that sheet should be removed and replaced. For large stone (Class II or greater), a 150 millimeter (6-inch) layer of granular filter will be necessary to prevent damage to the cloth.

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

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

Maintenance

Once a riprap installation has been completed, it should require very little maintenance. It should, however, be inspected periodically to determine if high flows have caused scour beneath the riprap or filter fabric or dislodged any of the stone. Care must be taken to properly control sediment-laden construction runoff which may drain to the point of the new installation. If repairs are needed, they should be accomplished immediately.

BMP: ROCK CHECK DAMS

Definition

Small temporary stone dams constructed across a swale or drainage ditch.

Purpose

To reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps sediment generated from adjacent areas or the ditch itself, mainly by ponding of the stormwater runoff. Field experience has shown it to perform more effectively than silt fences or straw bales in the effort to stabilize "wet-weather" ditches.

Conditions Where Practice Applies

This practice, utilizing a combination of stone sizes, is limited to use in small open channels which drain 4 hectares (10 acres) or less. It should not be used in a live stream as the objective should be to protect the live watercourse. Some specific applications include:

1. Temporary ditches or swales which, because of their short length of service, cannot receive a non-erodible lining but still need protection to reduce erosion.

2. Permanent ditches or swales which, for some reason, cannot receive a permanent non-erodible lining for an extended period of time.

3. Either temporary or permanent ditches or swales which need protection during the establishment of grass linings.

4. An <u>aid</u> in the sediment trapping strategy for a construction site. This practice <u>is not a substitute</u> for major perimeter trapping measures such as a SEDIMENT TRAP (BMP-13) or a SEDIMENT BASIN (BMP-14).

Planning Considerations

Check dams are effective in reducing flow velocity and thereby the potential for channel erosion. It is usually better to establish a protective vegetative lining before flow is confined or to install a structural channel lining than to install check dams. However, under circumstances where this is not feasible, check dams are useful.

Check dams installed in grass-lined channels may kill the vegetative lining if submergence after rains is too long and/or silting is excessive.

If check dams are used in grass-lined channels which will be mowed, care should be taken to remove all the stone when the dam is removed. This should include any stone which has washed downstream.

As previously mentioned, they have been found to be an effective aid in trapping sediment particles by virtue of their ability to pond runoff.

Specifications

No formal design is required for a check dam; however, the following criteria should be adhered to when specifying check dams:

1. The drainage area of the ditch or swale being protected shall not exceed 8,000 square meters (2 acres) when coarse aggregate is used alone and shall not exceed 40,500 square meters (10 acres) when a combination of Class I Riprap (added for stability) and coarse aggregate is used. Refer to Figure 20-1 for orientation of stone and a cross-sectional view of the measure. An effort should be made to extend the stone to the top of channel banks.

2. The maximum height of the dam shall be 1 meter (3 feet).

3. The center of the check dam must be at least 150 millimeters (6 inches) lower than the outer edges. Field experience has shown that many dams are not constructed to promote this "weir" effect. Stormwater flows are then forced to the stone-soil interface, thereby promoting scour at that point and subsequent failure of the structure to perform its intended function.

4. For added stability, the base of the check dam can be keyed into the soil approximately 150 millimeters (6 inches).

5. The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

6. Stone should be placed according to the configuration in Figure 20-1. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.

7. Filter cloth may be used under the stone to provide a stable foundation and to facilitate the removal of the stone. See BMP-19, RIPRAP, for required physical properties of the filter cloth.

Sediment Removal

Sediment should be removed from behind the check dams when it has accumulated to one half of the original height of the dam.

Removal of Practice

Unless they will be incorporated into a permanent stormwater management control, check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when they are no longer needed. In permanent structures, check dams should be removed when a permanent lining can be installed. In the case of grass-lined ditches, check dams should be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams should be seeded and mulched immediately after they are removed. The use of filter cloth underneath the stone will make the removal of the stone easier.

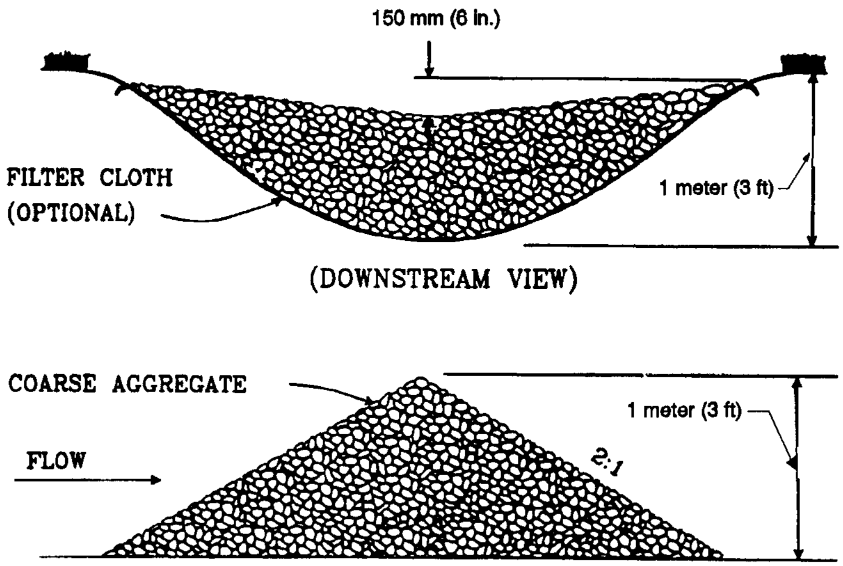
Maintenance

Check dams should be checked for sediment accumulation after each runoff-producing storm event. Sediment should be removed when it reaches one half of the original height of the measure.

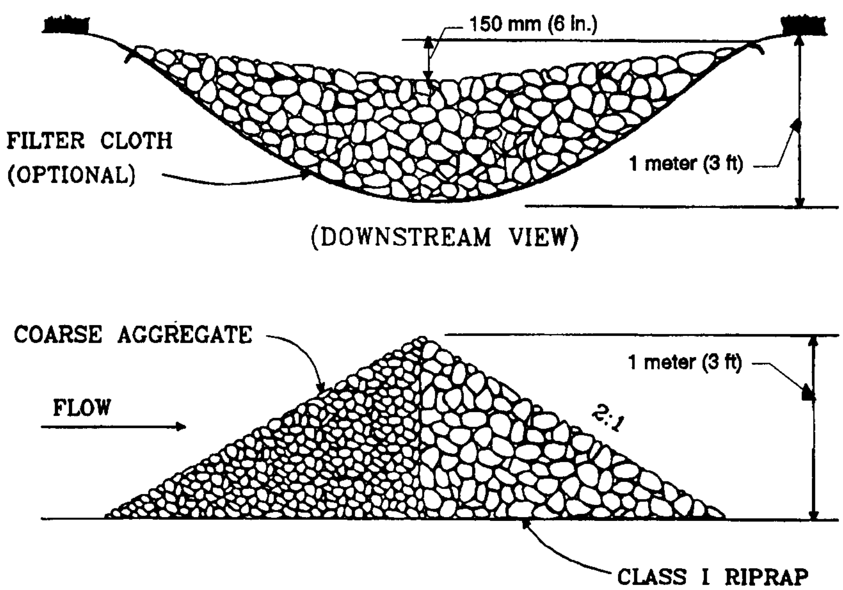
Regular inspections should be made to insure that the center of the dam is lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.

FIGURE 20-1: ROCK CHECK DAM

8,000 SQUARE METERS (2 ACRES) OR LESS OF DRAINAGE AREA:



8,000 - 40,500 SQUARE METERS OR LESS OF DRAINAGE AREA (2-10 ACRES)



BMP: LEVEL SPREADER

Definition

An outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

Purpose

To convert concentrated runoff to sheet flow and release it uniformly onto areas stabilized by existing vegetation.

Conditions Where Practice Applies

Where there is a need to divert stormwater away from disturbed areas to avoid overstressing erosion control measures; where sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion.

This practice applies only in those situations where the spreader can be constructed on undisturbed soil and the area below the level lip is uniform with a slope of 10% or less and is stabilized by natural vegetation. The runoff water should not be allowed to reconcentrate after release unless it occurs during interception by another measure (such as a permanent pond or detention basin) located below the level spreader.

Planning Considerations

The TEMPORARY DIVERSION DIKE, (BMP-9) and the TEMPORARY RIGHT-OF-WAY DIVERSION, (BMP-11) each call for a stable outlet for concentrated stormwater flows. The level spreader is a relatively low-cost structure to release small volumes of concentrated flow where site conditions are suitable.

The outlet area must be uniform and well-vegetated with slopes 10% or less. Particular care must be taken to construct the outlet lip completely level in a stable, undisturbed soil. Any depressions in the lip will concentrate the flow, resulting in erosion. Under higher design flow conditions, a rigid outlet lip design should be used to create the desired sheet flow conditions. Runoff water containing high sediment loads must be treated in a sediment trapping device before being released to a level spreader.

Design Criteria

No formal design is required. The following criteria must be met:

Spreader Dimensions-

Determine the capacity of the spreader by estimating the peak flow expected from a 10-year storm (Q_{10}).

Select the appropriate length, width and depth of the spreader from Table 21-1.

For design flows greater than 0.6 cubic meters per second (20 cfs), the measure should be designed by a qualified engineer.

A 6 meter (20-foot) transition section should be formed in the diversion channel so that the width of the diversion will smoothly tie in with the width of the spreader to ensure more uniform outflow.

The depth of the level spreader, as measured from the lip, shall be at least 155 millimeters (6 inches). The depth may be made greater to increase temporary storage capacity, improve trapping of debris and to enhance settling of any suspended solids.

TABLE 21-1
MINIMUM DIMENSIONS FOR LEVEL SPREADER

Design Flow Q_{10}		Depth		Width of Lower Side Slope of Spreader		Length	
m^3/sec	cfs	m	ft	m	ft	m	ft
0-0.3	0-10	0.15	0.5	1.8	6	3	10
0.3-0.6	10-20	0.18	0.6	1.8	6	6	20

Grade-

1. The grade of the channel for the last 6 meters (20 feet) of the dike or diversion entering the level spreader shall be less than or equal to 1%.

2. The grade of the level spreader channel shall be 0%.

Spreader Lip-

The release of the stormwater will be over the level lip onto an undisturbed well-vegetated area with a maximum slope of 10%. The level lip should be of uniform height and zero grade over the length of the spreader.

The level spreader lip may be stabilized by vegetation or may be of a rigid non-erodible material depending on the expected design flow:

	Design Flow	
Spreader lip	m^3/sec	(cfs)
Vegetated	0 - 0.1	0 - 4
Rigid	0.1 - 0.6	5 - 20

A vegetated level lip must be constructed with an erosion-resistant material, such as jute or excelsior blankets, to inhibit erosion and allow vegetation to become established.

For higher design flows and permanent installations, a rigid lip of non-erodible material, such as pressure-treated timbers or concrete curbing, should be used.

Construction Specifications

1. Level spreaders must be constructed on undisturbed soil (not fill material).

2. The entrance to the spreader must be shaped in such a manner as to insure that runoff enters directly onto the 0% channel.

3. Construct a 6 meter (20-ft) transition section from the diversion channel to blend smoothly to the width and depth of the spreader.

4. The level lip shall be constructed at 0% grade to insure uniform spreading of stormwater runoff.

5. Protective covering for vegetated lip should be a minimum of 1 meter (4 feet) wide extending 150 millimeters (6 inches) over the lip and buried 150 millimeters (6 inches) deep in a vertical trench on the lower edge. The upper edge should butt against smoothly cut sod and be securely held in place with closely spaced heavy duty wire staples.

6. Rigid level lip should be entrenched at least 50 millimeters (2 inches) below existing ground and securely anchored to prevent displacement. An apron of Coarse Aggregate should be placed to top of level lip and extended downslope at least 1 meter (3 feet). Place filter fabric under stone and use galvanized wire mesh to hold stone securely in place.

7. The released runoff must outlet onto undisturbed stabilized areas with slope not exceeding 10%. Slope must be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.

8. Immediately after its construction, appropriately seed and mulch the entire disturbed area of the spreader.

Maintenance

The measure shall be inspected after every rainfall and repairs made, if required. Level spreader lip must remain at 0% slope to allow proper function of measure. The contractor should avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, it shall be repaired immediately.

BMP: VEGETATIVE STREAMBANK STABILIZATION

Definition

The use of vegetation in stabilizing streambanks.

Purpose

To protect streambanks form the erosive forces of flowing water.

Conditions Where Practice Applies

Along banks in creeks, streams and rivers subject to erosion from excess runoff. This practice is generally applicable where bankfull flow velocity does not exceed 1.5 meters per second (5 ft./sec) and soils are erosion resistant. Above 1.5 meters per second, structural measures are generally required. This practice does not apply where tidal conditions exist.

Planning Considerations

A primary cause of stream channel erosion is the increased frequency of bank-full flows which often result from upstream development. Most natural stream channels are formed with a bank-full capacity to pass the runoff from a storm with a 11/2 to 2-year recurrence interval. However, in a typical urbanizing watershed, stream channels are subject to a 3 to 5-fold increase in the frequency of bank-full flows. As a result, stream channels that were once parabolic in shape and covered with vegetation are often transformed into wide rectangular channels with barren banks.

In recent years, a number of structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, if employed correctly, immediately insure a satisfactory protection of the banks. However, many such structures are expensive to build and to maintain and frequently cause downstream velocity problems. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent the re-establishment of native plants and animals, especially when the design is executed according to standard cross-sections which ignore natural variations of the stream system. Very often these structural measures destroy the appearance of the site.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural vegetation is more reliable and effective where the cover consists of natural plant communities which are native to the site. Planting vegetation is less damaging to the environment than installing structures. Vegetation also provides habitat for fish and wildlife and is aesthetically pleasing. Plants provide erosion protection to streambanks by reducing stream velocity, binding soil in place with a root mat and covering the soil surface when high flows tend to flatten vegetation against the banks. For these reasons, vegetation should always be considered first.

One disadvantage of vegetation is that it lowers the carrying capacity of the channel, which may promote flooding. Therefore, maintenance needs and the consequences of flooding should be considered. The erosion potential for the stream needs to be evaluated to determine the' best solutions. The following items should be considered in the evaluation:

1. The frequency of bankfull flow based on anticipated watershed development.

2. The channel slope and flow velocity, by design reaches.

3. The antecedent soil conditions.

4. Present and anticipated channel roughness ("n") values.

5. The location of channel bends along with bank conditions.

6. The location of unstable areas and trouble spots. Steep channel reaches, high erosive banks and sharp bends may require structural stabilization measures such as riprap, while the remainder of the streambank may require only vegetation.

Where streambank stabilization is required and velocities appear too high for the use of vegetation, one should consider structural measures (see BMP-23, STRUCTURAL STREAMBANK STABILIZATION) or the use of permanent erosion control matting (see BMP-36, SOIL STABILIZATION MATTING). Notably, <u>any applicable approval or permits from other state or federal agencies must be obtained prior to working in such areas</u>.

Vegetation Zones Along Watercourses-

At the edge of all natural watercourses, plant communities exist in a characteristic succession of vegetative zones, the boundaries of which are dependent upon site conditions such as the steepness and shape of the bank and the seasonal and local variations in water depth and flow rate. Streambanks commonly exhibit the following zonation:

1. Aquatic Plant Zone - This zone is normally permanently submerged. In Mid-Atlantic states, this zone is inhabited by plants such as pondweeds and water lilies, which reduce the water's flow rate by friction. The roots of these plants help to bind the soil, and they further protect the channel from erosion because the water flow tends to flatten them against the banks and bed of the stream.

2. Reed-Bank Zone - The lower part of this zone is normally submerged for only about half the year. In Mid-Atlantic states, this zone is inhabited by rushes, reed grasses, cattails, and other plants which bind the soil with their roots, rhizomes and shoots and slow the water's flow rate by friction.

3. Shrub Zone - This zone is flooded only during periods of average high water. In Mid-Atlantic states, the shrub zone is inhabited by trees and shrubs--such as willow, alder, dogwood and viburnum--with a high regenerative capacity. These plants hold the soil with their root systems and slow water speed by friction. They also protect tree trunks from damage caused by breaking ice and help to prevent the formation of strong eddies around large trees during flood flows. Shrub zone vegetation is particularly beneficial along the impact bank of a stream meander, where maximum scouring tends to occur. Infringement of shrub vegetation into the channel tends to reduce the channel width, increasing probability of floods. However, brief flooding of riverside woods and undeveloped bottomlands does no significant damage, and the silt deposits in these wooded areas are less of a problem than failed banks.

4. Tree Zone - This zone is flooded only during periods of very high water (i.e., the 2 year bank-full flow or greater flows). Typical plants in the Mid-Atlantic states are trees in the ashelm, alder-ash, and oak-hornbeam associations. These trees hold soil in place with their root systems.

Design Criteria

Table 22-1 provides general guidelines for maximum allowable velocities in streams to be protected by vegetation.

1. Ensure that channel bottoms are stable before stabilizing channel banks.

2. Keep velocities at bankfull flow non-erosive for the site conditions.

3. Provide mechanical protection such as rip-rap on the outside of channel bends if bankfull stream velocities approach the maximum allowable for site conditions.

4. Be sure that requirements of other state or federal agencies are met in the design in the case that other approvals or permits are necessary.

TABLE 22-1
CONDITIONS WHERE VEGETATIVE STREAMBANK STABILIZATION IS ACCEPTABLE

Frequency of Bankfull Flow	Max. Allowable Velocity in meters per second (m/sec) for Highly Erodible Soil	Max. allowable Velocity in meters per second (m/sec) for Erosion Resistant Soil
> 4 times/yr.	1.2 m/sec (4 ft/sec)	1.5 m/sec (5 ft/sec)
1 to 4 times/yr.	1.5 m/sec (5 ft/sec)	1.8 m/sec (6 ft/sec)
< 1 time/yr.	1.8 m/sec (6 ft/sec)	1.8 m/sec (6 ft/sec)

Planting Guidelines

Guidelines will be presented only for the reed-bank and shrub zones. The aquatic plant zone is difficult to implant and establish naturally when reed-bank vegetation is present. There are presently many experts in this field at the federal, state, and private sector levels who can be consulted concerning successful establishment of plants in the aquatic zone. The tree zone is least significant in terms of protecting banks from more frequent erosion-force flows, since this zone is seldom flooded. Also, shade from trees in this zone can prevent adequate establishment of vegetation in other zones.

1. <u>Establishing Reed-Bank Vegetation</u>

There are various ways of planting reed-bank vegetation. The following plants are considerable suitable:

Common Reed	(Phragmites communis)
Reed Canary Grass	(Phalaris arundinacae)
Great Bulrush	(Scirpus lacustris)
Common Cattail	(Typha latifolia)

The greatest protection seems to be provided by the Common Reed. It is a very robust plant whose stems become woody in the autumn, resulting in continued protection during the winter. Because the shoots and rhizomes are deeply and strongly rooted and densely intertwined, they bind the soil more firmly than any other reed. The stems and roots have dormant buds at the nodes and are capable of sprouting when planted. However, the Common Reed does grow high and thick, and periodic maintenance may be needed in order to achieve a neat appearance.

a. <u>Planting in Clumps</u>: The oldest and most common method of planting reeds is planting in clumps. The stems of the reed colony are scathed. Then square clumps are cut out of the ground and placed in pits prepared in advance on the chosen site. The clumps are planted at a depth where they will be submerged to a maximum of two-thirds of their height.

b. <u>Planting Rhizomes and Shoots:</u> Less material is needed for the planting of rhizomes and shoots, a procedure which can be used to establish the Common Reed, Reed Grass, Bulrush, Cattail and other plants. Slips are taken from existing beds during the dormant season, after the stems have been cut. Rhizomes and shoots are carefully removed from the earth without bruising the buds or the tips of the sprouts. They are placed in holes or narrow trenches, along the line of the average summer water level, so that only the stem sprouts are showing above the soil.

c. <u>Planting Stem Slips:</u> It is possible to plant stem slips of the Common Reed along slow-moving streams. Usually, three slips are set in a pit 0.3 to 0.5 meters (1 to 0.8 feet) deep. If the soil is packed or strong, the holes must be made with a dibble bar or some other metal planting tool. The pits should be located approximately 0.3 meters (1 foot) apart.

d. <u>Reed Rolls:</u> In many cases, the previously described methods do not consolidate the banks sufficiently during the period immediately after planting. Combined structures have therefore been designed, in which protection of the bank is at first insured by structural materials. Along slow to fairly fast streams, the most effective method of establishing reed-bank vegetation has been found to be the use of Reed Rolls. A trench 0.5 meters (1.5 feet) wide and deep is dug behind a row of stakes. Wire netting, such as 13 millimeter (0.5 inch) hardware cloth, is then stretched from both sides of the trench between upright planks. Onto this netting is dumped fill material such as coarse gravel, sod, or soil and other organic material. This material is then covered by reed clumps until the two edges of the wire netting can just be held together with wire. The upper edge of the roll should be no more than 50 millimeters (2 inches) above the level of the water. Finally, the planks are taken out, and any gaps along the sides of the roll are filled in with earth. This method provides greater protection from the possibility of a heavy flow washing away the vegetative materials before they have a chance to become established.

e. <u>Seeding:</u> Reed Canary Grass can be sown 13 millimeters (0.5 inches) deep on very damp bank soil, provided that the seeded surface is not covered by water for six months after sowing. Seed at a rate of 2.2 - 2.8 kg/ha (12-15 lbs/acre). Reed Canary Grass is a cool season grass and should not be seeded in the summer.

f. <u>Vegetation and Stone Facing</u>: Reed-bank and other types of vegetation can be planted in conjunction with rip-rap or other stone facing by planting clumps, rhizomes or shoots in the crevices and gaps along the line of the average summer water level.

2. <u>Establishing Shrub Zone Vegetation:</u> Stands of full-grown trees are of little use for protecting streambanks apart from the binding of soil with their roots. Shrubwood provides much better protection; and in fact, riverside stands of willow trees are often replaced naturally by colonies of shrub-like willows. Plants should be used which can easily adapt to the stream and site conditions.

   a. <u>Seeding and Sodding:</u> Frequently, if the stream is small and a good seedbed can be prepared, grasses can be used alone to stabilize the streambanks. To seed the shrub zone, first grade eroded or steep streambanks to a maximum slope of 2:1 (3:1 preferred). Existing trees greater than 100 millimeters (4 inches) in diameter should be retained whenever possible. Topsoil should be conserved for reuse. Seeding mixtures should be selected and operations performed according to

BMP-32, PERMANENT SEEDING. Some type of erosion control blanket, such as jute netting, excelsior blankets, or equivalent should be installed according to BMP-36, SOIL STABILIZATION BLANKETS & MATING. Sod can also be placed in areas where grass is suitable. Sod should be selected and installed according to BMP-33, SODDING. Turf should only be used where the grass will provide adequate protection, necessary maintenance can be provided, and establishment of other streambank vegetation is not practical or possible.

b. <u>Planting Cuttings and Seedlings:</u> Shrub willows, shrub dogwoods and alders can be put into the soil as cuttings, slips or stems. In dense shade, shrubs such as the Blue Arctic Willow (Salix purpurea nana) and the Silky Dogwood (Cornus amomum) or evergreen ground covers such as Lily Turf (Liriope Muscari) or Hall's Honeysuckle (Linicera hallsiana) are appropriate. The Silky Dogwood also works well in sunny areas. On larger streams, "Streamco" Purpleosier Willow (Salix purpurea "Streamco") and Bankers' Dwarf Willow (Salix x Cotteti) have been widely used with success. Two native river alders (Alnus serrulata and Alnus rugosa), which occur throughout the northeast, also show great promise for streambank stabilization, although they have not been fully tested. Again, the first step in the planting process is to grade eroded or steep slopes to a maximum slope of 2:1 (3:1 preferred), removing overhanging bank edges.

Willows can be planted as 1-year old, nursery-grown, rooted cuttings or as fresh hardwood cuttings gathered from local mother-stock plantings. Silky Dogwood and the alders should be nursery-grown seedlings 1 or 2 years old. Fresh cuttings should be 10 to 13 millimeters (3/8- to 1/2-inch) thick and 300 to 450 millimeters (12 to 18 inches) long. They should be kept moist. If not used at once, they should be stored in cool moist sand.

Streambanks are often difficult to plant, even when they are well-sloped. This is especially true in gravelly or strong banks. Where mattocks or shovels are unsatisfactory tools, a stiff steel bar, such as a crowbar, is better. The best tool for this purpose is a dibble bar, a heavy metal tool with a blade and a foot pedal. It is thrust into the ground to make a hole for the plant.

Rooted cuttings should be planted vertically in the bank with 25 or 50 millimeters (1 or 2 inches) of wood protruding above the ground surface. They should be stuck in a hole large enough to accommodate the root system when well spread. The plant roots must be maneuvered into the bottom of the hole so they will grow down instead of up. The roots should not be twisted, nor should they be exposed above the ground surface. After the plant is placed, the dibble bar can be installed a few inches away from the plant to close the hole. Slow-release fertilizer should be applied on the surface, not in the hole. The soil should be tamped adequately to provide complete contact between the soil and the cutting. Cuttings should be planted 0.3 meters (1 foot) on center in at least 3 rows located at the top, middle and bottom of the shrub zone.

Plant seedings of the river alders vertically in the bank to the depth they were growing in the nursery. Use the same procedure described previously. Plant one row of alders at 0.6 meter (2-foot) intervals at the base of the shrub zone, not more than 0.5 to 1 meters (1.5 to 3 feet) from the average summer water level or from the reeds. A greater distance is of no use unless a belt of tall perennial herb colonies is established between the reeds and the alders. Plant the next row 0.3 meters (2 feet) up the slope, with a third row 1.2 meters (4 feet) up the slope. Plant at least 3 rows. Locate the plants in a diamond pattern.

Since these plants are generally not effective for the first two years, grasses can be seeded immediately following their planting to provide initial streambank protection.

The seedbed should be roughened with rakes and fertilized with 90 to 180 kg/hectare (500 to 1000 pounds per acre) of 10-10-10, adjusted to meet the needs of the site. Special care should be used when fertilizing next to water sources to avoid any unnecessary introduction of nitrogen/phosphorus into the water. Seed should be broadcast, covered lightly and mulched with 735 kg of straw per hectare (4,000 lbs per acre) approximately 2-3 bales per 100 square meters or a minimum of 275 kilograms of wood fiber mulch per hectare (1500 pounds per acre), although it is prefrred to use 370 kilograms per hecatare (2000 pounds per acre). If straw is used, it should be properly anchored with netting or an effective tackifier. Erosion control blankets/mats are often very effective aids in the establishment of grasses or plant material along streambanks (see BMP-36, SOIL STABILIZATION BLANKETS & MATTING).

Willows and other softwoods can also be bound together in various ways in order to insure immediate protection of the streambank.

c. Fascine Rolls: Fascine rolls are bundles of brushwood and sticks, without branches if possible, that are filled with coarse gravel and rubble and wired tightly around the outside. They are 4 to 18 meters (12 to 60 feet) long and 100 to 400 millimeters (4 to 16 inches) in diameter. They are set against the bank so that the parts which are to take root touch the ground above the water level and are able to get sufficient moisture. Covering with earth improves the contact with the ground and retards the loss of moisture from the wood.

d. Willow Mattresses: The degree of streambank protection can be increased by using willow mattresses or packed fascine work. Willow mattresses consist of 100 to 200 millimeter (4 to 8 inch) thick layers of growing branches set perpendicular to the direction of the current or sloping downstream. With the broad ends of the branches oriented downwards. The branches are held together with interweaving wire or other branches at intervals of 0.6 to 0.8 meters (2 to 2.7 feet), set parallel to the direction of the current or at an angle of 30 degrees. If several layers of mattress are necessary, the tops of the lower layers should cover the bases of the upper layers. The bottom layer is fixed at the base in a trench previously dug at the base of the softwood zone. The whole mattress structure should be covered with 50 to 255 millimeters (2 to 10 inches) of earth or fine gravel.

e. Packed Fascine-Work: Packed fascine-work consists essentially of layers of branches laid one across the other to a depth of 200 to 300 millimeters (8 to 12 inches) and covered with fascine rolls. The spaces between the fascine rolls are filled with gravel, stones and soil so that no gaps remain; and a layer of soil and gravel 200 to 300 millimeters thick is added on top. Packed fascine-work is particularly suitable for repairing large breaches in the banks of streams with high water levels.

f. Combination with Stone Facing: In many places, the bank is not adequately protected by vegetation until the roots are fully developed, and temporary protection must be provided by inanimate materials. There is a wide choice of methods, including the planting of woody plants in the crevices of stone facing. For structural protection measures, see BMP-23, STRUCTURAL STREAMBANK PROTECTION.

Maintenance

Streambanks are always vulnerable to new damage. Repairs are needed periodically. Banks should be checked after every high-water event is over. Gaps in the vegetative cover should be fixed at once with new plants, and mulched if necessary. Fresh cuttings from other plants on the bank can be used, or they can be taken from mother-stock plantings if they are available. Trees that become established on the bank should be removed at once.

BMP: STRUCTURAL STREAMBANK STABILIZATION

Definition

Methods of stabilizing the banks of live streams with permanent structural measures.

Purpose

To protect streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Applicable to streambank sections which are subject to excessive erosion due to increased flows or disturbance during construction. Generally applicable where flow velocities exceed 1.5 meters/sec (5 ft/sec) or where vegetative streambank protection is inappropriate.

Planning Considerations

Stream channel erosion problems vary widely in type and scale and there are many different structural stabilization techniques which have been employed with varying degrees of effectiveness. The purpose of this specification is merely to point out some of the practices which are available and to establish some broad guidelines for their selection and design. Such structures should be planned and designed in advance by an engineer or some other qualified individual with appropriate experience. Many of the practices referenced here involve the use of manufactured products and should be designed and installed in accordance with the manufacturers' specifications.

Before selecting a structural stabilization technique, the designer should carefully evaluate the possibility of using vegetative stabilization (BMP-22) alone or in conjunction with structural measures, to achieve the desired protection. Vegetative techniques are generally less costly and more compatible with natural stream characteristics.

General Guidelines

Since each reach of channel requiring protection is unique, measures for streambank protection should be installed according to a plan and adapted to the specific site. Designs should be developed according to the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.

2. The bottom scour should be controlled, by either natural or artificial means, before any permanent type of bank protection can be considered feasible. This is not necessary if the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

3. Streambank protection should be started and ended at a stabilized or controlled point on the stream.

4. Changes in channel alignment shall be made only after an evaluation of the effect upon land use, interdependent waste water systems, hydraulic characteristics and existing structures.

5. Special attention should be given to maintaining and improving habitat for fish and wildlife.

6. The design velocity should be that of the peak discharge of the 10-year storm. Structural measures must be effective for this design flow and must be capable of withstanding greater flows without serious damage.

7. All requirements of state law and permit requirements of local, state and federal agencies must be met.

8. Stabilize all areas disturbed by construction as soon as the structural measures are complete.

Streambank Protection Measures

Riprap - heavy angular stone placed (preferably) or dumped onto the streambank to provide armor protection against erosion. .Riprap shall be designed and installed according to the practice entitled RIPRAP (BMP-19).

Gabions - rectangular, rock-filled wire baskets are pervious, semi-flexible building blocks which can be used to armor the bed and/or banks of channels or to divert flow away from eroding channel sections. Gabions should be designed and installed in accordance with manufacturer's standards and specifications. At a minimum, they should be constructed of a hexagonal triple twist mesh of heavily galvanized steel wire (galvanized wire may also receive a polyvinyl chloride coating). The design water velocity for channels utilizing gabions should not exceed those listed as follows:

Gabion Thickness		**Maximum Velocity**	
meters	feet	meters per second	feet per second
0.15	0.5	1.8	6
0.22	0.75	3.4	11
0.30	1.0	4.3	14

Deflection (groins or jetties) - Structural barriers which project into the stream to divert flow away from eroding streambank sections. Figure 23-1 contains general guidelines for designing and installing deflectors.

Installation of Structures Under Wave and/or Tidal Action

The installation of riprap, gabions or deflectors under significant wave action or under tidal conditions requires special design considerations to ensure stability of the measure and the area it protects. For situations where there is significant wave action affecting the shoreline of a nontidal lake or Pond, the design parameters presented in BMP-19, RIPRAP, should be used. Notably, there are many other site specific factors which should be incorporated into a design; hence, it is recommended that the design parameters presented only be used as minimum requirements and that a qualified professional be consulted when the installation of such a structure is contemplated.

Reinforced Concrete - may be used to armor eroding sections of the streambank by constructing retaining walls or bulk heads. Positive drainage behind these structures must be provided. Reinforced concrete may also be used as a channel lining (see BMP-17, STORMWATER CONVEYANCE CHANNEL).

Log Cribbing - a retaining structure built of logs to protect streambanks from erosion. Log cribbing is normally built on the outside of stream bends to protect the streambank from the impinging flow of the stream.

Grid Pavers - modular concrete units with interspersed void areas which can be used to armor the streambank while maintaining porosity and allowing the establishment of vegetation. These structures may be obtained in precast blocks or mats, or they may be formed and poured in place. Design and installation should be in accordance with manufacturer's instructions.

Maintenance

All structures should be maintained in an "as built" condition. Structural damage caused by storm events should be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank.

BMP-24

BMP: TEMPORARY VEHICULAR STREAM CROSSING

Definition

A temporary structural span installed across a flowing watercourse for use by construction traffic. Structures may include bridges, round pipes, pipe arches, or oval pipes.

Purposes

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

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

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than 260 hectares (1 square mile). Structures which must handle flow from larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

Planning Considerations

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

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

A temporary bridge crossing is a structure made of wood, metal, or other materials which provides access across a stream or waterway. It is the preferred method for temporary waterway crossings. Normally, bridge construction causes the least amount of disturbance to the stream bed and banks when compared to the other types of crossings. They can also be quickly removed and reused. In addition, temporary bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings. A temporary culvert crossing is a structure consisting of stone and a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossings. Temporary culverts are used where the channel is too wide for normal bridge construction or the anticipated loading of construction vehicles may prove unsafe for single span bridges. There is some disturbance within the stream during construction and removal of the temporary culvert crossing. The stone, along with the temporary culverts, can be salvaged and reused.

Design Criteria

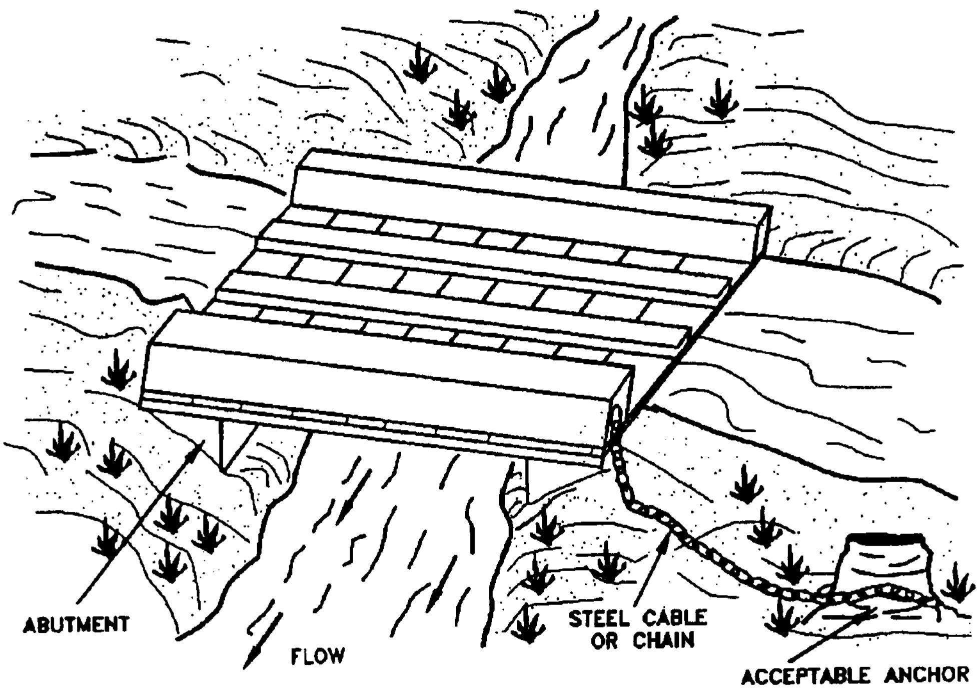
1. Temporary Bridge Crossing

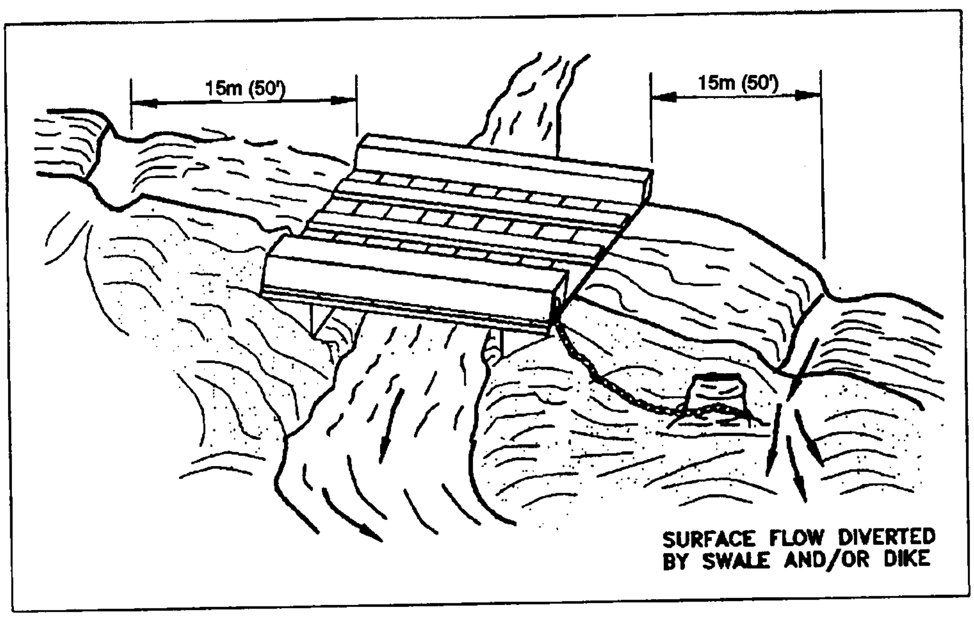
   a. Structures may be designed in various configurations. However, the materials used to construct the bridge must be able to withstand loading of the construction traffic. Figure 24-1 shows on example of such a crossing.

   b. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15degrees from a line drawn perpendicular to the center line of the stream at the intended crossing location.

   c. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 15 meters (50 feet) from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 15 meter minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 0.6 meters (2 feet) above the existing flood plain elevation.

FIGURE 24-1: TEMPORARY BRIDGE CROSSING





d. A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 15 meters (50 feet) (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 15 meter distance is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with BMP-11, TEMPORARY RIGHT OF WAY DIVERSION or BMP-9, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

e. Appropriate perimeter controls such as SILT FENCE (BMP-5) or TURBIDITY CURTAIN (BMP-27) must be employed when necessary along banks of stream parallel to the same.

f. All crossings shall have one traffic lane. The minimum width shall be 3.7 meters (12 feet) with a maximum width of 6 meters (20 feet).

9. Further design/construction recommendations for temporary bridge construction may be found in Construction Specifications.

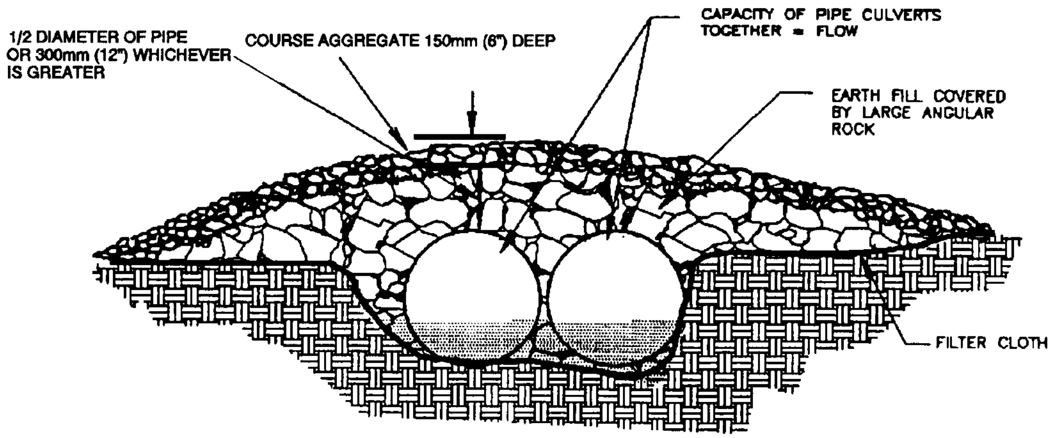
2. Temporary Culvert Crossing

a. Where culverts are installed, Coarse Aggregate or larger will be used to form the crossing. The depth of stone cover over the culvert shall be equal to one-half the diameter of the culvert or 300 millimeters (12 inches), whichever is greater. To protect the sides of the stone from erosion, riprap shall be used and designed in accordance with BMP-19, RIPRAP (see Figure 242).

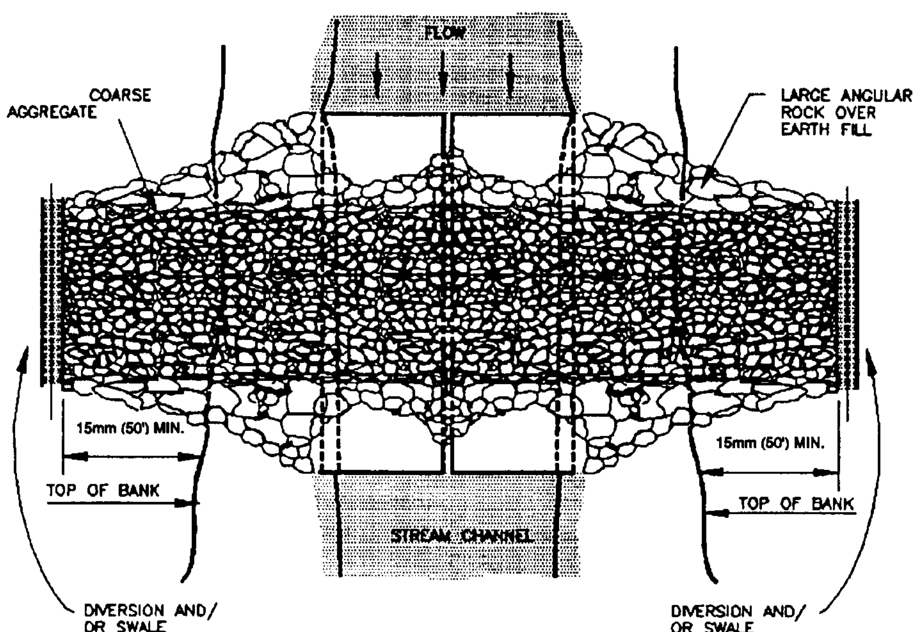
b. If the structure will remain in place for up to 14 days, the culvert shall be large enough to convey the flow from a 2-year frequency storm without appreciably altering the stream flow characteristics. See Table 24-1 for aid in selecting an appropriate culvert size (note all assumptions). If the structure will remain in place 14 days to 1 year, the culvert shall be large enough to convey the flow from a 10-year frequency storm. In this case, the hydrologic calculation and subsequent culvert size must be done for the specific watershed characteristics. If the structure must remain in place over 1 year, it must be designed as a permanent measure by a qualified professional.

c. Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert that may be used is 458 millimeters (18 inches).

FIGURE 24-2: TEMPORARY CULVERT CROSSING



ELEVATION



PLAN VIEW

TABLE 24-1:
PIPE DIAMETER FOR STREAM CROSSING [a]

Drainage Area, hectares (Acres)	Average Slope of Watershed			
	1%	4%	8%	16%
1-10 (1-25)	610 (24)	610 (24)	760 (30)	760 (30)
11-20 (26-50)	610 (24)	760 (30)	915 (36)	915 (36)
21-40 (51-100)	760 (30)	915 (36)	1068 (42)	1220 (48)
41-60 (101-150)	760 (30)	1068 (42)	1220 (48)	1220 (48)
61-80 (151-200)	915 (36)	1068 (42)	1220 (48)	1372 (54)
120-140 (301-350)	1068 (42)	1220 (48)	1524 (60)	1524 (60)
141-160 (351-400)	1068 (42)	1372 (54)	1524 (60)	1524 (60)
161-200 (451-500)	1068 (42)	1372 (54)	1524 (60)	1830 (72)
201-220 (501-550)	1220 (48)	1524 (60)	1524 (60)	1830 (72)
221-240 (551-600)	1220 (48)	1524 (60)	1524 (60)	1830 (72)
241-260 (601-640)	1220 (48)	1524 (60)	1830 (72)	1830 (72)

[a] Note: Table is based on Graphical Peak Discharge Method for 2-year frequency storm event, CN = 65; Rainfall depth = 9 millimeters (3.5) inches. Drainage areas listed are in hectares and (acres). Pipe diameters listed are in millimeters, mm and (inches).

d. All culverts shall be strong enough to support their cross-sectioned area under maximum expected loads.

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

f. The slope of the culvert shall be at least 20 millimeters per meter (0.25 inches per foot).

g. Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15 degrees from a line drawn perpendicular to the centerline of the stream at the intended crossing location.

h. The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 15 meters (50 feet) from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 15 meter minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 0.6 meters (2 feet) above the existing flood plain elevation.

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

1) Minimum thickness: 150 millimeters (6 inches).
2) Minimum width: equal to the width of the structure.

j. A water diverting structure such as a swale shall be constructed across the roadway on both roadway approaches, 15 meters (50 feet) maximum on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 15 meter distance is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with BMP-11, TEMPORARY Right OF WAY DIVERSION or BMP-9, TEMPORARY DIVERSION DIKE. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

Construction Specifications

Temporary Bridge Crossing (see Figure 24-1)

a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

b. The temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.

c. Abutments shall be placed parallel to and on stable banks.

d. Bridges shall be constructed to span the entire channel. If the channel width exceeds 2.5 meters (8 feet), as measured from top-of-bank to top-of-bank, then a footing, pier or bridge support may be constructed within the waterway. One additional footing, pier or bridge support will be permitted for each additional 2.5 meter width of the channel. No footing, pier or bridge support will be permitted within the channel for waterways which are less than 2.5 meters wide.

e. Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.

f. Decking materials shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.

g. Run planking (optional) shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels. Although run planks are optional, they may be necessary to properly distribute loads.

h. Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.

i. Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

j. All areas disturbed during installation shall be stabilized within 7 calendar days of that disturbance.

k. When the temporary bridge is no longer needed, all structures including abutments and other bridging materials should be removed immediately.

l. Final clean-up shall consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials shall be stored outside flood plain of the stream. Removal of the bridge and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.

2. Temporary Culvert Crossings

    a. Clearing and excavation of the stream bed and banks shall be kept to a minimum.

    b. The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration.

    c. Filter cloth shall be placed on the streambed and streambanks prior to placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum of 150 millimeters (6 inches) and a maximum of one 300 millimeters (1 foot) beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability. See BMP-19, RIPRAP, for required physical qualities of the filter cloth.

    d. The culvert(s) shall extend a minimum of 300 millimeters (1 foot) beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 12 meters (40 feet) in length.

    e. The culvert(s) shall be covered with a minimum of 0.3 meters (1 foot) of aggregate. If multiple culverts are used, they shall be separated by at least 300 millimeters (12 inches) of compacted aggregate fill. At a minimum, the bedding and fill material used in the construction of the temporary access culvert crossings shall conform with the aggregate requirements cited in part "i" under "Temporary Culvert Crossing."

    f. When the crossing has served its purpose, all structures including culverts, bedding and filter cloth materials shall be removed. Removal of the structure and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.

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

<u>Maintenance</u>

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

BMP-25

BMP: UTILITY STREAM CROSSING

Definition

A strategy for crossing small waterways when in-stream utility construction is involved.

Purposes

1. To help protect sediment from entering the stream from construction within approach areas.

2. To minimize the amount of disturbance within the stream itself

Conditions Where Practice Applies

Generally applicable to flowing streams with drainage areas less than 260 hectares (1 square mile). Structures or methodology for crossing streams with larger drainage areas should be designed by methods which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure.

Planning Considerations

Utility construction, by virtue of its sprawling, linear nature, frequently crosses and impacts live streams. There is a potential for excessive sediment loss into a stream by both the disturbance of the approach areas and by the work with the stream-bed and banks.

It is often a difficult task to decide what type of control to use as a utility stream crossing. A method such as the "boring and jacking" of pipe below a streambed, which would prevent disturbance within the watercourse, is a preferred method if it is practical. However, in cases where in-stream work is unavoidable, consideration must be given to providing adequate mitigation of sediment loss while minimizing the amount of encroachment and time spent working in the channel. There is some "give and take" as far as the installation of controls - sometimes there is less damage to the environment created by providing substantial controls for the approach areas and refraining from installing extensive measures in the stream itself. However, when the installation of the utility line within streambed and banks will take an extended period of construction time, consideration should be given to substantial in-stream controls or stream diversion in order to prevent excessive sedimentation damage.

As a result of the difficulty in choosing the right method for a utility stream crossing, designers and plan reviewers should always make site visits of proposed crossing to ensure that the most appropriate method is chosen. The designer and plan reviewer should also be aware that such modifications are subject to other state and federal construction permits.

The following are several methods for dealing with utility stream crossings (with varying construction time and stream size scenarios) which allow for "work in the dry" to prevent excessive sedimentation damage. By no means are these methods all inclusive. As with other control measures, site-specific design and innovative variations are encouraged.

Design Criteria (All methods)

1. The drainage area should be no greater than 260 hectares (640 acres).

2. All filter cloth used in the construction of the utility crossing must conform to physical requirements noted in BMP-19, RIPRAP.

3. Water diverting structures should be used at all trenching and/or construction road approaches 15 meters (50 feet) on either side of the crossing) as per BMP-24, VEHICULAR STREAM CROSSING.

4. Design criteria more specific to each particular crossing can be found in Figure 25-1 through 25-4.

FIGURE 25-1: DIVERSION CHANNEL CROSSING

See Figure 25-2
For Cross-Section A-A

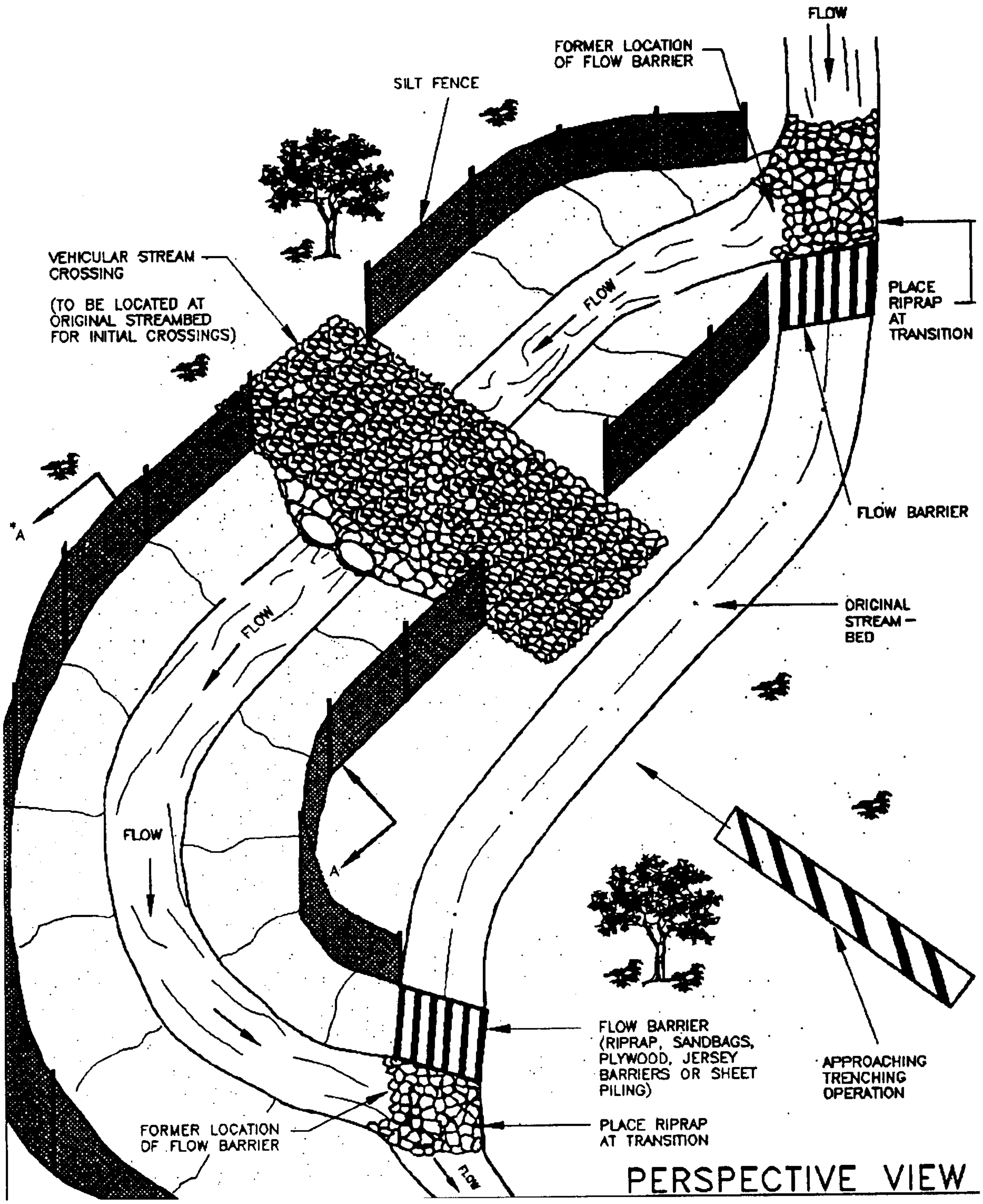
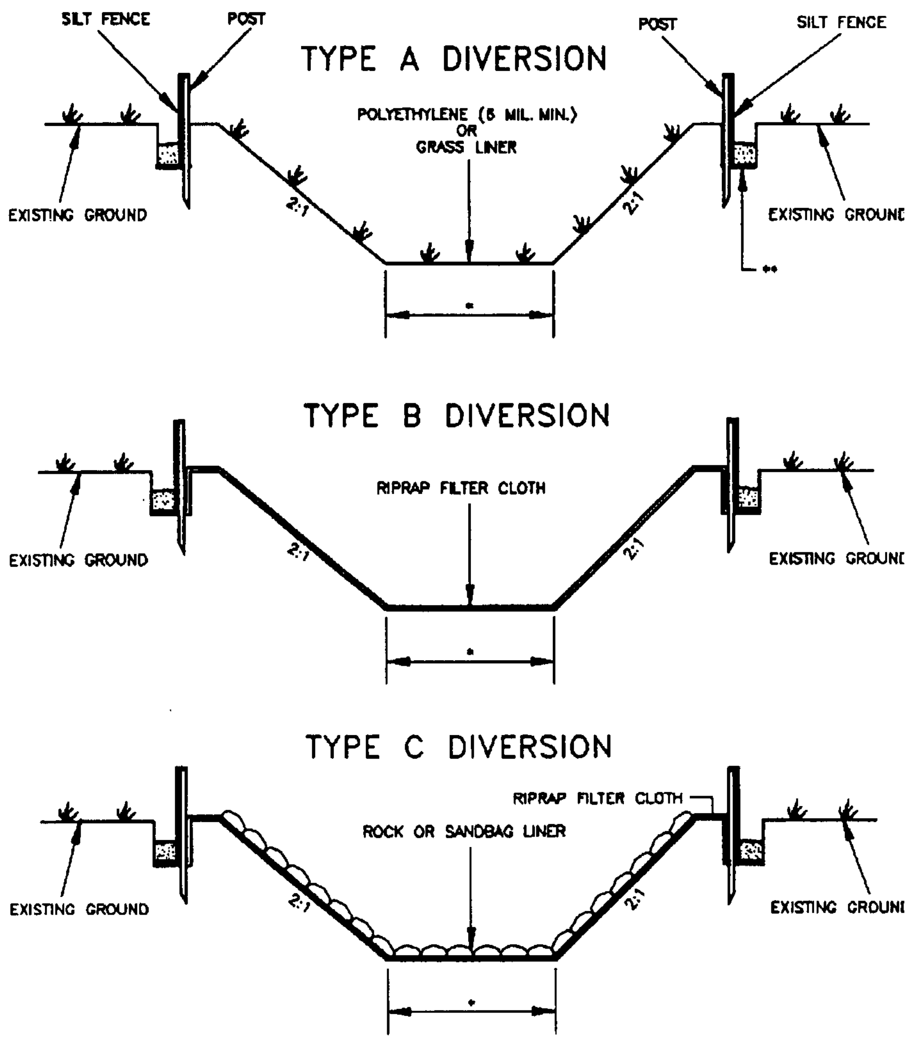


FIGURE 25-2: DIVERSION CHANNEL CROSSING

ACCEPTABLE LININGS
(CROSS SECTION A-A OF FIGURE 25-1)



* 2m (6') MIN. OR WIDTH OF EXISTING STREAM WHICHEVER IS LESS
** ENTRENCH SILT FENCE AND FILTER CLOTH IN SAME TRENCH

FIGURE 25-3: FLUME PIPE CROSSING

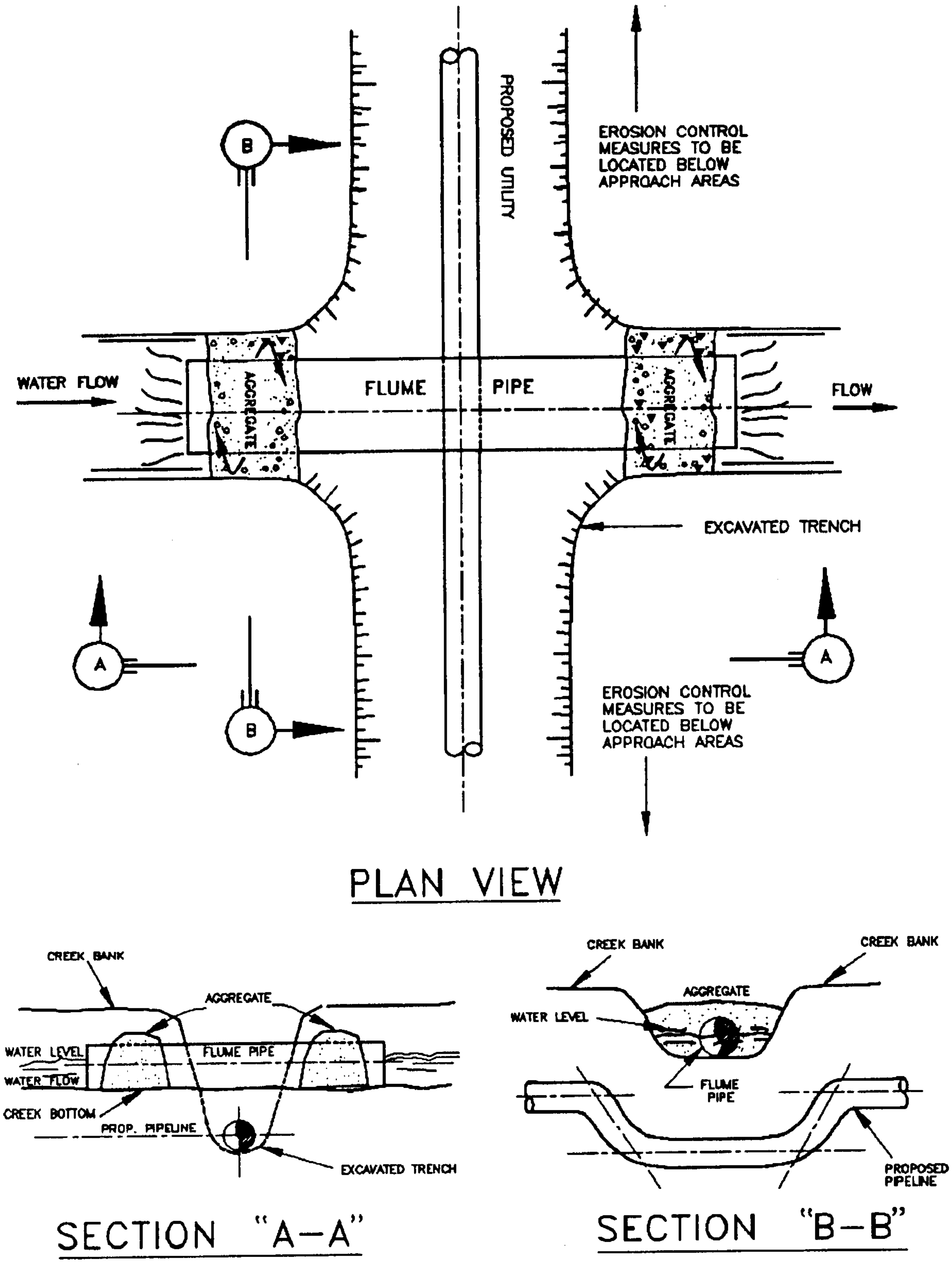
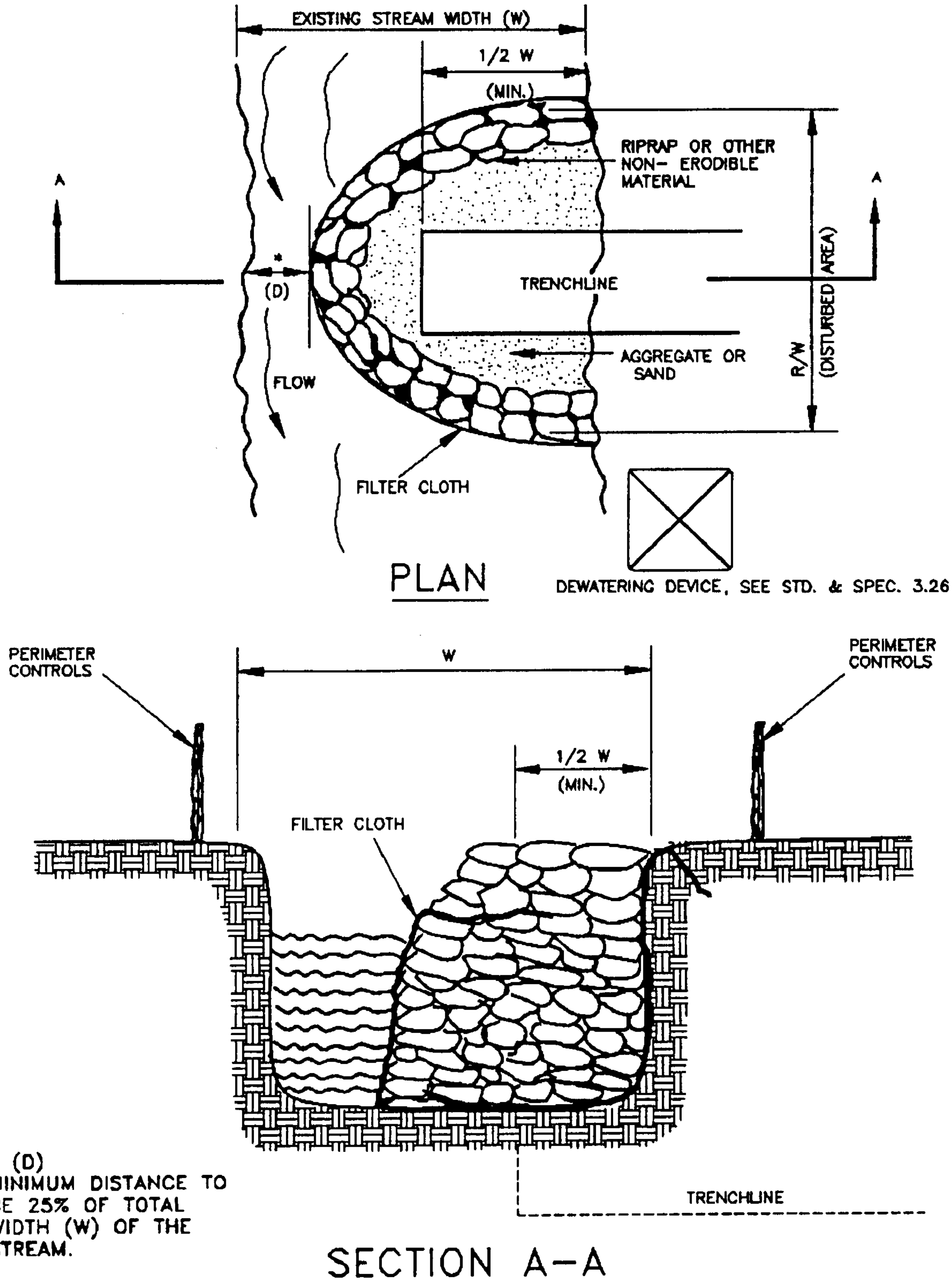


FIGURE 25-4: COFFERDAM CROSSING



* (D)
MINIMUM DISTANCE TO BE 25% OF TOTAL WIDTH (W) OF THE STREAM.

Construction Specifications

1. Diversion Channel Crossing - Preferred method if construction will remain in area of stream for an extended period (longer than 72 hours) and site conditions (such as width of stream) make diversion practical.

   a. The diversion channel crossing must be operational before work is done in the stream (construction will be performed "in the dry").

   b. Minimum width of bottom shall be 2 meters (6 feet) or equal to bottom width of existing streambed, whichever is less. Refer to Figures 25-1 and 25-2.

   c. Maximum steepness of side slopes shall be 2:1. Depth and grade may be variable, dependent on site conditions, but shall be sufficient to ensure continuous flow of water in the diversion.

   d. There are three types of diversion channel linings which can be used, based upon expected velocity of bankfull flow. Refer to Figure 25-2 and the following table:

TABLE 25-1: DIVERSION CHANNEL LININGS

Lining Material	Classification	Acceptable Velocity Range
Filter Cloth*, Polyethylene or Grass	TYPE A	0 - 0.6 m.p.s. (0 - 2.5 f.p.s.)
Filter Cloth*	TYPE B	0.75 -2.75 m.p.s. (2.5 - 9.0 f.p.s.)
Riprap and Filter Cloth*	TYPE C	2.75 - 4.0 m.p.s. (9.0 - 13.0 f.p.s.)

* Filter Cloth must meet the minimum physical requirements noted in BMP 19, RIPRAP.

e. Type A stream diversions may be seeded with a standard seed mix for the type of soils encountered and the time of year seed is sown. An average growth of 50 millimeters (2 inches) in height shall be achieved throughout the diversion with an 85% cover before water is turned through it.

f. Stream diversion liners shall be secured at the upstream and downstream sides with non-erodible weights such as riprap. These weights shall allow normal flow of the stream. Soil shall not be mixed in with stream diversion weights. Weights may also be needed along the stream diversion's length to secure liner.

g. Stream diversion liners should be overlapped when a continuous liner is not available or is impractical. Overlaps should be such that continuous flow of the steam is maintained. An upstream section should overlap a downstream section by a minimum of 500 millimeters (18 inches). Overlaps along the cross-section should be made such that a liner is placed in the steam diversion bottom first and additional pieces of liner on the slopes overlap the bottom piece by a minimum of 500 millimeters (18 inches).

h. Stream diversion liners shall be entrenched at the top of the diversion slopes (slopes breaks) along with a line of silt fence. Silt fence may be excluded if the diversion liner is extended to such a point that siltation of the stream will not occur. If silt fence is excluded, the diversion liner must be secured. Liners shall extend from slope break to slope break as shown in Figure 25-2.

i. Staples used in securing SOIL STABILIZATION BLANKETS AND MATING (see BMP-36) or non-erodible weights (riprap) shall be used as necessary to anchor stream diversion liners to the side slopes of the diversion. Wooden stakes should not be used on the diversion's bottom or side slopes.

j. Non-erodible materials such as riprap, jersey barriers, sandbags, plywood, or sheet piling, shall be used as flow barriers to divert the stream away from its original channel and to prevent or reduce water backup into a construction area.

k. The downstream flow barrier is to be removed prior to the upstream barrier when opening a stream diversion for the transport of water.

l. Streams should be rediverted upon completion of the utility crossing for which the diversion was built. Prior to rediversion, any materials (flow barrier) used to prevent water backup into the downstream end of the original streambed shall be removed. This material should not be placed in the downstream end of the diversion until after water has been rediverted to the original waterway. The stream should then be rediverted by removing all of the materials damming the upstream end of the original streambed and then placing it in the upstream end of the stream diversion. The diversion should be sealed off at the downstream end and then backfilled.

   Once started, any work to relocate a stream shall not be discontinued until it is completed.

m. Stream should be rediverted only after backfilling and restabilization of original streambed and banks is completed. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 2 meters on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to BMP-19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur <u>immediately</u> following the attainment of final grade.

n. Any dewatering discharge from this operation shall be placed into an approved DEWATERING STRUCTURE (see BMP-26).

2. <u>Flume Pipe Crossing</u> - To be used when in-stream construction will last less than 72 hours and stream is narrow, less than 3 meters (10 feet) wide, making "cofferdam" construction impractical.

   a. The flume pipe crossing must be made operational prior to the start of construction in the stream.

   b. The materials used (culvert(s), stone and filter fabric) must meet the physical constraints of those used in VEHICULAR STREAM CROSSING, BMP-24.

   c. A large flume pipe (or culvert) of an adequate size to support normal water channel flow (see Table 24-1) shall then be installed in the stream bed across the proposed pipeline trench centerline. Coarse aggregate (minimum size) or riprap shall be placed close to each end of the flume pipe so as to dam off the creek forcing the water to flow through the flume pipe (see Figure 25-3).

d. The entrapped water can then be pumped from the creek within the dammed off area and in the proposed trench centerline into an approved DEWATERING STRUCTURE (see BMP-26). The trench can then be dug under the flume pipe. The pipe sections will then be installed to the proper depth under the flume pipe. After pipe sections are installed, the ditch will be backfilled and restabilization shall be carried out.

e. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 3 meters on both sides of the centerline of the utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to BMP-19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by the Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur immediately following the attainment of final grade.

f. After completion of backfilling operation and restoration of stream/creek banks and leveling of stream bed, the flume pipe can then be removed. The gravel can be removed or spread in the stream bed depending on permit requirements. Sediment control in approach areas shall not be removed until all construction is completed in stream/creek crossing area. All ground contours shall be returned to their original condition.

3. <u>Cofferdam Utility Crossing</u> - To be used when stream diversion is not practical and stream is wide enough (3 meters or wider) to make cofferdam installation practical.

a. Construction is to be performed in low flow periods.

b. Crossing shall be accomplished in a manner that will not prohibit the flow of the stream. (See Figure 25-4).

c. As with all utility line crossings, approach areas must be controlled with perimeter measures such as silt fence or straw bales.

d. Remove large rocks, woody vegetation, or other material from the streambed and banks that may get in the way of placing the riprap, sandbags, sheet metal, or wood planks or installing the utility pipe or line.

e. Form a cofferdam by placing the riprap (or other non-erodible materials) in a semicircle along the side of the stream in which the utility installation will begin. It must be surrounded and underlain with filter cloth as shown in Figure 25-4. The height of and area within the dam will depend upon the size of the work area and the amount of steam flow. Stack materials as high as will be necessary to keep water from overtopping the dam and flooding the work area. When the stream flow is successfully diverted by the cofferdam, dewater the work area and stabilize it with aggregate or sand. Make sure to discharge the water into a sediment trapping device (see DEWATERING STRUCTURE, BMP-26).

g. Install the utility pipe or line in half the streambed as noted in Figure 25-4. Remove the riprap or other materials and begin placing them on the other side of the stream.

h. Restabilization shall consist of the installation of ungrouted riprap on all disturbed streambank areas (or on the area 6 feet on both sides of the centerline of its utility trench, whichever is greater) with slopes of 3:1 or greater. Refer to BMP-19, RIPRAP, for installation requirements. For slopes of 3:1 or less, vegetative stabilization may be used, pending approval by Plan-Approving Authority or inspection authority. Stabilization of its streambed and banks and the approach areas should occur <u>immediately</u> following the attainment of final grade.

<u>Maintenance</u>

Care must be taken to inspect any steam crossing area <u>at the end of each day to make sure that the construction materials are positioned securely.</u> This will ensure that the work area stays dry and that no construction materials float downstream.

BMP: DEWATERING STRUCTURE

Definition

A temporary settling and filtering device for water which is discharged from dewatering activities.

Purpose

To filter sediment-laden water prior to the water being discharged off-site.

Conditions Where Practice Applies

Wherever sediment-laden water must be removed from a construction site by means of pumping.

Planning Considerations

Water which is pumped from a construction site usually contains a large amount of sediment. A dewatering structure is designed to remove the sediment before water is released off-site.

This practice includes several types of dewatering structures which have different applications dependent upon site conditions and types of operation. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the Plan-Approving Authority.

A dewatering structure may not be needed if there is a well-stabilized, vegetated area onsite to which water may be discharged. The area must be stabilized so that it can filter sediment and at the same time withstand the velocity of the discharged water without eroding. A minimum filtering length of 23 meters (75 feet) must be available in order for such a method to be feasible.

Design Criteria

1. A dewatering structure must be sized (and operated) to allow pumped water to flow through the filtering device without overtopping the structure.

2. Material from any required excavation shall be stored in an area and protected in a manner that will prevent sediments from eroding and moving off-site.

3. An excavated basin (applicable to "Straw Bale/Silt Fence Pit") may be lined with filter fabric to help reduce scour and to prevent the inclusion of soil from within the structure.

4. Design criteria more specific to each particular dewatering device can be found in Figures 26-1 through 26-3.

Construction Specifications

1. Portable Sediment Tank (see Figure 26-1)

   a. The structure may be constructed with steel drums, sturdy wood or other material suitable for handling the pressure exerted by the volume of water.

   b. Sediment tanks will have a minimum depth of 600 mm (2 ft.).

   c. The sediment tank shall be located for easy clean-out and disposal of the trapped sediment and to minimize the interference with construction activities.

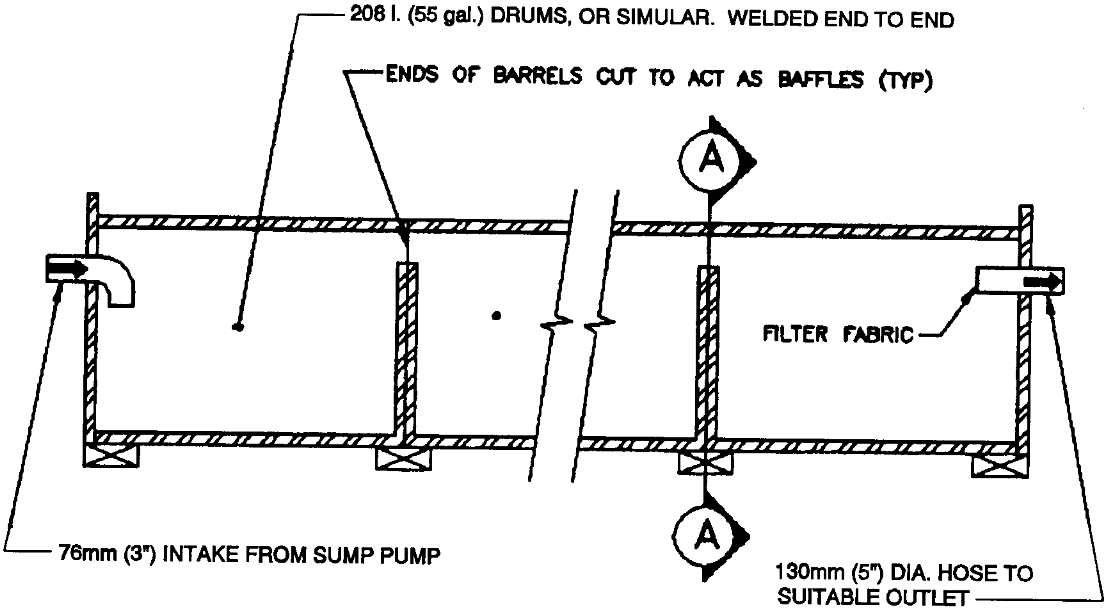
   d. The following formula shall be used to determine the storage volume of the sediment tank:

      Pump discharge (liter/min.) x 0.12 = cubic meters of storage required
      (Pump discharge (gallons/min.) x 16 = cubic feet of storage required)

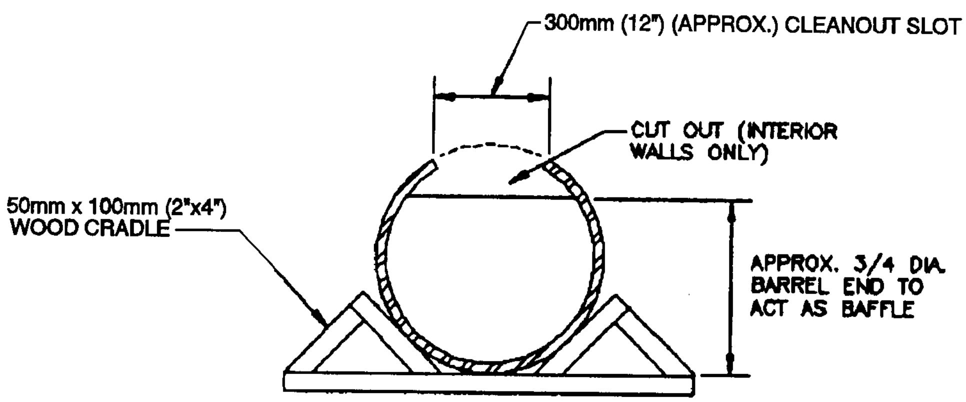
   e. Once the water level nears the top of the tank, the pump must be shut off while the tank drains and additional capacity is made available.

   f. The tank shall be designed to allow for emergency flow over top of the tank.

FIGURE 26-1: PORTABLE SEDIMENT TANK



ELEVATION



CROSS-SECTION A-A

g. Clean-out of the tank is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.

2. Filter Box (see Figure 26-2)

a. The box selected should be made of steel, sturdy wood or other materials suitable to handle the pressure requirements imposed by the volume of water. Normally readily available 208 liter (55 gallon) drums welded top to bottom will suffice in most cases.

b. Bottom of the box shall be made porous by drilling holes (or some other method).

c. Coarse aggregate shall be placed over the holes at a minimum depth of 300 millimeters (12 inches), metal "hardware" cloth may need to be placed between the aggregate and the holes if holes are drilled larger than the majority of the stone.

d. As a result of the fast rate of flow of sediment-laden water through the aggregate, the effluent must be directed over a well-vegetated strip of at least 15 meters (50 feet) after leaving the base of the filter box.

e. The box shall be sized as follows:
Pump discharge (liter/min.) x 0.12 = cubic meters of storage required
(Pump discharge (gallons/min.) x 16 = cubic feet of storage required)

f. Once the water level nears the top of the box, the pump must be shut off while the box drains and additional capacity is made available.

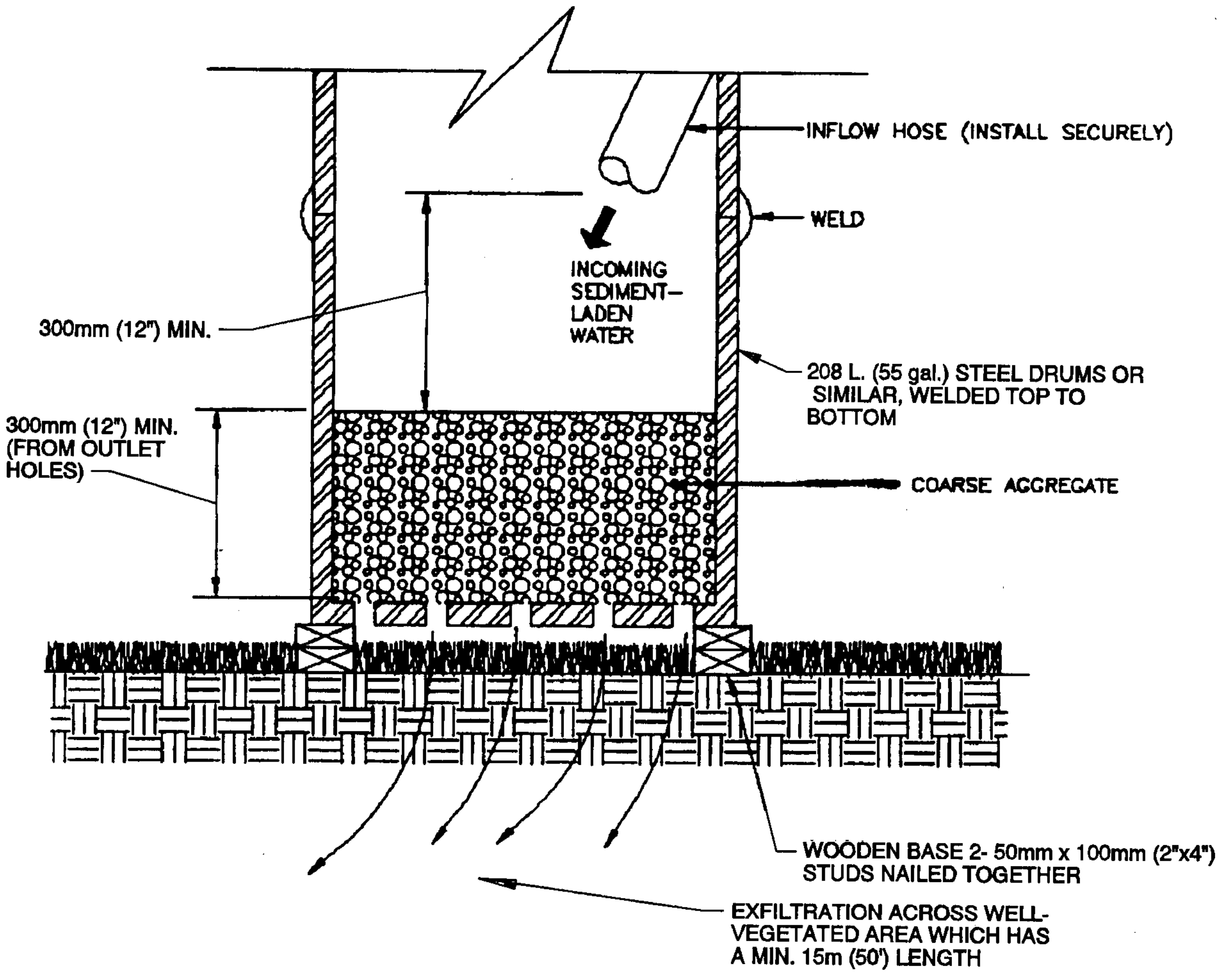
g. The box shall be designed/constructed to allow for emergency flow over the top of this box.

h. Clean-out of the box is required once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the clean-out point.

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

NOTE: Using a filter box only allows for minimal settling time for sediment particles; therefore, it should only be used when site conditions restrict the use of the other methods.

FIGURE 26-2: FILTER BOX



ELEVATION VIEW

3. Straw Bale./Silt Fence Pit (see Figure 26-3)

   a. Measure shall consist of straw bales, silt fence, a stone outlet (a combination of riprap and aggregate) and a wet storage pit oriented as shown in Figure 26-3.

   b. The structure must have a capacity which is dictated by the following formula:
   Pump discharge (liter/min.) x 0.12 = cubic meters of storage required
   (Pump discharge (gallons/min.) x 16 = cubic feet of storage required)

   In calculating the capacity, one should include the volume available from the floor of the excavation to the crest of the stone weir.

   c. In any case, the excavated area should be a minimum of 1 meter (3 feet) below the base of the perimeter measures (straw bales or silt fence).

   d. The perimeter measures must be installed as per the guidelines found in BMP-4, STRAW BALE BARRIER and BMP-5, SILT FENCE.

   e. Once the water level nears the crest of the stone weir (emergency overflow), the pump must be shut off while the structure drains down to the elevation of the wet storage.

   f. The wet storage pit may be dewatered only after a minimum of 6 hours of sediment settling time. This effluent should be pumped across a well vegetated area or through a silt fence prior to entering a watercourse.

   g. Once the wet storage area becomes filled to one-half of the, excavated depth, accumulated sediment shall be removed and properly disposed of.

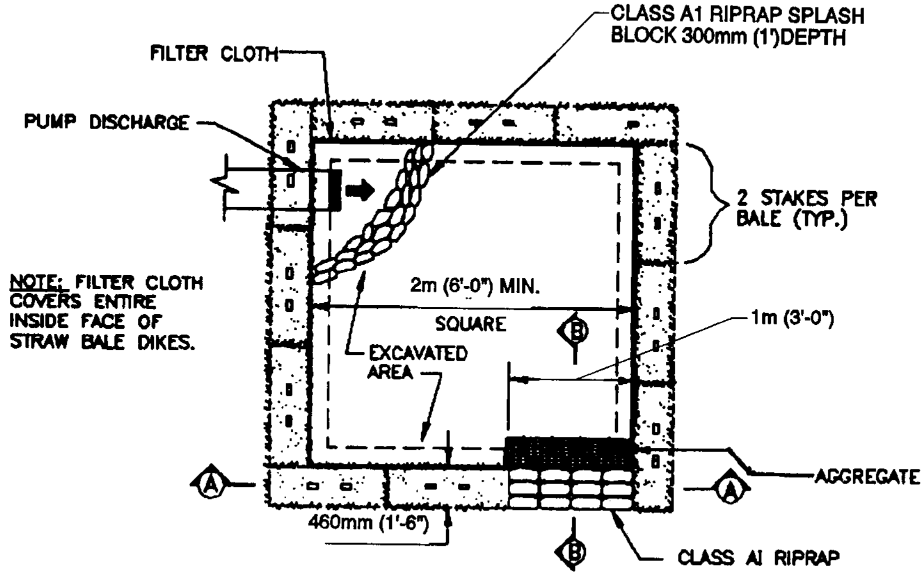
   h. Once the device has been removed, ground contours will be returned to original condition.

Maintenance (All dewatering structures)

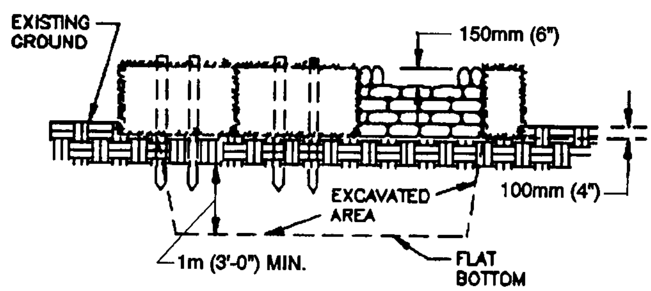
1. The filtering devices must be inspected frequently and repaired or replaced once the sediment build-up prevents the structure from functioning as designed.

2. The accumulated sediment which is removed from a dewatering device must be spread on-site and stabilized or disposed of at an approved disposal site as per approved plan.

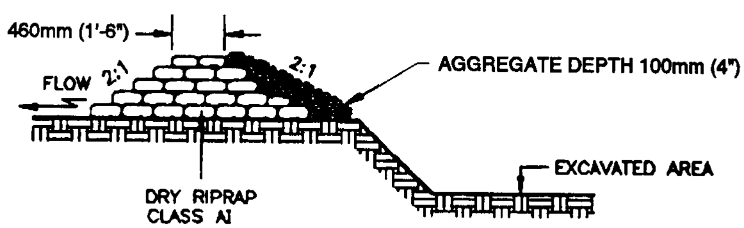
FIGURE 26-3: STRAW BALE/SILT FENCE PIT



PLAN VIEW



CROSS-SECTION A-A



CROSS-SECTION B-B

BMP: TURBIDITY CURTAIN

Definition

A floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water.

Purpose

To provide sedimentation protection for a watercourse from up-slope land disturbance or from dredging or filling within the watercourse.

Conditions Where Practice Applies

Applicable to non-tidal and tidal watercourses where intrusion into the watercourse by construction activities and subsequent sediment movement is unavoidable.

Planning Considerations

Soil loss into a watercourse results in long-term suspension of sediment. In time, the suspended sediment may travel large distances and affect wide-spread areas. A turbidity curtain is designed to deflect and contain sediment within a limited area and provide enough residence time so that soil particles will fall out of suspension and not travel to other areas.

Turbidity curtain types must be selected based on the flow conditions within the water body - whether it be a flowing channel, lake, pond, or a tidal watercourse. The specifications contained within this practice pertain to minimal and moderate flow conditions where the velocity of flow may reach 1.5 meters per second (5 feet per second), or a current of approximately 6 kilometers per hour (3 knots). For situations where there are greater flow velocities or currents, a qualified engineer and product manufacturer should be consulted.

Consideration must also be given to the direction of water movement in channel flow situations. Turbidity curtains are not designed to act as water impoundment dams and can not be expected to stop the flow of a significant volume of water. They are designed and installed to trap sediment, not to halt the movement of the water itself. In most situations, turbidity curtains should not be installed across channel flows.

In tidal or moving water conditions, provisions must be made to allow the volume of water contained within the curtain to change. Since the bottom of the curtain is weighted and external anchors are frequently added, the volume of water contained within the curtain will be much greater at high tide verses low tide and measures must be taken to prevent the curtain from submerging. In addition to allowing for slack in the curtain to rise and fall, water must be allowed to flow through the curtain if the curtain is to remain in roughly the same spot and to maintain the same shape. Normally, this is achieved by constructing part of the curtain from a heavy woven filter fabric. The fabric allows the water to pass through the curtain, but retains the sediment pollutants. Consideration should be given to the volume of water that must pass through the fabric and sediment particle size when specifying fabric permeability.

Sediment which has been deflected and settled out by the curtain may be removed if so directed by the on-site inspector or the Plan-Approving Authority. However, consideration must be given to the probable outcome of the procedure - will it create more of a sediment problem resuspension of particles and by accidental dumping of the material by the equipment involved? It is, therefore, recommended that the soil particles trapped by a turbidity curtain only be removed if there has been a significant change in the original contours of the affected area in the watercourse. Regardless of the decision made, soil particles should always be allowed to settle for a minimum of 6-12 hours prior to their removal by equipment or prior to removal of a turbidity curtain.

It is imperative that the intended function of the other controls in this chapter, to sediment out of the watercourse, be the strategy used in every erosion control plan. However, when proximity to the watercourse makes successfully mitigating sediment loss impossible, the use of the turbidity curtain during land disturbance is essential.

Design Criteria

1. Type I configuration (see Figure 27-1) should be used in protected areas where there is no current and the area is sheltered from wind and waves.

2. Type II configuration (see Figure 27-1) should be used in areas where there may be small to moderate current running up to 4 km/hr or 1 m/sec (2 knots or 3.5 feet per second) and/or wind and wave action can effect the curtain.

3. Type III configuration (see Figure 27-2) should be used in areas where considerable current up to 6 km/hr or 1.5 m/sec (3 knots or 5 feet per second) may be present, where tidal action may be present and/or where the curtain is potentially subject to wind and wave action.

FIGURE 27-1: TURBIDITY CURTAIN

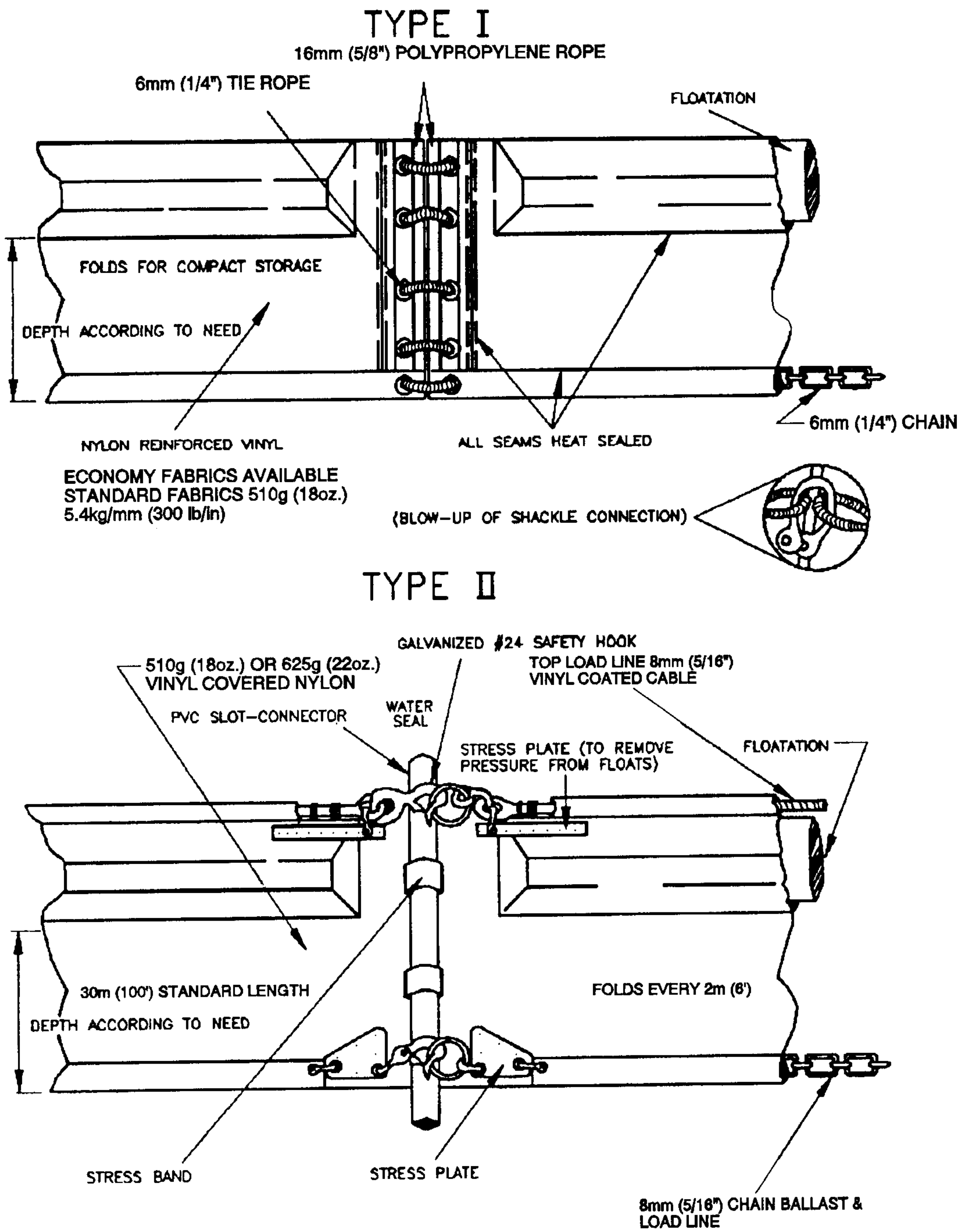
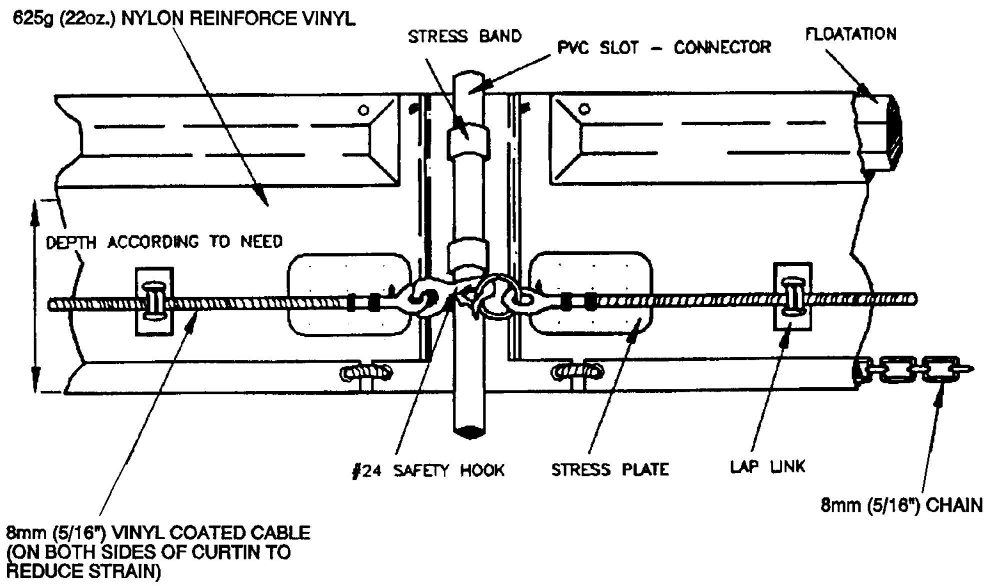
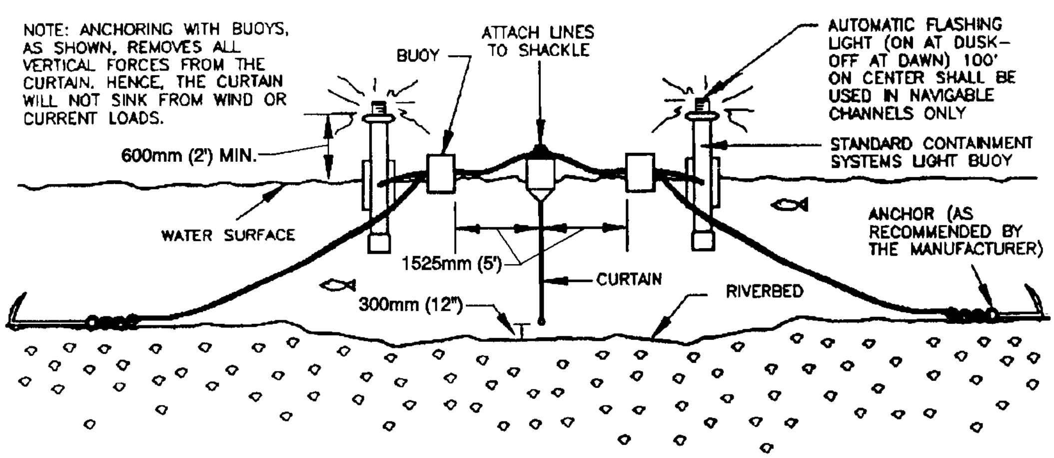


FIGURE 27-2: TURBIDITY CURTAIN

TYPE III



ORIENTATION WHEN INSTALLED
(TIDAL SITUATION - TYPE III)



4. Turbidity curtains should extend the entire depth of the watercourse whenever the watercourse in question is not subject to tidal action and/or significant wind and wave forces.

5. In tidal and/or wind and wave action situations, the curtain should never be so long as to touch the bottom. A minimum 300 millimeter (1-foot) "gap" should exist between the weighted lower end of the skirt and the bottom at "mean" low water. Movement of the lower skirt over the bottom due to tidal reverses or wind and wave action on the flotation system may fan and stir sediments already settled out.

6. In tidal and/or wind and wave action situations, it is seldom practical to extend a turbidity curtain depth lower than 3 to 4 meters (10 to 12 feet) below the surface, even in deep water. Curtains which are installed deeper than this will be subject to very large loads with consequent strain on curtain materials and the mooring system. In addition, a curtain installed in such a manner can "billow up" towards the surface under the pressure of the moving water, which will result in an effective depth which is significantly less than the skirt depth.

7. Turbidity curtains should be located parallel to the direction of flow of a moving body of water. <u>Turbidity Curtains should not be placed across the main flow of a significant body of moving water</u>.

8. When sizing the length of the floating curtain, allow an additional 10-20% variance in the straight line measurements. This will allow for measuring errors, make installing easier and reduce stress from potential wave action during high winds.

9. An attempt should be made to avoid an excessive amount of joints in the curtain; a minimum continuous span of 15 meters (50 feet) between joints is a good "rule of thumb."

10. For stability reasons, a maximum span of 30 meters (100 feet) between joints (anchor or stake locations) is also a good rule to follow.

11. The ends of the curtain, both floating upper and weighted lower, should "tend well up into the shoreline, especially if high water conditions are expected. The ends should be secured firmly to the shoreline (preferably to rigid bodies such as trees or piles) to fully enclose the area where sediment may enter the water.

12. When there is a specific need to extend the curtain to the bottom of the watercourse in tidal or moving water conditions, a heavy woven pervious filter fabric may be substituted for the normally recommended impervious

geotextile. This creates a "flow-through" medium which significantly reduces the pressure on the curtain and will help to keep it in the same relative location and shape during the rise and fall of tidal waters.

13. Typical alignments of turbidity curtains can be seen in Figure 27-3. The number and spacing of external anchors may vary depending on current velocities and potential wind and wave action; manufacturer's recommendations should be followed.

Construction Specifications

Materials-

1. Barriers should be a bright color (yellow or "international" orange are recommended) that will attract the attention of nearby boaters.

2. The curtain fabric must meet the minimum requirements noted in Table 27-1.

3. Seams in the fabric shall be either vulcanized welded or sewn, and shall develop the full strength of the fabric.

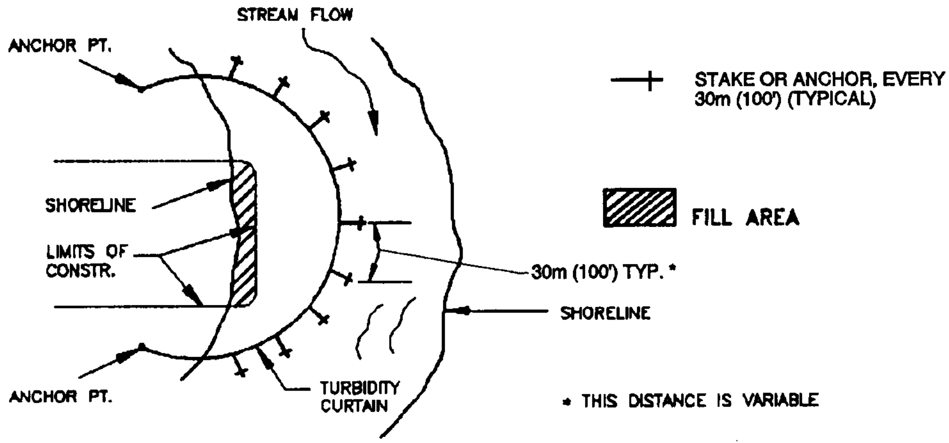
4. Floatation devices shall be flexible, buoyant units contained in an individual floatation sleeve or collar attached to the curtain. Buoyancy provided by the floatation units shall be sufficient to support the weight of the curtain and maintain a freeboard of at least 3 inches above the water surface level (see Figure 27-2).

TABLE 27-1
PHYSICAL PROPERTIES OF TURBIDITY CURTAIN FABRIC

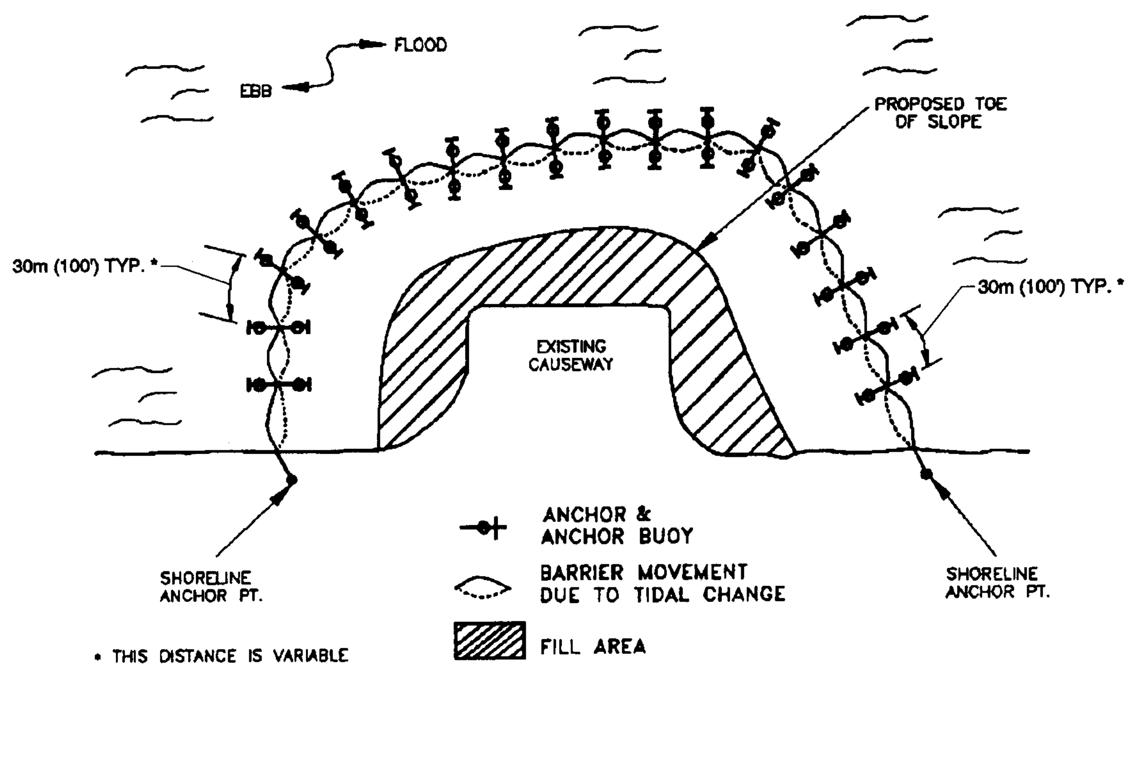
Physical Property	Requirement	
Thickness	45 mills	
Weight	grams per square meter	ounces per square yard
Type I	610	18
Type II	610 or 746	18 or 22
Type III	746	22
Grab Tensile Strength	136 kilograms	300 pounds
UV Inhibitor	Must be included	

FIGURE 27-3: TURBIDITY CURTAIN

TYPICAL LAYOUTS:
STREAMS, PONDS & LAKES (PROTECTED & NON-TIDAL)



TIDAL WATERS AND/OR HEAVY WIND & WAVE ACTION



5. Load lines must be fabricated into the bottom of all floating turbidity curtains. Type II and Type III must have load lines also fabricated into the top of the fabric. The top load line shall consist of woven webbing or vinyl-sheathed steel cable and shall have a break strength in excess of 4,500 kilograms (10,000 pounds). The supplemental (bottom) loadline shall consist of a chain incorporated into the bottom hem of the curtain of sufficient weight to serve as ballast to hold the curtain in a vertical position. Additional anchorage shall be provided as necessary. The load lines shall have suitable connecting devices which develop the full breaking strength for connecting to load lines in adjacent sections (see Figures 27-1 and 27-2 which portray this orientation).

6. External anchors may consist of wooden or metal stakes 50 x 100 millimeters (2 x 4 inch) or 60 millimeter (2.5-inch) minimum diameter wood or 2 kilogram per linear meter steel (1.33 pounds/linear foot) when Type I installation is used; when Type II or Type III installations are used, bottom anchors should be used.

7. Bottom anchors must be sufficient to hold the curtain in the same position relative to the bottom of the watercourse without interfering with the action of the curtain. The anchor may dig into the bottom (grappling hook, plow or fluke-type) or may be weighted (mushroom type) and should be attached to a floating anchor buoy via an anchor line. The anchor line would then run from the buoy to the top load line of the curtain. When used with Type III installations, these lines must contain enough slack to allow the buoy and curtain to float freely with tidal changes without pulling the buoy or curtain down and must be checked regularly to make sure they do not become entangled with debris. As previously noted, anchor spacing will vary with current velocity and potential wind and wave action; manufacturer's recommendations should be followed. See orientation of external anchors and anchor buoys for tidal installation in Figure 27-2.

Installation

1. In the calm water of lakes or ponds (Type I installation) it is usually sufficient to merely set the curtain end stakes or anchor points (using anchor buoys if bottom anchors are employed), then tow the curtain <u>in the furled condition</u> out and attach it to these stakes or anchor points. Following this, any additional stakes or buoyed anchors required to maintain the desired location of the curtain may be set and these anchor points made fast to the curtain. the furling lines should be cut to let the curtain skirt drop.

2. In rivers or in other moving water (Type II and Type III installations) it is important to set all the curtain anchor points. Care must be taken to ensure

that anchor points are of sufficient holding power to retain the curtain under the existing current conditions, prior to putting the furled curtain into the water. Again, anchor buoys should be employed on all anchors to prevent the current from submerging the flotation at the anchor points. If the moving water into which the curtain is being installed is tidal and will subject the curtain to currents in both directions as the tide changes, it is important to provide anchors on both sides of the curtain for two reasons:

a) Curtain movement will be minimized during tidal current reversals.

b) The curtain will not overrun the anchors and pull them out when the tide reverses.

When the anchors are secure, the <u>furled</u> curtain should be secured to the upstream anchor point and then sequentially attached to each next downstream anchor point until the entire curtain is in position. At this point, and before unfurling, the "lay" of the curtain should be assessed and any necessary adjustments made to the anchors. Finally, when the location is ascertained to be as desired, the furling lines should be cut to allow the skirt to drop.

3. <u>Always attach anchor lines to the flotation device, not to the bottom of the curtain</u>. The anchoring line attached to the floatation device on the downstream side will provide support for the curtain. Attaching the anchors to the bottom of the curtain could cause premature failure of the curtain due to the stresses imparted on the middle section of the curtain.

4. There is an exception to the rule that turbidity curtains should not be installed across channel flows; it occurs when there is a danger of creating a silt build-up in the middle of a watercourse, thereby blocking access or creating a sand bar. Curtains have been used effectively in large areas of moving water by forming a very long sided, sharp "V" to deflect clean water around a work site, confine a large part of the silt-laden water to the work area inside the "V' and direct much of the silt toward the shoreline. Care must be taken, however, not to install the curtain perpendicular to the water current.

5. See Figure 27-3 for typical installation layouts.

Removal

1. Care should be taken to protect the skirt from damage as the turbidity curtain is dragged from the water.

2. The site selected to bring the curtain ashore should be free of sharp rocks, broken cement, debris, etc. so as to minimize damage when hauling the curtain over the area.

3. If the curtain has a deep skirt, it can be further protected by running a small boat along its length with a crew installing furling lines before attempting to remove the curtain from the water.

Maintenance

1. The developer/owner shall be responsible for maintenance of the filter curtain for the duration of the project in order to ensure the continuous protection of the watercourse.

2. Should repairs to the geotextile fabric become necessary, there are normally repair kits available from the manufacturers; manufacturer's instructions must be followed to ensure the adequacy of the repair.

3. When the curtain is no longer required as determined by the inspector, the curtain and related components shall be removed in such a manner as to minimize turbidity. Remaining sediment shall be sufficiently settled before removing the curtain. Sediment may be removed and the original depth (or plan elevation) restored. Any spoils must be taken to upland area and be stabilized.

BMP-28

BMP: SUBSURFACE DRAIN

Definition

A perforated conduit such as pipe, tubing or tile installed beneath the ground to intercept and convey ground water.

Purposes

1. To prevent sloping soils from becoming excessively wet and subject to sloughing.

2. To improve the quality of the growth medium in excessively wet areas by lowering the water table.

3. To drain stormwater detention areas or structures.

Conditions Where Practice Applies

Wherever excess water must be removed from the soil. The soil must be deep and permeable enough to allow an effective system to be installed. Either a gravity outlet must be available or pumping must be provided. These standards do not apply to foundation drains.

Planning Considerations

Subsurface drainage systems are of two types, relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation, or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern (see Figure 28-1).

Interceptor drains are used to remove water as it seeps down a slope to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout (see Figure 28-2).

FIGURE 28-1: SURFACE DRAIN OUTLET

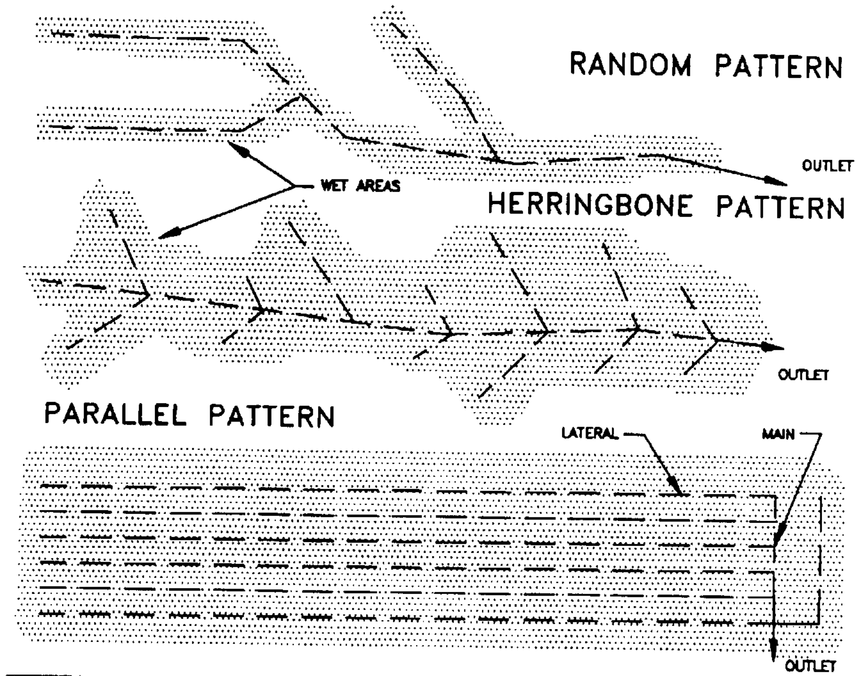
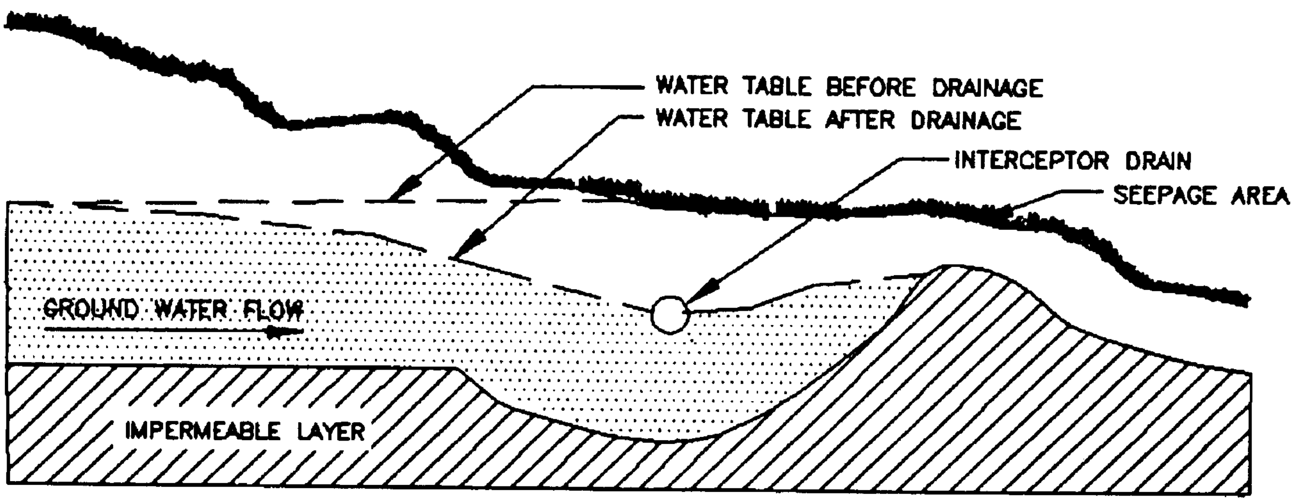


FIGURE 28-2: EFFECT OF SUBSURFACE DRAINAGE ON THE WATER TABLE



Design Criteria

Location -

Tree roots can often clog subsurface drain systems. Consequently, sub-surface drains should be located such that there are no trees within 15 meters (50 feet) of the drain.

Relief Drains - Relief drains should be located through the center of wet areas. They should drain in the same direction as the slope.

Interceptor drains - Interceptor drains should be located on the uphill side of wet areas. They should be installed across the slope and drain to the side of the slope.

Capacity of Drains -

The required capacity of a subsurface drain depends upon its use.

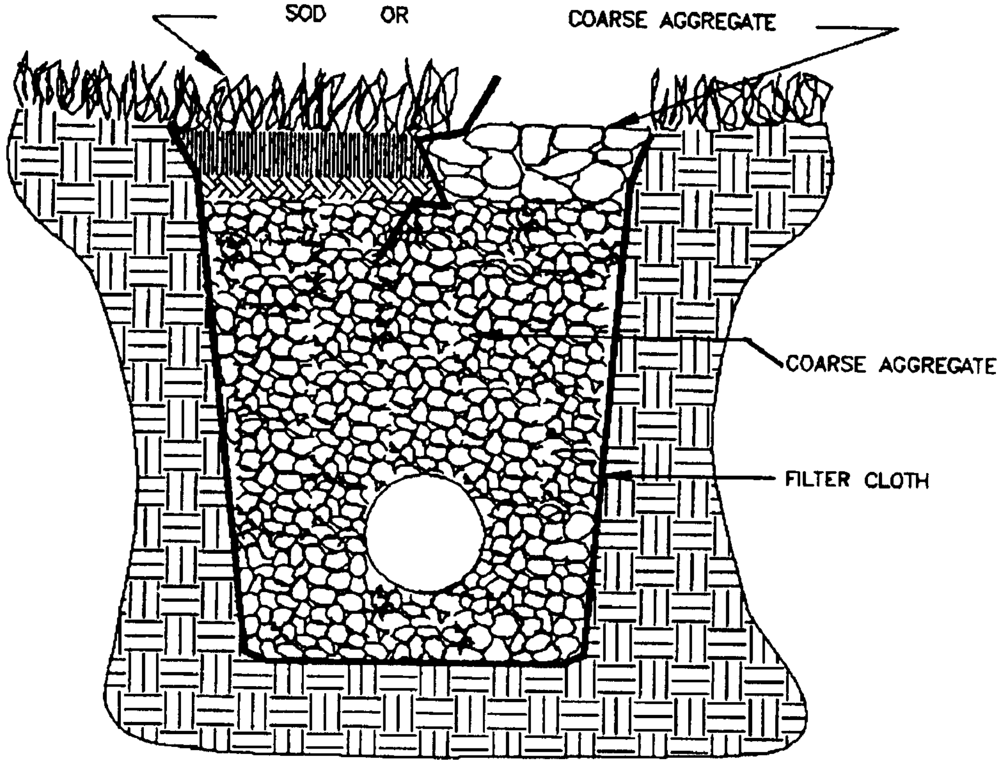
Relief Drains - Relief drains installed in a uniform pattern should remove a minimum of 25 millimeters (1 inch) of groundwater in 24 hours, approximately 0.003 cubic meters per hectare (0.042 cubic feet per acre). The design capacity must be increased accordingly to accommodate any surface water which enters directly into the system (see Figure 28-3).

Intercepts - Interceptor drains or relief drains installed in a random pattern should remove a minimum of 0.1 cubic meters per second per 1000 meter of length (1.5 cfs/1000 feet of length). This value should be increased for sloping land according to the values in Table 28-1. In addition, if a flowing spring or surface water enters directly into **the** system, this flow must be accommodated and the design capacity must be increased accordingly to take care of this flow (see Figure 28-4).

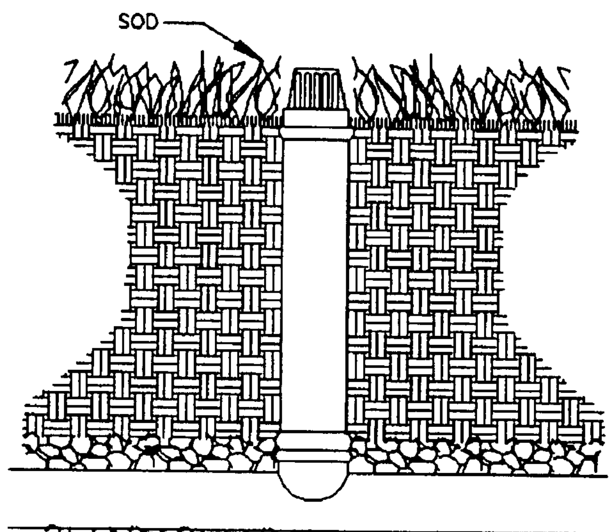
TABLE 28-1
WATER REMOVAL RATES FOR SLOPING LAND*

Land Slope	Water Removal Rates in cubic meters per second (cms) per 1000 meters (m)	
2 - 5%	0.15 cms/1000 m	1.65 cfs/1000 ft
6 - 12%	0.17 cms/1000 m	1.80 cfs/1000 ft
> 12%	0.18 cms/1000 m	1.95 cfs/1000 ft
* These rates depend on the soil types where the drains are installed. Heavier soils may result in slower water removal rates.		

FIGURE 28-3: SURFACE INLETS



NATURAL INLET



GRATED INLET

Size of Drains-

Subsurface drains should be sized for the required capacity using Table 28-4 and 28-5 in Appendix BMP28-a. The minimum diameter for a subsurface drain shall be 100 millimeters (4 inches).

Depth and Spacing -

Relief Drains - Relief drains installed in a uniform pattern should have equal spacing between drains and the drains should be at the same depth. Maximum depth is limited by the allowable load on the pipe, depth to impermeable layers in the soil, and outlet requirements. The minimum depth is 0.6 meters (2 foot) under normal conditions. The 0.6 meter depth is acceptable where the drain will not be subject to equipment loading or frost action. Spacing between drains is dependent on soil permeability and the depth of the drain. In general, however, a depth of 1 meter (3 feet) and a spacing of 15 meters (50 feet) will be adequate. A more economical system may be designed, if the necessary information is available, by using the equations found in Appendix 28-a.

Interceptor drain - The depth of installation of an interceptor drain is influenced mainly by the depth to which the water table is to be lowered. The maximum depth is limited by the allowable load on the pipe and the depth to an impermeable layer. Minimum depth should be the same as for relief drains.

One interceptor drain is usually sufficient. However, if multiple drains are to be used, determining the required spacing can be difficult. The best approach is to install the first drain - then if seepage or high water table problems occur downslope, install an additional drain a suitable distance downslope. This distance can be calculated from equations found in Appendix 28-a.

Velocity and Grade -

The minimum velocity required to prevent silting is 0.4 meters/sec (1.4 ft/sec). The line should be graded to achieve at least this velocity. Steep grades should be avoided. Table 28-2 lists maximum velocities for various soil textures.

Envelopes -

Envelopes shall be used around all drains for proper bedding and improved flow of groundwater into the drain. The envelope shall consist of 75 millimeters (3 inches) of aggregate placed completely around the drain. The stone shall be encompassed by a filter cloth separator in order to prevent the migration of surrounding soil particles into the drain (see Figure 28-4). Filter cloth must meet the physical requirements noted in BMP-19, RIPRAP.

TABLE 28-2
MAXIMUM VELOCITIES FOR VARIOUS SOIL TEXTURES

Soil Texture	Maximum Velocity	
	meters per second	feet per second
Sandy and Sandy Loam	1.1	3.5
Silt and Silt Loam	1.5	5.0
Silty Clay Loam	1.8	6.0
Clay and Clay Loam	2.1	7.0
Coarse Sand or Gravel	2.7	9.0

Surface Water -

Figure 28-3 shows two types of surface water inlets. The grated inlet should not be used where excessive sedimentation might be a problem.

Outlet -
The outlet of the subsurface drain shall empty into a channel or some other watercourse which will remove the water from the outlet. It shall be above the mean water level in the receiving channel. It shall be protected from erosion, undermining, damage from periods of submergence, and the entry of small animals into the drain.

The outlet shall consist of a 3 meter (10-foot) section of corrugated metal, cast iron, steel or schedule 40 PVC pipe without perforations. No envelope material shall be used around the pipe. At least two-thirds of the outlet pipe length shall be buried.

Materials -

Acceptable materials for subsurface drains include perforated, continuous closed-joint conduits of corrugated plastic, concrete, corrugated metal, asbestos cement, and bituminous fiber. The strength and durability of the pipe shall meet the requirements of the site in accordance with the manufacturers specifications.

Construction Specifications

1. The trench shall be constructed on a continuous grade with no reverse grades or low spots.

2. Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.

3. Deformed, warped, or otherwise unsuitable pipe shall not be used.

4. Envelopes or filter material shall be placed as specified with at least 75 millimeters (3 inches) of material on all sides of the pipe.

5. Backfilling shall be done immediately after placement of the pipe. No sections of pipe should remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.

6. The outlet section of the drain shall consist of at least 3 meters (10 feet) of non-perforated corrugated metal, cast iron, steel or schedule 40 PVC pipe. At least two-thirds of its length shall be buried.

Maintenance

1. Subsurface drains should be checked periodically to ensure that they are free-flowing and not clogged with sediment.

2. The outlet should be kept clean and free of debris.

3. Surface inlets should be kept open and free of sediment and other debris.

4. Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees.

5. Where drains are crossed by heavy vehicles, the line should be checked to ensure that it is not crushed.

APPENDIX 28-a

Subsurface drains are not generally designed to flow under pressure and the hydraulic gradient is parallel with the grade line. Consequently, the flow is considered to be open channel and Manning's Equation can be used. The metric conversion of this appendix has been delayed until standardized metric nomographs and charts are readily available. Typical metric conversions are listed where applicable. The required drain size can be determined by the following procedure:

1. Determine the flow the drain must carry.

2. Determine the gradient of the drain

3. From Table 28-3, determine "n" for the type of drain pipe to be used. Choose the correct Table (28-4 through 28-6) for the "n" just determined.

4. Enter the appropriate plate with the gradient of the pipe and the flow in the pipe. The intersection of the two lines must be to the right of the line for 1.4 ft/sec. If it is not, increase the gradient or flow capacity or both.

Example 1 -

Given:

A random subsurface drain is to be installed on a 1.0% grade, 700 feet in length, and using corrugated plastic pipe.

Calculate: The required size of the drain pipe.

Solution:

From the BMP, the required capacity of the pipe is:

$$1.5\ ft^3/sec/1000\ ft$$

$$Capacity = \frac{700 ft.}{1000 ft.} \times 1.5 ft.^3/sec = 1.05 ft^3/sec$$

From Table 28-3, n = 0.015 for corrugated plastic pipe.

From Table 28-5, choose a 8-inch pipe (200 millimeter).

Example 2 -

Given:

A relief drain installed in a gridiron pattern of 8 laterals, 500 feet long, 0.5% grade, and 50 feet on centers. A main 400 feet in length on a 0.5% grade will connect to the laterals. Use bitumenized fiber pipe for the main and laterals.

Calculate: The required size of the drain pipe.

Solution:

The drainage area for each lateral is 25 feet on either side of the pipe times the length. Therefore:

$$\frac{50\,ft \times 500\,ft}{43{,}560\,\frac{ft^2}{acre}} = 0.57\,acre$$

From the BMP, the drains must remove a minimum of 1 inch of groundwater in 24 hours or 0.042 cfs/acre.

$$0.042 \text{ cfs/acre} \times 0.57 \text{ acre} = 0.02 \text{ cfs}$$

From Table 28-3, n = 0.013 for bituminized fiber pipe.

From Table 28-5, a 4-inch pipe (100 millimeter) must be used for the laterals.

The first 25 feet of the main will drain 25 feet on either side of the pipe. The remaining 375 feet will drain only 25 feet on the side opposite from the laterals. In addition, the main will drain the laterals.

Drainage from main:

$$\frac{25ft \times 50ft}{43{,}560 ft^2/acre} + \frac{375ft \times 25ft.}{43{,}560 ft^2/acre} = 0.24 acre$$

Drainage from laterals:

8 x 0.57 acre = 4.56 acre

Total = 0.24 + 4.56 = 4.8 acre

Required capacity:

0.042 ft./sec./acre x 4.8 acre = 0.20 cfs

From Table 28-4, choose a 5-inch pipe (125 millimeter) for the main.

TABLE 28-3
"n" VALUES FOR SUBSURFACE DRAIN PIPES

Composition of Pipe or Tubing	"n" Value
Asbestos Cement	0.013
Bitumenized Fiber	0.013
Concrete	0.015
Corrugated Plastic	0.015
Corrugated Metal	0.025

Spacing of Relief Drains

If the necessary information is known, the following equation can be used to calculate drain spacing in lieu of the recommended standard:

$$S = \sqrt{\frac{4k(M^2 + 2AM)}{q}}$$

Where,

S = drain spacing, feet

k = average hydraulic conductivity, inches per hour (for practical purposes, hydraulic conductivity is equal to permeability).

M = vertical distance, after drawdown, of water table above drain at mid-point between lines, feet.

A = depth of barrier below drain, feet.

q = drainage coefficient, rate of water removal, inches/hour (in/hr).

Spacing of Interceptor Drains -

If one interceptor drain is not sufficient, the spacing of multiple drains can be calculated by the following equation:

$$Le=\frac{ki}{q}\,(de-dw+W_2)$$

Where,

Le = the distance downslope from the drain to the point where the water table is at the desired depth after drainage, feet. The second drain should be located at this point.

k = the average hydraulic conductivity of the subsurface profile to the depth of the drain, in./hr.

q = drainage coefficient, rate of water removal, in./hr.

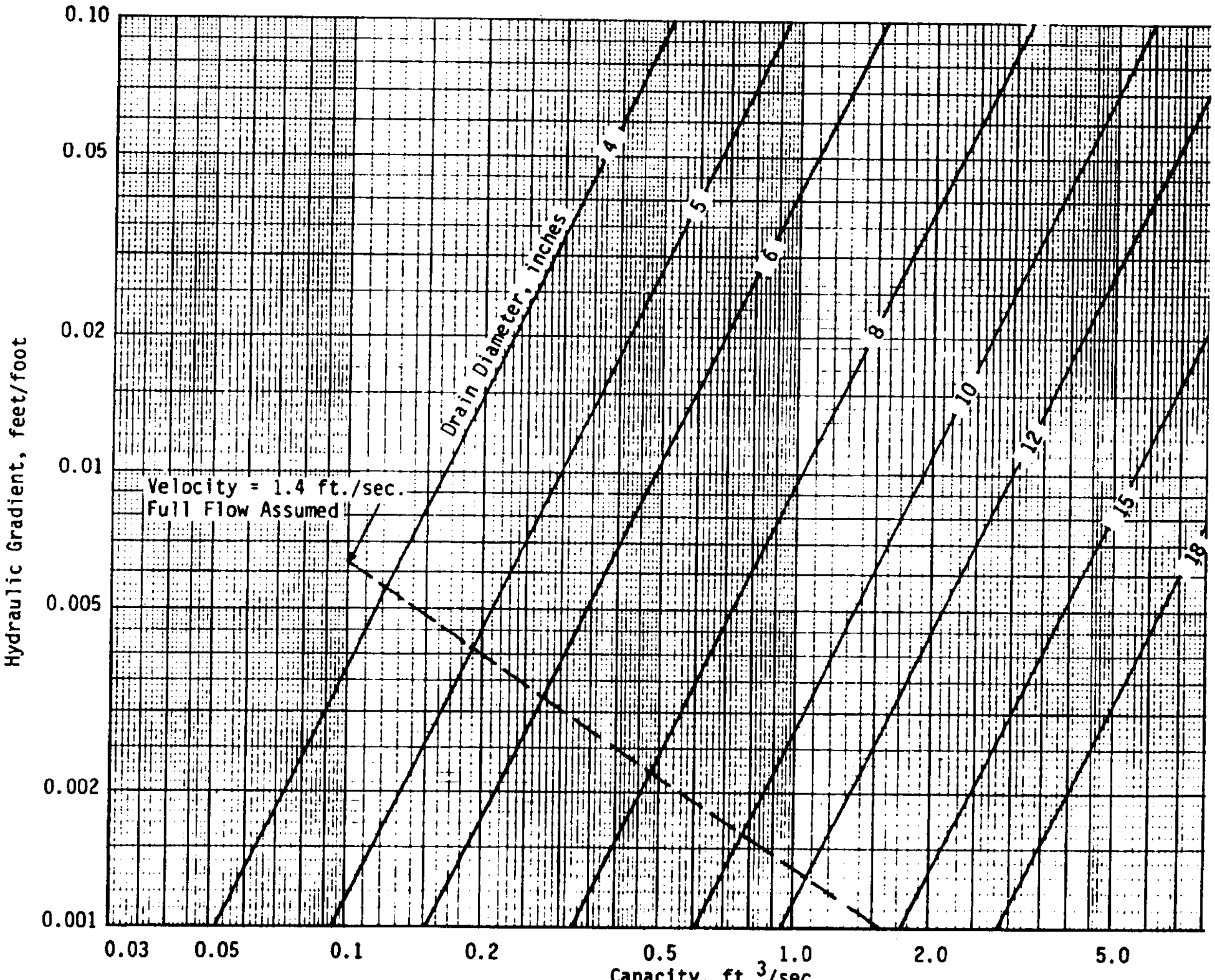
i = the hydraulic gradient of the water table before drainage, feet/foot.

de = the effective depth of the drain, feet.

dw = the desired minimum depth to water table after drainage, feet.

W_2 = the distance from the ground surface to the water table, before drainage, at the distance (Le) downslope from the drain, feet.

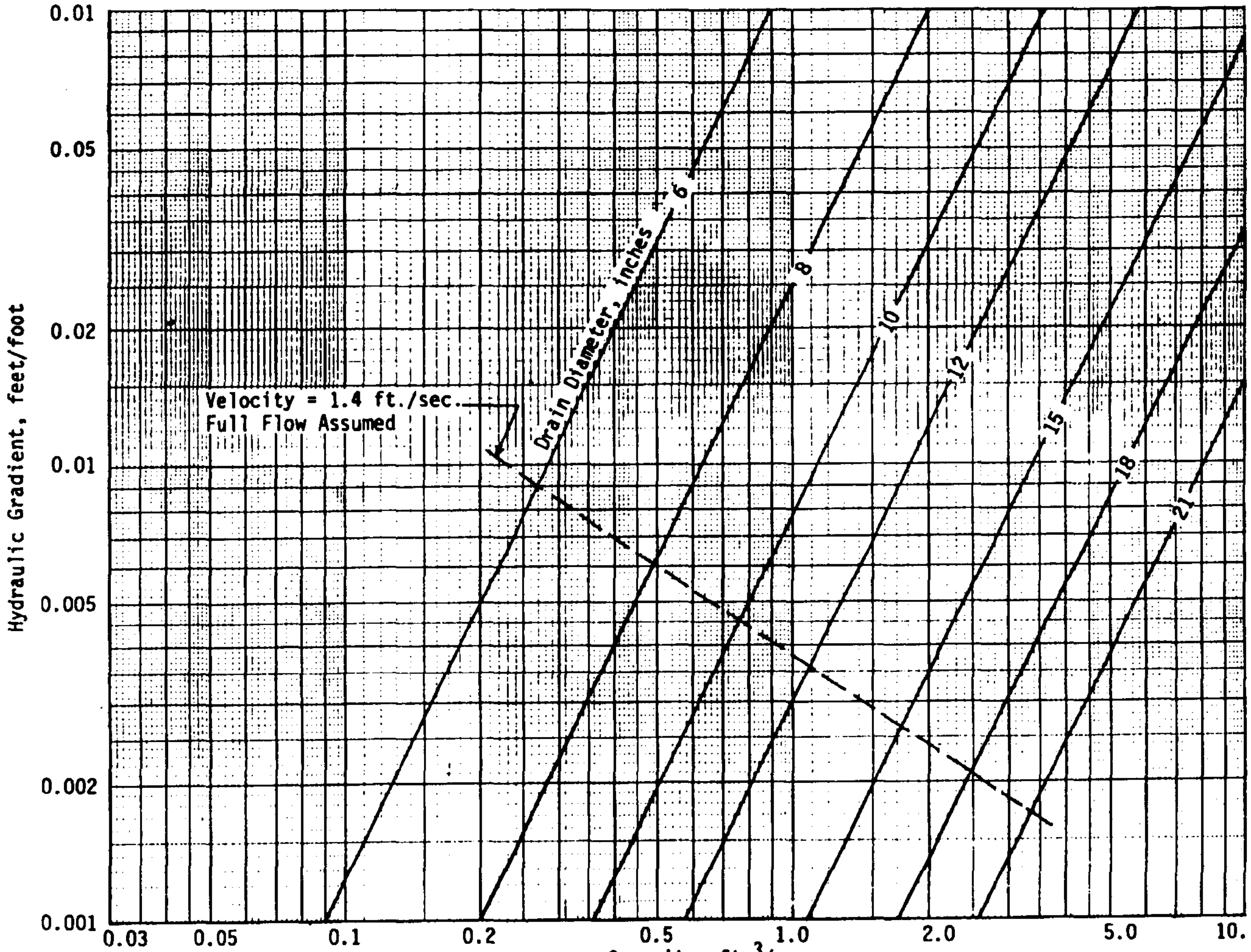
TABLE 28-5: SUBSURFACE DRAIN CAPACITY, n = 0.015



SUBSURFACE DRAIN CAPACITY, n = 0.015

Typical Metric Conversions:
Cubic meters per second = cubic feet per second x 35.3357
meter = feet x 0.3048
millimeters = inches x 25.4

TABLE 28-6: SUBSURFACE DRAIN CAPACITY, n = 0.025



SUBSURFACE DRAIN CAPCITY, n = 0.025

Typical Metric Conversions:
Cubic meters per second = cubic feet per second x 35.3357
meter = feet x 0.3048
millimeters = inches x 25.4

BMP-29

BMP: SURFACE ROUGHENING

Definition

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

Purposes

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

Conditions Where Practice Applies

1. All slopes steeper than 3:1 require surface roughening, either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.
2. Areas with grades less steep than 3:1 should have the soil surface lightly roughened and loose to a depth of 25 to 50 millimeters (2 to 4 inches) prior to seeding.
3. Areas which have been graded and will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.
4. Slopes with a stable rock face do not require roughening or stabilization.

Planning Considerations

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

Rough loose soil surfaces give lime, fertilizer and seed some natural coverage. Niches in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

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

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

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

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

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

<u>Specifications</u>

Cut Slope Applications For Areas Which Will Not Be Mowed -

Cut slopes with a gradient steeper than 3:1 shall be stair-step graded or grooved (Figures 29-1 and 29-2).

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

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

   Individual vertical cuts shall not be more than 75 millimeters (30 inches) on soft soil materials and not more than 1,000 millimeters (40 inches) in rocky materials.

FIGURE 29-1: STAIR STEPPING CUT SLOPES

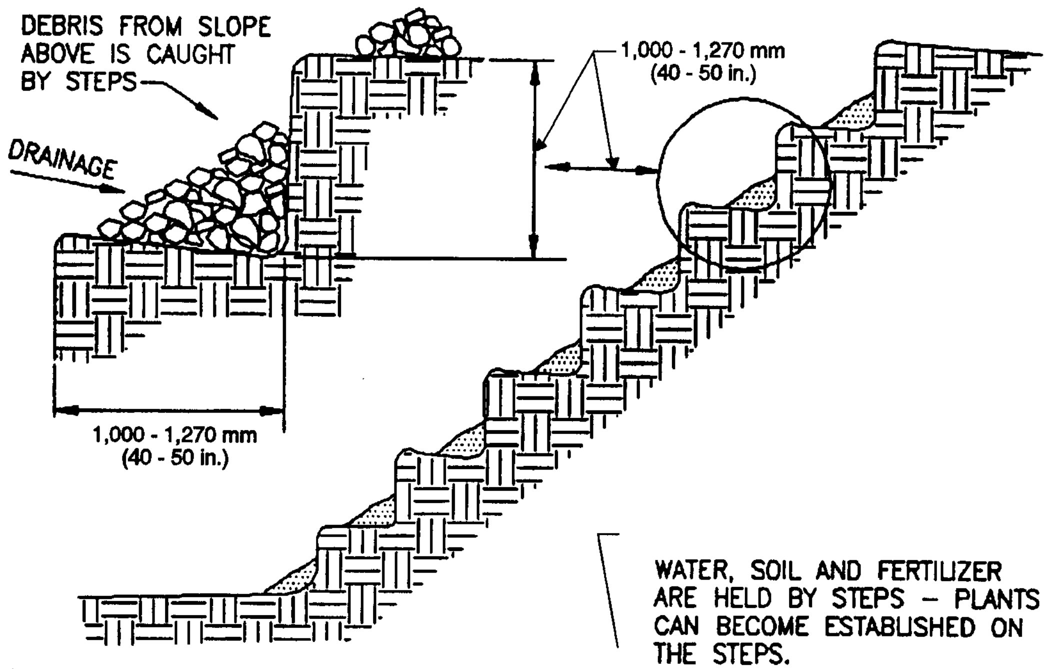


FIGURE 29-2: GROOVING SLOPES

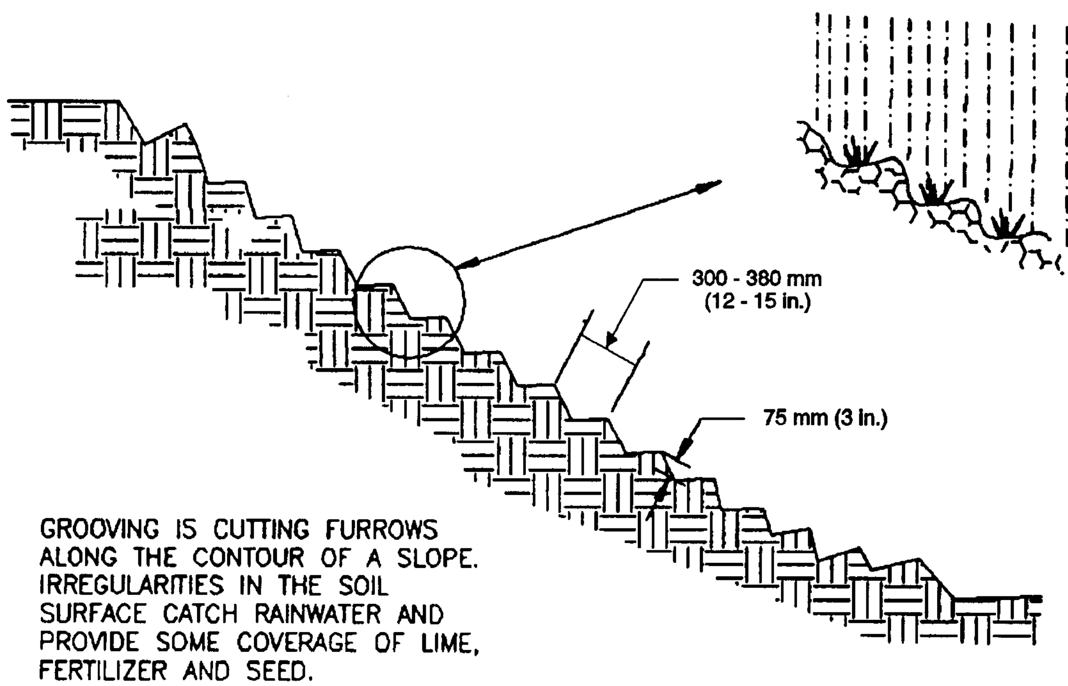
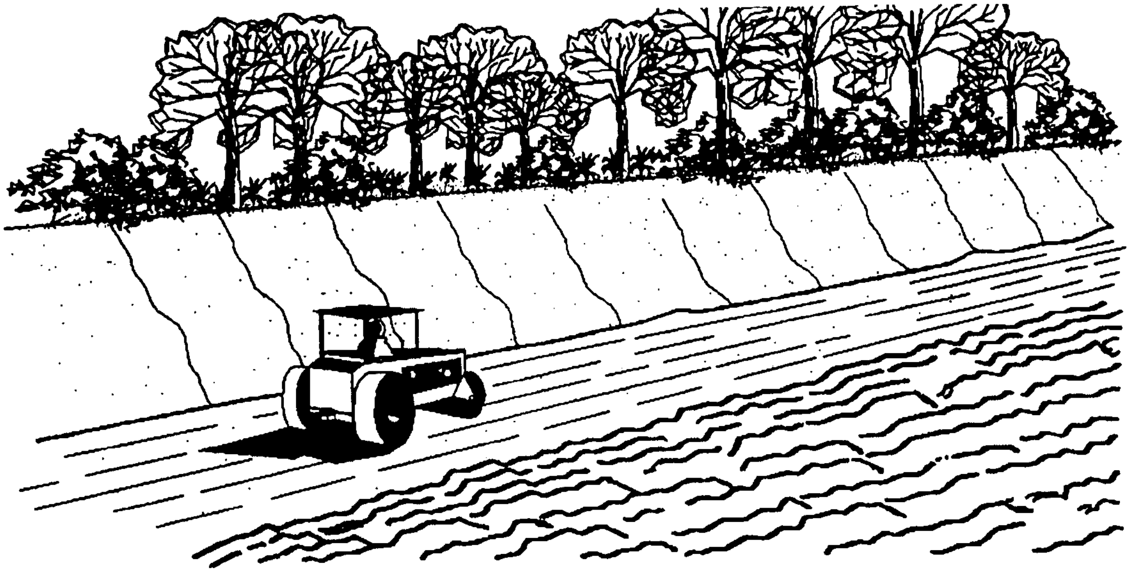
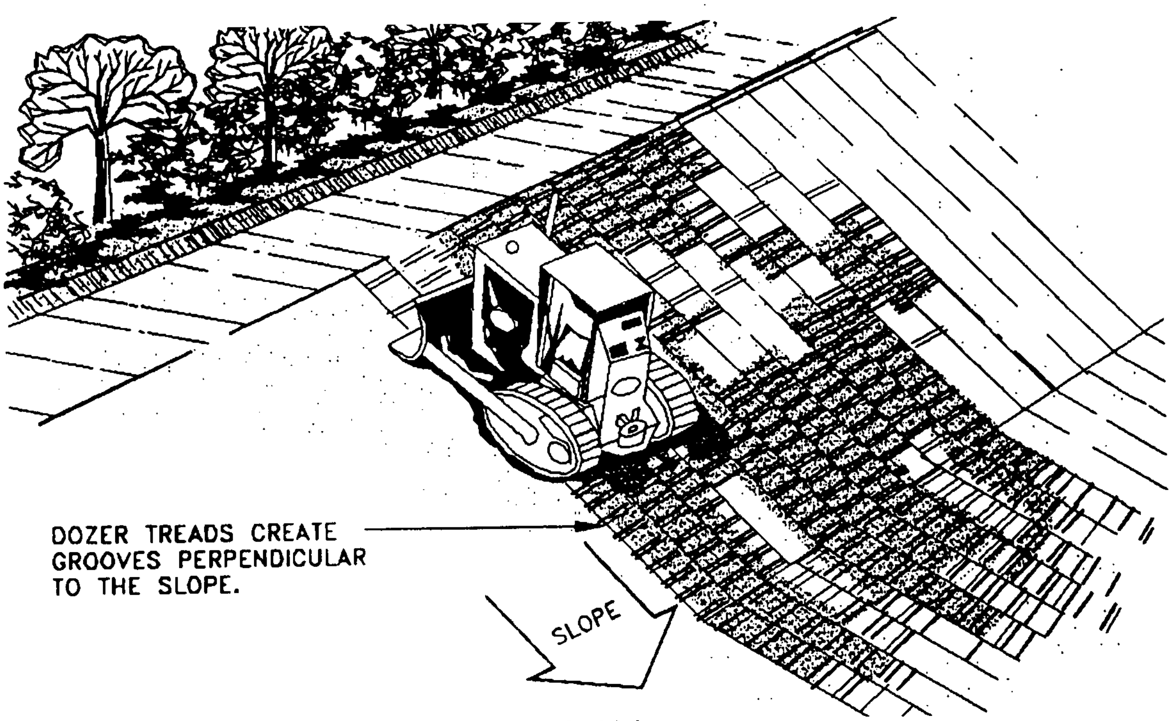


FIGURE 29-3: FILL SLOPE TREATMENT



EACH LIFT OF THE FILL IS COMPACTED, BUT THE OUTER FACE OF THE SLOPE IS ALLOWED TO REMAIN LOOSE SO THAT THE ROCKS, CLODS, ETC. REACH THE NATURAL ANGLE OF REPOSE.

FIGURE 29-4: TRACKING



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

   Grooves may be made with any appropriate implement which can be safely operated on the slope and which will not cause undue compaction. Suggested implements include discs, tillers, spring harrows, and the teeth on a front-end loader bucket. Such grooves shall not be less than 75 millimeters (3 inches) deep nor further than 400 millimeters (15 inches) apart.

Fill Slope Applications For Areas Which Will Not Be Mowed -

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

1. Groove according to #2 above.

2. As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface (see Figure 29-3).

Colluvial materials (soil deposits at the base of slopes or from old stream beds) shall not be used in fills as they flow when saturated.

At no time shall slopes be bladed or scraped to produce a smooth, hard surface.

Cuts Fills, and Graded Areas Which Will Be Mowed -

Mowed slopes <u>should not be steeper than 3:1</u>. Excessive roughness is undesirable where mowing is planned. These areas may be roughened with shallow grooves such as remain after tilling, discing, harrowing, raking, or use of a cultipacker-seeder. The final pass of any such tillage implement shall be on the contour (perpendicular to the slope).

Grooves formed by such implements shall be not less than 25 millimeter (1-inch) deep and not further than 30 millimeters (12-inches) apart. Fill slopes which are left rough as constructed may be smoothed with a dragline or pickchain to facilitate mowing.

Roughening With Tracked Machinery (see Figure 29-4) -

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

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

Seeding -

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

BMP: TOPSOILING

Definition

Methods of preserving and using the surface layer of undisturbed soil, often enriched in organic matter, in order to obtain a more desirable planting and growth medium.

Purpose

To provide a suitable growth medium for final site stabilization with vegetation.

Conditions Where Practice Applies

1. Where the preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium.

2. Where the subsoil or existing soil presents the following problems:

    a. The texture, pH, or nutrient balance of the available soil cannot be modified by reasonable means to provide an adequate growth medium.

    b. The soil material is too shallow to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth.

    c. The soil contains substances potentially toxic to plant growth.

3. Where high quality turf is desirable to withstand intense use or meet aesthetic requirements.

4. Where ornamental plants will be established.

5. Only on slopes that are 2:1 or flatter unless other measures are taken to prevent erosion and sloughing.

Planning Considerations

Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants, and supplying a large share of the water used by plants.

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

Advantages of topsoil include its high organic matter content and friable consistence, water holding capacity, and nutrient content.

In site planning, the option of topsoiling should be compared with that of preparing a seedbed in subsoil. The clay content of subsoils does provide high moisture availability and deter leaching of nutrients and, when properly limed and fertilized, subsoils may provide a good growth medium which is generally free of weed seeds. In many cases topsoiling may not be required for the establishment of less demanding, lower maintenance plant material. Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a required procedure when establishing vegetation on shallow soils, soils containing potentially toxic materials, and soils of critically low pH (high acid) levels.

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

1. Whether an adequate volume of topsoil exists on the site. Topsoil will be spread at a compacted depth of 50 to 100 millimeters (2 to 4 inches) (depths closer to 100 millimeters (4 inches) are preferred).

2. Location of the topsoil stockpile so that it meets specifications and does not interfere with work on the site.

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

4. Care must be taken not to apply topsoil to subsoil if the two soils have contrasting textures. Clayey topsoil over sandy subsoil is a particularly poor combination, as water may creep along the junction between the soil layers, causing the topsoil to slough. Sandy topsoil over a clay subsoil is equally as likely to fail.

5. If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. <u>Topsoiling of steep slopes should be discouraged unless good bonding of soils can be achieved</u>.

<u>Specifications</u>

Materials -

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

All topsoil shall be tested by a recognized laboratory for the following criteria:

> <u>Organic matter</u> content shall be not less than 1.5% by weight.
>
> <u>pH range</u> shall be from 6.0-7.5. If pH is less than 6.0, lime shall be added in accordance with soil test results or in accordance with the recommendations of the vegetative establishment practice being used.
>
> <u>Soluble salts</u> shall not exceed 500 ppm.

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

Stripping -

Topsoil operations should not be performed when the soil is wet or frozen. Stripping shall be confined to the immediate construction area. A 100 to 150 millimeter (4 to 6 inch) stripping depth is common, but depth may vary depending on the particular soil. All perimeter dikes, basins, and other sediment controls shall be in place prior to stripping.

Stockpiling -

Topsoil shall be stockpiled in such a manner that natural drainage is not obstructed and no off-site sediment damage shall result. Stockpiles should be stabilized or protected.

Side slopes of the stockpile shall not exceed 2:1.

Perimeter controls must be placed around the stockpile immediately; seeding of stockpiles shall be completed within 7 days of the formation of the stockpile, in accordance with BMP-31, TEMPORARY SEEDING if it is to remain dormant for longer than 30 days.

Site Preparation Prior to and Maintenance During Topsoiling -

Before topsoiling, establish needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, dikes, level spreaders, waterways, sediment basins, etc. These practices must be maintained during topsoiling.

Grading: Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.

Liming: Where the pH of the subsoil is 6.0 or less, or the soil is composed of heavy clays, agricultural limestone shall be spread in accordance with the soil test or the vegetative establishment practice being used.

Bonding: After the areas to be topsoiled have been brought to grade, and immediately prior to dumping and spreading the topsoil, the subgrade shall be loosened by discing or scarifying to a depth of at least 50 millimeters (2 inches) to ensure bonding of the topsoil and subsoil.

Applying Topsoil -

Topsoil shall not be placed while in a frozen or muddy condition, when topsoil or subgrade is excessively wet, or in a condition that may otherwise be detrimental to proper grading or proposed sodding or seeding. The topsoil shall be uniformly distributed to a minimum compacted depth of 25 millimeters (2 inches) on 3:1 or steeper slopes and 100 millimeters (4 inches) on flatter slopes. (See Table 30-1 to determine volume of topsoil required for application to various depths). Any irregularities in the surface, resulting from topsoiling or other operations, shall be corrected in order to prevent the formation of depressions or water pockets.

It is necessary to compact the topsoil enough to ensure good contact with the underlying soil and to obtain a level seedbed for the establishment of high maintenance turf. However, undue compaction is to be avoided as it increases runoff velocity and volume, and deters seed germination. Special consideration should be given to the types of equipment used to place topsoil in areas to receive fine turf. Avoid unnecessary compaction by heavy machinery whenever possible. In areas which are not going to be mowed, the surface should be left rough in accordance with SURFACE ROUGHENING (BMP-29).

Soil Sterilants -

No sod or seed shall be placed on soil which has been treated with soil sterilants until sufficient time has elapsed to permit dissipation of toxic materials.

TABLE 30-1
AMOUNT OF TOPSOIL REQUIRED
FOR APPLICATION TO VARIOUS DEPTHS

Depth		cubic meters per 1000 square meters	cubic yards per 1000 square feet	cubic meters per hectare	cubic yards per acre
millimeters	inches				
25	1	25.5	3.1	253	134
50	2	51.0	6.2	506	268
75	3	76.5	9.3	761	403
100	4	102.0	12.4	1014	537
125	5	127.6	15.5	1270	672
150	6	153.0	18.6	1523	806

BMP: TEMPORARY SEEDING

Definition

The establishment of a temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.

Purposes

1. To reduce erosion and sedimentation by stabilizing disturbed areas that will not be brought to final grade for a period of more than 30 days.

2. To reduce damage from sediment and runoff to downstream or off-site areas, and to provide protection to bare soils exposed during construction until permanent vegetation or other erosion control measures can be established.

Conditions Where Practice Applies

Where exposed soil surfaces are not to be fine-graded for periods longer than 30 days. Such areas include denuded areas, soil stockpiles, dikes, dams, sides of sediment basins, temporary roadbanks, etc. A permanent vegetative cover shall be applied to areas that will be left dormant for a period of more than 1 year.

Planning Considerations

Sheet erosion, caused by the impact of rain on bare soil, is the source of most fine particles in sediment. To reduce this sediment load in runoff, the soil surface itself should be protected. <u>The most efficient and economical means of controlling sheet and rill erosion is to establish vegetative cover</u>. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover. Temporary seeding is encouraged whenever possible to aid in "controlling" construction sites.

Temporary seeding also prevents costly maintenance operations on other erosion control systems. For example, sediment basin clean-outs will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. Perimeter dikes will be more effective if not choked with sediment.

Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Specifications

Prior to seeding, install necessary erosion control practices such as dikes, waterways, and basins.

Plant Selection -

Select plants appropriate to the season and site conditions from Tables 31-2 and 31-3. Note that Table 31-2 presents plants which can be used without extensive evaluation of site conditions; Table 31-3 presents more in-depth information on the plant materials.

Seedbed Preparation -

To control erosion on bare soil surfaces, plants must be able to germinate and grow. Seedbed preparation is essential.

1. An evaluation should be conducted to determine if lime is necessary for temporary seeding. In most soils, it takes up to 6 months for a pH adjustment to occur following the application of lime. Therefore, it may be difficult to justify the cost of liming a temporary site, especially when the soil will later be moved and regraded. The following table may be used to determine the actual need along with suggested application rates.

2. Fertilizer: Shall be applied as 670 kilograms per hectare (600 lbs/acre) of 10-20-10 (70 kilograms per 1,000 square meters (14 lbs/1,000 square feet) or equivalent nutrients. Lime and fertilizer shall be incorporated into the top 50 to 100 millimeters (2 to 4 inches) of the soil if possible.

3. Surface Roughening: If the area has been recently loosened or disturbed, no further roughening is required. When the area is compacted, crusted, or hardened, the soil surface shall be loosened by discing, raking, harrowing, or other acceptable means (see SURFACE ROUGHENING, BMP-29).

TABLE 31-1
LIMING REQUIREMENTS FOR TEMPORARY SITES

pH Test	Recommended Application of Agricultural Limestone
below 4.2	6,725 kilograms per hectare (3 tons per acre)
4.2 to 5.2	4,480 kilograms per hectare (2 tons per acre)
5.2 to 6	2,240 kilograms per hectare (1 ton per acre)

4. Tracking: Tracking with bulldozer cleats is most effective on sandy soils. This practice often causes undue compaction of the soil surface, especially in clayey soils, and does not aid plant growth as effectively as other methods of surface roughening.

Seeding -

Seed shall be evenly applied with a broadcast seeder, drill, cultipacker seeder or hydroseeder. Small grains shall be planted no more than 40 millimeters (1.5 inches) deep. Small seeds, such as Kentucky Bluegrass, should be planted no more than 6 millimeters (0.25) inches deep. Other Grasses and Legumes should be planted from 6 millimeters to 12 millimeters (0.25 inch to 0.5 inches) deep.

Mulching -

1. Seedings made in fall for winter cover and during hot and dry summer months shall be mulched according to MULCHING, BMP-35, except that hydromulches (fiber mulch) will not be considered adequate. Straw mulch should be used during these periods.

2. Temporary seedings made under favorable soil and site conditions during optimum spring and fall seeding dates may not require mulch.

Re-seeding -

Areas which fail to establish vegetative cover adequate to prevent rill erosion will be reseeded as soon as such areas are identified.

TABLE 31-2
ACCEPTABLE TEMPORARY SEEDING PLANT MATERIALS
"QUICK REFERENCE FOR ALL REGIONS"

Planting Dates	Species	Rate grams/sq. meter (lbs./acre)
Sept. 1 - Feb. 15	50/50 Mix of Annual Ryegrass (Lolium multi-florum) & Cereal (Winter) Rye (Secale cereale)	6 - 11 (50-100)
Feb. 16 - Apr. 30	Annual Ryegrass (Lolium multi-florum)	7 - 11 (60 -100)
May 1 - Aug. 31	German Millet (Setaria italica)	6 (50)

TABLE 31-3
TEMPORARY SEEDING PLANT MATERIALS, SEEDING RATES, AND DATES FOR MID-ATLANTIC STATES

SPECIES	SEEDING RATE		NORTH			SOUTH			PLANT CHARACTERISTICS
	Acre	1000 ft^2	3/1 to 4/30	5/1 to 8/15	8/15 to 11/1	3/1 to 4/30	5/1 to 8/15	8/15 to 11/1	
OATS (Avena sativa)	3 bu. (up to 100 lbs., not less than 50 lbs.)	2 lbs.	X	-	-	X	-	-	Use spring varieties (e.g., Noble).
RYE (Secale cereale)	2 bu. (up to 110 lbs., not less than 50 lbs.)	2.5 lbs.	X	-	X	X	-	X	Use for late fall seedings, winter cover. Tolerates cold and low moisture
GERMAN MILLET (Setaria italica)	50 lbs.	approx. 1 lb.	-	X	-	-	X	-	Warm-season annual. Dies at first frost. May be added to summer mixes.
ANNUAL RYEGRASS (Lolium multi-florum)	60 lbs.	1½ lbs.	X	-	X	X	-	X	May be added in mixes. Will mow out of most stands.
WEEPING LOVEGRASS (Eragrostis curvula)	15 lbs.	5½ ozs.	-	X	-	-	X	-	Warm-season perennial. May bunch. Tolerates hot, dry slopes and acid, infertile soils. May be added to mixes.
KOREAN LESPEDEZA (Lespedeza stipulacea)	25 lbs.	approx. 1½ lbs.	X	X	-	X	X	-	Warm season annual legume. Tolerates acid soils. May be added to mixes.

BMP: PERMANENT SEEDING

Definition

The establishment of perennial vegetative cover on disturbed areas by planting seed.

Purposes

1. To reduce erosion and decrease sediment yield from disturbed areas.
2. To permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials.
3. To improve wildlife habitat.
4. To enhance natural beauty.

Conditions Where Practice Applies

1. Disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil.
2. Rough-graded areas which will not be brought to final grade for a year or more.

Planning Considerations

Vegetation controls erosion by reducing the velocity and the volume of overland flow and protecting the bare soil surface from raindrop impact.

Areas which must be stabilized after the land has been disturbed require vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes.

Advantages of seeding over other means of establishing plants include the small initial establishment cost, the wide variety of grasses and legumes available, low labor requirement, and ease of establishment in difficult areas.

Disadvantages which must be dealt with are the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding, the potential need for weed control during the establishment phase, and a need for water and appropriate climatic conditions during germination.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done in the planning stages to increase the chances for successful seeding. Selection of the right plant materials for the site, good seedbed preparation, and conscientious maintenance are important.

Selecting Plant Materials - The factors affecting plant growth are climate, soils, and topography. In selecting appropriate plant materials, one should take into account the characteristics of the physiographic region in which the project is located.

Soils - Soils can be modified with lime and fertilizer, but climate cannot be controlled. Microclimate, or localized climate conditions, can affect plant growth. A south-facing slope is drier and hotter than a north-facing slope, and may require drought-tolerant plants. Shaded areas require shade-tolerant plants; the windward side of a ridge will be drier than the leeward, etc.

Land Use - A prime consideration in selecting which plants to establish is the intended use of the land. All of these uses - residential, industrial, commercial, recreational - can be separated into two major categories: high-maintenance and low-maintenance.

High-Maintenance will be mowed frequently, limed and fertilized regularly, and will either receive intense use (e.g., athletics) or require maintaining to an aesthetic standard (home lawns). Grasses used for these situations must be fine-leaved and attractive in appearance, able to form tight sod, and be long-lived perennials. They must be well-adapted to the geographic area where they are planted, because constant mowing puts turf under great stress. Sites where high-maintenance vegetative cover is desirable include homes, industrial parks, schools, churches, athletic playing surfaces as well as some recreational areas.

Low-maintenance areas will be mowed infrequently or not at all; lime and fertilizer may not be applied on a regular basis; the areas will not be subjected to intense use, nor required to have a uniform appearance. These plants must be able to persist with little maintenance over long periods of time. Grass and legume mixtures are favored for these sites because legumes are capable of fixing nitrogen from the air for their own use, and the use of the plants around them. Such mixed stands are better able to withstand adverse conditions.

Sites that would be suitable for low-maintenance vegetation include steep slopes, stream or channel banks, some commercial properties, and "utility turf" areas such as roadbanks.

Seedbed Preparation - The soil on a disturbed site must be modified to provide an optimum environment for seed germination and seedling growth. The surface soil must be loose enough for water infiltration and root penetration. The pH (acidity and alkalinity) of the soil must be such that it is not toxic and nutrients are available, usually between pH 6.0-7.0. Sufficient nutrients (added as fertilizer) must be present. After seed is in place, <u>it must be protected with a mulch to hold moisture and modify temperature extremes, and to prevent erosion while seedlings are growing</u>.

The addition of lime is equally as important as applying fertilizer. Lime is best known as a pH, or acidity, modifier, but it also supplies calcium and magnesium which are plant nutrients. Its effect on pH makes other nutrients more available to the plant. It can also prevent aluminum toxicity by making aluminum less soluble in the soil.

Maintenance: Even with careful, well-planned seeding operations, failures can occur. When it is clear that plants have-not germinated on an area or have died, these areas must be reseeded immediately to prevent erosion damage. However, it is extremely important to determine for what reason germination did not take place and make any corrective action necessary prior to reseeding the area. <u>Healthy vegetation is the most effective erosion control available</u>.

Specifications

Selection of Plant Materials -

Selection of plant materials is based on climate, topography, soils, land use, and planting season. To determine which plant materials are best adapted to a specific site, use Tables 32-1 and 32-2 which describe plant characteristics and list recommended varieties.

A more extensive description of plant materials (grasses and legumes) and their usage can be found in Appendix 32-c.

TABLE 32-1 CHARACTERISTICS OF COMMONLY SELECTED GRASSES

Common Name (Botanical Name)		Life Cycle	Season	pH Range	Germination Time in Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seed Per Pound	Maintenance Requirements	Remarks
Tall Fescue (Festuca arundinacea)		Perennial	Cool Season Plant	5.5 - 6.2	10 - 14	60 -85	Fair	Fair	Medium	Somewhat Poorly Drained	225K	Low when used for erosion control; high when used in lawn.	Better suited for erosion control and rough turf application.
Tall Fescues (Improved)		Perennial	Cool Season Plant	5.5 - 6.2	10-14	60-85	Fair	Good	Medium	Somewhat Poorly Drained	220K	Responds well to high maintenance.	Excellent for lawn and fine turf.
Kentucky Bluegrass (Poa pratense)		Perennial	Cool Season Plant	6.0 - 6.5	14	60 -75	Good	Poor	Medium	Somewhat Poorly Drained	2.2M	Needs fertile soil, favorable moisture. Requires several years to become well established.	Excellent for fine turfs-takes traffic, mowing. Poor drought/heat tolerance.
Perennial Tyegrass (Lolium perenne)		Perennial	Cool Season Plant	5.8 - 6.2	7 -10	60 - 75	Fair	Fair	Medium - High	Somewhat Poorly Drained	227K	Will tolerate traffic.	May be added to mises. Improved varieties will perform well all year.
Fine Fescues	Hard Fescue (Festuca longifolia)	Perennial	Cool Season Plant	5.0 - 6.2	10 - 14	60 - 80	Very Good	Good	Low	Moderately Well Drained	400K	Grows well in sun or shade and will tolerate infertile soils; improved disease resistance.	Exceeds all fine fescues in most tests. Excellent for low-maintenance situations.
	Chewing Fescue	Perennial	Cool Season Plant	5.0-6.2	10 - 14	60 - 80	Very Good	Good	Low	Moderately Well Drained	400K	Tolerates shade, dry infertile soils.	Poor traffic tolerance, less thatch than other fine fescues.
	Red Fescue (Festuca rubra)	Perennial	Cool Season Plant	5.0-6.2	10 -14	60 - 80	Very Good	Good	Low	Moderately Well Drained	400K	Low to medium fertility requirements. Requires well drained soil.	Spreads by rhizomes, tillers and stolons. Will not take traffic - very shade tolerant.
Reed Canarygrass (Phalaris arundinacea)		Perennial	Cool Season Plant	5.8 - 6.2	21	70 - 85	Good	Good	Medium - High	Very Poorly Drained	530K	Do not mow closely or often.	Conservation cover in wet areas.

TABLE 32-1 CHARACTERISTICS OF COMMONLY SELECTED GRASSES

Common Name (Botanical Name)	Life Cycle	Season	pH Range	Germination Time in Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seed Per Pound	Maintenance Requirements	Remarks
Redtop (Agrostis alba)	Perennial	Cool Season Plant	5.8 - 6.2	10	65 - 85	Good	Fair	Low	Poorly Drained	5M	Will tolerate poor, infertile soils; deep rooted.	Does will in erosion control mixes - not for lawns.
Weeping Lovegrass (Evagrostis curvula)	Perennial	Warm Season Plant	4.5 - 6.2	14	65 - 85	Fair - Poor	Good	Low - Medium	Somewhat Poorly Drained	1.5M	Low-fertility requirements; excellent drought tolerance.	Fast-growing, warm-season bunch grass. Excellent cover for erosion control.
Bermudagrass (Cynodon dactylon)	Perennial	Warm Season Plant	5.8 - 6.2	21	70 -95	Poor	Good	Medium - High	Somewhat Poorly Drained	1.8M hulled	High nitrogen utilization, excellent drought tolerance.	Common varieties used for erosion control. Hybrids used for fine turf.
Orchardgrass (Dactylis glomerata)	Perennial	Cool Season Plant	5.8 - 6.2	18	60 - 75	Fair	Fair	Medium	Somewhat Poorly Drained	625K	Does best on well-drained, loamy soil.	Good pasture selection - may be grazed.
Annual Ryegrass (Lolium multiflorum)	Annual	Cool Season Plant	5.8 - 6.2	7	60 - 70	Good	Poor	Medium - High	Somewhat Poorly Drained	227 K	Do not use in fine-turf areas.	May be added into mixes or established alone as temporary cover in spring and fall.
Rye (Secale cereale)	Annual	Cool Season Plant	5.8 - 6.2	7	55 -70	Very Good	Good	Low - Medium	Somewhat Poorly Drained	18K	Do not use in fine-turf areas.	May be added into mixes or established alone for late fall/winter cover.
Foxtail Millet (setaria italica)	Annual	Warm Season Plant	5.8 - 6.2	10	65 - 85	Very Poor	Good	Medium	Moderately Well Drained	220K	Establishes well during summer. Very low moisture requirements.	May be added to erosion-control mixes or extablished alone.

TABLE 32-2 CHARACTERISTICS OF LEGUMES APPROPRIATE FOR EROSION CONTROL

Common Name (Botanical Name)	Life Cycle	Season	pH Range	Germination Time in Days	Optimum Germination Temperature (°F)	Winter Hardiness	Drought Tolerance	Fertility	Soil Drainage Tolerance	Seed Per Pound	Maintenance Requirements	Remarks
Crownvetch (coronilla varia)	Perennial	Cool Season Plant	6.0 - 6.5	14 - 21	70	Good	Very Good	Medium	Moderately Well Drained	110K	Does best on well-drained soils. Minimum maintenance when established. May need phosphorus. Inoculation is essential.	Excellent for steep, rocky slopes. Produces colorful blooms in May/June. slow to establish. Does best when seeded in spring.
Sericea Lespedeza (Lespedeza cuneata)	Perennial	Warm Season Plant	5.8 - 6.2	21 - 28	70-85	Fair	Very Good	Low	Moderately Poorly Drained	335K	Grows in most well-drained soils. Low fertility requirements. Inoculation is essential.	Use hulled seed in spring; unhulled in fall. Very deep-rooted legume.
Flatpea (Lathyrus silvestrus)	Perennial	Cool Season Plant	5.0 - 7.0	14 - 28	65 -75	Good	Good	Low	Poorly Drained	15K	Needs lime and high phosphorus. Good shade tolerance.	Tolerates acidic and wetter soils better than other legumes.
Birdsfoot Trefoil (Lotus corniculatus)	Perennial	Cool Season Plant	6.0 - 6.5	7	65 - 70	Good	Fair	Medium	Somewhat Poorly Drained	375K	Inoculation is essential. Grows in medium-fertile, slightly acid soils.	Grows better on poorly drained soils than most legumes. Poor drought/heat tolerance.
Annual Lespedezas (Lespedeza striata, L. stipulacea)	Annual	Warm Season Plant	5.8 - 6.2	14	70 - 85	Fair	Very Good	Low	Moderately Well Drained	200K	Will grow on almost any well-drained soil.	Needs almost no nitrogen to survive.
Red Clover (Trifolium pratense)	Perennial	Cool Season Plant	6.0-6.5	7 - 14	70	Good	Fair	Medium	Somewhat Poorly Drained	275K	Needs high levels of phosphorus and potassium.	Acts as a biennial. Can be added to low-maintenance mixes.
White Clover (Trifolium repens)	Perennial	Cool Season Plant	6.0-6.5	10	70	Good	Poor	Medium	Poorly Drained	700K	Requires favorable moisture, fertile soils, high pH.	Spreads by soil surface stolons, white flowers.

Seedbed Requirements-

Vegetation should not be established on slopes that are unsuitable due to inappropriate soil texture, poor internal structure or internal drainage, volume of overland flow, or excessive steepness, until measures have been taken to correct these problems.

To maintain a good stand of vegetation, the soil must meet certain minimum requirements as a growth medium. The existing soil must have these characteristics:

1. Enough fine-grained material to maintain adequate moisture and nutrient supply.

2. Sufficient pore space to permit root penetration. A bulk density of 1.2 to 1.5 indicates that sufficient pore space is present. A fine granular or crumb-like structure is also favorable.

3. Sufficient depth of soil to provide an adequate root zone. The depth to rock or impermeable layers such as hardpans shall be 300 millimeters (12 inches) or more, except on slopes steeper than 2:1 where the addition of soil is not feasible.

4. A favorable pH range for plant growth. If the soil is so acidic that a pH range of 6.0-7.0 cannot be attained by addition of ph-modifying materials, then the soil is considered an unsuitable environment for plant roots and further soil modification would be required.

5. Freedom from toxic amounts of materials harmful to plant growth.

6. Freedom from excessive quantities of roots, branches, large stones, large clods of earth, or trash of any kind. Clods and stones may be left on slopes steeper than 3:1 if they do not significantly impede good seed soil contact.

If any of the above criteria cannot be met, i.e., if the existing soil is too coarse, dense, shallow, acidic, or contaminated to foster vegetation, then topsoil shall be applied in accordance with TOPSOILING, BMP-30.

Necessary structural erosion and sediment control practices will be installed prior to seeding. Grading will be carried out according to the approved plan.

Surfaces will be roughened in accordance with SURFACE ROUGHENING, BMP-29.

Soil Conditioners -

In order to modify the texture, structure, or drainage characteristics of a soil, the following materials may be added to the soil:

1. Peat is a very costly conditioner, but works well. If added, it shall be sphagnum moss peat, hypnum moss peat, reed-sedge peat or peat humus, from fresh-water sources. Peat shall be shredded and conditioned in storage piles for at least six months after excavation.

2. Sand shall be clean and free of toxic materials. Sand modification is ineffective unless you are adding 80 to 90% sand on a volume basis. This is extremely difficult to do on-site. If this practice is considered, consult a professional authority to ensure that it is done properly.

3. Vermiculite shall be horticultural grade and free of toxic substances. It is an impractical modifier for larger acreage due to expense.

4. Raw manure, is more commonly used in agricultural applications. However, when stored properly and allowed to compost, it will stabilize nitrogen and other nutrients. Manure, in its composted form, is a viable soil conditioner; however, its use should be based on site-specific recommendations offered by a professional in this field.

5. Thoroughly rotted sawdust shall have 3.5 kilograms of nitrogen added to each cubic meter (6 pounds per cubic yard) and shall be free of stones, sticks, and toxic substances.

6. The use of treated sewage sludge has benefitted from continuing advancements in its applications in the agricultural community. When composted, it offers an alternative soil amendment. Limitations include a potentially undesirable pH (because of lime added during the treatment process) and the possible presence of heavy metals. This practice should be thoroughly evaluated by a professional and be used in accordance with any local, state, and federal regulations.

Lime and Fertilizer -

Lime and fertilizer needs should be determined by soil tests. Soil tests may be performed by a reputable commercial laboratory. Reference Appendix 32-d for liming applications (in lbs.) needed to correct undesirable pH for various soil types.

Under unusual conditions where it is not possible to obtain a soil test, the following soil amendments will be applied:

Lime

Coastal Plain:	4,480 kg/ha (2 tons/acre) pulverized agricultural grade limestone (448 kg/1000 m^2 - 90 lbs/1000 ft^2)
Piedmont and Appalachian Region:	4,480 ka/ha (2 tons/acre) pulverized agricultural grade limestone (448 kg/1000 m^2 - 90 lbs/1000 ft^2)

Note: An agricultural grade of limestone should always be used.

Fertilizer

Mixed grasses and legumes:	1,120 kg/ha (1000 lbs/acre) of 10-20-10 or equivalent nutrients (112 kg/1000 m^2 - 1000 23 lbs./1000 ft^2).
Legume stands only:	1,120 kg/ha (1000 lbs/acre) 5-20-10 (112 kg/ 1000 m^2 - 23 lbs/1000 ft^2) is preferred; however, 1,120 kg/ha (1000 lbs/acre) of 10-20-10 or equivalent may be used.
Grass stands only:	1,120 kg/ha (1000 lbs/acre) 10-20-10 or equivalent nutrients, (112 kg/1000 m^2 - 1000 23 lbs./1000 ft^2).

Other fertilizer formulations, including slow-release sources of nitrogen (preferred from a water quality standpoint), may be used provided they can supply the same amounts and proportions of plant nutrients.

Incorporation - Lime and fertilizer shall be incorporated into the top 100-150 millimeters (4-6 inches) of the soil by discing or other means whenever possible. For erosion control, when applying lime and fertilizer with a hydroseeder, apply to a rough, loose surface.

Seeding

1. Certified seed will be used for all permanent seeding whenever possible. Certified seed is inspected by the state certifying agency. The seed must meet published state standards and bear an official "Certified Seed" label. (see Appendix 32-a).

2. Legume seed should be inoculated with the inoculant appropriate to the species. Seed of the Lespedezas, the Clovers and Crownvetch should be scarified to promote uniform germination.

3. Apply seed uniformly with a broadcast seeder, drill, culti-packer seeder, or hydroseeder on a firm, friable seedbed. Seeding depth should be 1/4 to 1/2 inch.

4. To avoid poor germination rates as a result of seed damage during hydroseeding, it is recommended that if a machinery breakdown of 30 minutes to 2 hours occurs, 50% more seed be added to the tank, based on the proportion of the slurry remaining in the tank. Beyond 2 hours, a frill rate of new seed may be necessary.

   Often hydroseeding contractors prefer not to apply lime in their rigs as it is abrasive. In inaccessible areas, lime may have to be applied separately in pelletized or liquid form. Surface roughening is particularly important when hydroseeding, as a roughened slope will provide some natural coverage of lime, fertilizer and seed.

   Legume inoculants should be applied at five times the recommended rate when inoculant is included in the hydroseeder slurry.

Mulching -

All permanent seeding must be mulched immediately upon completion of seed application. Refer to MULCHING, BMP-35.

Maintenance of New Seedings -

In general, a stand of vegetation cannot be determined to be fully established until it has been maintained for one full year after planting.

Irrigation: New seedings should be supplied with adequate moisture. Supply water as needed, especially late in the season, in abnormally hot or dry weather, or on adverse sites. Water application rates should be controlled to prevent excessive runoff. Inadequate amounts of water may be more harmful than no water.

Re-seeding: Inspect seeded areas for failure and make necessary repairs and re-seedings within the same season, if possible.

a. If vegetative cover is inadequate to prevent rill erosion, over-seed and fertilize in accordance with soil test results.

b. If a stand has less than 40% cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. The soil must be tested to determine if acidity or nutrient imbalances are responsible. Re-establish the stand following seedbed preparation and seeding recommendations.

Fertilization: Cool season grasses should begin to be fertilized 90 days after planting to ensure proper stand and density. Warm season fertilization should begin at 30 days after planting.

Apply maintenance levels of fertilizer as determined by soil test. In the absence of a soil test, fertilization should be as follows:

Cool Season Grasses (per 1000 m^2 per year)

20 kg nitrogen (N) (4 lbs/1000 ft^2)

5 kg phosphorus (P) (1 lbs/1000 ft^2)

10 kg potash (K) (2 lbs/1000 ft^2)

Seventy-five percent of the total requirements should be applied between September 1 and December 31st. The balance should be applied during the remainder of the year. **More than 5 kg. of soluble nitrogen per 1000 m^2 should not be applied at any one time (1 lb per 1,000 ft^2)**.

Warm Season Grasses

Apply 20-25 kg (4-5 lbs/1000 ft^2) nitrogen (N) between May 1 and August 15th per 1000 m^2 per year.

Phosphorus (P) and Potash (K) should only be applied according to soil test.

Note: The use of slow-release fertilizer formulations for maintenance of turf is encouraged to reduce the number of applications and the impact on groundwater.

Additional Information on the Successful Establishment of Grasses and Legumes

See Appendix 32-b for "helpful hints" in achieving high success rates in grass or legume plantings.

APPENDIX 32-a

SEED QUALITY CRITERIA

Where certified seed is not available, the minimum requirements for grass and legume seed used in vegetative establishment are as follows:

a. All tags on containers of seed shall be labeled to meet the requirements of the State Seed Law.

b. All seed shall be subject to re-testing by a recognized seed laboratory that employs a registered seed technologist or by a state seed lab.

c. All seed used shall have been tested within twelve (12) months.

d. Inoculant - the inoculant added to legume seed in the seed mixtures shall be a pure culture of nitrogen-fixing bacteria prepared for the species. Inoculants shall not be used later than the date indicated on the container. Twice the supplier's recommended rate of inoculant will be used on dry seedings; five times the recommended rate if hydroseeded.

e. The quality of the seed used shall be shown on the bag tags to conform to the guidelines in Table 32-3.

TABLE 32-3
QUALITY OF SEED*

	Minimum Seed Purity (%)	Minimum Germination (%)
Legumes		
Crownvetch	98	65**
Lespedeza, Korean	97	85**
Lespedeza, Sericea	98	85**
Grasses		
Bluegrass, Kentucky	97	85
Fescue, Tall (Improved, Turf-Type Cultivars)	98	85
Fescue, Tall (Ky-31)	97	85
Fescue, Red	98	85
Redtop	94	80
Reed Canarygrass	98	90
Perennial Ryegrass	98	87
Weeping Lovegrass	98	87
Annuals		
Annual Ryegrass	97	90
German Millet	98	85
Oats	98	80
Cereal Rye	98	85

* Seed containing prohibited or restricted noxious weeds should not be accepted. Seed should not contain in excess of 0.5% weed seed. To calculate percent pure, live seed, multiply germination times purity and divide by 100.

** Includes "hard seed"

APPENDIX 32-b

KEYS TO SUCCESSFUL ESTABLISHMENT OF GRASSES AND LEGUMES

Planning

Where feasible, grading operations should be planned around optimal seeding dates for the particular region. If the time of year is not suitable for seeding a permanent cover (perennial species), a temporary cover crop should be planted. Temporary seeding of annual species (small grains, ryegrasses or millets) often succeeds during periods of the year that are unsuitable for seeding permanent (perennial) species.

Variations in weather and local site conditions can modify the effects of regional climate on seeding success. For this reason, mixtures including both cool and warm season species are preferred for low-maintenance cover. Such mixtures promote cover which can adapt to a range of conditions. Many of these mixtures are not desirable, however, for high quality lawns, where variation in texture of the turf is inappropriate.

Selection

Species selection should be considered early in the process of preparing an erosion and sediment control plan. For practical, economical stabilization and long-term protection of disturbed sites, species selection should be made judiciously.

Seasonality must be considered when selecting species. Grasses and legumes are usually classified as warm or cool season in reference to their season of growth. Cool season plants realize most of their growth during the spring and fall and are relatively inactive or dormant during the hot summer months. Therefore, fall is the most favorable time to plant them. Warm season plants "green-up" late in the spring, grow most actively during the summer, and go dormant at the time of the first frost in fall. Spring and early summer are preferred planting times for warm season plants.

Seed Mixtures

As previously noted, the establishment of high quality turf frequently involves planting one single species. However, in seedings for erosion control purposes the inclusion of more than one species should always be considered. Mixtures need not be excessive in poundage or seed count. The addition of a quick-growing annual provides early protection and facilitates establishment of one or two perennials in a mix. More complex mixtures might include a quick-growing annual, one or two legumes and more than one perennial grass.

The addition of a "nurse" crop (quick-growing annuals added to permanent mixtures) is a sound practice for soil stabilization, particularly on difficult sites - those with steep slopes; poor, rocky, erosive soils; those seeded out the optimum seeding periods; or in any situation where the development of permanent cover is likely to be slow. The nurse crop germinates and grows rapidly, holding the soil until the slower-growing perennial seedlings become established.

APPENDIX 32-c
PLANT INFORMATION

ANNUAL GRASSES AND GRAINS -

Small grains are cool season annual grasses primarily grown for animal feed and human consumption. The grains used for soil stabilization are primarily Rye and Oats. Foxtail Millet, which is sometimes considered a small grain, is becoming a very popular and successful planting for soil stabilization.

1. Oats (Avenasativa): A cool season annual grass primarily grown for animal feed and human consumption, but also used for soil stabilization. Seeding rates are 112 kg per hectare bare ground or 11 kg per 1,000 square meter (100 lbs per acre or 2-1/2 lbs. per 1000 square feet.

2. Rye (Secale cereale): Often referred to as Winter Rye because of its winter hardiness, Rye is the most common small grain used for soil stabilization. It is also the most productive grain on dry, infertile, acid or sandy soils. It may be seeded in the fall for winter ground cover. By maturing early, it offers less competition during the late spring period, a critical time in the establishment of perennial species. Rye grain germinates quickly and is tolerant of poor soils. Including Rye grain in fall-seeded mixtures is almost always advantageous, but it is particularly helpful on difficult and erodible soils, erodible slopes or when seeding is late. Recomended rates are up to 112 kg per hectare (100 lbs per acre) for bare ground. Overly thick stands of Rye grain will suppress the growth of perennial seedlings. Approximately 56 kg per hectare (50 lbs per acre) is the maximum for this purpose and, where lush growth is expected, that rate should either be cut in half, or Rye grain should be totally eliminated from the mixture.

3. Foxtail Millet (Setaria italics): A warm season annual grass which may be used for temporary cover. German Millet germinates quickly and goes to seed quickly. These features make it an excellent companion grass for summer seedlings. It dies at first frost. Seeding rates are up to 56 kg per hectare (50 lbs. per acre) for temporary cover. Use 11 to 22 kg per hectare (10 to 20 lbs per acre) in mixes.

4. Annual Rye (Lolium multiflorum): A cool season annual grass used for temporary cover or as a nurse grass to allow for germination of permanent stands. Most commonly used in mixes for erosion control. Performs well in neutral to slightly acid soils. Use rates up to 112 kg per hectare (100 lbs per acre) for temporary cover. Use 11 to 22 kg per hectare (10 to 20 lbs per acre) in mixes.

ANNUAL LEGUMES -

1. Annual Lespedezas (Lespedeza striata)

Uses: Pasture, hay, erosion control soil improvement, wildlife food.

Description: Annual warm season legumes. Korean Lespedeza is larger and coarser than Common Lespedeza and grows to about 300 millimeters (12 inches). Seed of Korean is shiny and black, while seed of Common is stippled. Kobe is the most desirable variety of Common Lespedeza.

Adaptation: Optimum pH range is 6.0 to 6.5; will grow from 5.5 to 7.0. Will grow in soil textures ranging from sands to clays and through a wide range of fertility conditions.

Establishment: Seed should always be inoculated. May be seeded alone or mixed with grasses or small grains. Requires a firm seedbed; may be broadcast or drilled. Should be seeded in early spring at28 to 45 kg per hectare (25 to 40 lbs per acre) or 2 to 5 kg per 1,000 square meters (0.5 to 1 lb per 1,000 square feet), depending on use. (Use lower figure as half the seeding rate of any spring seeding with grass or grain.) Should not be mowed at less than 75 millimeters (3 inches). Lespedeza will not make a large contribution in sod grasses like Bluegrass; they do best in open sod grasses like tall fescue.

Sources: Seed of common variety (Kobe) and Korean varieties (Climax, Harbin and Rowan) are commercially available.

PERENNIALS -

1. Tall Fescue (Festuca arundinacea) -

Uses: Pasture, hay, recreation areas, lawns and stabilization of waterways, banks, slopes, cuts, fills, and spoils. It is the most widely used grass at this time for stabilizing large disturbed areas.

Description: A robust, cool season, long-lived, deep-rooted bunchy grass which may have short rhizomes (underground stems). Kentucky 31 is the best-known variety. A number of new varieties of Tall Fescue are becoming available for lawn and other fine-turf uses, and several offer definite improvements. However, their higher cost over the old standby, KY 31, is seldom justified when used for purposes of stabilization and erosion control.

Tall Fescue tolerates a wide range of seeding dates; however, with the possible exception of high mountain elevation, it is most dependable when planted in fall.

Adaptation: Adapted to a wide range of climatic conditions. Optimum pH range is 6.0 to 7.0; will tolerate from 3.0 to 8.0. Will grow on shallow and claypan soils if they are moist. Growth is limited more by moisture than by temperature extremes, but it will tolerate drought, infertile soils and moderate shade.

Establishment: Requires a firm seedbed. Hydroseeding is successful. Seeding rates vary from 112 kg per hectare (100 lbs per acre) for erosion control to 280 kg per hectare (250 lbs per acre) for lawns. Plant in early spring or from the middle of August through September. Legumes may not thrive in fescue stands due to the aggressive growth habits of this grass. Mowing is desirable on critical areas at least once every two years; lack of periodic mowing will encourage clumpiness.

Sources: Readily available as seed and sod.

2. Kentucky Bluegrass (Poa pratense) -

Use: Pasture, turf for lawns, athletic fields, golf courses, and playgrounds. Also used to stabilize waterways, slopes, cuts and fills. Choice food for grouse, turkeys, deer and rabbits.

Description: Long-lived, cool season perennial grass which forms a dense sod. Becomes dormant in the heat of summer since its growing season is spring and fall.

Adaptation: Best adapted to well drained, fertile soils of limestone origin. Optimum pH range is 6.0 to 7.0. Bluegrasses are better suited to high maintenance situations in the transition zone. Essentially dormant during dry or hot weather; however, it will normally survive severe drought.

Establishment: Requires a firm, weed-free seedbed and adequate fertilization (liberal phosphorus) and lime are important. Can be used with Tall Fescues at low rates. Minimum mowing height is 40 millimeters (1.5 inches). Critical erosion areas may be mowed only once per year, if desired. This grass is usually seeded with a mixture of other grasses or legumes; several varieties of Bluegrass should be used together to ensure good stand survival. Bare ground rates are 135 kg per hectare (120 lbs per acre). Overseed 5 to 8 kg per 1,000 square meters (1 to 1.5 lbs per 1000 square feet).

Sources: Readily available as seed and sod.

3. Perennial Ryegrass (Lolium perrenne) -

Uses: Erosion control, soil improvement lawns, pasture, and hay; newer varieties are excellent for high-traffic areas.

Description: Perennial Ryegrasses are an excellent selection where rapid establishment is desired. Cool season. Ryegrasses cross-pollinate freely so "Common Ryegrass" may be a mixture of annual and perennial species. Certified seed of Perennial Ryegrass varieties is produced: Blaser, Palmer, Goalie, Fiesta II, Ranger, Regal and Pennfine may be used.

Adaptation: Grows best on dark, rich soils in mild climates. Newer varieties have good drought tolerance but may require irrigation if under drought stress or heavy traffic. Will tolerate wet soils with good surface drainage.

Establishment: A firm, mellow surface over compact subsoils gives good results. Seed in fall or spring. Perennial Ryegrass may also be seeded in mid-August to early September. For turf, use a rate of 25 to 40 kg per 1,000 square meters (5 to 8 lbs per 1,000 square feet), if seeded alone; lesser amounts are suitable in mixtures, depending on the characteristics of the companion species. Generally not seeded alone except on athletic fields with intensive use. Perennial Ryegrass does best when used with bluegrass as 20 percent or less of the mixture. Ryegrasses germinate rapidly which makes them particularly suited to disturbed-area stabilization and temporary seeding. They will, however, tend to dominate stands in mixtures if percentage is too high.

Sources: Readily available commercially. Care should be taken to buy seed appropriate to the needs of the project.

4. Fine Fescues

   Red Fescue
   Hard Fescue
   Chewings Fescue

Uses: Excellent for shady, low maintenance areas and north-facing slopes. May be used to stabilize waterways, slopes, banks, cuts, fills, and as a cover crop in orchards.

Description: Red Fescue is a cool season perennial that occurs in two forms: bunchtype and creeping. Creeping Red Fescue forms a tight sod. The leaves of Red Fescue are narrow and wiry. Hard Fescues are slow-growing with excellent shade tolerance.

Adaptation: Shade tolerant and somewhat drought-resistant once established. Grows well in sandy and acidic soils. Optimum pH range is 4.5 to 6.0. Prefers well drained soils but requires adequate moisture for establishment. In areas of high temperature and humidity, some Fine Fescues may turn brown or deteriorate during the summer. Newer varieties of Hard Fescue are more drought tolerant.

Establishment: Rarely seeded in pure stands. Seedbed preparation and fertility adjustments are usually dictated by the other grasses in the mixture. Red Fescues may comprise 25 to 60% by weight of a seeding mixture. In shaded areas red fescue may be the key grass in the mixture. Mowing consistently below 40 millimeters (1.5 inches) is not recommended.

Sources: Readily available commercially. New Hard Fescues may be in short supply.

5. Bermudagrass (Cynodon dactylion)

Uses: Soil and water conservation, pasture, hay, silage, lawns, both high maintenance and general purpose turf, and stabilization of grassed waterways.

Description: A long-lived, warm season perennial that spreads by stolons and rhizomes (runners and underground stems). Height of stems of Common Bermudagrass may be 300 millimeters (12 inches). The stems are short-jointed and the leaves flat and spreading. Common Bermudagrass may be established vegetatively with sprigs (sections of stems) or from seeds; however, it has the potential to develop into a weed problem because it spreads vigorously. Cold-tolerant hybrids are usually specified. These are traditionally established from sprigs or sod, but seed is now available.

Adaptation: Makes its best growth when average daily temperatures are above 24 degrees Celsius (75 degrees Fahrenheit). Grows on a wide range of soils from heavy clays to deep sands. Optimum pH is 6.0 to 6.5. It is drought-resistant and salt-tolerant. Tolerates floods of short duration but will not thrive on waterlogged soils; does not persist under heavy shade. For rough areas, the varieties Midland (a forage hybrid) and Coastal are recommended. For fine-turf areas, Tufcote (a fine-leaved turf hybrid), Midiron, Tifway, and Vamont are used.

Establishment: By sodding or planting sprigs. Sprigs should be planted (by hand or machine) when soil is warm in a well-prepared, moist seedbed. One end of the sprig should extend above ground, and the other should be covered by firmly packed soil.

Sources: Readily available as seed, sprigs, and sod.

6. Reed Canarygrass (Phalaris arundinacea)

Pasture, hay silage, and erosion control. An excellent grass for stabilizing waterways, healing and controlling gullies, and protecting shorelines of ponds and reservoirs from wave action. Also provides good cover for shooting preserves. Can be used in deep gullies and drainage ditches where stream flow is rapid. Vigorous growth may impede flow in small, low velocity channels.

Description: A long-lived, cool season, clumpy perennial with coarse rhizomes (underground stems). Grows 1 to 2 meters (4 to 7 feet) tall. Most widely used variety is Ioreed.

Adaptation: Does best in a cool, moist climate. Makes best growth on fertile, moist, medium to fine soils; but will grow in a wide range of soil moisture conditions. Will also grow well on swampy or floodplain soils consisting of peat, muck or sand. Will withstand flooding, yet is quite drought-tolerant when mature. Optimum pH range 5.0 to 7.5.

Establishment: Requires a well-prepared seedbed that is firm and weed free. Seed in spring or late summer; drill seed alone or with a legume. Seed must fresh it should be labeled as having at least 70% germination tested within the last 6 months. Normally, pure stands should be established because this grass is not very compatible with other plants. Mowing should not occur more than twice a year on stabilized critical erosion areas or waterway as this will result in reduced stands.

Sources: Available commercially.

MISCELLANEOUS EROSION CONTROL GRASSES -

1. Weeping Lovegrass (Eragrostis curvula)

Uses: Fast-growing cover for erosion control. In the northeast, weeping lovegrass acts as a summer annual. The normal life of 3 to 5 years may be foreshortened by low winter temperatures. May provide permanent cover on southern exposure.

Description: A rapid-growing, warm season bunch grass introduced from East Africa. The long, narrow leaves are numerous, very fine, and droop over to the ground, hence the name. Leaf height is rarely above 300 millimeters (12 inches).

Adaptation: Prefers light-textured, well-drained soil; will thrive on soil of low fertility. Low winter temperatures may deplete stand.

Establishment: Easy to establish by seed; germinates rapidly and grows quickly. Lime and fertilizer needs are similar to those of Tall Fescue and Ryegrass. Requires pH of 5.5 or higher. May be planted any time after danger of frost and throughout the summer. Very fine seed, commonly added to erosion control seed mixtures. Use of hydroseeders is successful if the seeding rate is increased to compensate for the lack of a firm seedbed. Normal seeding rates are 6 to 22 kg per hectare (5 to 20 lbs per acre) in mixes.

Sources: Readily available from large seed companies.

2. Redtop (Agrostis alba)

Uses: Erosion control, pasture, companion grass in turf seedings and stabilizing ditch and channel banks, grassed waterways, and other disturbed areas.

Description: A coarse, cool season perennial grass with rhizomes (underground stems). Grows to 750 to 1,000 millimeters (30 to 40 inches).

Adaptation: Does better in the cool, humid areas. Will grow under a wide variety of soil and moisture conditions. Grows on very acid soils (pH 4.0 to 7.5) and poor, clay soils of low fertility. While drought-resistant, it is also a useful wetland grass.

Establishment: Has very small seed and requires a compact seedbed. May be sown in early spring or late summer. Seldom seeded alone except as temporary turf. Adequate fertilization is essential on critical areas to obtain good cover rapidly. Most commonly added to mixes, usually 2 to 3 kg per hectare (2 to 3 lbs per acre). Redtop will disappear from a stand under frequent low mowing.

Sources: Available from commercial sources.

LEGUMES -

1. Crownvetch (Coronilla varia)

Uses: For erosion control of critical areas such as steep roadbanks, surface mine spoil and industrial waste areas. It is also useful as a residential ground cover. It provides high-quality forage for ruminant animals and serves as a wildlife food and cover plant.

Description: A deep-rooted, cool season, perennial, herbaceous legume with a semi-reclining growth habit. It reaches 0.5 to 1 meter (2 to 3 feet) in height, and does not climb or twine. It fixes nitrogen in the soil and makes a dense mat of vegetative cover.

Adaptation: It grows best on well-drained soils with a pH range of 5.5 to 8.3. Will persist on more acid soils for a prolonged period once established. It is not adapted to soils with poor drainage. Crownvetch is winter hardy and drought-tolerant. Varieties commonly used are Chemung, Penngift and Emerald.

Establishment: Only inoculated seed should be used. Requires at least 560 kg per hectare (500 lbs. per acre) of 5-10-10 fertilizer (or the area should be fertilized according to soil test results). Soil acidity must be raised above a pH of 5.5. Crownvetch requires mulch and can be hydroseeded successfully. Seeding in the spring is most successful. Frost seeding may be used on steep or stony sites (seed in late winter, and allow frost action to work the seed into soil). Crownvetch often takes 2 to 3 years to establish a dense stand. A companion grass such as Perennial Ryegrass or Redtop needs to be mixed into the initial planting, but the Crownvetch will eventually crowd out the companion plants. It will not persist under frequent mowing.

Sources: Available commercially.

2. Flatpea (Lathyrus sylvestris)

Uses: Flatpea is an erosion control plant that provides a thick mat of vegetative cover, fixes nitrogen in the soil, and can be maintained with a minimum of management. It is useful on roadbanks, dams, borrow area, gravel pits, surface mine spoil, and industrial waste areas. It is an ideal plant for stabilizing logging roads and utility right-of-ways since it will restrict the invasion of many woody species. It also provides good wildlife cover and food.

Description: A cool season perennial legume. It will climb to a height of 2 meters (6.5 feet) if support is available, but the normal height is 1/2 - 1 meters (2 to 3 feet).

Adaptation: Flatpea is adaptable to a wide variety of soil conditions. It is drought-tolerant, cold-hardy, and does well on low-fertility sites such as sands, gravel, and soils from acid sandstones. It is not adapted to wet sites, but it will grow on somewhat poorly drained soils. It will tolerate minor shade and a minor degree of flooding. The optimum pH range is from 6.0 to 6.5. The only available variety is Lathco, developed by the USDA Soil Conservation Service.

Establishment: Use only inoculated seed. The seedbed should be scarified, if possible. The seed is normally drilled or band seeded, but on rough sites or steep slopes, it can be broadcast and then worked into the soil by light dragging. Where possible, a light application of mulch, properly anchored, will assure a good stand. Lime is essential if the soil is below a pH of 5.0. Fertilize according to a soil test or apply 450 kg per hectare (400 lbs per acre) of 10-20-10. Work lime and fertilizer into soil when preparing the seedbed. For a primary stand, use a seeding rate of 15 to 20 kilograms (30 to 40 lbs) in a mixture with 4 to 5 kilograms (8 to 10 lbs) of Perennial Ryegrass or 5 to 8 kilograms (10 to 15 lbs) of Tall Fescue. Flatpea is slow to germinate, so grasses are needed to provide quick cover. Early spring seedings in April or May are best; June seedings are less desirable. Grass seedings may be overseeded with Flatpea from November through March. Flatpea is usually not winter-hardy if seeded in mid or late summer; therefore, dormant seedings are recommended. Mulch with straw at a minimum rate of 3,400 kilograms per hectare (1.5 tons per acre) on all critical sites, and anchor. Little management is required. Remove woody vegetation if the site is invaded. Mowing is acceptable once the stand is established. Mow after full bloom at a 150 millimeter (6-inch) minimum height.

Sources: Lathco is commercially available.

3. Sericea Lespedeza (Lespedeza cuneata)

Uses: Hay, pasture, erosion control, cover crop, wildlife food.

Description: Warm season perennial legume with upright woody stems 300 to 450 millimeters (12 to 18 inches) tall. Roots widely branched penetrating soil 1 meter or more.

Adaptation: Best on well drained, deep soils of medium texture. Will also grow on sandy, rather acidic, infertile soils. Optimum pH range is 6.0 to 6.5, but will tolerate a range of 5.0 to 7.0. It is drought tolerant. Common varieties are Serala and Interstate.

Establishment: Seed from April to June. Requires a firm seedbed. Use only inoculated seed. Rates vary from 22 to 35 kg per hectare (20 to 30 lbs per acre) of unhulled seed. Requires phosphate and potash. Will not persist under frequent mowing (once a year recommended).

Sources: Seed of common varieties is commercially available.

4. White Clover (Trifolium repens)

Uses: Common White Clover is used mostly for pastures. Ladino clover, a giant white clover, is also used for hay and silage in mixtures with a grass. The thick growing, spreading characteristics of the common type make it ideal for erosion control.

Description: A cool season perennial legume. The common type has a prostrate type of growth, while the Ladino is more upright. Both spread by stolons (horizontal branches along ground) and by roots at the nodes. Representative common varieties used are Tillman, Common and White Dutch. Ladino is the only cultivar for the large type.

Adaptation: Thrives in cool climates and on moist, rich soils with full sun. Will not tolerate extremes of cold or drought. Where soil moisture is not adequate, Ladino is short-lived. Optimum soil pH is 6.5, but it will grow in a range of 5.0 to 7.5. Common White Clover volunteers readily in Bluegrass mixtures where moderate to high fertility is maintained. Stands are persistent.

Establishment: Ladino Clover requires inoculation, fertilizing, and liming for successful growth. Phosphorus and potash are the key fertilizer elements required. Ladino makes a good companion crop with grasses such as Orchardgrass, Bromegrass, Tall Fescue and Timothy. These grasses will normally crowd out the Ladino after 2 to 3 years. Seed should be planted (drilled or broadcast) at shallow depths, and a firm seedbed is desirable.

Sources: Available commercially.

Appendix 32-d

TABLE 32-4:

AMOUNT OF GROUND AGRICULTURAL LIMESTONE* IN KILOGRAMS PER THOUSAND SQUARE METERS NEEDED TO CORRECT pH LEVEL OF ACID SOILS TO 6.5

EXISTING pH	Soil Texture		
	Sandy Loam	Loam	Clay Loam
6.2	30 (20)	50 (35)	60 (40)
6.0	60 (40)	80 (55)	105 (70)
5.8	80 (55)	95 (65)	125 (85)
5.6	105 (70)	120 (80)	155 (105)
5.4	135 (90)	150 (100)	185 (125)
5.2	155 (105)	180 (120)	210 (140)
5.0	180 (120)	210 (140)	240 (160)
4.8	185 (125)	270 (180)	305 (205)
4.6	230 (155)	310 (210)	340 (230)
4.0	295 (200)	370 (250)	445 (300)

* - Lime should always be applied in accordance with the results of a soil test. Values in parenthesis are amounts in pounds per 1,000 square feet.

BMP-33

BMP: SODDING

Definition

Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod.

Purposes

1. To establish permanent turf immediately.

2. To prevent erosion and damage from sediment and runoff by stabilizing the soil surface.

3. To reduce the production of dust and mud associated with bare soil surfaces.

4. To stabilize drainageways where concentrated overland flow will occur.

5. For use as a filtering device for sediments in areas prior to achieving permanent stabilization.

Conditions Where Practice Applies

1. Disturbed areas which require immediate vegetative covers, or where sodding is preferred to other means of grass establishment.

2. Locations particularly suited to stabilization with sod are:

   - waterways carrying intermittent flow
   - area around drop inlets or in grassed swales
   - residential or commercial lawns where quick use or aesthetics are factors.

Planning Considerations

Extremes in temperature and moisture availability create severe stresses on both cool and warm season grasses. The selection of appropriate turf-establishment methods requires a great deal of forethought.

A quality turf containing the recommended mixtures and species can be established with either seed or sod. Soil preparation for the two methods is the same.

The advantages of properly installed sod include:

1. Immediate erosion control.

2. An instant green surface with no dust or mud.

3. Nearly year-round establishment capability.

4. Less chance of failure than seed.

5. Freedom from weeds.

6. Quick use of the sodded surface.

7. The option of buying a quality-controlled product with predictable results.

It is initially more costly to install sod than to seed. However, this cost is justified in places where sod can perform better than seed in controlling erosion.

In swales and waterways where concentrated flow will occur, properly pegged sod is preferable to seed because there is no lag time between installation and the time when the channel is protected by vegetation.

Drop inlets which will be placed in grassed areas can be kept free of sediments, and the grade immediately around the inlet can be maintained, by framing the inlet with sod strips.

Sod can be laid during times of the year when seeded grass may fail, so long as there is adequate water available for irrigation in the early weeks.

Ground preparation and proper maintenance are as important with sod as with seed. Sod is composed of living plants and those plants must receive adequate care in order to provide vegetative stabilization on a disturbed area.

Specifications

Soil Preparation -

1. Prior to soil preparation, areas to be sodded shall be brought to final grade in accordance with the approved plan.

2. Soil tests should be made to determine the exact requirements for lime and fertilizer.

   Under difficult circumstances where it is not possible to obtain a soil test, the following soil amendments shall be made:

   Pulverized agricultural limestone at 440 kg per 1,000 square meters (90 lbs per 1,000 square feet).

   Fertilizer at 122 kg per 1,000 square meters (25 lbs per 1,000 square feet) of 10-10-10 in fall, or 122 kg per 1,000 square feet of 5-10-10 in spring.

   Note: Equivalent nutrients may be applied with other fertilizer formulations.

   These amendments shall be spread evenly over the area to be sodded, and incorporated (if possible) into the top 75 to 150 millimeters (3 to 6 inches) of the soil by discing, harrowing or other acceptable means.

3. Prior to laying sod, the soil surface shall be clear of trash, debris, large roots, branches, stones and clods in excess of 25 millimeters (1 inch) in length or diameter. Sod shall not be applied to gravel or other non-soil surfaces.

4. Any irregularities in the soil surface resulting from top-soiling or other operations shall be filled or leveled in order to prevent the formation of depressions or water pockets.

5. Areas to be topsoiled and topsoil used shall fulfill the requirements of TOPSOILING, BMP-30. No sod shall be spread on soil which has been treated with soil sterilants or any other toxic herbicides until enough time has elapsed to permit dissipation of toxic materials.

Quality of Sod -

1. Sod used shall be state-certified. Certified turfgrass sod is grown from Certified seed, inspected and certified by the certifying agency of the states. This ensures genetic purity, high quality, freedom from noxious weeds and excessive insect or disease problems. The sod must meet published state standards and bear an official "Certified Turf" label on the bill of jading.

2. High-quality sod is also available outside of the state certified sod programs. When purchasing this sod, the consumer is encouraged to be aware of factors which are important in determining sod quality. High-quality sod will contain the best varieties and be free of serious disease, insect, or weed problems. It will be dense, have good color, and hold together well.

3. Sod shall be machine cut at a uniform soil thickness of 13 to 25 millimeters (0.5 to 1.0 inches) at the time of cutting. This thickness shall exclude shoot growth and thatch.

4. Pieces of sod shall be cut to the supplier's standard width and length, with a maximum allowable deviation in any dimension of 5%. Torn or uneven pads will not be acceptable.

5. Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended from a firm grasp on one end of the section.

6. Sod shall not be cut or laid in excessively wet or dry weather.

7. Sod shall be harvested, delivered, and installed within a period of 36 hours.

Choosing Appropriate Types of Sod -

The type of sod used must be composed of plants adapted to the locality. Selection of the type of sod best suited to your area is necessary to ensure that the sod performs well.

Sod Installation (See Figure 33-1) -

1. Sod should not be laid on soil surfaces that are frozen.

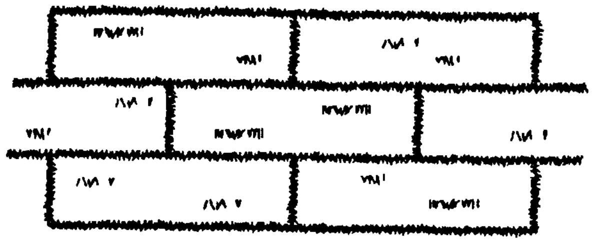
2. During periods of high temperature, the soil shall be lightly irrigated immediately prior to laying the sod, to cool the soil and reduce root burning and dieback.

3. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and butting tightly against each other. Lateral joints shall be staggered to promote more uniform growth and strength. Care shall be exercised to ensure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would cause drying of the roots.

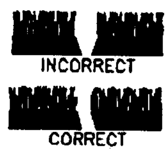
4. On slopes 3:1 or greater, or wherever erosion may be a problem, sod shall be laid with staggered joints and secured by stapling or other approved methods. Sod shall be installed with the length perpendicular to the slope (on the contour).

5. As sodding of clearly defined areas is completed, sod shall be rolled or tamped to provide firm contact between roots and soil.

Figure 33-1: SODDING

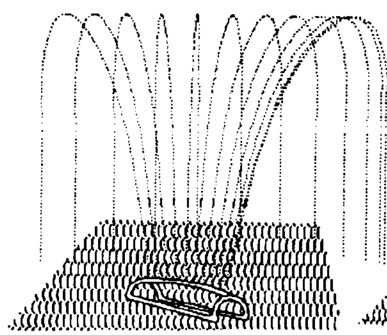


LAY SOD IN A STAGGERED PATTERN. BUTT THE STRIPS TIGHTLY AGAINST EACH OTHER. DO NOT LEAVE SPACES AND DO NOT OVERLAP. A SHARPENED MASON'S TROWEL IS A HANDY TOOL FOR TUCKING DOWN THE ENDS AND TRIMMING PIECES.

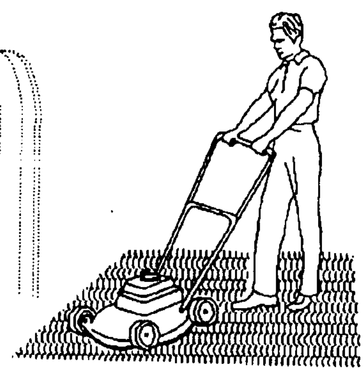


BUTTING – ANGLED ENDS CAUSED BY THE AUTOMATIC SOD CUTTER MUST BE MATCHED CORRECTLY.

ROLL SOD IMMEDIATELY TO ACHIEVE FIRM CONTACT WITH THE SOIL.

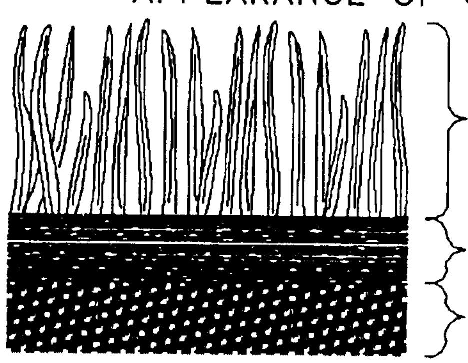


WATER TO A DEPTH OF 100 mm (4 in.) AS NEEDED. WATER WELL AS SOON AS THE SOD IS LAID.



MOW WHEN THE SOD IS ESTABLISHED - IN 2-3 WEEKS. SET THE HEIGHT OF THE MOWER 50 - 75 mm (2-3 in.).

APPEARANCE OF GOOD SOD



SHOOTS OR GRASS BLADES. GRASS SHOULD BE GREEN AND HEALTHY. MOWED AT A 50 - 75 mm (2-3 in.) CUTTING HEIGHT.

THATCH - GRASS CLIPPINGS AND DEAD LEAVES, UP TO 13 mm (0.5 in.) THICK.

ROOT ZONE - SOIL AND ROOTS SHOULD BE 13 - 20 mm (0.5 - 0.75 in.) THICK, WITH DENSE ROOT MAT FOR STRENGTH.

6. After rolling, sod shall be irrigated to a depth sufficient that the underside of the sod pad and the soil 100 millimeters (4 inches) below the sod is thoroughly wet.

7. Until such time a good root system becomes developed, in the absence of adequate rainfall, watering shall be performed as often as necessary to maintain moist soil to a depth of at least 100 millimeters (4 inches).

8. The first mowing shall not be attempted until the sod is firmly rooted, usually 2-3 weeks. Not more than one third of the grass leaf shall be removed at any one cutting.

Sodded Waterways (See Figure 33-2)-

1. Care should be taken to prepare the soil adequately in accordance with this specification. The sod type shall consist of plant materials able to withstand the designed velocity (see STORMWATER CONVEYANCE CHANNELS, BMP-17).

2. Sod strips in waterways shall be laid perpendicular to the direction of flow. Care should be taken to butt ends of strips tightly.

3. After rolling or tamping, sod shall be pegged or stapled to resist washout during the establishment period. Jute mesh or other netting may be pegged over the sod for extra protection in critical areas.

4. All other specifications for this practice shall be adhered to when sodding a waterway.

<u>Maintenance of Established Sod</u>

1. During the 2 to 3 week establishment stage, sod shall be watered as necessary to maintain adequate moisture in the root zone and prevent dormancy of sod.

2. No more than one third of the shoot (grass leaf) should be removed in any mowing. Grass height should be maintained between 50 and 75 millimeters (2 and 3 inches) unless otherwise specified.

3. After the first growing season, established sod will require fertilization and may require lime. Follow soil test recommendations when possible, or apply maintenance levels as outlined in Table 33-1.

FIGURE 33-2: SODDED WATERWAYS

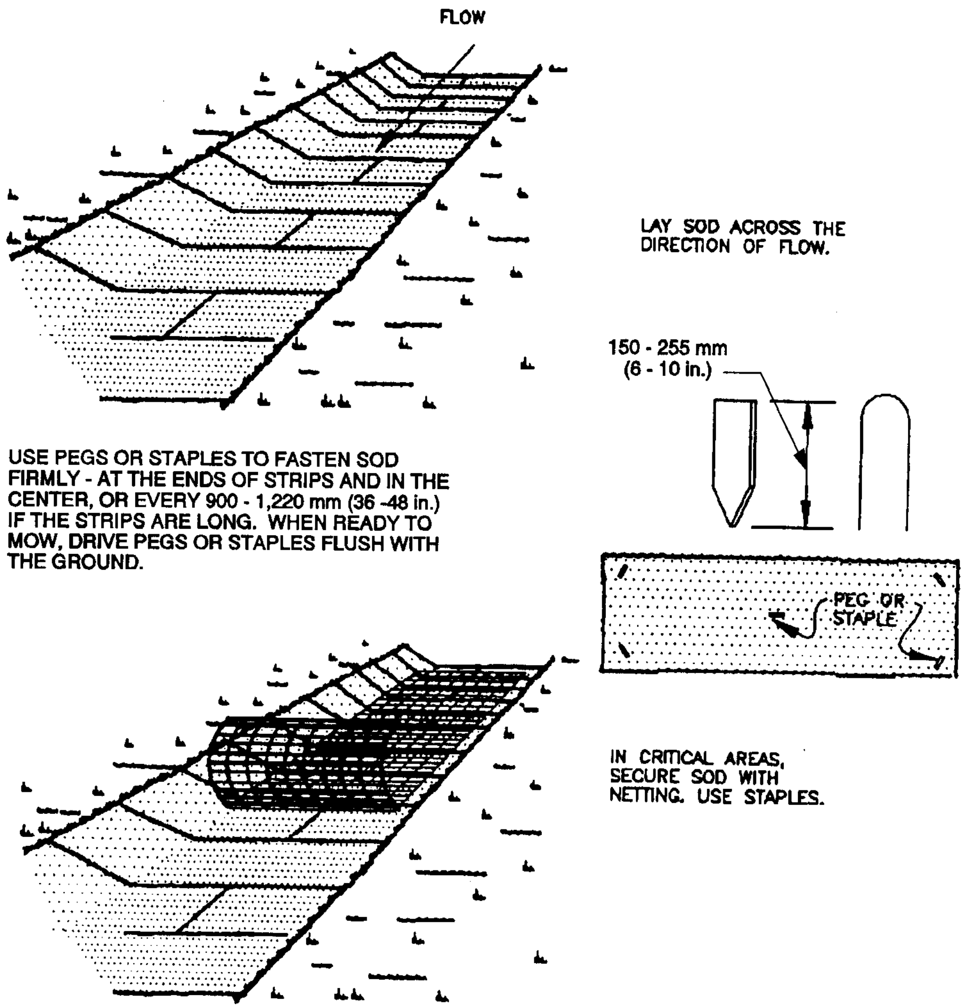


TABLE 33-1
MAINTENANCE FERTILIZATION OF ESTABLISHED SOD

Cool Season Grasses

20 kg nitrogen per 1,000 square meters per year
(4 lbs/1000 square feet/year)

5 kg phosphorus (P) per 1,000 square meters per year
(1 lbs./1000 square feet/year)

10 kg Potash (K) per 1,000 square meters per year
(2 lbs./1000 square feet/year)

75% of the total requirements should be applied between September 1 and December 31st. The balance should be applied during the remainder of the year

Warm Season Grasses

Apply 20-25 kg nitrogen (N) per 1,000 square meters per year
between May 1st and August 15th
(4-5 lbs/1000 square feet per year)

Phosphorus (P) and Potash (K) should only be applied according to soil tests.

Maintenance fertilization should utilize slow release fertilizers which reduce the number of applications per year and subsequently reduce the adverse impacts on groundwater.

BMP-34

BMP: BERMUDAGRASS & ZOYSIAGRASS ESTABLISHMENT

Definition

The establishment of vegetative cover with hybrid Bermudagrass or Zoysiagrass by planting sprigs, stolons, or plugs.

Purposes

1. To reduce erosion and decrease sediment yield from disturbed areas.

2. To stabilize disturbed areas with a specific plant material suited to the site at a cost of less than would be incurred by installing sod.

3. To establish vegetative cover more rapidly than would be possible using seed.

Conditions Where Practice Applies

1. In areas where hybrid Bermudagrass or Zoysiagrass is the desired plant material, and establishment with sod is not preferred.

2. Bermudagrass and Zoysiagrass are particularly suited to droughty, sandy sites or situations where high salt content is a problem. They should not be used in shaded areas or on poorly drained sites.

3. Where irrigation can be made available during the establishment phase.

Planning Considerations

Bermuda and Zoysia are warm season, permanent grasses which are well-suited to erosion control, as they have vigorous rhizomes and stolons (runners). There are two types of Bermudagrass grown, common and hybrid.

Common Bermudagrass produces seed and may be established with seed. However, it has the potential to become a weed problem because it spreads vigorously; it is also coarse and not suitable for fine turf. Common Bermuda has little cold tolerance and winterkills frequently.

Hybrid Bermudagrasses and Zoysiagrass are established mainly by sodding, sprigging, or plugging. There are recent developments in the turf industry that have allowed hybrid Bermuda stands to be established from seed; however, the technology is relatively new. These grasses produce a fine, tight turf, do not spread as vigorously as common Bermudagrass, exhibit good cold tolerance, and can withstand many adverse conditions. For these reasons, hybrid Bermudagrass and Zoysiagrass are the warm season permanent turf grasses of choice.

Sprigging: A sprig is a small section of rhizome (underground stem) 75 to 125 millimeters (3 to 5 inches) long, with at least one node or joint. Leaves should be present at the nodes. Stolons (runners) are above-ground stems that spread by creeping on the soil surface. A mixture of sprigs and stolons is usually used in "sprigging". Sprigs may be planted by machine or hand.

Plugging: Plugs are small sections of sod which are pressed into precut holes in the soil so that topgrowth is flush to the surface and leaves are exposed. Plugs are usually planted by hand; however, plugging machines are also available.

Notably, where speed is essential and cost is not an overriding constraint, sod should be used (see SODDING, BMP-33).

Both Zoysia and Bermuda are particularly suited to use in grasslined waterways. Depending upon the soil type, an established stand of can tolerate intermittent concentrated flows of water on slopes up to 10%. It is important to divert runoff from the waterway during the first three weeks of establishment to permit the grass to take root. If this cannot be done, the center of the waterway should be sodded to prevent washout.

Bermudagrass is drought-tolerant, salt-tolerant, and tolerates floods of short duration. It prefers a pH range from 6.0-7.0 with high nitrogen fertilization during the growing season. Most Bermudagrasses are adapted to the warmer climates; however, turf research has developed several varieties that continue to perform very well in the colder regions. Currently, varieties of all Bermudagrass will be dormant in winter and will turn brown at that time.

The Bermudagrass hybrids most frequently used differ in appearance, cold tolerance, and suitability for turf use. The following varieties are suggested for rough and fine-turf areas:

For Rough Areas -

Midland: A cold-hardy variety adapted in all areas of the state at medium to low elevations. Adapted for forage production, this is a tall-growing Bermuda (12-18 inches) and should be used in low-maintenance areas.

Coastal: Also a forage type, for low-maintenance areas.

For Fine-Turf Areas -

Midiron: A fine-turf type. Has a good to fair chance of surviving most winters.

Vamont: Similar cold tolerance and texture to Midiron but far more aggressive.

Tufcote: A fine-turf type. Less cold-hardy than Midiron.

Tifway: A fine-textured turf type. Not as cold-hardy as Tufcote.

It has been determined that Zoysia has limited potential for use in athletic field development due to recovery problems and slow establishment. Establishment is commonly achieved by sprigs or plugs and seeds pretreated with potassium hydroxide. The following varieties are presently listed on the recommended list:

Meyer: A broad blade is prevalent. This variety is considered more winter-hardy than others.

Emerald: A fine-turf type. A much finer blade than that found on Meyer. This variety is also much less winter-hardy.

Specifications

Soil Preparation -

Procedures for preparing the soil are the same for sprigging and plugging.

1. Bermuda and Zoysia require soil which is well drained, loose enough for root penetration, has a pH range between 6.0-7.0, and is free of toxic amounts of materials harmful to plant growth. If any of these criteria cannot be met, topsoil shall be applied in accordance with TOPSOILING, BMP-30.

2. Necessary erosion and sediment control practices will be installed prior to establishment of Bermudagrass. Final grading will be carried out according to the approved plan.

3. Surfaces will be roughened in accordance with SURFACE ROUGHENING, BMP-29.

4. The soil shall be free of debris, trash, large roots, and weeds.

Lime and Fertilizer -

Soil tests should be made to determine the exact requirements for lime and fertilizer. Soil tests may be conducted by a reputable commercial laboratory. Information on state soil tests is available from county or city agricultural extension agents.

Under difficult circumstances where it is not possible to obtain a soil test, the following soil

> Pulverized agricultural limestone: 440 kg/1,000 square meters (90 lbs/1,000 square feet). An agricultural grade of limestone should be used.
>
> Fertilizer: Apply 110 kg/1,000 sq. meters of 10-10-10 (1000 lbs./acre) and follow with additional nitrogen application as indicated by soil test conducted 30-60 days later.
>
> Note: Equivalent nutrients may be applied with other fertilizer formulations.

These amendments shall be spread evenly over the area to be sprigged, and incorporated into the top 75 to 150 millimeters (3-6 inches) of the soil by discing, harrowing or other acceptable means.

Any irregularities in the soil surface resulting from topsoiling or other operations shall be filled or leveled in order to prevent the formation of water pockets.

Soil preparation, liming, and fertilizing should be completed before delivery of sprigs or sod is requested. This material is perishable and should not remain on a pallet or in crates longer than 36 hours from the time of digging. The presence of mildew or distinct yellowing of the leaves is usually a good indication of damage to turf.

Sprigging and Plugging -

Sources: Sprigs can be purchased as sod and then shredded or can often be purchased by the bushel. For turf-type Bermudagrasses, Certified or Approved sod sources should be used. Plugs may be cut from sod as needed or purchased precut. Coastal and Midland Bermudagrasses may be available through agricultural sources. Interested persons should contact the county or city agricultural extension agent or the USDA-SCS district office for information on where these materials may be obtained. Sprigs shall be 75 to 125 millimeters (3 to 5 inches) long, having several nodes (joints). Plugs shall have a minimum diameter of 50 millimeters (2 inches).

Quantities of Material Needed:

Sprigging: 72- 108 square meters of sod per 1,000 square meters (8-12 square yards of sod per 1,000 square feet). One bushel of sprigs is approximately equal to 1 square yard of sod (with soil removed).

Plugging: About 72 square meters of sod per 1,000 square meters (12 square yards of sod for 1,000 square feet).

When to Plant: To establish quickly, many feel Bermudagrass should not be in a dormant state (leaves should be green). However there is research that shows some success with dormant installations. Nonetheless, in order that plants may develop adequate root structure before cold weather begins, plantings should be made no later than midsummer. May 1 through July 15 is the optimum season for Bermudagrass establishment.

How to Plant:

Sprigging: Sprigs may be broadcast over the surface by hand, planted in rows by machine, or applied with a hydrosprigger. Machines are available which will insert sprigs properly and firm the soil over them. When sprigs are broadcast or hydrosprigged, they should be partially covered with soil by light discing or topdressing with good soil. Ideally, half of the sprig should be covered with soil, and half (including some leaves) should be exposed. Soil should be firmed over the sprigs by using a cultipacker, or by rolling or tamping. When planted in rows, sprigs should be placed no more than 300 millimeters (12 inches) apart in rows which are 300 to 450 millimeters (12 to 18 inches) apart. Closer spacing is recommended for slopes, waterways, and highly erodible soils.

Plugging: Plugs should be inserted in the soil surface so that leaf tips are above the surrounding soil, and tamped firmly in place. Plugs should be placed in a grid pattern on 300 to 450 millimeter centers (12 to 18 inches). Closer spacing is recommended on critical areas. Plugs are usually placed by hand, but machines are available which can plug automatically.

Helpful Hints: The following are essential for good Bermudagrass or Zoysiagrass growth:

1. Adequate moisture - water immediately after planting, and water enough to keep soil moist to a depth of 100 millimeters (4 inches) during the first 4 weeks and as needed thereafter to sustain growth.

2. Sunlight - do not permit mulches, other plantings, etc. to shade new Bermudagrass stands.

3. Freedom from erosive forces - keep concentrated flows of water off of new plantings for 2 weeks to one month.

Weed Control: In order to become effectively established, Bermudagrass must not have to compete with weeds for sunlight, water, or space. Cultivating is impractical as growing stolons may be injured.

Oxadiazon or equivalent, applied immediately following sprigging at a rate of 110 - 170 kilograms per hectare (100-150 lbs./acre) depending on time of year gives excellent control of most broadleaf and grassy weeds; use 2-3 kilograms per hectare (2-3 lbs per acre) of active ingredient. For control of broadleaf weeds only, apply Dicamba (0.3 to 0.6 kilograms active ingredient/hectare (0.25 to 0.5 lbs per acre) and 2,4-D - 1.1 kilogram active ingredient/hectare (1 lb/acre). Use these herbicides when weeds are 50 to 75 millimeters tall (2- to 3-inches), but <u>not before-grass is well-rooted</u>.

<u>Maintenance</u>

Bermudagrass and Zoysiagrass sprigs and plugs can be expected to root in 5 to 10 days under optimum conditions. Full coverage of the soil by spreading plants can be obtained in 8-12 weeks with good growing conditions and proper maintenance.

Stands may be mowed when growth requires it. Coastal and Midland growths may be left unmowed except for once-a-year trimming to 150 millimeters (6 inches). Turf-type Bermudagrasses may be cut at 25 to 40 millimeters (1 to 1.5 inches).

For maintenance purposes, apply 5 kilograms actual nitrogen per 1,000 square meters (1 lb/1000 square feet) at 30-45 day intervals after initial installation until August 15th. Fertilizer must be of a type in which 50% or more of the nitrogen is water-insoluble.

BMP: MULCHING

Definition

Application of plant residues or other suitable materials to the soil surface.

Purposes

1. To prevent erosion by protecting the soil surface from raindrop impact and reducing the velocity of overland flow.

2. To foster the growth of vegetation by increasing available moisture and providing insulation against "extreme heat and cold.

Conditions Where Practice Applies

1. Areas which have been permanently seeded (see BMP-32, PERMANENT SEEDING) should be mulched immediately following seeding.

2. Areas which cannot be seeded because of the season should be mulched to provide some protection to the soil surface. An organic mulch should be used, and the area then seeded as soon weather or seasonal conditions permit. It is not recommended that fiber mulch be used alone for this practice; at normal application rates it just simply does not provide the protection that is achieved using other types of mulch.

3. Mulch may be used together with plantings of trees, shrubs, or certain ground covers which do not provide adequate soil stabilization by themselves.

4. Mulch shall be used in conjunction with temporary seeding operations as specified in TEMPORARY SEEDING, BMP-31.

Planning Considerations

Mulches are applied to the soil surface to conserve a desirable soil property or to promote plant growth. A surface mulch is one of the most effective means of controlling run-off and on disturbed land.

Mulches can increase the infiltration rate of the soil, reduce soil moisture loss by evaporation, prevent crusting and sealing of the soil surface, modify soil temperatures, and provide a suitable microclimate for seed germination.

Organic mulch materials, such as straw, wood chips, bark, and fiber mulch have been found to be the most effective.

Chemical soil stabilizers or soil binders should not be used alone for mulch. These materials are useful to bind organic mulches together to prevent displacement.

A variety of manufactured SOIL STABILIZATION BLANKET'S AND MATTING (see BMP-36) have been developed for erosion control in recent years. Some of these products can be used as mulches, particularly in critical areas such as waterways. They also may be used to hold other mulches to the soil surface.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season and economics. It is especially important to mulch liberally in midsummer and prior to winter, and on cut slopes and southern slope exposures.

Organic Mulches -

Straw - The mulch most commonly used in conjunction with seeding. The straw should come from wheat or oats (free of troublesome weed seeds) and may be spread by hand or machine. Straw can be windblown and must be anchored down by an acceptable method.

Hay - May be used in lieu of straw where volunteers will not present a problem, and may be spread by hand or machine. Hay can be windblown and must also be anchored or tacked down.

Corn Stalks - These should be shredded into 100 to 150 millimeter (4 to 6 inch) lengths. Stalks decompose slowly and are resistant to displacement.

Wood Chips - Suitable for areas that will not be closely mowed, and around ornamental plantings. Chips decompose slowly and do not require tacking. They must be treated with 6 kilograms of nitrogen per 1000 kilograms of chips (12 pounds per ton) to prevent nutrient deficiency in plants; however, can be a very inexpensive mulch if chips are obtained from trees cleared on the site.

Bark Chips, Shredded Bark - These are by-products of timber processing which are used in landscaped plantings. Bark is also a suitable mulch for areas planted to grasses and not closely mowed. It may be applied by hand or mechanically and is not usually toxic to grasses or legumes; additional nitrogen fertilizer is not required.

Fiber Mulch - Used in hydroseeding operations and applied as part of the slurry. It creates the best seed-soil contact when applied over top of (as a separate operation) newly seeded areas. These fibers do not require tacking, although tacking agents or binders are sometimes used in conjunction with the application of fiber mulch. This form of mulch does not provide sufficient protection to highly erodible soils. Additionally, fiber mulch will not be considered adequate mulch when used during the dry summer months or when used for late fall mulch cover. Use straw mulch during these periods. Fiber mulch may be used to tack (anchor) straw mulch. This treatment is well suited for steep slopes, critical areas, and areas susceptible to displacement.

There are other organic materials which make excellent mulches but are only available locally or seasonally. Creative use of these materials can reduce costs.

Chemical Mulches and Soil Binders -

A wide range of synthetic, spray-on materials are marketed to stabilize and protect the soil surface. These are emulsions or dispersions of vinyl compounds, rubber or other substances which are mixed with water and applied to the soil. They may be used alone in some cases as temporary stabilizers, or in conjunction with fiber mulches or straw.

When used alone, chemical mulches do not have the capability to insulate the soil or retain soil moisture that organic mulches have. This soil protection is also easily damaged by traffic. Application of these mulches is usually more expensive than organic mulching, and the mulches decompose in 60-90 days.

Blankets and Matting -

Field experience has shown that plastic netting, when used alone, does not retain soil moisture or modify soil temperature. In some cases it may stabilize the soil surface while grasses are being established, but is primarily used in grassed waterways and on slopes to hold straw or similar mulch in place.

Jute mesh and other soil stabilization blankets are good choices for mulching on difficult slopes and in minor drainage swales. Most of the soil stabilization mattings (used to create a permanent matrix for root growth within the soil) must receive mulching in order to properly stabilize an area. Notably, some manufacturers have recently developed permanent mattings which include self-contained, temporary mulching materials; however, these measures will have to meet the requirements noted in BMP-36, SOIL STABILIZATION BLANKET'S AND MATTING, before they can be recommended for use on steep slopes and in channel flow situations.

The most critical aspect of installing blankets and mats is obtaining firm continuous contact between the material and the soil. Without such contact, the material may fail and thereby allow erosion to occur. It is important to use an adequate number of staples and make sure the material is installed properly in order to maximize soil protection. These products are discussed in more detail in BMP-36, SOIL STABILIZATION BLANKETS & MATTING.

Specifications

Mulches -

Organic mulches may be used in any area where mulch is required, subject to the restrictions noted in Table 35-1.

Materials: Select mulch material based on site requirements, availability of materials, and availability of labor and equipment. Table 35-1 lists the most commonly used organic mulches. Other materials, such as peanut hulls and cotton burs, may be used With the permission of the local Plan-Approving Authority.

Prior to mulching: Complete the required grading and install needed sediment control practices.

Lime and fertilizer should be incorporated and surface roughening accomplished as needed. Seed should be applied prior to mulching except in the following cases:

a. Where seed is to be applied as part of a hydroseeder slurry containing fiber mulch.

b. Where seed is to be applied following a straw mulch spread during winter months.

Application: Mulch materials shall be spread uniformly, by hand or machine. When spreading straw mulch by hand, divide the area to be mulched into approximately 100 square meter (1,000 square feet) sections and place 34-44 kilograms of straw in each 100 square meter section to facilitate uniform distribution (70-90 lbs of straw per 1,000 square foot section).

Mulch Anchoring: Straw mulch must be anchored immediately after spreading to prevent displacement. Other organic mulches listed in Table 35-1 do not require anchoring. The following methods of anchoring straw may be used:

TABLE 35-1
ORGANIC MULCH MATERIALS AND APPLICATION RATES

MULCHES	RATES		NOTES
	Kilograms per 1,000 sq. meters	Pounds per 1000 sq. feet	
Straw or Hay	340 - 440 kg	70 - 90 lbs.	Free from weeds and coarse matter. Must be anchored. Spread with mulch blower or by hand.
Fiber Mulch	170 kg	35 lbs.	Do not use as mulch for winter cover or during hot, dry periods.* Apply as slurry.
Corn Stalks	905 - 1,345 kg	185- 275 lbs.	Cut or shredded in 4-6" lengths. Air-dried. Do not use in fine turf areas. Apply with mulch blower or by hand.
Wood Chips	905 - 1,345 kg	185 - 275 lbs.	Free of coarse matter. Air dried. Treat with 12 lbs nitrogen per ton. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand.
Bark Chips or Shredded Bark	0.8 - 1.5 cubic meters	1-2 cubic yards	Free of coarse matter. Air dried. Do not use in fine turf areas. Apply with mulch blower, chip handler, or by hand.

When fiber mulch is the only available mulch during periods when straw should be used, apply at a minimum rate of 220 kg/1,000 square metes (45 lbs./1000 sq. ft.)

1. Mulch anchoring tool (often referred to as a Krimper or Krimper Tool): This is a tractor-drawn implement designed to punch mulch into the soil surface. This method provides good erosion control with straw. It is limited to use on slopes no steeper than 3:1, where equipment can operate safely. Machinery shall be operated on the contour.

2. Fiber Mulch: A very common practice with widespread use today. Apply fiber mulch by means of a hydroseeder at a rate of 560-840 kilograms per hectare (500-750 pounds per acre) over top of straw mulch or hay. It has an added benefit of providing additional mulch to the newly seeded area.

3. Liquid mulch binders: Application of liquid mulch binders and tackifiers should be heaviest at edges of areas and at crests of ridges and banks, to prevent displacement. The remainder of the area should have binder applied uniformly. Binders may be applied after mulch is spread or may be sprayed into the mulch as it is being blown onto the soil.

   The following types of binders may be used:

   a. Synthetic binders - Formulated binders or organically formulated products may be used as recommended by the manufacturer to anchor mulch.

   b. Asphalt* - Any type of asphalt thin enough to be blown from spray equipment is satisfactory. Recommended for use are rapid curing (RC-70, RC-250, RC-800), medium curing (MC-250, MC-800) and emulsified asphalt (SS-1, CSS-1, CMS-2, MS-2, RS-1, RS-2, CRS-1, and CRS-2).

      Apply asphalt at 0.5 liters per square meter (10 gallons per 1,000 square feet). Do not use heavier applications as it may cause the straw to "perch" over rills. All asphalt designations are from the Asphalt Institute Specifications.

*Note: This particular method is not used as commonly today as it once was in the past. The development of hydraulic seeding equipment promoted the industry to turn to synthetic or organically based binders and tackifiers. When this method is used, environmental concerns should be addressed to ensure that petroleum-based products do not enter valuable water supplies. Avoid applications into waterways or channels.

4. Mulch netting: Lightweight plastic, cotton, or paper nets may be stapled over the mulch according to manufacturer's recommendations.

5. Peg and twine: Because it is labor-intensive, this method is feasible only in small areas where other methods cannot be used. Drive 200 to 250 millimeter (8- to 10-inch) wooden pegs to within 75 millimeters (3 inches) of the soil surface, every 1 meter (4 feet) in all directions. Stakes may be driven before or after straw is spread. Secure mulch by stretching twine between pegs in a criss-cross-within-a square pattern. Turn twine 2 or more times around each peg.

Chemical Mulches -

Chemical mulches* may be used alone only in the following situations:

a. Where no other mulching material is available.

b. In conjunction with temporary seeding during the times when mulch is not required for that practice.

c. From March 15 to May 1 and August 15 to September 30, provided that they are used on areas with slopes <u>no steeper</u> than 4: 1, which have been roughened in accordance with SURFACE ROUGHENING, BMP-29. If rill erosion occurs, another mulch material shall be applied immediately.

<u>Note:</u> Chemical mulches may be used to bind other mulches or with fiber mulch in a hydroseeded slurry at any time. Manufacturer's recommendations for application of chemical mulches shall be followed.

<u>Maintenance</u>

All mulches and soil coverings should be inspected periodically (particularly after rainstorms) to check for erosion. Where erosion is observed in mulched areas, additional mulch should be applied. Nets and mats should be inspected after rainstorms for dislocation or failure. If washouts or breakage occur, re-install netting or matting as necessary after repairing damage to the slope or ditch. Inspections should take place up until grasses are firmly established. Where mulch is used in conjunction with ornamental plantings, inspect periodically throughout the year to determine if mulch is maintaining coverage of the soil surface; repair as needed.

BMP: SOIL STABILIZATION BLANKETS & MATTING

Definition

The installation of a protective covering (blanket) or a soil stabilization mat on a prepared planting area of a steep slope, channel or shoreline.

Purpose

To aid in controlling erosion on critical areas by providing a microclimate which protects young vegetation and promotes its establishment. In addition, some types of soil stabilization mats are also used to raise the maximum permissible velocity of turf grass stands in channelized areas by "reinforcing the turf' to resist the forces of erosion during storm events.

Conditions Where Practice Applies

On short, steep slopes where erosion hazard is high and planting is likely to be too slow in providing adequate protective cover; in vegetated channels where the velocity of design flow exceeds "allowable" velocity; on streambanks or tidal shorelines where moving water is likely to wash out new plantings; or in areas where the forces of wind prevent standard mulching practices from remaining in place until vegetation becomes established.

Planning Considerations

Soil stabilization blankets and mats can be applied to problem areas to supplement nature's erosion control system (vegetation) in its initial establishment and in providing a safe and "natural" conveyance for high velocity stormwater runoff. They are being used today in many applications were previously a structural lining would have been required. Care must be taken to choose the type of blanket or matting which is most appropriate for the specific needs of a project. Two general types of blankets and mats are discussed within this management practice. However, with the abundance of soil stabilization products available today, it is impossible to cover all the advantages, disadvantages and specifications of all manufactured blankets and mats. Therefore, as with many erosion control-type products, there is no substitute for a thorough understanding of the manufacturer's instructions and recommendations and a site visit by a designer or plan reviewer to verify a product's appropriateness,

Treatment-1 is a degradable soil stabilization blanket which includes "combination" blankets consisting of a plastic netting which covers and is intertwined with a natural organic or manmade mulch; or, a jute mesh which is typically homogeneous in design and can act alone as a soil stabilization blanket.

It should be used to help establish vegetation on previously disturbed slopes - normally problem slopes of 3:1 or greater. Since the materials which compose the soil stabilization blankets will deteriorate over time, they should be used in permanent conveyance channels with the realization that the system's resistance to erosion is based on the type of vegetation planted and the existing soil characteristics. During the establishment of vegetation, **Treatment-1** should not be subjected to shallow or deep concentrated flows moving at greater than 1 meter per second (4 feet per second).

Treatment-1 provides the following benefits in the achievement of vegetative stabilization when properly applied over seed and.required amendments:

1. Protection of the seed and soil from raindrop impact and subsequent displacement.

2. Thermal consistency and moisture retention for seedbed area.

3. Stronger and faster germination of grasses and legumes.

4. Planing off excess stormwater runoff.

5. Prevention of sloughing of topsoil added to steeper slopes.

Treatment-2 is a soil stabilization matting which consists of a non-degradable, 3-dimensional plastic structure which can be filled with soil prior to planting. This configuration provides a matrix for root growth where the matting becomes entangled and penetrated by roots, forming continuous anchorage for surface growth and promoting enhanced energy dissipation. **Treatment-2** can be used on problem slopes (normally 3:1 or greater), and in stormwater conveyance channels.

In addition to those benefits noted for **Treatment-1, Treatment-2** provides the following benefits in the achievement of vegetative stabilization and in the replacement of more traditional channel linings such as concrete and riprap:

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

2. When embedded in the soil within stormwater channels, it acts with the vegetative root system to form an erosion resistant cover which resists hydraulic lift and shear forces.

Since **Treatment-2** is non-degradable, it can be used in permanent conveyance channels and can withstand higher velocities of flow than the vegetation and soil would normally allow. However, a 3 meter per second (10 feet per second) of flow should be the maximum allowed in a conveyance system which utilizes **Treatment-2.**

TREATMENT-1: SOIL STABILIZATION BLANKET

Allowable Velocity Range During Vegetation Establishment: 0 - 3 meters per second (0 - 4 feet per second).

Materials -

1. Combination Blankets - They shall consist of a photo-degradable plastic netting which covers and is entwined in a natural organic or man-made mulching material.

   The mulching material shall consist of wood fibers, wood excelsior, straw, coconut fiber, or man-made fibers, or a combination of the same. The blanket shall be of consistent thickness with the mulching material/fibers evenly distributed over its entire length. The mulching material/fibers must interlock or entwine to form a dense layer which not only resists raindrop impact, but will allow vegetation to penetrate the blanket.

   The blanket shall be nontoxic to vegetation and to the germination of seed and shall not be injurious to the unprotected skin of humans. At a minimum, the plastic netting must cover the top side of the blanket and possess a high web strength. The netting shall be entwined with the mulching material/fiber to maximize strength and provide for ease of handling.

2. Jute Mesh - It shall be of a uniform, open, plain weave, of undyed and unbleached single jute yam. The yam shall be of loosely twisted construction and shall not vary in thickness by more than one half of its normal diameter. Jute mesh shall be new and shall conform to the following:

a. Length of jute mesh shall be marked on each roll.

b. There shall be 15 millimeter (0.60-inch) openings (+/- 25%) between strands, lengthwise.

c. There shall be 23 millimeter (0.90-inch) openings (+/- 25%) between strands, lengthwise.

d. Weight shall average 0.5 kilograms per square meter (0.90 lbs per square yard) with a tolerance of 5%.

As previously noted, jute mesh provides such good coverage (large surface area of strands) and contains such small openings that it can be used alone as a blanket.

3. Other **Treatment-1** Products - These shall conform to manufacturer's specifications and be approved by the Plan-Approving Authority prior to being specified for a particular application. These products should be installed in accordance with manufacturer's recommendations, provided those recommendations are at least as stringent as this specification.

4. Staples - Staples for anchoring **Treatment-1** shall be No. 11-gauge wire or heavier. Their length shall be a minimum of 150 millimeters (6 inches). A larger staple with a length of up to 300 millimeters (12 inches) should be used on loose, sandy, or unstable soils.

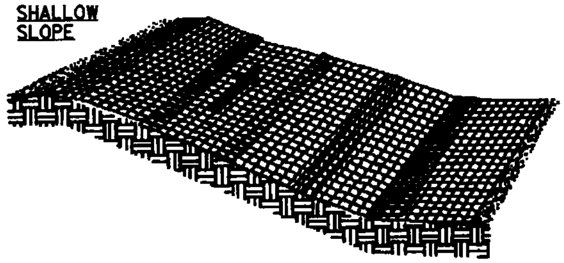
Installation Requirements

Site Preparation - After site has been shaped and graded to approved design, prepare a friable seedbed relatively free from clods and rocks more than 25 millimeters (1 inch) in diameter and any foreign material that will prevent uniform contact of the protective covering with the soil surface.

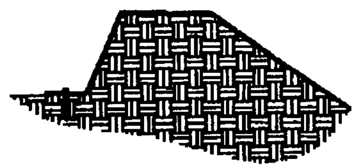
Planting - lime, fertilize, and seed in accordance with seeding or other type of planting plan. When using jute mesh on a seeded area, apply approximately one-half the seed after laying the mat. The protective covering can be laid over sprigged areas where small grass plants have been inserted into the soil. Where ground covers are to be planted, lay the protective covering first and then plant through the material as per planting design.

When open-weave nets are used, lime, fertilizer, seed and mulch should be applied before laying the net. When a combination blanket (such as an "excelsior" blanket) is used, seed and soil amendments must also be applied -before the blanket is laid. Orientation - See Figure 36-1 for orientation of **Treatment-1** for different topographic conditions.

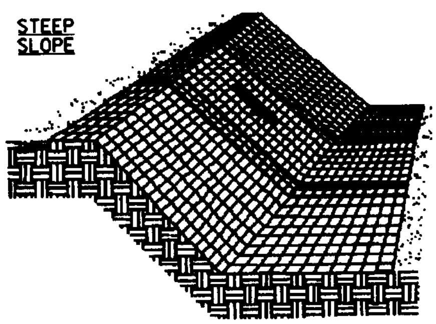
FIGURE 36-1: TYPICAL ORIENTATION OF TREATMENT-1 (SOIL STABILIZATION BLANKET)



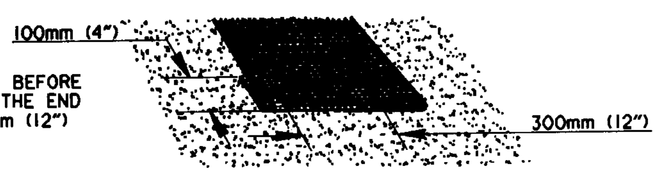
ON SHALLOW SLOPES, STRIPS OF NETTING PROTECTIVE COVERINGS MAY BE APPLIED ACROSS THE SLOPE.



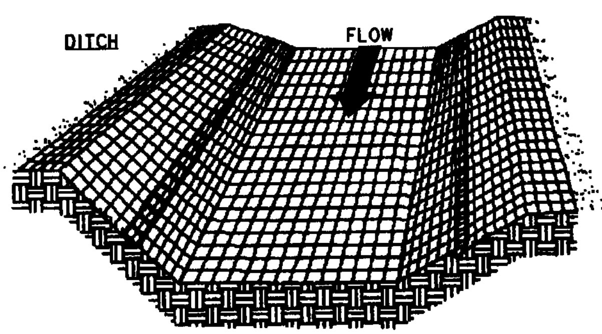
WHERE THERE IS A BERM AT THE TOP OF THE SLOPE, BRING NETTING MATERIAL OVER THE TOP AND ANCHOR BEHIND THE BERM.



ON STEEP SLOPES, APPLY PROTECTIVE COVERING PARALLEL TO THE DIRECTION OF FLOW AND ANCHOR SECURELY.

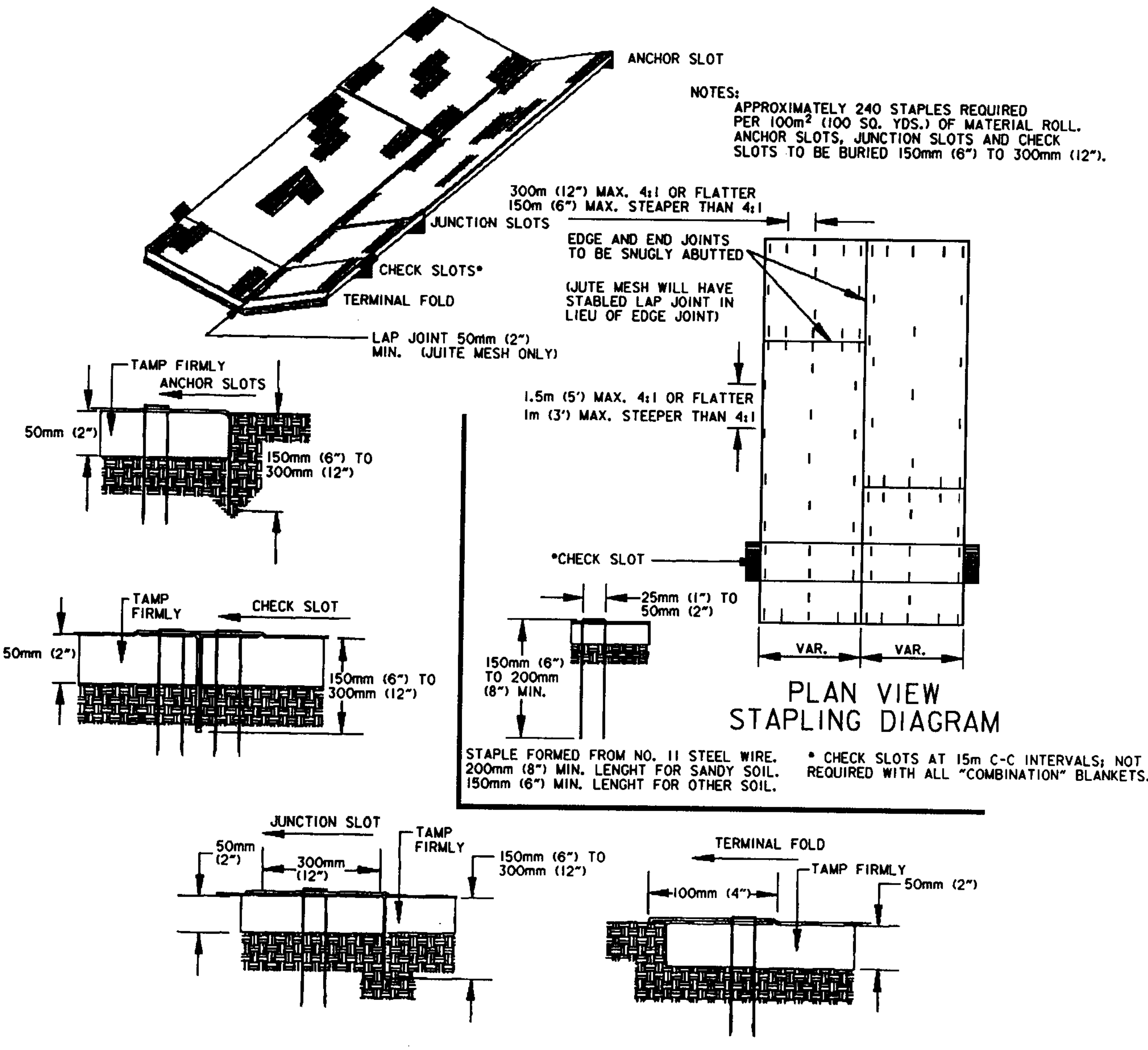


BRING MATERIAL DOWN TO A LEVEL AREA BEFORE TERMINATING THE INSTALLATION. TURN THE END UNDER 100mm (4") AND STAPLE AT 300mm (12") INTERVALS.



IN DITCHES, APPLY PROTECTIVE COVERING PARALLEL TO THE DIRECTION OF FLOW. USE CHECK SLOTS AS REQUIRED. AVOID JOINING MATERIAL IN THE CENTER OF THE DITCH IF AT ALL POSSIBLE.

FIGURE 36-2: TYPICAL TREATMENT-1 (SOIL STABILIZATION BLANKET) INSTALLATION CRITERIA



Laying and Stapling (see Figure 36-2) - If instructions have been followed, all needed check slots will have been installed, and the protective covering will be laid on a friable seedbed free from clods, rocks, roots, etc. that might impede good contact.

1. Start laying the protective covering from the top of the channel or top of slope and unroll down-grade.

2. Allow to lay loosely on soil - do not stretch.

3. Upslope ends of the protective covering should be buried in a anchor slot no less than 150 millimeters (6-inches) deep. Tamp earth firmly over the material. Staple the material at a minimum of every 300 millimeters (12 inches) across the top end.

4. Edges of the material shall be stapled every meter (3 feet). Where multiple widths are laid side by side, the adjacent edges shall be overlapped a minimum of 50 millimeters (2 inches) and stapled together.

5. Staples shall be placed down the center, staggered with the edges at 1 meter (3 foot) intervals.

Check slots - On highly erodible soils and on slopes steeper than 4:1, erosion check slots should be made every 15 meters (50 feet) (see Figure 36-2). Insert a fold of the material (separate piece) into a 150 millimeter (6-inch) trench and tamp firmly. Staple fold to "main" blanket at minimum 300 millimeter (12 - inch) intervals across the upstream and downstream portion of the blanket.

> Note: Many combination blankets are designed and manufactured to resist movement and uplift to a point which check slots may not be required. Plan designers and review authorities are urged to study manufacturers' recommendations and site conditions.

Joining Protective Coverings - Insert a new roll of material into an anchor slot, as with upslope ends. Overlap the end of the previous roll a minimum of 300 millimeters (12 inches), and staple across the end of the roll just below the anchor slot and across the material every 300 millimeters.

Terminal End - At the point at which the material is discontinued, or at which time the protective covering meets a structure of some type, fold 100 millimeters (4 inches) of the material underneath and staple every 300 millimeters (12 inches) (minimum).

At bottom of slopes - Lead net out onto a level area before anchoring. Turn ends under 100 millimeters (4 inches), and staple across end every 300 millimeters (12 inches).

Final Check - These installation techniques must be adhered to:

1. Protective blanket is in uniform contact with the soil.
2. All lap joints are secure.
3. All staples are driven flush with the ground.
4. All disturbed -areas have been seeded.

TREATMENT-2: SOIL STABILIZATION MATING

Allowable velocity range after vegetative establishment: 0 - 3 meters per second (0 - 10 feet per second).

Materials -

Matting - The majority of these products provide a three dimensional geomatrix of nylon, polyethylene, or randomly oriented monofilaments, forming a mat. These products contain ultra violet (UV) inhibiting stabilizers, added to the compounds to ensure endurance and provide "permanent root reinforcement."

The three dimensional feature creates an open space which is allowed to fill with soil. The roots of the grass plant become established within the mat itself, forming a synergistic root and mat system. As the grass becomes established, the two actually "reinforce" each other, preventing movement or damage to the soil. Allowable velocities are increased considerably over natural turf stands.

Selection of the appropriate matting materials along with proper installation become critical factors in the success of this practice. Consultation with the supplier or the manufacturer and thorough evaluation of performance data to ensure proper selection of a soil stabilization matting are also essential. Although many manufacturers claim their products may inhibit erosion associated with channel velocities of up to 6 meters per second (20 feet per second), it is recommended that any velocities that exceed 3 meters per second (10 feet per second) be properly protected with some form of structural lining (see BMP-17, STORMWATER CONVEYANCE CHANNEL).

Staples - Staples or anchoring methods and recommendations vary by manufacturers. The expectation of high velocities should dictate the use of more substantial anchoring.

Installation Requirements -

Site Preparation - After site has been shaped and graded to approved design, prepare a friable seedbed relatively free from clods and rocks more than 25 millimeters (1 inch) in diameter, and any foreign material that will prevent contact of the soil stabilization mat with the soil surface. If necessary, redirect any runoff away from the ditch or slope during installation.

Planting - Lime, fertilizer and seed in accordance with the approved plan, paying special attention to the plant selection that may have been chosen for the matted area. If the area has been seeded prior to installing the mat. make sure and reseed all areas disturbed during installation.

Mulching - Mulch (normally straw) should be applied following installation of **Treatment-2** at rates noted in BMP-35, MULCHING.

Laying and Securing - See Figures 36-3 - 36-5. Similar to installing **Treatment-1,** but Plan Approving Authority's requirements or manufacturer's recommendations must be followed as detailed. The key to achieving desired performance is dependent upon proper installation.

Check Slots - See Figure 36-3. Matting manufacturers vary significantly in their check slot requirements. Similar to the installation of **Treatment-1,** a check slot may be required when laying **Treatment-2** to "correct" the flow of water if it has the potential to undermine the matting. Most authorities require that the sides of the matting also be entrenched, creating a slope shelf for the material to rest on, preventing water from entering under the mat on the sides.

Securing the Material and Joining Mats - Again, product specifications vary - upstream and downstream terminal slots, new roll overlaps and multiple width installations differ by various products and manufacturers.

Final Check - These installation techniques must be adhered to:

1. Soil stabilization mat is in uniform contact with the soil.

2. All required slots and lapped joints are in place.

3. The material is properly anchored.

4. All disturbed areas are seeded.

Maintenance

All soil stabilization blankets and matting should be inspected periodically following installation, particularly after rainstorms to check for erosion and undermining. Any dislocation or failure should be repaired immediately. If washouts or breakage occurs, reinstall the material after repairing damage to the slope or ditch. Continue to monitor these areas until which time they become permanently stabilized; at that time an annual inspection should be adequate.

FIGURE 36-3: TYPICAL TREATMENT-2 SOIL STABILIZATION MATTING INSTALLATION

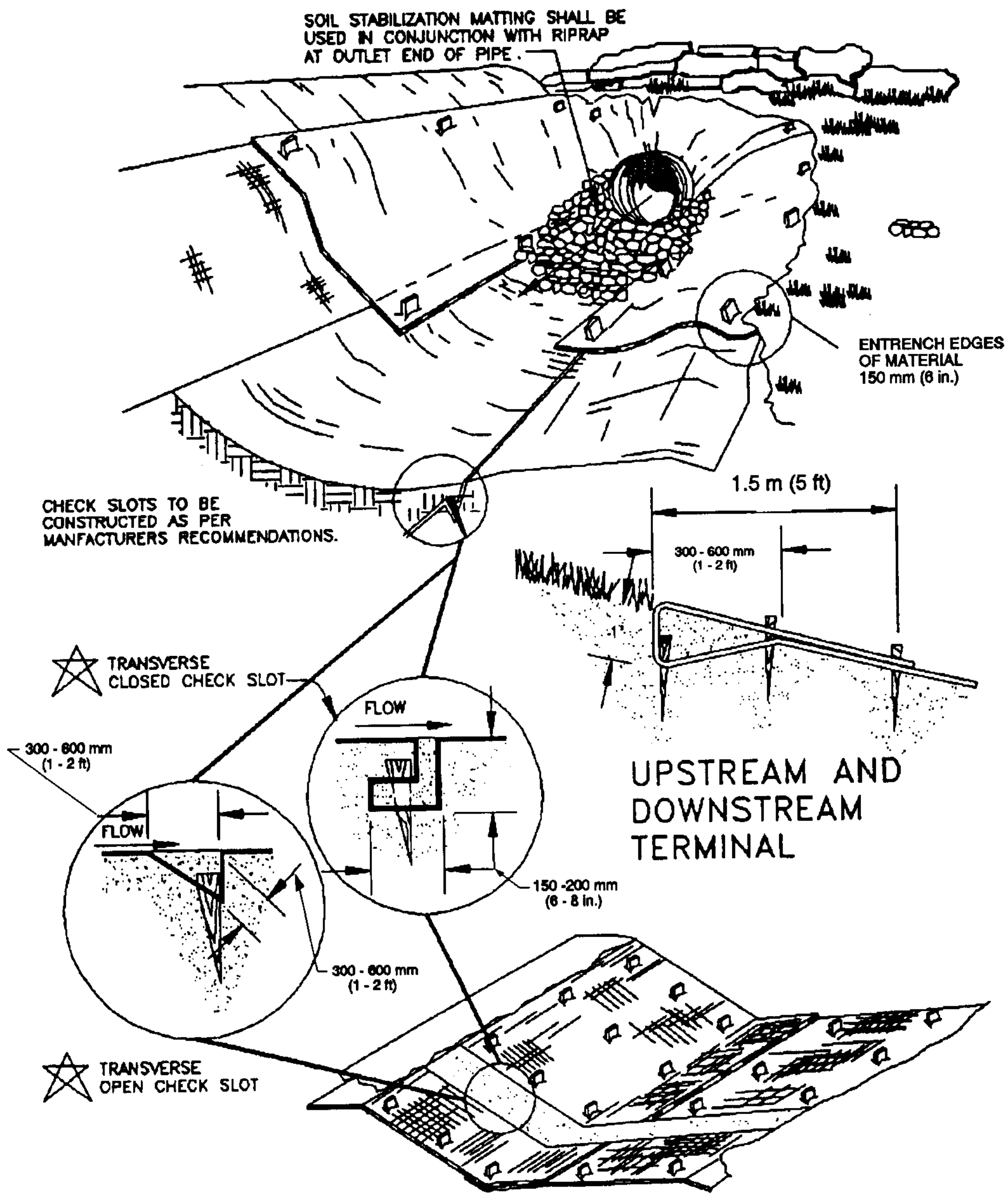


FIGURE 36-4: TYPICAL TREATMENT-2 SOIL STABILIZATION MATTING SLOPE INSTALLATION

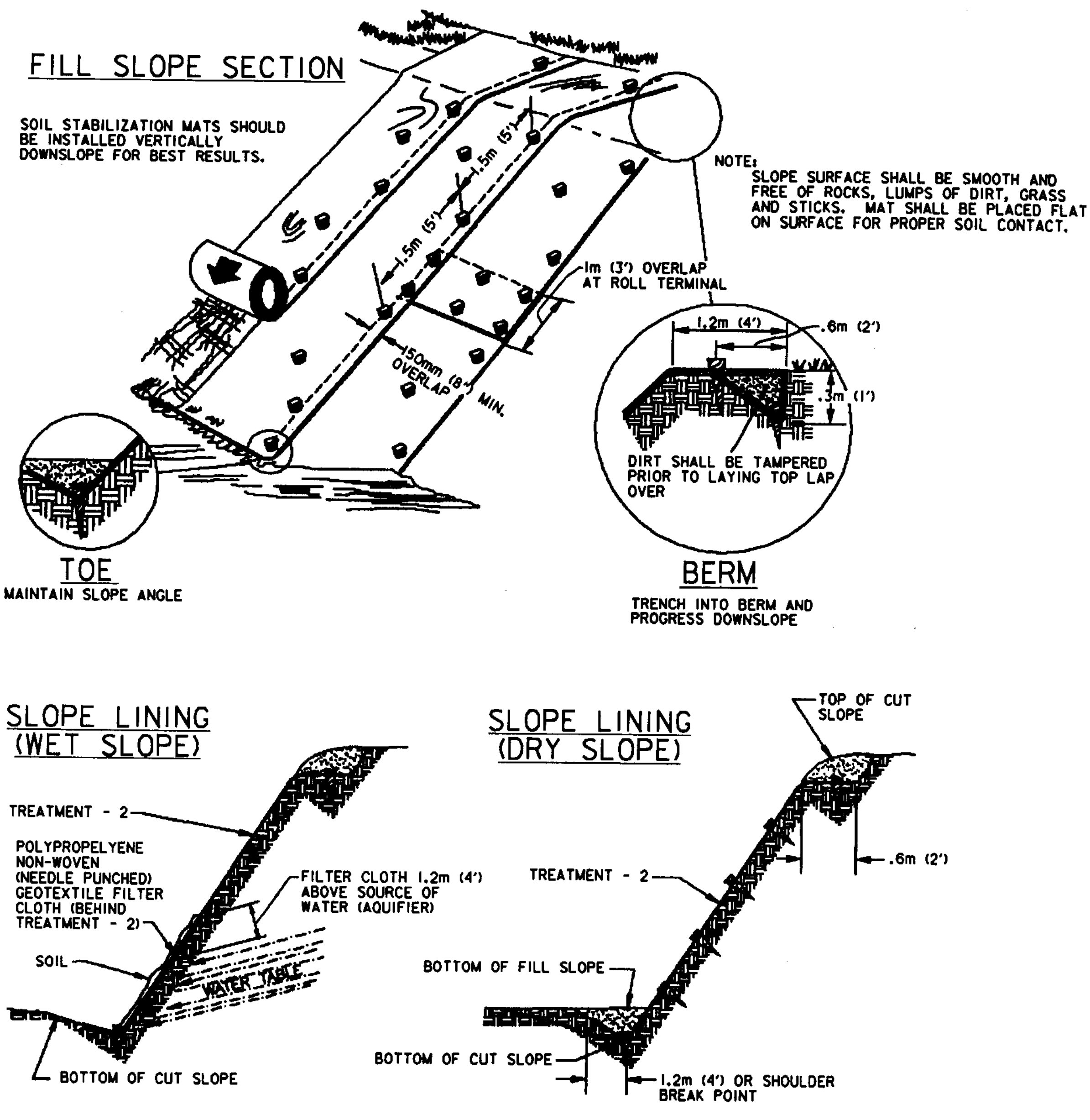
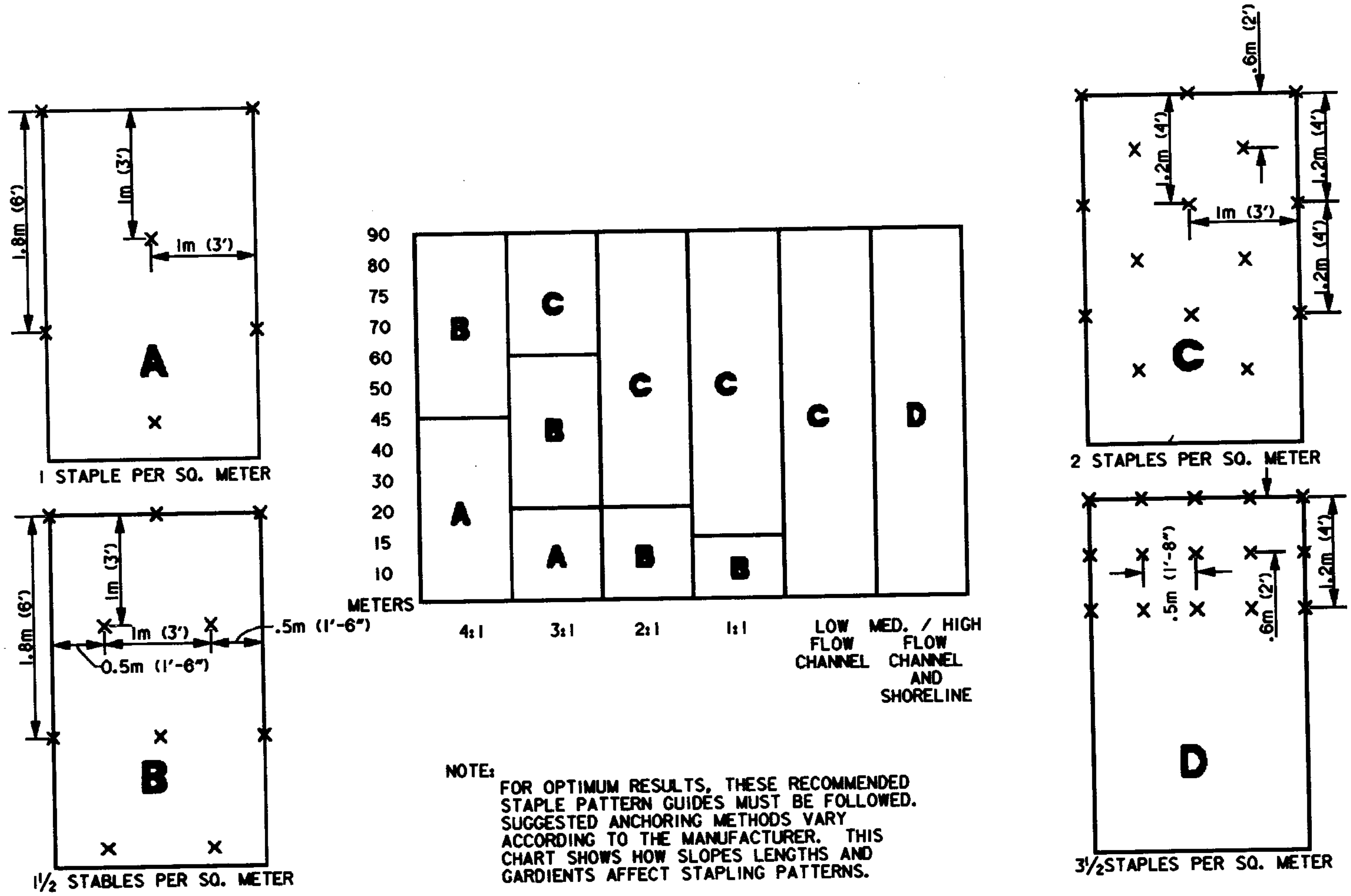


FIGURE 36-5: GENERAL STAPLE PATTERN GUIDE AND RECOMMENDATIONS FOR TREATMENT-2 (S01; STABILIZATION MATTING)



NOTE:
FOR OPTIMUM RESULTS, THESE RECOMMENDED STAPLE PATTERN GUIDES MUST BE FOLLOWED. SUGGESTED ANCHORING METHODS VARY ACCORDING TO THE MANUFACTURER. THIS CHART SHOWS HOW SLOPES LENGTHS AND GARDIENTS AFFECT STAPLING PATTERNS.

BMP-37

BMP: TREES, SHRUBS, VINES & GROUND COVERS

Definition

Stabilizing disturbed areas by establishing vegetative cover with trees, shrubs, vines, or ground covers.

Purposes

1. To aid in stabilizing soil in areas where vegetation other than turf is preferred.

2. To provide food and shelter for wildlife where wildlife habitat is desirable.

Conditions Where Practice Applies

1. In areas where turf establishment is difficult.

2. On steep or rocky slopes, where mowing is not feasible.

3. Where ornamentals are desirable for landscaping purposes.

4. Where woody plants are desirable for soil conservation, or to establish wildlife habitat.

Planning Considerations

Disturbed areas may be stabilized in many different ways. Most frequently, a permanent vegetative cover of grasses and legumes is established. There are locations, however, where other types of vegetation are preferred. The following situations are examples of ways in which trees, shrubs, vines, and ground covers may be used:

1. On cut and fill slopes adjacent to paved areas of shopping centers, schools, industrial parks, or other non-residential projects: woody plants and ground covers can be used on these slopes to control erosion. They will also help to control foot traffic, will not require as much maintenance as mowed lawns, and will be more attractive than unmowed grass cover.

2. In residential areas, slopes too steep to be mowed and areas along rights-of-way or easements may be planted in trees, shrubs, vines or ground covers to reduce maintenance and improve appearance.

3. The interested homeowner or small project developer may choose to use ornamental plants in problem areas - shade, steep slopes, inaccessible places - as alternatives to grass. Ground covers may be used to reduce or eliminate the need for mowing grass on level areas.

There are vast numbers of plants that may be used for these purposes. Information on such plants can be obtained from nurserymen, landscape architects, and extension agents.

This practice consists, instead, of a set of general guidelines for growing trees, shrubs, vines, and ground covers on disturbed land.

Guidelines

As noted, disturbed soil between trees and shrubs must be mulched or planted with permanent vegetation to prevent erosion. Refer to the other vegetative practices to select a method for stabilizing these areas.

Trees -

Selecting the Right Trees - In the urban and suburban environment, trees may be exposed to insufficient light and water; high velocity winds; salt from highway ice control programs; heat radiation from roads and buildings; pollutants from cars and industry; root amputation for water, sewer, and gas lines; topping to prevent interference with power lines; and covering of roots by pavement. New species and varieties of trees are being selected for the modern environment on the basis of their ability to withstand those difficult conditions and still provide the benefits associated with having trees (see Figure 37-1).

Selection of trees depends on the desired function of the tree, whether it be shade, privacy screening, noise screening, appearance, enhancement of wildlife habitat, or a combination of these. The following characteristics of the tree should be considered when making choices:

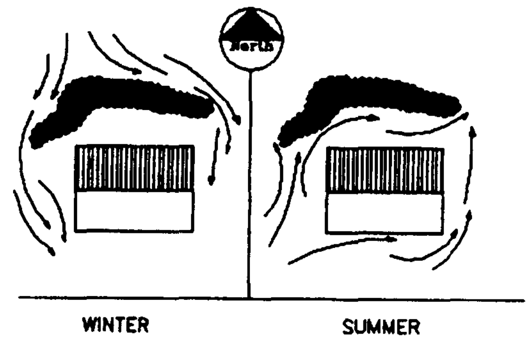
1. Hardiness - "Hardiness zones" are based on average annual minimum temperature.

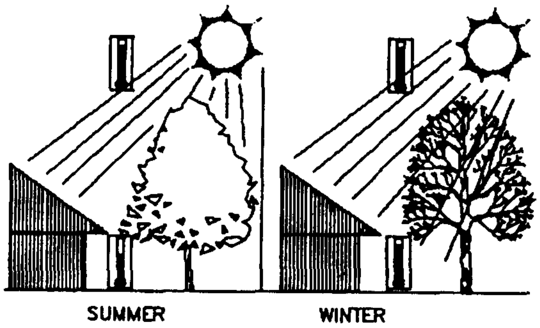
2. Mature height and spread - The eventual height of a tree must be considered in relation to planting location to avoid future problems with power lines and buildings (see Figure 37-2).

FIGURE 37-1: BENEFITS OF TREES

TEMPERATURE MODIFICATION

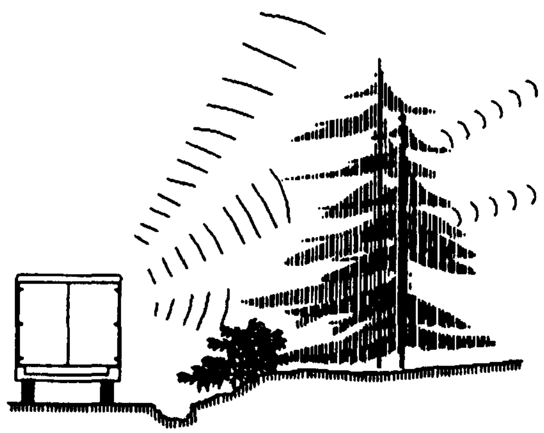
TREES AFFECT WIND SPEED AND DIRECTION, AND THUS TEMPERATURE. FOR EXAMPLE, AN EVERGREEN PLANTING ON THE NORTHWEST SIDE OF A BUILDING WILL REDUCE THE EFFECTS OF HARSH WINTER WINDS AND DIRECT COOL SUMMER BREEZES THROUGH THE AREA. TREES PROTECT THE SOIL FROM DRYING SUN AND WIND, REDUCING EVAPORATION AND MAINTAINING COOLER TEMPERATURES UNDER TREES. WHEN PROPERLY PLACED NEAR BUILDINGS, TREES OF PROPER SIZE WILL INSULATE BUILDINGS FROM EXTREME TEMPERATURE CHANGES IN WINTER AND SUMMER, HELPING REDUCE COSTS OF HEATING AND COOLING. DECIDUOUS TREES BLOCK OUT THE HOT SUMMER SUN, KEEPING THE HOME COOLER, AND ALLOW WARMTH OF WINTER SUN TO PASS THROUGH.





SOUND CONTROL

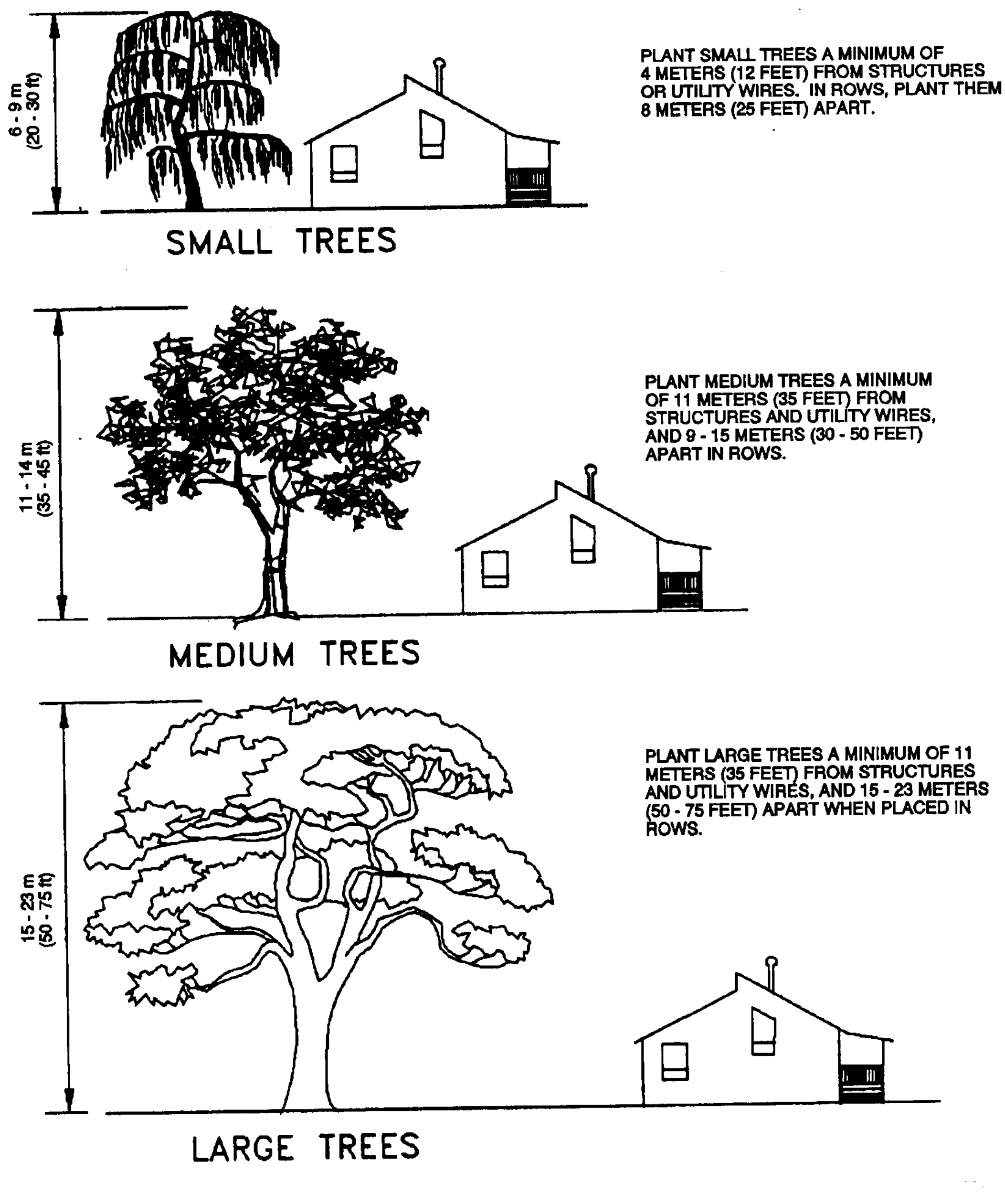
NOISES FROM NEARBY SOURCES CAN BE REDUCED THROUGH PROPER PLACEMENT OF TREES. THE DEGREE OF CONTROL DEPENDS ON THE DENSITY OF THE PLANTING AND INTENSITY AND DIRECTION OF SOUND WAVES. BOTH DECIDUOUS AND EVERGREEN TREES SHOULD BE USED FOR BEST EFFECT.



EROSION CONTROL

COARSE LEAF TEXTURES, HORIZONTAL BRANCHING HABITS, FIBROUS ROOT STSTEMS, AND ROUGH BARK ARE TREE CHARACTERISTICS MOST EFFECTIVE IN SLOWING WATER MOVEMENT AND WIND SPEED, THUS REDUCING EROSION PROBLEMS.

FIGURE 37-2: SPACING TREES FOR SAFETY AND EFFECTIVE LANDSCAPING



3. Growth rate - Some trees attain mature height at an early age, others take many years. If "instant shade" is desired, rapid growth is needed. Slow-growing trees are usually less brittle and live longer.

4. Root system - Some trees obstruct underground pipelines with fibrous roots.

5. Cleanliness - Maintenance problems can be avoided by not selecting trees that drop seedpods, flowers, or twigs in large amounts.

6. Moisture and fertility requirements - If good soil and drainage are not available, trees tolerant of poor growing conditions must be planted.

7. Ornamental effects - If a tree is unusually attractive in appearance, some other shortcomings may be overlooked.

8. Evergreen vs. deciduous - Evergreens retain their leaves throughout the year, and so are useful for privacy screens and noise screens. Deciduous trees drop their leaves in fall. They are preferable for shade trees.

At the same time as trees are being selected, the site where they will be planted should be evaluated. Consider the prior use of the land; adverse soil conditions, such as poor drainage or acidity, exposure to wind; temperature extremes; location of utilities, paved areas, and security lighting; and traffic patterns-

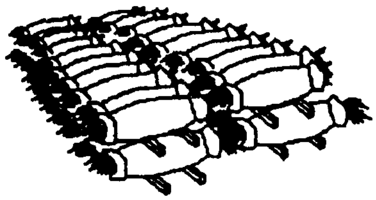
Sources of trees and how they may be bought - Trees are usually available at commercial nurseries as container-grown trees or as balled and burlapped trees. Container-grown trees can be planted at any time of year that the ground is not frozen, if sufficient water is provided. They should be purchased and planted when quite young, less than 50 millimeter (2 inches) diameter trunk, to avoid dealing with root-bound plants.

Balled and burlapped trees are usually larger; check to be sure that soil around roots was dug with the tree and not just packed around bare roots. The soil should have been kept moist.

Tree seedlings are available commercially and are also sold in lots of 50, 100, 500, or 1000 by state forest nurseries. Since 50 seedlings will only plant an area of 275 square meters (3000 square feet), it is permissible to plant fairly small areas as long as the purpose is conservation.

Planting Bare-Rooted Tree Seedlings
When - Trees to be planted as bare-rooted seedlings should be handled only while dormant in spring, or after leaf fall in autumn. Refer to Figure 37-3 for planting instructions.

FIGURE 37-3: PLANTING BARE-ROOTED SEEDLINGS



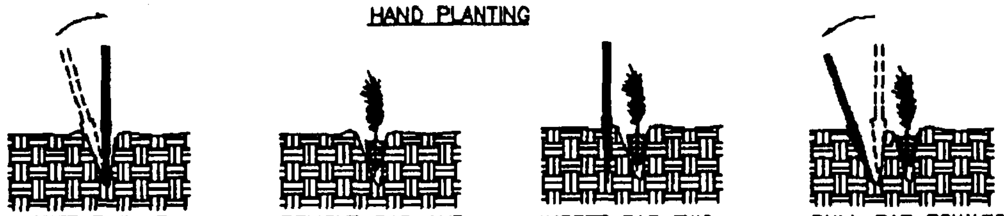
CARE OF SEEDLINGS UNTIL PLANTED

SEEDLINGS SHOULD BE PLANTED IMMEDIATELY. IF IT IS NECESSARY TO STORE MOSS-PACKED SEEDLINGS FOR MORE THAN 2 WEEKS, ONE PINT OF WATER PER PKG. SHOULD BE ADDED. IF CLAY-TREATED, DO NOT ADD WATER TO PKG. PACKAGES MUST BE SEPERATED TO PROVIDE VENTILATION TO PREVENT "HEATING". SEPARATE PACKAGES WITH WOOD STRIPS AND STORE OUT OF THE WIND IN A SHADED, COOL (NOT FREEZING) LOCATION.

CARE OF SEEDLINGS DURING PLANTING

WHEN PLANTING, ROOTS MUST BE KEPT MOIST UNTIL TREES ARE IN THE GROUND. DO NOT CARRY SEEDLINGS IN YOUR HAND EXPOSED TO THE AIR AND SUN. KEEP MOSS-PACKED SEEDLINGS IN A CONTAINER PACKED WITH WET MOSS OR FILLED WITH THICK MUDDY WATER. COVER CLAY-TREATED SEEDLINGS WITH WET BURLAP ONLY.

HAND PLANTING

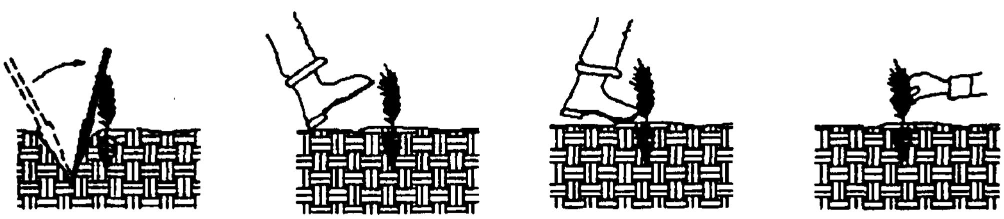


INSERT BAR AT ANGLE SHOWN AND PUSH FORWARD TO UPRIGHT POSITION.

REMOVE BAR AND PLACE SEEDLING AT CORRECT DEPTH.

INSERT BAR TWO INCHES TOWARD PLANTER FROM SEEDLING.

PULL BAR TOWARD PLANTER FIRMING SOIL AT BOTTOM OF ROOTS.



PUSH BAR FORWARD FROM PLANTER FIRMING SOIL AT TOP OF ROOTS.

FILL IN LAST HOLE BY STAMPING WITH HEEL.

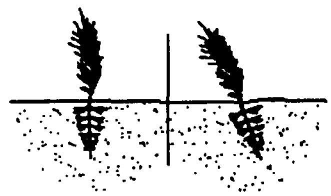
FIRM SOIL AROUND SEEDLING WITH FEET.

TEST PLANTING BY PULLING LIGHTLY ON SEEDLING.

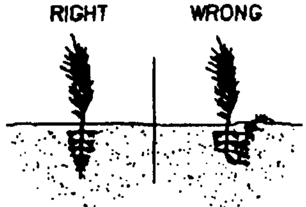
RIGHT WRONG

DON'T EXPOSE ROOTS TO AIR DURING FREEZE OR PLANT IN FROZEN GROUND.

PLANT SEEDLINGS UPRIGHT - NOT AT AN ANGLE.

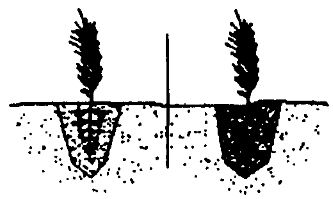


RIGHT WRONG



DO NOT BEND ROOTS SO THAT THEY GROW UPWARDS OUT OF THE GROUND.

ALWAYS PLANT IN SOIL - NEVER LOOSE LEAVES OR DEBRIS. PACK SOIL TIGHTLY.



When stabilizing the disturbed area between tree plantings, do not use grasses or legumes which will overshade the new seedlings. Where possible, a circle of mulch around seedlings will help them to compete successfully with herbaceous plants.

Transplanting Trees (Planting Balled-and-Burlapped and Container-Grown Trees)

When - Hardwoods should be transplanted in the late fall following their leaf drop. There is a single exception to this rule: "Willow" Oaks seem to survive at a greater rate when they are transplanted in the spring. Evergreens may be transplanted beginning with the fall cool down period (normally September) and may continue into spring prior to elongation of the new growth.

Tree preparation - Proper digging of a tree includes the conservation of as much of the root system as possible, particularly the fine roots. Soil adhering to the roots should be damp when tree is dug, and kept moist until planting. The soil (or "root") ball should be 12 millimeters in diameter for each millimeter of diameter of the trunk (12 inches per inch of trunk diameter). The tree should be carefully excavated and the soil ball wrapped in burlap and tied with rope. Use of a mechanical tree spade is also acceptable.

Evergreens, or any trees which are to be transported for a distance, should have the branches bound with soft rope to prevent damage.

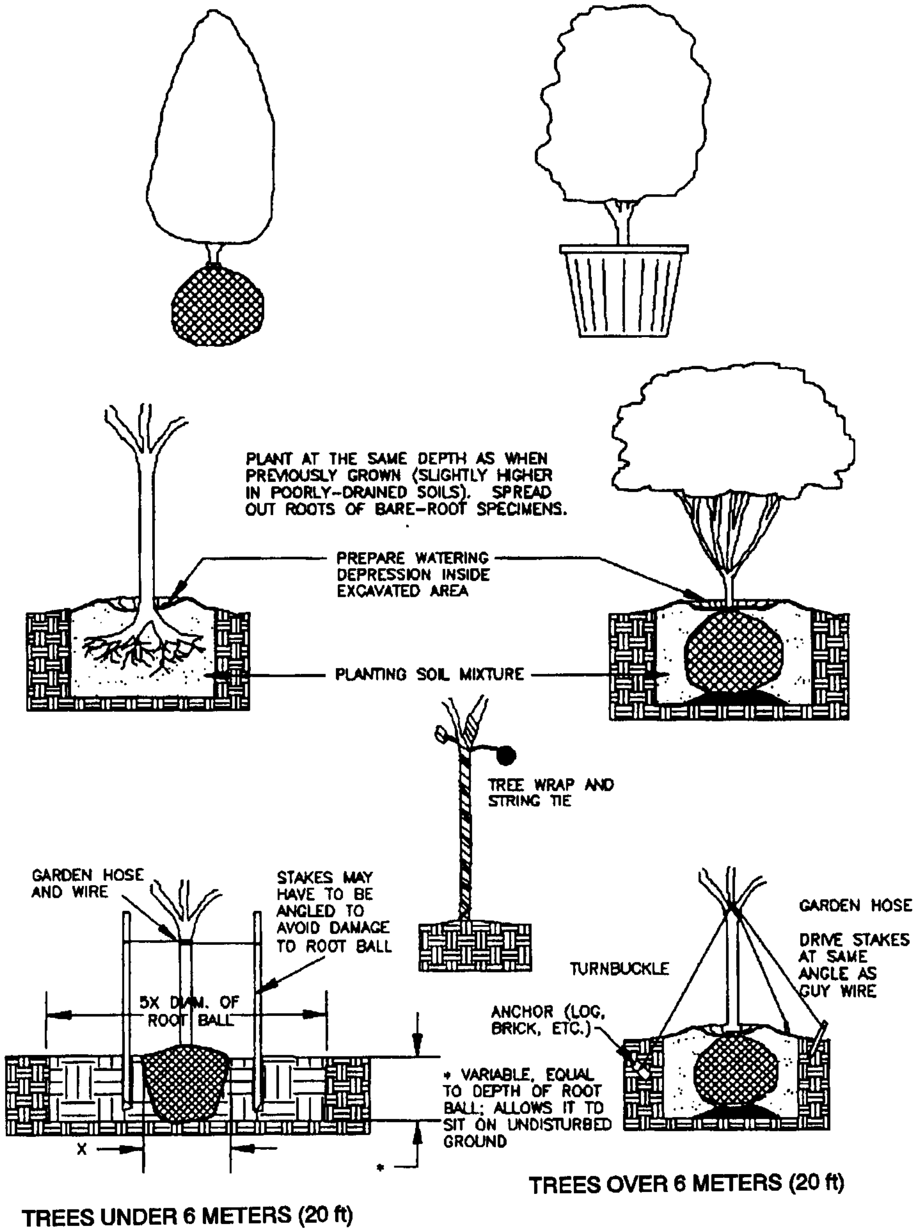
Site Preparation - Rather than digging a planting hole, rototill or loosen with a shovel, a shallow area the depth (height) of the soil ball and the width of five times the diameter of the soil ball or container. Organic material can be added to the loosened soil as long as the new material is used uniformly throughout the area.

Heavy or poorly drained soils are not good growth media for trees. When it is necessary to transplant trees into such soils, extra care should be taken. Properly installed drain tile will improve drainage.

Setting the tree - At the center of the prepared area, dig a shallow hole to set the tree. The hole should allow the root ball to sit on solid ground rather than loose soil. The upper surface of the root ball should be level with the existing soil. The tree may be set just a few millimeters higher than its former location, especially if soil is poorly drained. Do not set the tree lower than it was previously positioned. Soil to be placed around the root ball should be moist but not wet (see Figure 37-4).

Set the tree in the hole and remove the rope which holds the burlap. Cut away the burlap or, at a minimum, push it back into the bottom of the excavation. Do not break the soil of the root ball. Fill the hole with soil half-way, and tamp firmly around the root ball. Add water to settle the soil and eliminate air pockets. When the water has drained off, fill the hole the remainder of the way and tamp as before.

FIGURE 37-4: PLANTING BALLED - & - BURLAPPED & CONTAINER-GROWN TREES



Use extra soil to form a shallow basin around the tree, somewhat smaller than the diameter of the root ball (Figure 37-4). This will be for holding water when the tree is irrigated.

Note: Level the ground and eliminate these basins when winter sets in, as ice forming in the basin might injure the trunk.

Supporting the tree - Newly planted trees may need artificial support, especially in windy areas, to prevent excessive swaying. Stakes or guy wires may be used (see Figure 37-4). Use rubber hose and allow some slack in the guy to encourage strengthening of the plant. Remove all supports within six months of planting.

Watering - Soil around the tree should be thoroughly watered after the tree is set in place. When the soil becomes dry, the tree should be watered deeply but not too often. Mulching around the base of the tree is helpful in preventing roots from drying out.

Maintenance of Tree Plantings - Like all plants, trees require water and fertilizer to grow. Ideally, young trees should receive 25 millimeters (1 inch) of water each week for the first two years after planting. When rain does not supply this need, the tree should be watered deeply but not any more frequent than once per week.

Transplanted trees should be fertilized one year or so after planting. There are many sophisticated ways to supply fertilizer to trees, but some simple methods are adequate. The best material for small trees is well-rotted stable manure, if it can be obtained. Add it as a 50 millimeter (2-inch) layer of mulch around the tree annually. If chemical fertilizers are to be used, a formulation such as 10-8-6 or 10-6-4 is preferred. Use about 0.04 kilograms per each millimeter of trunk diameter (2 pounds per inch of trunk diameter) measured 1 meter (4 feet) from the ground. Thus, if the trunk diameter at 1 meter was 125 millimeters (5 inches), 5 kilograms (10 pounds) of fertilizer would be applied.

> Note: Evergreens - use one-half the recommended amount of chemical fertilizer or use only organic fertilizers such as cottonseed meal, bone meal, or manure.

Fertilizer must come in contact with the roots to benefit the tree. A simple way to insure this is to make holes in the tree's root area with a punchbar, crowbar, or augur. Holes should be 450 millimeters (18 inches) deep, spaced about 600 millimeters (2 feet) apart, and located around the drip line of the tree. Distribute the necessary fertilizer evenly into these holes, and close the holes with the heel of the shoe or by filling with topsoil or peat moss.

Fertilize trees in late fall or in early spring, before leaves emerge.

Shrubs

Much of what has been said about trees also applies to shrubs. A shrub is an erect, woody plant less than 5 meters (15 feet) tall, usually with several trunks rising from a common base. Some have the appearance of small trees, and some lie close to the ground.

Selecting appropriate shrubs - There are so many ornamental shrubs available that advising on the choice of any one is difficult. Shrubs are recommended for conservation planting because they enrich or hold the soil or encourage development of wildlife habitat. Information on other shrubs is available from nurserymen and extension agents.

Follow the general procedure for tree planting when planting shrubs.

Maintenance

Proper pruning, watering, and application of fertilizer every three years or so will keep shrubs, healthy. Maintain the mulch cover or turf cover surrounding the shrubs. A heavy layer of mulch reduces weeds and retains moisture.

VINES AND GROUND COVERS

Low-growing plants that sprawl, trail, spread, or send out runners come in many leaf types, colors and growth habits. Some are suitable only as part of a maintained landscape, and some can stabilize large areas with little care.

In addition to stabilizing disturbed soil, vines and ground covers can perform the following functions:

1. Maintain cover in areas where turf will not thrive.

2. Provide attractive cover that does not need mowing.

3. Help to define traffic areas and control pedestrian movement. People are more likely to walk on the grass than to walk on a thick bed of ivy or a prickly planting of juniper.

Information on vines and other ground cover is available from nurserymen.

Most all ground covers perform best when planted in the spring. Container-grown plants can be planted throughout the growing season if adequate water is provided.

Site preparation - Ground covers are plants that naturally grow very close together, causing severe competition for space, nutrients, and water. Soil for ground covers should be well prepared. A well-drained soil high in organic matter is best.

If the area to be planted is so large that adding amendments to the soil as a whole would be impractical, organic matter may be added only to each planting hole.

Lime and fertilize according to soil test, or add 25 kilograms of 10-10-10 and 50 kilograms of ground agricultural limestone to every 100 square meters (5 pounds and 10 pounds per 100 square feet respectively). Incorporate into the top 100 to 150 millimeters (4 to 6 inches) of the soil. Add organic matter up to one-third of the total soil volume, either over the whole area (a layer 50 millimeters (2 inches) deep mixed into the top 150 millimeters (6 inches) or in each planting hole, if the area is large.

Plants such as ivy, pachysandra, and periwinkle should be planted on 300 millimeter (1-foot) centers; large plants such as juniper can be spaced on 1 meter (3-foot) centers.

Mulching -The soil between trees and shrubs must be planted with cover vegetation or must be mulched. When establishing ground covers, it is not desirable to plant species that will compete strongly with the ground cover or will make maintenance difficult. A thick, durable mulch such as shredded bark or wood chips is recommended to prevent erosion and reduce weed problems. Pre-emergent herbicides may be necessary where weeding is not practical.

On slopes where erosion may be a problem, jute mesh or excelsior blankets may be installed prior to planting, and plants tucked into the soil through slits in the net. Such plants should be put in a staggered pattern to minimize erosion.

Maintenance

Trim old growth as needed to improve the appearance of ground covers. Most covers need once-a-year trimming to promote growth. Maintain mulch cover with additions of mulch where needed. Fertilize as described above, every 3 to 4 years.

BMP: TREE PRESERVATION & PROTECTION

Definition

Protection of desirable trees from mechanical and other injury during land disturbing and construction activity.

Purpose

To ensure the survival of desirable trees where they will be effective for erosion and sediment control, watershed protection, landscape beautification, dust and pollution control, noise reduction, shade and other environmental benefits while the land is being converted from forest to urban-type uses.

Conditions Where Practice Applies

Tree-inhabited areas subject to land disturbing activities.

Planning Considerations

New development often takes place on tracts of forested land. In fact, building sites are often selected because of the presence of mature trees. However, unless sufficient care is taken and planning done in the interval between buying the property and completing construction, much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and ground cover. This responsibility is usually exercised by agents - the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which we value trees so highly. Trees perform the following functions on a site:

1. Assist in stabilizing the soil and preventing erosion.

2. Help to decrease stormwater runoff through canopy interception and root zone absorption.

3. Moderate temperature changes and provide shade.

4. Moderate the effects of sun and wind.

5. Provide buffers and screens against noise.

6. Filter pollutants from the air.

7. Help to remove carbon dioxide from the air and release oxygen.

8. Provide a haven for animals and birds, which help to control insect populations.

9. Conserve and increase property values.

10. Provide psychological and aesthetic counterpoints to the man-made urban setting.

Stresses of Construction -

Trees may appear to be inanimate objects, but they are living organisms that are constantly involved in the process of respiration, food processing, and growth. Construction activities expose trees to a variety of stresses resulting in injury ranging from superficial wounds to death. An understanding of these stresses is helpful in planning for tree protection.

1. Surface Impacts: Natural and man-related forces exerted on the tree above the ground can cause significant damage to trees.

    a. Wind damage - Removal of some trees from groups will expose those remaining to greater wind velocities. Trees tend to develop anchorage where it is most needed. Isolated trees develop anchorage rather equally all around, with stronger root development on the side of the prevailing winds. The more a tree is protected from the wind, the less secure is its anchorage. The result of improper thinning is often wind-thrown trees. Selective removal in favor of a single tall tree may also create a lightning hazard.

    b. Excessive pruning - Unprotected trees are often "topped" or carelessly pruned to prevent interference with utility wires or buildings. If too many branches are cut, the tree may not be able to sustain itself. If the pruning is done without considering the growth habit, the tree may lose all visual appeal. If the branches are not pruned correctly, decay may set in.

c. Trunk damage - Tree trunks are often nicked or scarred by trucks and construction equipment. Such superficial wounds provide access to insects and disease.

2. Root Zone Impacts: Disturbing and delicate relationship between soil, roots, and the rest of the tree can damage or kill a tree. The roots of an existing tree are established in an area where essential materials (water, oxygen, and nutrients) are present. The mass of the root system is the correct size to balance the intake of water from the soil with the transpiration of water from the leaves.

   a. Raising the grade as little as 150 millimeters (6 inches) can retard the normal exchange of air and gases. Roots may suffocate due to lack of oxygen, or be damaged by toxic gases and chemicals released by soil bacteria.

   b. Raising the grade may also elevate the water table. This can cause drowning of the deeper roots.

   c. Lowering the grade is not usually as damaging as raising it. However, even shallow cuts of 150 to 200 millimeters (6 to 8 inches) will remove most of the topsoil, removing some feeder roots and exposing the rest to drying and freezing.

   d. Deep cuts may sever a large portion of the root system, depriving the tree of water and increasing the chance of wind-throw.

   e. Lowering the grade may lower the water table, inducing drought. This is a problem in large roadway cuts or underdrain installations.

   f. Trenching or excavating through a tree's root zone can eliminate as much as 40 percent of the root system. Trees suffering such damage usually die within 2 to 5 years.

   g. Compaction of the soil within the drip line (even a few feet beyond the drip line) of a tree by equipment operation, materials storage, or paving can block off air and water from roots.

   h. Construction chemicals or refuse disposed of in the soil can change soil chemistry or be toxic to trees. Most damage to trees from construction activities is due to the invisible root zone stresses.

Design Criteria

No formal design is required. However, in planning for the development of a wooded site where some trees will be preserved, a number of criteria must be considered.

Selecting Trees to be Retained -

The proper development of a wooded site requires completion of a plan for tree preservation before clearing and construction begins. Trees should be identified by species, and located on a topographical map, either as stands or as individuals, depending on the density and value of the trees. Base decisions on which trees to save on the following considerations:

1. Life expectancy and present age: Preference should be given to trees with a long life span, such as white oak, beech, and maple. Long-lived specimens that are past their prime may succumb to the stresses of construction, so smaller, younger trees of desirable species are preferred; they are more resilient and will last longer. However, if the cost of preservation is greater than the cost of replacement with a specimen of the same age and size, replacement may be preferred.

2. Health and disease susceptibility: Check for scarring caused by fire or lightning, insect or disease damage, and rotted or broken trunks or limbs. Pest- and pollution-resistant trees are preferred.

3. Structure: Check for structural defects that indicate weakness or reduce the aesthetic value of a tree: trees growing from old stumps, large trees with overhanging limbs that endanger property, trees with brittle wood (such as silver maple), misshapen trunks or crowns, and small crowns at the top of tall trunks. Open grown trees often have better form than those grown in the woods. Trees with strong tap or fibrous root systems are preferred to trees with weak rooting habits.

4. Cleanliness: Some trees such as elm and black locust are notoriously "dirty", dropping twigs, bark, fruit, or plant exudates. A clean tree is worth more than a dirty one. Trees which seed prolifically or sucker profusely are generally less desirable in urban areas. Thornless varieties are preferred.

5. Aesthetic values: Handsome bark and leaves, neat growth habit, fine fall color, and attractive flowers and fruit are desirable characteristics. Trees that provide interest during several seasons of the year enhance the value of the site.

6. Comfort: Trees help relieve the heat of summer and buffer strong winds throughout the year. Summer temperatures may be 10 degrees cooler under hardwoods than under conifers. Deciduous trees drop their leaves in winter, allowing the sun to warm buildings and soil. Evergreens are more effective wind buffers.

7. Wildlife: Preference should be given to trees that provide food, cover, and nesting sites for birds and game.

8. Adaptability to the proposed development:

   a. Consider the mature height and spread of trees; they may interfere with proposed structures and overhead utilities. Roots may interfere with walls, walks, driveways, patios, and other paved surfaces; or water lines, septic tanks, and underground drainage.

   b. Trees must be appropriate to the proposed use of the development; select trees which are pollution-tolerant for high-traffic and industrial areas, screen and buffer trees for noise or objectionable views, salt-tolerant species for areas exposed to deicing salts or ocean spray.

   c. Consider location of landfills. Gases generated in them can travel long distances underground, to injure distant trees. Choose species tolerant of anaerobic soil conditions.

   d. Determine the effect of proposed grading on the water table. Grading should not take place within the drip line of any tree to be saved.

9. Survival needs of the tree: Chosen trees must have enough room to develop naturally. They will be subject to injury from increased exposure to sunlight, heat radiated from buildings and pavement, and wind. It is best to retain groups of trees rather than individuals. As trees mature, they can be thinned gradually.

10. Relationship to other trees: Individual species should be evaluated in relation to other species on the site. A species with low value when growing among hardwoods will increase in value if it is the only species present. Trees standing alone generally have higher landscape value than those in a wooded situation. However, tree groups are much more effective in preventing erosion and excess stormwater runoff.

Site Planning for Tree Protection -

1. If lot size allows, select trees to be saved before siting the building. No tree should be destroyed or altered until the design of buildings and utility systems is final.

2. Critical areas, such as flood plains, steep slopes, and wetlands, should be left in their natural condition or only partially developed as open space.

3. Locate roadways to cause the least damage to valuable stands. Follow original contours, where feasible, to minimize cuts and fills.

4. Minimize trenching by locating several utilities in the same trench. Excavations for basements and utilities should be kept away from the drip line of trees.

5. Construction material storage areas and worker parking should be noted on the site plan, and located where they will not cause compaction over roots.

6. When retaining existing trees in parking areas, leave enough ground ungraded beyond the drip line of the tree to allow for its survival.

7. Locate erosion and sediment control measures at the limits of clearing and not in wooded areas, to prevent deposition of sediment within the drip line of trees being preserved. Sediment basins should be constructed in the natural terrain, if possible, rather than in locations where extensive grading and tree removal will be required.

<u>Specifications</u>

1. Groups of trees and individual trees selected for retention shall be accurately located on the plan and designated as "tree(s) to be saved." Individual specimens that are not part of a tree group shall also have their species and diameter noted on the plan.

2. At a minimum, the limits of clearing shall be located outside the drip line of any tree to be retained and, in no case, closer than 1.5 meters (5 feet) to the trunk of any tree.

3. Marking: Prior to construction and before the preconstruction conference, individual trees and stands of trees to be retained within the limits of clearing shall be marked at a height visible to equipment operators. A diagonal slash

of brightly colored paint approximately 200 to 250 millimeters (8 to 10 inches) in length is a common practice in areas where an accidental or purposeful alteration of the proper markings is a concern. In most situations, such as an area which is supposed to receive formal landscaping, a surveyor's ribbon or a similar material applied at a reasonable height encircling the tree will suffice.

4. Pre-Construction Conference: During any preconstruction conference, tree preservation and protection measures should be reviewed with the contractor as they apply to that specific project.

5. Equipment Operation and Storage: Heavy equipment, vehicular traffic, or stockpiles of any construction materials (including topsoil) shall not be permitted within the drip line of any tree to be retained. Trees being removed shall not be felled, pushed or pulled into trees being retained. Equipment operators shall not clean any part of their equipment by slamming it against the trunks of trees to be retained.

6. Fires: Fires shall not be permitted within 30 meters (100 feet) from the drip line of any trees to be retained. Fires shall be limited in size to prevent adverse effects on trees, and kept under surveillance.

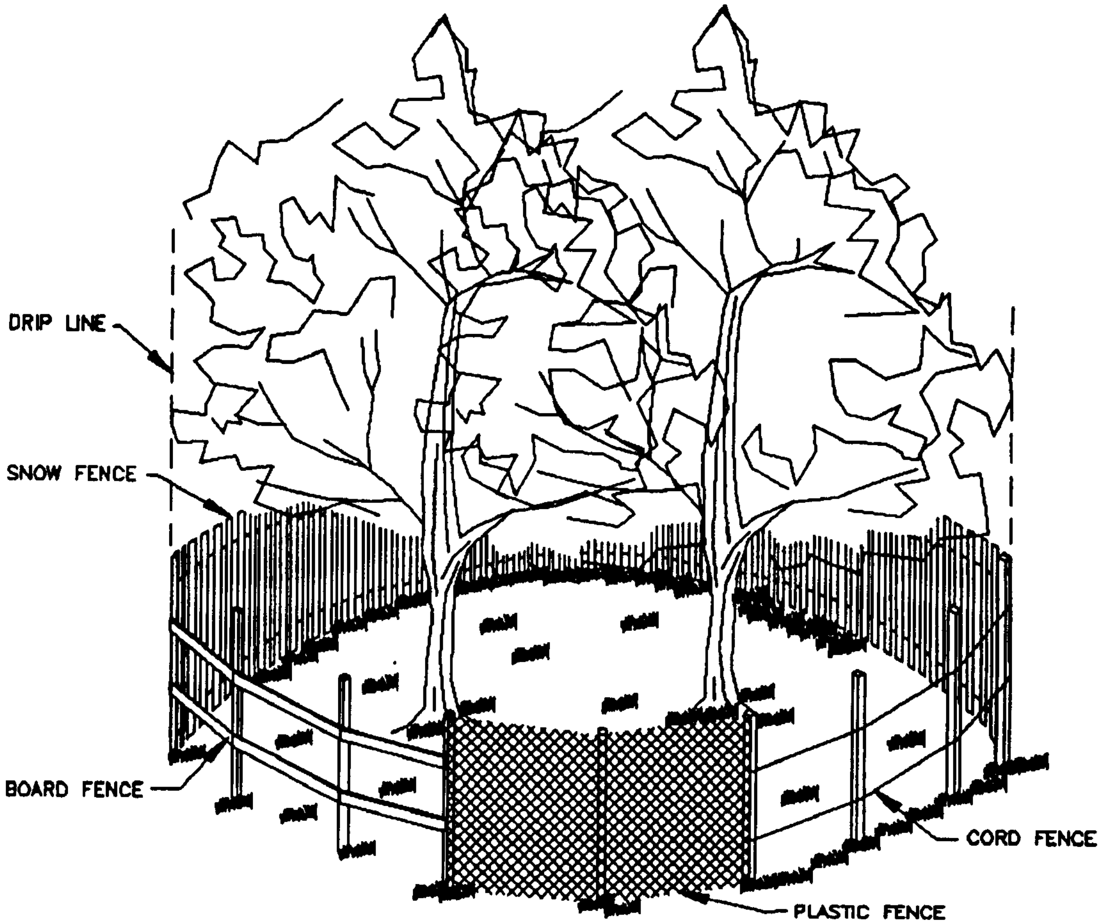
7. Storage and Disposal of Toxic Materials: No toxic materials shall be stored closer than 30 meters (100 feet) to the drip line of any trees to be retained. Paint, acid, nails, gypsum board, wire, chemicals, fuels, and lubricants shall not be disposed of in such a way as to injure vegetation.

8. Fencing and Armoring (See Figure 38-1): Any device may be used which will effectively protect the roots, trunk and tops of trees retained on the site. However, trees to be retained within 12 meters (40 feet) of a proposed building or excavation shall be protected by fencing. Personnel must be instructed to honor protective devices. The devices described are suggested only, and are not intended to exclude the use of other devices which will protect the trees to be retained.

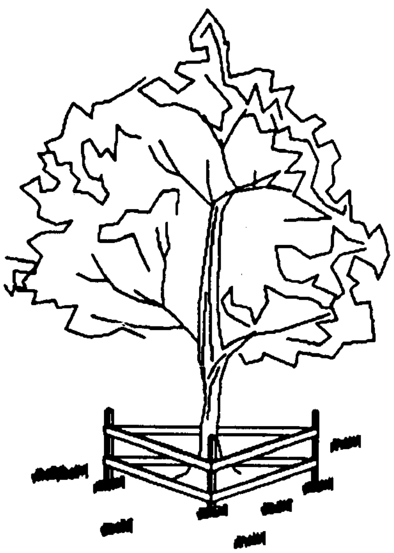
   a. Snow Fence - Standard 1 meter (40-inch) high snow fence shall be placed at the limits of clearing on standard steel posts set 2 meters (6 feet) apart.

   b. Board Fence - Board fencing consisting of 100 millimeter (4-inch) square posts set securely in the ground and protruding at least 1 meter (4 feet) above the ground shall be placed at the limits of clearing with a minimum of two horizontal boards between posts. If it is not practical to erect a fence at the drip line, construct a triangular fence

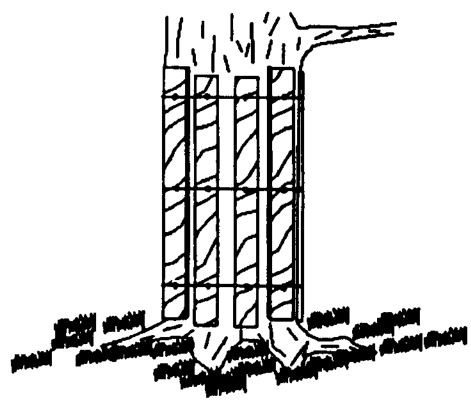
FIGURE 38-1: FENCING AND ARMORING



CORRECT METHODS OF TREE FENCING



TRIANGULAR BOARD FENCE



CORRECT TRUNK ARMORING

nearer the trunk. The limits of clearing will still be located at the drip line, since the root zone within the drip line will still require protection.

c. Posts with a minimum size of 50 millimeters (2 inches) square or 50 millimeters in diameter set securely in the ground and protruding at least 1 meter (4 feet) above the ground shall be placed at the limits of clearing with two rows of cord 6 millimeters (0.25 inches) or thicker at least 600 millimeters (2 feet) apart running between posts with strips of colored surveyor's flagging tied securely to the string at intervals no greater than 1 meter (3 feet).

d. Plastic Fencing - 1,000 millimeters (40 inches) high "international orange" plastic (polyethylene) web fencing secured to conventional metal "T" or "U" posts driven to a minimum depth of 450 millimeters (18 inches) on 2 meter (6-foot) minimum centers shall be installed at the limits of clearing. The fence should have the following minimum physical qualities:

Tensile yield:	Average 745 kilograms per meter width (2,000 pounds per 4-foot width)
Ultimate tensile yield:	Average 1,080 kilograms per meter width (2,900 lbs. per 4-foot width)
Elongation at break (%):	Greater than 1000%
Chemical resistance:	Inert to most chemicals and acids

e. Earth Berms - Temporary earth berms shall be constructed according to specifications for a TEMPORARY DIVERSION DIKE (BMP-9) with the base of the berm on the tree side located along the limits of clearing. Earth berms may not be used for this purpose if their presence will conflict with drainage patterns.

f. Additional Trees - Additional trees may be left standing as protection between the trunks of the trees to be retained and the limits of clearing. However, in order for this alternative to be used, the trunks of the trees in the buffer must be no more than 2 meters (6 feet) apart to prevent passage of equipment and material through the buffer. These additional trees shall be reexamined prior to the completion of construction and either be given sufficient treatment to ensure survival or be removed.

g. Trunk Armoring - As a last resort, a tree trunk can be armored with burlap wrapping and 50 millimeter (2-inch) studs wired vertically no more than 50 millimeters apart to a height of 1.5 meters (5 feet) encircling the trunk. If this alternative is used, the root zone within the drip line will still require protection. Nothing should ever be nailed to a tree.

Fencing and armoring devices shall be in place before any excavation or grading is begun, shall be kept in good repair for the duration of construction activities, and shall be the last items removed during the final cleanup after the completion of the project.

9. Raising the grade: When the ground level must be raised around an existing tree or tree group, the following considerations shall be made and steps taken to adequately care for the affected tree.

   a. A well may be created around the tree(s) slightly beyond the drip line to retain the natural soil in the area of the feeder roots.

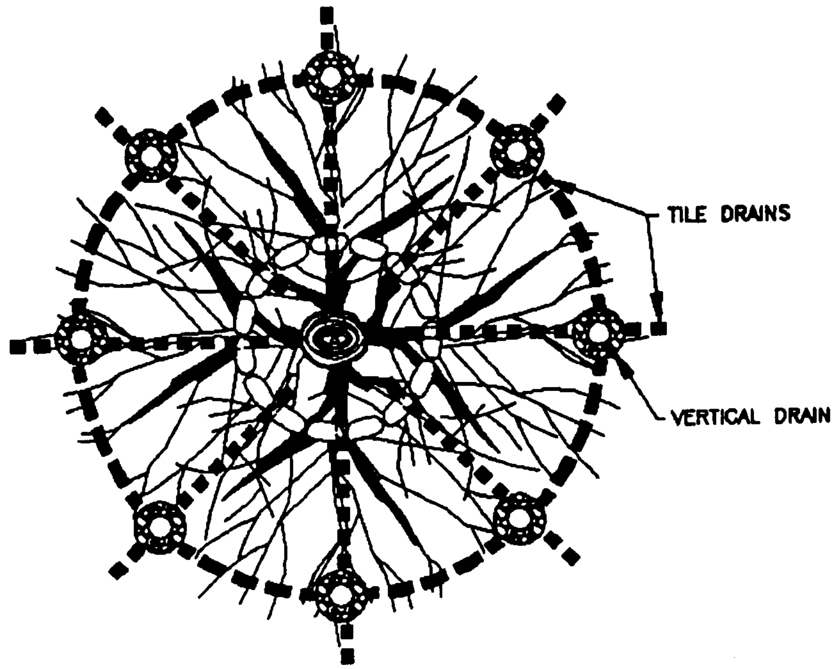
   b. In the case of an individual tree, when the above alternative is not practical or desirable, the following method is recommended to ensure survival of the tree (See Figure 38-2).

      1) Before making the fill, remove the green vegetation, sod, leaf litter, and other organic matter from beneath the tree or trees to a distance of 1 meter (3 feet) beyond the drip line and loosen the surface soil to a depth of approximately 75 millimeters (3 inches) without damaging the roots.

      2) Apply fertilizer in the root area of the tree to be retained. Fertilizer formulations and application rates and methods shall conform to the guidelines provided in Table 38-1.

      3) The dry well shall be constructed so as to allow for tree trunk diameter growth. A space of at least 0.3 meters (1 foot) between the tree trunk and the well wall is adequate for large, old, slow-growing trees. Clearance for younger trees shall be at least 0.6 meters (2 feet).

FIGURE 38-2: TREE WELL DETAIL



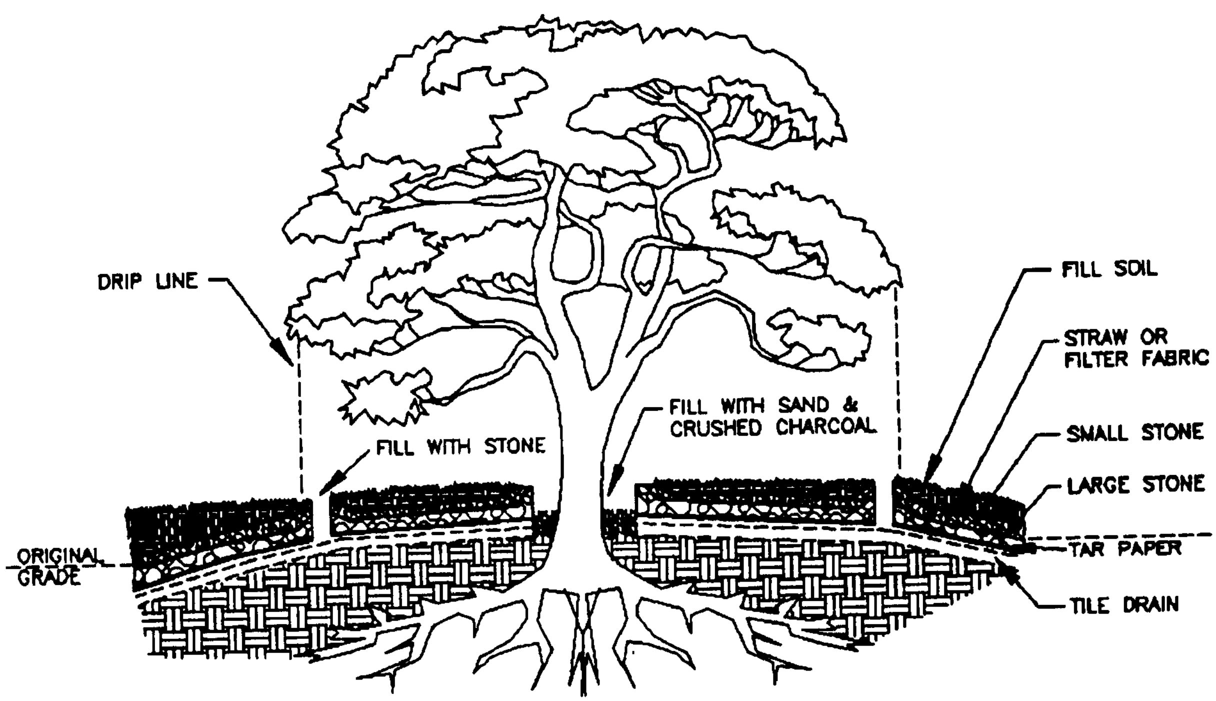


TABLE 38-1
TREE FERTILIZATION FOR PROTECTION FROM CONSTRUCTION ACTIVITY

Tree Type	Special Conditions	Application Rate & Method		Formulation
Broad-Leaf Deciduous	Greater than 150 millimeters (6 inches) dbh* except American Beeches and Crabapples	Normal	36-70 grams per mm (2-4 lbs/in) dbh; broadcast	Commercial 10-8-6 or 10-6-4
		Grade Change	70-90 grams per mm (4-5 lbs/in) dbh; broadcast	Commercial 10-6-4
	Smaller than 150 millimeters (6 inches) dbh, including all American Beeches and Crabapples	Normal	18-36 grams per mm (1-2 lbs/in) dbh; broadcast	Commercial 10-8-6 or 10-6-4
		Grade Change	36-54 grams per mm (2-3 lbs/in) dbh; broadcast	Commercial 10-6-4
Narrow-Leaf Evergreen	Greater than 150 millimeters (6 inches) dbh, located groups	10-20 kilograms per 100 square meters (2-4 lbs per 100 square feet) of bed area; broadcast		Commercial 10-6-4
	Greater than 150 millimeters (6 inches) dbh, single specimens in open area	36 grams per mm (2 lbs/in) dbh; broadcast		Commercial 10-6-4
	Smaller than 150 millimeters (6 inches) dbh	25 kilograms per 100 square meters (5 lbs per 100 square feet) of bed area; incorporated into soil		Tankage or Cottonseed Meal
Broad-Leaf Evergreen	Where nitrogen in soil is sufficient	Liberal quantities incorporated into soil and applied as mulch		Acid Peat Moss or Rotted Oak Leaf Mold
	Where additional nitrogen is necessary	Also add 25 kilograms per 100 square meters (5 lbs per 100 square feet) of bed area incorporated into soil		Tankage or Cottonseed Meal

*dbh = Diameter at breast height 1.4 meters (4.5) feet above ground level

4) The well shall be high enough to bring the top just above the level of the proposed fill. The well wall shall taper slightly away from the tree trunk at a rate of 80 millimeters per meter of wall height (1 inch per foot of wall height).

5) The well wall shall be constructed of large stones, brick, building tile, concrete blocks, or cinder blocks with care being taken to ensure that ample openings are left through the wall of the well to allow for free movement of air and water. Mortar shall only be used near the top of the well and only above the porous fill.

6) Drain lines composed of 100 millimeter (4-inch), high-quality drain tiles shall begin at the lowest point inside the well and extend outward from the tree trunk in a wheel-and-spoke pattern with the trunk as the hub. These radial drain lines shall slope away from the well at a rate of 10 millimeters per meter (0.125 inches per foot). The circumferential line of tiles should be located beneath the drip line of the tree. Vertical tiles or pipes shall be placed over the intersections of the two tile systems if a fill of more than 600 millimeters (2 feet) is contemplated. These vertical tiles shall be held in place with stone fill. Tile joints shall be tight. A few radial tiles shall extend beyond each intersection and shall slope sharply downward to ensure good drainage.

7) Tar paper or its approved equivalent shall be placed over the tile and/or pipe joints to prevent clogging, and large stone shall be placed around and over drain tiles and/or pipes for protection.

8) A layer of 50 to 150 millimeters (2 to 6 inches) of stone shall be placed over the entire area under the tree from the well outward at least as far as the drip line. For fills up to 600 millimeters (2-feet) deep, a layer of stone 200 to 300 millimeters (8 to 12 inches) thick should be adequate. A thicker layer of this stone, not to exceed 760 millimeters (30 inches), will be needed for deeper fills.

9) A layer of 20 to 25 millimeters (0.75 to 1-inch) stone covered by straw, fiber-glass mat or a manufactured filter fabric shall be used to prevent soil from clogging the space between stones. Cinders shall not be used as fill material.

10) Filling shall be completed with porous soil such as topsoil until the desired grade is reached. This soil shall be suitable to sustain specified vegetation.

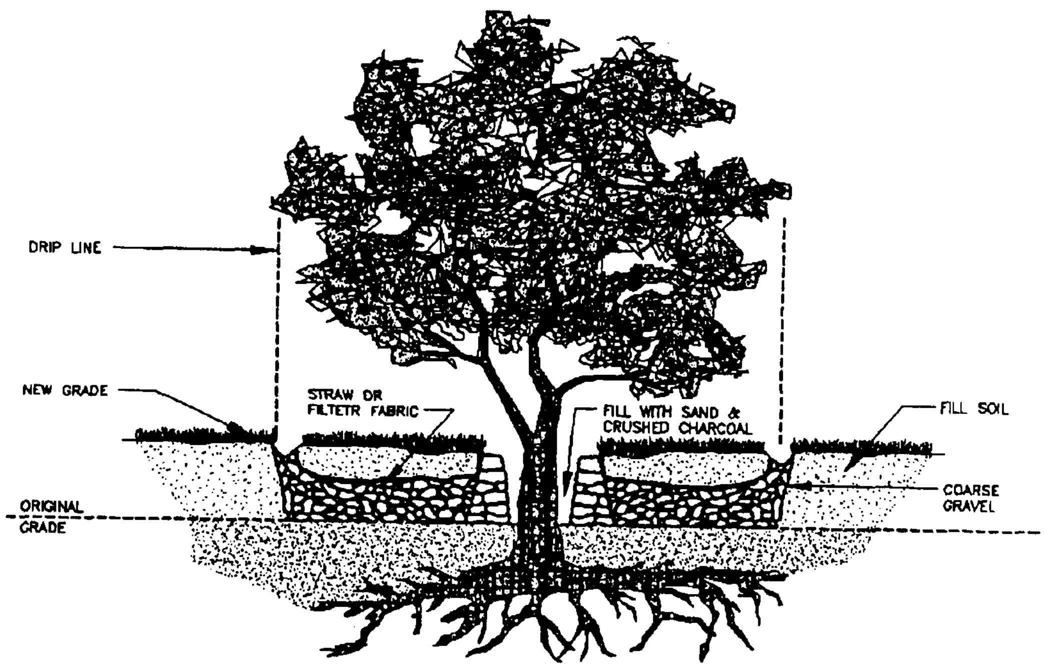
11) To prevent clogging of the drain lines, crushed stone shall be placed inside the dry well over the openings of the radial tiles. Vertical tiles shall also be filled with crushed rock and may also be covered with a screen.

12) To prevent anyone from falling into the dry well and leaves and debris from accumulating there, the area between the trunk and the well wall shall either be covered by an iron grate or filled with a 50-50 mixture of crushed charcoal and sand. (This will also prevent rodent infestation and mosquito breeding).

c. Where water drainage through the soil is not a problem, coarse gravel in the fill may be substituted for the tile. This material has sufficient porosity to ensure air drainage. Instead of the vertical tiles or pipes in the system, stones, crushed rock, and gravel may be added so that the upper level of these porous materials slants toward the surface in the vicinity below the drip line (see Figure 38-3).

d. Raising the grade on only one side of a tree or group of trees may be accomplished by constructing only half of one of these systems.

FIGURE 38-3: TREE WELL WITHOUT DRAIN TILES



10. Lowering the grade: Trees shall be protected from harmful grade cuts by the construction of a tree wall (See Figure 38-4).

    a. Following excavation, all tree roots that are exposed and/or damaged shall be trimmed cleanly, painted with tree paint, and covered with moist peat moss, burlap, or other suitable material to keep them from drying out.

    b. The wall shall be constructed of large stones, brick, building tile, or concrete block or cinder block in accordance with the detail in Figure 38-4.

    c. Backfill with peat moss or other organic material or with topsoil to retain moisture and aid in root development.

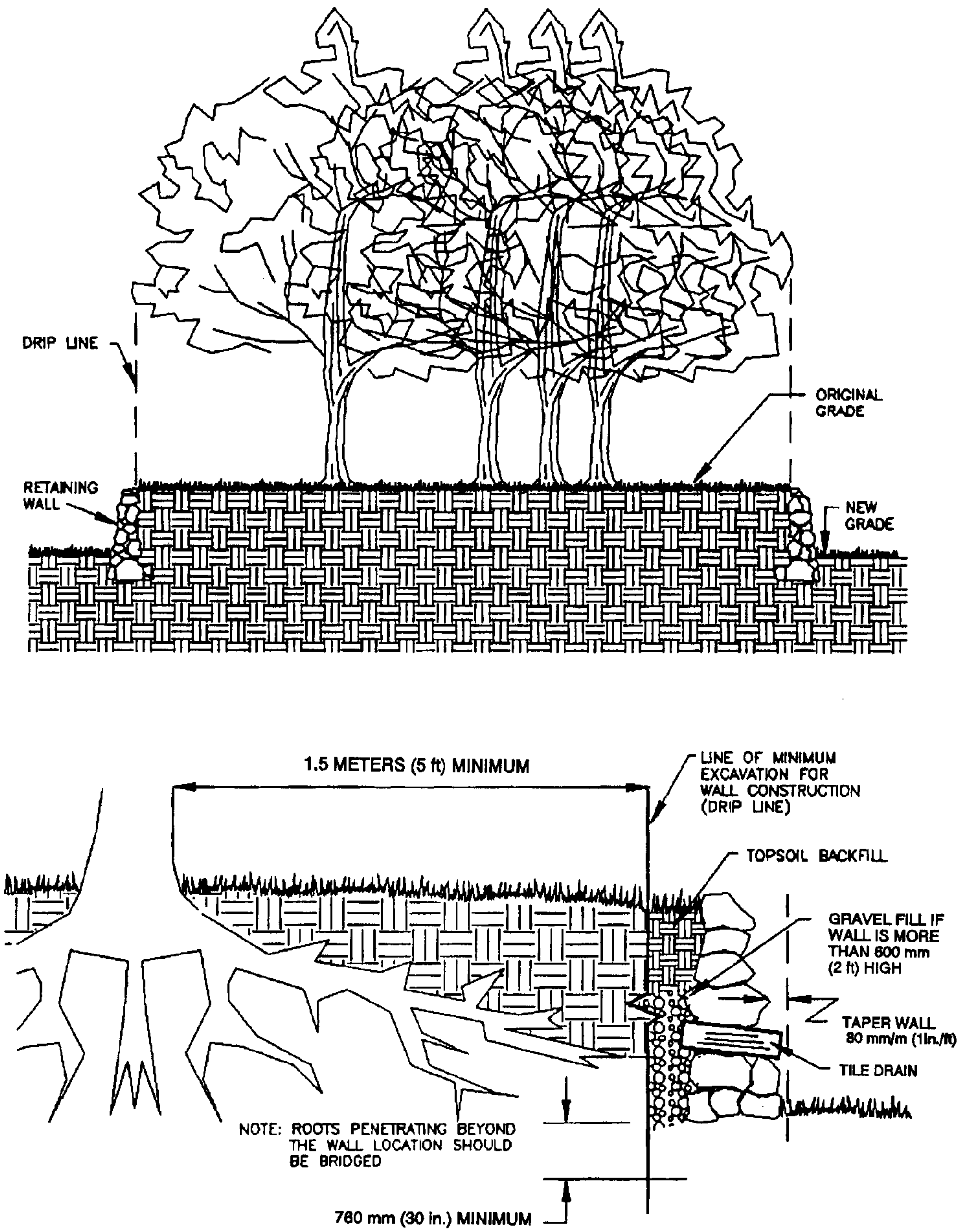
    d. Apply fertilizer and water thoroughly. Fertilizer formulations and application rates and methods shall conform to the guidelines provided in Table 38-1.

    e. Prune the tree crown, reducing the leaf surface in proportion to the amount of root loss.

    f. Provide drainage through the wall so water will not accumulate behind the wall.

    g. Lowering the grade on only one side of a tree or group of trees may be accomplished by constructing only half of this system.

FIGURE 38-4: TREE WALL DETAIL



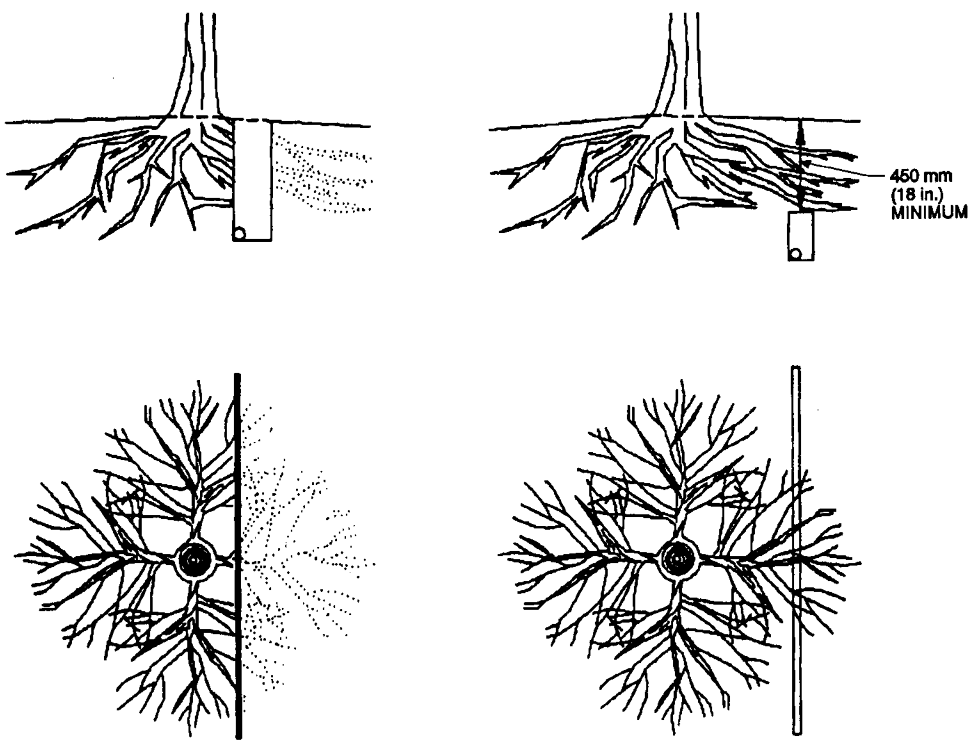
11. Trenching and Tunnelling:

a. Trenching shall be done as far away from the trunks of trees as possible, preferably outside the branches or crown spreads of trees, to reduce the amount of root area damaged, or killed by trenching activities.

b. Wherever possible, trenches should avoid large roots or root concentrations. This can be accomplished by curving the trench or by tunnelling under large roots and areas of heavy root concentration.

c. Tunnelling is more expensive initially, but it usually causes less soil disturbance and physiological impact on the root system (Figure 38-5). The extra cost may offset the potential cost of tree removal and replacement should the tree die.

FIGURE 38-5: TRENCHING VS. TUNNELING



DESTRUCTION OF FEEDER ROOTS WILL PROBABLY KILL THE TREE

TUNNELING UNDER THE TREE WILL PRESERVE IMPORTANT FEEDER ROOTS

Tunnelling is almost always preferred over the trenching method. The tunnel should be 450 millimeters (18 inches) or greater below the ground surface and should not be located under the center of the tree (an off-center tunnel has the least impact on the roots).

d. Roots shall not be left exposed to the air. They shall be covered with soil as soon as possible or protected and kept moistened with wet burlap or peat moss until the trench or tunnel can be filled.

e. The ends of damaged and cut roots shall be cut off smoothly and protected by painting promptly with a tree-wound dressing.

f. Trenches and tunnels shall be filled as soon as possible. Air spaces in the soil shall be avoided by careful filling and tamping.

g. Peat moss or other suitable material shall be added to the fill material as an aid to inducing and developing new root growth.

h. The tree shall be mulched and fertilized to conserve moisture, stimulate new root growth, and enhance general tree vigor.

i. If a large amount of the root system has been damaged and killed, the crown leaf surface shall be proportionately reduced to balance the reduced root system. This may be accomplished by pruning 20 to 30 percent of the crown foliage. If roots are cut during the winter, pruning shall be accomplished before the next growing season. If roots are cut during the growing season, pruning shall be done immediately.

12. Removal and Replacement of Damaged Trees: Should a tree intended and marked to be retained be damaged seriously enough that survival and normal growth are not possible, the tree shall be removed. If replacement is desirable and/or required, the replacement tree shall be of the same or similar species, 50 to 60 millimeter (2 to 2.5 inches) (minimum) caliper balled and burlapped nursery stock. However, today, with the aid of a "tree spade," the same caliper tree may be required as a replacement.

13. Clean-Up: Clean-up after a construction project can be a critical time for tree damage. Trees protected throughout the development operation are often destroyed by carelessness during the final clean-up and landscaping. Fences and barriers shall be removed last, after everything else is cleaned-up and carried away.

14. Maintenance: In spite of precautions, some damage to protected trees may occur. In such cases, the following maintenance guidelines should be followed:

   a. Soil Aeration - If the soil has become compacted over the root zone of any tree, the ground shall be aerated by punching holes with an iron bar. The bar shall be driven 300 millimeters (1-foot) deep and then moved back and forth until the soil is loosened. This procedure shall be repeated every 450 millimeters (18 inches) until all of the compacted soil beneath the crown of the tree has been loosened.

   b. Repair of Damage

      1) Any damage to the crown, trunk, or root system of any tree retained on the site shall be repaired immediately.

      2) Whenever major root or bark damage occurs, remove some foliage to reduce the demand for water and nutrients.

      3) Damaged roots shall immediately be cut off cleanly inside the exposed or damaged area. Cut surfaces shall be painted with approved tree paint, and moist peat moss, burlap, or top-soil shall be spread over the exposed area.

      4) To treat bark damage, carefully cut away all loosened bark back into the undamaged area, taper the cut at the top and bottom, and provide drainage at the base of the wound.

      5) All tree limbs damaged during construction or removed for any other reason shall be cut off above the collar at the preceding branch junction.

      6) Care for serious injuries shall be prescribed by a forester or a tree specialist.

   c. Fertilization: Broadleaf trees that have been stressed or damaged shall receive a heavy application of fertilizer to aid their recovery.

      1) Trees shall be fertilized in the late fall (after October 1) or the early spring (from the time frost is out of the ground until May 1). Fall applications are preferred, as the nutrients will be made available over a longer period of time.

2) Fertilizer shall be applied to the soil over the feeder roots. In no case should it be applied closer than 1 meter (3 feet) to the trunk.

   The root system of conifers extends some distance beyond the drip line. Increase the area to be fertilized by one fourth the area of the crown.

3) Fertilizer shall be applied using approved fertilization methods and equipment.

4) Formulations and application rates shall conform to the guidelines given in Table 38-1.

Maintain ground cover of organic mulch around trees that is adequate to prevent erosion, protect roots, and hold water.

BMP: DUST CONTROL

Definition

Reducing surface and air movement of dust during land disturbing, demolition and construction activities.

Purpose

To prevent surface and air movement of dust from exposed soil surfaces and reduce the presence of airborne substances which may present health hazards, traffic safety problems or harm animal or plant life.

Conditions Where Practice Applies

In areas subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventive measures are not taken.

Planning Considerations

Construction activities inevitably result in the exposure and disturbance of soil. Fugitive dust is emitted both during the activities (i.e., excavation, demolition, vehicle traffic, human activity) and as a result of wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in "heavy" construction activities, such as road and street construction and subdivision, commercial or industrial development which involve disturbance of significant areas of the soil surface. Research of construction sites has established an average dust emission rate of 270 kilograms per 1,000 square meter per month (1.2 tons/acre/month) for active construction. Earth-moving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions.

In planning for dust control, limiting the amount of soil disturbance at any one time should be a key objective. Therefore, phased clearing and grading operations and the utilization of temporary stabilization can significantly reduce dust emissions. Undisturbed vegetative buffers, 15 meter minimum widths (50 feet), left between graded areas and protected areas can also be very helpful in dust control.

Temporary Measures Used During Construction

1. Vegetative Cover - In areas subject to little or no construction traffic, a vegetatively stabilized surface will reduce dust emissions (see TEMPORARY SEEDING, BMP-31).

2. Mulch - When properly applied, mulch offers a fast, effective means of controlling dust. Not recommended for areas within heavy traffic pathways. Binders or tackifiers should be used to tack organic mulches (see MULCHING, BMP-35).

3. Tillage - This practice is designed to roughen and bring clods to the surface. It is an emergency measure which should be used before wind erosion starts. Begin plowing on windward side of site. Chisel-type plows spaced about 300 millimeters (12 inches) apart, spring-toothed harrows, and similar plows are examples of equipment which may produce the desired effect.

4. Irrigation - This is the most commonly used dust control practice. Site is sprinkled with water until the surface is wet. Repeat as needed. It offers fast protection for haul roads and other heavy traffic routes.

5. Spray-On Adhesives - Tremendous progress has been made in recent years in the development of products of this type. Most are effective on "mineral" soils and are ineffective on "muck" soils. These coherics are derived from a variety of compounds, both organic and synthetic based. Many of the adhesives will withstand heavy traffic loads. The organics include derivatives from pine tar and vegetable gum; synthetics may be acrylic or petroleum based. Table 39-1 lists various adhesives and provides corresponding information on mixing and application.

6. Stone - Stone can be used to stabilize roads or other areas during construction using crushed stone or coarse gravel (see CONSTRUCTION ROAD STABILIZATION, BMP-3).

7. Barriers - A board fence, wind fence, sediment fence, or similar barrier can help to control air currents and blowing soil. Place barriers perpendicular to prevailing air currents at intervals of about 15 times the barrier height. Where dust is a known problem, existing windbreak vegetation should be preserved.

8. Calcium Chloride - This chemical may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage. Application rates should be strictly in accordance with suppliers' specified rates.

TABLE 39-1
ADHESIVES USED FOR DUST CONTROL

Adhesive	Water Dilution Adhesive: Water	Type of Nozzle	Application Rate	
			Liters/1,000 square meters	Gallons/acre
Anionic Asphalt Emulsion	7 : 1	Coarse Spray	1,000	1,200
Latex Emulsion	12.5 : 1	Fine Spray	220	235
Resin in Water	4 : 1	Fine Spray	280	300
Acrylic Emulsion (Non-Traffic)	7 : 1	Coarse Spray	420	450
Acrylic Emulsion (Traffic)	3.5 : 1	Coarse Spray	328	350

<u>Permanent Methods</u>

1. Permanent Vegetation - The application of PERMANENT SEEDING (see BMP-32) and saving existing trees and large shrubs can help reduce soil and air movement from construction sites.

2. Stone - Crushed stone or coarse gravel can be used as a permanent cover which will provide control of soil emissions.

APPENDIX D

Inspection Checklist and Guidelines

Exhibit D-1

POLLUTION PREVENTION COMMITTEE MEMBERS

Construction Project Manager/Representative

____

Phone ____________________ 24 hr Phone ____________________

Designated Individuals

Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________
Name ____________________	Title ____________________	Company __________
Phone ____________________	24 hr Phone __________	____________________

Exhibit D-2

ARMY CORPS OF ENGINEERS

Storm Water Pollution Prevention Plan

Construction General Permit
Inspection and Maintenance Report Form

To be completed every 7 days and within 24 hours of a rainfall event of 13 mm (0.5 inch) or more

Project:____

Inspected By:__________________________Date:____________

Inspectors Qualifications:______________________________

Days Since Last Rainfall:________ Amount Of Last Rainfall________mm (Inches)

Structural Controls

AREA	DATE SINCE LAST DISTURBED	DATE OF NEXT DISTURBANCE	STABILIZED (yes/no)	STABILIZED WITH	CONDITION

STABILIZATION REQUIRED:

TO BE PERFORMED BY:__________________ ON OR BEFORE:______________

Exhibit D-3

ARMY CORPS OF ENGINEERS

Storm Water Pollution Prevention Plan

Construction General Permit
Inspection and Maintenance Report Form

To be completed every 7 days and within 24 hours of a rainfall event of 13 mm (0.5 inch) or more

Project:____

Inspected By:____________________________Date:______________

Inspectors Qualifications:___________________________________

____

____

____

Days Since Last Rainfall:_________ Amount Of Last Rainfall_________mm (Inches)

Vegetative Controls

AREA	DATE SINCE LAST DISTURBED	DATE OF NEXT DISTURBANCE	STABILIZED (yes/no)	STABILIZED WITH	CONDITION

STABILIZATION REQUIRED:

____

____

____

____

TO BE PERFORMED BY:____________________ ON OR BEFORE:_________

Exhibit D-4

ARMY CORPS OF ENGINEERS

Storm Water Pollution Prevention Plan

Construction General Permit
Inspection and Maintenance Report Form

To be completed every 7 days and within 24 hours of a rainfall event of 13 mm (0.5 inch) or more

Project:____

Inspected By:______________________________Date:_______________

Inspectors Qualifications:____

____

____

____

Days Since Last Rainfall:_________ Amount Of Last Rainfall_________mm (Inches)

Management Controls

AREA	**ACTIVITY DESCRIPTION**	**MAINTENANCE REQUIRED**	**STABILIZED** (yes/no)	**STABILIZED WITH**	**CONDITION**

STABILIZATION REQUIRED:

____

____

____

____

TO BE PERFORMED BY:____________________ ON OR BEFORE:____________________

Table D-5

EQUIPMENT MAINTENANCE AND INSPECTION

Inspection/Maintenance Conducted and Comments/Observations	Location/Equipment	Conducted By	Date

Table D-6

DRAINAGE SYSTEM MAINTENANCE AND INSPECTION

Outfall	Condition	Discharge Present	Follow-up	Inspector

APPENDIX E

Construction Project Work Sheets and Supporting Documentation

Table E-1

POLLUTANT LIST

Date	Pollutant Present	Use	Quantity Estimate

Table E-2

HISTORY OF PAST SPILLS

Date	Location Of Spill	Type of Material	Amount of Material	Cleanup Response

Table E-3

SAMPLING EVENT RECORDS

Date Sampled	Outfall Sampled	Analysis Performed	Analysis Method	Sampling Team

Table E-4

SPILL CONTROL AND COUNTERMEASURES

Location	Potential Chemical	Equipment Committed	Personnel

Table E-5

EMPLOYEE TRAINING SCHEDULE

Workshop Topic	Dates	Personnel Attending

EXHIBIT E-1

HAZARDOUS WASTE HANDLING CONTINGENCY PLAN

for

____
(Company Name)

____
(Location)

____
(Date)

(COMPANY NAME)

HAZARDOUS WASTE HANDLING CONTINGENCY PLAN

Construction activity name_______________________________
Location Address _______________________________
Telephone # _______________________________
EPA I.D. # _______________________________

PRIMARY EMERGENCY COORDINATOR:

Name _______________________________
Telephone # _______________________________
Home # _______________________________
Home Address _______________________________

SECONDARY EMERGENCY COORDINATOR:

Name _______________________________
Telephone # _______________________________
Home # _______________________________
Home Address _______________________________

Description of Waste Handled:

____
____
____
____

Maximum amount of waste on site: ____________ kg (lb)
Maximum amount generated per month: ____________ kg (lb)

EMERGENCY RESPONSE CONTACTS

LOCAL

Fire Department

Name ________________
Address ________________
Phone # ________________

Ambulance Service

Name ________________
Address ________________
Phone # ________________

Sheriff's Department

Name ________________
Address ________________
Phone # ________________

Hospital

Name ________________
Address ________________
Phone # ________________

*STATE

Dept. of Natural Resources

Name ________________
Address ________________
Phone # ________________

*FEDERAL

Environmental Protection Agency

Name ________________
Address ________________
Phone # ________________

Arrangements with Sheriff's Department

Access to site can be achieved by contacting one of the Emergency Coordinators. Do not allow any contact with the waste unless the emergency equipment specified in this plan is employed.

Arrangements with Fire Department

Material is/is not flammable or explosive.

Where possible, do not wash the waste solids away. The liquid should not enter any sewers or contaminate ground water. Absorb using clay, lime, sand, soda ash, or sawdust.

Arrangements with Local Hospital

Exposure by inhalation or ingestion is/is not likely. Skin contact with either solid or liquid waste can result in________________. Standard medical treatment for such condition is________________________.

Waste will contain a mixture of ________________________.

For eye contact,______________________________. If swallowed,____________________.

Emergency Response - Hazardous Waste Spill

An employee discovering the spillage will immediately contain it. Then immediately report it to a member of management.

A member of management will then contact the designated Emergency Coordinator.

The emergency coordinator will obtain the following information:

1. the material spilled
2. location of spillage of hazardous material
3. an estimate of quantity released
4. any injuries involved
5. the area contaminated by the spillage

Based on the information obtained, the coordinator will assess the magnitude and seriousness of the spillage. If the incident is within the capabilities of the company's emergency response organization, the Emergency Coordinator will contact and deploy the necessary personnel.

If the accident is beyond plant capabilities, the Emergency Coordinator will contact the appropriate agencies. A list of agencies and phone numbers is shown in Contingency Plan.

If a spill occurs in the hazardous waste storage area, the waste should contain no free liquid, but in the event that liquid is present, a dike should be made around the spill using the absorbent material located in the hazardous waste storage area.

When the waste is dry, after addition of sufficient absorbent, the material should be placed in 17H DOT approved drums. Drum must be marked with hazardous waste label. Accumulation start date should be marked on drum label.

If the spillage has come from a leaking hazardous waste drum, then the drum should be placed by forklift in a 303-ℓ (80-gallon) recovery drum, marked with a completed hazardous waste label including accumulation start date.

Only those persons involved in the emergency operation will be allowed within the designated hazard area. If possible, the area will be roped or otherwise blocked off.

The clean-up will be performed by personnel designated by the Emergency Coordinator. All nonessential personnel will be removed from the hazard area.

All materials contaminated during the clean-up operation must be placed in drums for proper disposal. The Emergency Coordinator has the responsibility for ensuring this is done.

In addition, the Emergency Coordinator must ensure that, in the affected area of the plant:

A. No waste that may be incompatible with the released material is treated, stored, or disposed of until clean-up procedures are completed.

B. All emergency equipment is clean and fit for its intended use before operations are resumed.

The Site Superintendent or his designate must:

A. In the event that the local emergency services have been required, or a spill has occurred which extends outside the jobsite area, notify the Regional Administrator and appropriate State and local authorities that the jobsite is in compliance with paragraphs (a) and (b) above before operations are resumed in the affected area of the jobsite.

B. The Site Superintendent or his designate must note in the operating record the time, date, and details of any incident that required implementation of the contingency plan. Within 15 days after the incident, he must submit a written report on the incident to the Regional Administrator including:

1. Name, address, and phone number of the company and jobsite.
2. Date, time, and type of accident.
3. Name and quantity of materials involved.
4. Extent of injuries, if any.
5. Assessment of actual or potential hazards to human health or the environment.
6. Estimated quantity and disposition of recovered material resulting from the incident.

The Site Superintendent also has the responsibility for the following items:

Employee Training

Employees working in areas containing hazardous waste will be given an introductory course in hazardous waste management and annual reviews thereafter, per parameter set forth in 40 CFR 265.16. The established company training program will be used.

Records

A copy of this contingency plan shall be kept in the corporate files, Site Supervisor's office, Site Superintendent's office, and all emergency coordinator's files.

This contingency plan will be revised for amendment:

A. When applicable regulations are revised.
B. When plan fails in an emergency.
C. When situations in the plan change, which increase the potential for release of waste.
D When the list of emergency coordinators changes.
E. When the list of emergency equipment changes.

HAZARDOUS WASTE STORAGE

EMERGENCY EQUIPMENT LISTING

A. Communication System. In the space below put locations of any outside intercoms or radios.

____

____

B. Eye Wash Stations - Safety Showers. One commercial brand eyewash bottle is located in the hazardous waste storage area.

C. Respirators. All operators have NIOSH approved half-face respirators with the appropriate filter cartridge.

D. Fire Suppression. Post location of fire extinguishers in waste storage area.

E. First Aid. A First Aid box is located and maintained in the ____.

F. Personal Protective Equipment. Rubber gloves, rubber boots, goggles or helmet with splash shield are worn by all operators when handling hazardous waste. Spares are available.

G. Spill Control. Oil dry or absorbent clay is available to soak up liquid and to make temporary dikes.

H. Storage Area and Waste Container Inspection. Weekly inspections are made to confirm the integrity of all containers and to ensure all safety equipment is available.

EXHIBIT E-2

CHEMICAL STORAGE CONTINGENCY PLAN

For

____
(Company Name)

____
(Location)

____
(Date)

I. GENERAL INFORMATION

____Company Name________________________________,
produces____

____

The construction activity consists of __________ hectares (acres).

Tank maximum capacities are shown below:

Tank Number	Contents	Maximum Capacity Liters (Gallons)

All tanks are labeled in accordance with State and Federal regulations.

Site Information:

The construction activity is located at _______________________. (On what road?)

Within 0.8-km (1/2-mile) radius of the jobsite:

- population
- any schools, hospitals, or any other institutional facilities?
- is land wooded or any water close by?
- any dwelling or businesses within 0.8 km (1/2 mile)?
- what is soil type?

II. SECURITY

1. All tanks are enclosed in diked containment areas.
2. Gates at the jobsite entrance are closed and locked when the jobsite is closed and not in operation.
3. (Add any other security information.)

III. FIRE AND SPILL CONTROL

Site Fire Marshal: Give name and title. Give any fire procedures, location of fire extinguishers and fire hoses.

Spill Containment Provisions

All storage tanks are located in diked containment areas. The dikes have sufficient capacity to hold the volume of the largest tank plus any accumulated rain water.

For dike containments that have no drains, spills may only be removed by pumping, thus preventing accidental release. Dike spill contents should be returned to the process but may be disposed of as a hazardous waste in a federally approved disposal site.

All transfer piping is above ground.

During all filling operations, one man is assigned to supervise the operations so that overflows do not occur.

Spill Containment and Disposal

1. Immediately contain the spill.
2. Use absorbent materials to make temporary barriers. Supplies of absorbent materials are located ______________________________.
3. Absorb any nonpumpable liquid with absorbent material.
4. Transfer the sludge to appropriate D.O.T.-approved 208-ℓ (55-gallon) drums for disposal.
5. Do not wash spills into the storm drains.
6. Report all leaks and spills to the supervisor.

Inspections

Equipment is inspected daily by operations and site management.

Leaks and spills are corrected promptly.

The Site Superintendent is the designated individual for all types of spill prevention. He has the responsibility to train applicable personnel to prevent discharges and ensure knowledge of applicable laws and regulations.

Coordination Agreements

The company has emergency response agreements regarding hazardous waste which will cover any spill occurrence.

Copies of the appropriate contingency plans are held by the:

Sheriff's Office
Fire Department
Hospital

Notifications

Any person discovering a spill will call the emergency coordinators listed in the Hazardous Waste Contingency Plans.

If the spill is a reportable quantity or leaves the property, then the agencies detailed below will be informed.

1. Department of Natural Resources (appropriate State Agency)
   Phone Number:____________________
2. Environmental Protection Agency (Federal)
   Phone Number:____________________
3. Fire Department (if necessary)
   Phone Number:____________________

Personnel Training

All assigned personnel are provided with training in safe handling of hazardous chemicals and hazardous waste. Training covers the use of respirators, protective safety equipment, proper hygiene, decontamination procedures, and contingency plans. Training is given on-the-job (OTJ) by the Emergency Coordinator or his designated person.

EXHIBIT E-3

OIL SPILL PREVENTION CONTROL

and

COUNTERMEASURE PLAN

(SPCC)

For

____

(Company Name)

____

(Location)

____

(Date)

I. PURPOSE

This plan is established to prevent the accidental release of oil from this construction activity into local ponds, streams, or ground water, per 40 CFR 110-13.

II. OIL STORAGE AREA INFORMATION

1. Tank size
2. Above ground, below ground, vertical or horizontal
3. Size class
4. Is tank surrounded by a concrete or earthen containment dike? Containment storage volume ____________.

III. PREVIOUS SPILL EXPERIENCE

(Enter last date of spill, if any.)

IV. FUELING PROCEDURES

1. One person will be assigned to supervise filling operations. He will ensure tanks are not overfilled by checking tank levels prior to and during filling.

2. Filling supervisor will place a warning sign in front of the tractor cab driver's door, reminding him to see that loading lines are disconnected before he pulls away.

3. All lines will be blown free of oil by compressed air before maintenance work is performed.

4. Loading lines will be capped when not in use.

5. Any sight glass valves will be kept in "off" position when not in use.

6. Tank weld seams, pipe fittings, flanges, and valves will be visually inspected during each filling operation. Any leaks or spills will be reported immediately to the Emergency Coordinator.

7. Vehicle traffic will be limited or prohibited in areas of oil transfer lines.

V. SECURITY

1. This construction activity is enclosed by a chain link fence, gates are locked when construction activity is unattended.

2. Containment dikes have no outlet valves or permanent sump pumps. Dikes are pumped after rainfalls by a portable sump pump after inspection to assure no oil contamination.

3. Oil pump starter control shall be locked in the "off" position when not in use.

4. Area is properly lighted for after dark operations. Lighting is adequate for night-time spill or leak detection.

VI. PERSONNEL TRAINING

Newly hired personnel are to be instructed in the operation and maintenance of oil handling equipment and the rules, regulations, and procedures as outlined in this plan. Annual training will be provided to them and other employees involved in oil handling and spill prevention measures.

VII. EMERGENCY COORDINATORS

Primary and secondary coordinators shall be listed in the "Hazardous Waste Contingency Plan." They will have authorization to commit construction activity resources necessary to carry out this plan.

VIII. REPORTABLE QUANTITIES

The exact quantity of oil spilled, which is to be reported to governing agencies, has not been determined as of this writing. Federal regulations specify only "a film or sheen upon or discoloration of the surface of the water..." should be reported.

APPENDIX F

Certification

SWPPP CERTIFICATION

Name ____

Title ____

Name of Construction Project ________________________

____

Location of Construction Project ______________________

____

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

Printed
Name____

Signature ____________________________________

Title ____

Date ____

NON-STORM WATER CERTIFICATION

Name ____

Title ____

Name of Construction Project ____________________________

____

Location of Construction Project ___________________________

____

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

Printed
Name____

Signature ____

Title ____

Date ____

THIS FORM REPLACES PREVIOUS FORM 3510-7 (8-92)
Please See Instructions Before Completing This Form

Form Approved. OMB No. 2040-0086
Approval expires: 8-31-98

NPDES FORM

EPA

United States Environmental Protection Agency
Washington, DC 20460

Notice of Termination (NOT) of Coverage Under a NPDES General Permit for Storm Water Discharges Associated with Industrial Activity

Submission of this Notice of Termination constitutes notice that the party identified in Section II of this form is no longer authorized to discharge storm water associated with industrial activity under the NPDES program. ALL NECESSARY INFORMATION MUST BE PROVIDED ON THIS FORM.

I. Permit Information

NPDES Storm Water General Permit Number: ____________ Check Here if You are No Longer the Operator of the Facility: ☐ Check Here if the Storm Water Discharge is Being Terminated: ☐

II. Facility Operator Information

Name: ____________ Phone: ____________

Address: ____________

City: ____________ State: ____ ZIP Code: ____________

III. Facility/Site Location Information

Name: ____________

Address: ____________

City: ____________ State: ____ ZIP Code: ____________

Latitude: ________ Longitude: ________ Quarter: ____ Section: ____ Township: ____ Range: ____

IV. Certification:

I certify under penalty of law that all storm water discharges associated with industrial activity from the identified facility that are authorized by a NPDES general permit have been eliminated or that I am no longer the operator of the facility or construction site. I understand that by submitting this Notice of Termination, I am no longer authorized to discharge storm water associated with industrial activity under this general permit, and that discharging pollutants in storm water associated with industrial activity to waters of the United States is unlawful under the Clean Water Act where the discharge is not authorized by a NPDES permit. I also understand that the submittal of this Notice of Termination does not release an operator from liability for any violations of this permit or the Clean Water Act.

Print Name: ____________ Date: ____________

Signature: ____________

Instructions for Completing Notice of Termination (NOT) Form

Who May File a Notice of Termination (NOT) Form

Permittees who are presently covered under an EPA-issued National Pollutant Discharge Elimination System (NPDES) General Permit (including the 1995 Multi-Sector Permit) for Storm Water Dicharges Associated with Industrial Activity may submit a Notice of Termination (NOT) form when their facilities no longer have any storm water discharges associated with industrial activity as defined in the storm water regulations at 40 CFR 122.26(b)(14), or when they are no longer the operator of the facilities.

For construction activities, elimination of all storm water discharges associated with industrial activity occurs when disturbed soils at the construction site have been finally stabilized and temporary erosion and sediment control measures have been removed or will be removed at an appropriate time, or that all storm water discharges associated with industrial activity from the construction site that are authorized by a NPDES general permit have otherwise been eliminated. Final stabilization means that all soil-disturbing activities at the site have been completed, and that a uniform perennial vegetative cover with a density of 70% of the cover for unpaved areas and areas not covered by permanent structures has been established, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

Where to File NOT Form

Send this form to the the following address:

Storm Water Notice of Termination (4203)
401 M Street, S.W.
Washington, DC 20460

Completing the Form

Type or print, using upper-case letters, in the appropriate areas only. Please place each character between the marks. Abbreviate if necessary to stay within the number of characters allowed for each item. Use only one space for breaks between words, but not for punctuation marks unless they are needed to clarify your response. If you have any questions about this form, telephone or write the Notice of Intent Processing Center at (703) 931-3230.

EPA Form 3510-7 (8-98)

Instructions - EPA Form 3510-7
Notice of Termination (NOT) of Coverage Under The NPDES General Permit
for Storm Water Discharges Associated With Industrial Activity

Section I Permit Information

Enter the existing NPDES Storm Water General Permit number assigned to the facility or site identified in Section III. If you do not know the permit number, telephone or write your EPA Regional storm water contact person.

Indicate your reason for submitting this Notice of Termination by checking the appropriate box:

If there has been a change of operator and you are no longer the operator of the facility or site identified in Section III, check the corresponding box.

If all storm water discharges at the facility or site identified in Section III have been terminated, check the corresponding box.

Section II Facility Operator Information

Give the legal name of the person, firm, public organization, or any other entity that operates the facility or site described in this application. The name of the operator may or may not be the same name as the facility. The operator of the facility is the legal entity which controls the facility's operation, rather than the plant or site manager. Do not use a colloquial name. Enter the complete address and telephone number of the operator.

Section III Facility/Site Location Information

Enter the facility's or site's official or legal name and complete address, including city, state and ZIP code. If the facility lacks a street address, indicate the state, the latitude and longitude of the facility to the nearest 15 seconds, or the quarter, section, township, and range (to the nearest quarter section) of the approximate center of the site.

Section IV Certification

Federal statutes provide for severe penalties for submitting false information on this application form. Federal regulations require this application to be signed as follows:

For a corporation: by a responsible corporate officer, which means: (i) president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision making functions, or (ii) the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25 million (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures;

For a partnership or sole proprietorship: by a general partner or the proprietor; or

For a municipality, State, Federal, or other public facility: by either a principal executive officer or ranking elected official.

Paperwork Reduction Act Notice

Public reporting burden for this application is estimated to average 0.5 hours per application, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate, any other aspect of the collection of information, or suggestions for improving this form, including any suggestions which may increase or reduce this burden to: Chief, Information Policy Branch, 2136, U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, or Director, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

NOTICE OF TERMINATION

NPDES No.______________

Name of Construction Project ______________________________________

____

Location of Construction Project: (If address is not available, locate approximate center of site by latitude and longitude to the nearest 15 seconds, or the section, township and range to the nearest quarter)

____

____

Operator:
Name ____
Address ____
Phone ____

Reason for
Termination:____

> "I certify under penalty of law that all storm water discharges associated with industrial activity from the identified facility that are authorized by an NPDES general permit have been eliminated or that I am no longer the operator of the construction activity. I understand that by submitting this notice of termination, that I am no longer authorized to discharge storm water associated with industrial activity under this general permit, and that discharging pollutants in storm water associated with industrial activity to waters of the United States is unlawful under the Clean Water Act where the discharge is not authorized by an NPDES permit. I also understand that the submittal of this notice of termination does not release me as operator from liability for any violations of this permit or the Clean Water Act."

Printed
Name ____

Signature ____

Title ____

Date ____

APPENDIX G
Record of Revision

Table G-1
Army Corps of Engineers

Storm Water Pollution Prevention Plan
for Construction Activities

Record of Revision

Revision Number	Date of Change	Date Entered	Signature of Person Entering Change

Exhibit G-1

Army Corps of Engineers

Storm Water Pollution Prevention Plan
for Construction Activities

Record of Revision

To all holders of the COE Storm Water Pollution Prevention Plan for Construction Activities:

Revision Number:________________________

Date:________________________

Attached are the revised pages of the COE SWPPP of which you have a copy. Please remove pages in your copy and replace them with these revisions. Record each revision on the preceding page of your copy.

Old Page (page number)	Revised Page (page number)	Date Entered	Signature of Person Entering Change

APPENDIX H

Section 313 Water Priority Chemicals*

*Source: *Federal Register*/Vol 57, No. 175/
WEDNESDAY, SEPTEMBER 9, 1992-
ADDENDUM B, page 41331-41335.

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	Common Name
75-07-0	Acetaldehyde
75865	Acetane cynohydrin
107-02-8	Acrolein
107-13-1	Acrylonitrile
309-00-2	Aldrin[1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-(1.alpha.,4.alpha.,4a.beta.,5.alpha.,8.alpha.,8a.beta.)-]
107-05-1	Allyl Chloride
7429-90-5	Aluminum (fume or dust)
7664-41-7	Ammonia
62-53-3	Aniline
120-12-7	Anthracene
7440-36-0	Antimony
7647189	Antimony pentachloride
28300745	Antimony potassium tartrate
7789619	Antimony tribromide
10025919	Antimony trichloride
7783564	Antimony trifluoride
1309644	Antimony trioxide
7440-38-2	Arsenic
1303328	Arsenic disulfide
1303282	Arsenic pentoxide
7784341	Arsenic trichloride
1327533	Arsenic trioxide
1303339	Arsenic trisulfide
1332-21-4	Asbestos (friable)
542621	Barium cyanide
71-43-2	Benzene
92-87-5	Benzidine
100470	Benzonitrile
98-88-4	Benzoyl chloride

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	**Common Name**
100-44-7	Benzyl chloride
7440-41-7	Beryllium
7787475	Beryllium chloride
7787497	Beryllium fluoride
7787555	Beryllium nitrate
111-44-4	Bis(2-chloroethyl) ether
75-25-2	Bromoform
74-83-9	Bromomethane (Methyl bromide)
85-68-7	Butyl benzyl phthalate
7440-43-9	Cadmium
543908	Cadmium acetate
7789426	Cadmium bromide
10108642	Cadmium chloride
7778441	Calcium arsenate
52740166	Calcium arsenite
13765190	Calcium chromate
592018	Calcium cyanide
133-06-2	Captan [1H-Isoindole-1,3(2H)-dione,3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-]
63-25-2	Carbaryl [1-Naphthalenol, methylcarbamate]
75-15-0	Carbon disulfide
56-23-5	Carbon tetrachloride
57-74-9	Chlordane [4,7-Methanoindan,1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-]
7782-50-5	Chlorine
59-50-7	Chloro-4-methyl-3-phenol *p*-Chloro-*m*-cresol
108-90-7	Chlorobenzene
75-00-3	Chloroethane (Ethyl chloride)
67-66-3	Chloroform
74-87-3	Chloromethane (Methyl chloride)
95-57-8	2-Chlorophenol

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	Common Name
106-48-9	4-Chlorophenol
1066304	Chromic acetate
11115745	Chromic acid
10101538	Chromic sulfate
7440-47-3	Chromium
1308-14-1	Chromium (Tri)
10049055	Chromous chloride
7789437	Cobaltous bromide
544183	Cobaltous formate
14017415	Cobaltous sulfamate
7440-50-8	Copper
108-39-4	*m*-Cresol
9548-7	*o*-Cresol
106-44-5	*p*-Cresol
1319-77-3	Cresol (mixed isomers)
142712	Cupric acetate
12002038	Cupric acetoarsenite
7447394	Cupric chloride
3251238	Cupric nitrate
5893663	Cupric oxalate
7758987	Cupric sulfate
10380297	Cupric sulfate, ammoniated
815827	Cupric tartrate
57-12-5	Cyanide
506774	Cyanogen chloride
110-82-7	Cyclohexane
94-75-7	2,4-D [Acetic acid, (2,4-dichlorophenoxy)-]
106-93-4	1,2-Dibromoethane (Ethylene dibromide)
84-74-2	Dibutyl phthalate
25321-22-6	Dichlorobenzene (mixed isomers)

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	**Common Name**
95-50-1	1,2-Dichlorobenzene
541-73-1	1,3-Dichlorobenzene
106-46-7	1,4-Dichlorobenzene
91-94-1	3,3'-Dichlorobenzidine
75-27-4	Dichlorobromomethane
107-06-2	1,2-Dichloroethane (Ethylene dichloride)
540-59-0	1,2-Dichloroethylene
120-83-2	2,4-Dichlorophenol
78-87-5	1,2-Dichloropropane
542-75-6	1,3-Dichloropropylene
62-73-7	Dichlorvos [Phosphoric acid, 2,2-dichloroethenyl dimethyl ester]
115-32-2	Dicofol [Benzenemethanol, 4-chloro-.alpha.-(4-chlorophenyl)-.alpha.-(trichloromethyl)-]
177-81-7	Di-(2-ethylhexyl phthalate (DEHP)
84-66-2	Diethyl phthalate
105-67-9	2,4-Dimethylphenol
131-11-3	Dimethyl phthalate
534-52-1	4,6-Dinitro-*o*-cresol
51-28-5	2,4-Dinitrophenol
121-14-2	2,4-Dinitrotoluene
606-20-2	2,6-Dinitrotoluene
117-84-0	*n*-Dioctyl phthalate
122-66-7	1,2-Diphenylhydrazine (Hydrazobenzene)
106-89-8	Epichlorohydrin
100-41-4	Ethylbenzene
106934	Ethylene dibromide
50-00-0	Formaldehyde
76-44-8	Heptachlor [1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-*indene*]
118-74-1	Hexachlorobenzene
87-68-3	Hexachloro-1,3-butadiene

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	**Common Name**
77-47-4	Hexachlorocyclopentadiene
67-72-1	Hexachloroethane
7647-01-0	Hydrochloric acid
74-90-8	Hydrogen cyanide
7664-39-3	Hydrogen fluoride
7439-92-1	Lead
301042	Lead acetate
7784409	Lead arsenate
7645252	" "
10102484	" "
7758954	Lead chloride
13814965	Lead fluoborate
7783462	Lead fluoride
10101630	Lead iodide
10099748	Lead nitrate
7428480	Lead stearate
1072351	" "
52652592	" "
7446142	Lead sulfate
1314870	Lead sulfide
592870	Lead thiocyanate
58-89-9	Lindane [Cyclohexane, 1,2,3,4,5,6-hexachloro- (1.alpha.,3.beta., 4.alpha.,5.alpha.,6.beta.)-]
14307358	Lithium chromate
108-31-6	Maleic anhydride
592041	Mercuric cyanide
10045940	Mercuric nitrate
7783359	Mercuric sulfate
592858	Mercuric thiocyanate
7782867	Mercurous nitrate
7439-97-6	Mercury

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	Common Name
72-43-5	Methoxychlor [Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4- methoxy-]
80-62-6	Methyl methacrylate
91-20-3	Naphthalene
7440-02-0	Nickel
15699180	Nickel ammonium sulfate
37211055	Nickel chloride
7718549	" "
12054487	Nickel hydroxide
14216752	Nickel nitrate
7786814	Nickel sulfate
7697-37-2	Nitric acid
98-95-3	Nitrobenzene
88-75-5	2-Nitrophenol
100-02-7	4-Nitrophenol
62-75-9	*N*-Nitrosodimethylamine
86-30-6	*N*-Nitrosodiphenylamine
621-64-7	*N*-Nitrosodi-*n*-propylamine
56-38-2	Parathion [Phosphorothioic acid, O,O-diethyl-O-(4-nitrophenyl) ester]
87-86-5	Pentachlorophenol (PCP)
108-95-2	Phenol
75-44-5	Phosgene
7664-38-2	Phosphoric acid
7723-14-0	Phosphorus (yellow or white)
1336-36-3	Polychlorinated biphenyls (PCBs)
7784410	Potassium arsenate
10124502	Potassium arsenite
7778509	Potassium bichromate
7789006	Potassium chromate
151508	Potassium cyanide
75-56-9	Propylene oxide

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	**Common Name**
91-22-5	Quinoline
7782-49-2	Selenium
7446084	Selenium oxide
7440-22-4	Silver
7761888	Silver nitrate
7631892	Sodium arsenate
7784465	Sodium arsenite
10588019	Sodium bichromate
7775113	Sodium chromate
143339	Sodium cyanide
10102188	Sodium selenite
7782823	
7789062	Strontium chromate
100-42-5	Styrene
7664-93-9	Sulfuric acid
79-34-5	1,1,2,2-Tetrachloroethane
127-18-4	Tetrachloroethylene (Perchloroethylene)
935-95-5	2,3,5,6-Tetrachlorophenol
78002	Tetraethyl lead
7440-28-0	Thallium
10031591	Thallium sulfate
108-88-3	Toluene
8001-35-2	Toxaphene
52-68-6	Trichlorfon [Phosphonic acid, (2,2,2-trichloro-1-hydroxyethyl)-dimethylester]
120-82-1	1,2,4-Trichlorobenzene
71-55-6	1,1,1-Trichloroethane (Methyl chloroform)
79-00-5	1,1,2-Trichloroethane
79-01-6	Trichloroethylene
95-95-4	2,4,5-Trichlorophenol
88-06-2	2,4,6-Trichlorophenol

SECTION 313 WATER PRIORITY CHEMICALS	
CAS Number	Common Name
7440-62-2	Vanadium (fume or dust)
108-05-4	Vinyl acetate
75-01-4	Vinyl chloride
75-35-4	Vinylidene chloride
108-38-3	*m*-Xylene
95-47-6	*o*-Xylene
106-42-3	*p*-Xylene
1330-20-7	Xylene (mixed isomers)
7440-66-6	Zinc (fume or dust)
557346	Zinc acetate
14639975	Zinc ammonium chloride
14639986	" " "
52628258	" " "
1332076	Zinc borate
7699458	Zinc bromide
3486359	Zinc carbonate
7646857	Zinc chloride
557211	Zinc cyanide
7783495	Zinc fluoride
557415	Zinc formate
7779864	Zinc hydrosulfite
7779886	Zinc nitrate
127822	Zinc phenolsulfonate
1314847	Zinc phosphide
16871719	Zinc silicofluoride
7733020	Zinc sulfate

APPENDIX I
Hazardous Substances and Reportable Quantities*

*40 CFR 302, "Designation, Reportable Quantities and Notification," TABLE 302.4

LIST OF HAZARDOUS SUBSTANCES AND REPORTABLE QUANTITIES

Note: All comments are located at the end of this table.

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Acenaphthene	83329		1*	2		B	100 (45.4)
Acenaphthylene	208968		1*	2		D	5000 (2270)
Acetaldehyde	75070	Ethanal	1000	1,4	U001	C	1000 (454)
Acetaldehyde, chloro-	107200	Chloroacetaldehyde	1*	4	P023	C	1000 (454)
Acetaldehyde, trichloro-	75876	Chloral	1*	4	U034	D	5000 (2270)
Acetamide, N-(aminothioxomethyl)-	591082	1-Acetyl-2-thiourea	1*	4	P002	C	1000 (454)
Acetamide, N-(4-ethoxyphenyl)-	62442	Phenacetin	1*	4	U187	B	100 (45.4)
Acetamide, 2-fluoro-	640197	Fluoroacetamide	1*	4	P057	B	100 (45.4)
Acetamide, N-9H-fluoren-2-yl-	53963	2-Acetylaminofluorene	1*	4	U005	X	1 (0.454)
Acetic acid	64197		1000	1		D	5000 (2270)
Acetic acid (2,4-dichlorophenoxy)-	94757	2,4-D Acid 2,4-D, salts and esters	100	1,4	U240	B	100 (45.4)
Acetic Acid, lead(2+) salt	301042	Lead acetate	5000	1,4	U144		#
Acetic acid, thallium(1+) salt	563688	Thallium(I)	1*	4	U214	B	100 (45.4)
Acetic acid (2,4,5-trichlorophenoxy)-	93765	2,4,5-T 2,4,5-T acid	100	1,4	U232	C	1000 (454)
Acetic acid, ethyl ester	141786	Ethyl acetate	1*	4	U112	D	5000 (2270)
Acetic acid, fluoro-, sodium salt	62748	Fluoroacetic acid, sodium salt	1*	4	P058	A	10 (4.54)
Acetic anhydride	108247		1000	1		D	5000 (2270)
Acetone	67641	2-Propanone	1*	4	U002	D	5000 (2270)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Acetone cyanohydrin	75865	Propanenitrile, 2-hydroxy-2-methyl-2-Methyllactonitrile	10	1,4	P069	A	10 (4.54)
Acetonitrile	75058		1*	4	U003	D	5000 (2270)
Acetophenone	98862	Ethanone, 1-phenyl-	1*	4	U004	D	5000 (2270)
2-Acetylaminofluorene	53963	Acetamide, N-9H-fluoren-2-yl-	1*	4	U005	X	1 (0.454)
Acetyl bromide	506967		5000	1		D	5000 (2270)
Acetyl chloride	75365		5000	1,4	U006	D	5000 (2270)
1-Acetyl-2-thiourea	591082	Acetamide, N-(aminothioxomethyl)-	1*	4	P002	C	1000 (454)
Acrolein	107028	2-Propenal	1	1,2,4	P003	X	1 (0.454)
Acrylamide	79061	2-Propenamide	1*	4	U007	D	5000 (2270)
Acrylic acid	79107	2-Propenoic acid	1*	4	U008	D	5000 (2270)
Acrylonitrile	107131	2-Propenenitrile	100	1,2,4	U009	B	100 (45.4)
Adipic acid	124049		5000	1		D	5000 (2270)
Aldicarb	116063	Propanal, 2-methyl-2-(methylthio)-,O-[(methylamino)carbonyl]oxime	1*	4	P070	X	1 (0.454)
Aldrin	309002	1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-10-hexachloro-1,4,4a,5,8,8a-hexahydro-,(1alpha,4alpha,4abeta,5alpha, 8alpha,8abeta)-	1	1,2,4	P004	X	1 (0.454)
Allyl alcohol	107186	2-Propen-1-ol	100	1,4	P005	B	100 (45.4)
Allyl chloride	107051		1000	1		C	1000 (454)
Aluminum phosphide	20859738		1*	4	P006	B	100 (45.4)
Aluminum sulfate	10043013		5000	1		D	5000 (2270)
5-(Aminomethyl)-3-isoxazolol	2763964	Muscimol 3(2H)-Isoxazolone, 5-(aminomethyl)-	1*	4	P007	C	1000 (454)
4-Aminopyridine	504245	4-Pyridinamine	1*	4	P008	C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Amitrole	61825	1H-1,2,4-Triazol-3-amine	1*	4	U011	A	10 (4.54)
Ammonia	7664417		100	1		B	100 (45.4)
Ammonium acetate	631618		5000	1		D	5000 (2270)
Ammonium benzoate	1863634		5000	1		D	5000 (2270)
Ammonium bicarbonate	1066337		5000	1		D	5000 (2270)
Ammonium bichromate	7789095		1000	1		A	10 (4.54)
Ammonium bifluoride	1341497		5000	1		B	100 (45.4)
Ammonium bisulfite	10192300		5000	1		D	5000 (2270)
Ammonium carbamate	1111780		5000	1		D	5000 (2270)
Ammonium carbonate	506876		5000	1		D	5000 (2270)
Ammonium chloride	12125029		5000	1		D	5000 (2270)
Ammonium chromate	7788989		1000	1		A	10 (4.54)
Ammonium citrate, dibasic	3012655		5000	1		D	5000 (2270)
Ammonium fluoborate	13826830		5000	1		D	5000 (2270)
Ammonium fluoride	12125018		5000	1		B	100 (45.4)
Ammonium hydroxide	1336216		1000	1		C	1000 (454)
Ammonium oxalate	6009707		5000	1		D	5000 (2270)
	5972736						
	14258492						
Ammonium picrate	131748	Phenol, 2,4,6-trinitro-, ammonium salt	1*	4	P009	A	10 (4.54)
Ammonium silicofluoride	16919190		1000	1		C	1000 (454)
Ammonium sulfamate	7773060		5000	1		D	5000 (2270)
Ammonium sulfide	12135761		5000	1		B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Ammonium sulfite	10196040		5000	1		D	5000 (2270)
Ammonium tartrate	14307438		5000	1		D	5000 (2270)
	3164292						
Ammonium thiocyanate	1762954		5000	1		D	5000 (2270)
Ammonium vanadate	7803556	Vanadic acid, ammonium salt	1*	4	P119	C	1000 (454)
Amyl acetate	628637		1000	1		D	5000 (2270)
iso-Amyl acetate	123922						
sec-Amyl acetate	626380						
tert-Amyl acetate	625161						
Aniline	62533	Benzenamine	1000	1,4	U012	D	5000 (2270)
Anthracene	120127		1*	2		D	5000 (2270)
Antimony††	7440360		1*	2		D	5000 (2270)
ANTIMONY AND COMPOUNDS	N/A		1*	2			**
Antimony pentachloride	7647189		1000	1		C	1000 (454)
Antimony potassium tartrate	28300745		1000	1		B	100 (45.4)
Antimony tribromide	7789619		1000	1		C	1000 (454)
Antimony trichloride	10025919		1000	1		C	1000 (454)
Antimony trifluoride	7783564		1000	1		C	1000 (454)
Antimony trioxide	1309644		5000	1		C	1000 (454)
Argentate(1-), bis(cyano-C)-, potassium	506616	Potassium silver cyanide	1*	4	P099	X	1 (0.454)
Aroclor 1016	12674112	POLYCHLORINATED BIPHENYLS (PCBs)	10	1,2		X	1 (0.454)
Aroclor 1221	11104282	POLYCHLORINATED BIPHENYLS (PCBs)	10	1,2		X	1 (0.454)
Aroclor 1232	11141165	POLYCHLORINATED BIPHENYLS (PCBs)	10	1,2		X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Aroclor 1242	53469219	POLYCHLORINATED BIPHENYLS (PCBs)	10	1,2		X	1 (0.454)
Aroclor 1248	12672296	POLYCHLORINATED BIPHENYLS (PCBs)	10	1,2		X	1 (0.454)
Aroclor 1254	11097691	POLYCHLORINATED BIPHENYLS (PCBs)	10	1,2		X	1 (0.454)
Aroclor 1260	11096825	POLYCHLORINATED BIPHENYLS (PCBs)	10	1,2		X	1 (0.454)
Arsenic††	7440382		1*	2,3		X	1 (0.454)
Arsenic acid	1327522	Arsenic acid H3AsO4	1*	4	P010	X	1 (0.454)
	7778394						
Arsenic acid H3AsO4	1327522	Arsenic acid	1*	4	P010	X	1 (0.454)
	7778394						
ARSENIC AND COMPOUNDS	N/A		1*	2			**
Arsenic disulfide	1303328		5000	1		X	1 (0.454)
Arsenic oxide As2O3	1327533	Arsenic trioxide	5000	1,4	P012	X	1 (0.454)
Arsenic oxide As2O5	1303282	Arsenic pentoxide	5000	1,4	P011	X	1 (0.454)
Arsenic pentoxide	1303282	Arsenic oxide As2O5	5000	1,4	P011	X	1 (0.454)
Arsenic trichloride	7784341		5000	1		X	1 (0.454)
Arsenic trioxide	1327533	Arsenic oxide As2O3	5000	1,4	P012	X	1 (0.454)
Arsenic trisulfide	1303339		5000	1		X	1 (0.454)
Arsine, diethyl-	692422	Diethylarsine	1*	4	P038	X	1 (0.454)
Arsinic acid, dimethyl-	75605	Cacodylic acid	1*	4	U136	X	1 (0.454)
Arsonous dichloride, phenyl-	696286	Dichlorophenylarsine	1*	4	P036	X	1 (0.454)
Asbestos†††	1332214		1*	2,3		X	1 (0.454)
Auramine	492808	Benzenamine, 4,4'-carbonimidoylbis (N,N-dimethyl-	1*	4	U014	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Azaserine	115026	L-Serine, diazoacetate (ester)	1*	4	U015	X	1 (0.454)
Aziridine	151564	Ethylenimine	1*	4	P054	X	1 (0.454)
Aziridine, 2-methyl-	75558	1,2-Propylenimine	1*	4	P067	X	1 (0.454)
Azirino[2',3':3,4]pyrrolo[1,2-a]indole-4,7-dione,6-amino-8-[[(aminocarbonyl)oxy]methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methyl-,[1aS-(1aalpha,8beta,8aalpha,8balpha)]-	50077	Mitomycin C	1*	4	U010	A	10 (4.54)
Barium cyanide	542621		10	1,4	P013	A	10 (4.54)
Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	56495	3-Methylcholanthrene	1*	4	U157	A	10 (4.54)
Benz[c]acridine	225514		1*	4	U016	B	100 (45.4)
Benzal chloride	98873	Benzene, dichloromethyl-	1*	4	U017	D	5000 (2270)
Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-	23950585	Pronamide	1*	4	U192	D	5000 (2270)
Benz[a]anthracene	56553	Benzo[a]anthracene 1,2-Benzanthracene	1*	2,4	U018	A	10 (4.54)
1,2-Benzanthracene	56553	Benz[a]anthracene Benzo[a]anthracene	1*	2,4	U018	A	10 (4.54)
Benz[a]anthracene, 7,12-dimethyl-	57976	7,12-Dimethylbenz[a]anthracene	1*	4	U094	X	1 (0.454)
Benzenamine	62533	Aniline	1000	1,4	U012	D	5000 (2270)
Benzenamine, 4,4'-carbonimidoylbis (N,N-dimethyl-	492808	Auramine	1*	4	U014	B	100 (45.4)
Benzenamine, 4-chloro-	106478	p-Chloroaniline	1*	4	P024	C	1000 (454)
Benzenamine, 4-chloro-2-methyl-, hydrochloride	3165933	4-Chloro-o-toluidine, hydrochloride	1*	4	U049	B	100 (45.4)
Benzenamine, N,N-dimethyl-4(phenylazo-)	60117	p-Dimethylaminoazobenzene	1*	4	U093	A	10 (4.54)
Benzenamine, 2-methyl-	95534	o-Toluidine	1*	4	U328	B	100 (45.4)
Benzenamine, 4-methyl-	106490	p-Toluidine	1*	4	U353	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Benzenamine, 4,4'-methylenebis(2-chloro-	101144	4,4'-Methylenebis(2-chloroaniline)	1*	4	U158	A	10 (4.54)
Benzenamine, 2-methyl-, hydrochloride	636215	o-Toluidine hydrochloride	1*	4	U222	B	100 (45.4)
Benzenamine, 2-methyl-5-nitro	99558	5-Nitro-o-toluidine	1*	4	U181	B	100 (45.4)
Benzenamine, 4-nitro-	100016	p-Nitroaniline	1*	4	P077	D	5000 (2270)
Benzene	71432		1000	1,2,3,4	U109	A	10 (4.54)
Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy-, ethyl ester	510156	Chlorobenzilate	1*	4	U038	A	10 (4.54)
Benzene, 1-bromo-4-phenoxy-	101553	4-Bromophenyl phenyl ether	1*	2,4	U030	B	100 (45.4)
Benzenebutanoic acid, 4-[bis(2-chloroethyl)amino]-	305033	Chlorambucil	1*	4	U035	A	10 (4.54)
Benzene, chloro-	108907	Chlorobenzene	100	1,2,4	U037	B	100 (45.4)
Benzene, chloromethyl-	100447	Benzyl chloride	100	1,4	P028	B	100 (45.4)
Benzenediamin, ar-methyl-	95807	Toluenediamine	1*	4	U221	A	10 (4.54)
	496720						
	823405						
1,2-Benzenedicarboxylic acid, dioctyl ester	117840	Di-n-octyl phthalate	1*	2,4	U107	D	5000 (2270)
1,2-Benzenedicarboxylic acid, [bis(2-ethylhexyl)]-ester	117817	Bis (2-ethylhexyl)phthalate Diethylhexyl phthalate	1*	2,4	U028	B	100 (45.4)
1,2-Benzenedicarboxylic acid, dibutyl ester	84742	Di-n-butyl phthalate Dibutyl phthalate n-Butyl phthalate	100	1,2,4	U069	A	10 (4.54)
1,2-Benzenedicarboxylic acid, diethyl ester	84662	Diethyl phthalate	1*	2,4	U088	C	1000 (454)
1,2-Benzenedicarboxylic acid, dimethyl ester	131113	Dimethyl phthalate	1*	2,4	U102	D	5000 (2270)
Benzene, 1,2-dichloro-	95501	o-Dichlorobenzene 1,2-Dichlorobenzene	100	1,2,4	U070	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Benzene, 1,3-dichloro-	541731	m-Dichlorobenzene 1,3-Dichlorobenzene	1*	2,4	U071	B	100 (45.4)
Benzene, 1,4-dichloro-	106467	p-Dichlorobenzene 1,4-Dichlorobenzene	100	1,2,4	U072	B	100 (45.4)
Benzene, 1,1'-(2,2-dichloroethylidene) bis[4-chloro-	72548	DDD TDE 4,4' DDD	1	1,2,4	U060	X	1 (0.454)
Benzene, dichloromethyl-	98873	Benzal chloride	1*	4	U017	D	5000 (2270)
Benzene, 1,3-diisocyanatomethyl-	584849	Toluene diisocyanate	1*	4	U223	B	100 (45.4)
	91087						
	26471625						
Benzene, dimethyl	1330207	Xylene (mixed)	1000	1,4	U239	C	1000 (454)
m-Benzene, dimethyl	108383	m-Xylene					
o-Benzene, dimethyl	95476	o-Xylene					
p-Benzene, dimethyl	106423	p-Xylene					
1,3-Benzenediol	108463	Resorcinol	1000	1,4	U201	D	5000 (2270)
1,2-Benzenediol,4-[1-hydroxy-2-(methylamino)ethyl]-	51434	Epinephrine	1*	4	P042	C	1000 (454)
Benzeneethanamine, alpha,alpha-dimethyl-	122098	alpha,alpha-Dimethylphenethylamine	1*	4	P046	D	5000 (2270)
Benzene, hexachloro-	118741	Hexachlorobenzene	1*	2,4	U127	A	10 (4.54)
Benzene, hexahydro-	110827	Cyclohexane	1000	1,4	U056	C	1000 (454)
Benzene, hydroxy-	108952	Phenol	1000	1,2,4	U188	C	1000 (454)
Benzene, methyl-	108883	Toluene	1000	1,2,4	U220	C	1000 (454)
Benzene, 2-methyl-1,3-dinitro-	606202	2,6-Dinitrotoluene	1000	1,2,4	U106	B	100 (45.4)
Benzene, 1-methyl-2,4-dinitro-	121142	2,4-Dinitrotoluene	1000	1,2,4	U105	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Benzene, 1-methylethyl-	98828	Cumene	1*	4	U055	D	5000 (2270)
Benzene, nitro-	98953	Nitrobenzene	1000	1,2,4	U169	C	1000 (454)
Benzene, pentachloro-	608935	Pentachlorobenzene	1*	4	U183	A	10 (4.54)
Benzene, pentachloronitro-	82688	Pentachloronitrobenzene (PCNB)	1*	4	U185	B	100 (45.4)
Benzenesulfonic acid chloride	98099	Benzenesulfonyl chloride	1*	4	U020	B	100 (45.4)
Benzenesulfonyl chloride	98099	Benzenesulfonic acid chloride	1*	4	U020	B	100 (45.4)
Benzene, 1,2,4,5-tetrachloro-	95943	1,2,4,5-Tetrachlorobenzene	1*	4	U207	D	5000 (2270)
Benzenethiol	108985	Thiophenol	1*	4	P014	B	100 (45.4)
Benzene, 1,1'-(2,2,2-tri-chloroethylidene) bis[4-chloro-	50293	DDT 4,4'DDT	1	1,2,4	U061	X	1 (0.454)
Benzene, 1,1'-(trichloroethylidene) bis[4-methoxy-	72435	Methoxychlor	1	1,4	U247	X	1 (0.454)
Benzene, (trichloromethyl)-	98077	Benzotrichloride	1*	4	U023	A	10 (4.54)
Benzene, 1,3,5-trinitro-	99354	1,3,5-Trinitrobenzene	1*	4	U234	A	10 (4.554)
Benzidine	92875	(1,1'-Biphenyl)-4,4'diamine	1*	2,4	U021	X	1 (0.454)
1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide	81072	Saccharin and salts	1*	4	U202	B	100 (45.4)
Benzo[a]anthracene	56553	Benz[a]anthracene 1,2-Benzanthracene	1*	2,4	U018	A	10 (4.54)
Benzo[b]fluoranthene	205992		1*	2		X	1 (0.454)
Benzo(k)fluoranthene	207089		1*	2		D	5000 (2270)
Benzo[j,k]fluorene	206440	Fluoranthene	1*	2,4	U120	B	100 (45.4)
1,3-Benzodioxole, 5-(1-propenyl)-	120581	Isosafrole	1*	4	U141	B	100 (45.4)
1,3-Benzodioxole, 5-(2-propenyl)-	94597	Safrole	1*	4	U203	B	100 (45.4)
1,3-Benzodioxole, 5-propyl-	94586	Dihydrosafrole	1*	4	U090	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Benzoic acid	65850		5000	1		D	5000 (2270)
Benzonitrile	100470		1000	1		D	5000 (2270)
Benzo[rst]pentaphene	189559	Dibenz[a,i]pyrene	1*	4	U064	A	10 (4.54)
Benzo[ghi]perylene	191242		1*	2		D	5000 (2270)
2H-1 Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenyl-butyl)-, & salts, when present at concentrations greater than 0.3%	81812	Warfarin, & salts, when present at concentrations greater than 0.3%	1*	4	P001	B	100 (45.4)
Benzo[a]pyrene	50328	3,4-Benzopyrene	1*	2,4	U022	X	1 (0.454)
3,4-Benzopyrene	50328	Benzo[a]pyrene	1*	2,4	U022	X	1 (0.454)
p-Benzoquinone	106514	2,5-Cyclohexadiene-1,4-dione	1*	4	U197	A	10 (4.54)
Benzotrichloride	98077	Benzene, (trichloromethyl)-	1*	4	U023	A	10 (4.54)
Benzoyl chloride	98884		1000	1		C	1000 (454)
1,2-Benzphenanthrene	218019	Chrysene	1*	2,4	U050	B	100 (45.4)
Benzyl chloride	100447	Benzene, chloromethyl-	100	1,4	P028	B	100 (45.4)
Beryllium††	7440417	Beryllium dust ††	1*	2,3,4	P015	A	10 (4.54)
BERYLLIUM AND COMPOUNDS	N/A		1*	2			**
Beryllium chloride	7787475		5000	1		X	1 (0.454)
Beryllium dust††	7440417	Beryllium††	1*	2,3,4	P015	A	10 (4.54)
Beryllium fluoride	7787497		5000	1		X	1 (0.454)
Beryllium nitrate	13597994		5000	1		X	1 (0.454)
	7787555						
alpha-BHC	319846		1*	2		A	10 (4.54)
beta-BHC	319857		1*	2		X	1 (0.454)

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delta-BHC	319868		1*	2		X	1 (0.454)
gamma-BHC	58899	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha,5alpha,6 beta)- Hexachlorocyclohexane (gamma isomer) Lindane	1	1,2,4	U129	X	1 (0.454)
2,2'-Bioxirane	1464535	1,2:3,4-Diepoxybutane	1*	4	U085	A	10 (4.54)
(1,1'-Biphenyl)-4,4'diamine	92875	Benzidine	1*	2,4	U021	X	1 (0.454)
(1,1'-Biphenyl)-4,4'diamine,3,3'dichloro-	91941	3,3'-Dichlorobenzidine	1*	2,4	U073	X	1 (0.454)
(1,1'-Biphenyl)-4,4'diamine,3,3'dimethoxy-	119904	3,3'-Dimethoxybenzidine	1*	4	U091	B	100 (45.4)
(1,1'-Biphenyl)-4,4'-diamine,3,3'-dimethyl-	119937	3,3'-Dimethylbenzidine	1*	4	U095	A	10 (4.54)
Bis (2-chloroethyl) ether	111444	Dichloroethyl ether Ethane, 1,1'-oxybis[2-chloro-	1*	2,4	U025	A	10 (4.54)
Bis(2-chloroethoxy) methane	111911	Dichloromethoxy ethane Ethane, 1,1'-[methylenebis(oxy)]bis(2-chloro-	1*	2,4	U024	C	1000 (454)
Bis (2-ethylhexyl)phthalate	117817	Diethylhexyl phthalate 1,2-Benzenedicarboxylic acid, [bis(2-ethylhexyl)] ester	1*	2,4	U028	B	100 (45.4)
Bromoacetone	598312	2-Propanone, 1-bromo-	1*	4	P017	C	1000 (454)
Bromoform	75252	Methane, tribromo	1*	2,4	U225	B	100 (45.4)
4-Bromophenyl phenyl ether	101553	Benzene, 1-bromo-4-phenoxy-	1*	2,4	U030	B	100 (45.4)
Brucine	357573	Strychnidin-10-one, 2,3-dimethoxy-	1*	4	P018	B	100 (45.4)
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	87683	Hexachlorobutadiene	1*	2,4	U128	X	1 (0.454)
1-Butanamine, N-butyl-N-nitroso-	924163	N-Nitrosodi-n-butylamine	1*	4	U172	A	10 (4.54)
1-Butanol	71363	n-Butyl alcohol	1*	4	U031	D	5000 (2270)
2-Butanone	78933	Methyl ethyl ketone (MEK)	1*	4	U159	D	5000 (2270)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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2-Butanone peroxide	1338234	Methyl ethyl ketone peroxide	1*	4	U160	A	10 (4.54)
2 Butanone, 3,3-dimethyl-1-(methylthio)-, O[(methylamino)carbonyl] oxime.	39196184	Thiofanox	1*	4	P045	B	100 (45.4)
2-Butenal	123739	Crotonaldehyde	100	1,4	U053	B	100 (45.4)
	4170303						
2-Butene, 1,4-dichloro-	764410	1,4-Dichloro-2-butene	1*	4	U074	X	1 (0.454)
2-Butenoic acid, 2-methyl, 7[[2,3-dihydorxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy] methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-1-ylester, [1S-[1alpha(Z),7(2S*,3R*),7aalpha]]-	303344	Lasiocarpine	1*	4	U143	A	10 (4.54)
Butyl acetate	123864		5000	1		D	5000 (2270)
iso-Butyl acetate	110190						
sec-Butyl acetate	105464						
tert-Butyl acetate	540885						
n-Butyl alcohol	71363	1-Butanol	1*	4	U031	D	5000 (2270)
Butylamine	109739		1000	1		C	1000 (454)
iso-Butylamine	78819						
sec-Butylamine	513495						
	13952846						
tert-Butylamine	75649						
Butyl benzyl phthalate	85687		1*	2		B	100 (45.4)
n-Butyl phthalate	84742	Di-n-butyl phthalate Dibutyl phthalate 1,2-Benzenedicarboxylic acid, dibutyl ester	100	1,2,4	U069	A	10 (4.54)
Butyric acid	107926		5000	1		D	5000 (2270)

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iso-Butyric acid	79312						
Cacodylic acid	75605	Arsinic acid, dimethyl-	1*	4	U136	X	1 (0.454)
Cadmium††	7440439		1*	2		A	10 (4.54)
Cadmium acetate	543908		100	1		A	10 (4.54)
CADMIUM AND COMPOUNDS	N/A		1*	2			**
Cadmium bromide	7789426		100	1		A	10 (4.54)
Cadmium chloride	10108642		100	1		A	10 (4.54)
Calcium arsenate	7778441		1000	1		X	1 (0.454)
Calcium arsenite	52740166		1000	1		X	1 (0.454)
Calcium carbide	75207		5000			A	10 (4.54)
Calcium chromate	13765190	Chromic acid H2CrO4, calcium salt	1000	1,4	U032	A	10 (4.54)
Calcium cyanide	592018	Calcium cyanide Ca(CN)2	10	1,4	P021	A	10 (4.54)
Calcium cyanide Ca(CN)2	592018	Calcium cyanide	10	1,4	P021	A	10 (4.54)
Calcium dodecylbenzenesulfonate	26264062		1000	1		C	1000 (454)
Calcium hypochlorite	7778543		100	1		A	10 (4.54)
Camphene, octachloro-	8001352	Toxaphene	1	1,2,4	P123	X	1 (0.454)
Captan	133062		10	1		A	10 (4.54)
Carbamic acid, ethyl ester	51796	Ethyl carbamate (urethane)	1*	4	U238	B	100 (45.4)
Carbamic acid, methylnitroso-, ethyl ester	615532	N-Nitroso-N-methylurethane	1*	4	U178	X	1 (0.454)
Carbamic chloride, dimethyl-	79447	Dimethylcarbamoyl chloride	1*	4	U097	X	1 (0.454)
Carbamodithioic acid, 1,2-ethanediylbis, salts & esters	111546	Ethylenebisdithiocarbamic acid, salts & esters	1*	4	U114	D	5000 (2270)

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Carbamothioic acid, bis(1-methylethyl)-, S-(2,3-dich-loro-2-propenyl) ester	2303164	Diallate	1*	4	U062	B	100 (45.4)
Carbaryl	63252		100	1		B	100 (45.4)
Carbofuran	1563662		10	1		A	10 (4.54)
Carbon disulfide	75150		5000	1,4	P022	B	100 (45.4)
Carbon oxyfluoride	353504	Carbonic difluoride	1*	4	U033	C	1000 (454)
Carbon tetrachloride	56235	Methane, tetrachloro-	5000	1,2,4	U211	A	10 (4.54)
Carbonic acid, dithallium(1+) salt	653739	Thallium(I) carbonate	1*	4	U215	B	100 (45.4)
Carbonic dichloride	75445	Phosgene	5000	1,4	P095	A	10 (4.54)
Carbonic difluoride	353504	Carbon oxyfluoride	1*	4	U033	C	1000 (454)
Carbonochloridic acid, methyl ester	79221	Methyl chlorocarbonate Methyl chloroformate	1*	4	U156	C	1000 (454)
Chloral	75876	Acetaldehyde, trichloro-	1*	4	U034	D	5000 (2270)
Chlorambucil	305033	Benzenebutanoic acid, 4-[bis(2-chloroethyl) amino]-	1*	4	U035	A	10 (4.54)
Chlordane	57749	Chlordane, alpha & gamma isomers Chlordane, technical 4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-	1	1,2,4	U036	X	1 (0.454)
CHLORDANE (TECHNICAL MIXTURE AND METABOLITES)	N/A		1*	2			**
Chlordane, alpha & gamma isomers	57749	Chlordane Chlordane, technical 4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-	1	1,2,4	U036	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Chlordane, technical	57749	Chlordane Chlordane, alpha & gamma isomers 4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahyrdo-	1	1,2,4	U036	X	1 (0.454)
CHLORINATED BENZENES	N/A		1*	2			**
CHLORINATED ETHANES	N/A		1*	2			**
CHLORINATED NAPHTHALENE	N/A		1*	2			**
CHLORINATED PHENOLS	N/A		1*	2			**
Chlorine	7782505		10	1		A	10 (4.54)
Chlornaphazine	494031	Naphthalenamine, N,N'-bis(2-chloroethyl)-	1*	4	U026	B	100 (45.4)
Chloroacetaldehyde	107200	Acetaldehyde, chloro-	1*	4	P023	C	1000 (454)
CHLOROALKYL ETHERS	N/A		1*	2			**
p-Chloroaniline	106478	Benzenamine, 4-chloro-	1*	4	P024	C	1000 (454)
Chlorobenzene	108907	Benzene, chloro-	100	1,2,4	U037	B	100 (45.4)
Chlorobenzilate	510156	Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy-, ethyl ester	1*	4	U038	A	10 (4.54)
4-Chloro-m-cresol	59507	p-Chloro-m-cresol Phenol, 4-chloro-3-methyl	1*	2,4	U039	D	5000 (2270)
p-Chloro-m-cresol	59507	Phenol, 4-chloro-3-methyl- 4-Chloro-m-cresol	1*	2,4	U039	D	5000 (2270)
Chlorodibromomethane	124481		1*	2		B	100 (45.4)
Chloroethane	75003		1*	2		B	100 (45.4)
2-Chloroethyl vinyl ether	110758	Ethene, 2-chloroethoxy-	1*	2,4	U042	C	1000 (454)
Chloroform	67663	Methane, trichloro-	5000	1,2,4	U044	A	10 (4.54)
Chloromethyl methyl ether	107302	Methane, chloromethoxy-	1*	4	U046	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
beta-Chloronaphthalene	91587	Naphthalene, 2-chloro- 2-Chloronaphthalene	1*	2,4	U047	D	5000 (2270)
2-Chloronaphthalene	91587	beta-Chloronaphthalene Naphthalene, 2-chloro-	1*	2,4	U047	D	5000 (2270)
2-Chlorophenol	95578	o-Chlorophenol Phenol, 2-chloro-	1*	2,4	U048	B	100 (45.4)
o-Chlorophenol	95578	Phenol, 2-chloro- 2-Chlorophenol	1*	2,4	U048	B	100 (45.4)
4-Chlorophenyl phenyl ether	7005723		1*	2		D	5000 (2270)
1-(o-Chlorophenyl)thiourea	5344821	Thiourea, (2-chlorophenyl)-	1*	4	P026	B	100 (45.4)
3-Chloropropionitrile	542767	Propanenitrile, 3-chloro-	1*	4	P027	C	1000 (454)
Chlorosulfonic acid	7790945		1000	1		C	1000 (454)
4-Chloro-o-toluidine, hydrochloride	3165933	Benzenamine, 4-chloro-2-methyl-, hydrochloride	1*	4	U049	B	100 (45.4)
Chlorpyrifos	2921882		1	1		X	1 (0.454)
Chromic acetate	1066304		1000	1		C	1000 (454)
Chromic acid	11115745		1000	1		A	10 (4.54)
	7738945						
Chromic acid H2CrO4, calcium salt	13765190	Calcium chromate	1000	1,4	U032	A	10 (4.54)
Chromic sulfate	10101538		1000	1		C	1000 (454)
Chromium††	7440473		1*	2		D	5000 (2270)
CHROMIUM AND COMPOUNDS	N/A		1*	2			**
Chromous chloride	10049055		1000	1		C	1000 (454)
Chrysene	218019	1,2-Benzphenanthrene	1*	2,4	U050	B	100 (45.4)
Cobaltous bromide	7789437		1000	1		C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Cobaltous formate	544183		1000	1		C	1000 (454)
Cobaltous sulfamate	14017415		1000	1		C	1000 (454)
Coke Oven Emissions	N/A		1*	3		X	1 (0.454)
Copper cyanide CuCN	544923	Copper cyanide	1*	4	P029	A	10 (4.54)
Copper††	7440508		1*	2		D	5000 (2270)
COPPER AND COMPOUNDS	N/A		1*	2			**
Copper cyanide	544923	Copper cyanide CuCN	1*	4	P029	A	10 (4.54)
Coumaphos	56724		10	1		A	10 (4.54)
Creosote	8001589		1*	4	U051	X	1 (0.454)
Cresol(s)	1319773	Cresylic acid Phenol, methyl-	1000	1,4	U052	C	1000 (454)
m-Cresol	108394	m-Cresylic acid				-	
o-Cresol	95487	o-Cresylic acid					
p-Cresol	106445	p-Cresylic acid					
Cresylic acid	1319773	Cresol(s) Phenol, methyl-	1000	1,4	U052	C	1000 (454)
m-Cresol	108394	m-Cresylic acid					
o-Cresol	95487	o-Cresylic acid					
p-Cresol	106445	p-Cresylic acid					
Crotonaldehyde	123739	2-Butenal	100	1,4	U053	B	100 (45.4)
	4170303						
Cumene	98828	Benzene, 1-methylethyl-	1*	4	U055	D	5000 (2270)
Cupric acetate	142712		100	1		B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Cupric acetoarsenite	12002038		100	1		X	1 (0.454)
Cupric chloride	7447394		10	1		A	10 (4.54)
Cupric nitrate	3251238		100	1		B	100 (45.4)
Cupric oxalate	5893663		100	1		B	100 (45.4)
Cupric sulfate	7758987		10	1		A	10 (4.54)
Cupric sulfate, ammoniated	10380297		100	1		B	100 (45.4)
Cupric tartrate	815827		100	1		B	100 (45.4)
CYANIDES	N/A		1*	2			**
Cyanides (soluble salts and complexes) not otherwise specified	57125		1*	4	P030	A	10 (4.54)
Cyanogen	460195	Ethanedinitrile	1*	4	P031	B	100 (45.4)
Cyanogen bromide	506683	Cyanogen bromide (CN)Br	1*	4	U246	C	1000 (454)
Cyanogen bromide (CN)Br	506683	Cyanogen bromide	1*	4	U246	C	1000 (454)
Cyanogen chloride	506774	Cyanogen chloride (CN)Cl	10	1,4	P033	A	10 (4.54)
Cyanogen chloride (CN)Cl	506774	Cyanogen chloride	10	1,4	P033	A	10 (4.54)
2,5-Cyclohexadiene-1,4-dione	106514	p-Benzoquinone	1*	4	U197	A	10 (4.54)
Cyclohexane	110827	Benzene, hexahydro-	1000	1,4	U056	C	1000 (454)
Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha,5alpha,6,beta)-	58899	gamma—BHC	1	1,2,4	U129	X	1 (0.454)
Cyclohexanone	108941		1*	4	U057	D	5000 (2270)
2-Cyclohexyl-4,6-dinitrophenol	131895	Phenol, 2-cyclohexyl-4,6-dinitro-	1*	4	P034	B	100 (45.4)
1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	77474	Hexachlorocyclopentadiene	1	1,2,4	U130	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
Cyclophosphamide	50180	2H-1,3,2-Oxazaphosphorin-2-amine, N,N-bis(2-chloroethyl)tetrahydro-,2-oxide	1*	4	U058	A	10 (4.54)
2,4-D Acid	94757	Acetic acid (2,4-dichlorophenoxy)-2,4-D, salts and esters	100	1,4	U240	B	100 (45.4)
2,4-D Ester	94111		100	1		B	100 (45.4)
	94791						
	94804						
	1320189						
	1928387						
	1928616						
	1929733						
	2971382						
	25168267						
	53467111						
2,4-D, salts and esters	94757	Acetic acid (2,4-dichlorophenoxy)-2,4-D Acid	100	1,4	U240	B	100 (45.4)
Daunomycin	20830813	5,12-Naphthacenedione, 8-acetyl-10-[(3-amino-2,3,6- trideoxy-alpha-L-lyxo-hexo-pyranosyl)oxy]-7,8,9,10- tetrahydro-6,8,11-trihydroxy-1-methoxy-, (8S-cis)-	1*	4	U059	A	10 (4.54)
DDD	72548	Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro- TDE 4,4' DDD	1	1,2,4	U060	X	1 (0.454)
4,4' DDD	72548	Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-DDD TDE	1	1,2,4	U060	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
DDE	72559	4,4' DDE	1*	2		X	1 (0.454)
4,4' DDE	72559	DDE	1*	2		X	1 (0.454)
DDT	50293	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-4,4'DDT	1	1,2,4	U061	X	1 (0.454)
4,4' DDT	50293	Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-DDT	1	1,2,4	U061	X	1 (0.454)
DDT AND METABOLITES	N/A		1*	2			**
Diallate	2303164	Carbamothioic acid, bis(1-methylethyl)-, S-(2,3,-dich-loro-2-propenyl) ester	1*	4	U062	B	100 (45.4)
Diazinon	333415		1	1		X	1 (0.454)
Dibenz[a,h]anthracene	53703	Dibenzo[a,h]anthracene 1,2:5,6-Dibenzanthracene	1*	2,4	U063	X	1 (0.454)
1,2:5,6-Dibenzanthracene	53703	Dibenz[a,h]anthracene Dibenzo[a,h]anthracene	1*	2,4	U063	X	1 (0.454)
Dibenzo[a,h]anthracene	53703	Dibenz[a,h]anthracene 1,2:5,6-Dibenzanthracene	1*	2,4	U063	X	1 (0.454)
Dibenz[a,i]pyrene	189559	Benzo[rst]pentaphene	1*	4	U064	A	10 (4.54)
1,2-Dibromo-3-chloropropane	96128	Propane, 1,2-dibromo-3-chloro-	1*	4	U066	X	1 (0.454)
Dibutyl phthalate	84742	Dibutyl phthalate n-Butyl phthalate 1,2-Benzenedicarboxylic acid, dibutyl ester	100	1,2,4	U069	A	10 (4.54)
Di-n-butyl phthalate	84742	Dibutyl phthalate n-Butyl phthalate 1,2-Benzenedicarboxylic acid, dibutyl ester	100	1,2,4	U069	A	10 (4.54)
Dicamba	1918009		1000	1		C	1000 (454)
Dichlobenil	1194656		1000	1		B	100 (45.4)
Dichlone	117806		1	1		X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Dichlorobenzene	25321226		100	1		B	100 (45.4)
1,2-Dichlorobenzene	95501	Benzene, 1,2-dichloro- o-Dichlorobenzene	100	1,2,4	U070	B	100 (45.4)
1,3-Dichlorobenzene	541731	Benzene, 1,3-dichloro m-Dichlorobenzene	1*	2,4	U071	B	100 (45.4)
1,4-Dichlorobenzene	106467	Benzene, 1,4-dichloro p-Dichlorobenzene	100	1,2,4	U072	B	100 (45.4)
m-Dichlorobenzene	541731	Benzene, 1,3-dichloro 1,3-Dichlorobenzene	1*	2,4	U071	B	100 (45.4)
o-Dichlorobenzene	95501	Benzene, 1,2-dichloro 1,2-Dichlorobenzene	100	1,2,4	U070	B	100 (45.4)
p-Dichlorobenzene	106467	Benzene, 1,4-dichloro 1,4-Dichlorobenzene	100	1,2,4	U072	B	100 (45.4)
DICHLOROBENZIDINE	N/A		1*	2			**
3,3'-Dichlorobenzidine	91941	[1,1'-Biphenyl]-4,4'diamine,3,3'dichloro-	1*	2,4	U073	X	1 (0.454)
Dichlorobromomethane	75274		1*	2		D	5000 (2270)
1,4-Dichloro-2-butene	764410	2-Butene, 1,4-dichloro-	1*	4	U074	X	1 (0.454)
Dichlorodifluoromethane	75718	Methane, dichlorodifluoro-	1*	4	U075	D	5000 (2270)
1,1-Dichloroethane	75343	Ethane, 1,1-dichloro- Ethylidene dichloride	1*	2,4	U076	C	1000 (454)
1,2-Dichloroethane	107062	Ethane, 1,2-dichloro- Ethylene dichloride	5000	1,2,4	U077	B	100 (45.4)
1,1-Dichloroethylene	75354	Ethene, 1,1-dichloro- Vinylidene chloride	5000	1,2,4	U078	B	100 (45.4)
1,2-Dichloroethylene	156605	Ethene 1,2-dichloro- (E)	1*	2,4	U079	C	1000 (454)
Dichloroethyl ether	111444	Bis (2-chloroethyl) ether Ethane, 1,1'-oxybis[2-chloro-	1*	2,4	U025	A	10 (4.54)
Dichloroisopropyl ether	108601	Propane, 2,2'-oxybis[2-chloro-	1*	2,4	U027	C	1000 (454)
Dichloromethoxy ethane	111911	Bis(2-chloroethoxy) methane Ethane, 1,1'-[methylenebis(oxy)]bis (2-chloro-	1*	2,4	U024	C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Dichloromethyl ether	542881	Methane, oxybis(chloro-	1*	4	P016	A	10 (4.54)
2,4-Dichlorophenol	120832	Phenol, 2,4-dichloro-	1*	2,4	U081	B	100 (45.4)
2,6-Dichlorophenol	87650	Phenol, 2,6-dichloro-	1*	4	U082	B	100 (45.4)
Dichlorophenylarsine	696286	Arsonous dichloride, phenyl-	1*	4	P036	X	1 (0.454)
Dichloropropane	26638197		5000	1		C	1000 (454)
1,1-Dichloropropane	78999		....	....			....
1,3-Dichloropropane	142289		....	....			....
1,2-Dichloropropane	78875	Propane, 1,2-dichloro- Propylene dichloride	5000	1,2,4	U083	C	1000 (454)
Dichloropropane—Dichloropropene (mixture)	8003198		5000	1		B	100 (45.4)
Dichloropropene	26952238		5000	1		B	100 (45.4)
2,3-Dichloropropene	78886		....	....			....
1,3-Dichloropropene	542756	1-Propene, 1,3-dichloro-	5000	1,2,4	U084	B	100 (45.4)
2,2-Dichloropropionic acid	75990		5000	1		D	5000 (2270)
Dichlorvos	62737		10	1		A	10 (4.54)
Dicofol	115322		5000	1		A	5000 (2270)
Dieldrin	60571	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-,(1aalpha,2beta,2aalpha,3beta, 6beta,6aalpha,7beta, 7aalpha)-	1	1,2,4	P037	X	1 (0.454)
1,2:3,4-Diepoxybutane	1464535	2,2'-Bioxirane	1*	4	U085	A	10 (4.54)
Diethylamine	109897		1000	1		B	100 (454.4)
Diethylarsine	692422	Arsine, diethyl-	1*	4	P038	X	1 (0.454)
1,4-Diethylenedioxide	123911	1,4-Dioxane	1*	4	U108	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Diethylhexyl phthalate	117817	Bis (2-ethylhexyl)phthalate 1,2,-Benzenedicarboxylic acid, [bis(2-ethylhexyl)] ester	1*	2,4	U028	B	100 (45.4)
N,N-'Diethylhydrazine	1615801	Hydrazine, 1,2-diethyl-	1*	4	U086	A	10 (4.54)
O,O-Diethyl S-methyl dithiophosphate	3288582	Phosphorodithioic acid, O,O-diethyl S-methyl ester	1*	4	U087	D	5000 (2270)
Diethyl-p-nitrophenyl phosphate	311455	Phosphoric acid, diethyl 4-nitrophenyl ester	1*	4	P041	B	100 (45.4)
Diethyl phthalate	84662	1,2-Benzenedicarboxylic acid, diethyl ester	1*	2,4	U088	C	1000 (454)
O,O-Diethyl O-pyrazinyl phosphorothioate	297972	Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester	1*	4	P040	B	100 (45.4)
Diethylstilbestrol	56531	Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-, (E)	1*	4	U089	X	1 (0.454)
Dihydrosafrole	94586	1,3-Benzodioxole, 5-propyl-	1*	4	U090	A	10 (4.54)
Diisopropylfluorophosphate	55914	Phosphorofluoridic acid, bis(1-methylethyl) ester	1*	4	P043	B	100 (45.4)
1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-,10-hexachloro-1,4,4a,5,8,8a-hexahydro-,(1alpha,4alpha,4abeta,5alpha,' 8alpha,	309002	Aldrin	1	1,2,4	P004	X	1 (0.454)
8abeta)-1,4,5,8-Dimenthanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro,(1alpha,4alpha,4abeta,5abeta, 8beta,	465736	Isodrin	1*	4	P060	X	1 (0.454)
8abeta)-2,7:3,6-Dimethanonaphth[2,3-b] oxirene,3,4,5,6,9,9-hexachloro-1a,2,2a,3,6, 6a,7,7a-octahydro-, (1aalpha,2beta,2aalpha, 3beta,6beta,	60571	Dieldrin	1	1,2,4	P037	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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6aalpha,7beta,7aalpha)-2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octa-hydro-,(1aalpha,2beta,2abeta,3alpha,6alpha,	72208	Endrin Endrin & metabolites	1	1,2,4	P051	X	1 (0.454)
6abeta,7beta,7aalpha)-Dimethoate	60515	Phosphorodithioic acid, O,O-dimethyl S-[2(methyla-mino)-2-oxoethyl] ester	1*	4	P044	A	10 (4.54)
3,3'-Dimethoxybenzidine	119904	[1,1'-Biphenyl]-4,4'diamine,3,3'dimethyoxy-	1*	4	U091	B	100 (45.4)
Dimethylamine	124403	methanamine, N-methyl	1000	1,4	U092	C	1000 (454)
p-Dimethylaminoazobenzene	60117	Benzenamine, N,N-dimethyl-4-(phenylazo-)	1*	4	U093	A	10 (4.54)
7,12-Dimethylbenz[a]anthracene	57976	Benz[a]anthracene, 7,12-dimethyl-	1*	4	U094	X	1 (0.454)
3,3'-Dimethylbenzidine	119937	[1,1'Biphynyl]-4,4'diamine,3,3'-dimethyl-	1*	4	U095	A	10 (4.54)
alpha,alpha-Dimethylbenzylhydroperoxide	80159	Hydroperoxide, 1-mehtyl-1-phenylethyl-	1*	4	U096	A	10 (4.54)
Dimethylcarbamoyl chloride	79447	Carbamic chloride, dimethyl-	1*	4	U097	X	1 (0.454)
1,1-Dimethylhydrazine	57147	Hydrazine, 1,1-dimethyl-	1*	4	U098	A	10 (4.54)
1,2-Dimethylhydrazine	540738	Hydrazine, 1,2-dimethyl-	1*	4	U099	X	1 (0.454)
alpha,alpha-Dimethylphenethylamine	122098	Benzeneethanamine, alpha,alpha-dimethyl-	1*	4	P046	D	5000 (2270)
2,4-Dimethylphenol	105679	Phenol, 2,4-dimethyl-	1*	2,4	U101	B	100 (45.4)
Dimethyl phthalate	131113	1,2-Benzenedicarboxylic acid, dimethyl ester	1*	2,4	U102	D	5000 (2270)
Dimethyl sulfate	77781	Sulfuric acid, dimethyl ester	1*	4	U103	B	100 (45.4)
Dinitrobenzene (mixed)	25154545		1000	1		B	100 (45.4)
m-Dinitrobenzene	99650		*				....
o-Dinitrobenzene	528290						....
p-Dinitrobenzene	100254						....
4,6-Dinitro-o-cresol and salts	534521	Phenol, 2-methyl-4,6-dinitro-	1*	2,4	P047	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Dinitrophenol	25550587		1000	1		A	10 (4.54)
2,5-Dinitrophenol	329715		....				....
2,6-Dinitrophenol	573568		....				....
2,4-Dinitrophenol	51285	Phenol, 2,4-dinitro-	1000	1,2,4	P048	A	10 (4.54)
Dinitrotoluene	25321146		1000	1,2		A	10 (4.54)
3,4-Dinitrotoluene	610399						
2,4-Dinitrotoluene	121142	Benzene, 1-methyl-2,4-dinitro-	1000	1,2,4	U105	A	10 (4.54)
2,6-Dinitrotoluene	606202	Benzene, 2-methyl-1,3-dinitro-	1000	1,2,4	U106	B	100 (45.4)
Dinoseb	88857	Phenol, 2-(1-methylpropyl)-4,6-dinitro	1*	4	P020	C	1000 (454)
Di-n-octyl phthalate	117840	1,2-Benzenedicarboxylic acid, dioctyl ester	1*	2,4	U107	D	5000 (2270)
1,4-Dioxane	123911	1,4-Diethylenedioxide	1*	4	U108	B	100 (45.4)
DIPHENYLHYDRAZINE	N/A		1*	2			**
1,2-Diphenylhydrazine	122667	Hydrazine, 1,2-diphenyl	1*	2,4	U109	A	10 (4.54)
Diphosphoramide, octamethyl-	152169	Octamethylpyrophosphoramide	1*	4	P085	B	100 (45.4)
Diphosphoric acid, tetraethyl ester	107493	Tetraethyl pyrophosphate	100	1,4	P111	A	10 (4.54)
Dipropylamine	142847	1-Propanamine, N-propyl-	1*	4	U110	D	5000 (2270)
Di-n-propylnitrosamine	621647	1-Propanamine, N-nitroso-N-propyl-	1*	2,4	U111	A	10 (4.54)
Diquat	85007		1000	1		C	1000 (454)
	2764729						
Disulfoton	298044	Phosphorodithioic acid, o,o-diethyl S-[2-(ethylthio)ethyl]ester	1	1,4	P039	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Dithiobiuret	541537	Thiomidodicarbonic diamide [(H2N) C(S)]2NH	1*	4	P049	B	100 (45.4)
Diuron	330541		100	1		B	100 (45.4)
Dodecylbenzenesulfonic acid	27176870		1000	1		C	1000 (454)
Endosulfan	115297	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide	1	1,2,4	P050	X	1 (0.454)
alpha - Endosulfan	959988		1*	2		X	1 (0.454)
beta - Endosulfan	33213659		1*	2		X	1 (0.454)
ENDOSALFAN AND METABOLITES	N/A		1*	2			**
Endosulfan sulfate	1031078		1*	2		X	1 (0.454)
Endothall	145733	7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid	1*	4	P088	C	1000 (454)
Endrin	72208	Endrin, & metabolites 2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9 -hexachloro-1a,2,2a,3, 6,6a,7,7a-octa-hydro-, (1 aalpha, 2beta, 2abeta,3alpha,6alpha, 6abeta,7beta, 7aalpha)-	1	1,2,4	P051	X	1 (0.454)
Endrin aldehyde	7421934		1*	2		X	1 (0.454)
ENDRIN AND METABOLITES	N/A		1*	2			**
Endrin, & metablites	72208	Endrin 2,7:3,6-Dimethanonephth [2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3, 6,6a,7,7a-octa-hydro-, (1 aalpha, 2beta, 2abeta,3alpha,6alpha,........................ 6abeta,7beta, 7aalpha)-	1	1,2,4	P051	X	1 (0.454)
Epichlorohydrin	106898	Oxirane, (chloromethyl)-	1000	1,4	U041	B	100 (45.4)

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Epinephrine	51434	1,2-Benzenediol,4-[1-hydroxy-2-(methylamino)ethyl]-	1*	4	P042	C	1000 (454)
Ethanal	75070	Acetaldehyde	1000	1,4	U001	C	1000 (454)
Ethanamine, N-ethyl-N-nitroso-	55185	N-Nitrosodiethylamine	1*	4	U174	X	1 (0.454)
1,2-Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienylmethyl)-	91805	Methapyrilene	1*	4	U155	D	5000 (2270)
Ethane, 1,2-dibromo-	106934	Ethylene dibromide	1000	1,4	U067	X	1 (0.454)
Ethane, 1,1-dichloro-	75343	Ethylidene dichloride 1,1-Dichloroethane	1*	2,4	U076	C	1000 (454)
Ethane, 1,2-dichloro-	107062	Ethylene dichloride 1,2-Dichloroethane	5000	1,2,4	U077	B	100 (45.4)
Ethanedinitrile	460195	Cyanogen	1*	4	P031	B	100 (45.4)
Ethane, hexachloro-	67721	Hexachloroethane	1*	2,4	U131	B	100 (45.4)
Ethane, 1,1'-[methylenebis(oxy)]bis(2-chloro-	111911	Bis(2-chloroethoxy) methane Dichloromethoxy ethane	1*	2,4	U024	C	1000 (454)
Ethane, 1,1'-oxybis-	60297	Ethyl ether	1*	4	U117	B	100 (45.4)
Ethane, 1,1'-oxybis[2-chloro-	111444	Bis (2-chloroethyl) ether Dichloroethyl ether	1*	2,4	U025	A	10 (4.54)
Ethane, pentachloro-	76017	Pentachloroethane	1*	4	U184	A	10 (4.54)
Ethane, 1,1,1,2-tetrachloro	630206	1,1,1,2-Tetrachloroethane	1*	4	U208	B	100 (45.4)
Ethane, 1,1,2,2-tetrachloro	79345	1,1,2,2-Tetrachloroethane	1*	2,4	U209	B	100 (45.4)
Ethanethioamide	62555	Thioacetamide	1*	4	U218	A	10 (4.54)
Ethane, 1,1,1-trichloro	71556	Methyl chloroform 1,1,1-Trichloroethane	1*	2,4	U226	C	1000 (454)
Ethane, 1,1,2-trichloro-	79005	1,1,2-Trichloroethane	1*	2,4	U227	B	100 (45.4)

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Ethanimidothioic acid, N-[[(methyl-amino) carbonyl]oxy]-, methyl ester	16752775	Methomyl	1*	4	P066	B	100 (45.4)
Ethanol, 2-ethoxy-	110805	Ethylene glycol monoethyl ether	1*	4	U359	C	1000 (454)
Ethanol, 2,2'-(nitrosoimino)bis-	1116547	N-Nitrosodiethanolamine	1*	4	U173	X	1 (0.454)
Ethanone, 1-phenyl-	98862	Acetophenone	1*	4	U004	D	5000 (2270)
Ethene, chloro-	75014	Vinyl chloride	1*	2,3,4	U043	X	1 (0.454)
Ethene, 2-Cloroethoxy-	110758	2-Chloroethyl vinyl ether	1*	2,4	U042	C	1000 (454)
Ethene, 1,1-dichloro-	75354	Vinylidene chloride 1,1-Dichloroethylene	5000	1,2,4	U078	B	100 (45.4)
Ethene, 1,2-dichloro-	156605	1,2-Dichloroethylene	1*	2,4	U079	C	1000 (45.4)
Ethene, tetrachloro-	127184	Perchloroethylene Tetrachlorethene Tetrachloroethylene	1*	2,4	U210	B	100 (45.4)
Ethene, trichloro-	79016	Trichloroethene Trichloroethylene	1000	1,2,4	U228	B	100 (45.4)
Ethion	563122		10	1		A	10 (4.54)
Ethyl acetate	141786	Acetic acid, ethyl ester	1*	4	U112	D	5000 (2270)
Ethyl acrylate	140885	2-Propenoic acid, ethyl ester	1*	4	U113	C	1000 (454)
Ethylbenzene	100414		1000	1,2		C	1000 (454)
Ethyl carbamate (urethane)	51796	Carbamic acid, ethyl ester	1*	4	U238	B	100 (45.4)
Ethyl cyanide	107120	Propanenitril	1*	4	P101	A	10 (4.54)
Ethylenebisdithiocarbamic acid, salts & esters	111546	Carbamodithioic acid, 1,2-ethanediylbis, salts & esters	1*	4	U114	D	5000 (2270)
Ethylenediamine	107153		1000	1		D	5000 (2270)
Ethylenediamine-tetraacetic acid (EDTA)	60004		5000	1		D	5000 (2270)

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Ethylene dibromide	106934	Ethane, 1,2-dibromo-	1000	1,4	U067	X	1 (0.454)
Ethylene dichloride	107062	Ethane, 1,2-dichloro- 1,2-Dichloroethane	5000	1,2,4	U077	B	100 (45.4)
Ethylene glycol monoethy ether	110805	Ethanol, 2-ethoxy-	1*	4	U359	C	1000 (454)
Ethylene oxide	75218	Oxirane	1*	4	U115	A	10 (4.54)
Ethylenethiourea	96457	2-Imidazolidinethione	1*	4	U116	A	10 (4.54)
Ethylenimine	151564	Aziridine	1*	4	P054	X	1 (0.454)
Ethyl ether	60297	Ethane, 1,1'-oxybis	1*	4	U117	B	100 (45.4)
Ethylidene dichloride	75343	Ethane, 1,1'-dichloro- 1,1-Dichloroethane	1*	2,4	U076	C	1000 (454)
Ethyl methacrylate	97632	2-Propenoic acid, 2-methyl-, ethyl ester	1*	4	U118	C	1000 (454)
Ethyl methanesulfonate	62500	Methanesulfonic acid, ethyl ester	1*	4	U119	X	1 (0.454)
Famphur	52857	Phosphorothioic acid, O,[4-[(di- methylamino) sulfonyl] phenyl] O,O-dimethyl ester	1*	4	P097	C	1000 (454)
Ferric ammonium citrate	1185575		1000	1		C	1000 (454)
Ferric ammonium oxalate	2944674		1000	1		C	1000 (454)
	55488874						
Ferric chloride	7705080		1000	1		C	1000 (454)
Ferric flouride	7783508		100	1		B	100 (45.4)
Ferric nitrate	10421484		1000	1		C	1000 (454)
Ferric sulfate	10028225		1000	1		C	1000 (454)
Ferrous ammonium sulfate	10045893		1000	1		C	1000 (454)
Ferrous chloride	7758943		100	1		B	100 (45.4)
Ferrous sulfate	7720787		1000	1		C	1000 (454)

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	7782630						
Flouranthene	206440	Benzo[j,k]flourene	1*	2,4	U120	B	100 (45.4)
Flourene	86737		1*	2		D	5000 (2270)
Flourine	7782414		1*	4	P056	A	10 (4.54)
Flouroacetamide	640197	Acetamide, 2-fluoro-	1*	4	P057	B	100 (45.4)
Flouracetic acid, sodium salt	62748	Acetic acid, fluoro-, sodium salt	1*	4	P058	A	10 (4.54)
Formaldehyde	50000		1000	1,4	U122	B	100 (45.4)
Formic acid	64186		5000	1,4	U123	D	5000 (2270)
Fulminic acid, mercury(2+)salt	628864	Mercury fulminate	1*	4	P065	A	10 (4.54)
Fumaric acid	110178		5000	1		D	5000 (2270)
Furan	110009	Furfuran	1*	4	U124	B	100 (45.4)
Furan, tetrahydro-	109999	Tetrahydrofuran	1*	4	U213	C	1000 (454)
2-Furancarboxaldehyde	98011	Furfural	1000	1,4	U125	D	5000 (2270)
2,5-Furandione	108316	Maleic anhydride	5000	1,4	U147	D	5000 (2270)
Furfural	98011	2-Furancarboxaldehyde	1000	1,4	U125	D	5000 (2270)
Furfuran	110009	Furan	1*	4	U124	B	100 (45.4)
Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)-	18883664	D-Glucose, 2-deoxy-2-[[(methylnitrosoamino)-carbonyl]amino] Streptozotocin	1*	4	U206	X	1 (0.454)
D-Glucose, 2-deoxy-2-[[(methylnitrosoamino)-carbonyl]amino]-	18883664	Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)-	1*	4	U206	X	1 (0.45)
Glycidylaldehyde	765344	Oxiranecarboxyaldehyde	1*	4	U126	A	10 (4.54)
Guanidien, N-methyl-N'-nitro-N-nitroso-	70257	MNNG	1*	4	U163	A	10 (4.54)
Guthion	86500		1	1		X	1 (0.454)

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HALOETHERS	N/A		1*	2			**
HALOMETHANES	N/A		1*	2			**
Heptachlor	76448	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-	1	1,2,4	P059	X	1 (0.454)
HEPTACHLOR AND METABOLITES	N/A		1*	2			**
Heptachlor epoxide	1024573		1*	2		X	1 (0.454)
Hexachlorobenzene	118741	Benzene, hexachloro-	1*	2,4	U127	A	10 (4.54)
Hexachlorobutadiene	87683	1,3-Butadiene, 1,1,2,3,4,5-hexachloro-	1*	2,4	U128	X	1 (0.454)
HEXACHLOROCYCLOHEXANE (all isomers)	608731		1*	2			**
Hexachlorocyclohexane (gammer isomer)	58899	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha,5alpha,6beta)- gamma-BHC Lindane	1	1,2,4	U129	X	1 (0.454)
Hexachlorocyclopentadiene	77474	1,3-Cyclopentadiene,1,2,3,4,5,5-hexachloro-	1	1,2,4	U130	A	10 (4.54)
Hexachloroethane	67721	Ethane, hexachloro-	1*	2,4	U131	B	100 (45.4)
Hexachlorophene	70304	Phenol, 2,2'-methylenebis[3,4,6-trichloro-	1*	4	U132	B	100 (45.4)
Hexachloropropene	1888717	1-Propene, 1,1,2,3,3,3-hexachloro-	1*	4	U243	C	1000 (454)
Hexaethyl tetraphosphate	757584	Tetraphosphoric acid, hexaethyl ester	1*	4	P062	B	100 (45.4)
Hydrazine	302012		1*	4	U133	X	1 (0.454)
Hydrazine, 1,2-diethyl-	1615801	N,N'-Diethylhydrazine	1*	4	U086	A	10 (4.54)
Hydrazine, 1,1-dimethyl-	57147	1,1-Dimethylhydrazine	1*	4	U098	A	10 (4.54)
Hydrazine, 1,2-dimethyl-	540738	1,2-Dimethylhydrazine	1*	4	U099	X	1 (0.454)
Hydrazine, 1,2-diphenyl-	122667	1,2-Diphenylhydrazine	1*	2,4	U109	A	10 (4.54)
Hydrazine, methyl-	60344	Methyl hydrazine	1*	4	P068	A	10 (4.54)

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Hydrazinecarbothioamide	79196	Thiosemicarbazide	1*	4	P116	B	100 (45.4)
Hydrochloric acid	7647010	Hydrogen chloride	5000	1		D	5000 (2270)
Hydrocyanic acid	74908	Hydrogen cyanide	10	1,4	P063	A	10 (4.54)
Hydrofluoric acid	7664393	Hydrogen flouride	5000	1,4	U134	B	100 (45.4)
Hydrogen chloride	7647010	Hydrochloric acid	5000	1		D	5000 (2270)
Hydrogen cyanide	74908	Hydrocyanic acid	10	1,4	P063	A	10 (4.54)
Hydrogen fluoride	7664393	Hydrofluoric acid	5000	1,4	U134	B	100 (45.4)
Hydrogen sulfide	7783064	Hydrogen sulfide H2S	100	1,4	U135	B	100 (45.4)
Hydrogen sulfide H2S	7783064	Hydrogen sulfide	100	1,4	U135	B	100 (45.4)
Hydroperoxide, 1-methyl-1-phenylethyl-	80159	alpha,alpha-Dimethylbenzylhydroperoxide	1*	4	U096	A	10 (4.54)
2-Imidazolidinethione	96457	Ethylenethiourea	1*	4	U116	A	10 (4.54)
Indeno(1,2,3-cd)pyrene	193395	1,10-(1,2-Phenylene)pyrene	1*	2,4	U137	B	100 (45.4)
1,3-Isobenzofurandione	85449	Phthalic anhydride	1*	4	U190	D	5000 (2270)
Isobutyl alcohol	78831	1-Propanol, 2-methyl-	1*	4	U140	D	5000 (2270)
Isodrin	465736	1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro, (1alpha,4alpha,4abeta,5beta, 8beta, 8abeta)-	1*	4	P060	X	1 (0.454)
Isophorone	78591		1*	2		D	5000 (2270)
Isophrene	78795		1000	1		B	100 (45.4)
Isopropanolamine dodecylbenzenesulfonate	42504461		1000	1		C	1000 (454)

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Isosafrole	120581	1,3-Benzodioxole,5-(1-propenyl)-	1*	4	U141	B	100 (45.4)
3(2H)-Isoxazolone, 5-(aminomethyl)-	2763964	Muscimol 5-(Aminomethyl)-3-isoxazolol	1*	4	P007	C	1000 (454)
Kepone	143500	1,2,4-Metheno-2H-cyclobuta[cd]pentalen-2-one,1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-	1	1,4	U142	X	1 (0.454)
Lasiocarpine	303344	2-Butenoic acid, 2-methyl-, 7[[2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy]methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-1-yl ester, [1S-[1alpha(Z), 7(2S*,3R*),7aalpha]]-	1*	4	U143	A	10 (4.54)
Lead††	7439921		1*	2			#
Lead acetate	301042	Acetic acid, lead(2+) salt	5000	1,4	U144		#
LEAD AND COMPOUNDS	N/A		1*	2			**
Lead arsenate	7784409		5000	1		X	1 (0.454)
	7645252						
	10102484						
Lead, bis(acetato-O)tetrahydroxytri	1335326	Lead subacetate	1*	4	U146	B	100 (45.4)
Lead chloride	7758954		5000	1		B	100 (45.4)
Lead fluoborate	13814965		5000	1		B	100 (45.4)
Lead fluoride	7783462		1000	1		B	100 (45.4)
Lead iodide	10101630		5000	1		B	100 (45.4)
Lead nitrate	10099748		5000	1		B	100 (45.4)
Lead phosphate	7446277	Phosphoric acid, lead(2+) salt (2:3)	1*	4	U145		#
Lead stearate	7428480		5000	1		D	5000 # (2270)

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	1072351						
	52652592						
	56189094						
Lead subacetate	1335326	Lead, bis(acetato-O)tetrahydroxytri	1*	4	U146	B	100 (45.4)
Lead sulfate	15739807		5000	1		B	100 (45.4)
	7446142						
Lead sulfide	1314870		5000	1		D	5000 # (2270)
Lead thiocyanate	592870		5000	1		B	100 (45.4)
Lindane	58899	Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha,5alpha, 6beta)-gamma-BHC Hexachlorocyclohexane (gamma isomer)	1	1,2,4	U129	X	1 (0.454)
Lithium Chromate	14307358		1000	1		A	10 (4.54)
Malathion	121755		10	1		B	100 (45.4)
Maleic acid	110167		5000	1		D	5000 (2270)
Maleic anhydride	108316	2,5-Furandione	5000	1,4	U147	D	5000 (2270)
Maleic hydrazide	123331	3,6-Pyridazinedione, 1,2-dihydro-	1*	4	U148	D	5000 (2270)
Malononitrile	109773	Propanedinitrile	1*	4	U149	C	1000 (454)
Melphalan	148823	L-Phenylalanine, 4-[bis(2-chloroethyl) amino]]	1*	4	U150	X	1 (0.454)
Mercaptodimethur	2032657		100	1		A	10 (4.54)
Mercuric cyanide	592041		1	1		X	1 (0.454)
Mercuric nitrate	10045940		10	1		A	10 (4.54)

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Mercuric sulfate	7783359		10	1		A	10 (4.54)
Mercuric thiocyanate	592858		10	1		A	10 (4.54)
Mercurous nitrate	10415755		10	1		A	10 (4.54)
	7782867						
Mercury	7439976		1*	2,3,4	U151	X	1 (0.454)
MERCURY AND COMPOUNDS	N/A		1*	2			**
Mercury, (acetate-O)phenyl	62384	Phenylmercury acetate	1*	4	P092	B	100 (45.4)
Mercury fulminate	628864	Fulminic acid, mercury(2+)salt	1*	4	P065	A	10 (4.54)
Methacrylonitrile	126987	2-Propenenitrile,2-methyl-	1*	4	U152	C	1000 (454)
Methanamine, N-methyl-	124403	Dimethylamine	1000	1,4	U092	C	1000 (454)
Methanamine, N-methyl-N-nitroso-	62759	N-Nitrosodimethylamine	1*	2,4	P082	A	10 (4.54)
Methane, bromo-	74839	Methyl bromide	1*	2,4	U029	C	1000 (454)
Methane, chloro-	74873	Methyl chloride	1*	2,4	U045	B	100 (45.4)
Methane, chloromethoxy-	107302	Chloromethyl methyl ether	1*	4	U046	A	10 (4.54)
Methane, dibromo-	74953	Methylene bromide	1*	4	U068	C	1000 (454)
Methane, dichloro-	75092	Methylene chloride	1*	2,4	U080	C	1000 (454)
Methane, dichlorodifluoro-	75718	Dichlorodifluoromethane	1*	4	U075	D	5000 (2270)
Methane, iodo-	74884	Methyl iodide	1*	4	U138	B	100 (45.4)
Methane, isocyanato-	624839	Methyl isocyanate	1*	4	P064		##
Methane, oxybis(chloro-	542881	Dichloromethyl ether	1*	4	P016	A	10 (4.54)
Methanesulfenyl chloride, trichloro-	594423	Trichloromethanesulfenyl chloride	1*	4	P118	B	100 (45.4)
Methanesulfonic acid, ethyl ester	62500	Ethyl methanesulfonate	1*	4	U119	X	1 (0.454)
Methane, tetrachloro-	56235	Carbon tetrachloride	5000	1,2,4	U211	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
Methane, tetranitro	509148	Tetranitromethane	1*	4	P112	A	10 (4.54)
Methane, tribromo-	75252	Bromoform	1*	2,4	U225	B	100 (45.4)
Methane, trichloro-	67663	Chloroform	5000	1,2,4	U044	A	10 (4.54)
Methane, trichlorofluoro	75694	Trichloromonofluoromethane	1*	4	U121	D	5000 (2270)
Methanethiol	74931	Methylmercaptan Thiomethanol	100	1,4	U153	B	100 (45.4)
6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6, 9,9a- hexahydro-, 3-oxide	115297	Endosulfan	1	1,2,4	P050	X	1 (0.454)
1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-	143500	Kepone	1	1,4	U142	X	1 (0.454)
4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-	76448	Heptachlor	1	1,2,4	P059	X	1 (0.454)
4,7-Methano-1H-indene, 1,2,3,4,5,6,8,8-octachloro-2,3,3a,4,5,5a-hexahydro-	57749	Chlordane Chlordane, alpha & gamma isomers Chlordane, technical	1	1,2,4	U036	X	1 (0.454)
Methanol	67561	Methyl alcohol	1*	4	U154	D	5000 (2270)
Methapyrilene	91805	1,2-Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienylmethyl)-	1*	4	U155	D	5000 (2270)
Methomyl	16752775	Ethanimidothioic acid, N-[[(methyl-amino)carbonyl]oxy]-, methyl ester	1*	4	P066	B	100 (45.4)
Methoxychlor	72435	Benzene, 1,1'-(2,2,2-trichloroethylidene) bis[4-methoxy-	1	1,4	U247	X	1 (0.454)
Methyl alchohol	67561	Methanol	1*	4	U154	D	5000 (2270)
Methyl bromide	74839	Methane, bromo-	1*	2,4	U029	C	1000 (454)
1-Methylbutadiene	504609	1,3-Pentadiene	1*	4	U186	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
Methyl chloride	74873	Methane, chloro-	1*	2,4	U045	B	100 (45.4)
Methyl chlorocarbonate	79221	Carbonochloridic acid, methyl ester Methyl chloroformate	1*	4	U156	C	1000 (454)
Methyl chloroform	71556	Ethane, 1,1,1-trichloro- 1,1,1-Trichloroethane	1*	2,4	U226	C	1000 (454)
Methyl chloroformate	79221	Carbonochloridic acid, methyl ester Methyl chlorocarbonate	1*	4	U156	C	1000 (454)
3-Methylcholanthrene	56495	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	1*	4	U157	A	10 (4.54)
4,4'-Methylenebis(2-chloroaniline)	101144	Benzenamine, 4,4'-methylenebis(2-chloro-	1*	4	U158	A	10 (4.54)
Methylene bromide	74953	Methane, dibromo-	1*	4	U068	C	1000 (454)
Methylene chloride	75092	Methane, dichloro-	1*	2,4	U080	C	1000 (454)
Methyl ethyl ketone (MEK)	78933	2-Butanone	1*	4	U159	D	5000 (2270)
Methyl ethyl ketone peroxide	1338234	2-Butanone peroxide	1*	4	U160	A	10 (4.54)
Methyl hydrazine	60344	Hydrazine, methyl-	1*	4	P068	A	10 (4.54)
Methyl iodide	74884	Methane, iodo-	1*	4	U138	B	100 (45.4)
Methly isobutyl ketone	108101	4-Methyl-2-pentanone	1*	4	U161	D	5000 (2270)
Methyl isocyanate	624839	Methane, isocyanato-	1*	4	P064		##
2-Methyllactonitrile	75865	Acetone cyanohydrin Propanenitrile, 2-hydroxy-2-methyl-	10	1,4	P069	A	10 (4.54)
Methylmercaptan	74931	Methanethiol Thiomethanol	100	1,4	U153	B	100 (45.4)
Methyl methacrylate	80626	2-Propenoic acid, 2-methyl, methyl ester	5000	1,4	U162	C	1000 (454)
Methyl parathion	298000	Phosphorothioic acid,),)-dimethyl O-(4-nitro-phenyl) ester	100	1,4	P071	B	100 (45.4)
4-Methyl-2-pentanone	108101	Methyl isobutyl ketone	1*	4	U161	D	5000 (2270)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Methylthiouracil	56042	4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-	1*	4	U164	A	10 (4.54)
Mevinphos	7786347		1	1		A	10 (4.54)
Mexacarbate	315184		1000	1		C	1000 (454)
Mitomycin C	50077	Azirino[2',3':3,4]pyrrolo[1,2-a]indole-4,7-dione,6-amino-8-[[(aminocarbonyl)oxy] methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methyl, [1aS-(1aalpha, 8beta, 8aalpha, 8balpha)]-	1*	4	U010	A	10 (4.54)
MNNG	70257	Guanidine, N-methyl-N'-nitro-N-nitroso-	1*	4	U163	A	10 (4.54)
Monoethylamine	75047		1000	1		B	100 (45.4)
Monomethylamine	74895		1000	1		B	100 (45.4)
Multi Source Leachate			1*	4	F039	X	1 (0.454)
Muscimol	2763964	3(2H)-Isoxazolone, 5-(aminomethyl)- 5-(Amino-methyl)-3-isoxazolol	1*	4	P007	C	1000 (454)
Naled	300765		10	1		A	10 (4.54)
5,12-Naphthacenedione, 8-acetyl-10-[3-amino-2,3,6-trideoxy-alpha-L-lyxo-hexopyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy, (8S-cis)-	20830813	Daunomycin	1*	4	U059	A	10 (4.54)
1-Naphthalenamine	134327	alpha-Naphthylamine	1*	4	U167	B	100 (45.4)
2-Naphthalenamine	91598	beta-Naphthylamine	1*	4	U168	A	10 (4.54)
Naphthalenamine,N,N'-bis(2-chloroethyl)-	494031	Chlornaphazine	1*	4	U026	B	100 (45.4)
Naphthalene	91203		5000	1,2,4	U165	B	100 (45.4)
Naphthalene, 2-chloro-	91587	beta-Chloronaphthalene 2-Chloronaphthalene	1*	2,4	U047	D	5000 (2270)
1,4-Naphthalenedione	130154	1,4-Naphthoquinone	1*	4	U166	D	5000 (2270)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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2,7-Naphthalenedisulfonic acid, 3,3'-[(3,3'-dimethyl-(1,1'-byphenyl)-4,4'-diyl)-bis(azo)]bis(5-amino-4-hydroxy)tetrasodium salt	72571	Trypan blue	1*	4	U236	A	10 (4.54)
Naphtenic acid	1338245		100	1		B	100 (45.4)
1,4-Naphthoquinone	130154	1,4-Naphthalenedione	1*	4	U166	D	5000 (2270)
alpha-Naphthylamine	134327	1,-Naphthalenamine	1*	4	U167	B	100 (45.4)
beta-Naphthylamine	91598	2,-Naphthalenamine	1*	4	U168	A	10 (4.54)
alpha-Naphthylthiourea	86884	Thiourea, 1-naphthalenyl-	1*	4	P072	B	100 (45.4)
Nickel††	7440020		1*	2		B	100 (45.4)
Nickel ammonium sulfate	15699180		5000	1		B	100 (45.4)
NICKEL AND COMPOUNDS	N/A		1*	2			**
Nickel carbonyl	13463393	Nickel carbonyl Ni(CO)4, (T-4)-	1*	4	P073	A	10 (4.54)
Nickel carbonyl Ni(CO)4, (T-4)-	13463393	Nickel carbonyl	1*	4	P073	A	10 (4.54)
Nickel chloride	7718549		5000	1		B	100 (45.4)
	37211055						
Nickel cyanide	557197	Nickel cyanide Ni(CN)2	1*	4	P074	A	10 (4.54)
Nickel cyanide Ni(CN)2	557197	Nickel cyanide	1*	4	P074	A	10 (4.54)
Nickel hydroxide	12054487		1000	1		A	10 (4.54)
Nickel nitrate	14216752		5000	1		B	100 (45.4)
Nickel sulfate	7786814		5000	1		B	100 (45.4)
Nicotine, & salts	54115	Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)-	1*	4	P075	B	100 (45.4)
Nitric acid	7697372		1000	1		C	1000 (454)
Nitric acid, thallium (1+) salt	10102451	Thallium (I) nitrate	1*	4	U217	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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Nickel oxide	10102439	Nittrogen oxide NO	1*	4	P076	A	10 (4.54)
p-Nitroaniline	100016	Benzenamine, 4-nitro-	1*	4	P077	D	5000 (2270)
Nitrobenzene	98953	Benzene, nitro-	1000	1,2,4	U169	C	1000 (454)
Nitrogen dioxide	10102440	Nitrogen oxide NO2	1000	1,4	P078	A	10 (4.54)
	10544726						
Nitrogen oxide NO	10102439	Nitric oxide	1*	4	P076	A	10 (4.54)
Nitrogen oxide NO2	10102440	Nitrogen dioxide	1000	1,4	P078	A	10 (4.54)
	10544726						
Nitroglycerine	55630	1,2,3-Propanetriol, trinitrate-	1*	4	P081	A	10 (4.54)
Nitrophenol (mixed)	25154556		1000	1		B	100 (45.4)
m-Nitrophenol	554847					B	100 (45.4)
o-Nitrophenol	88755	2-Nitrophenol					
p-Nitrophenol	100027	Phenol, 4-nitro- 4-Nitrophenol					
o-Nitrophenol	88755	2-Nitrophenol	1000	1,2		B	100 (45.4)
p-Nitrophenol	100027	Phenol, 4-nitro- 4-Nitrophenol	1000	1,2,4	U170	B	100 (45.4)
2-Nitrophenol	88755	o-Nitrophenol	1000	1,2		B	100 (45.4)
4-Nitrophenol	100027	p-Nitrophenol Phenol, 4-nitro-	1000	1,2,4	U170	B	100 (45.4)
NITROPHENOLS	N/A		1*	2			**
2-Nitropropane	79469	Propane, 2-nitro-	1*	4	U171	A	10 (4.54)
NITROSAMINES	N/A		1*	2			**
N-Nitrosodi-n-butylamine	924163	1-Butanamine, N-butyl-N-nitroso-	1*	4	U172	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
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N-Nitrosodiethanolamine	1116547	Ethanol, 2,2'-(nitrosoimino)bis-	1*	4	U173	X	1 (0.454)
N-Nitrosodiethylamine	55185	Ethanamine, N-ethyl-N-nitroso-	1*	4	U174	X	1 (0.454)
N-Nitrosodimethylamine	62759	Methanamine, N-methyl-N-nitroso-	1*	2,4	P082	A	10 (4.54)
N-Nitrosodiphenylamine	86306		1*	2		B	100 (45.4)
N-Nitroso-N-ethylurea	759739	Urea, N-ethyl-N-nitroso-	1*	4	U176	X	1 (0.454)
N-Nitroso-N-methylurea	684935	Urea, N-methyl-N-nitroso	1*	4	U177	X	1 (0.454)
N-Nitroso-N-methylurethane	615532	Carbamic acid, methylnitroso-, ethyl ester	1*	4	U178	X	1 (0.454)
N-Nitrosomethylvinylamine	4549400	Vinylamine, N-methyl-N-nitroso-	1*	4	P084	A	10 (4.54)
N-Nitrosopiperidine	100754	Piperidine, 1-nitroso-	1*	4	U179	A	10 (4.54)
N-Nitrosopyrrolidine	930552	Pyrrolidine, 1-nitroso-	1*	4	U180	X	1 (0.454)
Nitrotoluene	1321126		1000	1		C	1000 (454)
m-Nitrotoluene	99081						
o-Nitrotoluene	88722						
p-Nitrotoluene	99990						
5-Nitro-o-toluidine	99558	Benzenamine, 2-methyl-5-nitro-	1*	4	U181	B	100 (45.4)
Octamethylpyrophosphoramide	152169	Diphosphoramide, octamethyl-	1*	4	P085	B	100 (45.4)
Osmium oxide OsO4 (T-4)-	20816120	Osmium tetroxide	1*	4	P087	C	1000 (454)
Osmium tetroxide	20816120	Osmium oxide OsO4 (T-4)-	1*	4	P087	C	1000 (454)
7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid	145733	Endothall	1*	4	P088	C	1000 (454)
1,2-Oxathiolane, 2,2-dioxide	1120714	1,3-Propane sultone	1*	4	U193	A	10 (4.54)
2H-1,3,2-Oxazaphosphorin-2-amine, N,N-bis(2-chloroethyl)tetrahydro-, 2-oxide	50180	Cyclophosphamide	1*	4	U058	A	10 (4.54)

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Oxirane	75218	Ethylene oxide	1*	4	U115	A	10 (4.54)
Oxiranecarboxyaldehyde	765344	Glycidylaldehyde	1*	4	U126	A	10 (4.54)
Oxirane, (chloromethyl)-	106898	Epichlorohydrin	1000	1,4	U041	B	100 (45.4)
Paraformaldehyde	30525894		1000	1		C	1000 (454)
Paraldehyde	123637	1,3,5-Trioxane, 2,4,6-trimethyl-	1*	4	U182	C	1000 (454)
Parathion	56382	Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester	1	1,4	P089	A	10 (4.54)
Pentachlorobenzene	608935	Benzene, pentachloro-	1*	4	U183	A	10 (4.54)
Pentachloroethane	76017	Ethane, pentachloro-	1*	4	U184	A	10 (4.54)
Pentachloronitrobenzene (PCNB)	82688	Benzene, pentachloronitro-	1*	4	U185	B	100 (45.4)
Pentachlorophenol	87865	Phenol, pentachloro-	10	1,2,4	U242	A	10 (4.54)
1,3-Pentadiene	504609	1-Methylbutadiene	1*	4	U186	B	100 (45.4)
Perchloroethylene	127184	Ethene, tetrachloro- Tetrachloro- ethene Tetrachlor-oethylene	1*	2,4	U210	B	100 (45.4)
Phenacetin	62442	Acetamide, N-(4-ethoxyphenyl)-	1*	4	U187	B	100 (45.4)
Phenanthrene	85018		1*	2		D	5000 (2270)
Phenol	108952	Benzene, hydroxy-	1000	1,2,4	U188	C	1000 (454)
Phenol, 2-chloro-	95578	o-Chlorophenol 2-Chlorophenol	1*	2,4	U048	B	100 (45.4)
Phenol, 4-chloro-3-methyl-	59507	p-Chloro-m-cresol 4-Chloro-m-cresol	1*	2,4	U039	D	5000 (2270)
Phenol, 2-cyclohexyl-4,6-dinitro-	131895	2-Cyclohexyl-4,6-dinitrophenol	1*	4	P034	B	100 (45.4)
Phenol, 2,4-dichloro-	120832	2,4-Dichlorophenol	1*	2,4	U081	B	100 (45.4)
Phenol, 2,6-dichloro	87650	2,6-Dichlorophenol	1*	4	U082	B	100 (45.4)
Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-, (E)	56531	Diethylstilbestrol	1*	4	U089	X	1 (0.454)

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Phenol, 2,4-dimethyl-	105679	2,4-Dimethylphenol	1*	2,4	U101	B	100 (45.4)
Phenol, 2,4-dinitro-	51285	2,4-Dinitrophenol	1000	1,2,4	P048	A	10 (4.54)
Phenol, methyl-	1319773	Cresol(s) Cresylic acid	1000	1,4	U052	C	1000 (454)
m-Cresol	108394	m-Cresylic acid					
o-Cresol	95487	o-Cresylic acid					
p-Cresol	106445	p-Cresylic acid					
Phenol, 2-methyl-4,6-dinitro-	534521	4,6-Dinitro-o-cresol and salts	1*	2,4	P047	A	10 (4.54)
Phenol, 2,2'-methylenebis[3,4,6-trichloro-	70304	Hexachlorophene	1*	4	U132	B	100 (45.4)
Phenol, 2-(1-methylpropyl)-4,6-dinitro	88857	Dinoseb	1*	4	P020	C	1000 (454)
Phenol, 4-nitro-	100027	p-Nitrophenol 4-Nitrophenol	1000	1,2,4	U170	B	100 (45.4)
Phenol, pentachloro-	87865	Pentachlorophenol	10	1,2,4	U242	A	10 (4.54)
Phenol, 2,3,4,6-tetrachloro-	58902	2,3,4,6-Tetrachlorophenol	1*	4	U212	A	10 (4.54)
Phenol, 2,4,5-trichloro-	95954	2,4,5-Trichlorophenol	10	1,4	U230	A	10 (4.54)
Phenol, 2,4,6-trichloro-	88062	2,4,6-Trichlorophenol	10	1,2,4	U231	A	10 (4.54)
Phenol, 2,4,6-trinitro-, ammonium salt	131748	Ammonium picrate	1*	4	P009	A	10 (4.54)
L-Phenylalanine, 4-[bis(2-chloroethyl) amino]]	148823	Melphalan	1*	4	U150	X	1 (0.454)
1,10-(1,2-Phenylene)pyrene	193395	Indeno(1,2,3-cd)pyrene	1*	2,4	U137	B	100 (45.4)
Phenylmercury acetate	62384	Mercury, (acetato-O)phenyl-	1*	4	P092	B	100 (45.4)
Phenylthiourea	103855	Thiourea, phenyl-	1*	4	P093	B	100 (45.4)
Phorate	298022	Phosphorodithioic acid, O,O-diethyl S-(ethylthio), methyl ester	1*	4	P094	A	10 (4.54)
Phosgene	75445	Carbonic dichloride	5000	1,4	P095	A	10 (4.54)

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Phosphine	7803512		1*	4	P096	B	100 (45.4)
Phosphoric acid	7664382		5000	1		D	5000 (2270)
Phosphoric acid, diethyl 4-nitrophenyl ester	311455	Diethyl-p-nitrophenyl phosphate	1*	4	P041	B	100 (45.4)
Phosphoric acid, lead(2+) salt (2:3)	7446277	Lead phosphate	1*	4	U145		#
Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl]ester	298044	Disulfoton	1	1,4	P039	X	1 (0.454)
Phosphorodithioic acid, O,O-diethyl S-(ethylthio), methyl ester	298022	Phorate	1*	4	P094	A	10 (4.54)
Phosphorodithioic acid, O,O-diethyl S-methyl ester	3288582	O,O-Diethyl S-methyl dithiophosphate	1*	4	U087	D	5000 (2270)
Phosphorodithioic acid, O,O-dimethyl S-[2(methylamino)-2-oxoethyl] ester	60515	Dimethoate	1*	4	P044	A	10 (4.54)
Phosphorofluoridic acid, bis(1-methylethyl) ester	55914	Diisopropylfluorophosphate	1*	4	P043	B	100 (45.4)
Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester	56382	Parathion	1	1,4	P089	A	10 (4.54)
Phosphorothioic acid, O,[4-[(dimethylamino) sulfonyl]phenyl]O,O-dimethyl ester	52857	Famphur	1*	4	P097	C	1000 (454)
Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester	298000	Methyl parathion	100	1,4	P071	B	100 (45.4)
Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester	297972	O,O-Diethyl O-pyrazinyl phosphorothioate	1*	4	P040	B	100 (45.4)
Phosphorus	7723140		1	1		X	1 (0.454)
Phosphorus oxycloride	10025873		5000	1		C	1000 (454)
Phosphorus pentasulfide	1314803	Phosphorus sulfide Sulfur phosphide	100	1,4	U189	B	100 (45.4)
Phosphorus sulfide	1314803	Phosphorus pentasulfide Sulfur phosphide	100	1,4	U189	B	100 (45.4)
Phosophorus trichloride	7719122		5000	1		C	1000 (454)

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PHTHALATE ESTERS	N/A		1*	2			**
Phthalic anhydride	85449	1,3-Isobenzofurandione	1*	4	U190	D	5000 (2270)
2-Picoline	109068	Pyridine, 2-methyl-	1*	4	U191	D	5000 (2270)
Piperidine, 1-nitroso-	100754	N-Nitrosopiperidine	1*	4	U179	A	10 (4.54)
Plumbane, tetraethyl-	78002	Tetraethyl lead	100	1,4	P110	A	10 (4.54)
POLYCHLORINATED BIPHENYLS (PCBs)	1336363		10	1,2		X	1 (0.454)
Aroclor 1016	12674112	POLYCHLORINATED BIPHENYLS (PCBs)					
Aroclor 1221	11104282	POLYCHLORINATED BIPHENYLS (PCBs)					
Aroclor 1232	11141165	POLYCHLORINATED BIPHENYLS (PCBs)					
Aroclor 1242	53469219	POLYCHLORINATED BIPHENYLS (PCBs)					
Aroclor 1248	12672296	POLYCHLORINATED BIPHENYLS (PCBs)					
Aroclor 1254	11097691	POLYCHLORINATED BIPHENYLS (PCBs)					
Aroclor 1260	11096825	POLYCHLORINATED BIPHENYLS (PCBs)					
POLYNUCLEAR AROMATIC HYDROCARBONS	N/A		1*	2			**
Potassium arsenate	7784410		1000	1		X	1 (0.454)
Potassium arsenite	10124502		1000	1		X	1 (0.454)
Potassium bichromate	7778509		1000	1		A	10 (4.54)
Potassium chromate	7789006		1000	1		A	10 (4.54)
Potassium cyanide	151508	Potassium cyanide K (CN)	10	1,4	P098	A	10 (4.54)
Potassium cyanide K(CN)	151508	Potassium cyanide	10	1,4	P098	A	10 (4.54)
Potassium hydroxide	1310583		1000	1		C	1000 (454)
Potassium permanganate	7722647		100	1		B	100 (45.4)
Potassium silver cyanide	506616	Argentate (1-), bis(cyano-C)-, potassium	1*	4	P099	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Pronamide	23950585	Benzamide, 3.5-dichloro-N-(1,1-dimethyl-2-propynyl)-	1*	4	U192	D	5000 (2270)
Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime	116063	Aldicarb	1*	4	P070	X	1 (0.454)
1-Propanamine	107108	n-Propylamine	1*	4	U194	D	5000 (2270)
1-Propanamine, N-propyl-	142847	Dipropylamine	1*	4	U110	D	5000 (2270)
1-Propanamine, N-nitroso-N-propyl-	621647	Di-n-propylnitrosamine	1*	2,4	U111	A	10 (4.54)
Propane, 1,2-dibromo-3-chloro-	96128	1,2-Dibromo-3-chloropropane	1*	4	U066	X	1 (0.454)
Propane, 2-nitro-	79469	2-Nitropropane	1*	4	U171	A	10 (4.54)
1,3-Propane sultone	1120714	1,2-Oxathiolane, 2,2-dioxide	1*	4	U193	A	10 (4.54)
Propane, 1,2-dichloro-	78875	Propylene dichloride 1,2-Dichloropropane	5000	1,2,4	U083	C	1000 (454)
Propanedinitrile	109773	Malononitrile	1*	4	U149	C	1000 (454)
Propanenitrile	107120	Ethyl cynide	1*	4	P101	A	10 (4.54)
Propanenitrile, 3-chloro-	542767	3-Chloropropionitrile	1*	4	P027	C	1000 (454)
Propanenitrile, 2-hydroxy-2-methyl-	75865	Acetone cyanohydrin 2-Methyllactonitrile	10	1,4	P069	A	10 (4.54)
Propane, 2,2'-oxybis[2-chloro-	108601	Dichloroisopropyl ether	1*	2,4	U027	C	1000 (454)
1,2,3-Propanetriol, trinitrate-	55630	Nitroglycerine	1*	4	P081	A	10 (4.54)
1-Propanol, 2,3-dibromo-, phosphate (3:1)	126727	Tris(2,3-dibromopropyl) phosphate	1*	4	U235	A	10 (4.54)
1-Propanol, 2-methyl-	78831	Isobutyl alcohol	1*	4	U140	D	5000 (2270)
2-Propanone	67641	Acetone	1*	4	U002	D	5000 (2270)
2-Propanone, 1-bromo-	598312	Bromoacetone	1*	4	P017	C	1000 (454)
Propargite	2312358		10	1		A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Propargyl alcohol	107197	2-Propyn-1-ol	1*	4	P102	C	1000 (454)
2-Propenal	107028	Acrolein	1	1,2,4	P003	X	1 (0.454)
2-Propenamide	79061	Acrylamide	1*	4	U007	D	5000 (2270)
1-Propene, 1,1,2,3,3,3-hexachloro-	1888717	Hexachloropropene	1*	4	U243	C	1000 (454)
1-Propene, 1,3-dichloro-	542756	1,3-Dichloropropene	5000	1,2,4	U084	B	100 (45.4)
2-Propenenitrile	107131	Acrylonitrile	100	1,2,4	U009	B	100 (45.4)
2-Propenenitrile, 2-methyl-	126987	Methacrylonitrile	1*	4	U152	C	1000 (454)
2-Propenoic acid	79107	Acrylic acid	1*	4	U008	D	5000 (2270)
2-Propenoic acid, ethyl ester	140885	Ethyl acrylate	1*	4	U113	C	1000 (454)
2-Propenoic acid, 2-methyl-, ethyl ester	97632	Ethyl methacrylate	1*	4	U118	C	1000 (454)
2-Propenoic acid, 2-methyl-, methyl ester	80626	Methyl methacrylate	5000	1,4	U162	C	1000 (454)
2-Propen-1-ol	107186	Allyl alcohol	100	1,4	P005	B	100 (45.4)
Propionic acid	79094		5000	1		D	5000 (2270)
Propionic acid, 2-(2,4,5-trichlorophenoxy)-	93721	Silvex (2,4,5-TP) 2,4,5-TP acid	100	1,4	U233	B	100 (45.4)
Propionic anhydride	123626		5000	1		D	5000 (2270)
n-Propylamine	107108	1-Propanamine	1*	4	U194	D	5000 (2270)
Propylene dichloride	78875	Propane, 1,2-dichloro- 1,2-Dichloropropane	5000	1,2,4	U083	C	1000 (454)
Propylene oxide	75569		5000	1		B	100 (45.4)
1,2-Propylenimine	75558	Aziridine, 2-methyl-	1*	4	P067	X	1 (0.454)
2-Propyn-1-ol	107197	Propargyl alcohol	1*	4	P102	C	1000 (454)
Pyrene	129000		1*	2		D	5000 (2270)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Pyrethrins	121299		1000	1		X	1 (0.454)
	121211						
	8003347						
3,6-Pyridazinedione, 1,2-dihydro-	123331	Maleic hydrazide	1*	4	U148	D	5000 (2270)
4-Pyridinamine	504245	4-Aminopyridine	1*	4	P008	C	1000 (454)
Pyridine	110861		1*	4	U196	C	1000 (454)
Pyridine, 2-methyl-	109068	2-Picoline	1*	4	U191	D	5000 (2270)
Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)	54115	Nicotine, & salts	1*	4	P075	B	100 (45.4)
2,4-(1H,3H)-Pyrimidinedione, 5-[bis (2-chloroethyl)amino]-	66751	Uracil mustard	1*	4	U237	A	10 (4.54)
4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-	56042	Methylthiouracil	1*	4	U164	A	10 (4.54)
Pyrrolidine, 1-nitroso-	930552	N-Nitrosopyrrolidine	1*	4	U180	X	1 (0.454)
Quinoline	91225		1000	1		D	5000 (2270)
RADIONUCLIDES	N/A		1*	3			§
Reserpine	50555	Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy-, methyl ester (3beta, 16beta, 17alpha, 18beta, 20alpha)-	1*	4	U200	D	5000 (2270)
Resorcinol	108463	1,3-Benzenediol	1000	1,4	U201	D	5000 (2270)
Saccharin and salts	81072	1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide	1*	4	U202	B	100 (45.4)
Safrole	94597	1,3-Benzodioxole, 5-(2-propenyl)-	1*	4	U203	B	100 (45.4)
Selenious acid	7783008		1*	4	U204	A	10 (4.54)
Selenious acid, dithallium (1+) salt	12039520	Thallium selenite	1*	4	P114	C	1000 (454)
Selenium††	7782492		1*	2		B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
SELENIUM AND COMPOUNDS	N/A		1*	2			**
Selenium dioxide	7446084	Selenium oxide	1000	1,4	U204	A	10 (4.54)
Selenium oxide	7446084	Selenium dioxide	1000	1,4	U204	A	10 (4.54)
Selenium sulfide	7488564	Selenium sulfide SeS2	1*	4	U205	A	10 (4.54)
Selenium sulfide SeS2	7488564	Selenium sulfide	1*	4	U205	A	10 (4.54)
Selenourea	630104		1*	4	P103	C	1000 (454)
L-Serine, diazoacetate (ester)	115026	Azaserine	1*	4	U015	X	1 (0.454)
Silver††	7440224		1*	2		C	1000 (454)
SILVER AND COMPOUNDS	N/A		1*	2			**
Silver cyanide	506649	Silver cyanide Ag(CN)	1*	4	P104	X	1 (0.454)
Silver cyanide Ag (CN)	506649	Silver cyanide	1*	4	P104	X	1 (0.454)
Silver nitrate	7761888		1	1		X	1 (0.454)
Silvex (2,4,5-TP)	93721	Propionic acid, 2-(2,4,5-trichlorophenoxy)- 2,4,5-TP acid	100	1,4	U233	B	100 (45.4)
Sodium	7440235		1000	1		A	10 (4.54)
Sodium arsenate	7631892		1000	1		X	1 (0.454)
Sodium arsenite	7784465		1000	1		X	1 (0.454)
Sodium azide	26628228		1*	4	P105	C	1000 (454)
Sodium bichromate	10588019		1000	1		A	10 (4.54)
Sodium bifluoride	1333831		5000	1		B	100 (45.4)
Sodium bisulfite	7631905		5000	1		D	5000 (2270)
Sodium chromate	7775113		1000	1		A	10 (4.54)
Sodium cyanide	143339	Sodium cyanide Na(CN)	10	1,4	P106	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
Sodium cyanide Na (CN)	143339	Sodium cyanide	10	1,4	P106	A	10 (4.54)
Sodium dodecylbenzenesulfonate	25155300		1000	1		C	1000 (454)
Sodium fluoride	7681494		5000	1		C	1000 (454)
Sodium hydrosulfide	16721805		5000	1		D	5000 (2270)
Sodium hydroxide	1310732		1000	1		C	1000 (454)
Sodium hypochlorite	7681529		100	1		B	100 (45.4)
	10022705						
Sodium methylate	124414		1000	1		C	1000 (454)
Sodium nitrite	7632000		100	1		B	100 (45.4)
Sodium phosphate, dibasic	7558794		5000	1		D	5000 (2270)
	10039324						
	10140655						
Sodium phosphate, tribasic	7601549		5000	1		D	5000 (2270)
	7758294						
	7785844						
	10101890						
	10124568						
	10361894						
Sodium selenite	10102188		1000	1		B	100 (45.4)
	7782823						
Streptozotocin	18883664	D-Glucose, 2-deoxy-2-[[(methylnitrosoamino)-carbonyl]amino]- Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)-	1*	4	U206	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Strontium chromate	7789062		1000	1		A	10 (4.54)
Strychnidin-10-one	57249	Strychnine, & salts	10	1,4	P108	A	10 (4.54)
Strychnidin-10-one, 2,3-dimethoxy-	357573	Brucine	1*	4	P018	B	100 (45.4)
Strychnine, & salts	57249	Strychnidin-10-one	10	1,4	P108	A	10 (4.54)
Styrene	100425		1000	1		C	1000 (454)
Sulfur monochloride	12771083		1000	1		C	1000 (454)
Sulfur phosphide	1314803	Phosphorus pentasulfide Phosphorus sulfide	100	1,4	U189	B	100 (45.4)
Sulfuric acid	7664939		1000	1		C	1000 (454)
	8014957						
Sulfuric acid, dithallium (1+) salt	7446186	Thallium (I) sulfate	1000	1,4	P115	B	100 (45.4)
	10031591						
Sulfuric acid, dimethyl ester	77781	Dimethyl sulfate	1*	4	U103	B	100 (45.4)
2,4,5-T acid	93765	Acetic acid, (2,4,5-trichlorophenoxy) 2,4,5-T	100	1,4	U232	C	1000 (454)
2,4,5-T amines	2008460		100	1		D	5000 (2270)
	1319728						
	3813147						
	6369966						
	6369977						
2,4,5-T esters	93798		100	1		C	1000 (454)
	1928478						
	2545597						

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
	25168154						
	61792072						
2,4,5-T salts	13560991		100	1		C	1000 (454)
2,4,5-T	93765	Acetic acid, (2,4,5-trichlorophenoxy) 2,4,5-T acid	100	1,4	U232	C	1000 (454)
TDE	72548	Benzene, 1,1'-(2,2-dichloroethylidene)bis(4-chloro-DDD 4,4' DDD	1	1,2,4	U060	X	1 (0.454)
1,2,4,5-Tetrachlorobenzene	95943	Benzene, 1,2,4,5-tetrachloro-	1*	4	U207	D	5000 (2270)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1746016		1*	2		X	1 (0.454)
1,1,1,2-Tetrachloroethane	630206	Ethane, 1,1,1,2-tetrachloro-	1*	4	U208	B	100 (45.4)
1,1,2,2-Tetrachloroethane	79345	Ethane, 1,1,2,2-tetrachloro-	1*	2,4	U209	B	100 (45.4)
Tetrachloroethene	127184	Ethene, tetrachloro- Perchloroethylene Tetrachloroethylene	1*	2,4	U210	B	100 (45.4)
Tetrachloroethylene	127184	Ethene, tetrachloro- Perchloroethylene Tetrachloroethene	1*	2,4	U210	B	100 (45.4)
2,3,4,6-Tetrachlorophenol	58902	Phenol, 2,3,4,6-tetrachloro-	1*	4	U212	A	10 (4.54)
Tetraethyl lead	78002	Plumbane, tetraethyl-	100	1,4	P110	A	10 (4.54)
Tetraethyl pyrophosphate	107493	Diphosphoric acid, tetraethyl ester	100	1,4	P111	A	10 (4.54)
Tetraethyldithiopyrophosphate	3689245	Thiodiphosphoric acid, tetraethyl ester	1*	4	P109	B	100 (45.4)
Tetrahydrofuran	109999	Furan, tetrahydro-	1*	4	U213	C	1000 (454)
Tetranitromethane	509148	Methane, tetranitro-	1*	4	P112	A	10 (4.54)
Tetraphosphoric acid, hexaethyl ester	757584	Hexaethyl tetraphosphoate	1*	4	P062	B	100 (45.4)
Thallic oxide	1314325	Thallium oxide Tl2O3	1*	4	P113	B	100 (45.4)
Thallium††	7440280		1*	2		C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Thallium and compounds	N/A		1*	2			**
Thallium (I) acetate	563688	Acetic acid, thallium (1+) salt	1*	4	U214	B	100 (45.4)
Thallium (I) carbonate	6533739	Carbonic acid, dithallium (1+) salt	1*	4	U215	B	100 (45.4)
Thallium (I) chloride	7791120	Thallium chloride TlCl	1*	4	U216	B	100 (45.4)
Thallium chloride TlCl	7791120	Thallium (I) chloride	1*	4	U216	B	100 (45.4)
Thallium (I) nitrate	10102451	Nitric acid, thallium (1+) salt	1*	4	U217	B	100 (45.4)
Thallium oxide Tl2O3	1314325	Thallic oxide	1*	4	P113	B	100 (45.4)
Thallium selenite	12039520	Selenious acid, dithallium (1+) salt	1*	4	P114	C	1000 (454)
Thallium (I) sulfate	7446186	Sulfuric acid, dithallium (1+) salt	1000	1,4	P115	B	100 (45.4)
	10031591						
Thioacetamide	62555	Ethanethioamide	1*	4	U218	A	10 (4.54)
Thiodiphosphoric acid, tetraethyl ester	3689245	Tetraethyldithiopyrophosphate	1*	4	P109	B	100 (45.4)
Thiofanox	39196184	2-Butanone, 3,3-dimethyl-1-(methylthio)-, O[(methylamino) carbonyl] oxime	1*	4	P045	B	100 (45.4)
Thioimidodicarbonic diamide [(H2N)C(S)] 2NH	541537	Dithiobiuret	1*	4	P049	B	100 (45.4)
Thiomethanol	74931	Methanethiol Methylmercaptan	100	1,4	U153	B	100 (45.4)
Thioperoxydicarbonic diamide [(H2N)C(S)] 2S2, tetramethyl-	137268	Thiram	1*	4	U244	A	10 (4.54)
Thiophenol	108985	Benzenethiol	1*	4	P014	B	100 (45.4)
Thiosemicarbazide	79196	Hydrazinecarbothioamide	1*	4	P116	B	100 (45.4)
Thiourea	62566		1*	4	U219	A	10 (4.54)
Thiourea, (2-chlorophenyl)-	5344821	1-(o-Chlorophenyl)thiourea	1*	4	P026	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Thiourea, 1-naphthalenyl-	86884	alpha-Naphthylthiourea	1*	4	P072	B	100 (45.4)
Thiourea, phenyl-	103855	Phenylthiourea	1*	4	P093	B	100 (45.4)
Thiram	137268	Thioperoxydicarbonic diamide [(H2N)C(S)] 2S2, tetramethyl-	1*	4	U244	A	10 (4.54)
Toluene	108883	Benzene, methyl-	1000	1,2,4	U220	C	1000 (454)
Toluenediamine	95807	Benzenediamine, ar-methyl-	1*	4	U221	A	10 (4.54)
	496720						
	823405						
	25376458						
Toluene diisocyanate	584849	Benzene, 1,3-diisocyanatomethyl-	1*	4	U223	B	100 (45.4)
	91087						
	26471625						
o-Toluidine	95534	Benzenamine, 2-methyl-	1*	4	U328	B	100 (45.4)
p-Toluidine	106490	Benzenamine, 4-methyl-	1*	4	U353	B	100 (45.4)
o-Toluidine hydrochloride	636215	Benzenamine, 2-methyl-, hydrochloride	1*	4	U222	B	100 (45.4)
Toxaphene	8001352	Camphene, octachloro-	1*	1,2,4	P123	X	1 (0.454)
2,4,5-TP acid	93721	Propionic acid 2-(2,4,5-trichlorophenoxy)- Silvex (2,4,5-TP)	100	1,4	U233	B	100 (45.4)
2,4,5-TP esters	32534955		100	1		B	100 (45.4)
1H-1,2,4-Triazol-3-amine	61825	Amitrole	1*	4	U011	A	10 (4.54)
Trichlorfon	52686		1000	1		B	100 (45.4)
1,2,4-Trichlorobenzene	120821		1*	2		B	100 (45.4)
1,1,1-Trichloroethane	71556	Ethane, 1,1,1-trichloro- Methyl chloroform	1*	2,4	U226	C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
1,1,2-Trichloroethane	79005	Ethane, 1,1,2-trichloro-	1*	2,4	U227	B	100 (45.4)
Trichloroethene	79016	Ethene, trichloro- Trichloroethylene	1000	1,2,4	U228	B	100 (45.4)
Trichloroethylene	79016	Ethene, trichloro- Trichloroethene	1000	1,2,4	U228	B	100 (45.4)
Trichloromethanesulfenyl chloride	594423	Methanesulfenyl chloride, trichloro-	1*	4	P118	B	100 (45.4)
Trichloromonofluoromethane	75694	Methane, trichlorofluoro-	1*	4	U121	D	5000 (2270)
Trichlorophenol	25167822		10	1		A	10 (4.54)
2,3,4-Trichlorophenol	15950660						
2,3,5-Trichlorophenol	933788						
2,3,6-Trichlorophenol	933755						
2,4,5-Trichlorophenol	95954	Phenol, 2,4,5-trichloro-	10*	1,4	U230	A	10 (4.54)
2,4,6-Trichlorophenol	88062	Phenol, 2,4,6-trichloro-	10*	1,2,4	U231	A	10 (4.54)
3,4,5-Trichlorophenol	609198						
2,4,5-Trichlorophenol	95954	Phenol, 2,4,5-trichloro-	10*	1,4	U230	A	10 (4.54)
2,4,6-Trichlorophenol	88062	Phenol, 2,4,6-trichloro-	10	1,2,4	U231	A	10 (4.54)
Triethanolamine dodecylbenzenesulfonate	27323417		1000	1		C	1000 (454)
Triethylamine	121448		5000	1		D	5000 (2270)
Trimethylamine	75503		1000	1		B	100 (45.4)
1,3,5-Trinitrobenzene	99354	Benzene, 1,3,5-trinitro-	1*	4	U234	A	10 (4.54)
1,3,5-Trioxane, 2,4,6-trimethyl-	123637	Paraldehyde	1*	4	U182	C	1000 (454)
Tris(2,3-dibromopropyl) phosphate	126727	1-Propanol, 2,3-dibromo-, phosphate [(3:1)	1*	4	U235	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Trypan blue	72571	2,7-Naphthalenedisulfonic acid, 3,3'-3,3'-dimethyl-(1,1'-biphenyl)-4,4'-diyl)-bis(azo)]bis(5-amino-4-hydroxy)-tetrasodium salt	1*	4	U236	A	10 (4.54)
Unlisted Hazardous Wastes Characteristic of Corrosivity	N/A		1*	4	D002	B	100 (45.4)
Unlisted Hazardous Wastes Characteristics: Characteristic of Toxicity:	N/A		1‡	4			
Arsenic (D004)	N/A		*1	4	D004	X	1 (0.454)
Barium (D005)	N/A		*1	4	D005	C	1000 (454)
Benzene (D018)	N/A		1000	1,2,3,4	D018	A	10 (4.54)
Cadmium (D006)	N/A		*1	4	D006	A	10 (4.54)
Carbon tetrachloride (D019)	N/A		5000	1,2,4	D019	A	10 (4.54)
Chlordane (D020)	N/A		1	1,2,4	D020	X	1 (0.454)
Chlorobenzene (D021)	N/A		100	1,2,4	D021	B	100 (45.4)
Chloroform (D022)	N/A		5000	1,2,4	D022	A	10 (4.54)
Chromium (D007)	N/A		*1	4	D007	A	10 (4.54)
o-Cresol (D023)	N/A		1000	1,4	D023	C	1000 (454)
m-Cresol (D024)	N/A		1000	1,4	D024	C	1000 (454)
p-Cresol (D025)	N/A		1000	1,4	D025	C	1000 (454)
Cresol (D026)	N/A		1000	1,4	D026	C	1000 (454)
2,4-D (D016)	N/A		100	1,4	D016	B	100 (45.4)
1,4-Dichlorobenzene (D027)	N/A		100	1,2,4	D027	B	100 (45.4)
1,2-Dichloroethane (D028)	N/A		5000	1,2,4	D028	B	100 (45.4)
1,1-Dichloroethylene (D029)	N/A		5000	1,2,4	D029	B	100 (45.4)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
2,4-Dinitrotoluene (D030)	N/A		1000	1,2,4	D030	A	10 (4.54)
Endrin (D012)	N/A		1	1,4	D012	X	1 (0.454)
Heptachlor (and epoxide) (D031)	N/A		1	1,2,4	D031	X	1 (0.454)
Hexachlorobenzene (D032)	N/A		*1	2,4	D032	A	10 (4.54)
Hexachlorobutadiene (D033)	N/A		*1	2,4	D033	X	1 (0.454)
Hexachloroethane (D034)	N/A		*1	2,4	D034	B	100 (45.4)
Lead (D008)	N/A		*1	4	D008		(#)
Lindane (D013)	N/A		1	1,4	D013	X	1 (0.454)
Mercury (D009)	N/A		*1	4	D009	X	1 (0.454)
Methoxychlor (D014)	N/A		1	1,4	D014	X	1 (0.454)
Methyl ethyl ketone (D035)	N/A		*1	4	D035	D	5000 (2270)
Nitrobenzene (D036)	N/A		1000	1,2,4	D036	C	1000 (454)
Pentachlorophenol (D037)	N/A		10	1,2,4	D037	A	10 (4.54)
Pyridine (D038)	N/A		*1	4	D038	C	1000 (454)
Selenium (D010)	N/A		*1	4	D010	A	10 (4.54)
Silver (D011)	N/A		*1	4	D011	X	1 (0.454)
Teterachloroethylene (D039)	N/A		*1	2,4	D039	B	100 (45.4)
Toxaphene (D015)	N/A		1	1,4	D015	X	1 (0.454)
Trichloroethylene (D040)	N/A		1000	1,2,4	D040	B	100 (45.4)
2,4,5-Trichlorophenol (D041)	N/A		10	1,4	D041	A	10 (4.54)
2,4,6-Trichlorophenol (D042)	N/A		10	1,2,4	D042	A	10 (4.54)
2,4,5-TP (D017)	N/A		100	1,4	D017	B	100 (45.4)
Vinyl chloride (D043)	N/A		*1	2,3,4	D043	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Unlisted Hazardous Wastes Characteristic of Ignitability	N/A		1*	4	D001	B	100 (45.4)
Unlisted Hazardous Wastes Characteristic of Reactivity	N/A		1*	4	D003	B	100 (45.4)
Uracil mustard	66751	2,4-(1H,3H)-Pyrimidinedione, 5-[bis(2-chloroethyl)amino]-	1*	4	U237	A	10 (4.54)
Uranyl acetate	5411093		5000	1		B	100 (45.4)
Uranyl nitrate	10102064		5000	1		B	100 (45.4)
	36478769					B	
Urea, N-ethyl-N-nitroso-	759739	N-Nitroso-N-ethylurea	1*	4	U176	X	1 (0.454)
Urea, N-methyl-N-nitroso	684935	N-Nitroso-N-methylurea	1*	4	U177	X	1 (0.454)
Vanadic acid, ammonium salt	7803556	Ammonium vanadate	1*	4	P119	C	1000 (454)
Vanadium oxide V205	1314621	Vanadium pentoxide	1000	1,4	P120	C	1000 (454)
Vanadium pentoxide	1314621	Vanadium oxide V205	1000	1,4	P120	C	1000 (454)
Vanadyl sulfate	27774136		1000	1		C	1000 (454)
Vinyl chloride	75014	Ethene, chloro-	1*	2,3,4	U043	X	1 (0.454)
Vinyl acetate	108054	Vinyl acetate monomer	1000	1		D	5000 (2270)
Vinyl acetate monomer	108054	Vinyl acetate	1000	1		D	5000 (2270)
Vinylamine, N-methyl-N-nitroso-	4549400	N-Nitrosomethylvinylamine	1*	4	P084	A	10 (4.54)
Vinylidene chloride	75354	Ethene, 1,1-dichloro- 1,1-Dichloroethylene	5000	1,2,4	U078	B	100 (45.4)
Warfarin, & salts, when present at concentrations greater than 0.3%	81812	2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenyl-butyl)-, & salts, when present at concentrations greater than 0.3%	1*	4	P001	B	100 (45.4)
Xylene (mixed)	1330207	Benzene, dimethyl	1000	1,4	U239	C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
m-Benzene, dimethyl	108383	m-Xylene					
o-Benzene, dimethyl	95476	o-Xylene					
p-Benzene, dimethyl	106423	p-Xylene					
Xylenol	1300716		1000	1		C	1000 (454)
Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-, methyl ester (3beta,16beta,17alpha,18beta,20alpha)-	50555	Reserpine	1*	4	U200	D	5000 (2270)
Zinc††	7440666		1*	2		C	1000 (454)
ZINC AND COMPOUNDS	N/A		1*	2			**
Zinc acetate	557346		1000	1		C	1000 (454)
Zinc ammonium chloride	52628258		5000	1		C	1000 (454)
	14639975						
	14639986						
Zinc borate	1332076		1000	1		C	1000 (454)
Zinc bromide	7699458		5000	1		C	1000 (454)
Zinc carbonate	3486359		1000	1		C	1000 (454)
Zinc chloride	7646857		5000	1		C	1000 (454)
Zinc cyanide	557211	Zinc cyanide Zn(CN)2	10	1,4	P121	A	10 (4.54)
Zinc cyanide Zn(CN)2	557211	Zinc cyanide	10	1,4	P121	A	10 (4.54)
Zinc fluoride	7783495		1000	1		C	1000 (454)
Zinc formate	557415		1000	1		C	1000 (454)
Zinc hydrosulfite	7779864		1000	1		C	1000 (454)
Zinc nitrate	7779886		5000	1		C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
m-Benzene, dimethyl	108383	m-Xylene					
o-Benzene, dimethyl	95476	o-Xylene					
p-Benzene, dimethyl	106423	p-Xylene					
Xylenol	1300716		1000	1		C	1000 (454)
Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-, methyl ester (3beta,16beta,17alpha,18beta,20alpha)-	50555	Reserpine	1*	4	U200	D	5000 (2270)
Zinc††	7440666		1*	2		C	1000 (454)
ZINC AND COMPOUNDS	N/A		1*	2			**
Zinc acetate	557346		1000	1		C	1000 (454)
Zinc ammonium chloride	52628258		5000	1		C	1000 (454)
	14639975						
	14639986						
Zinc borate	1332076		1000	1		C	1000 (454)
Zinc bromide	7699458		5000	1		C	1000 (454)
Zinc carbonate	3486359		1000	1		C	1000 (454)
Zinc chloride	7646857		5000	1		C	1000 (454)
Zinc cyanide	557211	Zinc cyanide Zn(CN)2	10	1,4	P121	A	10 (4.54)
Zinc cyanide Zn(CN)2	557211	Zinc cyanide	10	1,4	P121	A	10 (4.54)
Zinc fluoride	7783495		1000	1		C	1000 (454)
Zinc formate	557415		1000	1		C	1000 (454)
Zinc hydrosulfite	7779864		1000	1		C	1000 (454)
Zinc nitrate	7779886		5000	1		C	1000 (454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Zinc phenosulfonate	127822		5000	1		D	5000 (2270)
Zinc phosphide	1314847	Zinc phosphide Zn3P2, when present at concentrations greater than 10%	1000	1,4	P122	B	100 (45.4)
Zinc phosphide Zn3P2, when present at concentrations greater than 10%	1314847	Zinc phosphide	1000	1,4	P122	B	100 (45.4)
Zinc silicofluoride	16871719		5000	1		D	5000 (2270)
Zinc sulfate	7733020		1000	1		C	1000 (454)
Zirconium nitrate	13746899		5000	1		D	5000 (2270)
Zirconium potassium fluoride	16923958		5000	1		C	1000 (454)
Zirconium sulfate	14644612		5000	[illegible]		D	5000 (2270)
Zirconium tetrachloride	10026116		5000	1		D	5000 (2270)
F001			1*	4	F001	A	10 (4.54)
The following spent halogenated solvents used in degreasing; all spent solvent mixtures/blends used in degreasing containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.							
(a) Tetrachloroethylene	127184		1*	2,4	U210	B	100 (45.4)
(b) Trichloroethylene	79016		1000	1,2,4	U228	B	100 (45.4)
(c) Methylene chloride	75092		1*	2,4	U080	C	1000 (454)
(d) 1,1,1-Trichloroethane	71556		1*	2,4	U226	C	1000 (454)
(e) Carbon tetrachloride	56235		5000	1,2,4	U211	A	10 (4.54)
(f) Chlorinated fluorocarbons	N/A					D	5000 (2270)
F002			1*	2,4	F002	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
The following spent halogenated solvents; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002,F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures.							
(a) Tetracholoroethylene	127184		1*	4	U210	B	100 (45.4)
(b) Methylene chloride	75092		1*	2,4	U080	C	1000 (454)
(c) Trichloroethylene	79016		1000	1,2,4	U228	B	100 (45.4)
(d) 1,1,1-Trichloroethane	71556		1*	2,4	U226	C	1000 (454)
(e) Chlorobenzene	108907		100	1,2,4	U037	B	100 (45.4)
(f) 1,1,2-Trichloro-1,2,2-trifluoroethane	76131					D	5000 (2270)
(g) o-Dischlorobenzene	95501		100	1,2,4	U070	B	100 (45.4)
(h) Trichlorofluoromethane	75694		1*	4	U121	D	5000 (2270)
(i) 1,1,2-Trichloroethane	79005		1*	2,4	U227	B	100 (45.4)
F003			1*	4	F003	B	100 (45.4)
The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents:							
(a) Xylene	1330207					C	1000 (454)
(b) Acetone	67641					D	5000 (2270)
(c) Ethyl acetate	141786					D	5000 (2270)
(d) Ethylbenzene	100414					C	1000 (454)
(e) Ethyl ether	60297					B	100 (45.4)
(f) Methyl isobutyl ketone	108101					D	5000 (2270)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
(g) n-Butyl alcohol	71363					D	5000 (2270)
(h) Cyclohexanone	108941					D	5000 (2270)
(i) Methanol	67561					D	5000 (2270)
F004			1*	4	F004	C	1000 (454)
The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents:							
(a) Cresols/Cresylic acid	1319773		1000	1,4	U052	C	1000 (454)
(b) Nitrobenzene	98953		1000	1,2,4	U169	C	1000 (454)
F005			1*	4	F005	B	100 (45.4)
The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents:							
(a) Toluene	108883		1000	1,2,4	U220	C	1000 (454)
(b) Methyl ethyl ketone	78933		1*	4	U159	D	5000 (2270)
(c) Carbon disulfide	75150		5000	1,4	P022	B	100 (45.4)
(d) Isobutanol	78831		1*	4	U140	D	5000 (2270)
(e) Pyridine	110861		1*	4	U196	C	1000 (454)
F006			1*	4	F006	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Wastewater treatment sludges from electroplating operations except from the following processes: (1) sulfuric acid anodizing of aluminum, (2) tin plating on carbon steel, (3) zinc plating (segregated basis) on carbon steel, (4) aluminum or zinc-aluminum plating on carbon steel, (5) cleaning/stripping associated with tin, zinc and aluminum plating on carbon steel, and (6) chemical etching and milling of aluminum.							
F007			1*	4	F007	A	10 (4.54)
Spent cyanide plating bath solutions from electroplating operations.							
F008			1*	4	F008	A	10 (4.54)
Plating bath residues from the bottom of plating baths from electroplating operations where cyanides are used in the process.							
F009			1*	4	F009	A	10 (4.54)
Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process.							
F010			1*	4	F010	A	10 (4.54)
Quenching bath residues from oil baths from metal heat treating operations where cyanides are used in the process.							
F011			1*	4	F011	A	10 (4.54)
Spent cyanide solution from salt bath pot cleaning from metal heat treating operations.							
F012			1*	4	F012	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Quenching wastewater treatment sludges from metal heat treating operations where cyanides are used in the process.							
F019			1	4	F019	A	10 (4.54)
Wastewater treatment sludges from the chemical conversion coating of aluminum except from zirconium phosphating in aluminum can washing when such phosphating is an exclusive conversion coating process.							
F020			1*	4	F020	X	1 (0.454)
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri-or-tetrachlorophenol, or of intermediates used to produce their pesticide derivatives. (This listing does not include wastes from the production of hexachlorophene from highly purified 2,4,5-trichlorophenol.)							
F021			1*	4	F021	X	1 (0.454)
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of pentachlorophenol, or of intermediates used to produce its derivatives.							
F022			1*	4	F022	X	1 (0.454)
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzenes under alkaline conditions.							

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
F023			1*	4	F023	X	1 (0.454)
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri- and tetrachlorophenols. (This listing does not include wastes from equipment used only for the production or use of hexachlorophene from highly purified 2,4,5-tri-chlorophenol.)							
F024			1*	4	F024	X	1 (0.454)
Wastes, including but not limited to distillation residues, heavy ends, tars, and reactor cleanout wastes, from the production of chlorinated aliphatic hydrocarbons, having carbon content from one to five, utilizing free radical catalyzed processes. (This listing does not include light ends, spent filters and filter aids, spent dessicants(sic), wastewater, wastewater treatment sludges, spent catalysts, and wastes listed in Section 261.32.)							
F025			1*	4	F025	X	##1 (0.454)
Condensed light ends, spent filters and filter aids, and spent dessicant wastes from the production of certain chlorinated aliphatic hydrocarbons, by free radical catalyzed processes. These chlorinated aliphatic hydrocarbons are those having carbon chain lengths ranging from one to and including five, with varying amounts and positions of chlorine substitution.							
F026			1*	4	F026	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzene under alkaline conditions.							
F027			1*	4	F027	X	1 (0.454)
Discarded unused formulations containing tri-, tetra-, or pentachlorophenol or discarded unused formulations containing compounds derived from these chlorophenols. (This listing does not include formulations containing hexachlorophene synthesized from prepurified 2,4,5-tri-chlorophenol as the sole component.)							
F028			1*	4	F028	X	1 (0.454)
Residues resulting from the incineration or thermal treatment of soil contaminated with EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027.							
F032			1*	4	F032	X	1 (0.454)
Wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that currently use or have previously used chlorophenolic formulations (except wastes from processes that have had the F032 waste code deleted in accordance with §261.35 and do not resume or initiate use of chlorophenolic formulations). This listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol.							

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
F034			1*	4	F034	X	1 (0.454)
Wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that use creosote formulations. This listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol.							
F035			1*	4	F035	X	1 (0.454)
Wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that use inorganic preservatives containing arsenic or chromium. This listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and/or penetachlorophenol.							
F037			1*	4	F037	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Petroleum refinery primary oil/water/solids separation sludge--Any sludge generated from the gravitational separation of oil/water/solids during the storage or treatment of process wastewaters and oily cooling wastewaters from petroleum refineries. Such sludges include, but are not limited to, those generated in: oil/water/solids separators; tanks and impoundments; ditches and other conveyances; sumps; and stormwater units receiving dry weather flow. Sludge generated in stormwater units that do not receive dry weather flow, sludges generated from non-contact once-through cooling waters segregated for treatment from other process or oily cooling waters, sludges generated in aggressive biological treatment units as defined in §261.31(b)(2) (including sludges generated in one or more additional units after wastewaters have been treated in aggressive biological treatment units) and K051 wastes are not included in this listing.							
F038			1*	4	F038	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
Petroleum refinery secondary (emulsified) oil/water/solids separation sludge--Any sludge and/or float generated from the physical and/or chemical separation of oil/water/solids in process wastewaters and oily cooling wastewaters from petroleum refineries. Such wastes include, but are not limited to, all sludges and floats generated in: induced air flotation (IAF) units, tanks and impoundments, and all sludges generated in DAF units. Sludges generated in stormwater units that do not receive dry weather flow, sludges generated from once-through non-contact cooling waters segregated for treatment from other process or oil cooling wastes, sludges and floats generated in aggressive biological treatment units as defined in §261.31(b)(2) (including sludges and floats generated in one or more additional units after wastewaters have been treated in aggressive biological treatment units) and F037, K048, and K051 wastes are not included in this listing.							
K001			1*	4	K001	X	1 (0.454)
Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol.							
K002			1*	4	K002		#
Wastewater treatment sludge from the production of chrome yellow and organge pigments.							
K003			1*	4	K003		#
Wastewater treatment sludge from the production of molybdate orange pigments.							
K004			1*	4	K004	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Wastewater treatment sludge from the production of zinc yellow pigments.							
K005			1*	4	K005		#
Wastewater treatment sludge from the production of chrome green pigments.							
K006			1*	4	K006	A	10 (4.54)
Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated).							
K007			1*	4	K007	A	10 (4.54)
Wastewater treatment sludge from the production or iron blue pigments.							
K008			1*	4	K008	A	10 (4.54)
Oven residue from the production of chrome oxide green pigments.							
K009			1*	4	K009	A	10 (4.54)
Distillation bottoms from the production of acetaldehyde from ethylene.							
K010			1*	4	K010	A	10 (4.54)
Distillation side cuts from the production of acetaldehyde from ethylene.							
K011			1*	4	K011	A	10 (4.54)
Bottom stream from the wastewater stripper inthe production of acrylonitrile.							
K013			1*	4	K013	A	10 (4.54)
Bottom stream from the acetonitrile column in the production of acrylonitrile.							

			Statutory			Final RQ	
Hazardous Substance	CASRN	Regulatory Synonyms	RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
K014			1*	4	K014	D	5000 (2270)
Bottoms from the acetonitrile purification column in the production of acrylonitrile.							
K015			1*	4	K015	A	10 (4.54)
Still bottoms from the distillation of benzyl chloride.							
K016			1*	4	K016	X	1 (0.454)
Heavy ends or distillation residues from the production of carbon tetrachloride.							
K017			1*	4	K017	A	10 (4.54)
Heavy ends (still bottoms) from the purification column in the production of epi-chlorohydrin.							
K018			1*	4	K018	X	1 (0.454)
Heavy ends from the fractionation column in ethyl chloride production.							
K019			1*	4	K019	X	1 (0.454)
Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production.							
K020			1*	4	K020	X	1 (0.454)
Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production.							
K021			1*	4	K021	A	10 (4.54)
Aqueous spent antimony catalyst waste from fluoromethanes production.							
K022			1*	4	K022	X	1 (0.454)
Distillation bottom tars from the production of phenol/acetone from cumene.							

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
K023			1*	4	K023	D	5000 (2270)
Distillation light ends from the production of phthalic anhydride from naphthalene.							
K024			1*	4	K024	D	5000 (2270)
Distillation bottoms from the production of phthalic anhydride from naphthalene.							
K025			1*	4	K025	A	10 (4.54)
Distillation bottoms from the production of nitrobenzene by the nitration of benzene.							
K026			1*	4	K026	C	1000 (454)
Stripping still tails from the production of methyl ethyl pyridines.							
K027			1*	4	K027	A	10 (4.54)
Centrifuge and distillation residues from toluene diisocyanate production.							
K028			1*	4	K028	X	1 (0.454)
Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane.							
K029			1*	4	K029	X	1 (0.454)
Waste from the product steam stripper in the production of 1,1,1-trichloroethane.							
K030			1*	4	K030	X	1 (0.454)
Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene.							
K031			1*	4	K031	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
By-product salts generated in the production of MSMA and cacodylic acid.							
K032			1*	4	K032	A	10 (4.54)
Wastewater treatment sludge from the production of chlordane.							
K033			1*	4	K033	A	10 (4.54)
Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane.							
K034			1*	4	K034	A	10 (4.54)
Filter solids from the filtration of hexachlorocyclo-pentadiene in the production of chlordane.							
K035			1*	4	K035	X	1 (0.454)
Wastewater treatment sludges generated in the production of creosote.							
K036			1*	4	K036	X	1 (0.454)
Still bottoms from toluene reclamation distillation in the production of disulfoton.							
K037			1*	4	K037	X	1 (0.454)
Wastewater treatment sludges from the production of disulfoton.							
K038			1*	4	K038	A	10 (4.54)
Wastewater from the washing and stripping of phorate production.							
K039			1*	4	K039	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Filter cake from the filtration of diethylphosphorodithioic acid in the production of phorate.							
K040			1*	4	K040	A	10 (4.54)
Wastewater treatment sludge from the production of phorate.							
K041			1*	4	K041	X	1 (0.454)
Wastewater treatment sludge from the production of toxaphene.							
K042			1*	4	K042	A	10 (4.54)
Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T.							
K043			1*	4	K043	A	10 (4.54)
2,6-Dichlorophenol waste from the production of 2,4-D.							
K044			1*	4	K044	A	10 (4.54)
Wastewater treatment sludges from the manufacturing and processing of explosives.							
K045			1*	4	K045	A	10 (4.54)
Spent carbon from the treatment of wastewater containing explosives.							
K046			1*	4	K046	B	100 (45.4)
Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds.							
K047			1*	4	K047	A	10 (4,54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Pink/red water from TNT operations.							
K048			1*	4	K048		#
Dissolved air flotation (DAF) float from the petroleum refining industry.							
K049			1*	4	K049		#
Slop oil emulsion solids from the petroleum refining industry.							
K050			1*	4	K050	A	10 (4.54)
Heat exchanger bundle cleaning sludge from the petroleum refining industry.							
K051			1*	4	K051		#
API seperator sludge from the petroleum refining industry.							
K052			1*	4	K052	A	10 (4.54)
Tank bottoms (leaded) from the petroleum refining industry.							
K060			1*	4	K060	X	1 (0.454)
Ammonia still lime sludge coking operations.							
K061			1*	4	K061		#
Emission control dust/sludge from the primary production of steel in electric furnances.							
K062			1*	4	K062		#
Spent pickle liquor generated by steel finishing operations of facilities within the iron and steel industry (SIC Codes 331 and 332).							
K064			1*	4	K064		##

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
Acid plant blowdown slurry/sludge resulting from thickening of blowdown slurry from primary copper production.							
K065			1*	4	K065		##
Surace impoundment solids contained in and dredged from surface impoundments at primary lead smelting facilities.							
K066			1*	4	K066		##
Sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production.							
K069			1*		K069		#
Emission control dust/sludge from secondary lead smelting.							
K071			1*	4	K071	X	1 (0.454)
Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used.							
K073			1*	4	K073	A	10 (4.54)
Chlorinated hydrocarbon waste from the purification step of the diaphragm cell process using graphite anodes in chlorine production.							
K083			1*	4	K083	B	100 (45.4)
Distillatin bottoms from aniline extraction.							
K084			1*	4	K084	X	1 (0.454)
Wastewater treatment sludges generated during the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds.							

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
K085			1*	4	K085	A	10 (4.54)
Distillation or fractionation column bottoms from the production of chlorobenzenes.							
K086			1*	4	K086		#
Solvent washes and sludges, caustic washes and sludges, or water washes and sludges from cleaning tubs and equipment used in the formulation of ink from pigments, driers, soaps, and stabilizers containing chromium and lead.							
K087			1*	4	K087	B	100 (45.4)
Decanter tank tar sludge from coking operations.							
K088			1*	4	K088		
Spent potliners from primary aluminum reduction.							
K090			1*	4	K090		
Emission control dust or sludge from ferrochromiumsilicon production.							
K091			1	4	K091		
Emission control dust or sludge from ferrochromium production.							
K093			1*	4	K093	D	5000 (2270)
Distillation light ends from the production of phthalic anhydride from ortho-xylene.							
K094			1*	4	K094	D	5000 (2270)
Distillation bottoms from the production of phthalic anhydride from ortho-xylene.							

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
K095			1*	4	K095	B	100 (45.4)
Distillation bottoms from the production of 1,1,1-trichloroethane.							
K096			1*	4	K096	B	100 (45.4)
Heavy ends from the heavy ends column from the production of 1,1,1-trichloroethane.							
K097			1*	4	K097	X	1 (0.454)
Vacuum stripper discharge from the chlordane chlorinator in the production of chlordane.							
K098			1*	4	K098	X	1 (0.454)
Untreated process wastewater from the production of toxaphene.							
K099			1*	4	K099	A	10 (4.54)
Untreated wastewater from the production of 2,4-D.							
K100			1*	4	K100		#
Waste leaching solution from acid leaching of emission control dust/sludge from secondary lead smelting.							
K101			1*	4	K101	X	1 (0.454)
Distillation tar residues from the distillation of aniline-based compounds in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds.							
K102			1*	4	K102	X	1 (0.454)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory RQ	Statutory Code†	Statutory RCRA Waste Number	Final RQ Category	Final RQ Pounds (Kg)
Residue from the use of activated carbon for decolorization in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds.							
K103			1*	4	K103	B	100 (45.4)
Process residues from aniline extraction from the production of aniline.							
K104			1*	4	K104	A	10 (4.54)
Combined wastewater streams generated from nitrobenzene/aniline production.							
K105			1*	4	K105	A	10 (4.54)
Separated aqueous stream from the reactor product washing step in the production of chlorobenzenes.							
K106			1*	4	K106	X	1 (0.454)
Wastewater treatment sludge from the mercury cell process in chlorine production.							
K107			10	4	K107	X	10 (4.54)
Column bottoms from product separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazines.							
K108			10	4	K108	X	10 (4.54)
Condensed column overheads from product separation and condensed reactor vent gases from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides.							
K109			10	4	K109	X	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Spent filter cartridges from product purification from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides.							
K110			10	4	K110	X	10 (4.54)
Condensed column overheads from intermediate separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides.							
K111			1*	4	K111	A	10 (4.54)
Product washwaters from the production of dinitrotoluene via nitration of toluene.							
K112			1*	4	K112	A	10 (4.54)
Reaction by-product water from the drying column in the production of toluenediamine via hydrogenation of dinitrotoluene.							
K113			1*	4	K113	A	10 (4.54)
Condensed liquid light ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.							
K114			1*	4	K114	A	10 (4.54)
Vicinals from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.							
K115			1*	4	K115	A	10 (4.54)
Heavy ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.							
K116			1*	4	K116	A	10 (4.54)

Hazardous Substance	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Organic condensate from the solvent recovery column in the production of toluene diisocyanate via phosgenation of toluenediamine.							
K117			1*	4	K117	X	1 (0.454)
Wastewater from the reaction vent gas scrubber in the production of ethylene bromide via bromination of ethene.							
K118			1*	4	K118	X	1 (0.454)
Spent absorbent solids from purification of ethylene dibromide in the production of ethylene dibromide.							
K123			1*	4	K123	A	10 (4.54)
Process wastewater (including supernates, filtrates, and washwaters) from the production of ethylene-bisdithiocarbamic acid and its salts.							
K124			1*	4	K124	A	10 (4.54)
Reactor vent scrubber water from the production of ethylenebisdithiocarbamic acid and its salts.							
K125			1*	4	K125	A	10 (4.54)
Filtration, evaporation, and centrifugation solids from the production of ethylenebisdithiocarbamic acid and its salts.							
K126			1*	4	K126	A	10 (4.54)
Baghouse dust and floor sweepings in milling and packaging operations from the production or formulation of ethylenebisdithiocarbamic acid and its salts.							
K131			100	4	K131	X	100 (45.4)

	CASRN	Regulatory Synonyms	Statutory			Final RQ	
			RQ	Code†	RCRA Waste Number	Category	Pounds (Kg)
Wastewater from the reactor and spent sulfuric acid from the acid dryer in the production of methyl bromide.							
K132			1000	4	K132	X	1000 (454)
Spent absorbent and wastewater solids from the production of methyl bromide.							
K136			1*	4	K136	X	1 (0.454)
Still bottoms from the purification of ethylene dibromide in the production of ethylene dibromide via bromination of ethene.							

† - Indicates the statutory source as defined by 1, 2, 3, and 4 below.
†† - No reporting of releases of this hazardous substance is required if the diameter of the pieces of the solid metal released is equal to or exceeds 100 micrometers (0.004 inches).
††† - The RQ for asbestos is limited to friable forms only.
1 - Indicates that the statutory source for designation of this hazardous substance under CERCLA is CWA Section 311(b)(4).
2 - Indicates that the statutory source for designation of this hazardous substance under CERCLA is CWA Section 307(a).
3 - Indicates that the statutory source for designation of this hazardous substance under CERCLA is CAA Section 112.
4 - Indicates that the statutory source for designation of this hazardous substance under CERCLA is RCRA Section 3001.
1* - Indicates that the 1-pound RQ is a CERCLA statutory RQ.
- Indicates that the RQ is subject to change when the assessment of potential carcinogenicity is completed.
- The Agency may adjust the statutory RQ for this hazardous substance in a future rulemaking; until then the statutory RQ applies.
§ - The adjusted RQs for radionuclides may be found in 40 CFR 302, Appendix B.
** - Indicates that no RQ is being assigned to the generic or broad class.

Appendix J
GLOSSARY

Aeration: A process which promotes biological degradation of organic matter. The process may be passive (as when waste is exposed to air) or active (as when a mixing or bubbling device introduces the air).

Backfill: Earth used to fill a trench or an excavation.

Baffles: Finlike devices installed vertically on the inside walls of liquid waste transport vehicles that are used to reduce the movement of the waste inside the tank.

Baseline General Permit: A storm water permit (issued under the NPDES program) intended to initially cover the majority of storm water discharges associated with industrial activities. For example, EPA is planning to issue two baseline general permits: NPDES General Permits for Storm Water Discharges from Construction Activities that are classified as "Associated with Industrial Activity" and NPDES General Permits for Storm Water Discharges from Industrial Activities that are classified as "Associated with Industrial Activities." EPA is also encouraging delegated states which have an approved general permits program to issue baseline general permits.

Berm: An earthen mound used to direct the flow of runoff around or through a structure.

Best Management Practices (BMP's): Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMP's also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. With regard to construction, these may include structural devices or nonstructural practices that are designed to prevent pollutants from entering water or to direct the flow of water.

Biodegradable: The ability to break down or decompose under natural conditions and processes.

Boom: 1. A floating device used to contain oil on a body of water. 2. A piece of equipment used to apply pesticides from ground equipment such as a tractor or truck.

Buffer strip or zone: Strips of grass or other erosion-resistant vegetation between a waterway and an area of more intensive land use.

By-product: Material, other than the principal product, that is generated as a consequence of an industrial process.

Calibration: A check of the precision and accuracy of measuring equipment.

CERCLA: Comprehensive Emergency Response, Compensation, and Liability Act.

Chock: A block or wedge used to keep rolling vehicles in place.

Clay lens: A naturally occurring, localized area of clay that acts as an impermeable layer to runoff infiltration.

Commencement of construction: The initial disturbance of soils associated with clearing, grading, or excavating activities or other construction activities.

Concrete aprons: A pad of nonerosive concrete material designed to prevent scour holes developing at the outlet ends of culverts, outlet pipes, grade stabilization structures, and other water control devices.

Conduit: Any channel or pipe for transporting the flow of water.

Conveyance: Any natural or man-made channel or pipe in which concentrated water flows.

Corrosion: The dissolving and wearing away of metal caused by a chemical reaction such as between water and the pipes that the water contacts, chemicals touching a metal surface, or contact between two metals.

Culvert: A covered channel or a large-diameter pipe that directs water flow below the ground level.

CWA: The Clean Water Act or the Federal Water Pollution Control Act.

Dedicated portable asphalt plant: A portable asphalt plant that is located on or contiguous to a construction site and that provides asphalt only to the construction site that the plant is located on or adjacent to. The term dedicated portable asphalt plant does not include facilities that are subject to the asphalt emulsion effluent limitation guideline at 40 CFR 443.

Dedicated portable concrete plant: A portable concrete plant that is located on or contiguous to a construction site and that provides concrete only to the construction site that the plant is located on or adjacent to.

Denuded: Land stripped of vegetation such as grass, or land that has had vegetation worn down due to impacts from the elements or humans.

Dike: An embankment to confine or control water, often built along the banks of a river to prevent overflow of lowlands; a levee.

Director: The Regional Administrator of the Environmental Protection Agency or an authorized representative.

Discharge: A release or flow of storm water or other substance from a conveyance or storage container.

Drip guard: A device used to prevent drips of fuel or corrosive or reactive chemicals from contacting other materials or areas.

Emission: Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities and from motor vehicle, locomotive, or aircraft exhausts.

Erosion: The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or timber-cutting.

Excavation: The process of removing earth, stone, or other materials.

Fertilizer: Materials such as nitrogen and phosphorus that provide nutrients for plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

Filter fabric: Textile of relatively small mesh or pore size that is used to (a) allow water to pass through while keeping sediment out (permeable), or (b) prevent both runoff and sediment from passing through (impermeable).

Filter strip: Usually long, relatively narrow area of undisturbed or planted vegetation used to retard or collect sediment for the protection of watercourses, reservoirs, or adjacent properties.

Final stabilization: The point at which all soil disturbing activities at the site have been completed and a uniform perennial vegetative cover with a density of 70 percent of the cover for unpaved areas and areas not covered by permanent structures has been established or equivalent permanent stabilization measures such as the use of riprap, gabions, or geotextiles have been employed.

Flange: A rim extending from the end of a pipe; *can* be used as a connection to another pipe.

Flow channel liner: A covering or coating used on the inside surface of a flow channel to prevent the infiltration of water into the ground.

Flowmeter: A gauge that shows the speed of water moving through a conveyance.

Flow-weighted composite sample: A composite sample consisting of a mixture of aliquots collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge.

General permit: A permit issued under the NPDES program to cover a certain class or category of storm water discharges. These permits allow for a reduction in the administrative burden associated with permitting storm water discharges associated with industrial activities.

Grading: The cutting and/or filling of the land surface to a desired slope or elevation.

Hazardous substance: 1. Any material that poses a threat to human health and/or the environment. Hazardous substances can be toxic, corrosive, ignitable, explosive, or chemically reactive. 2. Any substance listed in 40 CFR 302.4 or 49 CFR 171.8 and which may be required by EPA to be reported if a designated quantity of the substance is spilled in the waters of the United States or if otherwise emitted into the environment.

Hazardous waste: By-products of human activities that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

Holding pond: A pond or reservoir, usually made of earth, built to store polluted runoff for a limited time.

Illicit connection: Any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges authorized by an NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire-fighting activities.

Infiltration: 1. The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. 2. A land application technique where large volumes of wastewater are applied to land, allowed to penetrate the surface and percolate through the underlying soil.

Inlet: An entrance into a ditch, storm sewer, or other waterway.

Intermediates: A chemical compound formed during the making of a product.

Irrigation: Human application of water to agricultural or recreational land for watering purposes.

Jute: A plant fiber used to make rope, mulch, netting, or matting.

Lagoon: A shallow pond where sunlight, bacterial action, and oxygen work to purify wastewater.

Land application: Discharge of wastewater onto or into the ground for treatment or reuse.

Land treatment units: An area of land where materials are temporarily located to receive treatment. Examples include: sludge lagoons, stabilization pond.

Landfills: 1. Sanitary landfills are land disposal sites for nonhazardous solid wastes at which the waste is spread in layers, compacted to the smallest practical volume, and cover material applied at the end of each operating day.
2. Secure chemical landfills are disposal sites for hazardous waste. They are selected and designed to minimize the chance of release of hazardous substances into the environment.

Large and medium municipal separate storm sewer systems: All municipal separate storm sewers that are either: (i) located in an incorporated place (city) with a population of 100,000 or more as determined by the latest Decennial Census by the Bureau of Census (these cities are listed in Appendices F and G of 40 CFR Part 122); or (ii) located in the counties with unincorporated urbanized populations of 100,000 or more, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties (these counties are listed in Appendices H and I of 40 CFR Part 122); or (iii) owned or operated by a municipality other than those described in paragraph (i) or (ii) and that are designated by the Director as part of the large or medium municipal separate storm sewer system.

Leaching: The process by which soluble constituents are dissolved in a solvent such as water and carried down through the soil.

Level spreader: A device used to spread out storm water runoff uniformly over the ground surface as sheetflow (i.e., not through channels). The purpose of level spreaders is to prevent concentrated, erosive flows from occurring and to enhance infiltration.

Liming: Treating soil with lime to neutralize acidity levels.

Liner: 1. A relatively impermeable barrier designed to prevent leachate from leaking from a landfill. Liner materials include plastic and dense clay. 2. An insert or sleeve for sewer pipes to prevent leakage or infiltration.

Liquid level detector: A device that provides continuous measures of liquid levels in liquid storage areas or containers to prevent overflows.

Material storage areas: Onsite locations where raw materials, products, final products, by-products, or waste materials are stored.

Mulch: A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Noncontact cooling water: Water used to cool machinery or other materials without directly contacting process chemicals or materials.

Notice of Intent (NOI): An application to notify the permitting authority of a facility's intention to be covered by a general permit; exempts a facility from having to submit an individual or group application.

NPDES: EPA's program to control the discharge of pollutants to waters of the United States. See the definition of "National Pollutant Discharge Elimination Systems" in 40 CFR 122.2 for further guidance.

NPDES Permit: An authorization, license, or equivalent control document issued by EPA or an approved State agency to implement the requirements of the National Pollutant Discharge Elimination System (NPDES) as specified in 40 CFR 122.2.

Oil and grease traps: Devices which collect oil and grease, removing them from water flows.

Oil sheen: A thin, glistening layer of oil on water.

Oil/water separator: A device installed, usually at the entrance to a drain, which removes oil and grease from water flows entering the drain.

Organic pollutants: Substances containing carbon which may cause pollution problems in receiving streams.

Organic solvents: Liquid organic compounds capable of dissolving solids, gases, or liquids.

Outfall: The point, location, or structure where wastewater or drainage discharges from a sewer pipe, ditch, or other conveyance into a receiving body of water.

Permeability: The quality of a soil that enables water or air to move through it. Usually expressed in mm/hour (inches/hour) or mm/day (inches/day).

Permit: An authorization, license, or equivalent control document issued by EPA or an approved State agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.

Permit Issuing Authority (or Permitting Authority): The State agency or EPA Regional office which issues environmental permits to regulated facilities.

Plunge pool: A basin used to slow flowing water, usually constructed to a design depth and shape. The pool may be protected from erosion by various lining materials.

Pneumatic transfer: A system of hoses which uses the force of air or other gas to push material through; used to transfer solid or liquid materials from tank to tank.

Point source: Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, or vessel or other floating craft, from which pollutants are or may be discharged.

Pollutant: Any dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended (42 (U.S.C. 2011 *et sea.*)), heat, wrecked or discharged equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. It does not mean:
(i) Sewage from vessels; or
(ii) Water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil and gas production and disposed of into a well, if the well used either to facilitate production or for disposal purposes is approved by the authority of the State in which the well is located, and if the State determines that the injection or disposal will not result in the degradation of ground or surface water resources (Section 502(6) of the CWA).

Radioactive materials covered by the Atomic Energy Act are those encompassed in its definition of source, by-product, or special nuclear materials. Examples of materials not covered include radium and accelerator-produced isotopes. See *Train v. Colorado Public Interest Research Group, Inc.*, 426 U.S. 1 (1976).

Porous pavement: A human-made surface that will allow water to penetrate through and percolate into soil (as in porous asphalt pavement or concrete). Porous asphalt pavement is comprised of irregular shaped crush rock precoated with asphalt binder. Water seeps through into lower layers of gravel for temporary storage, then filters naturally into the soil.

Precipitation: Any form of rain or snow.

Preventative maintenance program: A schedule of inspections and testing at regular intervals intended to prevent equipment failures and deterioration.

Process wastewater: Water that comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, waste product, or wastewater.

PVC (polyvinyl chloride): A plastic used in pipes because of its strength; does not dissolve in most organic solvents.

Raw material: Any product or material that is converted into another material by processing or manufacturing.

RCRA: Resource Conservation and Recovery Act.

Recycle: The process of minimizing the generation of waste by recovering usable products that might otherwise become waste. Examples are the recycling of aluminum cans, wastepaper, and bottles.

Reportable Quantity (RQ): The quantity of a hazardous substance or oil that triggers reporting requirements under CERCLA or the Clean Water Act. If a substance is released in amounts exceeding its RQ, the release must be reported to the National Response Center, the State Emergency Response Commission, and community emergency coordinators for areas likely to be affected.

Residual: Amount of pollutant remaining in the environment after a natural or technological process has taken place, e.g., the sludge remaining after initial wastewater treatment, or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

Retention: The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass.

Retrofit: The modification of storm water management systems in developed areas through the construction of wet ponds, infiltration systems, wetland plantings, streambank stabilization, and other BMP techniques for improving water quality. A retrofit can consist of the construction of a new BMP in the developed area, the enhancement of an older storm water management structure, or a combination of improvement and new construction.

Rill erosion: The formation of numerous, closely spread streamlets due to uneven removal of surface soils by storm water or other water.

Riparian habitat: Areas adjacent to rivers and streams that have a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

Runoff: That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into the receiving waters.

Runoff coefficient: The fraction of total rainfall that will appear at the conveyance as runoff.

Runon: Storm water surface flow or other surface flow which enters property other than that where it originated.

Sanitary sewer: A system of underground pipes that carries sanitary waste or process wastewater to a treatment plant.

Sanitary waste: Domestic sewage.

SARA: Superfund Amendments and Reauthorization Act.

Scour: The clearing and digging action of flowing water, especially the downward erosion caused by stream water in sweeping away mud and silt from the streambed and outside bank of a curved channel.

Sealed gate: A device used to control the flow of liquid materials through a valve.

Secondary containment: Structures, usually dikes or berms, surrounding tanks or other storage containers and designed to catch spilled material from the storage containers.

Sediment trap: A device for removing sediment from water flows; usually installed at outfall points.

Sedimentation: The process of depositing soil particles, clays, sands, or other sediments that were picked up by flowing water.

Sediments: Soil, sand, and minerals washed from land into water, usually after rain. They pile up in reservoirs, rivers, and harbors, destroying fish-nesting areas and holes of water animals and cloud the water so that needed sunlight might not reach aquatic plants. Careless farming, mining, and building activities will expose sediment materials, allowing them to be washed off the land after rainfalls.

Sheet erosion: Erosion of thin layers of surface materials by continuous sheets of running water.

Sheetflow: Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

Shelf life: The time for which chemicals and other materials can be stored before becoming unusable due to age or deterioration.

Significant materials: as defined at 40 CFR Part 122.26(b)(12) include, but are not limited to:

Raw materials; fuels; materials such as solvents, detergents and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101 (14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); any chemical the facility is required to report pursuant to section 313 of Title III of the Superfund Amendments and Reauthorization Act (SARA); fertilizers; pesticides; and waste product such as ashes, slag, and sludge that have a potential to be released with storm water discharges.

Slag: Nonmetal containing waste leftover from the smelting and refining of metals.

Slide gate: A device used to control the flow of water through storm water conveyances.

Sloughing: The movement of unstabilized soil layers down a slope due to excess water in the soils.

Sludge: A semisolid residue from any of a number of air or water treatment processes. Sludge can be a hazardous waste.

Soil: The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of plants.

Solids dewatering: A process for removing excess water from solids to lessen the overall weight of the wastes.

Source control: A practice or structural measure to prevent pollutants from entering storm water runoff or other environmental media.

Spent solvent: A liquid solution that has been used and is no longer capable of dissolving solids, gases, or liquids.

Spill guard: A device used to prevent spills of liquid materials from storage containers.

Spill Prevention Control and Countermeasures Plan (SPCC): Plan consisting of structures, such as curbing, and action plans to prevent and respond to spills of hazardous substances as defined in the Clean Water Act.

Stopcock valve: A small valve for stopping or controlling the flow of water or other liquid through a pipe.

Storm drain: A slotted opening leading to an underground pipe or an open ditch for carrying surface runoff.

Storm water: Runoff from a storm event, snowmelt runoff, and surface runoff and drainage.

Storm water discharge associated with industrial activity: The discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under 40 CFR Part 122. For the categories of industries identified in subparagraphs (i) through (x) of this subsection, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. For the categories of industries identified in subparagraph (xi), the term includes only storm water discharges from all the areas (except access roads and rail lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste material, by-products, or industrial machinery *are exposed to storm water*. For the purposes of this paragraph, material handling activities include the: storage, loading and unloading,

transportation, or conveyance of any raw material, intermediate product, finished product, by-product, or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above-described areas. Industrial facilities (including industrial facilities that are Federally, State, or municipally owned or operated) that meet the description of the facilities listed in this paragraph (i)-(xi) include those facilities designated under the provision of 122.26(a)(1)(v). The following categories of facilities are considered to be engaging in "industrial activity" for purposes of this subsection: (i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR Subchapter N (except facilities with toxic pollutant effluent standards which are excepted under category (xi) of this paragraph);
(ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283 and 285) 29, 311, 32 (except 323), 33, 3441, 372; (iii) Facilities classified as Standard Industrial Classifications 10 though 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.1 1 (1) because the performance bond issued to the facility by the appropriate authority has been released, or except for areas of noncoal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990, and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, by-products or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining mining claim); (iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of RCA; (v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under Subtitle D of RCA; (vi) Facilities involved in the recycling of materials, including metal scrap yards, battery reclaimers, salvage yards, and automobiles junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093; (vii) Steam

electric power generating facilities, including coal handling sites; (viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (i)-(vii) or (ix)-(xi) of this subsection are associated with industrial activity; (ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including lands dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 3,785,000 liters per day (1.0 mgd) or more, or required to have an approved pretreatment program under 40 CFR 403. Not included are farm lands, domestic gardens, or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with Section 405 of the CWA; (x) Construction activity including clearing, grading, and excavation activities except: operations that result in the disturbance of less than 2 hectares (5 acres) of total land area which are not part of a larger common plan of development or sale; (xi) Facility under Standard Industrial Classification 20, 21, 22, 23, 24, 34, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-25, (and which are not otherwise included within categories (ii)-Ix));

Note: The Transportation Act of 1991 provides an exemption from storm water permitting requirements for certain facilities owned or operated by municipalities with a population of less than 100,000. Such municipalities must submit storm water discharge permit applications for only airports, power plants, and uncontrolled sanitary landfills that they own or operate, unless a permit is otherwise required by the permitting authority.

Subsoil: The bed or stratum of earth lying below the surface soil.

Sump: A pit or tank that catches liquid runoff for drainage or disposal.

Surface impoundment: Treatment, storage, or disposal of liquid wastes in ponds.

Surface water: All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, wetlands impoundments, seas, estuaries, etc.); also refers to springs, wells, or other collectors which are directly influenced by surface water.

Swale: An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales direct storm water flows into primary drainage channels and allow some of the storm water to infiltrate into the ground surface.

Tarp: A sheet of waterproof canvas or other material used to cover and protect materials, equipment, or vehicles.

Topography: The physical features of a surface area including relative elevations and the position of natural and human-made features.

Toxic Pollutants: Any pollutant listed as toxic under Section 501 (a)(1) or, in the case of "sludge use or disposal practices," any pollutant identified in regulations implementing Section 405(d) of the CWA. Please refer to 40 CFR Part 122 Appendix D.

Treatment: The act of applying a procedure or chemicals to a substance to remove undesirable pollutants.

Tributary: A river or stream that flows into a larger river or stream.

Underground storage tanks (USTS): Storage tanks with at least 10 percent or more of its storage capacity underground (the complete regulatory definition is at 40 CFR Part 280.12).

Waste: Unwanted materials left over from a manufacturing or other process.

Water table: The depth or level below which the ground is saturated with water.

Waters of the United States:

(a) All waters, which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;

(b) All interstate waters, including interstate "wetlands";

(c) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:

(1) Which are or could be used by interstate or foreign travelers for recreational or other purposes;

(2) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or

(3) Which are used or could be used for industrial purposes by industries in interstate commerce;

(d) All impoundments of waters otherwise defined as waters of the United States under this definition;

(e) Tributaries of waters identified in paragraphs (a) through (d) of this definition;

(f) The territorial sea; and

(g) "Wetlands" adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition. Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.1 1 (m) which also meet the criteria of this definition) are not waters of the United States. This exclusion applies only to man-made bodies of water which neither were originally created in waters of the United States (such as disposal area in wetlands) nor resulted from the impoundment of waters of the United States.

Waterway: A channel for the passage or flow of water.

Wet well: A chamber used to collect water or other liquid which is generally pumped out with the use of a pump.

Wetlands: An area that is regularly saturated by surface or groundwater and subsequently is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions. Examples include: swamps, bogs, fens, marshes, and estuaries.

Wind break: Any device designed to block wind flow and intended for protection against any ill effects of wind.

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