APPENDIX "M"
SWMPs & BMPs

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APPENDIX "M"
SWMPs & BMPs

A. GENERAL DISCUSSION General legal issues relating to storm water quality were presented in Section III. In Section IX, an expanded treatment was given to Stormwater Quality, including discussion of EPA and CDH regulations, NPDES/CDPS Permitting, Best Management Practices (BMPs) and general concepts relating to construction activity, and Stormwater Management Plans (SWMPs). In this Appendix, focus is on application of all these principles as they relate to Construction Activity Permits.

B. STORMWATER MANAGEMENT PLAN (SWMP) Guidance is provided in Section IX regarding site and construction factors to consider in preparing a SWMP, and also a planning and design approach. The Colorado Department of Health (CDH) has prepared a guideline for preparing SWMPs that must be submitted to them for review. A slightly modified version of that document is provided herein as Exhibit "M-1" on page M-8 for reference.

C. NPDES/CDPS CONSTRUCTION ACTIVITY PERMIT The CDH permit application for construction activity may change from time to time, and prior to preparation of an application, CDH should be contacted to determine the latest version for use. However, the version current as of May 1994, prepared 11/93, is provided herein as Exhibit "M-2" on page M-23 as information that may be of benefit.

D. BEST MANAGEMENT PRACTICES (BMPs) The SWMP, which is required by the permitting process, requires use of BMPs for water quality control. The balance of this appendix deals with BMPs.

Best Management Practices (BMPs) are defined as nonstructural and structural practices which, when properly implemented, operated, and maintained, provide the most efficient and practical means of reducing or preventing pollution of stormwater.

E. BMP SELECTION FACTORS Selection of the most appropriate combination of BMPs for a specific project should be based upon a careful review of the characteristics of the site that affect its potential for erosion and controllable erosion factors. These controllable factors are:

- Good Planning and design
- Construction scheduling
- Limiting exposed areas
- Runoff velocity reduction
- Sediment trapping

- Good operational procedures

For each of the six controllable factors there are many tactics available for effectively reducing the volume and velocity of stormwater runoff, the amount of the site exposed to runoff, and the potential for non-sediment pollution. BMPs are organized on the matrix shown in Table "M-1" on page M-7 according to these six controllable factors. Each BMP is also cross-referenced to the type(s) of controls which the individual BMPs provide. Many of the BMPs achieve control in more than one category which should be taken into account when selecting BMPs for maximum effectiveness. The type of controls are:

- Perimeter control/diversion
- Slope protection
- Sediment trapping
- Drainageway and stream protection
- Temporary stabilization
- Permanent stabilization
- Non-sediment pollution control

F. SELECTION PROCESS The site designer should select the control tactics which are best suited to the site, then select from suggested BMPs based upon consideration of cost, material availability, topography, location, and duration of exposure. In selecting BMPs suitable for a site and developing a SWMP, a five-step selection process may be used. A discussion of this step-by-step approach follows.

Step 1: Construction Scheduling The first step in selecting BMPs is to compare the project schedule with on-site management measures that can limit the exposure of the project site to erosion and sedimentation. The management measures to be examined all have a similar goal, which is to minimize the amount of site subject to erosion. Consider the following strategies:

- Sequence construction activities so that denuded areas are not exposed for long periods of time.
- Schedule landscaping and other work that permanently stabilizes the area to be done immediately after the land has been graded to its final contour.
- Alter the project schedule to minimize the amount of denuded areas during the wet summer months of July, August, and September and the winter months of November, December, and January.

- Construct permanent stormwater control facilities early in the project schedule and then utilize these structures for controlling erosion and sedimentation. For example, stormwater detention basins could be built early in a large project and used as sedimentation basins during the rest of the construction period.

Step 2: Limiting Exposed Area The second step is to examine the site plan to determine appropriate methods for reducing the volume of stormwater which will run across the denuded areas of the project site. Limiting the exposure of graded areas to off-site runoff may involve vegetative and structural controls as well as on-site management options. To effectively determine appropriate volume control measures, the designer should review a map of the project site with sufficient topographic detail so that existing and proposed drainage patterns can be identified and existing and proposed permanent stormwater control structures located. On this map, identify the following:

- Locations where stormwater enters and exits the site. Include both sheet and channel flow for the existing and final grading contours.
- Locate permanent stormwater collection, drainage and control structures.
- Identify locations subject to high rates of erosion, areas of steep slopes, and unlined channels. Long slopes over 100' in length are considered as areas of moderate to high erosion potential.
- Categorize slopes as:

Low Erosion Potential	0-5%
Moderate Erosion Potential	5-10%
High Erosion Potential	> 10%

- Identify those areas where existing vegetation will not be disturbed by construction activity, and establish clearing limits.
- Identify the boundaries between drainage basins if your site has more than 1 drainage outlet, and then calculate the approximate area of each drainage basins.

Methods for reducing the volume of runoff affecting your construction site:

a. **Runoff Volume Reduction:**

1) Divert upslope water from entering the unvegetated areas of the construction site by constructing dikes and swales.

2) Divert or intercept stormwater before it reaches long and/or steep slopes. Use temporary dikes, swales, or pipe slope drains.

3) Release captured stormwater at a slow and controlled rate to prevent damage to downstream drainageways and structures.

b. Vegetative Controls:

1) Increase the soil's ability to absorb moisture through vegetative means, surface roughening, and mulching.

2) Stage grading so the native vegetation provides a buffer to slow and disperse runoff.

Step 3: Runoff Velocity Reduction The third step involves selecting BMPs to reduce the velocity of runoff across denuded areas, steep slopes, and drainage channels. Structural practices to be considered are listed under the "Runoff Velocity Reduction" portion of Table "M-1" on page M-7. Appropriate applications of these BMPs should include:

- Limit length of slopes to 50 feet. Construct mid-slope diversion (swales) on longer slopes to intercept runoff.
- Build check dams or other energy dissipation structures in unlined drainage channels to slow runoff velocity and encourage settlement of sediments.
- Roughen slopes to increase the absorption of rainfall and slow runoff.
- Limit slopes to 3H:1V, where practical.
- Provide for spreading of concentrated stormwater flows into overland sheet flow.
- Intercept runoff before it reaches steep slopes using diversion dikes, swales, or other barriers.
- Protect slopes with mulches, matting, or other types of temporary or permanent soil stabilization.
- Provide velocity reducing structures or riprap linings at stormwater outfalls.

Step 4: Sediment Trapping Once measures have been taken to limit exposure, runoff volume, and velocity, the last step in controlling erosion and sedimentation is to separate as much sediment from the stormwater as possible before the water leaves the project site. The appropriate controls for doing this all work on the same principle of slowing runoff velocity with temporary barriers or basins which pond the

stormwater to allow sediments to settle out. Appropriate strategies for implementing sediment trapping controls include:

- Direct sediment-laden stormwater to temporary sediment traps.
- Direct off-site stormwater away from denuded areas and away from temporary sediment traps.
- Construct temporary sediment traps or basins at the drainage outlet for the site. When more than one basin is required due to the size of the site, construct these basins to operate in parallel. Do not allow the discharge from one basin to enter the inlet of another basin.
- When permanent stormwater detention basins are to be constructed, convert these basins to temporary use as a sediment trap or basin.
- Construction sites with relatively flat slopes that produce sheet flow runoff are appropriate for temporary sediment barriers such as, silt fences, straw bale barriers, sand bag barriers, and gravel filter berms.
- Protect municipal storm drainage structures from sediment clogging by providing inlet protection for area drains and curb inlets.

<u>Step 5: Operational Procedures</u> The fifth step in selecting practices to control stormwater pollution deals with preventing contamination of stormwater by materials other than sediment. Table "M-1" on page M-7 provides several methods for preventing non-sediment stormwater pollution by construction materials, equipment, and wastes. Not all of these practices will apply to every construction site. The suitability of a BMP depends upon how the operator conducts his or her activities. For example, the BMP on Equipment Maintenance Procedures may or may not apply to a given project if maintenance work is done off-site. The SWMP designer should consider all of the suggested Good Operation Practices and select those which are appropriate for the project. For a particular project, the contractor may develop other BMPs which would better meet the specific site needs.

After the SWMP designer has reviewed the five controllable factors and selected appropriate BMPs, the final stage of the process is to review the site map. All BMPs should be located with all major structural and non-structural controls, and areas of permanent or temporary stabilization shown.

The BMP exhibits in this manual provide design, construction, inspection, and maintenance standards for temporary controls. In using these BMPs, the designer should be aware that these standards are temporary measures and are not for permanent drainage improvements. Other BMPs may be utilized which are permanent.

Flow diversions should not adversely impact off-site properties The historic flow patterns should be maintained.

G. BMP EXHIBITS Many BMP exhibits are provided in Maricopa County, Vol III, and UD & FCD, Vol III, both of which are excellent sources of information on erosion control and BMPs. For convenience, a sample of BMPs from those sources are modified or reproduced and presented herein consisting of Exhibits M-3 through M-30 beginning on page M-32. However, the BMPs presented herein are by no means all-inclusive.

This table is modified from Maricopa County, Vol. III

CONTROL FACTOR	BMP TITLE	SYMBOL	A PERIMETER CONTROL DIVERSION	B SLOPE PROTECTION	C SEDIMENT TRAPPING	D DRAINAGEWAY AND STREET PROTECTION	E TEMPORARY STABILIZATION	F PERMANENT STABILIZATION	G NON SEDIMENT POLLUTION CONTROL	Reference Page	Reference Exhibit
PLANNING	SCHEDULING CONSIDERATIONS		●	●	●	●	●	●	●	–	–
	CONSTRUCTION PHASING		●	●		●	●			–	–
	PRESERVATION OF WASHES					●	●	●		–	–
	OPEN SPACE BUFFERS		●	●			●	●		–	–
VEGETATIVE CONTROLS	VEGETATIVE BUFFER ZONES						●			125	M-28,29
	TREES, SHRUBS, VINES, AND GROUND COVERS			●			●	●		119	M-26
	MULCHING	M(V)		●			●			64	M-12
	EROSION CONTROL MATTINGS	M(T)		●			●			52	M-9
	PROTECTION OF TREES AND VEGETATION IN CONSTR. AREAS	P.A.	●			●		●		68	M-13
REDUCE AREA OF EXPOSURE	DIVERSION DIKES	D.D.	●	●						40	M-6
	DRAINAGE SWALE	D.S.	●	●						44	M-7
	SLOPE DRAINS	S.D.		●						94	M-19
	CONSTRUCTION ENTRANCE STABILIZATION	C.E.S.			●		●		●	35	M-4
	CONSTRUCTION ROAD STABILIZATION	C.R.S.	●				●			38	M-5
	DUST CONTROL	D.C.			●		●			46	M-8
RUNOFF VELOCITY REDUCTION	CHECK DAMS	C.D.			●	●				32	M-3
	ROCK OUTLET PROTECTION			●		●	●			72	M-14
	SURFACE ROUGHENING	SR		●		●	●			115	M-25
SEDIMENT TRAPPING	STRAW BALE BARRIER	S.B.B.	●		●					112	M-24
	SILT FENCE	SF	●		●					89	M-18
	STORM DRAIN INLET PROTECTION	I.P.			●					106	M-23
	SEDIMENT TRAP	S.T.			●					84	M-17
	SEDIMENT BASIN	S.B.			●					79	M-16
	SANDBAG BARRIER (BERM)	S.B.B.	●		●					75	M-15
	GRAVEL FILTER BERM	G.F.B.	●		●					60	M-11
GOOD OPERATION PRACTICES	EQUIPMENT MAINTENANCE PROCEDURES	E.M.P.							●	56	M-10
	SOLID WASTE MANAGEMENT	S.W.M.							●	100	M-20
	WASHDOWN AREAS	W.A.							●	123	M-27
	STORAGE AREA OF CHEMICALS AND MATERIALS	S.A.							●	105	M-22
	WATERWAY CROSSING					●			●	137	M-30
	SPILL CONTAINMENT PLAN	S.C.P.							●	102	M-21

Table "M-1"

Selection Matrix for Construction Site BMPs

This Exhibit is a reproduction of a CDH WQCD document of same title prepared 3/94, except that a few portions that are redundant of other material presented in this manual have been omitted, and any references thereto revised.

A. INTRODUCTION

Stormwater Management Plans (SWMPs) are a required item under the Construction Stormwater Discharge Permit. This document is designed to help you develop a SWMP for your construction project. It explains what each of the SWMP requirements means, and gives some options for you to consider in developing Best Management Practices (BMPs) that are best suited to your site **during construction**.

This guidance document primarily addresses the SWMP requirements in the construction general permit. Other requirements and limitations, such as chemical use, sampling, annual reporting, etc., are detailed in the permit. Also note that the SWMP and the stormwater permit only cover discharges of **stormwater**.

Construction dewatering is a separate issue, and must be covered by the Division's general permit for construction dewatering (regardless of the size of the construction project). Pumping or draining groundwater that has infiltrated into an excavation requires a construction dewatering permit. Stormwater that mixes with groundwater in an excavation is subject to the controls in the construction dewatering permit.

This guidance document assumes that the SWMP will be completed and implemented at the time the project breaks ground, and will be revised if necessary as construction proceeds.

B. GENERAL GUIDANCE

BMPs: Best Management Practices (BMPs) can describe a wide range of management procedures, schedules of activities, prohibitions on practices, and other management practices. BMPs also include operating procedures, treatment requirements and practices to control site runoff, drainage from materials storage, spills or leaks, etc.

Nonstructural BMPs, such as preventive maintenance or preserving natural vegetation, are mainly definitions of operational or managerial techniques. In addition, there are a multitude of structural BMPs which should be considered, depending upon the construction activity. Structural BMPs include physical processes ranging from

diversion structures to silt fences to retention ponds.

Most of the BMPs referenced here are widely used in the construction industry. They generally involve a simple and low cost approach, and can be very effective when properly installed and maintained.

The stormwater permit requires the use of self-designed SWMPs. These plans are based on the use of BMPs. For construction sites, there are several types of BMPs: those that prevent erosion, those which prevent pollutants from the construction materials from mixing with stormwater, and those which trap pollutants before they can be discharged.

Sediment controls typically include:

- minimizing the amount of disturbed soil
- preventing runoff from off-site areas from flowing across disturbed areas
- slowing down the runoff flowing across the site
- removing sediment from on-site runoff before it leaves the site

Implementation: While erosion and sediment controls are not new ideas in construction, the timing of installation may now differ. The SWMP focus is primarily on controls used **during** earth disturbing activities. This means that hay bales, silt fences, etc. should be in place **before** grading begins, not after.

Common Sense Approach: Your SWMP is intended to be a usable document, not a paper exercise. Therefore, do not include measures which may sound good, but are unreasonable or not feasible for your site. Failure to implement your SWMP, even if the BMPs listed do not make sense, puts you in automatic violation of your permit. For example, a blanket statement that runoff from **all** disturbed areas will be controlled by silt fences, even if the slope or channels are too steep/narrow for this particular BMP, would be unreasonable.

On the other hand, if a particular BMP is listed in the SWMP, but then later turns out to be impractical or ineffective, the SWMP should be amended to reflect the changes/improvements made.

SWMP Items, Format: When preparing your plan, make sure to **address each item.** If it is not applicable to your site, briefly explain why. A simple "Not Applicable" is not enough.

In addition, your SWMP should follow the same format as the SWMP requirements

b) Describe the sequence of events involved in the construction project, such as grading, excavation, etc.

c) This information, which is also required in the application, is useful in determining the extent of control measures needed.

d) The runoff coefficient ("C" value) is the percentage of precipitation volume which will not be absorbed by the surface. Typical "C" values are shown in Appendix B of the SWMM manual.

e) It is necessary to include the percentage of existing vegetative ground cover in order to determine, after construction, when the site has been finally stabilized. See Part I.B.4 of the permit for final stabilization criteria. Final stabilization of the site is necessary before coverage under the permit can be terminated.

f) Describe the activities which will take place at the site which may have an impact on stormwater. These may include such things as the following: equipment or vehicle washing; fertilizers, chemicals, or other materials storage; vehicle maintenance or fueling; waste incineration, treatment, storage or disposal; haul roads; off-site vehicle tracking; loading/unloading areas, etc.

g) Will there be any discharge from the project site, during construction, which is not from stormwater? If so, describe the source and how it will be handled.

h) This information is also required in the application. For example, "runoff from the east side of the site will go to a roadside ditch which discharges to Jimmy Smith Gulch; runoff from the west side of the site will go to an unnamed tributary to Westerly Creek."

I.B.2. *Site Map*

Each plan shall provide a generalized site map or maps which indicate:

- ***construction site boundaries***
- ***all areas of soil disturbance***
- ***areas of cut and fill***
- ***areas used for storage of building materials, soils or wastes***
- ***location of any dedicated asphalt or concrete batch plants***
- ***location of major erosion control facilities or structures***
- ***springs, streams, wetlands and other surface waters***
- ***boundaries of 100-year flood plains, if determined***

A site map must be developed for each construction project. The site map must show those items listed above. It does not need to be drawn to scale, but it should be legible and easy to read. [An example of a site map is provided in Section IX of the SWMM manual.]

The construction plans may be used, if they are amended to include all required information. Local municipalities may also have maps suitable as bases to begin mapping procedures. If no other suitable base maps are available, one must be developed. Regardless of the source of the base map, the site map needs to be of suitable scale to show the construction portion of the site and the features within it.

In addition to the items specifically mentioned above, it is useful to also indicate on the map the following:

- Drainage basins for each outfall:
  Field inspection can usually accomplish this task with acceptable accuracy. Look for high areas such as crests of hills, parking lots, roads, etc. which would form the division between drainages. Gullies and swales are indicators of stormwater flow direction. Obviously, if runoff is observed during a storm, most uncertainties can be eliminated. The drainage areas shown should include the portions of the site where the activities described in I.B.1.f (above) occur, as well as those portions (such as upslope areas) contributing stormwater that mixes with runoff from the construction area.
- Surface water bodies (including dry water courses):
  Mark on the site map any surface water bodies, including lakes, streams, springs, wetlands, detention ponds, roadside or irrigation ditches, etc. These do not necessarily need to be within the construction portion of the site, but may be adjacent to it or impacted by stormwater runoff. Also include any existing storm sewers.
- Existing and planned structural stormwater pollution control measures:
  Show on the map the location of any structural stormwater pollution control measures, such as detention ponds, diversion ditches, covered material storage areas, fuel farm secondary containment structures, etc.
- Areas where industrial activities take place, as identified in Part I.B.1.a, above.
- Paved and unpaved areas where the runoff coefficient may be different.

In addition, other features could be included to make the SWMP a more comprehensive and usable plan. For example, a later section of the SWMP includes requirements for material handling and spill prevention procedures, which could include a site map showing where materials are stored. By including materials handling, loading and storage areas on the site map, all information would be in one place on a single base map.

I.B.3. BMPs for Stormwater Pollution Prevention

The plan shall include a narrative description of appropriate controls and measures that will be implemented before and during construction activities at the facility.
The plan shall clearly describe the relationship between the phases of construction and the implementation and maintenance of controls and measures. For example, which controls will be implemented during each of the following stages of construction: clearing and grubbing necessary for perimeter controls, initiation of perimeter controls, remaining clearing and grubbing, road grading, storm drain installation, final grading, stabilization, and removal of control measures.

The description of controls shall address the following minimum components:

a) Erosion and Sediment Controls

1) Structural Practices. A description of structural site management practices which will minimize erosion and sediment transport. Such practices may include: straw bales, silt fences, earth dikes, drainage swales, sediment traps, subsurface drains, pipe slope drains, inlet protection, outlet protection, gabions, and temporary or permanent sediment basins.

2) Non-Structural Practices. A description of interim and permanent stabilization practices, including site-specific scheduling of the implementation of the practices. Site plans should ensure that existing vegetation is preserved where possible and that disturbed areas are stabilized. Non-structural practices may include: temporary seeding, permanent seeding, mulching, geotextiles, sod stabilization, vegetative buffer strips, protection of trees, and preservation of mature vegetation.

Best Management Practices (BMPs)

This is the key part of the SWMP - a narrative description of the appropriate stormwater management practices for the permittee's site.

The first thing to do is assess the potential of various sources at the site to contribute pollutants to stormwater discharges associated with industrial activity. In addition to the actual construction and ground disturbance activities, evaluate the following types of activities for the reasonable potential for contributing pollutants to runoff: loading and unloading operations; outdoor storage activities; vehicle and equipment maintenance and fueling; significant dust or particulate generating processes; and on-site waste disposal practices. Some of the factors to consider include the quantity of chemicals used or discharged, site conditions (slope, soil permeability, etc.), and the likelihood of contact with stormwater.

→ **In each case where stormwater pollution potential exists, appropriate preventive measures (that is, BMPs) must be taken and documented.**

When selecting BMPs, the most important ones to evaluate first are those which limit the source of the pollutant. It is much more efficient, from both a cost and environmental standpoint, to prevent the pollution in the first place than to clean up contaminated stormwater. For example, mulching disturbed ground to reduce erosion, in most cases, is easier and more effective than trying to capture and treat the sediment-laden runoff before it reaches state waters. As another example, a BMP requiring that any vehicle maintenance that involves fluid exchange must take place under a roof, results in the removal of a pollutant source (i.e., oil/hydraulic fluids) from possible contact with stormwater.

Once source reduction BMPs have been evaluated, then more costly options, such as mitigation of impacts, or stormwater treatment through detention storage, should be considered if necessary. The BMPs selected are up to the judgment of the individual permittee, based on the conditions at the site. However, it is important to keep in mind that a fully implemented SWMP will constitute compliance with Best Available Technology (BAT) and Best Conventional Technology (BCT), as mandated under the Federal Clean Water Act. Basically, this means that, in order to comply with your permit, the appropriate measures must be taken in keeping with the pollutant(s) involved and the risk potential at the facility.

Based on an assessment of the potential of various sources at the site to contribute pollutants to stormwater, the plan should describe the control measures that are reasonable and appropriate. Estimated dates of compliance for the chosen BMPs to be implemented and maintained are also needed. Any existing controls should also be discussed. The plan shall identify both structural and non-structural control measures that are necessary to limit erosion.

A list of common BMPs, for construction and other industrial activities, is provided in Section G of Appendix "M", SWMM.

I.B.3.b) *Materials Handling and Spill Prevention*

The SWMP shall identify any procedures or significant materials handled at the site that could contribute pollutants to runoff. These could include: exposed storage of building materials, fertilizers or chemicals; waste piles; and equipment maintenance or fueling procedures. Areas or procedures where potential spills can occur shall have spill prevention and response procedures identified.

Measures to control stormwater pollution from dedicated concrete batch plants or dedicated asphalt batch plants covered by this certification, must be identified in the SWMP.

This area will involve all industrial activities at the site (except construction practices covered under the erosion and sediment controls) which have the potential to contaminate stormwater. This includes routine maintenance activities involving fertilizers, pesticides, detergents, fuels, solvents, oils, etc. It is a good idea to discuss each activity separately. Judge the potential for the material to be found in stormwater using, at a minimum, the following criteria:

- the intensity of the activity (i.e., does it occur every day, or just once a month, etc.) Can it be scheduled to occur only during dry weather?
- the size of the area over which the activity takes place, the surface type (pavement, gravel, vegetation, etc.), and other physical characteristics such as slope
- ability of product storage and loading/unloading facilities (fuel tanks, drum storage, etc.) to contain spills and leaks
- the concentration and toxicity of materials which can be expected to be found in the site's stormwater runoff
- the contamination of storage facilities with the substances being stored (e.g, used oil drums or tanks coated with spilled oil)

(Obviously, if no chemicals, fuels or other materials are stored or handled on site, the part of the SWMP dealing with potential spills is not necessary. The SWMP should then include a statement to this effect.)

Where materials can impact stormwater runoff, existing and planned practices that reduce the potential for contamination shall be described. For example, materials should be stored and handled in covered areas to prevent contact with stormwater, and chemicals should be

stored within berms or secondary containment devices to prevent leaks and spills from entering stormwater runoff.

In general, spill prevention and response procedures should include the following:

- notification procedures to be used in the event of an accident. At the very least, the SWMP Administrator should be notified. Depending on the nature of the spill and the material involved, the Colorado Dept. of Health, downstream water users, or other agencies may also need to be notified.
- instructions for clean-up procedures
- provisions for absorbents to be made available for use in fuel areas, and for containers to be available for used absorbents.
- prohibition on the washing of concrete trucks and other equipment into the storm drainage system

I.B.4. Final Stabilization and Longterm Stormwater Management

> ***A description of the measures used to achieve final stabilization and measures to control pollutants in stormwater discharges that will occur after construction operations have been completed.***
>
> ***Final stabilization is reached when all soil disturbing activities at the site have been completed, and uniform vegetative cover has been established with a density of at least 70 percent of pre-disturbance levels or equivalent permanent, physical erosion reduction methods has been employed. The Division may, after consultation with the permittee and upon good cause, amend the final stabilization criteria for specific operations.***

Typically, the stormwater discharge associated with construction activity is eliminated when the site is finally stabilized. 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 (except those portions covered by pavement or a structure) should be finally stabilized once all construction activities are completed.

Stormwater management controls to prevent or control pollution of stormwater after construction is completed should be addressed here. They typically include retention or detention ponds, infiltration measures, vegetative swales, and natural depressions.

New developments, buildings, etc., will incorporate elements of stormwater quality control into their design. The SWMP must be prepared consistent with these structural and nonstructural controls. Many of the temporary controls used for sediment control can be modified into permanent structural controls. Where possible, permanent stormwater quality controls can be constructed at the initial stages of construction, or modified at the end of construction. This can increase the efficiency of the controls by using them during both the building and operational phases of the project.

I.B.5. Other Controls

> ***A description of other measures to control pollutants in stormwater discharges, including plans for waste disposal and limiting off site soil tracking.***

See the discussion in Appendix C, Exhibit M-1n.

I.B.6. Inspection and Maintenance

> ***A description of procedures to inspect and maintain in good and effective operating condition the vegetation, erosion and sediment control measures and other protective measures identified in the SWMP.***

The permit requires that a thorough inspection of the stormwater management system be performed at least every 14 days, and after any precipitation or snowmelt event that causes surface erosion. Part I.C.6 of the permit outlines the inspection requirements.

Additionally, this part of the SWMP should also include maintenance of the BMPs which are discussed in Part 4.f. Set up a schedule appropriate to the activity and the BMP. Preventive maintenance should be coupled with periodic inspections. If there are already inspections/preventive maintenance programs or practices or equipment in place, include them here.

Preventive maintenance involves the regular inspection and testing of site equipment and operational systems. These inspections should uncover conditions, such as cracks or slow leaks, which could cause breakdowns or failures that result in discharge of pollutants to storm sewers and surface waters. The program should prevent breakdowns and failures by adjustment, repair or replacement of equipment. An effective preventive maintenance program should include the following elements, at a minimum:

- identification of equipment, sediment and erosion controls, and site areas that should be inspected
- appropriate and timely maintenance, repair or replacement of control measures and equipment
- maintenance of complete records on inspections, equipment, and systems

In order to adequately define a preventive maintenance program, review the information gathered so far in terms of materials handling, risk assessment, etc., to determine where equipment failure could result in spills or leaks of contaminants. This section will be highly specific to each site.

An effective and efficient recordkeeping system is an important item of the SWMP because it will serve many functions. Perhaps the easiest way of setting up a good recordkeeping system is to create a SWMP Daily Log in which all items can be entered. Entries into the log could include anything relating to the SWMP, stormwater contamination, contacts with suppliers, etc.

Keeping accurate and complete records serves several functions. First, keeping records of spills, leaks, SWMP implementation, etc. is a requirement of the general permit; therefore, enforcement action, including fines, could result if records are not adequate. Second, by keeping accurate and detailed records, you will have documentation of events which could prove invaluable should complications arise concerning the permit, lawsuits, etc. And third, it will make compiling your annual report to the Division much easier.

The following list includes the types of activities and information you may want to include in a SWMP Log Book:

- records of spills, leaks, or overflows, including time and date, weather conditions, etc.
- implementation of specific items in the SWMP
- training events (given or attended)
- events involving materials handling and storage
- contacts with regulatory agencies and personnel
- notes of employee activities, contact, notifications, etc.
- maintenance and repair of stormwater management controls
- preventive maintenance activities
- inspection activities

Additional information such as dated photographs, field notebooks, drawings and maps, etc. can also be included where appropriate.

D. REFERENCES

"A Guide to Industrial Stormwater BMPs," William Ruzzo, 1992.

California Stormwater Best Management Practice Handbook - Construction Activity, as prepared for CA Stormwater Quality Task Force, by CDM, 3/93.

Compliance Manual for NPDES Stormwater Permits for Colorado Airports, as prepared for the Colorado Division of Aeronautics, by Resource Consultants & Engineers, Inc., 11/92.

Stormwater Management During Construction, Training Course Student Workbook, Red Rocks Community College, 1993.

Stormwater Management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices, EPA Publication No. 832-R-92-005, 9/92.

APPENDIX C

Good Housekeeping/Operation and Maintenance Techniques:

Good housekeeping is an important pollution control measure. It requires the maintenance of a clean, orderly site. This part of the SWMP should address cleaning and maintenance schedules, trash disposal and collection practices, grounds maintenance, etc.

Most construction operations already adhere to some form of "Good Housekeeping" routine, whether they realize it or not. Permittees must now put these practices down in writing and ensure that they are adequate to meet the needs of the site. To prepare this section, begin by summarizing any activities which already take place, such as trash removal, oil recycling, etc.

Most good housekeeping practices involve simple common sense. The basic pollution prevention concept is that a clean site will have less potential for stormwater contamination. The following checklist can serve as a starting point for the assessment of existing or needed good housekeeping practices. Since each project is different, include any additional items pertinent to your site.

- is there evidence of drips or leaks from equipment or machinery at the site?
- is garbage/trash/construction debris removed regularly?
- are proper clean-up procedures used for spilled materials?
- are there abandoned machinery, parts, etc. around the site?
- is every effort made to order only materials that are required, thus minimizing the amounts of materials stored?
- what other practices routinely performed constitute good housekeeping?
- are signs posted at appropriate locations indicating where to dispose of waste oils and refuse?
- are locations where spill clean-up equipment and materials are stored appropriately marked?
- are fertilizers and other chemicals applied to landscaped areas judiciously applied, using only that quantity required?
- are portable toilet facilities properly maintained?

The following good housekeeping BMPs are recommended methods for the storage of materials, including lubricants, hydraulic fluids, grounds revegetation materials (fertilizers, pesticides, herbicides, etc.), refuse, etc.:

Material Storage and Inventory:

- the centralized used oil tank shall be emptied frequently enough to ensure it never reaches capacity (e.g., at least once per month). This area will be kept free of trash and spilled oil.
- all refuse dumpsters and receptacles shall be equipped with functional lids to prevent precipitation from entering.
- storage containers, drums, and bags shall be stored away from direct traffic routes to prevent accidental spills.
- empty drums shall be covered to prevent collection of precipitation.
- containers shall be stored on pallets or similar devices to prevent corrosion of the containers, which can result when containers come in contact with moisture on the ground.
- all chemical substances present at the site shall be identified.
- all of the chemical substances used in the workplace shall be listed, and the Material Safety Data Sheet (MSDS) obtained for each. The MSDSs will be readily available for use; i.e., posted at the locations where the materials are stored and handled.
- all containers shall be labeled to show the name and type of substance, stock number, expiration date, health hazards, including reactivity, corrosivity, ignitability and toxicity, suggestions for handling, and first aid information. (This information can usually be found on the MSDS. Unlabeled chemicals and chemicals with deteriorated labels are often disposed of unnecessarily or improperly.)

Employee Training: An important non-structural BMP is training of facility personnel. Even the most comprehensive SWMP is useless if no one knows about it. In order to make the SWMP an effective management tool, personnel must be informed of the procedures and how they are to be implemented. Any training session should include actual field observations of the BMPs being discussed.

New or temporary personnel and sub-contractors working at the site also need to be trained in the SWMP procedures as soon as possible. Sub-contractors should be provided with a copy, as well as being informed if they are liable for conditions set forth within it.

This is a reproduction of a CDH WQCD document entitled "Stormwater Discharges Associated with Construction Activity".

This application is for use by all stormwater dischargers engaged in construction activities. Construction activities include clearing, grading, excavation, and other ground disturbance activities. Construction does not include routine maintenance performed by public agencies, or their agents to maintain original line and grade, hydraulic capacity, or original purpose of the facility.

Application Due Dates: At least ten days prior to the anticipated date of discharge (start of construction), the owner or operator of the construction activity shall submit an application as provided by the Water Quality Control Division (the "Division"). This form may be reproduced.

Permit Fee: Do not send any payment with this application. You will be billed once you are covered under a permit.

Application Completeness: All items of the application must be completed accurately and in their entirety or the application will be deemed incomplete, and processing of the permit will not begin until all information is received. Each application shall be submitted by certified mail or hand delivered, only to:

Colorado Department of Health
Water Quality Control Division
WQCD-PE-B2
4300 Cherry Creek Drive South
Denver, Colorado 80222-1530
Attention: Permits and Enforcement Section

If you have questions on completing this application, you may contact the Section at (303) 692-3590.

INSTRUCTIONS

Item 1 - Provide the name and address of the permit applicant, including the company name, local contact, and mailing address. Indicate whether the applicant is the

GENERAL PERMIT APPLICATION: CONSTRUCTION ACTIVITY	Exhibit M-2a

owner, developer or contractor of the construction site, and the status as a private, federal, state, county or other public entity. Include the applicant Federal taxpayer identification number (nine digits). Public entities should use their Federal employer identification number. This number will be used as an identifier for billing purposes.

Item 2 - Provide the street address of the construction site. For the approximate center point of the property, both types of descriptions (legal, in terms of Township, Range and ¼ section, and longitude/latitude, to the nearest 15 seconds) must be included. This information is easily obtainable from a U.S. Geological Survey topographical map, available at area map stores. Also include the name of the construction project.

Item 3 - Briefly describe the nature of the construction activities. Include such things as what is being constructed, the ultimate land use, construction methods, or other factors which might affect stormwater quality.

Item 4 - Provide the current estimated start and completion dates for the construction project.

Item 5 - Provide the total area of the construction site and the area that will undergo disturbance, in acres. Note: aside from clearing, grading and excavation activities, disturbed areas also include areas receiving overburden, and areas with heavy equipment/vehicle traffic.

Item 6 - Identify the receiving water. Receiving waters are any waters of the state of Colorado. These include any and all surface waters that are contained in or flow in or through the state of Colorado (except for water withdrawn for use until use and treatment have been completed). This definition includes all water courses, even if they are usually dry.

If stormwater from the construction site enters a ditch or storm sewer system, identify that system and indicate the ultimate receiving water for the ditch or storm sewer. Note: a stormwater discharge permit does not allow a discharge into a ditch or municipal storm sewer system without the approval of the owner/operator of that system.

GENERAL PERMIT APPLICATION: CONSTRUCTION ACTIVITY	Exhibit M-2b

Item 7 - Indicate any other environmental permits, such as city or county grading or erosion control permits or dredge and fill (ACOE 404) permits, that are held for this construction site. Include the permit number.

If you currently have a discharge permit from the Division for the discharge of process water (such as construction dewatering), include the number here.

If this item does not apply to you, enter "Not Applicable" to show that you considered the question.

Item 8 - The certification of completion of a Stormwater Management Plan (SWMP) **must** be signed by the applicant or their authorized agent. Appendix A [of this Exhibit] contains the requirements for the SWMP **during the period of construction** (as listed in the general permit). Submittal of the SWMP is **not** required, however it must be developed and implemented and kept at the construction site. The Division reserves the right to request the SWMP at any time.

Item 9 - The application **must be signed** to be considered complete. In all cases, it shall be signed as follows:

a) In the case of corporations, by a principal executive officer of at least the level of vice-president or his or her duly authorized representative, if such representative is responsible for the over-all operation of the facility from which the discharge described in the application originates.

b) In the case of a partnership, by a general partner.

c) In the case of a sole proprietorship, by the proprietor.

d) In the case of a municipal, state, or other public facility, by either a principal executive officer, ranking elected official, or other duly authorized employee.

GENERAL PERMIT APPLICATION

STORMWATER DISCHARGES
ASSOCIATED WITH:

CONSTRUCTION ACTIVITY

(Permit No. COR-030000)

FOR AGENCY USE ONLY	
Certification Number: C O R - 0 3	
Date Received (Year Month Day)	Fee Category

Please print or type. All items must be completed accurately and in their entirety or the application will be deemed incomplete and processing of the permit will not begin until all information is received. Please refer to the instructions for information about the required items. An original signature of the applicant is required.

1. **Name and address of the permit applicant:**

Company Name _____

Mailing Address _____

City, State and Zip Code _____

Phone Number (___) _____ Who is applying? Owner ☐ Developer ☐ Contractor ☐

Federal Taxpayer (or Employer) ID#: __ __ __ __ __ __ __ __ __

Entity Type: Private ☐ Federal ☐ State ☐ County ☐ City ☐ Other: _____

Local Contact (familiar with facility) _____

Title _____ Phone Number _____

2. **Location of the construction site:**

Street Address _____

City, State and Zip Code _____

County _____ Name of plan or development _____

Legal Location (Township, Range, section, 1/4 section): _____

Latitude and Longitude _____

3. **Briefly describe the nature of the construction activity:**

_____

_____

_____

_____

_____

GENERAL PERMIT APPLICATION: CONSTRUCTION ACTIVITY

Exhibit M-2d

4. Anticipated construction schedule:

Commencement date: _____ Completion date: _____

5. Area of the construction site: Total area (acres) _____

Area to undergo disturbance (acres) _____

6. The name of the receiving stream(s). (If discharge is to a ditch or storm sewer, also include the name of the ultimate receiving water): _____

_____

7. Other environmental permits held for this construction activity (include permit number):

_____

_____

_____

8. Stormwater Management Plan Certification:

"I certify under penalty of law that a complete Stormwater Management Plan, as described in Appendix A of this application, has been prepared for my facility. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the Stormwater Management Plan is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for falsely certifying the completion of said SWMP, including the possibility of fine and imprisonment for knowing violations."

_____

Signature of Applicant Date Signed

_____

Name (printed) Title

9. Signature of Applicant (legally responsible person)

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment."

_____

Signature of Applicant Date Signed

_____

Name (printed) Title

GENERAL PERMIT APPLICATION: CONSTRUCTION ACTIVITY	Exhibit M-2e

APPENDIX A

CONTENTS OF THE STORMWATER MANAGEMENT PLAN (SWMP)

The SWMP shall be prepared in accordance with good engineering, hydrologic and pollution control practices. (The SWMP need not be prepared by a registered engineer.) The main objective of the plan is to identify Best Management Practices (BMPs) which when implemented will meet the terms and conditions of the general permit. **Note:** The Division has a guidance document available on construction SWMP preparation (call 303-692-3590).

The plan shall identify potential sources of pollution (including sediment) which may reasonably be expected to affect the quality of stormwater discharges associated with construction activity from the facility. In addition, the plan shall describe and ensure the implementation of BMPs which will be used to reduce the pollutants in stormwater discharges associated with construction activity. **The BMPs must be implemented before construction/grading begins.** Construction operations must implement the provisions of the SWMP required under this part as a condition of this permit.

The SWMP shall include the following items, at a minimum:

1. **Site Description**

Each plan shall provide a description of the following:

a) A description of the construction activity.
b) The proposed sequence for major activities.
c) Estimates of the total area of the site, and the area of the site that is expected to undergo clearing, excavation or grading.
d) An estimate of the runoff coefficient of the site before and after construction activities are completed and any existing data describing the soil, soil erosion potential or the quality of any discharge from the site.
e) A description of the existing vegetation at the site and an estimate of the percent vegetative ground cover.

f) The location and description of any other potential pollution sources, such as vehicle fueling, storage of fertilizers or chemicals, etc.

g) The location and description of any anticipated non-stormwater components of the discharge, such as springs and landscape irrigation return flow.

h) The name of the receiving water(s) and the size, type and location of any outfall or, if the discharge is to a municipal separate storm sewer, the name of that system, the location of the storm sewer discharge, and the ultimate receiving water(s).

2. **Site Map**

Each plan shall provide a generalized site map or maps which indicate:

- construction site boundaries
- all areas of soil disturbance
- areas of cut and fill
- areas used for storage of building materials, soils or wastes
- location of any dedicated asphalt or concrete batch plants
- location of major erosion control facilities or structures
- springs, streams, wetlands and other surface waters
- boundaries of 100-year flood plains, if determined

3. **BMPs for Stormwater Pollution Prevention**

The plan shall include a narrative description of appropriate controls and measures that will be implemented before and during construction activities at the facility.

The plan shall clearly describe the relationship between the phases of construction and the implementation and maintenance of controls and measures. For example, which controls will be implemented during each of the following stages of construction: clearing and grubbing necessary for perimeter controls, initiation of perimeter controls, remaining clearing and grubbing, road grading, storm drain installation, final grading, stabilization, and removal of control measures.

The description of controls shall address the following minimum components:

a) Erosion and Sediment Controls

1) **Structural Practices.** A description of structural site management practices which will minimize erosion and sediment transport. Such practices may include: straw bales, silt fences, earth dikes, drainage swales, sediment traps, subsurface drains, pipe slope drains, inlet protection, outlet protection, gabions, and temporary or permanent sediment basins.

2) **Non-Structural Practices.** A description of interim and permanent stabilization practices, including site-specific scheduling of the implementation of the practices. Site plans should ensure that existing vegetation is preserved where possible and that disturbed areas are stabilized. Non-structural practices may include: temporary seeding, permanent seeding, mulching, geotextiles, sod stabilization, vegetative buffer strips, protection of trees, and preservation of mature vegetation.

b) Materials Handling and Spill Prevention

The SWMP shall identify any procedures or significant materials handled at the site that could contribute pollutants to runoff. These could include: exposed storage of building materials, fertilizers or chemicals; waste piles; and equipment maintenance or fueling procedures. Areas or procedures where potential spills can occur shall have spill prevention and response procedures identified.

Measures to control stormwater pollution from dedicated concrete batch plants or dedicated asphalt batch plants covered by this certification, must be identified in the SWMP.

4. **Final Stabilization and Longterm Stormwater Management**

A description of the measures used to achieve final stabilization and measures to control pollutants in stormwater discharges that will occur **after** construction operations have been completed.

Final stabilization is reached when all soil disturbing activities at the site have been completed, and uniform vegetative cover has been established with a density of at least 70 percent of pre-disturbance levels or equivalent permanent, physical erosion reduction methods has been employed. The Division may, after consultation with the permittee and upon good cause, amend the final stabilization criteria for specific operations.

5. **Other Controls**

A description of other measures to control pollutants in stormwater discharges, including plans for waste disposal and limiting off site soil tracking.

6. **Inspection and Maintenance**

A description of procedures to inspect and maintain in good and effective operating condition the vegetation, erosion and sediment control measures and other protective measures identified in the SWMP.

DESCRIPTION

Small temporary dams constructed across a swale or drainage ditch.

PURPOSE

Check dams reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch, and slow water velocity to allow sediment capture.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
* Sediment trapping
* Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATION

Check dams are used to reduce the velocity of channel flow in smaller channels and temporary swales. This practice is limited to use in small open channels which drain 10 acres or less.

LIMITATIONS

Check dams should not be used in live streams. Do not install in channels which have already been lined or vegetated.

PLANNING CONSIDERATIONS

Check dams only perform their function of reducing velocities of concentrated flows and energy if they have been sized and constructed correctly and are maintained properly.

CHECK DAMS	C.D.  Symbol	**Exhibit M-3a**

- Advantages:
  - Check dams reduce the need for more stringent erosion control practices in the swale due to the decreased velocity and energy of runoff.

DESIGN & SIZING CRITERIA

Check dams can be constructed of either rock or logs. Provide a deep sump immediately upstream.

The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

Rock check dams shall be constructed of appropriately sized rock of D50 equal to 8"-12" minimum. The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.

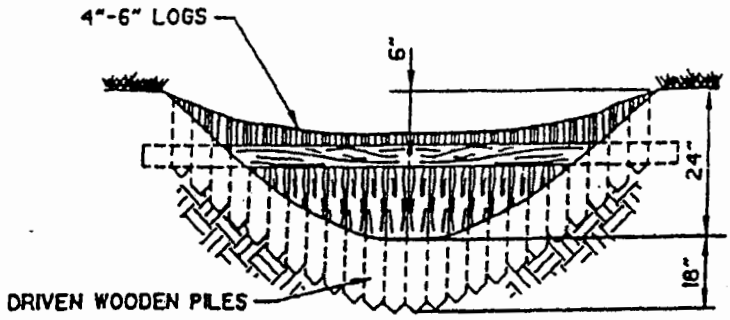
Log check dams shall be constructed of 4 to 6-inch diameter logs. The logs shall be embedded into the soil at least 18 inches.

In the case of grass-lined ditches and swales, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

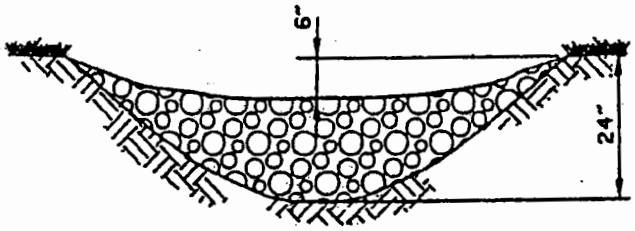
MAINTENANCE REQUIREMENTS

Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches on half the sump depth.

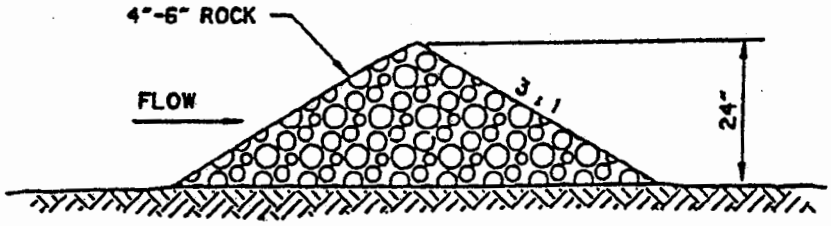
CHECK DAMS	C.D.  Symbol	**Exhibit M-3b**



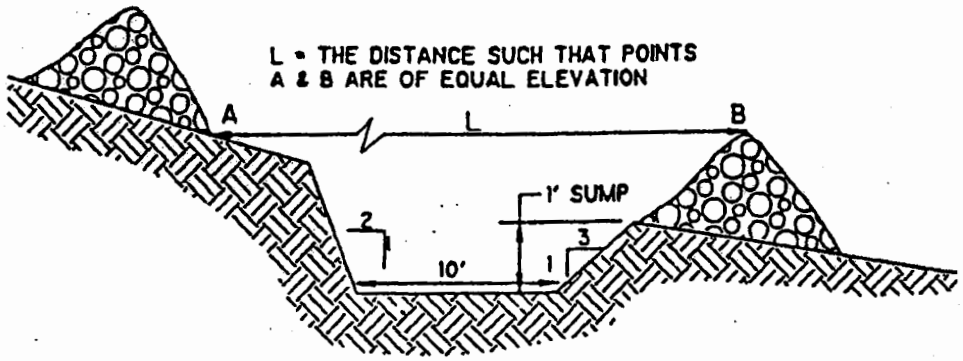
LOG CHECK DAM



ROCK CHECK DAM



ROCK CHECK DAM CROSS-SECTION



SPACING BETWEEN CHECK DAMS

CHECK DAMS	C.D. Symbol	Exhibit M-3c

DESCRIPTION

A stabilized pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewall: or parking area

PURPOSE

The purpose of a stabilized construction entrance is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets. Reducing trackout of sediments and other pollutants onto paved roads helps prevent deposition of sediments into local storm drains and production of airborne dust.

CONDITIONS WHERE PRACTICE APPLIES

* Perimeter control
_ Slope protection
_ Sediment trapping
* Drainageway & stream protection
_ Temporary stabilization
* Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

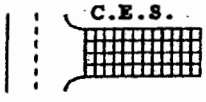
APPROPRIATE APPLICATIONS

A stabilized construction entrance should be used at all points of construction ingress and egress. NPDES permits require that appropriate measures be implemented to prevent trackout of sediments onto paved roadways.

LIMITATIONS

The stabilized construction entrance plan should be reviewed as part of the project traffic control plan.

- Construct on level ground.
- Stabilized construction entrances are rather expensive to construct and when a wash rack is included, a sediment trap of some kind must also be provided to collect wash water runoff.

CONSTRUCTION ENTRANCE STABILIZATION	 Symbol	**Exhibit M-4a**

PLANNING CONSIDERATIONS

Stabilized construction entrances are not very effective in removing sediment from equipment leaving a construction site. Efficiency is greatly increased, though when a washing rack is included as part of a stabilized construction entrance. Build on level ground.

- Advantages:
  - Does remove some sediment from equipment and serves to channel construction traffic in and out of the site.

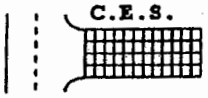
DESIGN & SIZING CONSIDERATIONS

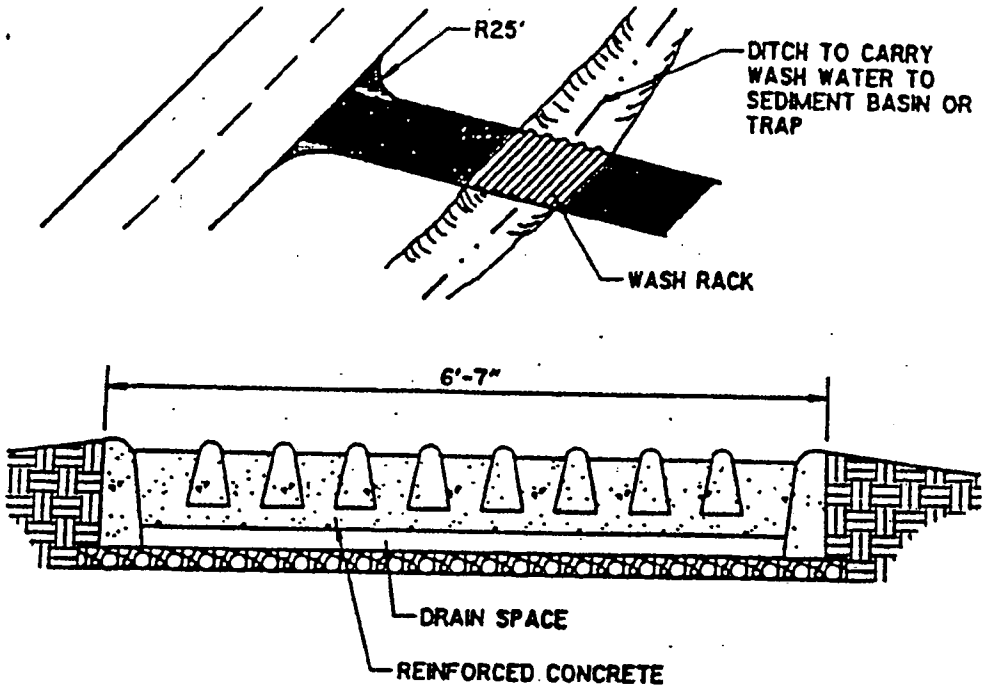
The aggregate for stabilized construction entrance aprons shall be 1 to 3 inches in size, washed, well-graded gravel or crushed rock The apron dimensions recommended are 30 ft x 50 ft. and 6 inches deep.

- Entrance must be properly graded to prevent runoff from leaving the construction site.
- When wash areas are provided washing shall be done on an area stabilized with crushed stone which drains into a properly constructed sediment trap or basin (pond).

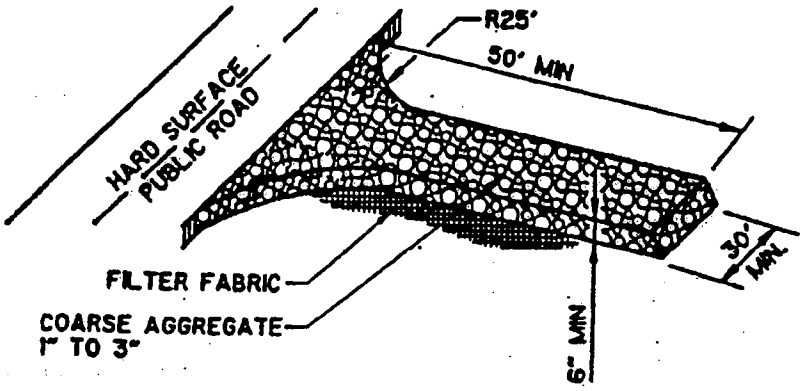
MAINTENANCE REQUIREMENTS

- Inspect monthly and after each rainfall.
- Replace gravel mat when surface voids are no longer visible. Periodic top dressing with additional stone will be required
- All sediments deposited on paved roadways must be removed within 24 hours.
- Remove gravel and filter fabric upon completion of construction.

CONSTRUCTION ENTRANCE STABILIZATION	 Symbol	**Exhibit M-4b**



WASH RACK



STABILIZED CONSTRUCTION ENTRANCE

CONSTRUCTION ENTRANCE STABILIZATION	C.E.S. Symbol	Exhibit M-4c

DESCRIPTION

The temporary stabilization of access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes with gravel or by chemical stabilization immediately after grading.

PURPOSE

To reduce erosion of temporary road beds by construction traffic.

CONDITIONS WHERE PRACTICE APPLIES

* Perimeter control
_ Slope protection
_ Sediment trapping
_ Drainageway & stream protection
* Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

- Wherever parking areas are constructed, whether permanent or temporary, for use by constructlon traffic.
- For phased construction projects where roadways are graded for utility installations, but will not be paved immediately.
- Detour roadways.
- When roadway construction occurs in wet weather.

LIMITATIONS

Measures on temporary roads must be cheap to install and also to remove. Application of aggregate or chemical stabilization to construction roads may need to be made more than once during a construction period.

PLANNING CONSIDERATIONS

Roads graded for construction vehicles are especially susceptible to erosion. The exposed soil surface is continually disturbed resulting in erosion, dust problems, and transport runoff waters along their surfaces. During wet weather, the roads may generate significant

CONSTRUCTION ROAD STABILIZATION	 Symbol	**Exhibit M-5a**

Permanent roads and parking areas should be paved as soon as possible after grading. As an alternative where construction will be phased, the early application of gravel or chemical stabilization may solve potential erosion and stability problems.

DESIGN & SIZING CRITERIA

A 6-inch course of 2 to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or the completion of utility installation within the right-of-way. A 4-inch course of aggregate base course may be used in lieu of the crushed rock. Chemical stabilization may also be used upon compacted native sub-grade. Acceptable chemical stabilization methods are listed in the Dust Control BMP fact sheet. These chemical controls should be applied per the manufacturers directions.

Temporary roads should follow the contour of the natural terrain to the maximum extent possible. Slope should not exceed 15 percent. Roadways should be carefully graded to drain transversely. Provide drainage swales on each side of the roadway for a normal crown section, or to the downstream side for a super-elevated section. Simple gravel berms without a trench can also be used. Installed drainage inlets shall be protected to prevent sediment-laden water entering the drain sewer system.

MAINTENANCE REQUIREMENTS

Inspect stabilized areas regularly, especially after large storm events. Add rock or gravel if necessary to stabilize any erosion.

CONSTRUCTION ROAD STABILIZATION	CRS Symbol	**Exhibit M-5b**

D. DIKE

DESCRIPTION

A temporary berm or ridge of compacted soil, located in such a manner as to channel water to a desired location.

PURPOSE

The purpose of an earth dike is to direct runoff to a sediment trapping device or stabilized outlet, to reduce the potential for erosion. Earth dikes can also be used for diverting clean water away and sheet flows away from disturbed areas and unprotected slopes.

CONDITIONS WHERE PRACTICE APPLIES

* Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Earth dikes are often constructed upstream of disturbed areas and around construction sites. The dikes should remain in place until the disturbed areas arc permanently stabilized. The dikes must be on-site and maintain the inflow and outflow conditions at the site to the historic drainage pattern.

LIMITATIONS

Limit to upstream drainage areas of 10 acres or less and for slopes less than 5 percent. For larger areas more permanent structures should be built.

- Often times earth dikes create more disturbed area on site and become barriers to construction equipment.
- Earth dikes must be stabilized immediately which adds cost and maintenance concerns.
- Diverted stormwater flow may cause flood damage to adjacent areas.

DIVERSION DIKE	 D.D. Symbol	**Exhibit M-6a**

PLANNING CONSIDERATIONS

An earth dike itself does not control erosion or remove sediment from runoff, rather it directs runoff to an erosion control device such as a sediment trap or directs runoff away from an erodible area. Temporary diversion dikes should not adversely impact adjacent properties and must conform to local floodplain management regulations.

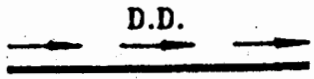
♦ Advantages:

- Earth dikes can handle flows from large drainage areas and are easy to install.
- Also, once stabilized, earth dikes require little maintenance.
- Uses on-site materials.

DESIGN & SIZING CRITERIA

Temporary Diversion Dikes

1. All dikes shall be compacted by earth-moving equipment.
2. All dikes shall have positive drainage to an outlet.
3. Top width may be wider and side slopes may be flatter if desired to facilitate crossing by construction traffic.
4. Location should be adjusted as needed to utilize a stabilized safe outlet.
5. Earth dikes shall have an outlet that functions with a minimum of erosion. Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin when either the &e channel or the drainage area above the &e are not adequately stabilized.

DIVERSION DIKE	 **D.D.** Symbol	**Exhibit M-6b**

6. Temporary stabilization, when necessary, shall be as scheduled below:

FLOW CHANNEL STABILIZATION

TYPE OF TREATMENT	CHANNEL GRADE	ROCK (D50) STABILIZATION
1	0.5-1.0%	4" Rock
2	1.1-2.0%	6" Rock
3	2.1-4.0%	8" Rock
4	4.1-5%	Rip-Rap 8-12"

A. Stone or recycled concrete equivalent, in a layer at least 8 inches in thickness and be pressed into the soil with construction equipment.

B. Riprap to be in a layer at least two times the D50 and pressed into the soil.

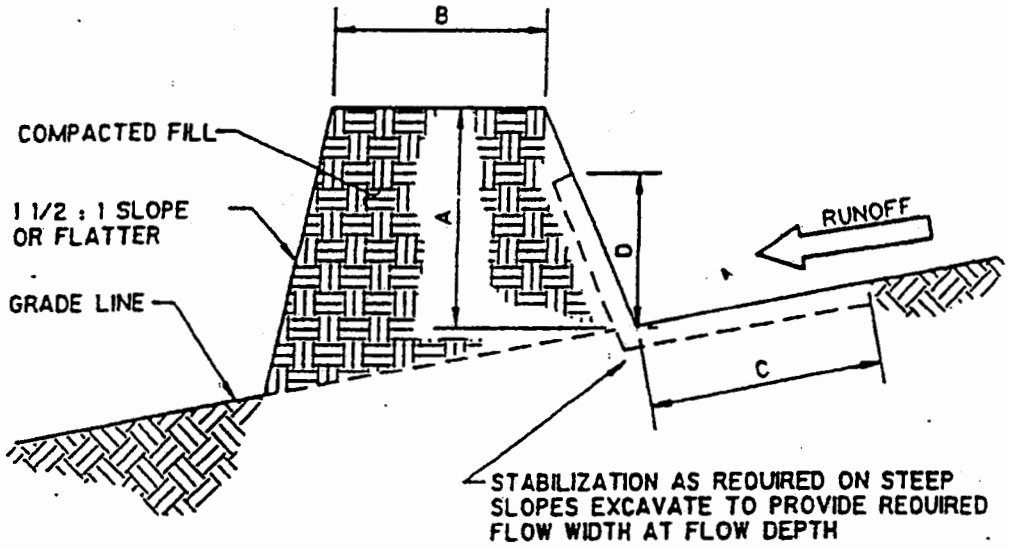
C. Approved equivalents can be substituted for any of the above materials.

7. Filter cloth may be used for dikes in use for long periods.

MAINTENANCE REQUIREMENTS

Inspection and required maintenance must be provided after each rain event.

DIVERSION DIKE	D.D. Symbol	**Exhibit M-6c**



REQUIREMENTS BASED ON UPSTREAM DRAINAGE AREA

	DIKE 1 (5 ACRES OR LESS)	DIKE 2 (5-10 ACRES)
A-DIKE HEIGHT	18"	36"
B-DIKE WIDTH	24"	36"
C-FLOW WIDTH	4'	6'
D-FLOW DEPTH	8"	15"

TEMPORARY DIVERSION DIKE

DIVERSION DIKE	D.D. Symbol	Exhibit M-6d

D. SWALE

DESCRIPTION

A temporary drainage way with a lining of grass, stone, asphalt, concrete, or other material. Permanent channels must be designed and constructed in accordance with appropriate local design standards.

PURPOSE

Drainage swales are used as perimeter controls or slope protection to convey runoff without causing erosion by intercepting runoff from above unprotected slopes or at the perimeter and directing the runoff to a stabilized outlet, sediment trapping device or stabilized outlet.

CONDITIONS WHERE PRACTICE APPLIES

* Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

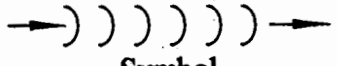
APPROPRIATE APPLICATION

Drainage swales are placed to divert upland flows away from a disturbed area or exposed slope and to direct on-site sediment-laden water to a trapping device. The temporary drainage swales must be on-site and maintain the historic drainage patterns for inflow and outflow from the site.

LIMITATIONS

Temporary drainage swales or any diversion of runoff should not adversely impact upstream or downstream properties and must conform to local floodplain management regulations.

- Constructing the proper swale to handle the desired runoff flows often requires engineering design work which can be costly.
- Swales can be expensive to construct if a liner is required.

DRAINAGE SWALE	D.S.  Symbol	**Exhibit M-7a**

PLANNING CONSIDERATIONS

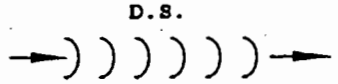
Drainage swales will effectively convey runoff and avoid erosion only if the proper type of geometry and lining is used. Care should be taken to assure that runoff leaving the swale is at non-erosive velocities.

- Drainage swales can transport large volumes of concentrated flows with little maintenance once established.

DESIGN & SIZING CRITERIA

In addition to other hydraulic design criteria presented in this manual, the following criteria must be met:

1. All temporary swales shall have uninterrupted positive grade to an outlet.
2. Diverted runoff from a disturbed area shall be conveyed to a sediment trapping device.
3. Diverted runoff from an undisturbed area shall outlet directly into an undisturbed stabilized area at non-erosive velocity.
4. 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 swale.
5. The swale shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities which will impede normal flow.
6. Fills shall be compacted by earth moving equipment.
7. All earth removed and not needed on construction shall be placed so that it will not interfere with the functioning of the swale.

DRAINAGE SWALE	D.S.  Symbol	**Exhibit M-7b**

D. SWALE

8. Stabilization shall be as per the chart below:

FLOW STABILIZATION

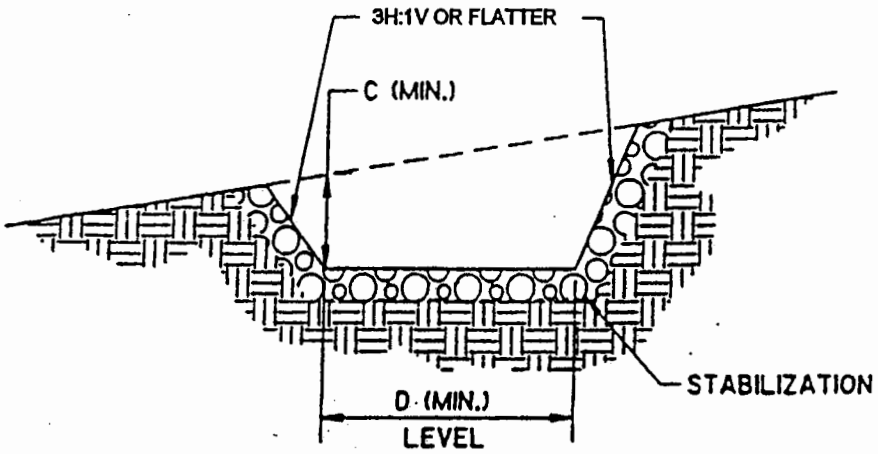
TYPE OF TREATMENT	CHANNEL GRADE	D50 Swale A (5 AC or Less)	D50 Swale B (5AC-10AC)
1	0.5-1.0%	4" Rock	4" Rock
2	1.1-2.0%	6" Rock	6" Rock
3	2-3%	8" Rock	Riprap 6-12"
4	3.1-5%	8-12" Rip-Rap	Engineered

MAINTENANCE

Periodic inspection and required maintenance must be provided after each rain event.

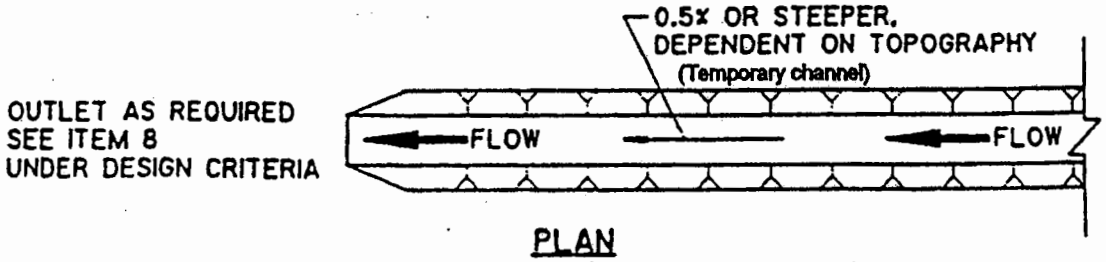
These temporary drainage swales are intended to fill with sediment during large storm events, and will require maintenance.

DRAINAGE SWALE	D.S. Symbol	Exhibit M-7c



	SWALE A	SWALE B
C	1'	1'
D	4'	6'

CROSS SECTION



PLAN

DRAINAGE SWALE

DRAINAGE SWALE	D.S. Symbol	Exhibit M-7d

DESCRIPTION

A comprehensive plan to limit off-site sedimentation by controlling the sites potential for producing air borne fugitive dust and track-out of sediments.

PURPOSE

Sediments which are transported from construction sites by stormwater runoff, wind, erosion and vehicle trackout are often re-dispersed to the air by subsequent vehicular traffic and high winds. Likewise, these sediments may be transported by the next rainfall into public storm sewer systems. Implementation of control measures to minimize the generation of fugitive dust from construction sites will also limit quantity of sediments in stormwater.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
* Sediment trapping
_ Drainageway & stream protection
* Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Primary sources of dust from development and construction activities are:

- Grading Operations (land clearing and earthmoving)
- Drilling and blasting
- Batch drop operations (loader operation)
- Exposed areas, cleared unstabilized area
- Vehicle traffic on unpaved surfaces
- Sediment tracking on paved surfaces
- Blasting and wrecking ball operations
- Soil and debris storage piles

DUST CONTROL	 Symbol	**Exhibit M-8a**

PLANNING CONSIDERATIONS

Many of the reasonably available control measures for controlling fugitive dust from construction sites can also be implemented as Best Management Practices for stormwater pollution prevention. Those best management practices include:

- Pave, vegetate, or chemically stabilize access points to paved roads.
- Provide covers for trucks transporting materials that contribute dust.
- Provide for wet suppression or chemical stabilization of exposed soils.
- Provide for rapid cleanup of sediments deposited on paved roads.
- Furnish stabilized construction road entrances and vehicle wash down areas.
- Stabilize unpaved haul roads, parking and staging areas.
- Implement dust control measures for material stockpiles.
- Prevent drainage of sediment-laden stormwater onto paved surfaces.
- Stabilize abandoned construction sites using vegetation or chemical stabilization methods.
- Limit the amount of areas disturbed by clearing and earth moving operations by scheduling these activities in phases.

The following Table, Dust Control Application provides guidance on the appropriate best management practices recommended for typical field operations and conditions

There are many products available as dust palliatives for chemically stabilizing gravel roadways and stockpiles. The types of chemicals available and recommendations for their use are tabulated in the chart of Commonly Used Dust Palliatives.

MAINTENANCE REQUIREMENTS

Dust control is an ongoing process during site construction. Re-application of dust control measure may be necessary until construction is complete.

DUST CONTROL	 Symbol	**Exhibit M-8b**

Symbol

Exhibit M-8c

TABLE: DUST CONTROL APPLICATORS

FIELD CONDITION	PERMANENT VEGETATION	MULCHING	WET SUPPRESSION (WATERING)	CHEMICAL DUST SUPPRESSION	GRAVEL OR ASPHALT SURFACING	SAND FENCES	TEMPORARY GRAVEL CONSTRUCTION ENTRANCES\ EQUIPMENT WASH DOWN	HAUL TRUCK COVERS	MINIMIZE EXTENT OF AREA DISTURBED
DISTURBED AREAS NOT SUBJECT TO TRAFFIC	X	X	X	X	X				
DISTURBED AREAS SUBJECT TO TRAFFIC			X	X	X				X
MATERIAL STOCK PILE STABILIZATION			X	X		X			
DEMOLITION			X				X	X	
CLEARING/ EXCAVATION			X	X					X
TRUCK TRAFFIC ON UNPAVED ROADS			X	X	X			X	
MUD/DIRT CARRYOUT					X		X		

DUST CONTROL

Symbol

Exhibit M-8d

COMMONLY USED CHEMICAL DUST PALLIATIVES

	SALTS	LIGNOSULFONATES	BITUMENS
	DELIQUESCENT AND HYDROSCOPIC CHEMICALS	ORGANIC NON-BITUMINOUS BINDERS	PETROLEUM BASED PRODUCTS[1]
CHEMICAL TYPES	• Calcium Chloride[2] • Magnesium Chloride • Natural Brines	• Calcium Lignosulfonate • Sodium Lignosulfonate • Ammonium Lignosulfonate	• Bunker Oil • Asphalt Primer • Emulsified Asphalt
LIMITATIONS	Can lose effectiveness in dry periods with low humidity. Leaches from road in heavy rain. Not recommended for gravel road surfaces with low fines. Recommended 10-20% fines.	Not affected by dry weather and low humidity. Leached from road in heavy rain if not sufficiently cured. Best performance on gravel roads with high surface fines (10-30%) and dense compact surface with no loose gravel.	Generally effective regardless of climatic conditions may pothole in wet weather. Best performance on gravel roads with 5-10% fines.
COMMENTS	Calcium Chloride is popular. May become slippery when wet on gravel surfaces with high fines.	Ineffective on gravel surfaces low in fines. May become slippery when wet on gravel surfaces with high fines content.	Creates a hardened crust.

[1]Motor oils and oil treatments are not recommended due to adverse effects on plant life and groundwater.

[2]Not recommended due to adverse effects on plant life.

DUST

DESCRIPTION

Installing natural or synthetic mattings on steep slopes and/or prepared vegetative seed beds.

PURPOSE

Erosion control matting is used to reduce rainfall impact, hold soil in place, and absorb and hold moisture near the soil surface. The matting may be used alone or with a mulch during the establishment of protective vegetative cover on critical slopes.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
* Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

In channels where designed flow exceed 3 fps; on steep slopes; when planting is likely to be slow; and on stream banks where flow is likely to wash out new vegetative plantings.

LIMITATIONS

Properly installed nettings provide excellent erosion control but do so at relatively high cost. Typically netting is used in areas of concentrated channel flow and steep slopes.

PLANNING CONSIDERATIONS

Matting strengths and uses vary; the manufacturer specifications should be followed. In most cases the matting alone is not acceptable for flow velocities greater than 6 fps. The matting provides additional protection for flow and for revegetation.

EROSION CONTROL MATTINGS	 Symbol	**Exhibit M-9a**

DESIGN & SIZING CRITERIA

Jute Mat - shall be cloth of a uniform plain weave of undyed and unbleached single jute yarn and weighing an average of 1.2 pounds per linear yard of cloth with a tolerance of plus or minus five (5) percent, with approximately 78 warp ends per width of cloth and 41 weft ends per linear yard of cloth. The yarn shall be of a loosely twisted construction having an average twist of not less than 1.6 turns per inch and shall not vary in thickness by more than ½ its normal diameter.

Straw Mat - shall be a machine produced mat consisting of 70% (±3%) agricultural straw and 30% (±3%) coconut fiber. The blanket shall be of consistent thickness with the straw and coconut fiber evenly distributed. The blanket shall be covered on the top side with polypropylene netting having an approximate 5/8" x 5/8" mesh containing ultraviolet additives to resist breakdown, and on the bottom with a polypropylene netting with an approximate ½" x ½" mesh. The blanket shall be sewn together with cotton thread.

Excelsior Mat - shall be wood excelsior, 48 inches in width plus or minus one inch and weighing 0.8 pound per square yard plus or minus ten percent. The excelsior material shall be covered with a netting to facilitate handling and to increase strength.

Glass Fiber Matting - of bonded textile glass fibers with an average fiber diameter of eight to twelve microns, two to four inch strands of fiber bonded with phenol formaldehyde resin. Mat shall be roll type, water permeable, minimum thickness ¼ inch, maximum thickness ½ inch, density not less than three pounds per cubic foot.

Other Mulch Nettings - such as paper, plastic, cotton or fiber glass matting shall be installed according to the manufacturer's recommendations.

Staples - for anchors shall be Number 11 gauge wire or heavier, and the length shall be six to ten inches, minimum

INSTALLATION

Site Preparation:

After the site has been shaped and graded to the approved design, prepare a friable seed bed relatively free from clods and rocks more than 1 ½ inches in diameter and any foreign

EROSION CONTROL MATTINGS	 Symbol	**Exhibit M-9b**

material that will prevent contact of the protective mat with the soil surface.

Planting:

Fertilize and seed in accordance with seeding or other type of planting plan. When using jute matting on a seeded area, apply approximately ½ the seed before laying the mat and the remainder after laying the mat. The protective matting can be laid over sprigged areas when grass has been planted. Where vines or other ground covers are to be planted, lay the protective matting first and then plant through matting.

Erosion Stops:

Erosion stops are made of glass fiber strips, excelsior matting strips or tightfolded jute. Matting blanket or strips should be used on steep, highly erodible sites. The stops are placed in narrow trenches six to twelve inches deep across the channel and left flush with the soil surface. They are to cover the full cross section of designed flow.

Laying and Securing Matting:

Before laying the matting, all erosion stops should be installed and the friable seed bed made free of clods, rocks, and roots. Most matting comes with manufacturer's recommendations for installation. The matting should be unrolled starting at the upper end of the channel, allowing a four-inch overlap of mattings along the center of channel. To secure, bury the top ends of matting in a narrow trench, minimum of six inch depth. Backfill trench and tamp firmly to conform to channel cross section. Secure with a row of staples about four inches down slope from trench with staples twelve inches apart.

Where matting crosses erosion stops, reinforce with a double row of staples, six- inch spacing, staggered pattern on either side of erosion stop. Likewise, overlaps joining the length of matting together and the discharge end of the matting liner should be similarly secured with a double row of staples.

Mechanical or manual laydown equipment shall be capable of handling full rolls of fabric, and laying the fabric smoothly, without wrinkles or folds. The equipment shall be in accordance with the fabric manufacturer's recommendations or as approved by the Engineer.

EROSION CONTROL MATTINGS	 Symbol	**Exhibit M-9c**

The surface upon which the separation fabric will be placed shall be compacted and finished according to the manufacturer's recommendations.

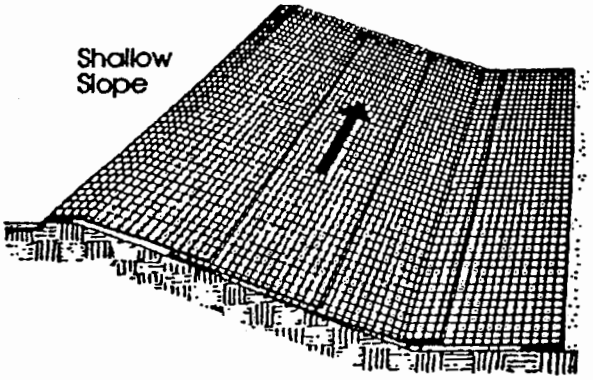
- Final Check:

  - Make sure matting is uniformly in contact with the soil.
  - All lap joints are secure.
  - All staples are flush with the ground.
  - All disturbed areas seeded

MAINTENANCE REQUIREMENTS

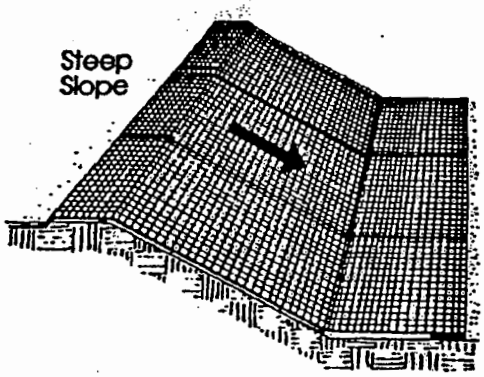
Inspect monthly and after each significant rainfall. Re-anchor loosened nettings and replace lost net and staples as required.

EROSION CONTROL MATTINGS	 Symbol	**Exhibit M-9d**



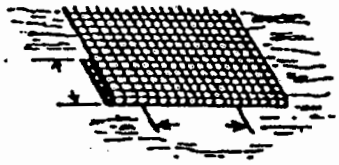
On shallow slopes, strips of netting may be applied across the slope.

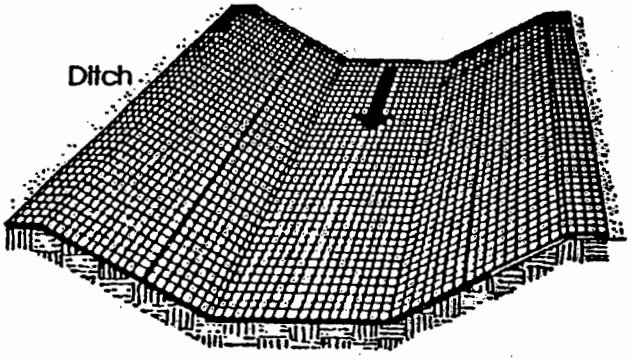
Where there is a berm at the top of the slope, bring the netting over the berm and anchor it behind the berm.



On steep slopes, apply strips of netting parallel to the direction of flow and anchor securely.

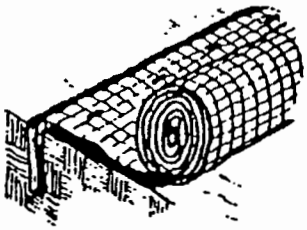
Bring netting down to a level area before terminating the installation. Turn the end under 6" and staple at 12" intervals.



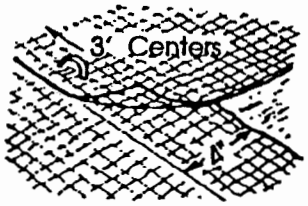


In ditches, apply netting parallel to the direction of flow. Use check slots every 15 feet. Do not join strips in the center of the ditch.

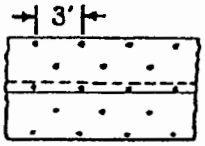
EROSION CONTROL MATTINGS	MAT Symbol	Exhibit M-9e

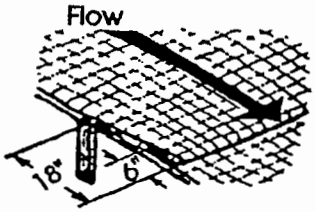


Anchor Slot: Bury the up-channel end of the net in a 6" deep trench. Tamp the soil firmly. Staple at 12" intervals across the net.

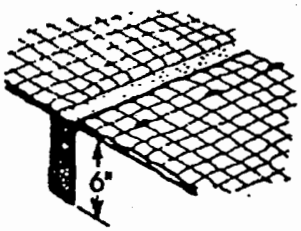


Overlap: Overlap edges of the strips at least 4". Staple every 3 feet down the center of the strip.

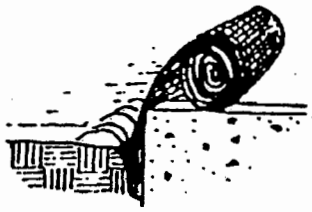




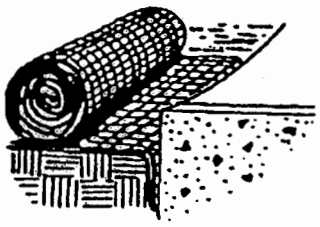
Joining Strips: Insert the new roll of net in a trench, as with the Anchor Slot. Overlap the up-channel end of the previous roll 18" and turn the end under 6". Staple the end of the previous roll just below the anchor slot and at the end at 12" intervals.



Check Slots: On erodible soils or steep slopes, check slots should be made every 15 feet. Insert a fold of the net into a 6" trench and tamp firmly. Staple at 12" intervals across the net. Lay the net smoothly on the surface of the soil - do not stretch the net, and do not allow wrinkles.



Anchoring Ends At Structures: Place the end of the net in a 6" slot on the up-channel side of the structure. Fill the trench and tamp firmly. Roll the net up the channel. Place staples at 12" intervals along the anchor end of the net.



EROSION CONTROL MATTINGS	MAT Symbol	Exhibit M-9f

DESCRIPTION

Establish a program of equipment maintenance procedures which will reduce contamination of on-site soils.

PURPOSE

Non-sediment stormwater pollution can occur through improper disposal of equipment fluids and disposables such as filters, batteries, and tires. An established program of maintenance procedures can prevent job site pollution and contamination of stormwater.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
* Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Applicable for large construction sites where heavy equipment and truck storage and maintenance yards are located on-site.

LIMITATIONS

Comply with local codes and ordinances regarding on-site equipment maintenance and disposal of fluids and consumables.

PLANNING CONSIDERATIONS

1. Properly dispose of or recycle used oils, hydraulic fluids, and gear lubricants. Do not dump fuels and lubricants into pits or on the ground. Never place used oil in a dumpster or pour down a storm drain.

2. Properly dispose of or recycle used batteries.

EQUIPMENT MAINTENANCE PROCEDURES	(E.M.P.) Symbol	**Exhibit M-10a**

3. Do not bury used tires.

4. Do not dispose of extra paints and coatings by dumping liquid onto the ground or throwing in dumpsters. Allow coatings to dry or harden before disposal into covered dumpsters.

5. Repair leaks of hydraulic fluids, oils, and other fluids as soon as possible.

6. Use steam or high pressure water instead of thinners and solvents to wash down heavy equipment. Locate the wash down area in a contained area, and dispose of wash water and detergents to the sanitary sewer system only after grit is removed.

7. Provide spill containment dikes and stored oil and chemical drums.

MAINTENANCE REQUIREMENTS

1. Maintain waste oil containers in leak proof condition.

2. Clean equipment radiators to maximize cooling efficiency and prevent boil overs.

3. Inspect equipment for damaged hoses and leaky gaskets daily. Repair or replace as needed.

DESCRIPTION

A temporary berm constructed of open graded rock installed at the toe of a slope, or the perimeter of a developing or disturbed area

PURPOSE

To intercept and detain sediment laden water from an unprotected area, detain the sediment and release the water in sheet flow.

CONDITIONS WHERE PRACTICE APPLIES

* Perimeter control
_ Slope protection
* Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Where a temporary measure is needed to retain sediments such as:

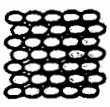
- Near the toe of slopes.
- At construction site perimeters.
- May be used as check dams across one or more lanes of construction traffic temporary roads, or unsurfaced rights of way subject to construction traffic.

♦ Advantages:

- May be less costly than other temporary barriers.
- Relatively efficient at Sediment Removal.

♦ Disadvantages:

- Removal of temporary gravel berms may be difficult.

GRAVEL FILTER BERM	G.F.B.  Symbol	Exhibit M-11a

LIMITATIONS

- Maximum drainage area, 5 acres.
- Not recommended to be built on landscaped areas due to the difficulty of clean up.

PLANNING CONSIDERATIONS

- Construct along a level contour for intercepting sheet flow.
- Provide an undisturbed or stabilized outlet suitable for sheet flow.
- Allow ample room for sediment removal equipment between the berm and toe-of-slope.
- Installation in stream beds requires large rock, staking of woven wire sheathing, and daily inspection.

DESIGN & SIZING CRITERIA

In Non-Traffic Areas:

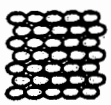
- Maximum flow through rate per square foot of berm = 60 gpm
- Height = 18 inches minimum
- Top width = 24 inches minimum
- Side slopes = 2:1 or flatter
- Build on a level contour.
- Rock: 3/4 inch to 3 inches open graded for sheet flow and 3 to 5 inches open graded for concentrated flow.

In Construction Traffic Areas:

- Height = 12 inches maximum
- Provide multiple berms in series, as shown.

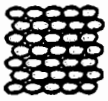
-every 300 feet on slopes less than 5 percent
-every 200 feet on slopes 5 to 10 percent

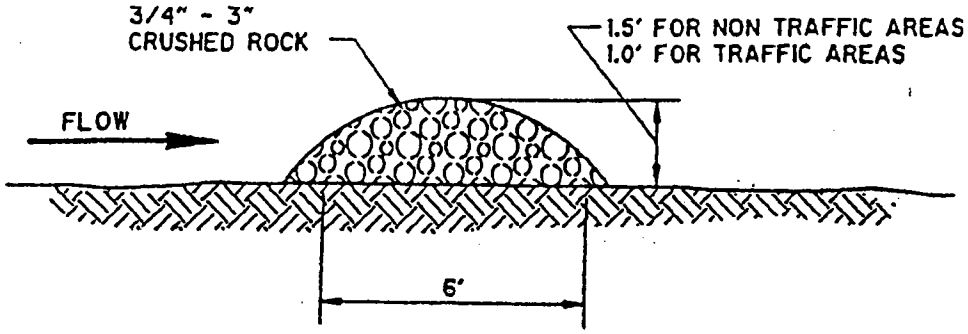
-every 100 feet on slopes greater than 10 percent

GRAVEL FILTER BERM	G.F.B.  Symbol	Exhibit M-11b

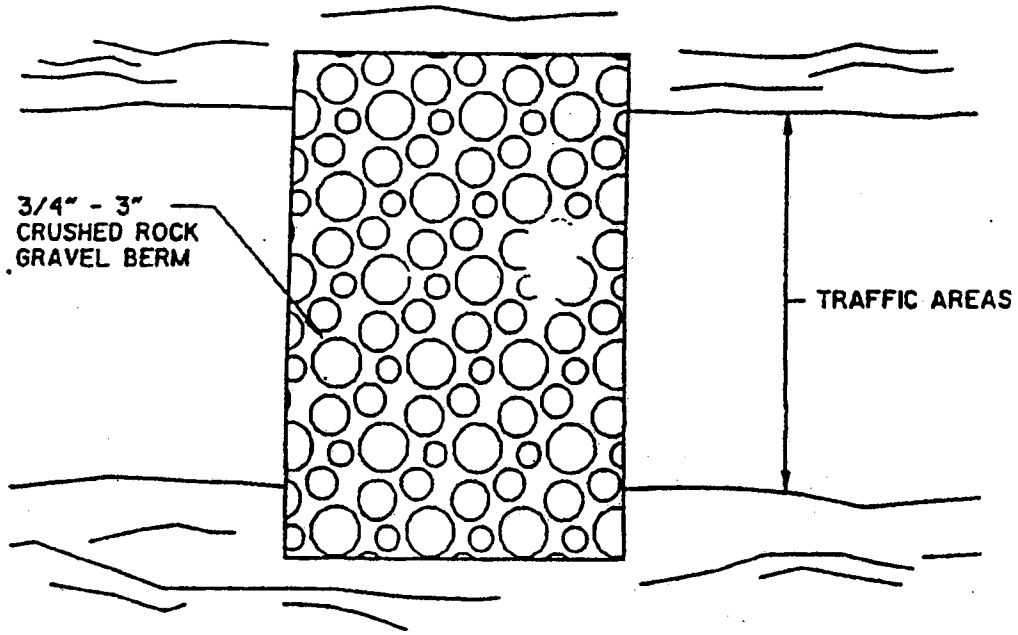
MAINTENANCE REQUIREMENTS

- Remove retained sediments when depth reaches 1/3 of berm height or 1 foot, whichever occurs first.
- Inspect monthly and after each rainfall. Reshape berm as needed, replace lost or dislodged rock
- Remove gravel filter berm at the end of construction

GRAVEL FILTER BERM	**G.F.B.**  Symbol	**Exhibit M-11c**

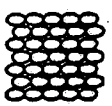


SECTION



PLAN

GRAVEL FILTER BERM

GRAVEL FILTER BERM	G.F.B.  Symbol	**Exhibit M-11d**

MULCH

DESCRIPTION

Providing a stabilized surface for seeding and/or prevention of erosion. Mulches include organic materials, straw, wood chips, bark or other wood fibers, decomposed granite, gravels, a variety of netting or mats of organic or non-organic materials, and chemical soil stabilization.

PURPOSE

The purposes of using mulch are: (a) prevent erosion by protecting the soil surface from raindrop impact and reducing the velocity of overland flow and (b) to foster the growth of vegetation by increasing available moisture and providing insulation against extreme heat and cold.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
* Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

1. Areas which have been permanently seeded should be mulched immediately following seeding.
2. Areas which cannot be seeded because of the season, but will be seeded at a later date should be mulched to provide some protection to the soil surface. An organic mulch (not wood fiber alone) shall be used, and the area then seeded as soon as feasible in spring.
3. Mulch should be used together with plantings of trees, shrubs, or certain ground covers which do not provide adequate soil stabilization by themselves.
4. Mulch should be used in conjunction with temporary seeding operations when climatic conditions allow or temporary irrigation is provided.

MULCHING	 Symbol	Exhibit M-12a

LIMITATIONS

Mulching is appropriate for temporary or permanent methods of erosion control. Organic mulches, straw and wood fiber are appropriate in landscaped or revegetated areas as temporary controls. Permanent mulches more appropriate for arid regions include gravels and decomposed granite.

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 runoff 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 wood fiber, have been found to be the most effective where re-vegetation will be provided by reseeding.

Chemical soil stabilizers are less effective mulches when used alone. These materials are useful to bind organic mulches together or to stabilize flat areas such as roadways. Decomposed granite, gravels and bark are effective as ground cover in landscaped areas.

A variety of nets and mats have been developed for erosion control in recent years, and these are also used as mulches, particularly in critical areas such as waterways. They 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, landscape requirements, and economics.

DESIGN CRITERIA

Mulching consists of furnishing all materials, preparing the soil surface and applying the mulch to all soil surface areas designated on the project plans or established by the Engineer.

MULCHING	 Symbol	**Exhibit M-12b**

MATERIALS

Compliance with the requirements of Subsection 213.02 of the 1991 CDOT Standard Specifications for Road and Bridge Construction is recommended.

WOOD FIBER MULCH: Wood fiber mulch shall consist of a specially prepared wood fiber processed to contain no growth or germination inhibiting factors. The mulch shall be from virgin wood and be manufactured and processed so the fibers will remain in uniform suspension in water under agitation to form a homogeneous slurry.

STRAW MULCH: Straw mulch shall be from the current season's crop. A letter of certification from the supplier shall be required to show that the straw was baled less than 12 months from the delivery date.

EMULSIFIED ASPHALT: Emulsified asphalt shall be type SS-1 or CSS-1.

BINDER: Binder shall be free flowing, noncorrosive powder produced from natural plant gum marketed under M-Binder, M145 Binder, AZTAC or approved equal.

PREPARATION/METHODS AND EQUIPMENT

The equipment and methods used to distribute mulching materials shall be such as to provide an even and uniform application of mulch and/or other materials at the specified rate. The mulch can be spread by hand or by mulch-blowing equipment.

APPLYING MULCH: Mulch shall be immediately affixed by either crimping or tacking. The Engineer shall determine which areas are not conducive to anchoring by crimping and will direct the contractor to anchor such mulch by tacking.

Within 24 hours after each area is planted, straw mulch shall be uniformly applied at the rate of approximately 2-1/2 tons per acre for crimped areas and 1-3/4 tons per acre for tacked areas.

ANCHORAGE BY CRIMPING: Mulch shall be anchored into the soil with a heavy disc with flat, serrated discs at least 1/4 inch thick having dull edges and spaced no more than nine inches apart. Mulch shall be anchored to a depth of at least two inches and shall not be covered with an excessive amount of soil. Anchoring operations shall be across the slopes where practical with no more than two passes of the anchoring

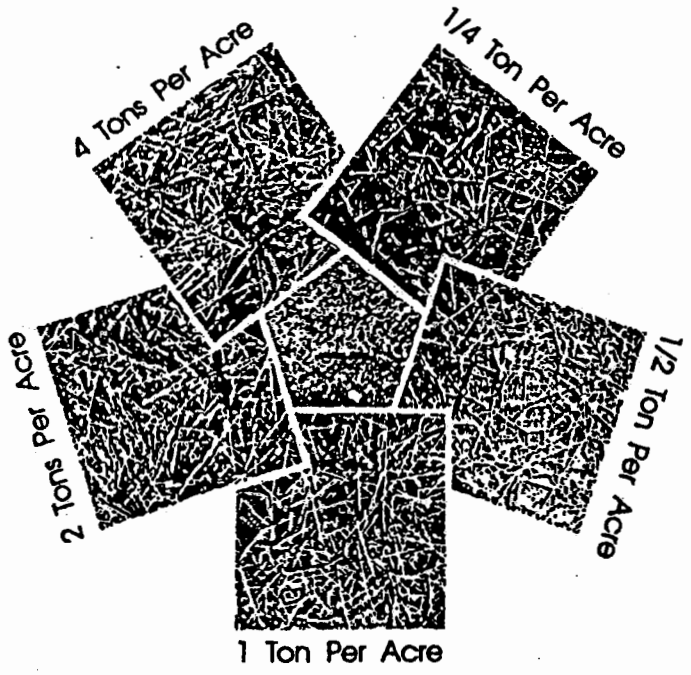
MULCHING	 Symbol	**Exhibit M-12c**

equipment. Immediately following the crimping operation the crimped area shall be tacked as specified under Anchorage by Tacking.

ANCHORING BY TACKING: Mulch shall be anchored by tacking using either emulsified asphalt uniformly applied at the rate of approximately 500 gallons per acre or a slurry consisting of a minimum of 150 pounds of binder, 400 pounds of wood fiber mulch, and 700 gallons of water per acre.

MANTENANCE REQUIREMENTS

Maintenance requirements will vary greatly based upon the type of mulch used and the type of vegetation to be established. Mulches are not usually intended to be permanent; but are extended only as a base for re-seeding or revegetation. Where a permanent anchor for vegetation is required, along steep slopes or areas of higher velocity flows, then a geotextile mat or net is recommended.



MULCHING	MU Symbol	Exhibit M-12d

DESCRIPTION

Protection of desirable trees from mechanical and other injury while the land is being developed.

PURPOSE

To employ the necessary protective measures to insure the survival of desirable trees for shade, beautification, and vegetative cover.

CONDITIONS WHERE PRACTICE APPLIES

* Perimeter control
_ Slope protection
_ Sediment trapping
* Drainageway & stream protection
_ Temporary stabilization
* Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Criteria for deciding upon the trees to remain on site:

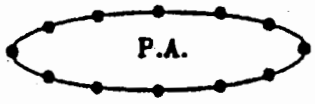
- Aesthetic values: Foliage, crown characteristics, texture.
- Freedom from disease and rot.
- Life span of trees: Some are considered short-lived trees.
- Environmental values: Habitat; screening; and buffers.
- Space needed: For future growth and relationship to structures, utilities, driveways and streets.

EFFECTIVENESS:

Mature trees have extensive root systems that help to hold soil in place thus reducing erosion.

ADVANTAGES:

Saving existing mature trees on site beautifies the area and saves money by limiting the number of new trees required to be planted.

PROTECTION OF TREES/NATURAL AREA IN CONSTRUCTION AREAS	 Symbol	**Exhibit M-13a**

LIMITATIONS

Tree protection can be implemented on most construction projects where trees are present. For sites with diverse topography, it is often difficult and expensive to save existing trees while grading the site satisfactorily for the planned development.

PLANNING CONSIDERATIONS

Methods for protecting existing trees:

- Stake off root system limits (drip line of tree).
- Fence off tree along the drip line.
- Flag or mark trees to remain in place.
- Tree wells and retaining walls (permanent).

DESIGN & SIZING CRITERIA

Protecting existing trees with "Tree Wells." The work under this item shall consist of the materials required to construct tree wells as necessary based upon long term protection requirements and as shown on landscape plans (see Tree Well Detail on sheet d of this exhibit).

Rock Mulch

Rock mulch shall be in accordance with the following gradation:

Sieve Size	Percent Passing
3 inch	75-100
2 inch	25-75
1.5 inch	0-25

Wall Construction Rocks

The rock shall be clean, durable, free from segregations, seams, cracks and other structural defects or imperfections as approved by the Engineer, and shall meet the following gradation:

Sieve Size	Percent Passing
12 inch	75-100
8 inch	25-75
6 inch	0-25

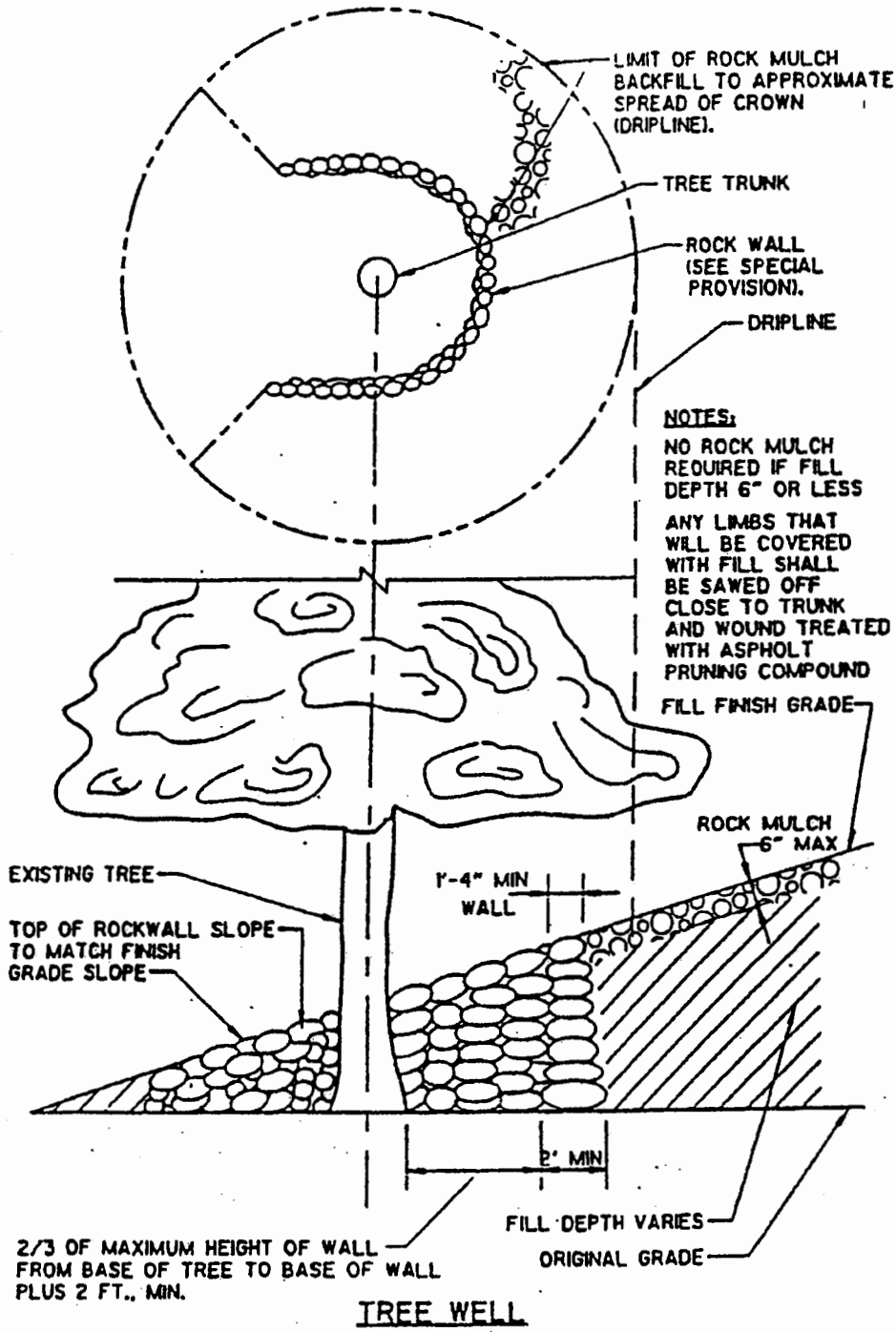
PROTECTION OF TREES/NATURAL AREA IN CONSTRUCTION AREAS	 Symbol	**Exhibit M-13b**

Mortar shall consist of one part portland cement and two parts fine aggregate by volume. Hydrated lime shall conform to the requirements of ASTM C-207, Type N, to the extent of 10% by volume of cement, may be added to the mortar. Hydrated lime shall be treated as an additive and not a replacement for cement.

MAINTENANCE REQUIREMENTS

Maintenance requirements are low. During construction the limits of grading or disturbance should be clearly marked at all times. Irrigation or maintenance of native trees or vegetation should conform to specifications on the Landscape Plan.

PROTECTION OF TREES/NATURAL AREA IN CONSTRUCTION AREAS	 Symbol	**Exhibit M-13c**



TREE WELL

PROTECTION OF TREES/NATURAL AREA IN CONSTRUCTION AREAS	P.A. Symbol	**Exhibit M-13d**

DESCRIPTION

A section of rock protection placed at the outlet end of culverts, conduits or channels. Grouted riprap and concrete rubble are also used for pipe outlet stabilization.

PURPOSE

The purpose of the rock outlet protection is to reduce the velocity, and energy of water, such that the flow will not erode the receiving downstream reach.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
_ Sediment trapping
* Drainageway & stream protection
* Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

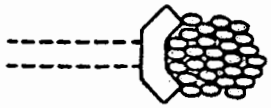
APPROPRIATE APPLICATIONS

This practice applies where discharge velocities and energies at the outlets of culverts, conduits or channels are sufficient to erode the next downstream reach.

Rock outlet protection is usually less expensive and easier to install than concrete aprons or energy dissipators. It also serves to trap sediment and reduce flow velocities. Rock size should be increased for high velocity flows.

LIMITATIONS

Rock outlet protection may need continual maintenance because large storms often wash away the stone and leave the area susceptible to erosion. Grouted or wire-tied rock riprap can minimize maintenance requirements.

ROCK OUTLET PROTECTION	 Symbol	**Exhibit M-14a**

PLANNING CONSIDERATIONS

Rock outlet protection is effective when the rock is sized and placed properly. When this is accomplished, rock outlets do much to limit erosion at pipe outlets. If runoff is sediment-laden, a sediment trap below the pipe outlet is recommended.

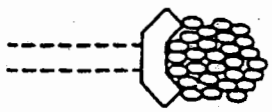
Permanent rock riprap protection should be designed and sized by the engineer as part of the culvert, conduit or channel design.

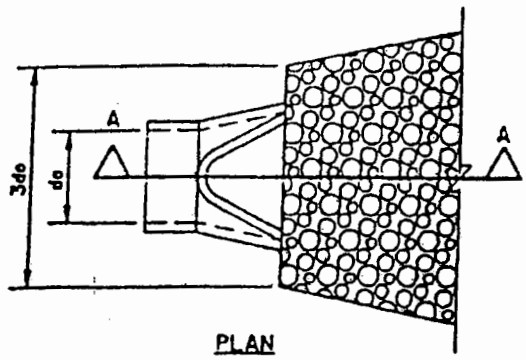
DESIGN & SIZING CRITERIA

General recommendations for rock size and length of outlet protection mat shown in the rock outlet protection figure. Best results are obtained when sound, durable, angular rock is used.

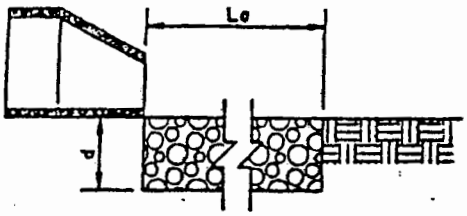
MAINTENANCE

Inspect monthly and after each rainfall. Replace rocks as needed.

ROCK OUTLET PROTECTION	 Symbol	**Exhibit M-14b**

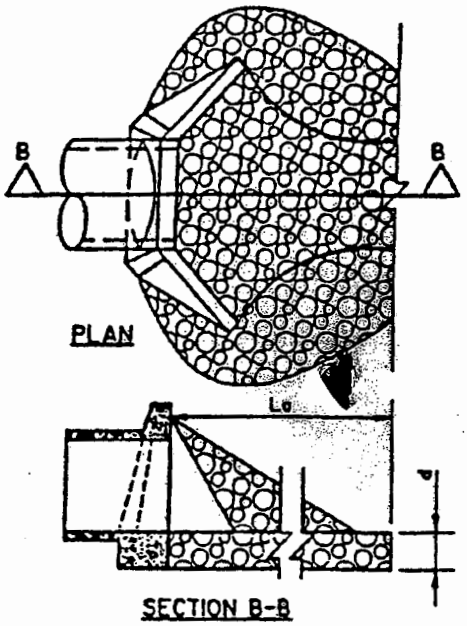


PLAN



SECTION A-A

PIPE OUTLET TO FLAT AREA
WITH NO DEFINED CHANNEL



PLAN

SECTION B-B

PIPE OUTLET TO WELL-DEFINED CHANNEL

NOTES

1. APRON LINING MAY BE RIPRAP, GROUTED RIPRAP, OR CONCRETE.
2. WHEREAS TECHNICAL DESIGN PROCEDURES EXIST FOR DETERMING La, USE THE FOLLOWING TABLE FOR TEMPORARY ROCK OUTLET PROTECTION.

PIPE SIZE	AVERAGE ROCK DIA.	La
12"	6"	12'
15"	10"	18'
18"	12"	21'
21"	15"	25'
24"	15"	30'

3. d = 1.5 TIMES THE MAXIMUM STONE DIAMETER BUT NOT LESS THAN 6 INCHES.

PIPE OUTLET CONDITIONS

ROCK OUTLET PROTECTION	Symbol	Exhibit M-14c

DESCRIPTION

A temporary berm constructed of stacked sandbags installed across a channel or right of way in a developing.

PURPOSE

The purpose of a sandbag berm is to intercept sediment-laden water from disturbed areas.

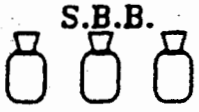
CONDITIONS WHERE PRACTICE APPLIES

* Perimeter control
_ Slope protection
* Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Sandbag berms may be used during construction activities in stream beds and utility construction in channels, temporary channel crossing for construction equipment, etc. Sandbag berms may also be installed parallel to roadway construction. Sandbag berms may also be used to create temporary sediment traps, retention basins and in place of straw bales or silt fences. Examples of applications include:

- Check dams across stream channels.
- Barrier for utility trenches or other construction in a stream channel.
- Temporary channel crossing.
- Barrier on a slope in place of straw bales or silt fences.
- Direct or divert flow.
- Create temporary sediment basin or retention basin.
- Near the toe of slopes.
- At construction perimeter.

SANDBAG BERM	S.B.B.  Symbol	**Exhibit M-15a**

- Advantages:
  - Provides a semi-permeable barrier in potentially wet areas.
  - More permanent than silt fences or straw bales.
  - Allows for easy relocation on site to meet changing needs during construction.

LIMITATIONS

Use should be restricted to construction of low berms 18 inches or less.

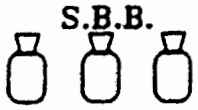
PLANNING CONSIDERATIONS

Sandbag berms are appropriate to use when construction of check dams or sumps in a stream is undesirable. The sandbag berms can provide the same function as a check dam without disturbing the stream or vegetation. The sandbag berm will also allow a small sediment retention area to be created prior to construction of final detention basins.

DESIGN & SIZING CRITERIA

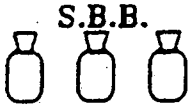
For installation of a sandbag berm, the following criteria shall be observed.

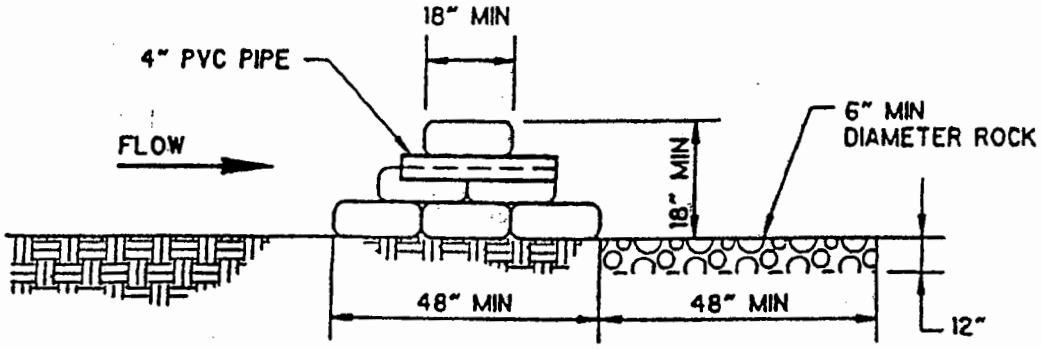
- Drainage Area - Less than 10 acres.
- Height of Berm - 24 inches maximum height, measured from the top of the existing ground at the upslope toe to the top of berm.
- Width of Berm - 48 inches minimum width measured at the bottom of the berm; 18 inches at the top.
- Sandbag Size - Length 24 to 30 inches, width 16 to 18 inches and thickness six (6) to eight (8) inches. Weight 90 to 125 pounds.
- Sandbag Material - Polypropylene, polyethylene or polyamide woven fabric, minimum unit weight four ounces per square yard, mullen burst strength exceeding 300 psi and ultraviolet stability exceeding 70 percent.
- Grade of Sand- Coarse sand, gravel.
- Runoff water shall flow over the tops of the sandbags or through four (4) inch pipes embedded below the top layer of bags.

SANDBAG BERM	**S.B.B.**  Symbol	**Exhibit M-15b**

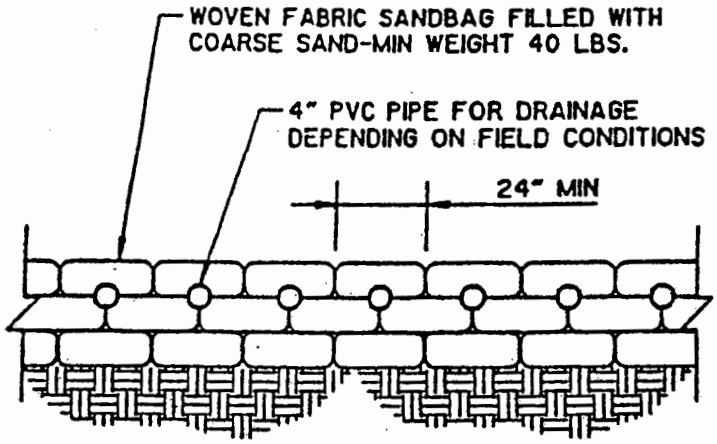
MAINTENANCE REQUIREMENTS

- The sandbag berm shall be inspected after each rain. The sandbags shall be reshaped or replaced as needed during inspection. Additional inspections shall be made daily by the responsible party.
- When silt depth reaches 6", remove and properly dispose of accumulated sediments.

SANDBAG BERM	S.B.B.  Symbol	**Exhibit M-15c**



CROSS-SECTION



FRONT VIEW

SANDBAG BERM

SANDBAG BERM	**S.B.B.** Symbol	**Exhibit M-15d**

DESCRIPTION

A temporary basin with a controlled storm water release structure formed by constructing an embankment of compacted soil across a drainageway, or other suitable locations.

PURPOSE

To collect and store sediment from sites cleared and/or graded during construction or for extended periods of time before reestablishment of permanent vegetation and/or construction of structures. It is intended to help prevent damaging erosion on the site which results in silt-laden runoff. The basin is a temporary measure (with a design life less than 1 year) and is to be maintained until the site area is permanently protected against erosion or a permanent detention basin is constructed.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
* Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Sedimentation basins are suitable for nearly all types of construction projects. Basins should be located at the stormwater outlet from the site. A typical application would include temporary dikes (berms) and/or channel to divert runoff to the basin inlet.

Many development projects will be required to provide a storm water detention basin which may be easily adapted to service as a sedimentation pond.

LIMITATIONS

Sediment basins and ponds must be installed only within the property limits where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment basins and ponds are attractive

SEDIMENT BASIN	 Symbol	**Exhibit M-16a**

to children and can be very dangerous. Local ordinances regarding health and safety must be adhered to. If fencing of the pond is required, the type of fence and its location shall be shown on the SWMP.

- Generally temporary sedimentation basins are for disturbed upstream drainage areas of 10 acres or more.
- Because of additional detention time, sediment ponds may be capable of trapping smaller sediment particles than traps. However, they are most effective when used in conjunction with other BMPs such as seeding or mulching.
- Ponds may become an "attractive nuisance" and care must be taken to adhere to all safety practices.
- Sediment ponds are only practically effective in removing sediment down to about the medium silt size fraction. Sediment-laden runoff with smaller size fractions (fine silt and clay) will pass through untreated emphasizing the need to control erosion to the maximum extent first.

PLANNING CONSIDERATIONS

♦ Effectiveness

- Sediment basins are at best only 70-80 percent effective in trapping sediment which flows into them. 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.

- Whenever possible, construct the sedimentation basins before clearing and grading work begins.

♦ 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 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 stream but should be located to trap sediment-laden runoff before it enters the 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.

SEDIMENT BASIN	 Symbol	**Exhibit M-16b**

♦ DESIGN & SIZING CRITERIA

The sediment basin may be formed by partial excavation and/or by construction of a compacted embankment. It may have one or more inflow points carrying polluted runoff. Baffles to spread the flow throughout the basin should be included. A securely anchored riser pipe is the principal discharge mechanism along with an emergency overflow spillway. The riser pipe shall be solid with two 1-inch diameter dewatering holes located at the top of the sediment storage volume on opposite sides of the riser pipe as shown in the attached Figure. Outlet protection is provided to reduce erosion at the pipe outlet.

- The sediment pond volume is the sum of the sediment storage (1 foot in depth) plus a settling volume of 2 to 4 feet in depth. The total volume is 3,600 cubic feet per acre of upstream disturbed soil for a sediment basin.

Computing the settling zone volume: The settling zone volume may be approximated by assuming a 2 foot depth above the sediment storage volume and extending the 3:1 side slopes as necessary, or by computing the precise volume as outlined below. The maximum settling zone depth shall be 4 feet.

Pond surface area:

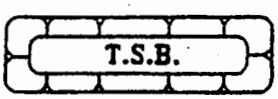
The settling zone volume is determined by the pond surface area which is computed using the following equation: $(SA) = 1.2Q_2 / V_{SED}$

Provide a minimum of 3600 cubic feet total volume per acre of drainage.

The settling velocity of the design soil particle which is medium silt (0.02 mm) has a settling velocity (V_{SED}) Of 0.00096 ft/sec. As a rule it will not be necessary to use a particle size of less than 0.02 mm for a temporary sediment basin. Note that in choosing V_{SED} of 0.00096 ft/sec the surface area equates to a surface area (SA) of 1250 sq. ft. per cfs of inflow.

Settling depth (SD) should not be less than 2 feet and is also governed by the sediment storage volume surface area and relationship to the basin length (L). The basin length is defined as the average distance from the inlet to the outlet of the pond.

The ratio of L/SD should be less than 200.
The settling volume is therefore the surface area (SA) times (SD), required settling depth.

SEDIMENT BASIN	 Symbol	Exhibit M-16c

To complete the design of the sediment pond:

Total sediment pond volume and dimension are determined as outlined below:

a The details shown in the attached figure may be useful in designing the sediment pond.

b. Determine pond geometry for the sediment storage volume calculated above using 3 feet in depth and 3:1 side slopes from the bottom of the basin. Note, the basin bottom is level.

c. Extend the pond side slopes (at 3:1 max.) as necessary to obtain the settling zone volume at 2 foot depth minimum or as determined above.

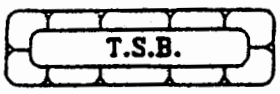
d. Adjust the geometry of the basin to effectively combine the settling zone volume and sediment storage volumes while preserving the depth and side slope criteria.

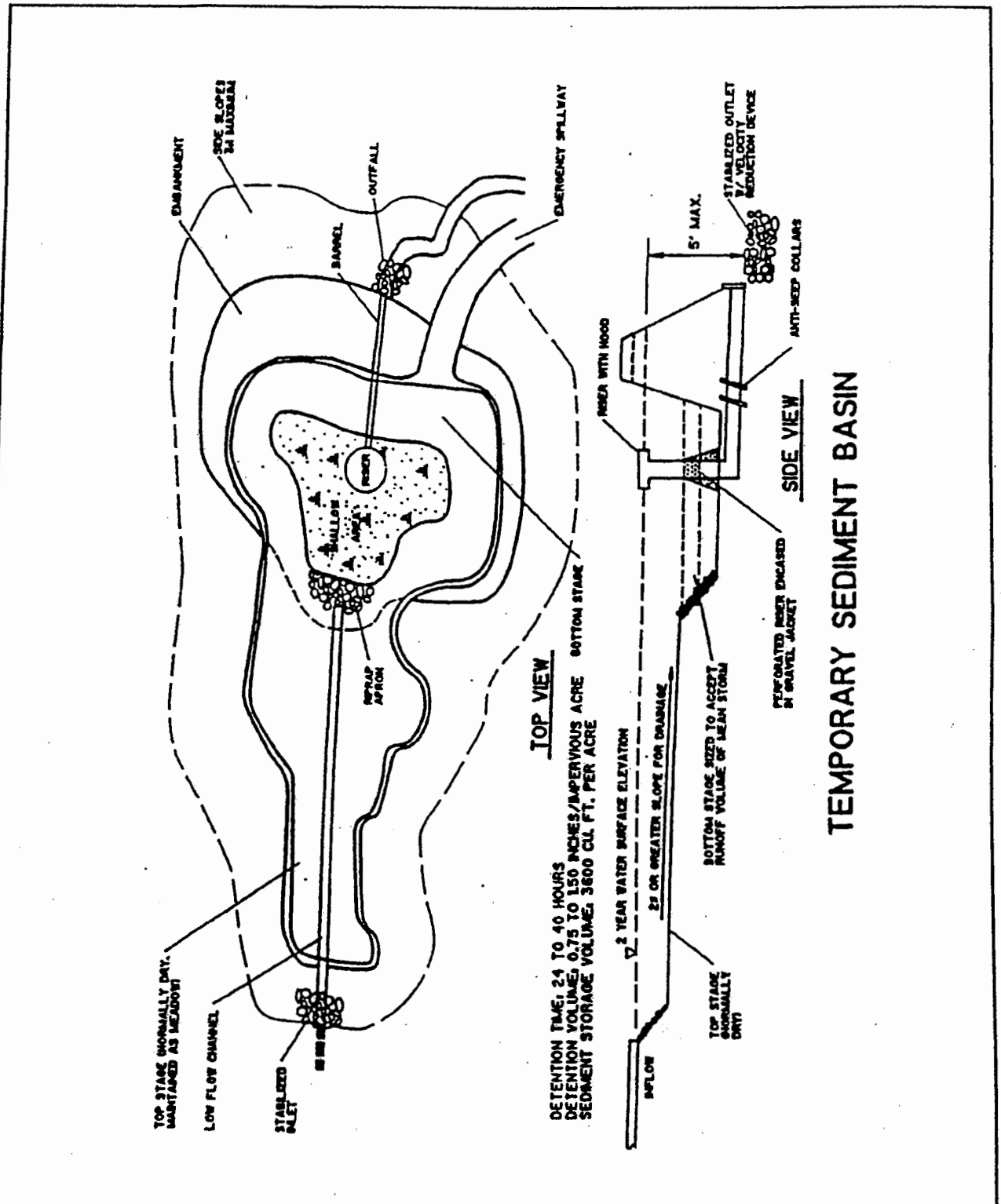
e. Provide an emergency spillway with a crest elevation 1 foot above the top of the riser pipe.

f. Provide baffles to prevent short-circuiting A 6:1 aspect ratio between the basin length and width of the pond is desirable.

MAINTENANCE REQUIREMENTS

Inspections should be made regularly, especially after each storm event of 0.5 inches or more. Sediment should be removed when it fills one half of the pond's total sediment storage area The effectiveness of a sediment pond is based less on its size than on regular sediment removal.

SEDIMENT BASIN	 Symbol	Exhibit M-16d



SEDIMENT BASIN	T.S.B. Symbol	Exhibit M-16e

DESCRIPTION

A small temporary ponding area, with a gravel outlet, formed by excavation and/or by constructing an earthen embankment.

PURPOSE

To collect and store sediment from sites cleared and/or graded during construction. It is intended for use on relatively small building areas, with no unusual drainage features, and projected quick build-out time. It should help in reducing silt-laden runoff The trap is a temporarv measure (with a design life of approximately 6 months) and is to be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
* Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Proposed building sites where the tributary drainage area is less than 10 acres. Typically installed in a drainageway and/or point of discharge from a disturbed area

LIMITATIONS

1. Serves only limited areas.

2. Sediment traps are only practically effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

SEDIMENT TRAP	**S.T.** Symbol	**Exhibit M-17a**

PLANNING CONSIDERATIONS

Sediment traps should be used only for small drainage areas. If the contributing drainage area is greater than 10 acres, refer to Sediment Basins, or subdivide the catchment area into smaller drainage basins.

Sediment must be removed from the trap after each rainfall event Plans shall detail how this sediment is to be disposed of, such as by use in fill areas onsite, or removal to an approved off-site dump. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Sediment traps and ponds must be installed only on sites where failure of the structure would not result in loss of life, damage to home or buildings, or interruption of use of or service public roads or utilities. Also, sediment traps and ponds are attractive to children and can be dangerous. The following recommendations should be implemented to reduce risks.

1. Install continuous fencing around the sediment trap or pond. Consult local ordinances regarding requirements for maintaining health and safety.
2. Restrict basin side slopes to 3:1 or flatter (temporary basin).

DESIGN & SIZING CRITERIA

The sediment trap may be formed completely by excavation or by construction of a compacted embankment. It shall have a 1.5 foot deep sump for sediment storage. The outlet shall be a weir/spillway section, with the area below the weir acting as a filter for sediment and the upper area as the overflow spillway depth.

The effectiveness of sediment traps is directly related to the size of the trap. In Maricopa County the recommended sediment trap size is 3600 cubic feet per acre of disturbed upstream drainage area for drainage areas of 10 acres or less. This roughly equates to a trap volume necessary to pond the precipitation from a 1 inch rain event.

After determining the necessary volume, size the trap by adding an additional 1 ½ feet for sediment accumulation to the volume computed.

SEDIMENT TRAP	**S.T.** Symbol	**Exhibit M-17b**

To complete the design of the temporary sediment trap:

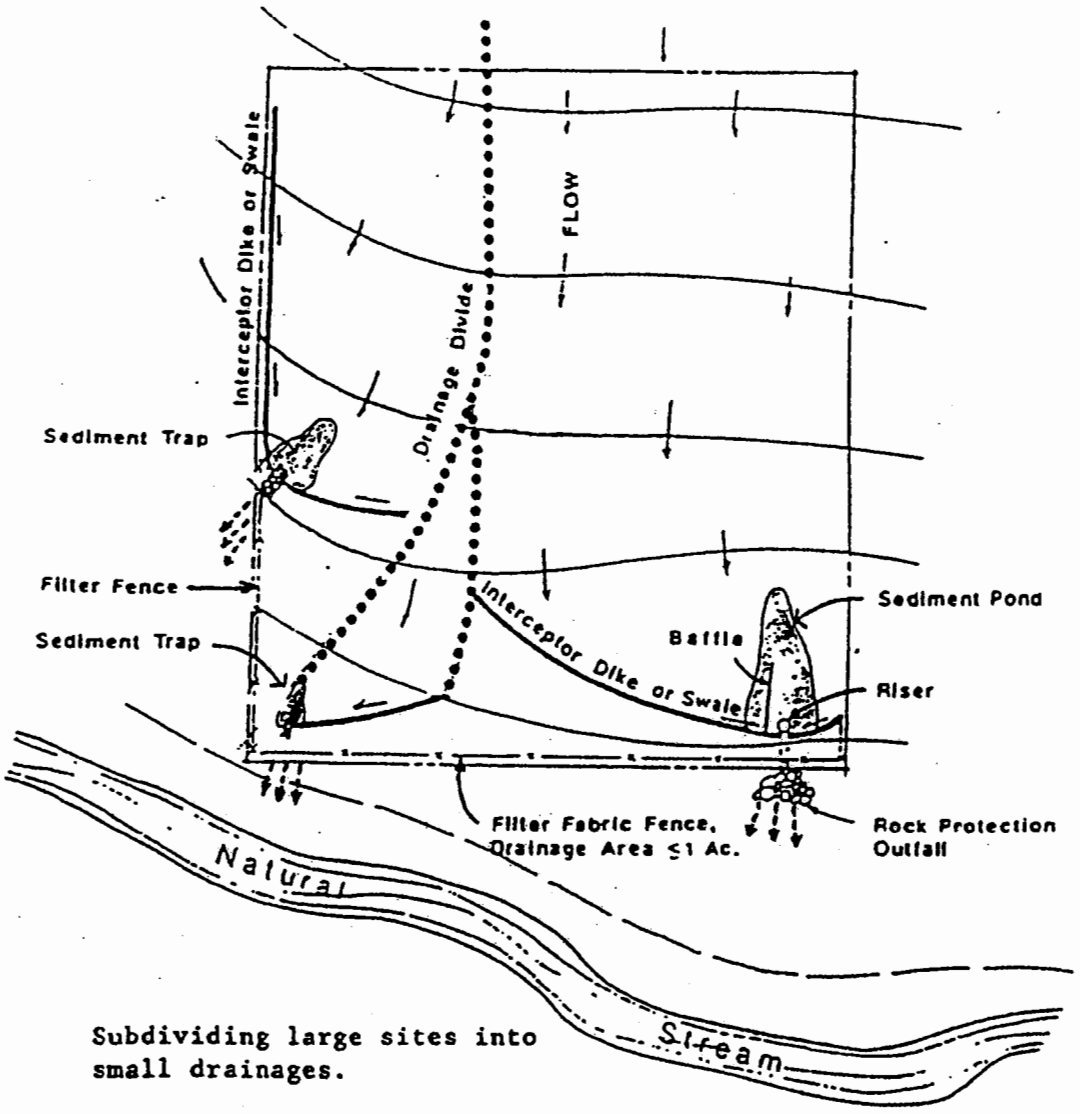
a. Calculate required trap volume
   Required Volume = 3600 cubic feet per acre

b. A 3:1 or flatter aspect ratio between the trap length and width of the trap is desirable. Length is defined as the average distance from the inlet to the outlet of the trap.
c. Determine the bottom and top surface area of the sediment storage volume to be provided using 1 feet in depth for sediment storage, 2 feet settling depth and 3:1 side slopes from the bottom of the trap. Note the trap bottom should be level.
d. Determine the total trap dimensions by adding the depth required for the 2-year, 24-hour design storm above the surface of the sediment storage volume, while not exceeding 3:1 side slopes (see attached figure).
   Required Depth = 31 ½ feet (2 feet settling depth and 1 ½ feet sediment storage)

MAINTENANCE REQUIREMENTS

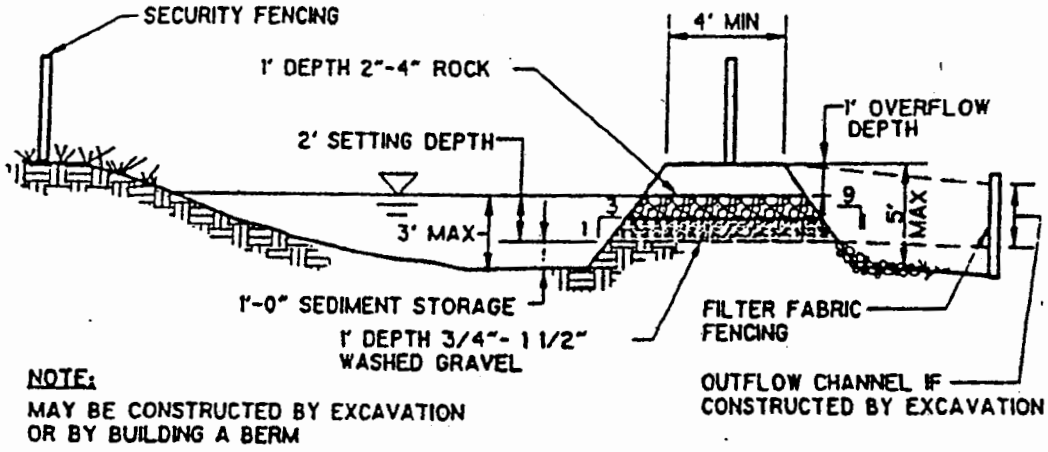
The key to having a functional sediment trap is continual monitoring and regular maintenance. The size of the trap is less important to its effectiveness than is regular sediment removal. Sediment should be removed from the trap when it reaches approximately one foot in depth (assuming a 1.5 foot sediment accumulation depth. Regular monthly inspections should be done and additional inspections made after each large runoff-producing storm.

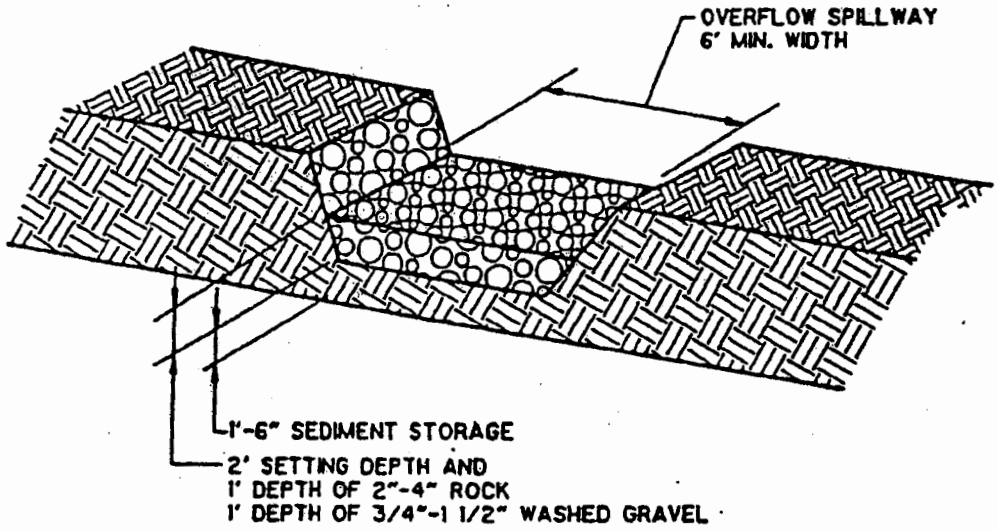
SEDIMENT TRAP	**S.T.** Symbol	**Exhibit M-17c**



Subdividing large sites into small drainages.

SEDIMENT TRAP	S.T. Symbol	Exhibit M-17d





TEMPORARY SEDIMENT TRAP

SEDIMENT TRAP	**S.T.** Symbol	**Exhibit M-17e**

DESCRIPTION

A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts, entrenched, and, depending upon the strength of the fabric used, with wire fence for support.

PURPOSE

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

* Perimeter control
_ Slope protection
* Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Filter fences must be provided just upstream of the point(s) of discharge of runoff from a site, before the flow becomes concentrated. They may also be used.

1. Below disturbed areas where runoff may occur in the form of sheet and rill erosion; wherever runoff has the potential to impact downstream resources.
2. Perpendicular to minor swales or ditch lines for up to one acre contributing drainage areas.

Not intended for use in detaining concentrated flows.

Synthetic fabric filter fences are only applicable for sheet or overland flows and not the volumes of water in concentrated flows.

SILT FENCE	**SF** Symbol	**Exhibit M-18a**

LIMITATIONS

- Filter fences will create a temporary sedimentation pond on the upstream side of the fence which may cause temporary flooding. Fences not constructed on a level contour will be overtopped by concentrated flow resulting in failure of the filter fence.
- Filter fences are not practical where large flows of water are involved, hence the need to restrict their use to drainage areas of one acre or less, and flow rates of less than 0.5 cfs.
- Problems may arise from incorrect selection of pore size and/or improper installation.
- Do not allow water depth to exceed 1.5 feet at any point.
- Improperly installed fences are subject to failure from undercutting, overtopping, or collapsing.

PLANNING CONSIDERATIONS

Laboratory work at the Virginia Highway and Transportation Research Council has shown that silt fences can trap a much higher percentage of suspended sediments than can straw bales. Silt fences are preferable to straw barriers in many cases. However while the failure rate of silt fences is lower than that of straw barriers, there are many instances locally in which silt fences have been improperly installed. The installation methods outlined here can improve performance.

- Construct along a level contour.
- Silt fences should remain in place until the disturbed area is permanently stabilized.
- Provide sufficient room for sediment removal equipment between the silt fence and toes of slopes or other obstructions.
- The ends of the filter fence should be turned uphill to prevent stormwater from flowing around the fence.
- Provide an undisturbed or stabilized outlet suitable for sheet flow.
- Do not construct in live streams or intermittently flowing channels.

DESIGN & SIZING CRITERIA

- Upstream drainage area limited to 1 acre or less when used alone or in combination with sediment basin in a larger site.

SILT FENCE	SF Symbol	**Exhibit M-18b**

- Maximum slope steepness perpendicular to fence line, 1:1.
- Maximum sheet or overland flow path length to the fence <_ 100 feet.
- No concentrated flows greater than 0.5 cfs.

Selection of a filter fabric is based on soil conditions at the construction site (which affect the equivalent opening size (EOS) fabric specification) and characteristics of the support fence (which affect the choice of tensile strength). The designer shall specify a filter fabric that retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging. The following criteria is recommended for selection of the equivalent opening size:

1. If 50 percent or less of the soil, by weight, will pass the U.S. standard sieve No. 200, select the EOS to retain 85 percent of the soil. The EOS should not be finer than EOS 70.

2. For all other soil types, the EOS should be no larger than the openings in the U.S. Standard Sieve No. 70 [0.0083 in. (0.21 mm.)] except where direct discharge to a stream, lake, or wetland will occur, then the EOS shall be no larger than Standard Sieve No. 100.

To reduce the chance of clogging, it is preferable to specify a fabric with openings as large as allowed by the criteria No fabric should be specified with an EOS smaller than U.S. Standard Sieve No. 100 [0.0059 in. (0.15 mm.)]. If 85 percent or more of a soil, by weight, passes through the openings in a No. 200 sieve [0.0029 in. (0.074 mm.)], filter fabric shall not be used. Most of the particles in such a soil would not be retained if the EOS was-too large, and they would clog the fabric quickly if the EOS was small enough to capture the soil.

Selection of fabric tensile strength and bursting strength characteristics shall be supported with wire mesh in and as recommended by the fabric manufacturer. Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable life at a temperature range of 0° F. to 120° F.

♦ Typical Installation:

Filter fences are to be constructed on a level contour to maximize the available ponding area and prevent concentration of flow against the fence.

SILT FENCE	**SF** Symbol	**Exhibit M-18c**

a Posts shall be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 30 inches.

b. A trench shall be excavated approximately 8 inches wide and 12 inches deep along the line of posts and upslope from the barrier.

c. When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1- inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches.

d. The standard strength filter fabric shall be stapled or wired to the fence, and 20 inches of the fabric shall extend into the trench. When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated and the filter fabric stapled or wired directly to the posts.

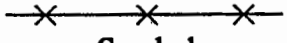
e. The use of joints should be avoided. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6 inch overlap and both ends securely fastened to the post.

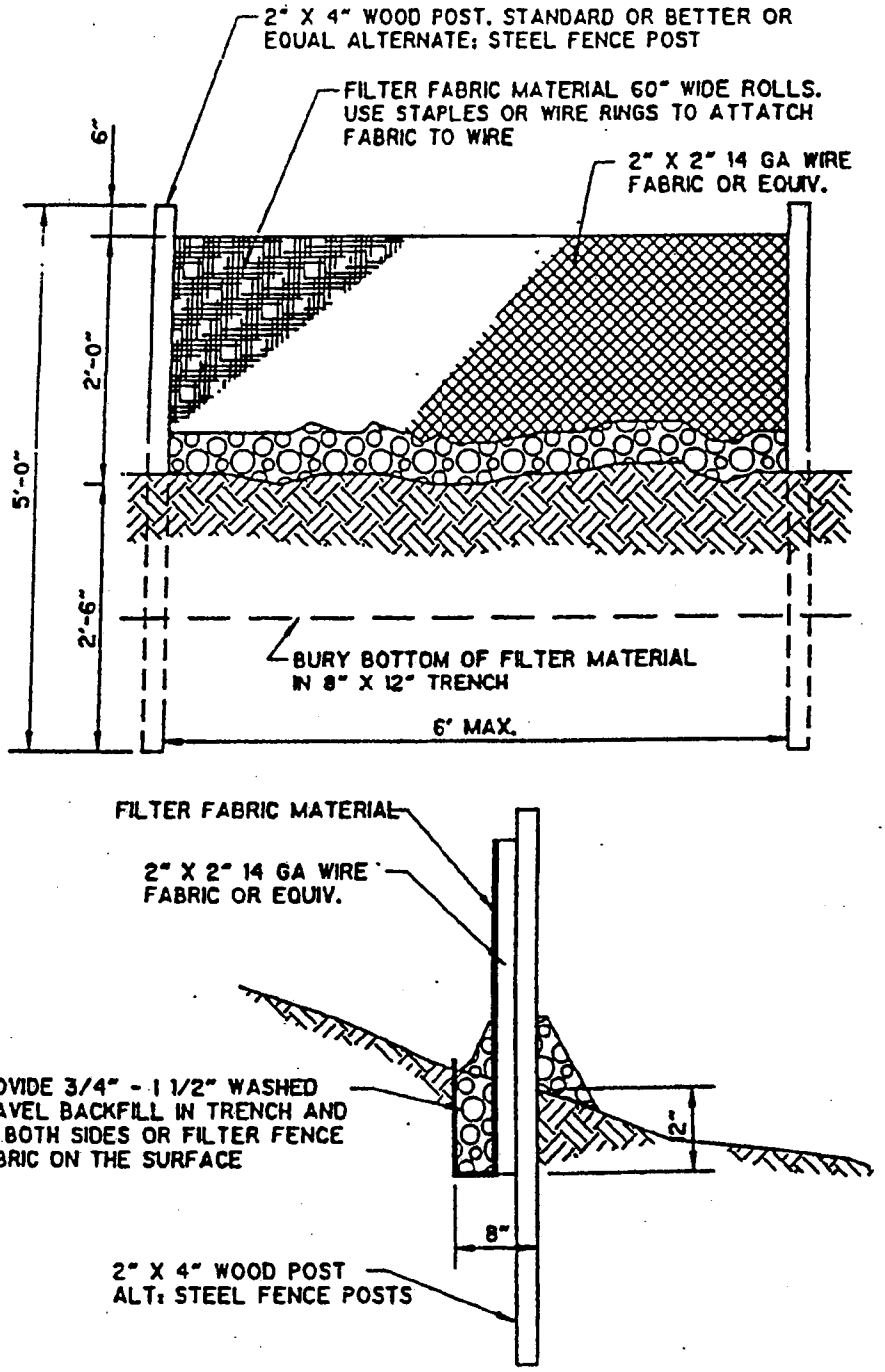
f. The trench shall be backfilled with 3/4-inch minimum diameter washed gravel or compacted native material.

MAINTENANCE REQUIREMENTS

Inspect monthly during dry periods and immediately after each rainfall. Repair as necessary. Sediment must be removed when it reaches approximately one third the height of the fence, especially if heavy rains are expected.

Filter fences should not be removed until the upslope area has been permanently stabilized.

SILT FENCE	**SF**  Symbol	**Exhibit M-18d**



SILT FENCE

SILT FENCE	SF Symbol	**Exhibit M-18e**

DESCRIPTION

A temporary pipe or chute drain placed from the top of a slope to the bottom of a slope.

PURPOSE

The purpose of the structure is to convey concentrated runoff down slopes without causing erosion.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

Pipe and chute slope drains are used where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion. Typically used in conjunction with top of slope diversion dikes or swales. May also be used as an emergency spillway for a sediment basin.

LIMITATIONS

Maximum drainage area per pipe slope drain is 5 acres. For large areas use a paved chute, rock lined channel, or additional pipes or chutes.

- During large storms slope drains may become clogged or overcharged, resulting in increased slope erosion.
- Also, dissipation of high flow velocities at the pipe outlet is required to avoid downstream erosion.
- Failure of this type of temporary structure can result in flooding and severe erosion.

SLOPE DRAIN	S.D. ← Symbol	**Exhibit M-19a**

PLANNING CONSIDERATIONS

Slope drains are highly effective in eliminating slope erosion because water is not allowed to flow directly on the slope.

- Slope drains allow no chance of erosion down a slope because all flow is confined to erosion resistant conveyance facilities.
- Slope drains are easy to install and require little maintenance.

DESIGN & SIZING CRITERIA

Temporary pipe slope drains shall not be sized smaller than as shown in the following table:

MINIMUM PIPE DIAMETER	MAXIMUM UPSTREAM DRAINAGE AREA (ACRES)
12"	0.5
18"	1.5
21"	2.5
24"	3.5
30"	5.0

The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent. The soil around and under the pipe and entrance section shall be thoroughly compacted. The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.

Slope drain sections shall be securely fastened together and anchored to the soil, and be waterproof.

Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe or chute.

The area below the outlet must be stabilized with a riprap apron per attached construction drawings.

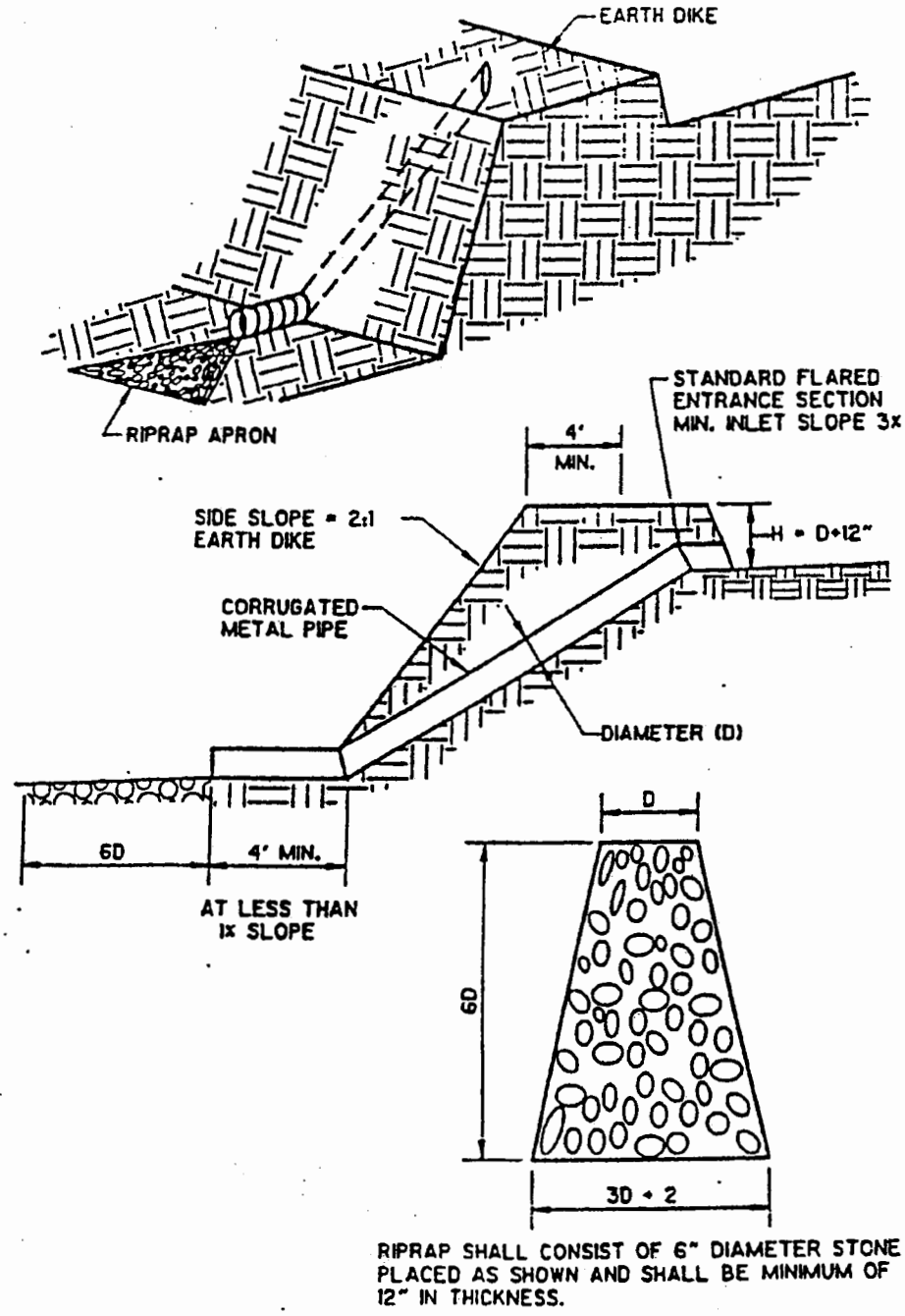
If the slope drain is conveying sediment-laden water, direct all flows into a sediment trapping facility.

SLOPE DRAIN	S.D. ← Symbol	**Exhibit M-19b**

MAINTENANCE REQUIREMENTS

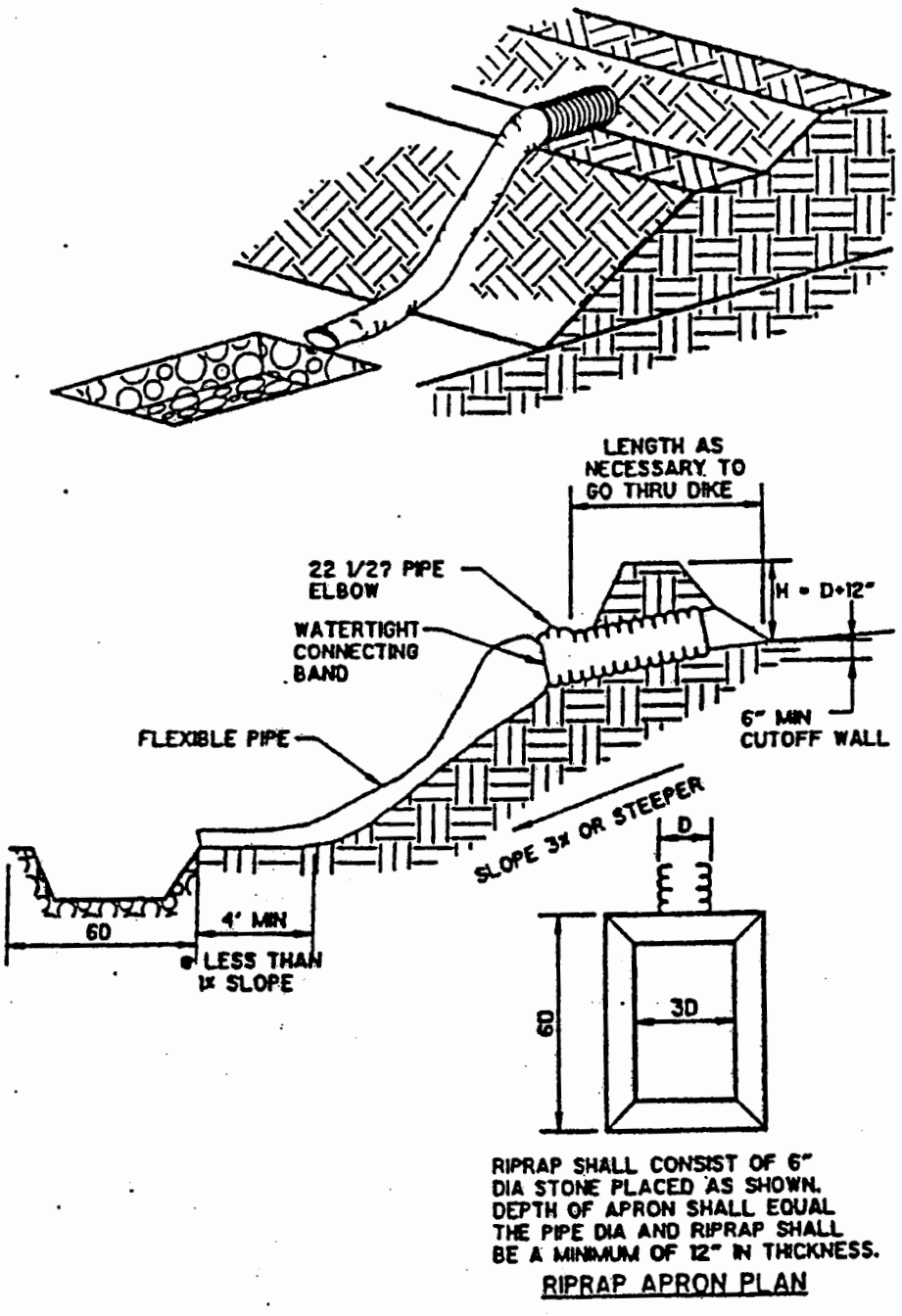
Check inlet and outlet points regularly, and especially after heavy storms. The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags. The outlet point should be free of erosion and installed with appropriate outlet protection.

SLOPE DRAIN	S.D. ← Symbol	**Exhibit M-19c**



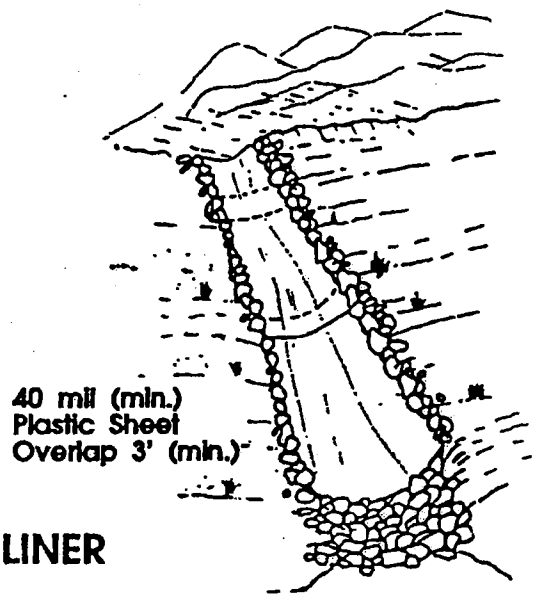
PIPE SLOPE DRAIN (RIGID)

SLOPE DRAIN	S.D. ← Symbol	**Exhibit M-19d**



PIPE SLOPE DRAIN (FLEXIBLE)

SLOPE DRAIN	S.D. ← Symbol	**Exhibit M-19e**



DITCH LINER

SLOPE DRAIN	S.D. ← Symbol	**Exhibit M-19f**

DESCRIPTION

The routine collection and regular disposal of accumulated solid waste generated at the construction site.

PURPOSE

Solid waste is one of the major pollutants caused by construction. Construction debris is solid waste generated from trees and shrubs removed during land clearing, demolition of existing structures, and the installation of structures. Other waste products include wood and paper from packaging and building materials, scrap metals, sanitary wastes, rubber, plastic and glass pieces, masonry products, and others. Domestic waste products include food containers such as beverage cans, coffee cups, lunch-wrapping paper and plastic wrappers.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
* Non-sediment pollution control

APPROPRIATE APPLICATIONS

Proper solid waste management is applicable to all constuction activities. Care should be taken to ensure that toxic wastes and construction chemicals are not disposed of in dumpster designated for clean construction debris or domestic waste.

SOLID WASTE MANAGEMENT	(S.W.M.) Symbol	**Exhibit M-20a**

PLANNING CONSIDERATIONS

The major control mechanism for these pollutants is to provide adequate disposal facilities. Collected solid waste should be removed and disposed of at authorized disposal areas on a regular basis. Sanitary facilities must be convenient and well maintained to avoid indiscriminate soiling of adjacent areas.

A contingency plan should be developed in case toxic or hazardous materials are found on-site.

DESIGN & SIZING CRITERIA

Solid Waste Management Plan must consider volume of construction debris based upon area to be graded, materials to be removed and materials generated during construction. The Solid Waste Management Plan must also consider the number of employees on site. Disposal for all construction debris and all domestic garbage must be coordinated with the local jurisdiction and disposed of in an appropriate solid waste management facility permitted for the type of waste materials.

MAINTENANCE REQUIREMENTS

Collection of on site trash should be done on a regular basis. Trash container and dumpsters should be maintained on an as needed basis. Where possible provide cover for dumpsters and waste containers to prevent the entry of rainwater, and loss of contents by high winds.

Have a contingency plan in place should hazardous or toxic materials be discovered.

SOLID WASTE MANAGEMENT	S.W.M. Symbol	**Exhibit M-20b**

SPILL

DESCRIPTION

An emergency plan to contain spills of dangerous, hazardous, or toxic wastes which mitigates environmental damage and provides prompt notice to proper authorities.

PURPOSE

The Spill Prevention Plan should include measures to limit the scope of the spill and minimize environmental damage.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
* Non-sediment pollution control

APPROPRIATE APPLICATIONS

This practice is applicable to all construction sites. Those sites located near natural watercourses, canals, and reservoirs are at highest risk of an uncontained spill contaminating surface waters.

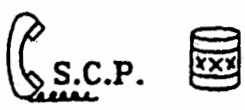
LIMITATIONS

This plan deals with emergency spill response. Proper storage, use, and disposal of dangerous, hazardous, and toxic wastes should be observed at all times to minimize the potential for a spill.

PLANNING CONSIDERATIONS

The construction site management team should develop the spill prevention plan and ensure that the plan is communicated to all field personnel.

All spills regardless of size and/or type of spill should be reported to the proper agencies.

SPILL CONTAINMENT PLAN	 Symbol	**Exhibit M-21a**

If a hazardous material spill could reach surface water, the contractor must also contact the "National Response Center" at 1-800 424-8802 (24 hr.).

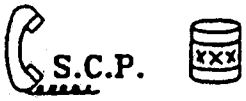
DESIGN & SIZING CRITERIA

Identify the types of hazardous materials which may be used on the project and develop a strategy to stop leaks at the source of the spill. Develop a strategy to contain the materials already spilled using available materials and equipment.

Contact local Fire Marshall to review the accuracy and adequacy of your spill containment plan. Request Fire Marshall to review on-site storage areas to determine specific requirements and appropriate containment techniques.

MAINTENANCE REQUIREMENTS

- Comply with suggestions and requirements set by local Fire Department.
- Update spill containment plan during the course of construction as changes occur in the types of chemicals being stored.
- If a spill occurs follow proper procedure as required in the Spill Containment Plan. Dispose of materials per agency or manufacturer's instruction.

SPILL CONTAINMENT PLAN	 Symbol	**Exhibit M-21b**

DESCRIPTION

Provide covered storage areas for construction materials. Create a spill proof perimeter around the storage area.

PURPOSE:

Rain can wash pollutants from improperly stored materials into local drainage systems. By properly covering and storing chemicals, materials, and waste containers so that they are protected from rainwater, non-sediment pollution of stormwater can be reduced.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
* Non-sediment pollution control

APPROPRIATE APPLICATIONS:

Locate chemical storage areas away from low areas, drainageways and stream banks.

PLANNING CONSIDERATIONS:

The best method for controlling chemical pollution is to provide adequate controls at the points of storage and use. The following recommendations are intended to prevent the contamination of on-site sediments.

1. Store chemical drums on an angle so that the top of the drum will shed rainwater. This will prevent contamination of the contents of the drum as well as reduce corrosion of the bottom of the drum
2. Do not- store chemicals, drums and bagged materials directly on the ground. Where possible, cover stockpiled materials.
3. Provide spill containment dikes around chemical and fuel storage tanks. Line with plastic film to prevent soil contamination.

STORAGE AREA OF CHEMICALS & MATERIALS	 **S.A.** Symbol	**Exhibit M-22a**

4. Wash up waters from water-based paints may go into a sanitary sewer.

5. Dispose of oil-based paints,solvents, thinners, and mineral spirits through a licensed waste management firm

6. Follow the recommendations of the manufacturer to dispose of construction chemicals such as curing compounds, form releases, etc.

7. Try to keep chemical products in their original containers, and keep them well labeled. Use proper devices to transfer chemicals from one container to another.

8. Follow manufacturers instructions regarding uses, protective equipment, ventilation, flammability, and mixing of chemicals.

DESIGN AND SIZING CRITERIA:

The contractor should contact the local Fire Marshall to review the site materials, chemicals and proposed storage area to determine specific requirements. See Flammable and Combustible Liquid Code, NFPA30.

MAINTENANCE REQUIREMENTS:

As specified by the local Fire Deparment, revisions may be necessary to the Protected Chemical and Materials Storage Area Plan during the course of construction based upon materials to be stored on site.

If a spill occurs which equals or exceeds the reportable quantity (RQ) for a 24-hour period as defined by the EPA in 40 CFR Part 110, 40 CFR Part 117, and 40 CFR Part 302, then:

- Report spill to the National Response Center, 1-800-424-8802, within 24 hours.
- Revise SWMP to show corrective actions.
- Notify EPA within 14 days.

STORAGE AREA OF CHEMICALS & MATERIALS	 S.A. Symbol	**Exhibit M-22b**

DESCRIPTION

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

_ Perimeter control
_ Slope protection
* Sediment trapping
* Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

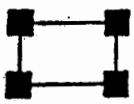
Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Different types of structures are applicable to different conditions:

♦ Advantages:

- Inlet protection prevents sediment from entering the storm drain system and clogging it.

LIMITATIONS

- Ponding will occur at the inlet with possible short term flooding.
- Curb inlets on slopes cannot be effectively protected because the stormwater will bypass the inlet and continue downgrade.
- Filter fabric fences are limited to storm drain inlets for small drainage areas of five acre or less. For larger drainage areas, smaller sediment catchment areas are recommended

STORM DRAIN INLET PROTECTION	 I.P. Symbol	Exhibit M-23a

PLANNING CONSIDERATIONS

Where storm sewers are made operational before their drainage area is stabilized, or where construction is adjacent to an existing storm sewer, large amounts of sediment may enter the storm sewer system. In cases 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 local government.

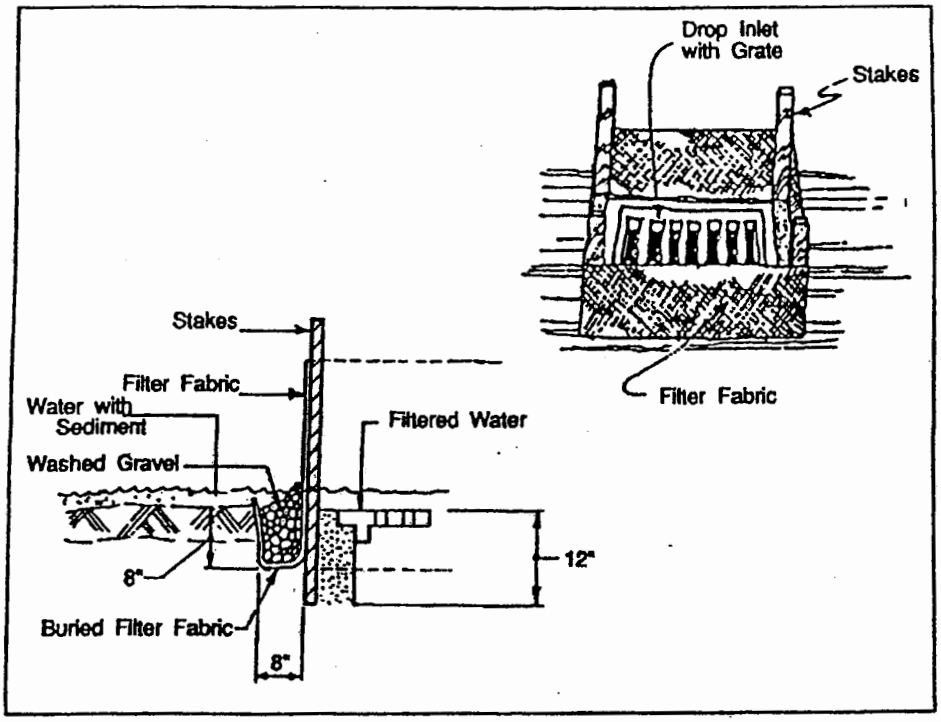
DESIGN & SIZING CRITERIA

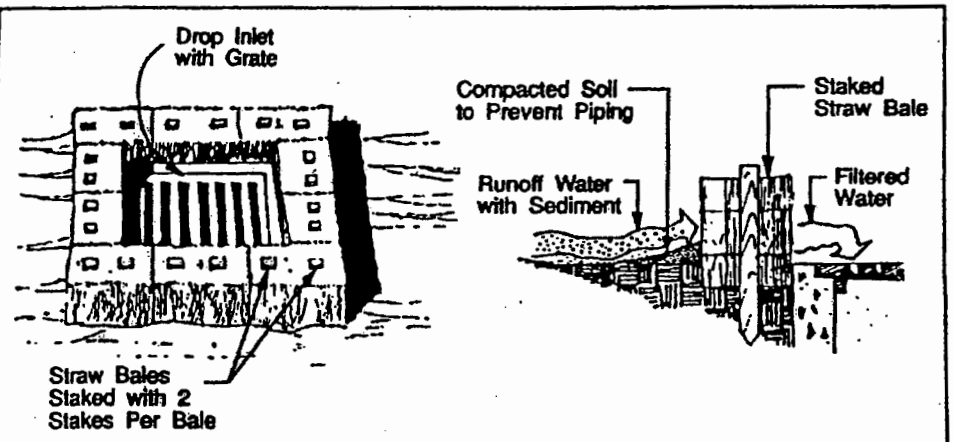
Reference is made to the details that follow for the various types of protection devices.

MAINTENANCE REQUIREMENTS

Inspections should be made on a regular basis, especially after large storm events. If the fabric becomes clogged, it should be replaced. Sediment should be removed when it reaches approximately one-half the height of the fence, gravel, or straw bales. If a sump is used, sediment should be removed when it fills approximately one-half the depth of the hole.

STORM DRAIN INLET PROTECTION	 **I.P.** Symbol	**Exhibit M-23b**



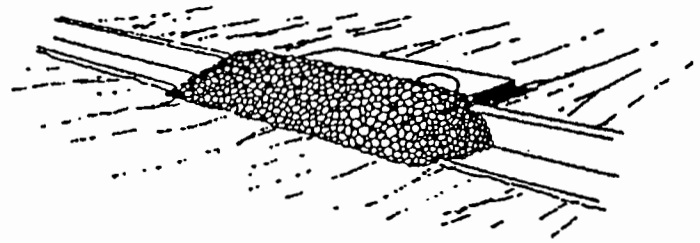


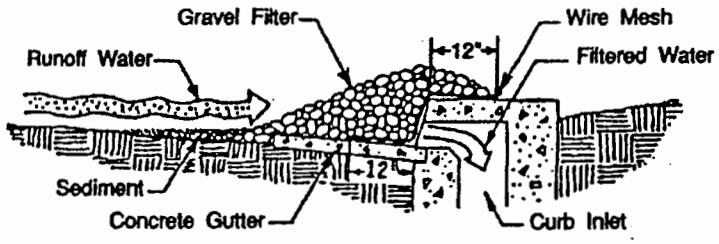
Specific Application

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

STRAW BALE DROP INLET SEDIMENT FILTER

STORM DRAIN INLET PROTECTION	 I.P. Symbol	**Exhibit M-23c**

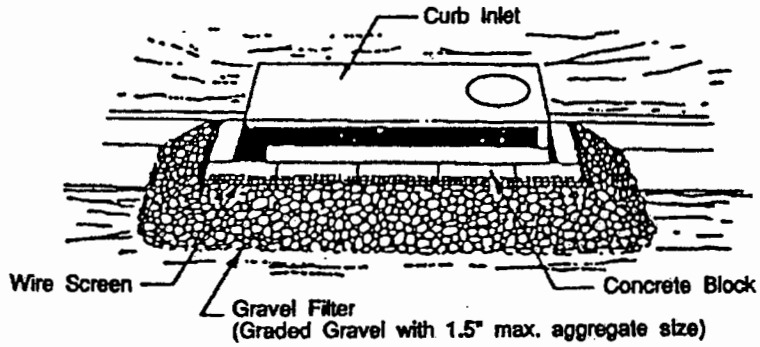




Specific Application

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

Note: Alternate design could utilize gravel filled bags.



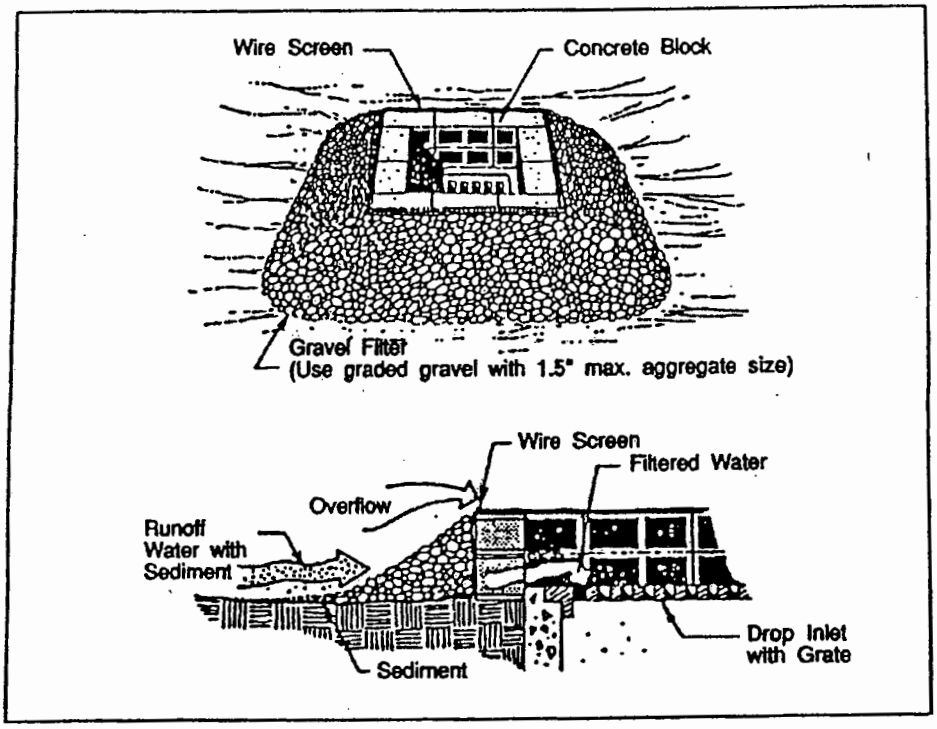
Specific Application

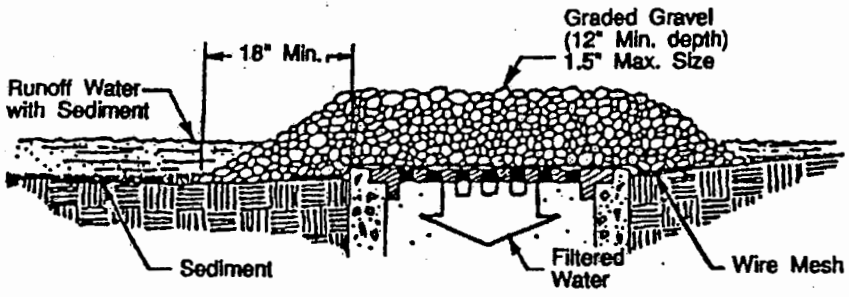
This method of inlet protection is applicable at curb inlets where an overflow capability is necessary to prevent excessive ponding in front of the structure.

Note: Alternate design could utilize gravel filled bags.

STORM DRAIN INLET PROTECTION	I.P. Symbol	**Exhibit M-23d**

SD INLET



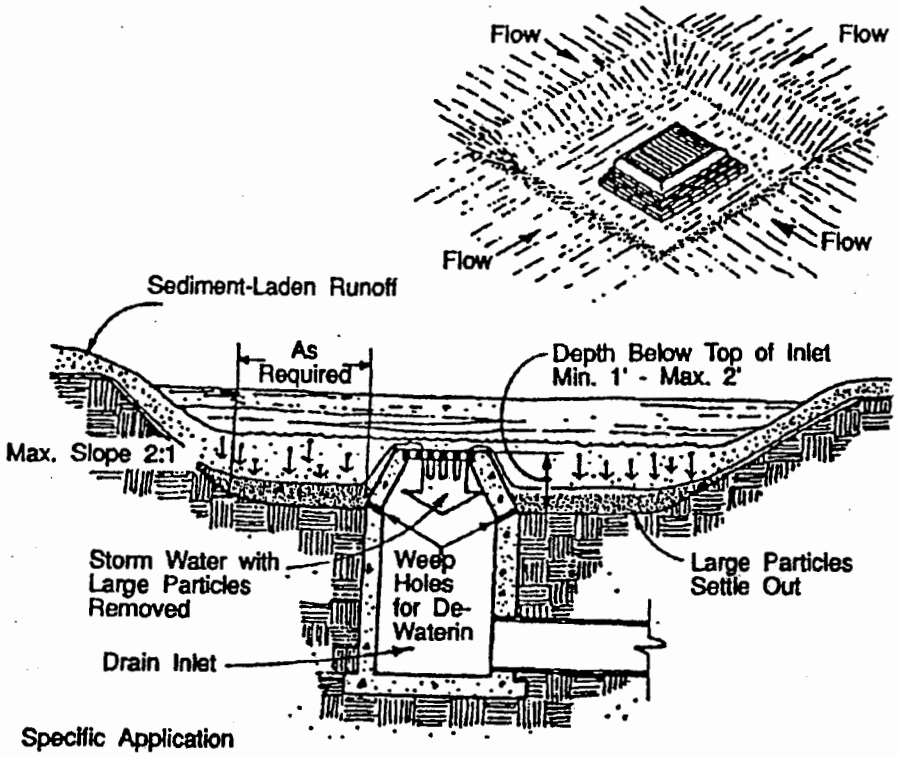


Specific Application

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

Note: Alternate design could utilize gravel-filled bags.

STORM DRAIN INLET PROTECTION	I.P. Symbol	**Exhibit M-23e**



Specific Application

This method of inlet protection is applicable where heavy flows are expected and where an overflow capability and ease of maintenance are desirable.

STORM DRAIN INLET PROTECTION	I.P. Symbol	**Exhibit M-23f**

DESCRIPTION

A temporary barrier of straw bales or similar material used to intercept sediment laden runoff from small drainage areas of disturbed soil.

PURPOSE

The purpose of a straw bale dike is to reduce runoff velocity and cause deposition of the transported sediment load.

CONDITIONS WHERE PRACTICE APPLIES

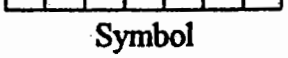
* Perimeter control
_ Slope protection
* Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

The straw bale dike is used where there are no concentrations of water in a channel or drainage way, and where erosion would occur from sheet flow. These barriers are typically constructed, below disturbed areas subject to sheet flow of runoff to intercept and detain sediment.

LIMITATIONS

- Straw bale dikes are not to be used for extended periods of time because they tend to rot and fall apart.
- Suitable only for sheet flow on slopes of 2% or flatter.
- Not appropriate for large drainage areas, limit to one acre or less.
- Straw bales lose their effectiveness rapidly due to rotting, thus constant maintenance is required.
- Not recommended for concentrated flow, channel flow, and live streams.
- Bale bindings of jute or cotton not recommended.

STRAW BALE BARRIERS	**S.B.B.**  Symbol	**Exhibit M-24a**

PLANNING CONSIDERATIONS

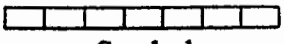
When installed and maintained properly, straw bale dikes remove approximately 67% of the sediment transported in construction site runoff. This optimum efficiency can only be achieved through careful maintenance with special attention to replacing rotted or broken bales. Barrier should be constructed on a level contour to prevent concentration of flow against a small portion of the barrier.

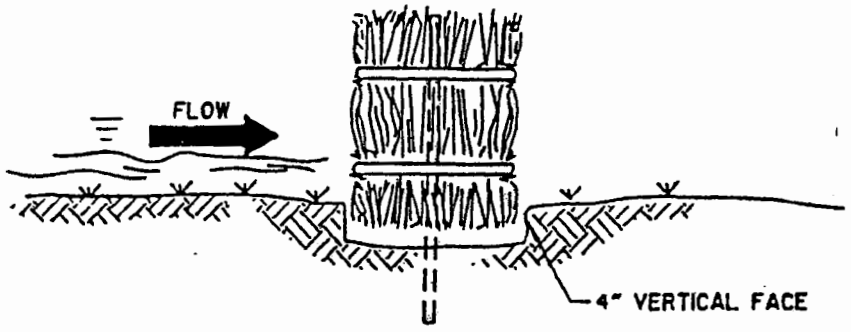
DESIGN & SIZING CRITERIA

1. Bales shall be placed on the contour and in a row with ends tightly abutting the adjacent bales.
2. Maximize ponding by locating barrier away from the toe-of-slopes. This also provides access for maintenance.
3. Each bale shall be embedded in the soil a minimum of four inches and placed so the bindings are horizontal. Bindings placed on soil will soon disintegrate and cause the barrier to fail.
4. Bales shall be securely anchored in place by either two stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale at an angle to force the bales together. Stakes shall be driven flush with the bale.
5. Bales shall be removed when they have served their usefulness so as not to block or impede storm flow or drainage.

MAINTENANCE REQUIREMENTS

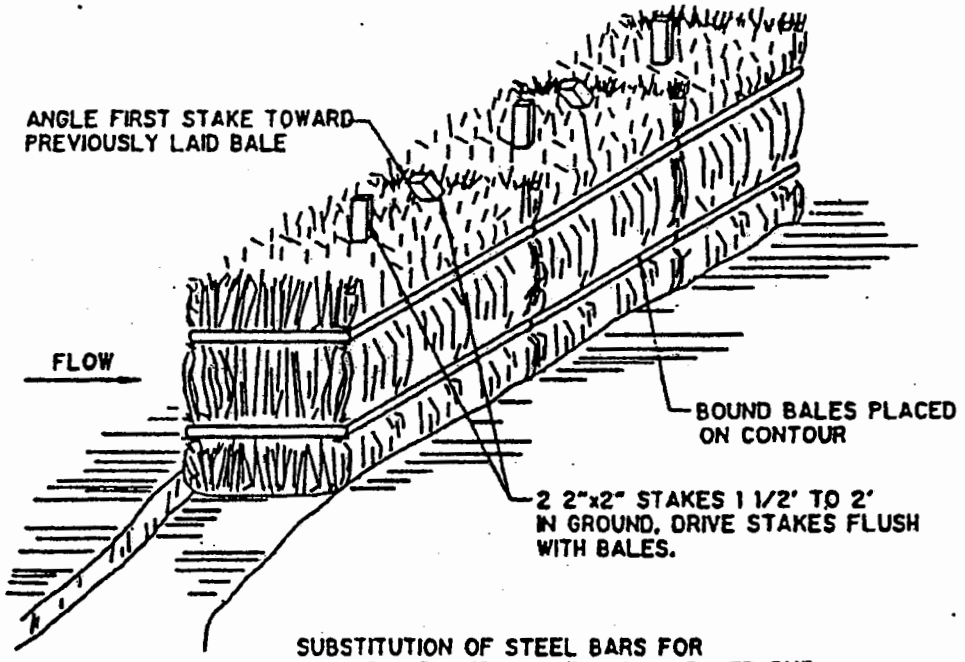
Inspect monthly and after each rain event. Remove and properly dispose of detained sediments when silt depth reaches 6".

STRAW BALE BARRIERS	**S.B.B.**  Symbol	**Exhibit M-24b**



• PROMOTES ON SITE SEDIMENTATION
BY CREATING A TEMPORARY POND.

BEDDING DETAIL



SUBSTITUTION OF STEEL BARS FOR
WOODEN STAKES IS NOT RECOMMENDED DUE
TO POTENTIAL FOR DAMAGING CONSTRUCTION EQUIPMENT

ANCHORING DETAIL

STRAW BALE BARRIERS

STRAW BALE BARRIERS	**S.B.B.** Symbol	**Exhibit M-24c**

DESCRIPTION

Provision of a rough soil surface with horizontal depressions created by operating a tiller or other suitable equipment on the contour or by leaving slopes in a roughened condition by not fine grading them.

PURPOSE

To aid in establishment of vegetative cover, reduce runoff velocity, and increase infiltration, and provide for sediment trapping.

CONDITIONS WHERE PRACTICE APPLIES

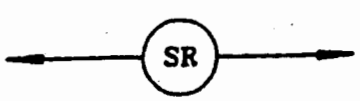
_ Perimeter control
* Slope protection
_ Sediment trapping
* Drainageway & stream protection
* Temporary stabilization
_ Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

APPROPRIATE APPLICATIONS

All non-vegetated, erodible slopes steeper than 3:1, and greater than 5 vertical feet, require surface roughening, either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.

Surface roughening provides erosion protection on bare soil while vegetative cover is being established by slowing the runoff and allowing infiltration.

It is an inexpensive and simple erosion control measure for roadway cut slopes.

SURFACE ROUGHENING	 Symbol	**Exhibit M-25a**

LIMITATIONS

While this is a cheap and simple method of erosion control, it is of limited effectiveness in anything more than a moderate storm

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 they encourage water infiltration, speed the establishment of vegetation, and decreased 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. Stairs should be wide enough to work with standard earth moving equipment.

SURFACE ROUGHENING	 Symbol	**Exhibit M-25b**

3. Areas which will be mowed (there areas should have slopes less 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.

DESIGN & SIZING CRITERIA

Graded areas with slopes greater than 3:1 but less than 2:1 should be roughened before seeding. This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, in leaving a pattern of cleat imprints parallel to slope contours.

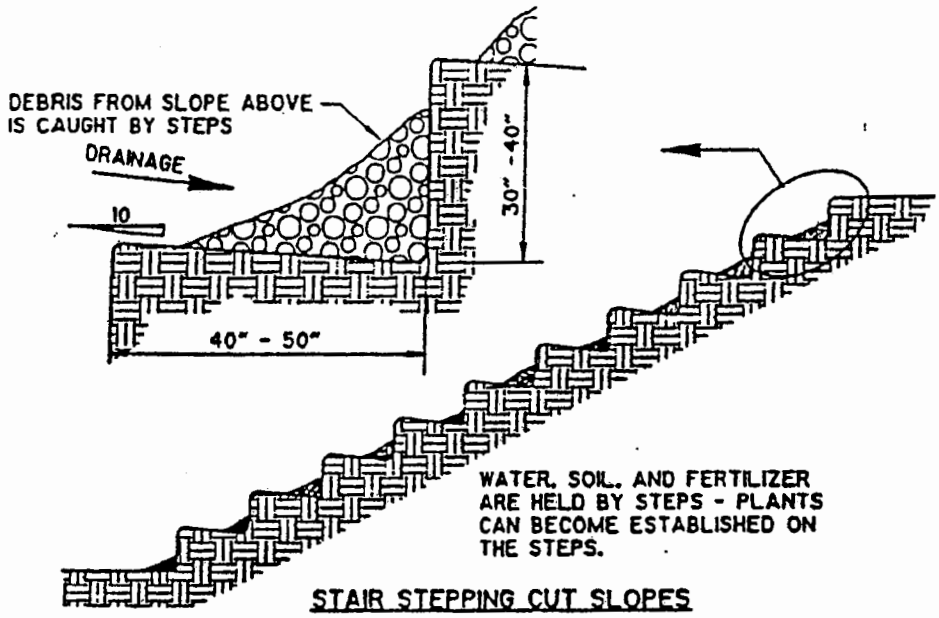
Graded areas steeper than 2:1 should be stair-stepped with benches as shown in the attached figure. The stair-stepping will help vegetation become established and also trap soil eroded from the slopes above.

MAINTENANCE REQUIREMENTS

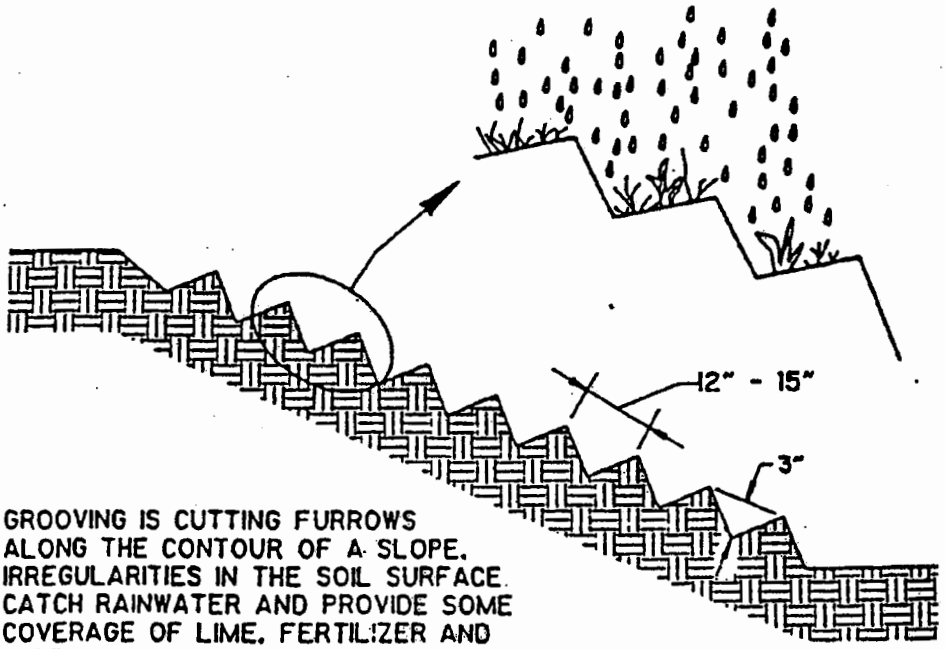
Areas which are to be re-vegetated in this manner should be seeded as quickly as possible.

Regular inspections should be made of the area

SURFACE ROUGHENING	SR Symbol	**Exhibit M-25c**



STAIR STEPPING CUT SLOPES



GROOVING IS CUTTING FURROWS ALONG THE CONTOUR OF A SLOPE. IRREGULARITIES IN THE SOIL SURFACE CATCH RAINWATER AND PROVIDE SOME COVERAGE OF LIME, FERTILIZER AND SEED.

GROOVING SLOPES

STAIR-STEPPING CUT SLOPES AND GROOVING SLOPES

SURFACE ROUGHENING	SR Symbol	**Exhibit M-25d**

DESCRIPTION

Trees, shrubs, vines, and ground covers can provide superior, low-maintenance, and long-term erosion protection. They are particularly useful for site aesthetics.

PURPOSE

Preserving and protecting trees can often result in a more stable and aesthetically pleasing development. Trees stabilize the soil and help prevent erosion, decrease stormwater runoff, moderate temperature, provide buffers and screens, filter pollutants from the air, supply oxygen, provide habitat for wildlife, and increase property values.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
* Temporary stabilization
* Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

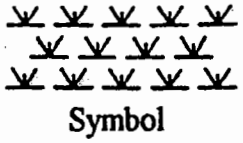
APPLICATIONS

1. On steep or rocky slopes, where mowing is not feasible.

2. Where ornamentals are desirable for landscaping purposes.

3. Where woody plants are desirable for soil conservation or to establish wildlife habitats.

Because many types of woody plants and ground covers are available, and because site conditions and land use vary so widely, this practice consists of a set of general guidelines for growing trees, shrubs, vines, and ground covers on disturbed land. Much of the information provided in this practice regarding trees also applies to shrubs. A shrub is a woody plant less than 15 feet tall, usually with several trunks rising from a common base.

TREES, SHRUBS, VINES AND GROUND COVERS	 Symbol	**Exhibit M-26a**

In addition to stabilizing disturbed soil, vegetation can:

1. Provide attractive cover that does not need mowing.

2. Define traffic and pedestrian areas.

Low-growing plants that sprawl, trail, spread, or send out runners can come in many leaf types, colors, and growth habits. Some are suitable only as a part of a maintained landscaping and some can stabilize large areas with little care.

LIMITATIONS

Construction activities are likely to injure or kill trees unless adequate protective measures are taken. Direct contact by equipment is the most obvious problem, but damage is also caused by root stress from filling, excavating, or compacting too close to trees.

PLANNING CONSIDERATIONS

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 cover can be used on these slopes toe control erosion. They will also help to control foot traffic.

2. Trees, shrubs, vines, or ground covers may be planted in residential areas, along rights-of-way, or easements to reduce maintenance and improve appearance.

TREES:

Some desirable characteristics to consider in selecting existing trees to be protected include: tree vigor, tree species, tree age, tree size and shape, and use as a wildlife food source and habitat. Trees to be saved should be clearly marked so that no construction activity will take place within the drip line of the tree.

At the same time as existing trees are being selected for salvage and protection on site, new plantings should be considered. 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 problems.

TREES, SHRUBS, VINES AND GROUND COVERS	 Symbol	**Exhibit M-26b**

TRANSPLANTING TREES:

Tree preparation - Proper digging of a tree includes the conservation of as much of the root system as possible. Soil adhering to the roots should be damp when the tree is dug, and kept moist until planting. The soil ball should be 12 inches in diameter for each inch of diameter of the trunk

Site preparation - Refer to landscape plans and specifications for site and soil preparation.

Supporting the tree - Newly planted trees need artificial support to prevent excessive swaying.

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 often. Mulching around the base of the tree is helpful in preventing roots from drying out.

SHRUBS:

Follow the general procedure for tree planting when planting shrubs.

VINES AND GROUND COVERS:

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.

The entire area should be spaded, disced, or roto-tilled to a depth of six to eight inches. Two to three inches of organic material, such as good topsoil or peat, should be spread over the entire area

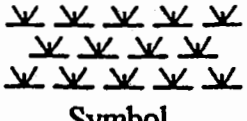
PLANTING - The following steps will help insure good plant growth:

1. Arrange the plantings on the contour.

2. Dig the holes 1/3 larger than the plant root ball.

3. Plant at the same level that the plants grow.

4. Use good topsoil or soil mixture with a lot of organics.

TREES, SHRUBS, VINES AND GROUND COVERS	 Symbol	**Exhibit M-26c**

5. Fill hole 1/3 to 1/2 full, shake plants to settle soil among roots, then water

6. Leave saucer-shaped depression around the plant to hold water.

7. Water thoroughly and regularly.

8. Space plants according to plant type and coverage desired

DESIGN & SIZING CRITERIA

MATERIALS

There are many different species of plants from which to choose, but care must be taken in their selections It is essential to select planting materials suited to both the intended use and specific site characteristics. Vegetative plans must include close-growing plants or an adequate mulch with all plantings of trees, shrubs, vines, and ground covers.
There are vast species of plants that may be used for erosion purposes. Information can be obtained from local nurserymen, landscape architects, and extension agents.

MAINTENANCE REQUIREMENTS

Specific maintenance requirements may be listed on landscape plans and specifications. General requirements include:

TREES:

Young trees should receive an inch of water each week for the first two years after planting. Transplanted trees should be fertilized on an annual basis.

SHRUBS:

Proper pruning, watering, and application of fertilizer is necessary to maintain healthy and vigorous shrubs. A heavy layer of mulch reduces weeds and retains moisture.

VINES AND GROUND COVER

Trim old growth as needed to improve the appearance of ground covers.

TREES, SHRUBS, VINES AND GROUND COVERS	 Symbol	**Exhibit M-26d**

DESCRIPTION

A temporary pit or bermed area for washout of concrete trucks, tools, mortar mixers, etc.

PURPOSE

Improper washout of concrete trucks, tools, etc. may allow fresh concrete or cement laden mortar to enter a storm drainage system.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
_ Sediment trapping
_ Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
* Non-sediment pollution control

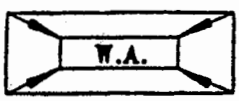
APPROPRIATE APPLICATIONS

Effective when vehicles, tools, and mixers can be moved to the pit location. Where this is not practical, temporary ponds may be constructed to allow for settling and hardening of cement and aggregates. Washout area/pits are appropriate for minor amounts of wash water which result from cleaning of aggregate materials or concrete trucks, tools, etc.

PLANNING CONSIDERATIONS

1. Wash out into a slurry pit which will later be backfilled. Do this only with the approval of the property owner.

2. Wash out into a temporary pit where the concrete wash can harden, be broken up, and then properly disposed of off-site.

WASHOUT AREA	 Symbol	**Exhibit M-27a**

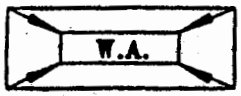
DESIGN & SIZING CRITERIA

1. Locate wash out pits away from storm drains, open ditches, or stormwater receiving waters.

2. DO NOT wash out concrete trucks into storm drains, sanitary sewers, street gutters, or stormwater channels.

MAINTENANCE REQUIREMENTS

Properly dispose of hardened concrete products on a routine basis to prevent the buildup of waste materials to an unmanageable size and to maintain percolation of water.

WASHOUT AREA	 Symbol	**Exhibit M-27b**

DESCRIPTION

Grass buffer strips are uniformly graded and densely vegetated areas of irrigated turf grass. Grass buffer strips differ from grass-lined swales as they are designed to accommodate overland sheet flow rather than concentrated or channelized flow. They can be used to remove larger sediment from sheet flow runoff flowing off impervious areas.

Whenever concentrated runoff occurs, it should be evenly distributed across the width of the buffer strip via a porous pavement strip or another type of structure to achieve sheet-flow conditions. Grass buffers can also be combined with riparian zones in treating sheet flows and in stabilizing channel banks adjacent to major drainageways and receiving waters. Buffer strips can be interspersed with shrubs and trees that can take up nutrients and provide shading. In a semiarid climate, irrigation is required to maintain a healthy and dense grass on the grass buffer strip to withstand runoff from impervious areas.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
* Temporary stabilization
* Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

GENERAL APPLICATION

Grass buffer strips can be used in residential and commercial areas and are located adjacent to impervious areas of the site. When used, they should be incorporated into site drainage, street drainage, and master drainage planning. Because their effectiveness depends on having an evenly distributed sheet flow over their surface, the size of the contributing area, and the associated volume of runoff have to be limited. Flow can be directly accepted from an impervious area such as from a parking lot and building roofs, provided the flow is distributed uniformly over the strip with a level spreader device. Grass buffer strips provide only marginal pollutant removal and require that followup structural BMPs be provided. They do, however, help to reduce some of the runoff volume from very small storms.

VEGETATIVE BUFFER ZONES: GRASS BUFFER STRIPS	Exhibit M-28a

ADVANTAGES/DISADVANTAGES

General. Grass and other vegetation provide aesthetically pleasing green space, which can be incorporated into a development landscaping plan. In addition, their use adds little cost to a development that has to provide open space, and their maintenance should be no different than routine maintenance of the site's landscaping. Eventually, the grass strip next to the spreader will have accumulated sufficient sediment to block runoff. At that point in time, a portion of the strip will need to be removed and replaced.

When buffer strips are used over unstable slopes, soils, or vegetation, they can lead to the formation of rills and gullies that disrupt sheet flow. The resultant short-circuiting will invalidate the intended water quality benefits. Grass buffer strip areas should be protected from excessive pedestrian or vehicular traffic that can damage the grass cover and affect even sheet-flow distribution. A mixture of grass and trees may offer benefits for increased slope stability.

Physical Site Suitability. The site, after final grading, should have a uniform slope and be capable of maintaining an even sheet flow throughout. Typical slopes of the site before final grading can range from 2 to 10 percent. The allowable tributary area depends on the width, length, and the soils that lay under the buffer strip. SCS Hydrologic Soil Groups A and B provide the best infiltration capacity, while Soil Groups C and D provide best site stability. The swelling potential of underlying soils should also be taken into account in how the soils may affect adjacent structures and pavement when water is delivered to the grassed areas.

Pollutant Removal. Pollutant removal depends on many factors such as soil permeability, site slope, the flow path length along the buffer strip, the characteristics of drainage area, runoff volumes and velocities, and the type of vegetation. The general pollutant removal of both particulate and soluble pollutants is projected to be low to moderate. Grass buffer strips rely primarily upon the settling and interception of solids, and to only a minor degree, on biological uptake and runoff infiltration.

DESIGN CRITERIA SND SIZING

Grass buffer strip design is based primarily on maintaining sheet-flow conditions across a uniformly graded, irrigated, dense grass cover strip. General sizing requirements provided below are used to determine the design width and length of the continuous grass buffer strip. Other information is provided on the details.

VEGETATIVE BUFFER ZONES: GRASS BUFFER STRIPS	Exhibit M-28b

GRASS BUFFER STRIP DESIGN CONSIDERATIONS AND CRITERIA

Criteria	Design Considerations
Design Length	General guidance suggests applying a hydraulic load no greater than 0.05 cfs/linear foot of buffer strip during a 2-year storm to maintain a sheet flow of less than 1 inch throughout dense grass that is at least 2 inches high.
Design Width	The design width (WG) (the distance along the sheet flow direction) shall be the greater of the following: $W_G \geq 8$ feet $W_G \geq 0.2\ L_1$ Where: L_1 = The length of flow path of the sheet flow over the upstream impervious surface.
Geometry	A rectangular shape strip is preferred and should be free of gullies or rills that concentrate the overland flow.
Flow Distribution	Runoff must be evenly distributed onto the grass strip. Slotted curbing or other spreader devices can be used to apply flows. Concentrated flow needs to use a level spreader to evenly distribute flow onto the strip.
Vegetation	Dense turf is needed to promote sedimentation and entrapment and to protect against erosion. Irrigated turf grass should be maintained to a blade height of 2 to 4 inches. The strip typically needs to be irrigated during dry weather. Although trees and other vegetation can increase infiltration, they can cause uneven sheet flow across the strip.
Outflow Collection	Most of the runoff during significant events will not be infiltrated and will require a collection and conveyance system. A grass-lined swale can be used for this purpose and can provide another BMP level. The buffer strip can also drain to a storm sewer or to a street gutter.

VEGETATIVE BUFFER ZONES: GRASS BUFFER STRIPS

Exhibit M-28c

MAINTENANCE CONSIDERATIONS

Grass buffer strips require general maintenance of the turf grass cover and repair of any rill or gully development. A summary of specific maintenance requirements and a suggested frequency of action is provided below.

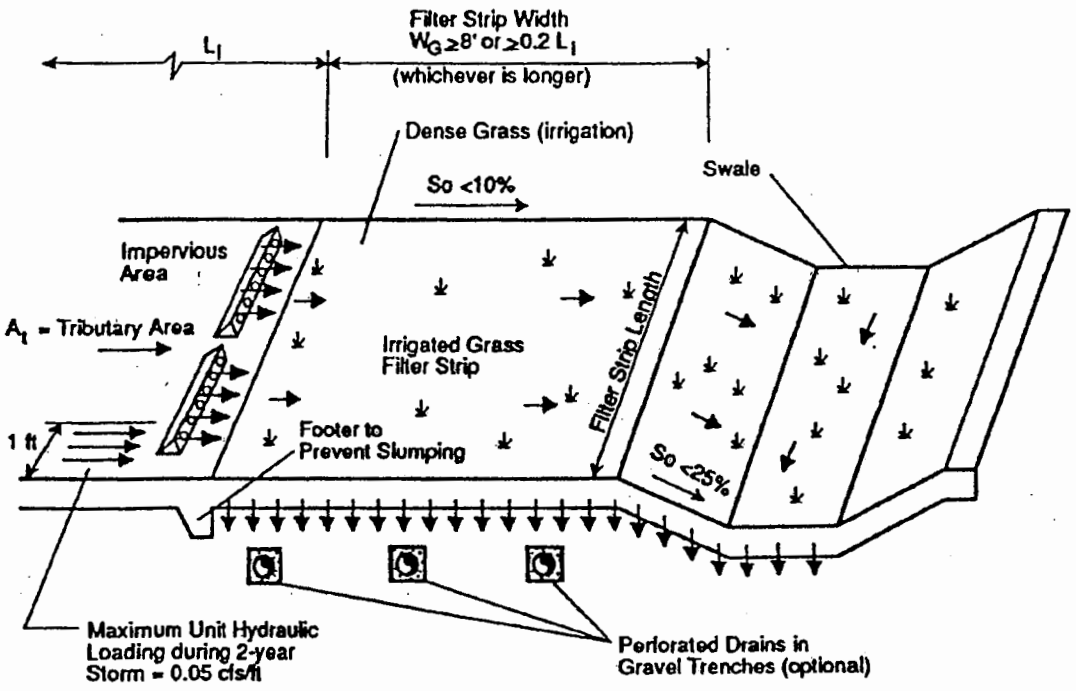
VEGETATIVE BUFFER ZONES: GRASS BUFFER STRIPS	**Exhibit M-28d**

Irrigated Grass Buffer Strip Maintenance Considerations

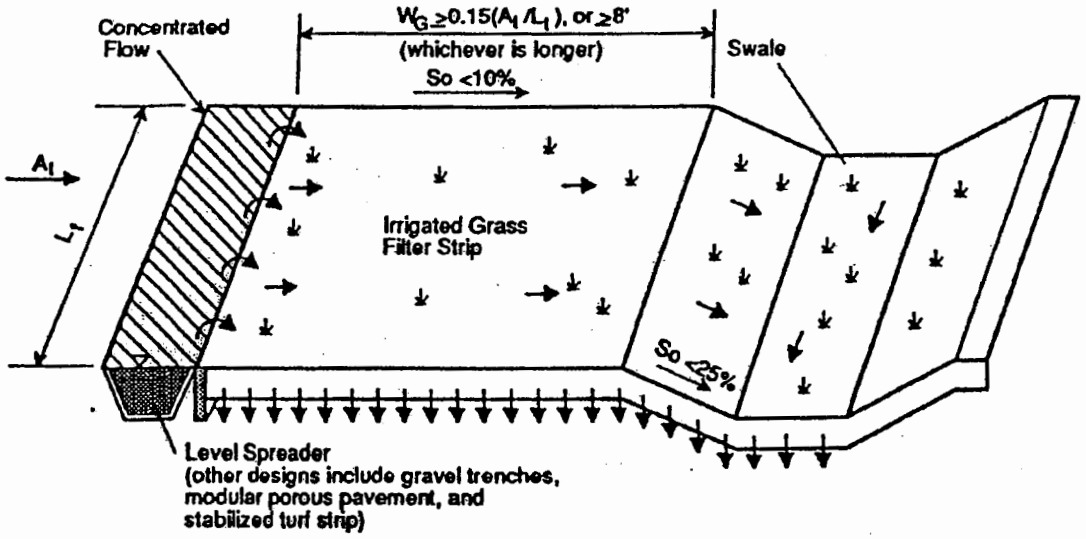
Required Action	Maintenance Objective	Frequency of Action
Lawn mowing	Maintain a dense grass cover at a recommended length of 2 to 4 inches Collect and dispose of cuttings offsite or use a mulching mower.	Routine As needed or recommended by inspection.
Lawn care	Use the minimum amount of biodegradable, nontoxic fertilizers and herbicides needed to maintain dense grass cover, free of weeds. Reseed and patch damaged areas.	Routine-As needed
Irrigation	Adjust the timing sequence and water cover to maintain the required minimum soil moisture for dense grass growth. Do not overwater.	As needed.
Litter removal	Remove litter and debris to prevent gully development, enhance aesthetics, and prevent floatables from being washed offsite.	Routine-As needed by inpection.
Inspections	Inspect irrigation, turf grass density, flow distribution, gully development, and traces of pedestrian or vehicular traffic and request repairs as needed.	Annually and after each major storm (that is, larger than 0.75 inches in percipitation).
Turf replacement	To lower the turf below the surface of the adjacent pavement, use a level flow spreader, so that sheet flow is not blocked and will not cause water to back up onto the upstream pavement.	As needed when water padding becomes too high or too frequent a problem. The need for turf replacement will be higher if the pavement is sanded in winter to improve tire traction on ice. Otherwise, expect replacement once every 5 to 15 years.

VEGETATIVE BUFFER ZONES: GRASS BUFFER STRIPS

Exhibit M-28e



ONSITE FLOW CONTROL



CONCENTRATED FLOW CONTROL

Note: Not to Scale

VEGETATIVE BUFFER ZONES: GRASS BUFFER STRIPS	Exhibit M-28f

DESCRIPTION

Grass-lined swales are densely vegetated drainageways with low-pitched sideslopes that collect and slowly convey runoff. Design of their longitudinal slope and cross-section size forces the flow to be slow and shallow, thereby facilitating sedimentation while limiting erosion. Berms or check dams should be installed perpendicular to the flow as needed to slow it down and to encourage settling and infiltration.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
* Slope protection
_ Sediment trapping
_ Drainageway & stream protection
* Temporary stabilization
* Permanent stabilization & exposure limits
_ Non-sediment pollution control appropriate

GENERAL APPLICATION

Swales can be located to collect overland flows from areas such as parking lots, buildings, residential yards, roadways and grass buffer strips. They can be made a part of the plans to minimize a directly connected impervious area. Grass-lined swales can be used as an alternative to curb-and-gutter systems. Swales are set below adjacent ground level, and runoff enters the swales over grassy banks. The potential exists for wetland vegetation to become established if the swale experiences standing water or if there is a base flow. A site with a base flow should be managed as either a swale with an unlined trickle channel, or as a wetland bottom channel, the latter providing an additional BMP to stormwater runoff.

In most applications, a followup BMP will be needed to enhance water quality to the maximum extent practicable. However, if a swale is designed to act as an extended detention basin for adjacent runoff, followup BMPs may not be needed, provided the runoff from adjacent public streets is also intercepted by the swale.

ADVANTAGES/DISADVANTAGES

General. A grass-lined swale, which can be more aesthetically pleasing than concrete or rocklined drainage systems, is generally less expensive to construct. Although limited by the infiltration capacity of local soils, this BMP can also

VEGETATIVE BUFFER ZONES: GRASS-LINED SWALES	Exhibit M-29a

provide some reduction in runoff volumes from small storms. Dense grasses can reduce flow velocities and protect against erosion during larger storm events. Swales in residential and commercial settings can also be used to limit the extent of directly connected impervious areas.

The disadvantages of using grass swales include the possibility of soggy and wet areas in front yards, the potential for mosquito breeding areas, and the potential need for more right-of-way than is needed for a storm sewer.

Physical Site Suitability. Grass swales are practical only at sites with general ground slopes of less than 3 to 4 percent and are definitely not practical for sites steeper than 6 percent. The longitudinal slopes of a swale should be kept to less than 1.0 percent, which often necessitates the use of grade control checks or drop structures. Where the general terrain slope exceeds 3 percent, a grass swale is often practical only on the upslope side of the adjacent street.

When soils with high permeability (for example, SCS HSG Class A or B) are available, the swale can be used to infiltrate a portion of the runoff into the ground, but such soils are not required for effective application of this BMP.

Pollutant Removal. Removal rates reported in literature vary and fall into the low to medium range. Under good soil conditions and low flow velocities, moderate removal of suspended solids and associated other constituents can be expected. H soil conditions permit, infiltration can remove low to moderate loads of soluble pollutants when flow velocities are very low. As a result, small frequent storms can benefit the most.

DESIGN AND SIZING CRITERIA

Swales should be sized to maintain a low velocity during small storms and to collect and convey larger runoff events-all for the projected fully developed land use conditions. If the design flows are not based on fully developed land conditions, the swales will be undersized and will not provide the intended pollutant removal or flow attenuation.

A hearty turf grass must be used so that it will foster dense vegetation, because many storm events occur in early spring when the grass may still be dormant and prone to erosion. Irrigation, fertilization, and erosion protection of newly planted grass or sod are also necessary. Permanent irrigation in some cases may also be necessary. Using swales can possibly replace both curb-and-gutter systems and storm sewer systems in the upper

VEGETATIVE BUFFER ZONES: GRASS-LINED SWALES	Exhibit M-29b

portions of each watershed when properly designed to meet the 2-year storm. However, if one or both sides of the swale are to be used as grass buffers also, their design has to follow the requirements of Grass Buffer Strips, Exhibit M-28.

Additional information is provided below.

VEGETATIVE BUFFER ZONES: GRASS-LINED SWALES	Exhibit M-29c

GRASS-LINED SWALE DESIGN CONSIDERATIONS AND CRITERIA

Criteria	Design Considerations
Velocity	Maintaining low velocities in a swale during small, frequent storms encourages sedimentation and infiltration. Design the swale for a velocity of 2 fps or less during the 2-year event. Use a Mannings roughness coefficient of n=0.035 and set the longitudinal channel slope and channel cross-section dimensions to limit the flow velocity.
Swale Geometry	A shallow trapezoidal or triangular channel cross-section is preferred. A maximum depth of 3 feet is recommended during a 2-year storm. Swale side slopes should be no steeper than 4:1 and preferably 5:1 or flatter.
Longitudinal Slope	Providing a mild slope helps maintain the flow velocities recommended above. Typically, longitudinal slopes will be between 0.2 percent and 0.5 per cent, but shall not exceed 1.0 percent. Sites with greater slopes should use grade control checks or small drop structures to maintain the required longitudinal slope.
Grade Checks	Slow velocities down through the use of grade control checks in a swale to promote sedimentation and infiltration. Provide them as needed to maintain the longitudinal slope and to limit maximum flow velocity.
Vegetation	Dense turf grass cover is recommended to promote sedimentation, filtration, and nutrient uptake, to limit erosion, and to help maintain low flow velocities.
Street and Driveway Crossings	Small culverts at each street crossing and driveway crossings may be usedto provide onsite stormwater capture and to use the swale, if adequate volume is available, as an extended detention basin.
Drainage and Flood Control	Check the water surface during larger storms such as the 100-year flood to ensure that drainage from such events is being handled without flooding critical areas or residential, commercial, and industrial structures.

VEGETATIVE BUFFER ZONES: GRASS-LINED SWALES

Exhibit M-29d

MAINTENANCE CONSIDERATIONS

Healthy grass can generally be maintained without using fertilizers because runoff from lawns and other areas contains the needed nutrients. Occasionally inspecting the grass over the first few years will help to determine if any problems are developing and to plan for long-term restorative maintenance needs.

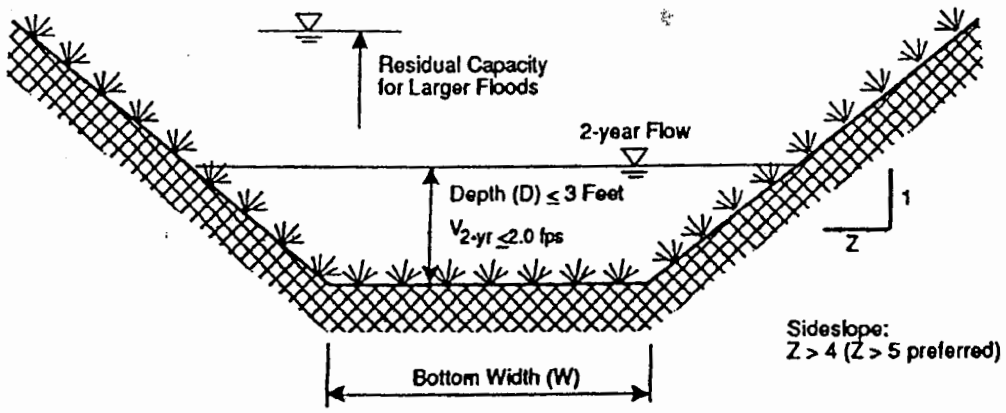
Additional information is provided below.

GRASS-LINED SWALE MAINTENANCE CONSIDERATIONS

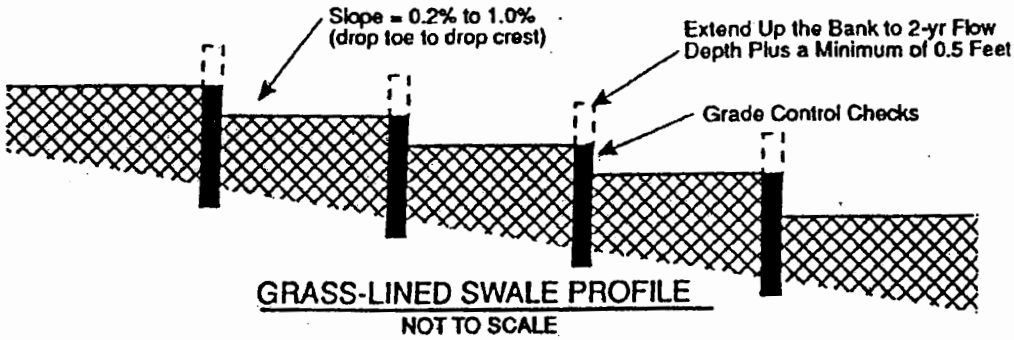
Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and lawn care	Maintain irrigated grass at 2 to 4 inches tall and nonirrigated native grass at 6 to 8 inches tall. Collect cuttings and dispose of them offsite or use a mulching mower.	Routine-As needed.
Debris and litter removal	Keep the area clean for aesthetic reasons, which also reduces floatables being flushed downstream.	Routine-As needed by inspection, but no less than two times per year.
Sediment removal	Remove accumulated sediment near culverts and in channels to maintain flow capacity. Replace the grass areas damaged in the process.	Routine-As needed by inspection. Estimate the need to remove sediment from 3 to 10 percent of total length per year, as determined by annual inspection.
Grass reseeding and mulching	Maintain a healthy dense grass in channel and side slope.	Nonroutine-As needed by annual inspection.
Inspections	Check the grass for uniformity of cover, sediment accumulation in the swale, and near culverts.	Routine-Annual inspection is suggested.

VEGETATIVE BUFFER ZONES: GRASS-LINED SWALES

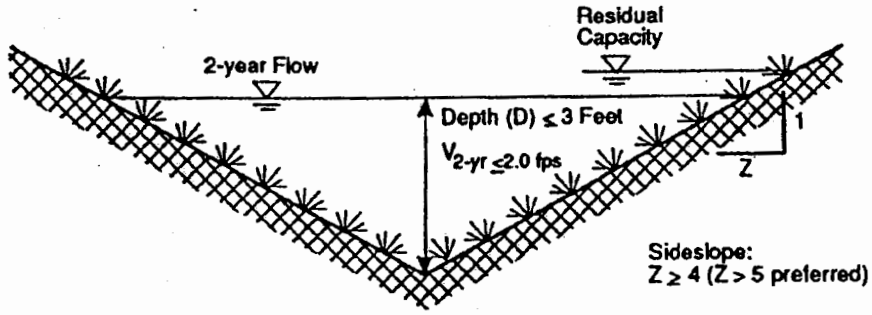
Exhibit M-29e



TRAPEZOIDAL GRASS-LINED SWALE SECTION
NOT TO SCALE



GRASS-LINED SWALE PROFILE
NOT TO SCALE



TRIANGULAR GRASS-LINED SWALE SECTION
NOT TO SCALE

VEGETATIVE BUFFER ZONES: GRASS-LINED SWALES	Exhibit M-29f

DESCRIPTION

A temporary access stream crossing is a structure placed across a waterway to provide access for construction purposes for a period of less than one year.

PURPOSE

The purpose of the temporary access waterway crossing is to provide a safe, pollution free access across a stream. Temporary access waterway crossings are necessary to prevent construction equipment from damaging the stream and tracking sediment and other pollutants into the waterway.

CONDITIONS WHERE PRACTICE APPLIES

_ Perimeter control
_ Slope protection
_ Sediment trapping
* Drainageway & stream protection
_ Temporary stabilization
_ Permanent stabilization & exposure limits
* Non-sediment pollution control

APPROPRIATE APPLICATIONS

- Effectiveness:
  - Temporary Access Culvert: A temporary access culvert may be effective in controlling erosion.
  - Temporary Access Ford: A temporary access ford offers very little sediment and erosion control and is really only effective in ephemeral stream channel.

- Advantages:
  - Temporary Access Culvert: A temporary culvert is easily constructed and allows for heavy equipment loading.
  - Temporary Access Ford: A temporary ford is the least expensive waterway crossing and allows for maximum load limits. It also offers very low maintenance.

WATERWAY CROSSING	 Symbol	**Exhibit M-30a**

LIMITATIONS

- Temporary Access Culvert: Temporary culverts need maintenance often and can cause erosion if the culvert becomes clogged.
- Temporary Access Ford: A temporary ford offers little erosion control.

NOTE:Special care must be taken for all these practices when crossing an environmentally sensitive streams. Oils or other potentially hazardous materials shall not be used for surface treatments.

PLANNING CONSIDERATIONS

For minor washes, no crossing may be necessary. For larger streams, the contractor should consider the time of year, construction schedule, and construction requirements. For crossing intermittently flowing streams- a shallow access ford or culvert is recommended.

DESIGN & SIZING CRITERIA

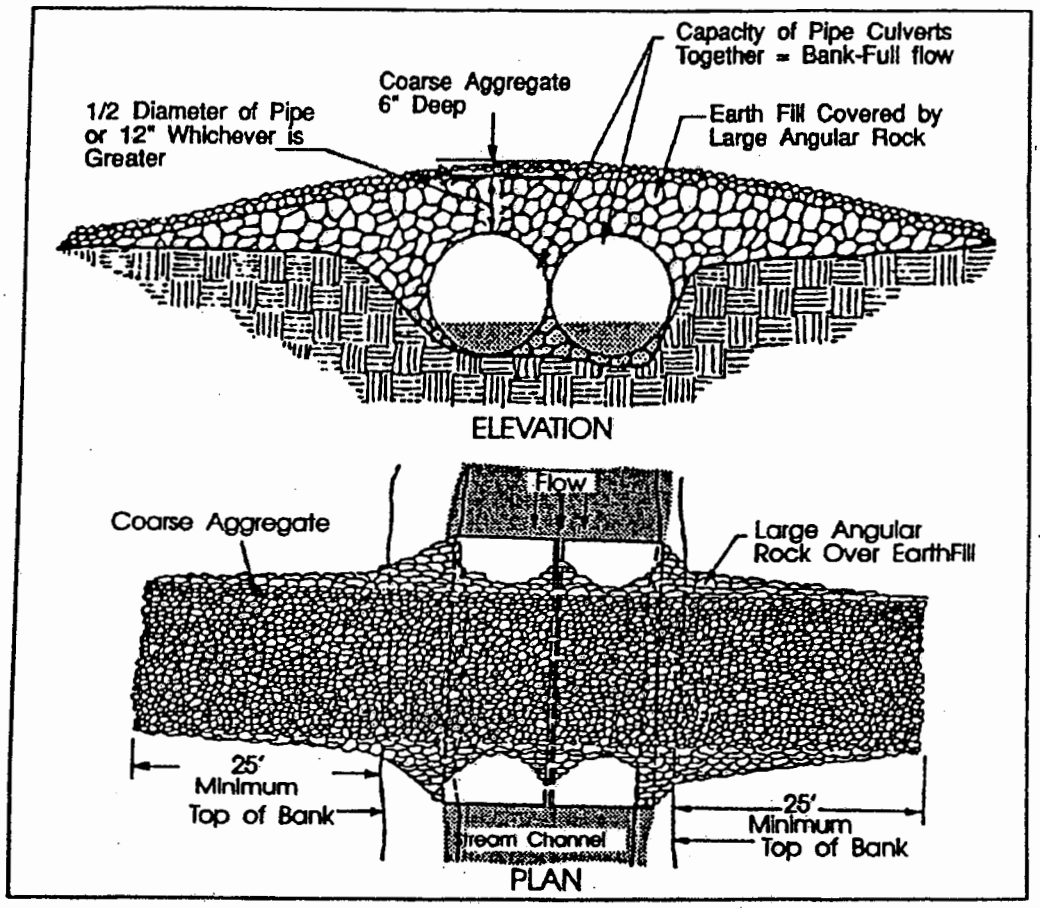
Temporary culvert shall be sized for the 2 year storm event.

MAINTENANCE REQUIREMENTS

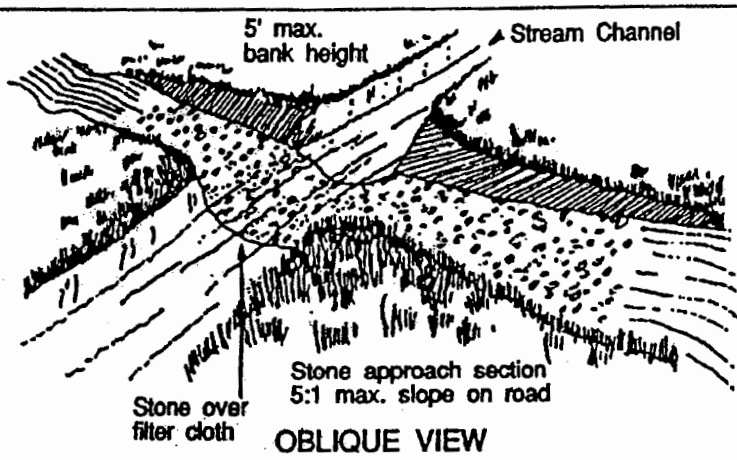
Inspect monthly and after each significant rainfall.

- Replace lost aggregates to restore access.
- Clean silt deposits from culverts.
- Inspect for erosion, undercutting and settlement.

WATERWAY CROSSING	 Symbol	**Exhibit M-30b**



WATERWAY CROSSING	WC Symbol	Exhibit M-30c



Design Criteria:

- As a minimum, design the structure to pass bankfull flow or peak flow, whichever is less, from a 2-year peak storm, without overtopping.
- Ensure that design flow velocity at the outlet of the crossing structure is nonerosive for the receiving stream channel. See Vol. II, Major Drainage, Section 5.3

WATERWAY CROSSING	 Symbol	Exhibit M-30d

APPENDIX "N"
DETENTION VOLUME & THE MODIFIED RATIONAL METHOD

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NOTE: ALL REFERENCE TO 2-YEAR DESIGN STORM SHALL BE CHANGED TO 5-YEAR DESIGN STORM.

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APPENDIX "N"
DETENTION VOLUME & THE MODIFIED RATIONAL METHOD

1. General Discussion Criteria and design requirements for detention basins are covered in Section VIII, and are not treated further here. However, one aspect of detention basin design is determining the volume required, which is integrated with outlet work design. If non-computer methods are used, procedures are usually iterative and tedious. They also are typically based upon the Modified Rational Method (MRM). In this appendix, procedures are provided which not only simplify the manual calculation process, but which reduce the likelihood of misuse of the MRM.

2. Manual Calculation Procedures Without simplification or restriction to specific types of outlet facilities, hand calculations are generally iterative. While this would not pose a serious problem, it is realized that a few simplifying assumptions and/or relationships could significantly reduce design effort, and still allow for detention/outlet facility designs that probably have less inaccuracy associated with them than there is with the base hydrologic data upon which they are based.

Use of the simplified manual calculation procedures presented herein are not required. One may, if desired, pursue a more detailed design. Sophisticated procedures for certain types of outlets are provided in an SCS publication entitled Hydraulics of Two-Stage Risers. However, it is assumed that most will be interested in an allowed simplified procedure, which the balance of this appendix addresses.

The simplified manual calculation procedures involve the following concepts or steps, which are subsequently discussed in more detail:

(i) Rational Method Hydrology;
(ii) Basic Hydraulic Relationships;
(iii) Modified Rational Method;
(iv) Geometrically Designing the Detention Basin;
(v) Calculating the Volume-Depth Relationship;
(vi) Sizing the Lower Stage Outlet; and
(vii) Designing the Upper Stage Outlet.

a. Rational Method Hydrology The manual procedures presented herein are based upon use of the Rational Method for hydrological calculations. This is partly due to the frequent use of the Rational Method, and partly due to the fact that most computer programs which estimate storm runoff also contain routines for reservoir or pond routing of runoff, and therefore manual calculations are not necessary.

Procedures require only the normal hydrological calculations; that is, the pre- and post-development Tc and C values, area, and peak runoff rates.

b. Basic Hydraulic Relationships Use of basic relationships can greatly simplify and even eliminate the iterative nature of detention/outlet works design. The relationships may not be exact, but are deemed to be sufficiently close to be within hydrological error. The basic relationships are presented along with a review of a few concepts.

1) Maximum Detention Release (Qmax) The total developed runoff from a site may not exceed the historic rate. Developed runoff may consist of detention release and flow which leaves the site directly, bypassing the detention facility. This is exemplified in Figure "N-1", where it is shown that the maximum release from the detention pond (Qmax) cannot exceed the historic peak (Q_h) minus bypass runoff (Qb).

2) Average Detention Release (Qr) The maximum detention release (Qmax) occurs when ponded water is at the highest level. Most of the time, the water surface level is rising or lowering; therefore, the average release rate is somewhat less than Qmax. The average release rate is "Qr". For single stage outlets, Qr will occur when water depth is approximately half the maximum for vertical walled basins, and when water depth is approximately two-thirds maximum for basins with sloping sides. For multiple stage outlets, the basic relationship is not so simple, but may be approximated.

The basic relationships are incorporated into the equations presented in Figure "N-2" on pages N-8 and N-9, which allow direct estimation of Qr for the 2 year and 100 year storm based upon Qmax.

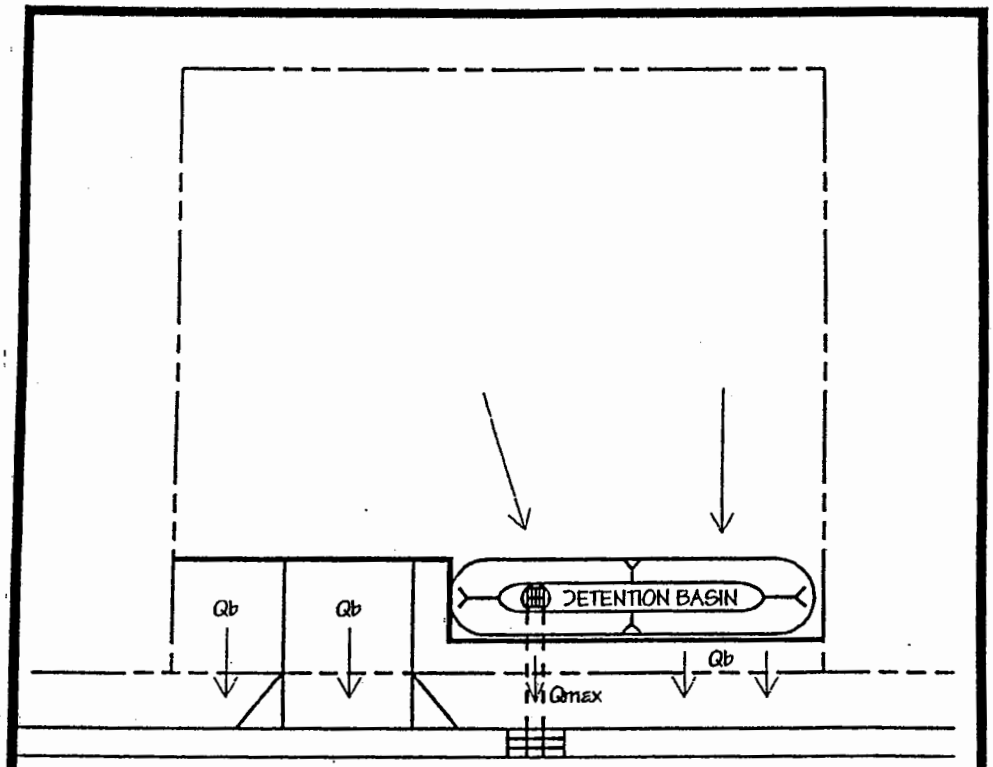
c. Modified Rational Method The Modified Rational Method is a commonly used means of sizing detention facilities. Unfortunately, a deficiency in the method itself and user misapplication often result in underestimating required detention volume. Causes of error are:

(i) Truncation of rainfall after the critical storm duration, which is a method deficiency;

(ii) The release rate is commonly equated to the historical runoff rate, which is unlikely given hydraulic limitations;

(iii) Equations commonly used do not account for the likely shift in Tc from pre- to post-development conditions (which may or may not be a problem); and

(iv) The critical duration Td is approximated, and calculations are consequently based on a reduced volume.



Maximum release from detention pond Qmax ≤ Historic peak Q_h minus direct bypass runoff Qb

$Qmax \leq Q_h - Qb$

DETERMINATION OF Qmax	FIGURE "N-1"

The first error is difficult to deal with quantitatively. Significant error is mitigated by the restriction that the method may not be used for watersheds larger than 25 acres.

The second error is caused by the user of the method. Pond release rates may be governed by pipe flow, or orifice or weir flow into an inlet. Outflow will begin at zero cfs, and is allowed to peak at Qmax which may equal the historic rate Q_h minus Qb, if any, and recedes back to zero. Acceptable approximations of the average release Qr during the time of interest are provided in subsection "b" above and Figure N-2.

The third and fourth errors are due to the selected equation and user application. Both may be avoided by use of equations presented in "Applied Hydrology". Use of these equations for determining the critical duration is mandatory if the Modified Rational Method is used.

The ominous looking but simple equations, modified to incorporate local and regional IDF data prepared by Henz Meteorological Services (Mesa County,

1991), along with other relationships required for using the Modified Rational Method, are presented in Table "N-1" on page "N-10".

d. Geometrically Designing the Detention Basin With known required storage volumes required per subsection "c" above, Figure "N-3" on page N-11 may be used along with known site and desired finish conditions to size and geometrically design the detention basin.

e. Calculating the Volume-Depth Relationship Available incremental and total volumes of the detention basin may be calculated per criteria presented in Figure "N-4" on page N-12. By calculating available volume at incremental heights, a volume-depth (V-D) relationship may be determined and graphed. Usually only 2 or 3 calculations are adequate if taken at key points, such as at the inlet and toe and top of embankment slopes.

f. Lower Stage Outlet Entering the V-D graph with the V_2 calculated per "c" above, one may directly read the ponded two year water depth, or d_2. Knowing d_2 and $Qmax_2$, the lower stage outlet may be sized. The capacity of the lower stage outlet could also be determined for greater depths, providing adequate information to allow plotting the lower outlet depth-discharge (D-Q) curve. If plotted on the V-D curve, with storage volume on the left ordinate, depth on the bottom abscissa, and discharge on the right ordinate, a handy V-D-Q graph is formed.

g. Upper Stage Outlet Although it would not minimize detention volume, one could provide a single stage outlet that would just meet the criteria for one design storm, resulting in an overdesign for the other; that is, the release rate may be below the historic rate for one of the design storms. If this approach is taken, the capacity of the selected outlet must be checked under both storm conditions.

The more probable design approach, particularly for larger watersheds, is to provide a two-stage outlet, with the upper stage outlet invert beginning at d_2. By entering V_{100} onto the V-D (or V-D-Q) graph, one may directly read the maximum water depth ponded in the 100 year storm event, or d_{100}. Using d_{100}, one may calculate the capacity of the lower stage outlet, or read it directly from the graph if it was plotted. The allowed capacity of the upper stage outlet is $Qmax_{100}$ minus the lower outlet capacity at d_{100}. Note that d_{100} is the total water depth in the pond, which is usually not the depth or height used in upper outlet weir or orifice calculations. Knowing the allowable capacity and available water depth, the upper stage outlet may be sized. (At this point, a few calculations at different depths would allow plotting the depth-discharge curve for the upper outlet, and also the plotting of the composite or total depth discharge curve. Observation of the graph could provide a double check on the analysis.)

Sizing the upper outlet so that the combined outlet capacity just meets or at least does not exceed historic rates is a common procedure, with an outlet pipe or channel

provided which does not restrict flow or result in a hydraulic gradeline which interferes with outlet hydraulics. However, an alternative approach is to oversize the upper outlet, and let the outlet pipe hydraulics govern the 100-year flow rate. The advantage of this approach is that the oversized upper outlet is less affected by clogging, and the system will generally operate more often as planned. A disadvantage is the ability to select pipe sizes and conditions that match hydraulic gradeline requirements.

A third approach is to incorporate advantages of both of the other two alternatives. This involves using an upper outlet that is not oversized and an outfall facility as with the first approach, but to provide, such as at the top of a riser, an overflow inlet which could reduce the effect of clogging and also accept runoff in greater than 100-year events.

3. <u>Summary of Manual Calculation Procedures</u> The following summary not only outlines the steps involved in sizing a detention basin, but numerically corresponds with the steps provided on the worksheet in Table "N-2" on page N-13.

1) Determine the entire area involved. This is the same for both the 2- and 100-year condition.

2) Select an appropriate historic condition runoff coefficient (C) value for the 2- and 100-year storms (see Appendix "B").

3) Calculate an appropriate historic condition runoff time of concentration (Tc) value for the 2- and 100-year storms (see Appendix "E").

4) Select the appropriate intensity (I) values for the historic condition 2- and 100-year storms using Table "A-1" in Appendix "A".

5) Using the Rational Method equation, calculate runoff using the equation Q=CIA.

6-10) Repeat steps (1) through (5) above under developed conditions, limited to only the subbasin(s) having runoff that will bypass the proposed detention period.

11) Qmax is equal to Qp_h of step (5) minus Qb of step 10.

12) Determine the average detention pond release rate Qr from Figure "N-2a" or "N-2b" as appropriate. The shaded column provides direct values of Qr based upon the Qmax determined in step (11).

13-15) For the developed condition of the subbasin which contributes to the detention pond, repeat steps (1) through (3) above.

16-20) Using the appropriate column of Table "N-1", calculate parameters of the Modified Rational Method (MRM) and required storage volumes.

21-28) Using geometric requirements presented in Figure "N-3" and procedures presented in Figure "N-4", calculate basin volumes and plot the corresponding values and curve (straight line segments) on the graph. (Note that the graph is dimensionless, with scale to be established by the user.)

29) Enter the Volume ordinate with the V_2 value from step (20), and proceed horizontally across to the detention basin Volume-Depth (V-D) curve, then proceed vertically down to the Depth abscissa. Obtain the maximum water depth for the 2-year storm event (d_2).

30) Adjust as applicable the water depth d_2 from step (29) to obtain the head of water (H_L) on the lower stage outlet (see Figure "N-2a" or "N-2b").

31) Having the head H_L from step (30) and $Qmax_2$ from step (11), size/design the lower stage outlet using equations presented in the "Qmax" column of Figure "N-2". The "C" coefficients and other orifice and weir information are presented in Appendix "K". Note that velocity head is not a factor for flow from detention basins.

32) Enter the Volume ordinate with the V_{100} value from step (20), and proceed horizontally across to the detention basin Volume-Depth (V-D) curve, then proceed vertically down to the Depth abscissa. Obtain the maximum water depth for the 100-year storm event (d_{100}).

33) Calculate the capacity Q_L of the lower stage outlet designed in step (30) for the d_{100} water level condition. Calculate Q_L at various depths, including at d=0, d_2, and d_{100}, and plot the lower outlet capacity (optional).

34) Calculate the height of water that will act on the upper outlet. Usually, the upper stage outlet begins at d_2; consequently, the available depth would be d_{100} minus d_2. Adjust from water depth "d" to head "h", as appropriate (see Figure "N-2").

35) Set the upper outlet capacity Qu equal to $Qmax_{100}$ from step (11) minus Q_L (at d_{100}) from step (33).

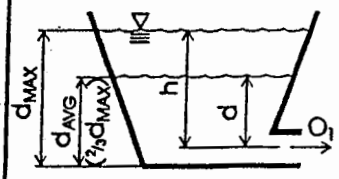
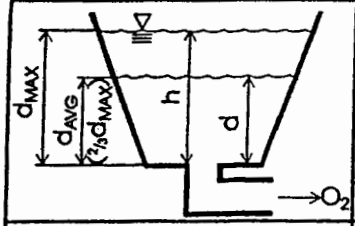
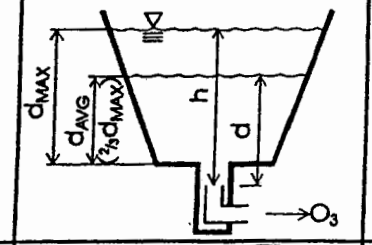
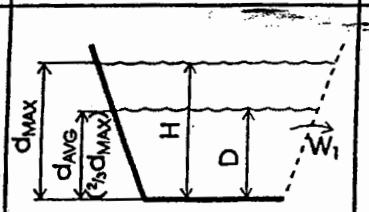
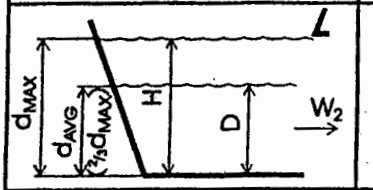
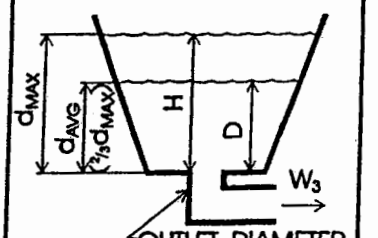
36) Having the allowed outflow rate Qu from step (35) and the available head Hu from step (34), size/design the upper stage outlet using equations presented in the "Qmax" column of Figure "N-2". The "C" coefficients and other orifice

and weir information are presented in Appendix "K". Note that velocity head is not a factor for flow from detention basins. Calculate Qu at d_2, d_{100}, and possibly at a midpoint depth, and plot the upper outlet capacity (optional). Also, the combined lower and upper outlet capacities may be plotted together.

37) Outfall facilities must be capable of conveying outflow. The hydraulic gradient should be checked to ensure that backwater conditions do not affect the conditions upon which Qr in step (12) was originally based.

38) As a safety factor against clogging or greater than 100-year flows, a means of spill-over into the outflow conveyance facility or over-embankment spillway should be provided.

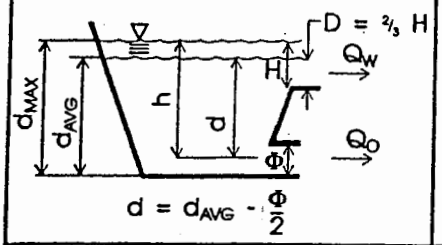
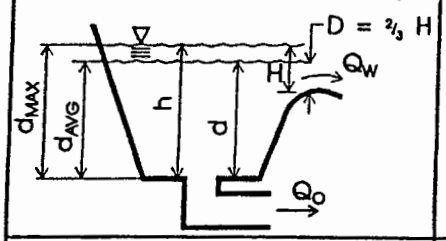
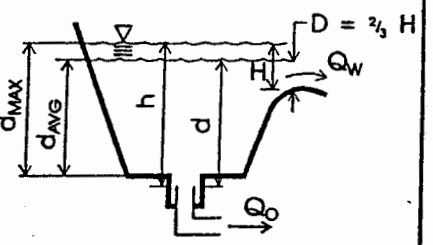
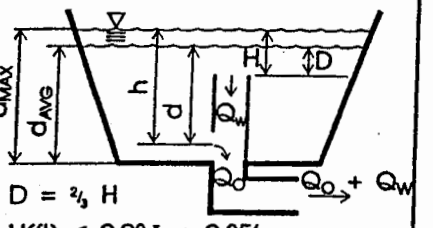
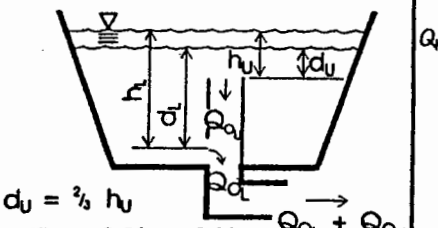
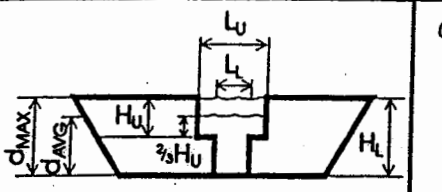
Qr = Average reservoir release rate during a given storm = $(\Sigma Q_{ORIFICE} + \Sigma Q_{WEIR}) \leq (Q_{historic} - Q_{bypass})$
NOTE: Equations assume that downstream pipes or channels do not impede orifice or weir flow.

	DIAGRAM	Q_{MAX}	Qr based on d	Qr based on Q_{MAX} or h
ORIFICE ONLY		$Q_{MAX}=CA(2gh)^{.5}$ $[h \neq d_{MAX}, d \neq d_{AVG}]$	$Qr = CA(2gd)^{0.5}$	$Qr = 0.82\ Q_{MAX} = 0.82[CA(2gh)^{.5}]$ If orifice diameter is small compared to the water depth, it may be reasonable to use d_{MAX} to the orifice invert and the following modified equation: $Qr \approx 0.75\ Q_{MAX} \approx 0.75[CA(2gd_{MAX})^{.5}]$
		$Q_{MAX}=CA(2gh)^{.5}$ $[h = d_{MAX}, d = d_{AVG}]$	$Qr = CA(2gd)^{0.5}$	$Qr = 0.82\ Q_{MAX} = 0.82[CA(2gh)^{.5}]$
		$Q_{MAX}=CA(2gh)^{.5}$ $[h \neq d_{MAX}, d \neq d_{AVG}]$	$Qr = CA(2gd)^{0.5}$	$Qr = 0.82\ Q_{MAX} = 0.82[CA(2gh)^{.5}]$
WEIR ONLY		$Q_{MAX} = CLH^{1.5}$ $[h = d_{MAX}, d = d_{AVG}]$	$Qr = CLD^{1.5}$	$Qr = 0.55\ Q_{MAX} = 0.55[CLH^{1.5}]$
		$Q_{MAX} = CLH^{1.5}$ $[h = d_{MAX}, d = d_{AVG}]$	$Qr = CLD^{1.5}$	$Qr = 0.55\ Q_{MAX} = 0.55[CLH^{1.5}]$
		$Q_{MAX} = CLH^{1.5}$ $[h = d_{MAX}, d = d_{AVG}]$ [L = Perimeter length]	$Qr = CLD^{1.5}$	$Qr = 0.55\ Q_{MAX} = 0.55[CLH^{1.5}]$

CALCULATING APPROXIMATE STORAGE RELEASE RATES | **FIGURE N-2a**

Qr = Average release rate during a given storm = $(\Sigma\ Q_{ORIFICE} + \Sigma\ Q_{WEIR}) \leq (Q_{historic} - Q_{bypass})$
NOTE: Equations assume that downstream pipes or channels do not impede orifice or weir flow.

ORIFICE AND WEIR COMBINATIONS

DIAGRAM	Q_{MAX}	Qr based on d	Qr (rough) based on Q_{MAX}
 $d = d_{AVG} - \frac{\Phi}{2}$	$Q_{MAX} = Q_O + Q_W$ $= CA(2gh)^{0.5} + CLH^{1.5}$ $[h \neq d_{MAX}, d \neq d_{AVG}]$	$Qr = Q_O + Q_W$ $= CA(2gd)^{0.5} + CLD^{1.5}$	$Qr \approx 0.65\ Q_{MAX}$
	$Q_{MAX} = Q_O + Q_W$ $= CA(2gh)^{0.5} + CLH^{1.5}$ $[h = d_{MAX}, d = d_{AVG}]$	$Qr = Q_O + Q_W$ $= CA(2gd)^{0.5} + CLD^{1.5}$	$Qr \approx 0.65\ Q_{MAX}$
	$Q_{MAX} = Q_O + Q_W$ $= CA(2gh)^{0.5} + CLH^{1.5}$ $[h \neq d_{MAX}, d \neq d_{AVG}]$	$Qr = Q_O + Q_W$ $= CA(2gd)^{0.5} + CLD^{1.5}$	$Qr \approx 0.65\ Q_{MAX}$
 D = ⅔ H H(ft) ≤ 0.08Φ + 0.35' Φ = Riser width or diameter(ft)	$Q_{MAX} = Q_O + Q_W$ $= CA(2gh)^{0.5} + CLH^{1.5}$ $[h \neq d_{MAX}, d \neq d_{AVG}]$	$Qr = Q_O + Q_W$ $= CA(2gd)^{0.5} + CLD^{1.5}$	$Qr \approx 0.65\ Q_{MAX}$
 $d_U = ⅔\ h_U$ h_U(ft) > 0.08Φ +0.35' Φ = Riser width or diameter(ft)	$Q_{MAX} = Q_{O_L} + Q_{O_U}$ $= CA(2gh_L)^{0.5} + CA(2gh_U)^{0.5}$	$Qr = Q_{O_L} + Q_{O_U}$ $= CA(2gd_L)^{0.5} + CA(2gd_U)^{0.5}$	$Qr \approx 0.70\ Q_{MAX}$
DBL WEIR 	$Q_{MAX} = Q_{W_L} + Q_{W_U}$ $= CL_L H_L^{1.5} + C(L_U - L_L)H_U^{1.5}$	$Qr = Q_{W_L} + Q_{W_U}$ $= CL_L(H_L - \frac{H_U}{3})^{1.5} +$ $C(L_U - L_L)(.67H_U)^{1.5}$	$Qr \approx 0.50\ Q_{MAX}$

CALCULATING APPROXIMATE STORAGE RELEASE RATES | **FIGURE N-2b**

This table is based upon equations in (Chow) and local meteorology (Mesa County, 1991)

Storm Event	Grand Valley	Outside of Grand Valley
2 Year	$Td_2 = \left[\frac{507.82\ C_dA}{Qr - \frac{Qr^2Tc_d}{53.4C_dA}}\right]^{0.5} - 19.0$ $Id_2^* = \frac{26.71}{Td_2 + 19.01}$	$Td_2 = \left[\frac{805.3\ C_dA}{Qr - \frac{Qr^2Tc_d}{87.3C_dA}}\right]^{0.5} - 18.4$ $Id_2^* = \frac{43.67}{Td_2 + 18.44}$
100 Year	$Td_{100} = \left[\frac{1972.9\ C_dA}{Qr - \frac{Qr^2Tc_d}{209.9C_dA}}\right]^{0.5} - 18.8$ $Id_{100}^* = \frac{104.94}{Td_{100} + 18.80}$	$Td_{100} = \left[\frac{2091.0\ C_dA}{Qr - \frac{Qr^2Tc_d}{22.38\ C_dA}}\right]^{0.5} - 18.7$ $Id_{100}^* = \frac{111.88}{Td_{100} + 18.69}$

$$Qd = C_dA(Id) \qquad K = Tc_h/Tc_d$$

$$V = 60\left[Td\ (Qd - Qr) - QrTc_d + \frac{KQrTc_d}{2} + \frac{Qr^2Tc_d}{2Qd}\right]$$

A factor of 60 in the volume equation converts time from minutes to seconds, yielding cubic feet volume.

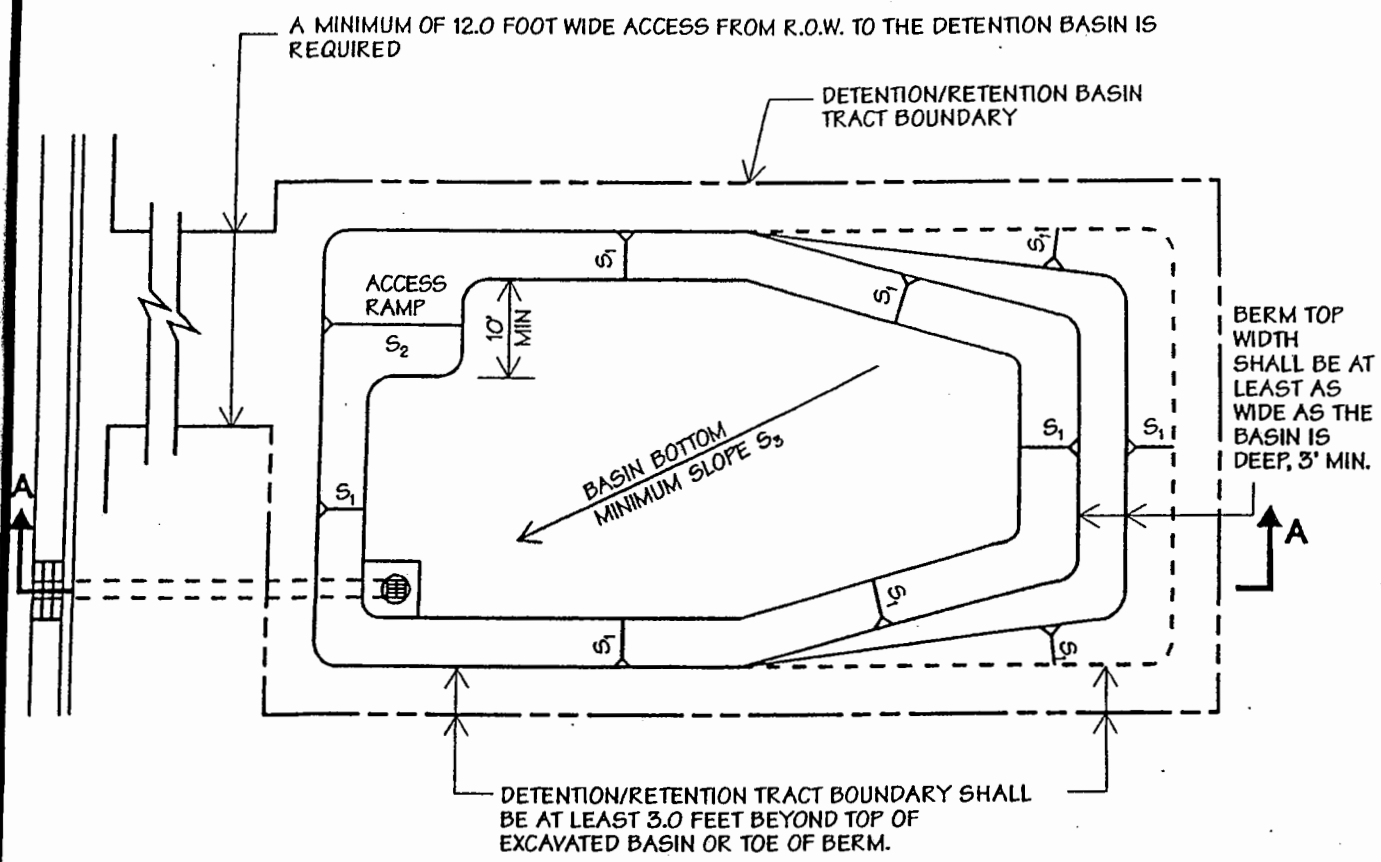
*Id may be selected directly from Table "A-1" in Appendix "A"

Td = Time of critical storm duration, minutes;
C = Runoff coefficient;
A = Area in acres;
Qr = Detention pond average release rate, cfs
(Note that this will not likely be the historic rate Q_h; nor even Qmax);
Tc = Time of concentration, minutes;
Id = Intensity at Td, inches per hour;
Qd = Runoff rate at Td, cfs;
K = Ratio of pre- and post-development Tc; and
V = Storage volume in ft^3.

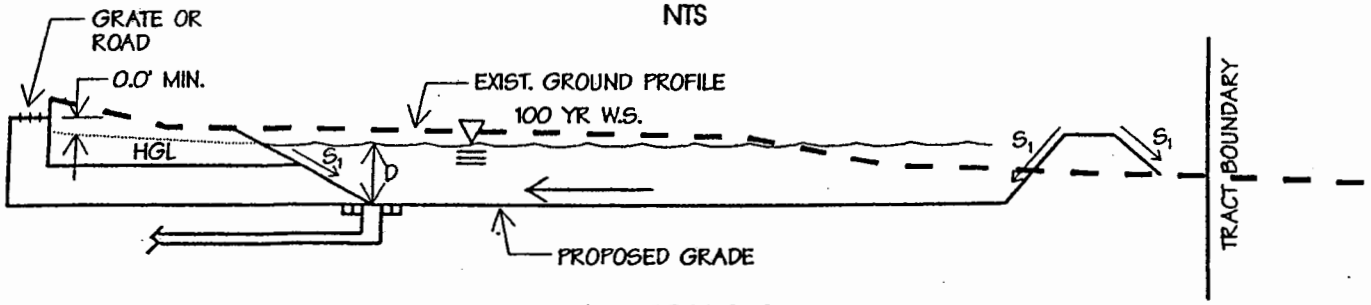
The meaning of subscripts used are as follows:

2 = 2-year storm condition;
100 = 100-year storm condition;
h = historic condition; and
d = developed condition.

MODIFIED RATIONAL METHOD EQUATIONS | **TABLE "N-1"**



PLAN VIEW
NTS



SECTION A-A
NTS

STEEPEST S_1: 4H:1V FOR BASINS ON PUBLIC LANDS AND PARKS
3H:1V FOR SEEDED OR SODDED SLOPES
2H:1V FOR RIPRAP OR OTHER APPROVED SLOPE PROTECTION
VERTICAL WALLS WITH SAFETY RAILING LIMITED TO ONE SIDE ONLY WHERE APPROVED BY THE CITY ENGINEER OR COUNTY DEVELOPMENT ENGINEER

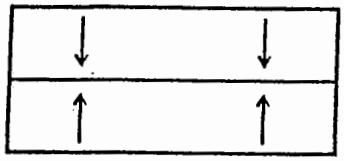
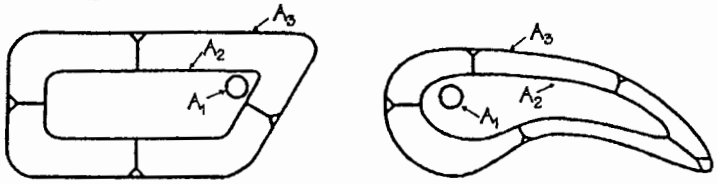
STEEPEST S_2: 6H:1V FOR ACCESS RAMP, ALL SURFACES

MINIMUM S_3: 0.5% FOR CONCRETE CHANNEL
1.0% FOR ASPHALT (PARKING LOT)
2.0% FOR ALL OTHER SURFACES

MAXIMUM D: 4' RETENTION BASIN
8' WET OR DRY DETENTION FACILITY
>8' SPECIAL APPROVAL REQUIRED, BUT MAY BE ALLOWED FOR MULTIPLE USE PONDS OR FOR STEEP TERRAINS

MINIMUM D: 4' WET PONDS (SEE PAGE VIII-1)

DETENTION BASIN GEOMETRIC REQUIREMENTS	FIGURE N-3

BASIN SHAPE		
BASIN TYPE	VERTICAL WALLS AND/OR PRISMATIC BASINS	FAIRLY UNIFORM SHAPE AND SIDE SLOPES OR HIGHLY IRREGULAR SHAPE AND SIDE SLOPES
VOLUME CALCULATION METHOD	AVERAGE END AREA METHOD	CONIC METHOD
EQUATION	$V = \left(\frac{A_n + A_{n+1}}{2}\right) L$	$V = \Sigma V_{n \text{ to } n+1}$ $V_{n \text{ to } n+1} = [A_n + A_{n+1} + (A_n A_{n+1})^{.5}]\frac{h}{3}$

WHERE:
- V = Volume (ft)
- A_n = Horizontal area (ft^2) at elevation "n"
- A_{n+1} = Horizontal area (ft^2) at elevation "n+1"
- h = Vertical height (ft) between elevation "n" and "n+1"
- $V_{n \text{ to } n+1}$ = Volume between elevation "n" and "n+1"
- L = Length (ft) between two ends

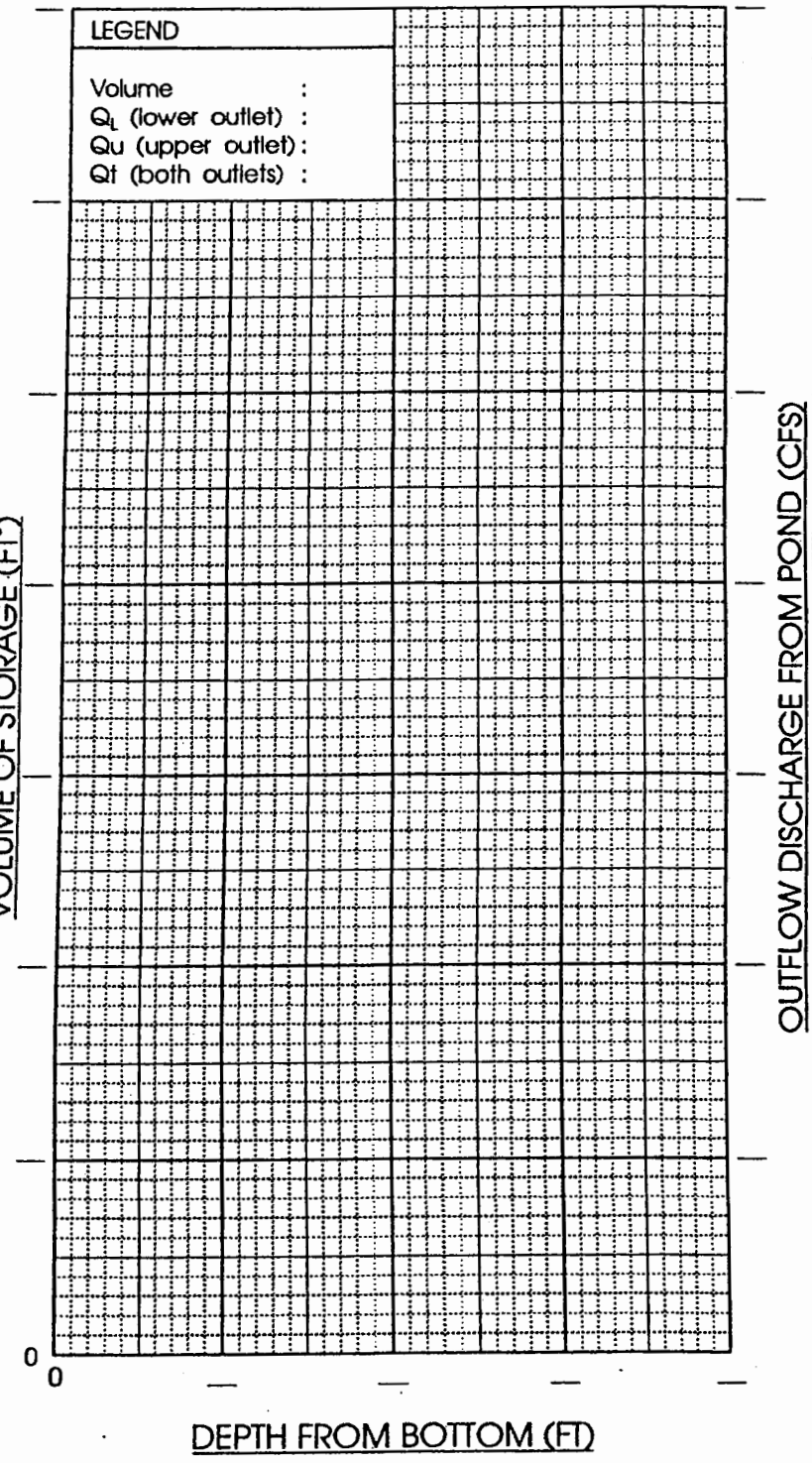
NOTE: The above equations may be used in succession for incremental heights within a basin. An area should be selected at all significant changes in shape or side slope.

CALCULATING STORAGE VOLUME | **FIGURE N-4**

Project:_____ Design by:_____ Date:_____

	STEP*	PARAMETER	2-YEAR VALUE	100-YEAR VALUE
HISTORIC TOTAL SITE RUNOFF	1	A (acres)		
	2	C_h		
	3	Tc_h (min)		
	4	I_h (in/hr)		
	5	Qp_h (cfs)		
DEV. BYPASS: SEE FIG. "N-1"	6	A (acres)		
	7	C_d		
	8	Tc_d		
	9	I_d (in/hr)		
	10	Qb (cfs)		
Qr: SEE FIG "N-2"	11	Qmax (cfs)		
	12	Qr (cfs)		
DEV. AREA ABOVE POND	13	A (acres)		
	14	C_d		
	15	Tc_d (min)		
MRM PARAMETERS: SEE TABLE "N-1"	16	Td (min)		
	17	Id (in/hr)		
	18	Qd (cfs)		
	19	K		
	20	V (ft^3)		
DETENTION POND: SEE FIGURES "N-3" & "N-4"	21	A_1 (ft^2)		
	22	A_2 (ft^2)		
	23	A_3 (ft^2)		
	24	h_{1-2} (ft)		
	25	h_{2-3} (ft)		
	26	V_{1-2} (ft^3)		
	27	V_{2-3} (ft^3)		
	28	V_{1-3} (ft^3)		
OUTLET WORKS: USE GRAPH, FIG. "N-2", & APPENDIX "K"	29	d_2 (ft)		
	30	H_L (ft)		
	31	Lower Outlet		
	32	d_{100} (ft)		
	33	Q_L (cfs)		
	34	Hu (ft)		
	35	Qu (cfs)		
	36	Upper Outlet		
OUTFALL WORKS	37	Are outfall conveyance facilities adequate to allow conditions assumed during Qr determination?		
	38	Provide means of overflow for greater than 100-year water depths (spill to outlet works or over embankments).		

VOLUME-DEPTH DISCHARGE (V-D-Q) GRAPH



* Steps correspond with enumerated procedures explained on pages N-5, N-6 and N-7.

MANUAL DETENTION VOLUME CALCULATION WORKSHEET

TABLE "N-2"

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