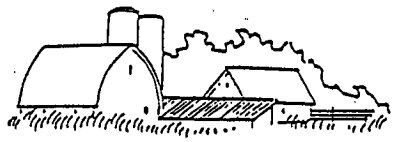
BEST MANAGEMENT

WETLANDS PRACTICES

FOR AGRICULTURE



July 1993
Amended September 1998

NH Department of Agriculture, Markets & Food

In Cooperation With:

NH Association of Conservation Districts
NH Association of Wetland Scientists
NH Department of Environmental Services - Wetlands Bureau
New Hampshire Farm Bureau Federation
Rockingham County Conservation District
USDA Natural Resources Conservation Service

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CHAPTER 1

INTRODUCTION

INTRODUCTION

Many agriculture activities in New Hampshire may involve working in land which falls under the definition of "wetlands". According to New Hampshire Wetlands Law RSA 482-A, no person shall excavate, remove, fill, dredge, or construct any structure in areas of wetlands without first obtaining a permit from the NH Department of Environmental Services - Wetlands Bureau. The Wetlands Bureau has been charged by the legislature with protecting the state's submerged lands and wetlands from despoliation and unregulated alteration and operates under the provisions of RSA 482-A and the Code of Administrative Rules (Chapters Wt 100 through Wt 800).

The New Hampshire Wetlands Bureau defines wetlands as an area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal conditions, do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Surface waters including lakes, ponds, rivers, brooks, and seasonal streams are also regulated, as well as land adjacent to tidal waters which are within 100 feet of the highest observable tide line (including upland areas).

Wetlands perform various functions and are an important component of the natural environment. Wetland functions include but are not limited to groundwater recharge/discharge, flood storage and desynchronization, dissipation of erosive forces, sediment and toxicant retention, nutrient retention and transformation, aquatic diversity, fish/shellfish and wildlife habitat, and habitat for threatened/endangered species.

Every agricultural conservation practice that impacts wetland areas involves some risk of soil erosion and sedimentation that may affect water quality. With a common understanding of the risks, and the practices to mitigate those risks, and through the use of this publication, the agricultural producer/landowner and the government working together can protect our state's water resources.

Maintenance or improvement of existing crop or pasture land for continued agricultural use which impact wetlands are under the NH Wetlands Bureau jurisdiction. Utilizing the Best Management Wetlands Practices (BMWP) for minimizing impacts in agricultural operations under a Board permit process can ensure that minimum environmental impacts will occur to wetlands.

This publication is primarily a reference and planning tool designed to help the agricultural producer to become better informed about the best management practices for reducing soil erosion and controlling sedimentation from agricultural operations

that impact wetlands. These BMWPs are based on standards and specifications of the USDA Natural Resources Conservation Service. The impacted areas are wet meadows within agricultural fields that are currently being farmed or were farmed in the past. These impacts may be new conservation practices, or may be for the purpose of maintenance of existing practices.

When using this publication, it is important to remember that for every situation encountered, there may be more than one correct method to prevent erosion and sedimentation. Flexibility and understanding are important, since the intent of any best management practice is to keep sediment out of streams and to keep wetland impacts restricted to agriculturally-altered wet meadow plant communities. These goals can be accomplished through a cooperative working relationship between the NH Department of Environmental Services - Wetlands Bureau, the County Conservation Districts, and the agricultural producer/owner rather than an enforcement posture.

The address, telephone and fax numbers of the NH Department of Agriculture, Markets & Food, the Wetlands Bureau, and the County Conservation District offices are listed below.

New Hampshire Department of Agriculture, Markets & Food
25 Capitol Street
PO Box 2042
Concord, NH 03302-2042
Tel: 271-3551
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NH DES - Wetlands Bureau
6 Hazen Drive
PO Box 95
Concord, NH 03302-0095
Tel: 271-2147
Fax: 271-6588

Belknap County Conservation District
719 Main Street, Room 203
Laconia, NH 03246-2772
Tel: 528-8713
Fax: 528-8783

Carroll County Conservation District
73 Main Street
PO Box 533
Conway, NH 03818-0533
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Cheshire County Conservation District
RR 1, Box 315
Walpole, NH 03608-9744
Tel: 756-2988
Fax: 756-2978

Coos County Conservation District
4 Mayberry Lane
Lancaster, NH 03584-3616
Tel: 788-4651
Fax: 788-2538

Grafton County Conservation District
RR 2, Box 148-B
Woodsville, NH 03785-9402
Tel: 747-2001
Fax: 747-3477

Hillsborough County Conservation District
468 Route 13, South
Milford, NH 03055-3442
Tel: 673-2409
Fax: 673-0597

Merrimack County Conservation District
The Concord Center
10 Ferry Street, Box 312
Concord, NH 03301-5081
Tel: 223-6023
Fax: 223-6030

Rockingham County Conservation District
118 North Road
Brentwood, NH 03833-6614
Tel: 679-2790
Fax: 679-2860

Strafford County Conservation District
259 County Farm Road, Unit 3
Dover, NH 03820-6015
Tel: 749-3037
Fax: 743-3667

Sullivan County Conservation District
24 Main Street
Newport, NH 03773
Tel: 863-4297
Fax: 863-4730

CHAPTER 2

ACCESS

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

ACCESS ROADS

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A road system, temporary or permanent, installed for transportation of agricultural produce by vehicle.

Purpose

To provide for an efficient transportation system for removing agricultural products while also protecting agricultural land and water quality, for recreation, agricultural access, or other needed agricultural management activities.

Conditions Where Practice Applies

Where area and volume to be harvested makes it necessary and economically feasible to install such a road system.

Guidelines

1. A well thought out efficient transportation system will minimize the area disturbed and vulnerable to erosion.

2. Keep the length of the truck road to a minimum. Have gravel or wood chips for about 200 feet prior to entering on a public highway to reduce the amount of mud on the highway.

3. Road grades should be kept to 10% or less. Steeper grades are permissible for short distances. Long level sections are difficult to drain properly. Grades between 3% and 5% are desirable.

4. Place roads on high ground with gentle grades. Avoid sharp curves. Fifty foot minimum radius for large trucks.

5. Minimum road width is 10 feet for one-way traffic and 15 feet for two-way traffic. Increase the tread width by a minimum of 4 feet for trailers.

6. Use a construction fabric underlayment in areas with potential seeps or spring time wet areas.

7. Move surface water quickly off road surfaces and onto undisturbed land. Ditches should be used to efficiently divert water away from the road surface. Water entering a roadway should be moved under or away from the roadway before gaining sufficient flow and velocity to erode ditches. Drainage ditches should not end where they will feed water directly into streams or other surface waters.

8. If streams must be crossed, do so by the most direct route and preferably at right angles to the stream. A bridge, culvert, or ford of acceptable design may be required.

9. Road grades approaching stream crossings shall be broken and surface water dispersed before it reaches the watercourse.

10. Restrict vehicle traffic on soft roads during the wet season of the year.

11. Restrict vehicle traffic during heavy rains.

12. Check with the State of New Hampshire - Department of Transportation or the local town officials to determine if a driveway permit is required.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

ACCESS ROAD FINAL STABILIZATION

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Planting vegetation such as grasses and legumes on exposed mineral soil and erodible segments of access roads.

Purpose

To permanently stabilize the site; to reduce damages from sediment and runoff; provide wildlife food value and habitat; enhance natural beauty; maintenance of a right-of-way is desired.

Conditions Where Practice Applies

Areas of exposed mineral soil that are subject to erosion and where a permanent vegetative cover is needed.

Guidelines

1. Old or new water diversion structures such as water bars, culverts, broad based dips, etc., must be operative before stabilization is initiated.

2. Where feasible, prepare a seedbed by grading, removing debris, and scarifying the soil to a minimum depth of 3 inches. When the area to be seeded has recently been loosened to the extent that an adequate seedbed exists, no additional treatment is required.

3. Lime and fertilizer should be thoroughly applied to the seedbed as indicated by soil test.

(a) Lime to a pH of 6.0, but in the absence of a soil test, apply a minimum of 2 tons per acre of ground agricultural limestone (high magnesium).

(b) Fertilize at the minimum rate of 500 pounds of 10-10-10 per acre.

4. Seeded areas should be closed off from all use until cover is adequately established.

5. Inspect all seeded areas for failures and make necessary repairs.

6. Grasses and other herbaceous cover can stabilize bare mineral soil and minimize erosion.

7. Close off vehicle access with a gate or fence.

TABLE 2-1 -- SEEDING MIXTURES FOR TEMPORARY SEEDINGS[1]

For Excessively Well to Somewhat Poorly Drained Soils

Area/Purpose	Soil pH	Shade	Appropriate Mixture[2] (lbs/ac)
Roads Trails Landings Burned Over	4.5-7.5	Heavy to None	Creeping Red Fescue at 40 Redtop at 2
Roads Trails Landings	5.5-7.5	Heavy to None	Annual Ryegrass at 40
Roads Trails Landings Wildlife	5.5-7.5	Moderate to None	Winter Rye at 112 (2 bu.)

1 Seeding Dates. Seed disturbed areas as soon as possible. Seed as early in the spring as the ground can be worked and in the late summer - early fall based on local recommendations.

2 On critical areas or droughty sites, apply hay or straw mulch at the rate of 90 pounds per 1000 square feet. Anchor mulch on steep slopes or where subjected to concentrated flow.

TABLE 2-2 -- SEEDING MIXTURES FOR PERMANENT SEEDINGS[1]

Area/Purpose	Drainage Class	Soil pH	Shade	Appropriate Mixture[2] lbs/ac
Winter Road Landings Wildlife	Poorly	5.0-7.5	Moderate to None	Reed Canarygrass at 15 Birdsfoot Trefoil at 10[3] Redtop at 2
Roads Trails Landings Burned Over	Excessively to Somewhat Poorly	4.5-7.5	Heavy to None	Creeping Red Fescue at 20 Tall Fescue - 20 Redtop at 2
Roads Trails Landings Burned Over Brush Control	Excessively to Somewhat Poorly	5.5-7.5	Moderate to None	Flatpea at 20[3] Tall Fescue - 15 Redtop at 2
Roads Landings Wildlife	Well to Moderately Poorly	5.0-7.5	Moderate to None	Creeping Red Fescue at 20 Birdsfoot Trefoil at 8[3] Redtop at 2
Roads Landings Wildlife	Well to Moderately Well	5.5-7.5	Moderate to None	Crownvetch at 15[3] Tall Fescue - 15 Creeping Red Fescue at 10 Redtop at 2

1 Seeding Dates. Seed disturbed areas as soon as possible. Seed early in the spring as soon as the ground can be worked and in the late summer - early fall based on local recommendations.

2 Include 10 to 20 pounds per acre of winter rye when seeding after Sept. 15th. On critical areas or droughty sites, apply hay or straw mulch at the rate of 90 pounds per 1000 square feet. Anchor mulch on steep slopes or where subjected to concentrated flow.

3 Inoculate legumes separately with an inoculant which is specifically recommended for the legume being seeded.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

CROSS DRAINAGE CULVERTS

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Definition

Corrugated pipe, well casing, dredge pipe, or other suitable material placed under an access road to transmit ditch runoff and seeps from a drainage area of less than 10 acres.

Purpose

To collect and safely transmit water flows from side ditches and seeps, under access roads without eroding a drainage system or road surface.

Conditions Where Practice Applies

For any size operation where cross drainage of stormwater is required temporarily or permanently.

Guidelines

1. Allow for periods of high flow, such as spring runoff or cloudbursts.

2. The minimum size culvert to be installed is 12 inch diameter and 20 feet in length.

3. When constructing roads on sidehill locations, ditch uphill side of the roadway to intercept surface runoff.

4. Allow inlet end of culvert to extend into side ditch so that it intercepts water flowing in the ditch. Construct a berm across the side ditch to assist in diverting water into the culvert.

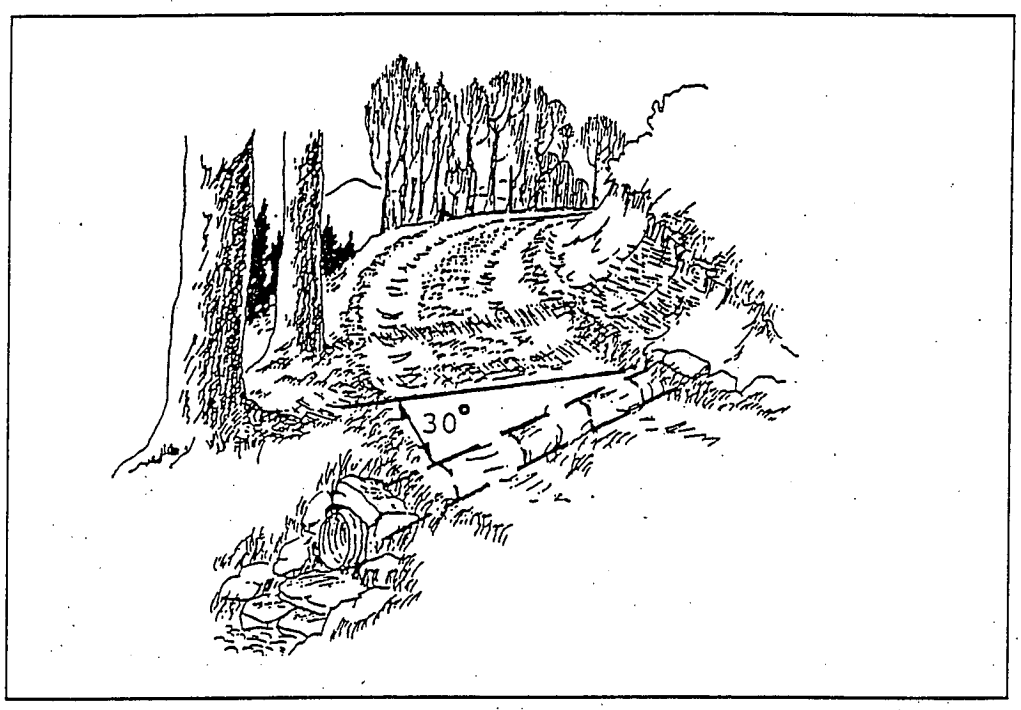
5. Allow outlet end of culvert to extend beyond any fill and empty onto an apron of rock, gravel or logs.

6. Space culverts according to road grade:

On gentle slopes (1-2%)	300 feet
On moderate slopes (3-10%)	150 feet
On steep slopes (10% +)	100 feet or less

7. Culverts should be installed at a 30 to 35 degree angle downward.

FIGURE 2-1 -- CROSS DRAINAGE CULVERT INSTALLATION



Source: Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire

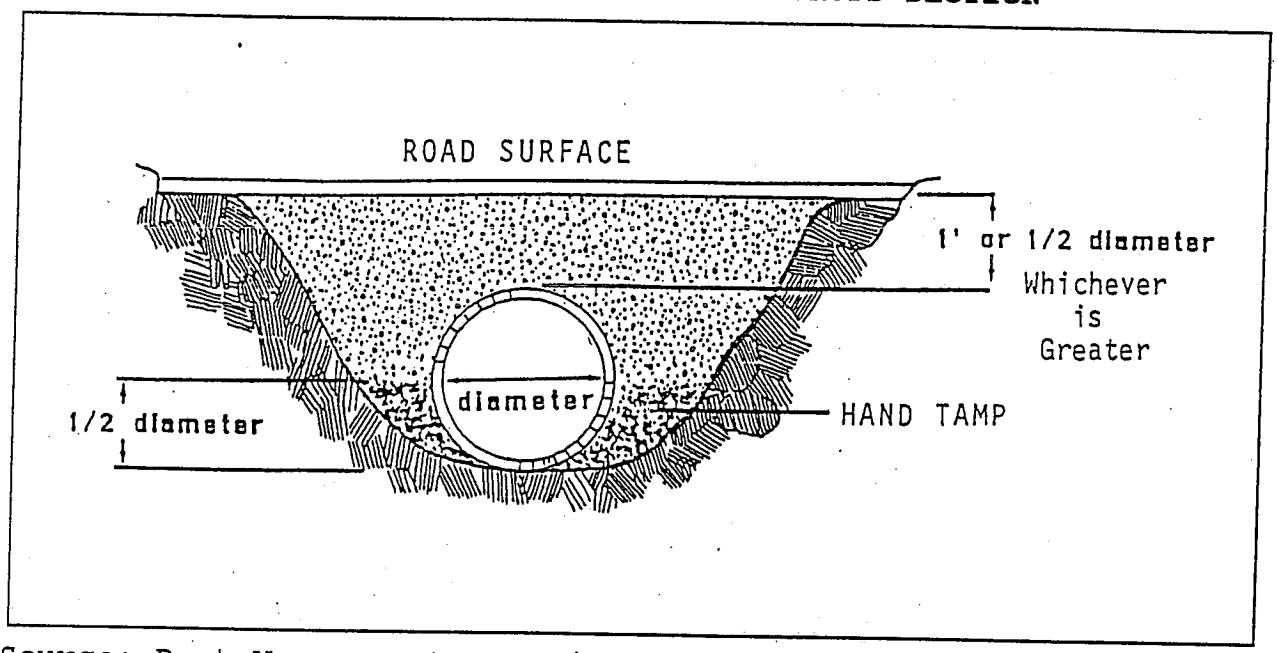
8. Culverts should be sloped at least 5 inches for every 10 feet of length to permit self-cleaning.

9. Culverts, when not maintained, are very likely to become blocked with rocks, ice, or other debris. Runoff water can become rerouted over and around the culvert and may wash out sections of road into brooks, streams, ponds, or wetlands. It is important to clean culverts regularly. Check after every storm.

10. Culvert size selection should be based on the size of the drainage area of a watershed and should be able to handle the largest required flow.

11. Estimate drainage area by taking measurements on a USGS topographic map, using contour lines to define the drainage limits. The Soil Conservation Service can assist you with determination of drainage area.

FIGURE 2-2 -- INSTALLATION CROSS SECTION



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BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

CROWNING

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Definitions

A section of road is sloped slightly (2 to 4 percent) from the center line of the road to the outside edges of the roadbed.

Purpose

Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly onto the undisturbed land or into a ditch which will carry the water into a culvert.

Conditions Where Practice Applies

Used when soils are easily saturated or highly erodible, when adjacent areas are relatively level with roadbed, or on steep side hills.

FIGURE 2-3 -- CROWNED ROAD

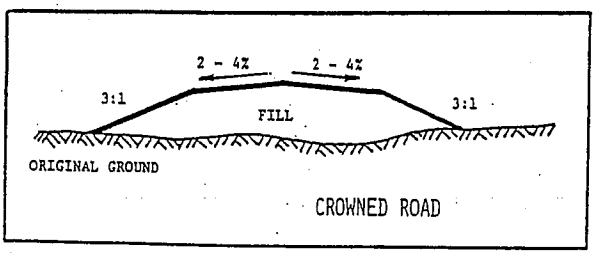
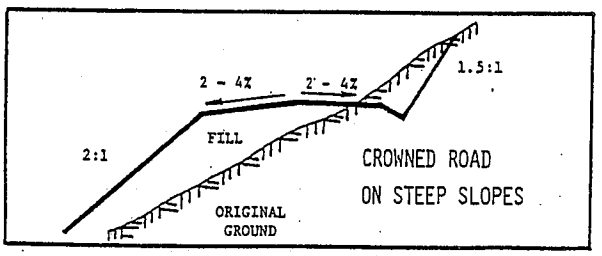


FIGURE 2-4 -- CROWNED ROAD ON STEEP SLOPES



Source: Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

PIPELINE

Intent

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Definition

Pipeline installed for conveying water for livestock.

Scope

This practice applies to pipelines having an inside diameter of less than 4 inches that are installed for livestock watering.

Purpose

To convey water from a source of supply to points of use.

Conditions Where Practice Applies

Where conveyance of water in a closed conduit is desirable or necessary to conduct water from one point to another, to conserve the supply, or for reasons of sanitation.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff and infiltration. Compare to centralized water facilities that has increased soil compaction because of traffic from livestock, vehicles, and humans.

2. Effects on surface and groundwater of broken pipelines.

3. The impact of water available at remote sites as a factor in keeping livestock out of streams and lakes, with the resulting reduction in bank erosion, sediment yield, and the direct deposit of manure in water courses.

4. Effects of bacteria, nutrients, salts, and organic matter on surface and groundwater because of increased recreation activity caused by the availability of water.

5. Effects of erosion and sediment yield from disturbed areas during construction.

Design Criteria

Capacity. For supplying livestock water, the installation shall have a capacity to provide at least 12 gallons per head per day for beef cattle and horses, 25 gallons dairy cattle, and 1.5 gallons for sheep and goats.

The size of pipe shall be determined by the use of any acceptable method which considers the proper head losses. Charts and tables in Chapter 12, Springs and Wells, of the USDA Soil Conservation Service Engineering Field Handbook may be used.

The minimum capacity of the pipeline shall be one-half gallon per minute. The minimum inside diameter of the pipe shall be ¾ inch.

Sanitary protection. If water from the pipeline is likely to be used for human consumption, the requirements of the state health department for materials and installation must be met.

Pipe. Steel pipe shall meet the requirements specified in ASTM-A-120 or in AWWA Specification C-202. If because of local conditions, a coal-tar enamel protective coating is needed for steel pipe, the coating shall meet the requirements of AWWA Specification C-203. Plastic pipe shall meet the requirements of AWWA Specification C-203. Plastic pipe shall meet the requirements specified in ASTM-D-2282, D-2239, D-2241, or D-3035 for acrylonitrile-butadiene-styrene (ABS), polyethylene (PE), and polyvinyl chloride (PVC), as appropriate.

Drainage. Valves or unions shall be installed at low points in the pipeline so that the line can be drained as needed.

Vents. For design velocities lower than 8 feet per second, some provision shall be included in the design for removing air. If parts of the line are above the hydraulic gradient, periodic use of an air pump may be required.

Joints. Watertight joints having a strength equal to that of the pipe shall be used. Couplings must be of material compatible with that of the pipe. If they are made of materials susceptible to corrosion, provisions must be made to prevent corrosion.

Vegetation. Disturbed areas shall be established to vegetation or otherwise stabilized as soon as practicable after construction. Seedbed preparation, seeding, fertilizing, and mulching shall comply with instructions provided in technical guides.

Visual resources. The visual design of pipelines in areas of high public visibility and those in fragile areas shall be carefully considered.

Plans and Specifications

Plans and specifications for installing pipelines shall be in keeping with this Best Management Wetlands Practice for Agriculture and shall describe the requirements for applying the practice to achieve its intended purpose.

Placement

Pipelines shall be placed so that they are protected against hazards imposed by traffic, farm operations, freezing temperatures, or soil cracking. Other means of protection must be provided if the depth required for protection is impracticable because of shallow soils over rock or for other reasons. Abrupt changes in grade must be avoided to prevent rupture of the pipe.

Trenches for plastic pipelines shall be free of rocks and other sharp-edged materials, and the pipe shall be carefully placed to prevent damage.

Plastic pipelines may be placed by plow-in equipment if soils are suitable and rocks and boulders will not damage the pipe.

Testing

Pipelines shall be pressure tested by one of the following methods:

1. Before backfilling, fill the pipe with water and test at the design working head or at a minimum head of 10 feet, whichever is greater. All leaks must be repaired, and the test must be repeated before backfilling.

2. Pressure test at the working pressure for two hours. The allowable leakage shall not be greater than one gallon per diameter inch per mile. If the test exceeds this rate, the defect must be repaired until retests show that the leakage is within the allowable limits, but all visible leaks must be repaired.

Backfilling

All backfilling shall be completed before the line is placed in service. For plastic or copper pipe, the initial backfill shall be of selected material that is free of rocks or other sharp-edged material that can damage the pipe. Deformation or displacement of the pipe must not occur during backfilling.

Plastic pipelines installed by the plow-in method require surface compaction and shaping in addition to the normal plow-in operations.

Installation and backfilling shall be done in a workmanlike manner. Provisions shall be provided for stabilizing disturbed areas and controlling erosion, if necessary.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

POLED FORD

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. These stream banks may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Temporary stream crossing in a defined channel using poles or cull logs as the roadbed.

Purpose

To be used as a stream crossing rather than a bridge or culvert.

Conditions Where Practice Applies

Can be constructed and used during periods of no or low flow. Fords are used for crossing streams with light use truck haul roads and skid trails where there is limited potential for sedimentation of the stream.

Guidelines

1. Installation of fords is permissible only when it is not feasible to construct a bridge or install a pipe culvert, i.e., streams having no or low banks.

2. Fords are prohibited on all streams in watersheds tributary to drinking water intakes or reservoirs for public and private water supplies, where ford is within 2,000 feet of such intakes or reservoir.

3. Shall not be crossed when they are overtopped with water.

4. Constructed on sound stable stream bottoms.

5. Use geo-textile fabric or other appropriate bedding if needed to stabilize the approaches to the crossing.

6. Find stream banks that are firm and level with approaches that are reasonably level for a distance of 50 feet on each side on the stream crossing.

7. Place 8 to 10 inch diameter poles or cull logs side by side on the streambed to serve as the roadbed.

8. The top width of these fords should be at least 10 feet.

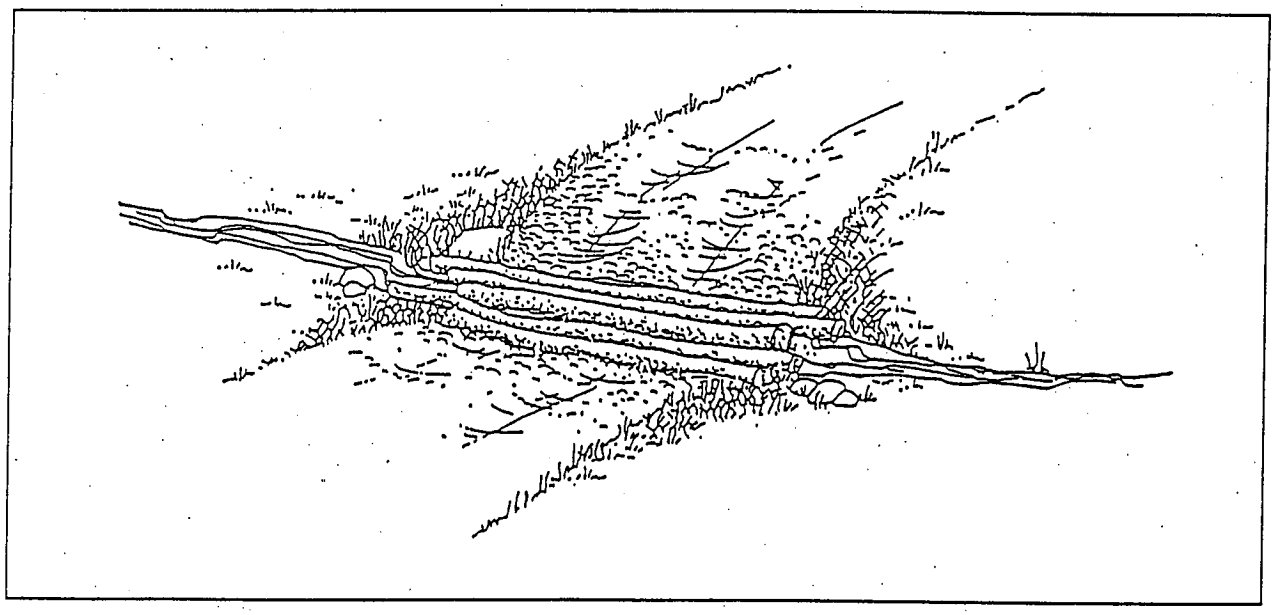
9. Poles and logs must be removed immediately after use.

10. After fords have been overtopped with water, repair and maintenance will be required.

11. Poled fords should be inspected regularly to make sure the stream is not becoming turbid.

12. Do not gravel or fill over poled fords.

FIGURE 2-5 -- POLED FORD



Source: Muriel Munson

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

STONE FORD

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. These stream banks may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Stream crossing using the stable stream bottom or stone fill as the roadbed.

Purpose

To be used as a stream crossing rather than a bridge or culvert.

Conditions Where Practice Applies

A perennial stream ford can be constructed and used during periods of low flow. When the drainage area exceeds one square mile, a log box culvert or a bridge should be installed.

Guidelines

1. Installation of fords is permissible only when it is not feasible to construct a bridge or install a pipe culvert, i.e. streams having no or low banks.

2. Fords are prohibited on all streams in watersheds tributary to drinking water intakes or reservoirs for public and private water supplies, where the ford is within 2,000 feet of such intake or reservoir.

3. Shall not be crossed when they are overtopped with water.

4. Skidding across stone fords is prohibited.

5. Constructed on sound stable stream bottoms, whenever possible.

6. Use geo-textile fabric or other appropriate bedding if needed.

7. Use angular rock fill material of at least 75 percent greater than 5 inches in diameter. Use larger sizes for large drainage areas.

8. Use 2 inch round stone on surface of ford to protect tires from sharp edges of angular rock.

9. Height of fill to be at least .5 feet above low flow water level. However, total fill not to exceed 2 feet above stream bottom.

10. The top width of these fords should be at least 10 feet.

11. Side slopes of the fords should be greater than or equal to 2:1 upstream and 3:1 downstream.

12. After fords have been overtopped with water, repair and maintenance will be required.

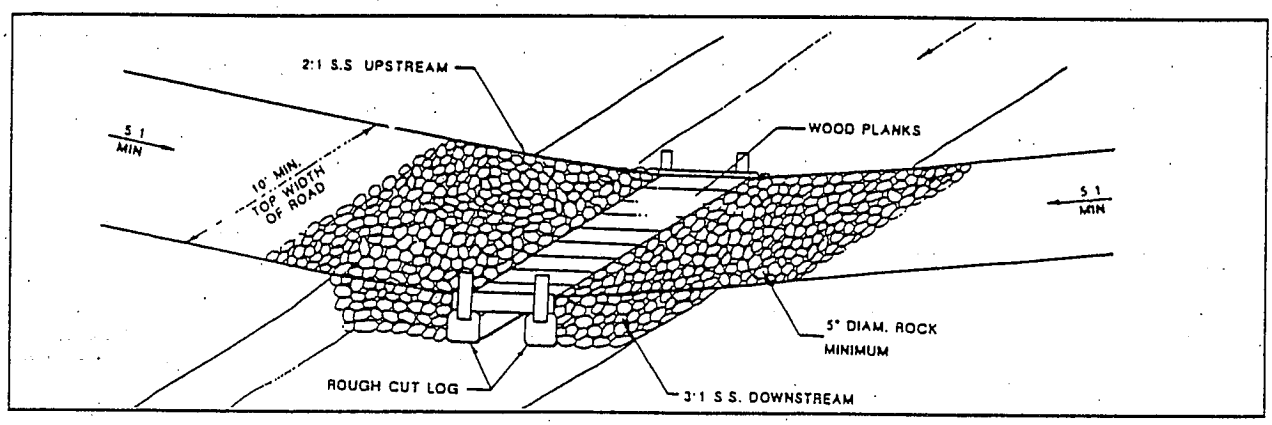
13. The log box culvert may float during overtopping and should be anchored.

14. Large stones or boulders on the downstream face of a stone ford will increase its life.

15. Roads and trail grades approaching stream crossings shall be broken and surface water dispersed so it will not reach the stream.

16. Find stream banks that are firm and level with approaches that are reasonably level for a distance of 50 feet on each side of the stream crossing.

FIGURE 2-6 -- STONE FORD



Source: USDA Soil Conservation Service

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

STREAM CROSSINGS

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. These stream banks may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Corrugated pipe, well casing, dredge pipe or wooden box culvert placed under an access road to permit crossing of an intermittent or live stream. A bridge may be designed in conjunction with the access road in order to cross over an intermittent or live stream.

Purpose

To transmit water flow of intermittent or live streams under access roads. To carry a single lane road over a stream to enable more direct routing while keeping equipment and products out of the water.

Conditions Where Practice Applies

Where restrictions such as topography or property lines make it necessary to cross a stream. Stream crossings are a major concern in the construction and use of access roads because of the potential for large amounts of sediment to enter a stream.

Guidelines

1. Keep the number of stream crossings to a minimum.

2. Culverts are perhaps the most common method of crossing streams.

3. Culvert size selection should be based on the size of the drainage area of a watershed and should be able to handle the largest required stream flow.

4. The tables for determining culvert and emergency spillway sizes should only be used when the drainage area contains 80% or more forested land. In all other cases, use detailed hydrologic procedures to compute peak discharge, culvert size, and emergency spillway size.

TABLE 2-3 -- SIZING PIPE CULVERTS FOR STREAM CROSSINGS
(80% or Greater Forested Land)

Acres of Drainage		Recommended
Shallow and High Elevation Soils	Normal Forest Soils	Pipe Culvert Diameter in Inches
2	9	12
4	16	15
7	25	18
12	40	21
16	55	24
27	84	30
47	130	36

5. Estimate drainage area by taking measurements on a USGS topographic map, using contour lines to define the drainage limits. The Soil Conservation Service can assist you with determination of drainage area.

6. If the culvert is not sized to carry the 10% chance (10-year frequency) storm discharge, then use an emergency spillway in conjunction with the pipe design.

TABLE 2-4 -- SUGGESTED EMERGENCY SPILLWAY DIMENSIONS
(Use only with 80% or greater forested area.)

Pipe Culvert Diameter in Inches	Parabolic (ft.)		Trapezoidal (ft.)		
	d	t	d	t	b
12	0.5	12.0	0.5	11.5	4.5
15	0.5	12.0	0.5	11.5	4.5
18	0.5	17.0	0.5	15.0	8.0
21	0.75	12.0	0.75	13.5	3.0
24	0.75	22.0	0.75	19.5	9.0
30	1.0	23.0	1.0	22.5	8.5
36	1.0	33.0	1.0	29.0	15.0

Design Criteria

1. Entire drainage is in natural or agricultural land use with 80% or greater forested land to use charts.

2. Culverts sized for two year storm flow.

3. Emergency spillway sized for ten year storm flow.

Specifications

1. Construct during periods of no or low flow and as quickly as possible.

2. Install culvert crossing at right angle to the stream. A maximum of 15 degree skew is allowed as an exception where approach conditions are difficult.

3. Align approach and exit with culvert crossing center line with as little curvature as possible.

4. Road and trail grades approaching stream crossings should be broken and surface water dispersed before it reaches the watercourse.

5. Stream alignment should be straight at the point of crossing and of uniform profile so as not to obstruct the flow of water.

6. Find stream banks that are firm and level and approaches that are reasonably level for a distance of 50 feet on each side of the stream crossing.

7. Minimum acceptable culvert crossing top width is 10 feet.

8. Place culverts in the natural drainage channel.

9. Place culverts on the same grade as the stream bed. The minimum culvert grade is 2 to 4 percent.

10. Inlet should be located on or below the stream bed, not above.

11. Avoid placing fill under the culvert to obtain the desired grade.

12. Seat the culvert(s) and pack with clean washed stone; fill to half the diameter of the culvert and hand tamp.

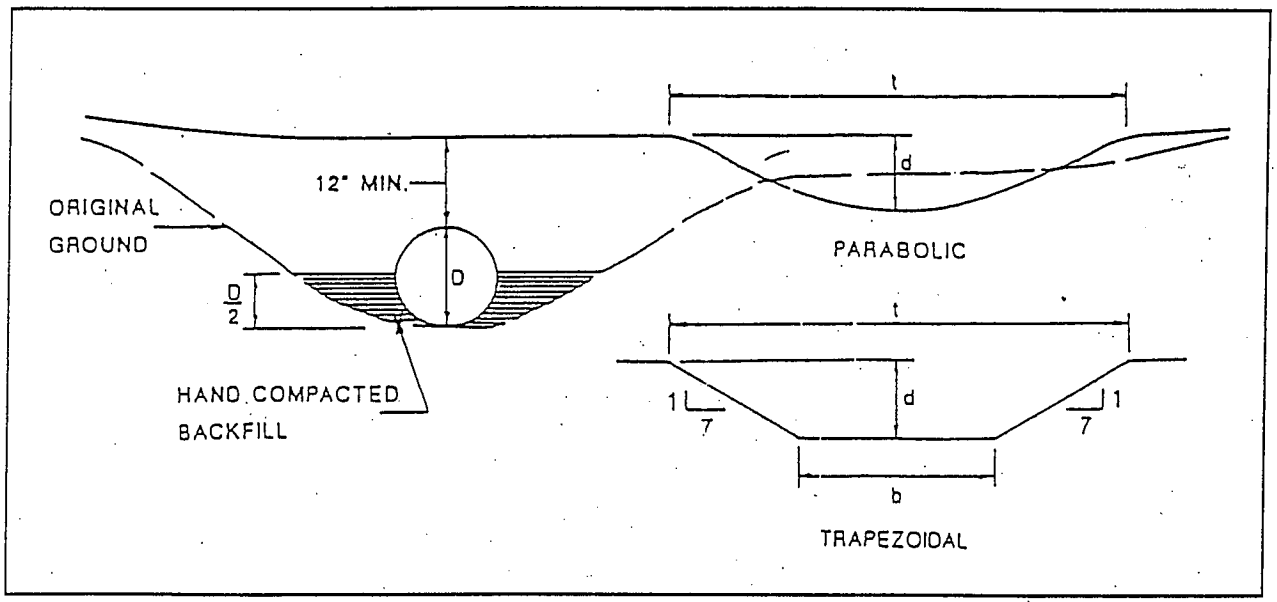
13. Cover culvert with a minimum of one foot of clean stone material or one-half the culvert diameter, whichever is greater. If adequate cover cannot be achieved, then two smaller culverts should be installed.

14. Allow inlet and outlet ends of the culvert to extend at least one foot beyond the toe of the fill.

15. Protect the upstream end of the fill around the culvert from erosion by placement of a rock header.

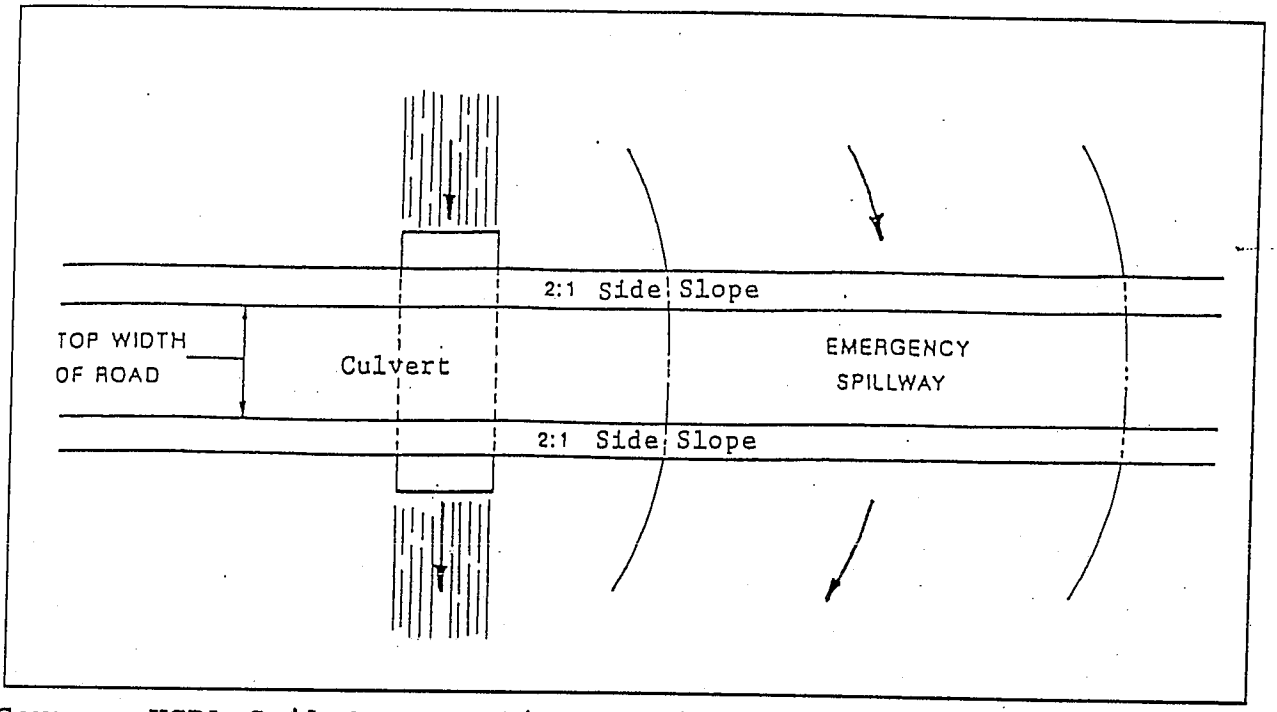
16. Protect the downstream end of the fill around the culvert from erosion by placement of a rock header or by seeding and mulching.

FIGURE 2-7 -- INSTALLATION CROSS SECTION



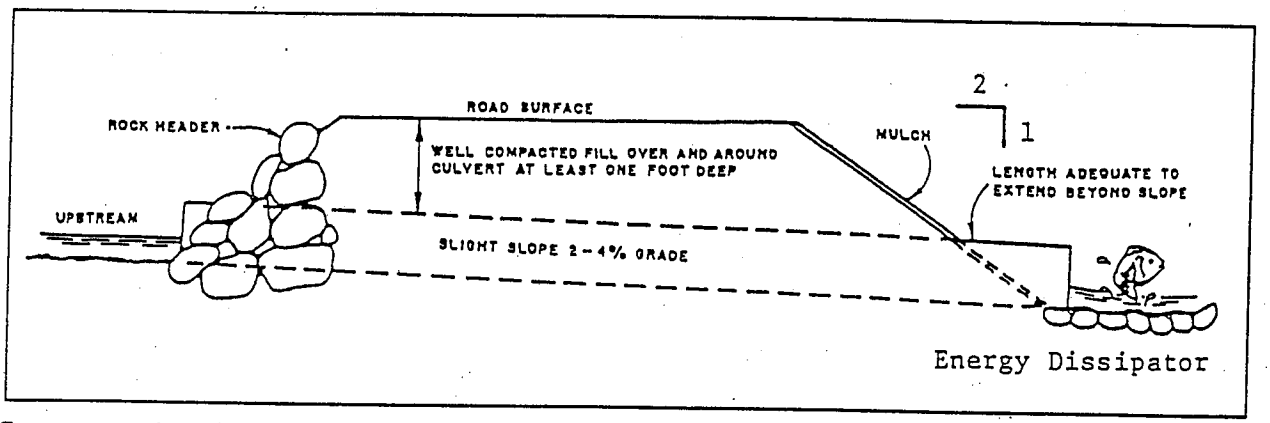
Source: USDA Soil Conservation Service

FIGURE 2-8 -- INSTALLATION PLAN VIEW



Source: USDA Soil Conservation Service

FIGURE 2-9 -- ENERGY DISSIPATOR



Source: Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

WATER BARS

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

An earthen or reinforced berm constructed across an access road.

Purpose

To intercept and divert water from side ditches and road surfaces, therefore minimizing erosion by decreasing the slope length of surface water flow.

Conditions Where Practice Applies

Utilized on any sloping road where surface water runoff may cause erosion.

Guidelines

1. Install water bars with a skidder blade, dozer blade, or by hand.

2. Install water bars at the top of any sloping road or trail and at proper spacing along steep sections.

3. Water bars may be shallow or deep depending on the need.

4. Soil should be left along the lower side of the water bar.

5. Should be constructed at a 30 to 35 degree angle downslope from a line perpendicular to the direction of the road.

6. Should drain at a 3% outslope onto undisturbed litter or vegetation.

7. The uphill end of the water bar should extend beyond the side ditch line of the road or trail to fully intercept any water flow.

8. The downhill end of the water bar should be fully open and extended far enough beyond the edge of the road or trail to disperse runoff water onto undisturbed land.

9. Place rocks, slash, or logs to disperse water coming from a water bar.

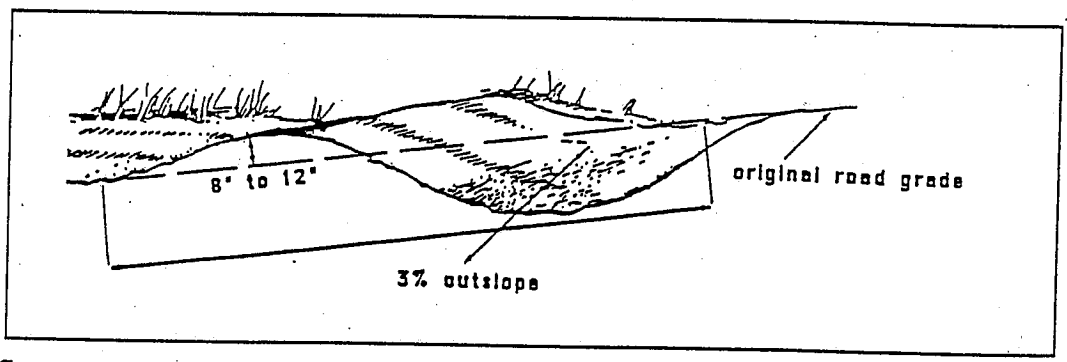
10. The following guidelines should be used in order to preserve effective water bars.

- Reinforce the water bars
- Keep travel to a minimum
- Use only in dry weather
- Make frequent inspections
- Maintain as needed

TABLE 2-5 -- SPACING FOR WATER BARS

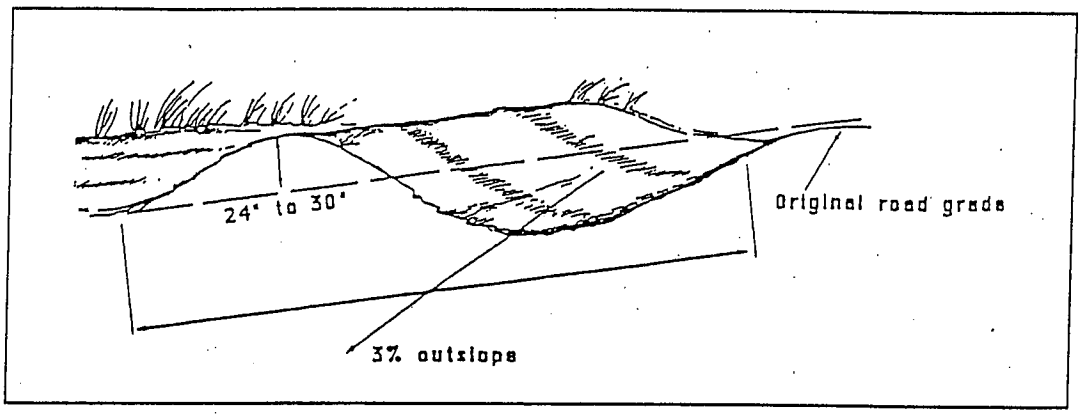
Road/Trail Grade (percent)	Spacing Between WaterBars (feet)
2	250
5	135
10	80
15	60
20	45
30	35

FIGURE 2-10 -- SHALLOW WATER BAR



Source: Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire

FIGURE 2-11 -- DEEP WATER BAR



Source: Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire

CHAPTER 3

FIELD IMPROVEMENTS

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

BEDDING

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Plowing, blading, or otherwise elevating the surface of flat land into a series of broad, low ridges separated by shallow, parallel channels.

Purpose

To provide improved surface drainage at relatively low cost by establishing adjoining parallel beds or land running in the direction of the available natural slope. This is accomplished by moving soil toward the center of beds to form a series of low ridges and shallow parallel channels that will minimize water pondage, provide gradients for removing runoff, permit efficient operation of tillage and harvesting equipment, or eliminate sources for mosquito production.

Conditions Where Practice Applies

This practice applies to poorly drained areas of flat to nearly flat land usually having slow permeable soils. It is generally applicable where land use does not warrant more intensive drainage. Soils must be of sufficient depth to provide a satisfactory root zone after bedding.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Potential for a change in rates of plant growth and transpiration because of changes in the volume of soil water.

3. Effects on downstream flows or aquifers that would affect other water uses or users.

4. Effects on the relation of the soil surface to the water table to ensure a suitable rooting depth for crops.

5. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.

6. Effects on the use and management of nutrients and pesticides and their effect on surface and groundwater quality.

7. Effects on the movement of dissolved substances below the root zone and to groundwater.

8. Effects of water levels on soil processes such as nutrient use by the plant.

9. Effects on wetlands or water-related wildlife habitats.

10. Effects on the visual quality of downstream water.

Design Criteria

Bedding shall run in the direction of the available land slope without causing harmful erosion. Bedding is usually established without detailed engineering surveys. Beds shall be shaped and cross-row ditches provided where required to provide free movement of water from the crown to the parallel channels. Crowns shall provide a cross slope of not less than 0.3 percent.

Crown height, width, and maximum length of beds shall be determined on the basis of site conditions.

Parallel channels may be shallow and side slopes steep or flat, based on the depth of the soil, crops grown, and local construction and maintenance methods. Parallel channels shall be graded toward an outlet.

An outlet, natural or constructed, must have sufficient capacity and depth to provide for removal of water from the parallel channels.

Plans and Specifications

Plans and specifications for bedding shall be in keeping with this BMWP and shall describe the essential requirements for properly applying the practice to achieve its intended purpose. If beds are formed with on-farm equipment, it may take 2 to 3 years to complete beds to the required height.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

BRUSH CONTROL [1]

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Ditches or streams in the field may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Management and manipulation of stands of brush by mechanical, chemical, or biological means, or by controlled burning on rangeland, native pasture, pastureland, recreation land, and wildlife land. (Includes reducing excess brush to restore natural plant community balance and manipulating brush stands through selective and patterned control methods to meet specific needs of the land and objectives of the land user.)

Purpose

To improve or restore a quality plant cover to (1) reduce sediment and improve watershed quality; (2) increase quality and production of desirable plants for livestock and wildlife; (3) maintain or increase wildlife habitat values; (4) enhance aesthetic and recreation qualities; (5) maintain open land; and (6) protect life and property.

Conditions Where Practice Applies

(1) On brush infested land with the potential to produce desirable native or adapted forage plants; (2) where adjustments in grazing management alone will not restore the kind of plant cover needed to attain the conservation objectives within a reasonable time; (3)

---

[1] "Brush" as used in this BMWP includes woody half-shrubs, shrubs, and trees which invade lands on which they are not part of the natural (climax) plant community or which occur in amounts significantly in excess of that which is natural to the site.

where brush management will improve wildlife, recreation or natural beauty; (4) where control of woody phreatophytes is necessary to conserve moisture; or (5) where reduction of brush is necessary to the safety of life and property in areas of high wildfire hazard.

Considerations

Mechanical, chemical and biological procedures and controlled burning are used singly or in combinations depending upon many factors including: (1) kind of land (site); (2) topography; (3) species of woody plants-whether they are root sprouters or non-sprouters; (4) size, abundance and distribution of woody plants; (5) hazards of treatment, if any; (6) objectives of the land users; and (7) costs in relation to expected benefits.

It is the policy of the US Department of Agriculture and of the Soil Conservation Service to encourage the use of pest control methods of least potential hazard to man, animals and the environment. Non-chemical methods of brush management should be recommended whenever feasible.

Conservationists are to (1) encourage cooperators to fully consider present and future land use opportunities in relation to brush management, including its expected effect on (a) wildlife habitat, (b) potential recreation use, and (c) attractiveness of the landscape; and (2) determine that the landowner understands the technical requirements, possible hazards, and costs of the practice and that he will apply the kind of grazing management and maintenance measures that will insure success.

Considerations for water quality and quality include:

a. Effects of improved vegetation on the water budget, especially on volumes and rates of infiltration and runoff.

b. Where applicable, consider the effects of snow catch and melt on the water budget.

c. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.

d. Effects on downstream flows or aquifers that would affect other water uses or users.

e. Effects of short-term soil disturbance on erosion and movement of sediment and soluble and sediment-attached substances carried by runoff.

Specifications

1. Identify the species of vegetation to be controlled.

2. Select appropriate control methods.

   a. Chemical
   Refer all requests to the UNH Cooperative Extension for recommendations and specific site treatment. Cooperators using chemical herbicides should be cautioned as follows:

   If herbicides are handled or applied improperly, of if unused portions are not disposed of safely, they may injure humans, domestic animals, desirable plants, and fish or other wildlife and may contaminate nearby crops and other vegetation. Follow the directions and heed all precautions on the container label. Herbicides should not be used over or directly adjacent to ponds, lakes, or streams. Cooperators should be aware of and adhere to the provisions of local, county, state or federal laws and regulations concerning the use of agricultural chemicals.

   b. Mechanical
   Brush will be controlled by mowing, cutting, girdling, bulldozing or tillage. Semi-permanent control may be accomplished by using bog harrows, plows, roto-tillers or bulldozers. Temporary control may be accomplished by using rotary mowers, sickle bar mowers or hand mowing. Apply control treatment prior to seed production. Mowing, bulldozing and tillage will be avoided during nesting season, generally prior to July 15, when the primary objective is brush control for the benefit of wildlife. Stumps will be cut low enough to prevent interference with the planned use of the area. Bulldozing will be accomplished in a manner that is least conductive to erosion. (Note: mowing incidental to the harvesting of forage is not considered to be within the intent of this practice.)

3. Additional considerations.
   a. Reapply control measures as necessary to obtain satisfactory control.

b. If species being controlled include plants that become toxic in the wilted stage, such as black cherry and black locust, exclude livestock until plant debris no longer presents hazardous conditions.

c. Consideration should be given to natural beauty provided by brush through flowering, fruiting and fall foliage.

d. For kinds of brush and trees that should be favored for wildlife habitat, refer to the Best Management Wetlands Practice for Wildlife Wetland Habitat Management.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

CHANNEL VEGETATION

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Establishing and maintaining adequate plants on channel banks, berms, spoil, and associated areas.

Purpose

To stabilize channel banks and adjacent areas and reduce erosion and sedimentation. To maintain or enhance the quality of the environment, including visual aspects and fish and wildlife habitat.

Conditions Where Practice Applies

On channel banks, berms, spoil, and associated areas; except grassed waterways, diversions and areas with protective linings, those covered with water for an extended period, or in areas where conditions will not support adequate vegetation.

Considerations

Evaluate slopes and soil material, time of year for proper establishment of vegetation, necessity for irrigation, visual aspects, fish and wildlife, fire hazards and special needs when construction is done from one side. Other considerations include:

1. Protection of channel vegetation from sediment deposits resulting from wind and water erosion;

2. Provisions for safety and protection of human life and property in all aspects of design, application, and maintenance;

3. Methods by which endangered and threatened plants and nationally recognized natural vegetated areas will be identified and protected;

4. Requirements for overseeding or planting woody or herbaceous vegetation on the unexcavated side when construction is done from one side;

5. Identification of desirable trees and other vegetation and means for their preservation;

6. Special techniques for establishing and maintaining vegetation near inlets, outlets, or other appurtenances;

7. Potential runoff from bare soil during construction;

8. Effects on the water budget components, especially on volumes and rates of runoff;

9. Effects of nutrients or pesticides in runoff during establishment of vegetation; and

10. Effects of streambank erosion before vegetative establishment.

Specifications

An adequate vegetative cover stabilizes the channel area and provides for temporary or permanent protection or both.

Side slopes. Specify side slopes that permit establishing and maintaining desired vegetation and that have been effective in the past. In urban and recreation areas, flatter side slopes may be required to provide for public safety and enhancement of visual resources.

Species selection. Specify species that are suited to the soil, climate, and exposure. They must provide a lasting cover to protect the channel area and to maintain the channel design capacity. Use special-purpose plantings outside the channel for wildlife, recreation, or visual resources.

Seedbed preparation. Specify seedbed preparation, fill rills and gullies, and remove stones and debris.

Fertilizer and soil amendments. Specify fertilizers and soil amendments, including analyses, rate, method of application, and requirements for top-dressing.

Planting. Specify dates, rates, and methods of seeding, sprigging, sodding or planting.

Mulching. Specify types and rates of mulch materials and the method of anchoring.

Irrigation. Specify irrigation if it is needed for establishing vegetation.

Controlled access. Control access to channels, as needed, by fencing or by other means to protect slopes and vegetation from damage.

Maintenance. Provide for:

1. Periodic inspection and evaluation of channel vegetation to determine maintenance needs;

2. Management of vegetative growth, as applicable, by mowing, controlled grazing, approved chemicals, or other means to maintain the desired cover;

3. Reseeding or replanting, along with the use of fertilizers and/or soil amendments and irrigation, as needed; and

4. Repair of appurtenances and fences.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

DIVERSION

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Channels may be dominated by shrubs if part of a maintenance project. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

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

Purpose

To divert excess water from areas to sites where it can be used or disposed of safely.

Conditions Where Practice Applies

This practice applies to sites where:

1. Runoff from higher lying areas is damaging cropland, pastureland, farmsteads, feedlots, or conservation practices such as terraces or strip cropping.

2. Surface and shallow subsurface flow caused by seepage is damaging sloping upland.

3. Runoff is in excess and available for diversion and use on nearby sites.

4. A diversion is required as part of a pollution abatement system.

5. A diversion is required to control erosion and runoff on urban or developing areas and construction sites.

Diversions shall not be substituted for terraces on land requiring terracing for erosion control.

Diversions shall not be used below high sediment-producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with or before the diversions.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and groundwater recharge.

2. The type of outlet, time of water detention, geology and topography of the site.

3. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.

4. Effects of nutrients and pesticides on surface and groundwater quality.

5. Filtering effects of vegetation on movement of sediment and dissolved and sediment-attached substances.

6. Short-term and construction-related effects on the quality of downstream water.

7. Effects on the movement of dissolved substances below the root zone and toward the groundwater.

8. Potential for uncovering or redistributing toxic materials and low productive soils that might cause undesirable effects on the water or plants.

9. Effects of the disposal of a concentrated water flow.

Design Criteria

Capacity. Diversions protecting agricultural land and those that are part of a pollution abatement system must have the capacity to

carry the peak runoff from a 10-year-frequency storm as a minimum, with a freeboard not less than 0.3 ft.

Diversions designed to protect urban areas, buildings, and roads, and those designed to function in connection with other structures, shall have enough capacity to carry the peak runoff expected from a storm frequency consistent with the hazard involved, but not less than a 10-year frequency.

Cross Section. The channel may be parabolic, V-shaped or trapezoidal. The diversion shall be designed to have stable side slopes. The ridge height shall include a reasonable settlement factor. The ridge shall have a minimum top width of 4 feet at the design elevation. The minimum cross section shall meet the specified dimensions. The top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement.

Grade and velocity. Channel grades may be uniform or variable. Channel velocity shall not exceed that considered non-erosive for the soil and planned treatment.

Location. The location of the diversion shall be determined by outlet conditions, topography, land use, cultural operations, soil type, and length of slope.

A diversion in a cultivated field must be aligned to permit use of modern farming equipment.

Protection against sedimentation. If movement of sediment into the channel is a significant problem, a vegetated filter strip shall be used except where soil and/or climate preclude the use of such strips. Then, the design shall include extra capacity for sediment and be supported by supplemental structures, cultural or tillage practices, or special maintenance measures.

Outlets. Each diversion must have an adequate outlet. The outlet may be a grassed waterway, a vegetated or paved area, a grade stabilization structure, a stable watercourse, or an underground outlet. The outlet must convey runoff to a point where outflow will not cause damage. Vegetative outlets shall be installed before diversion construction to insure establishment of vegetative cover in the outlet channel. Underground outlets consist of an inlet and underground conduit, and the release rate when combined with storage is to be such that the design storm will not overtop the diversion ridge.

The design elevation of the water surface in the diversion shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Vegetation. Disturbed areas that are not to be farmed shall be established to grass as soon as practicable after construction. If the soils or climatic conditions preclude the use of vegetation and protection is needed, nonvegetative means, such as mulches or gravel, may be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with recommendations in technical guides. The sod shall be maintained and trees and brush controlled by chemical or mechanical means.

Construction Specifications

All ditches or gullies shall be filled, and trees and other obstructions shall be removed before construction begins or shall be part of the construction.

Areas to be occupied by constructed fills shall be cleared of trees, brush and other debris, and stumps larger than 1 inch shall be grubbed to a minimum depth of one foot.

Spoil shall be placed or graded in a manner that will permit surface water to enter the channel freely, without erosion.

The diversion shall be constructed to planned alignment, grade, and cross section. The ridge shall have a minimum 4 foot width at the design storm elevation and in no case will a slope be steeper than 2:1.

There will be a minimum freeboard of 0.3 feet, plus a reasonable settlement factor above the design storm elevation. If movement of sediment in the channel is a sufficient problem, a vegetated filter strip at least 6 feet wide above the upper edge of the back slope, will be established.

If underground conduits are located under diversion ridges, mechanical compaction, water packing, and installation and backfill of conduit trenches shall be made in advance to allow adequate settlement. The materials used for the inlet and conduit shall be suitable for the purpose intended and shall meet the requirements of subsurface drains. Diversion ridges constructed across gullies or depressions shall be compacted by machinery travel or other means sufficient to insure proper functioning of the diversion. The surface of the completed diversion shall be reasonably smooth and present a finished appearance.

If it is necessary, topsoil shall be stockpiled and spread over excavations and other areas to facilitate re-vegetation. If vegetation is needed, seedbed preparation, seeding, fertilizing, and mulching shall comply with recommendations in local technical guides.

A maintenance program should be established to maintain diversion capacity, storage, ridge height, and the outlets. Diversion ridges can be hazardous for farming operations or mowing. Any hazards must be brought to the attention of the responsible person.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

LAND SMOOTHING

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Removing ruts and other irregularities on the land surface by use of special equipment.

Purpose

Improve surface drainage, provide for more effective use of precipitation, obtain more uniform planting depths, provide for more uniform cultivation, improve equipment operation and efficiency, improve terrace alignment, and facilitate contour cultivation.

Conditions Where Practice Applies

This practice applies on areas where depressions, mounds, old terraces, turn rows, and other surface irregularities interfere with the application of needed soil and water conservation and management practices.

It is limited to areas having adequate soil depth or where topsoil can be salvaged and replaced.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and groundwater recharge.

2. Potential for changes in plant growth and transpiration because of changes in the volume of soil water.

3. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.

4. Effects on the use and management of nutrients and pesticides.

5. Effects on downstream water quality.

6. Effects on the visual quality of downstream water resources.

Design Criteria

The extent of rough grading required and tolerances of the finished smoothing job shall be in keeping with the requirements of the planned cropping system.

Plans and Specifications

Plans and specifications for land smoothing shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction operations shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.

The land to be smoothed shall be cleared of vegetative matter and trash.

Irregularities shall be smoothed to the degree required for the planned use and the requirements of subsequent tillage, floating, or planing to be performed.

Where possible, the ground surface should be plowed or disked prior to smoothing.

At least three passes of a land plane or leveler should be made over the land to be smoothed. This should consist of one pass along each diagonal and the last pass generally in the direction of cultivation.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

OBSTRUCTION REMOVAL

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Removal and disposal of unwanted, unsightly or hazardous buildings, structures, vegetation, landscape features, trash, and other materials.

Purpose

To safely remove and dispose of unwanted obstructions and materials in order to apply conservation practices or facilitate planned use of abandoned mine lands, farms, ranches, construction sites, and recreation areas.

Conditions Where Practice Applies

On land where existing obstructions interfere with planned use and development.

Considerations

1. Effects upon components of the water budget, especially effects on volume and rate of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on the visual quality or downstream water resources.

3. Short-term and construction-related effects on the quality of water resources.

Design Criteria

Rock piles, boulders, stones, fences, hedge rows, abandoned buildings and structures, trash, and similar obstructions that would interfere with planned use and development shall be removed. All debris such as broken concrete and masonry, structural steel and wood, stones, stumps, slash, and sterile or toxic soil material shall be disposed of so that they will not impede subsequent work or cause damage to off site or other areas. Disposal shall be by burning, burying, or removing to an approved land fill in an environmentally acceptable manner. All required gully shaping shall be performed to specified dimensions and grades. Gully fills shall be compacted to the required density. The cover over buried materials shall be designed to be adequate for the planned use, treatment, and vegetation. Historical or archeological significant and scenic values shall be identified and preserved as appropriate.

Plans and Specifications

Plans and specifications for obstruction removal shall be in keeping with this BMWP and shall describe the requirements for applying and achieving the practice purpose.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

PRECISION LAND FORMING

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Reshaping the surface of land to planned grades.

Purpose

To improve surface drainage, provide more effective use of rainfall, facilitate installation of more workable drainage systems, reduce the incidence of mosquito infestation, control erosion, improve water quality, and prevent damage to land by water-logging.

Conditions Where Practice Applies

On all land that is suitable for the purposes required and where precision land forming is practical. Soils shall be of sufficient depth and suitable textures so that after precision land forming is completed an adequate root zone remains to permit the planned use of the land and application of proper conservation measures, soil amendments, and fertilizer.

All precision land forming shall be planned as an integral part of an overall system to facilitate the conservation use of soil and water resources.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, deep percolation, and evaporation.

2. Potential for changes in plant growth and transpiration resulting from changes in the volume of soil water.

3. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.

4. Effects from the use and management of nutrients and pesticides on surface and groundwater quality.

5. Short-term and construction effects of installation on downstream water.

6. Potential for earth moving to uncover or redistribute toxic materials, such as saline soils, and make them available to water or plants.

7. Downstream temperature changes.

8. Effects on the visual quality of downstream water resources.

Design Criteria

Design and installation shall be based on adequate engineering surveys and investigation. If the land is to be formed for more than one purpose, it must be formed to meet the requirements of the most restrictive purpose and crop.

All forming work must be designed within the slope limits required for the proposed use and provide for the removal of excess surface water. If other conservation practices such as grassed waterways, drainage field ditches and filter strips are needed to accomplish the stated purpose, they shall be included in the plans for improvement.

Slope Requirements. Slope may be uniform in the direction of flow or may increase or decrease.

Reverse grades in the direction of planned water flow shall not be permitted. Short level sections are permissible to meet field conditions. Cross slopes must be designed so that "breakthroughs" from rainfall runoff are held to a minimum.

Slope to Control Erosion Caused by Runoff from Rainfall. Design field grades shall be such that erosion caused by runoff from rainfall can be controlled within the limits permissible for conservation farming. When benching between land formed plots exceeds 1 foot (304 mm), a permanent grassed area or border ridge

must be left between the plots to reduce the possibility of gully erosion.

Surface Drainage. All precision land forming systems shall include plans for removing or otherwise providing for control of excess water.

Designs must provide field elevations and field grades that will permit proper functioning of the planned drainage facilities.

Borrow Computations. Excavation and fill material required for or obtained from such structures as ditches, ditch pads, and roadways shall be considered part of the precision land-forming design, and the appropriate yardage shall be included when balancing cuts and fills and determining borrow requirements.

Construction Specifications

Specifications will be in keeping with this BMWP and will describe the requirement for proper installation of the practices to achieve its intended purposes.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

The land surface must be free of all trash or vegetative material that would materially reduce the effectiveness of the grading operation.

The land shall be graded to the designed elevations. Fills of more than 6 inches shall be built up by spreading the soil in layers. Grading operations shall not be performed when the ground is frozen or under soil moisture conditions that will result in excessive damage to soil structure.

Soil for land forming operations shall be obtained from the designated cut areas in the field or from other designated borrow areas as specified in the plan.

The spoil available from adjacent ditches and the fill required for roads, dikes, etc., shall be considered in developing the grading plans.

After cuts and fills have been completed, the surface shall be smoothed to remove minor irregularities.

All grading work shall be finished in accordance with the design and to tolerances specified. The completed job shall present a good appearance.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

SUBSURFACE DRAIN

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A conduit, such as tile, pipe, or tubing, installed beneath the ground surface that collects and/or conveys drainage water.

Purpose

A subsurface drain is installed for one or more of the following reasons: to improve the soil environment for vegetative growth by regulating the water table and groundwater flow; intercept and prevent water movement into a wet area; relieve artesian pressures; remove surface runoff; serve as an outlet for other subsurface drains; remove water from around buildings, roads, airports, play areas, and other physical improvements, and regulate water to control health hazards caused by insects.

Conditions Where Practice Applies

Subsurface drains are used in areas where the soils and outlet conditions allow excess water to be removed to the extent required to permit the planned land use. The benefits derived must justify the installation of subsurface drains. The outlet of the drain shall be adequate for the quantity and quality of effluent to be disposed. Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under state law.

Considerations

Subsurface drains are normally used to lower the water table in a certain area, or to serve as an outlet for small detention structures. Installation of drain pipes in less permeable soils may require an envelope of granular drain material to maximize effectiveness.

Clogging by tree roots and crushing by vehicular traffic are common causes of drain failures. Where subsurface drains may be subject to these conditions, heavy pipe or other precautions should be considered.

Design Criteria

General. The planning and design of subsurface drains shall be based on adequate onsite surveys and investigations.

Required Capacity. The required capacity shall be determined by applicable drainage coefficient or inflow rate obtained from one or more of the following:

1. Application of a locally tried and proven coefficient.
2. Experience on similar sites and/or soils.
3. Onsite measurement, investigation, or estimates.
4. Application of Darcy's law to lateral or artesian subsurface flows.

Subsurface drains shall be large enough to convey the required capacity to an adequate outlet. The minimum nominal diameter shall be 4 inches. The size of the drain shall be computed using Manning's Formula or design charts in Figures 3-1 and 3-2.

Depth, Spacing, and Location. The depth, spacing, and location shall be based on site conditions and be such as to provide adequate drainage for the planned land use.

To provide adequate protection of the conduit, the depth of cover over subsurface drains shall not be less that 2.0 feet in mineral soils, or 2.5 feet in organic soils. In organic soils the minimum cover applies after initial subsidence has taken place. Exceptions to the minimum depth of cover may be permitted within 50 feet of the outlet where the conduit is not subject to damage by equipment

travel, or through minor depressions within 100 feet of the upstream end of individual or lateral lines.

Minimum Grade. The minimum grades for drains are as follows:

Drain Diameter	Minimum Grade
4 inches	0.1%
5 inches	0.07%
6 inches or more	0.05%

Where subsurface drains are installed in soil that contains a high percentage of silt and very fine sand that may be washed into the drain, the conduit shall be placed on a grade that will result in a minimum velocity of 1.5 ft/sec for design flow, or an approved filter shall be placed around the drain.

Maximum Grade Protection. On sites where topographic conditions require the use of drain lines on grades where design velocities will be greater than indicated in the table below, special measures shall be used to protect the conduit. These measures shall be specified for each job based on the particular conditions of the job site. The protective measures shall include one or more of the following:

1. Wrapping open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric type filter material.

2. Placing the conduit in a sand and gravel envelope or binding with least erodible soil available.

3. Sealing joints or using a watertight pipe or non-perforated continuous tubing.

4. Enclosing continuous perforated pipe or tubing with fabric type filter material or properly graded sand and gravel.

TABLE 3-1 -- MAXIMUM PERMISSIBLE VELOCITY WITHOUT PROTECTIVE MEASURES

USDA Soil Texture	Velocity--ft/sec
Sand and Sandy Loam	3.5
Silt and Silt Loam	5.0
Silty Clay Loam	6.0
Clay and Clay Loam	7.0
Coarse Sand or Gravel	9.0

Materials for Subsurface Drains. Subsurface drains include conduits of concrete, metal, plastic, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements of the site.

Filters and Filter Material. Suitable filters shall be used around conduits where required by site conditions to prevent sediment accumulation in the conduit. The need for a filter shall be determined by the characteristics of the soil materials at drain depth and the velocity of flow in the conduit.

Not less than 3 inches of filter material shall surround the conduit when using sand-gravel filters. The filter shall be designed to prevent the material in which the installation is made from entering the conduit. Not more than 10 percent of the filter shall pass the No. 60 sieve and not more than 5 percent of the filter shall pass the No. 200 sieve.

Artificial fabric or mat type filter materials may be used provided the effective opening size, strength, durability, and permeability are adequate to provide constant filtering of the soil to protect subsurface drain operation throughout the expected life of the system.

Envelopes and Envelope Material. Envelopes shall be used around subsurface drains where required for proper bedding of the conduit, or where necessary to improve the characteristics of flow of groundwater into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit. Envelope materials shall consist of sand-gravel material, all of which shall pass a 1.5 inch sieve, 90 to 100 percent shall pass a No. 60 sieve, and not more than 5 percent shall pass a No. 200 sieve.

Placement and Bedding. All subsurface drains, whether flexible conduit such as plastic or bituminized fiber or rigid conduits such as clay or concrete shall be laid to a neat line and grade. The conduit shall be placed and bedded as described in ASTM F449 "Standard Recommended Practice for Subsurface Installation of Corrugated Thermoplastic Tubing for Agricultural Drainage or Water Table Control". Rigid drainage conduits such as clay or concrete drain tile will not need the 90 degree "V" groove in the trench

bottom but all other applicable placement and bedding requirements will be adhered to.

Use of Heavy Duty Corrugated Plastic Drainage Tubing. Heavy duty corrugated plastic drainage tubing shall be specified where rocky soils are expected to be encountered during installation operations. This quality of tubing will also be specified when cover over the tubing is expected to exceed 10 feet or trench widths are expected to exceed 24 inches. (This refers to trench width in the area of the tubing and at least 1 foot above the top of tubing.)

Auxiliary Structures and Subsurface Drain Protection. The outlet shall be protected against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain. An 8-foot minimum continuous section of pipe without open joints or perforations shall be used at the outlet end of the line and shall outlet at least 0.5 foot above the normal elevation of low flow in the outlet ditch. Corrugated plastic tubing shall not be used for the outlet section.

The pipe and its installation shall conform to the following requirements:

1. Where there is a hazard of vegetation burning on the outlet ditch bank, the material from which the outlet pipe is fabricated shall be fire resistant. Where the hazard of burning is high, the outlet pipe shall be fireproof.

2. Two-thirds of the pipe shall be buried in the ditch bank and the cantilevered section shall extend to the toe of the ditch side slope or the side slope shall be protected from erosion. The minimum length of pipe shall be 8 feet.

3. Where ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered portion of the pipe will be protected from the current in the ditch.

4. Headwalls which are used for subsurface drain outlets shall be adequate in strength and design to avoid washouts and other failures.

Watertight conduit strong enough to withstand the loads on it shall be used where subsurface drains cross under other ditches.

Conduits under roadways shall be designed to withstand the expected loads. Shallow subsurface drains through depressional areas and near outlets shall be protected against hazards of farm and other equipment, and freezing and thawing. Junction boxes shall be used where more than two main lines join.

Where surface water is to be admitted to subsurface drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. Auxiliary surface waterways shall be used where feasible.

The upper end of each subsurface drain line shall be capped with a tight fitting cap of the same material as the conduit or other durable material unless connected to a structure.

Maintenance

Subsurface drains should be checked periodically to see that the outlet pipe of the drain is free flowing. The outlet ditch should be checked to see that erosion is not taking place. If the subsurface drain has a surface inlet, the inlet should be checked periodically to see that the inlet is not clogged with vegetation or debris. Repairs to the drain should be made promptly.

Construction Specifications

Inspection and Handling of Materials. Material for subsurface drains shall be given a careful inspection before installation. Clay and concrete tile shall be checked for damage from handling and where applicable from freezing and thawing prior to installation. Bituminized fiber and plastic pipe and tubing shall be protected from hazards causing deformation or warping. Plastic pipe and tubing with physical imperfections shall not be installed. A damaged section shall be removed and a suitable joint made connecting the replaced and retained sections. All material shall be satisfactory for its intended use and shall meet applicable specifications and requirements.

Placement. All subsurface drains shall be laid to line and grade and covered with approved blinding, envelope, or filter material to a depth of not less than 3 inches over the top of the drain. If the option to install an impervious sheet over the drain is used, at least 3 inches of blinding material must cover the sheet. No reversals in grade of the conduit shall be permitted.

Where the conduit is to be laid in a rock trench, or where rock is exposed at the bottom of the trench, the rock shall be removed below grade enough that the trench may be backfilled, compacted, and bedded; and when completed, the conduit shall be not less than 2 inches from rock.

When corrugated polyethylene tubing is being installed, no more than 5 percent stretch will be allowed. Special precautions must be taken on hot bright days to be sure the stretch limit is not exceeded and excessive deflection is not caused by premature backfilling.

Earth backfill material shall be placed in the trench in such a manner that displacement of the conduit will not occur and so that the filter and bedding material, after backfilling, will meet the requirements of the plans and specifications.

When a filter is required, all openings in the subsurface drain shall be protected by the filter, or the bottom and sides of the conduit are to be protected by the filter when the top of conduit as well as part of side filter material is to be covered by a sheet of impervious plastic. No portion of the conduit containing openings is to be left exposed under conditions which require the use of a filter.

When sand-gravel filter material is used, the trench shall be over-excavated 3 inches and backfilled to grade with filter material. After placement of the conduit upon the filter material, additional filter material shall be placed over the conduit to fill the trench to a depth of 3 inches over the conduit. A plastic sheet and friable soil can be used in lieu of filter material as the backfill over the subsurface drain when specified. The sand-gravel filter material shall be a unified classification system mixture of sand and gravel within the gradation required by the base material in the trench.

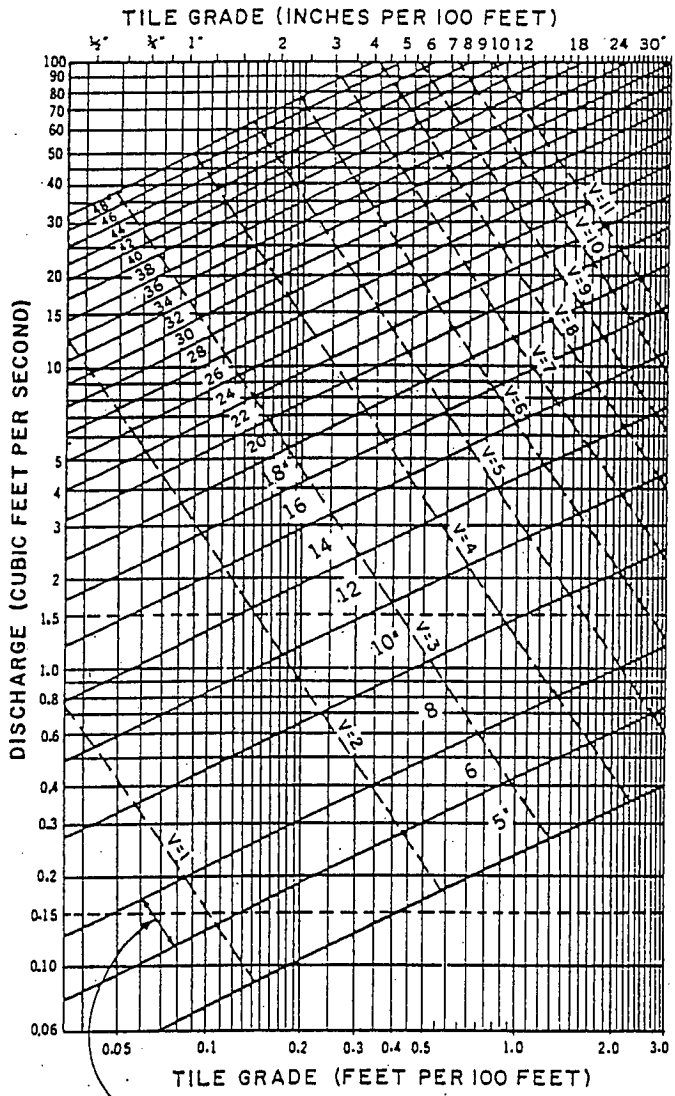
During installation and at the end of each day's work, the conduit will be protected from the entrance of soil or other debris.

The upper end of each individual subsurface drain shall be blocked with a plug or cap of material of equal strength and durability of that of the conduit.

Materials. Subsurface drains include conduits of clay, concrete, bituminized fiber, metal, plastic, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements of the site.

FIGURE 3-1 -- DRAIN CHART - CLAY, CONCRETE TILE AND BITUMINIZED FIBER PIPE

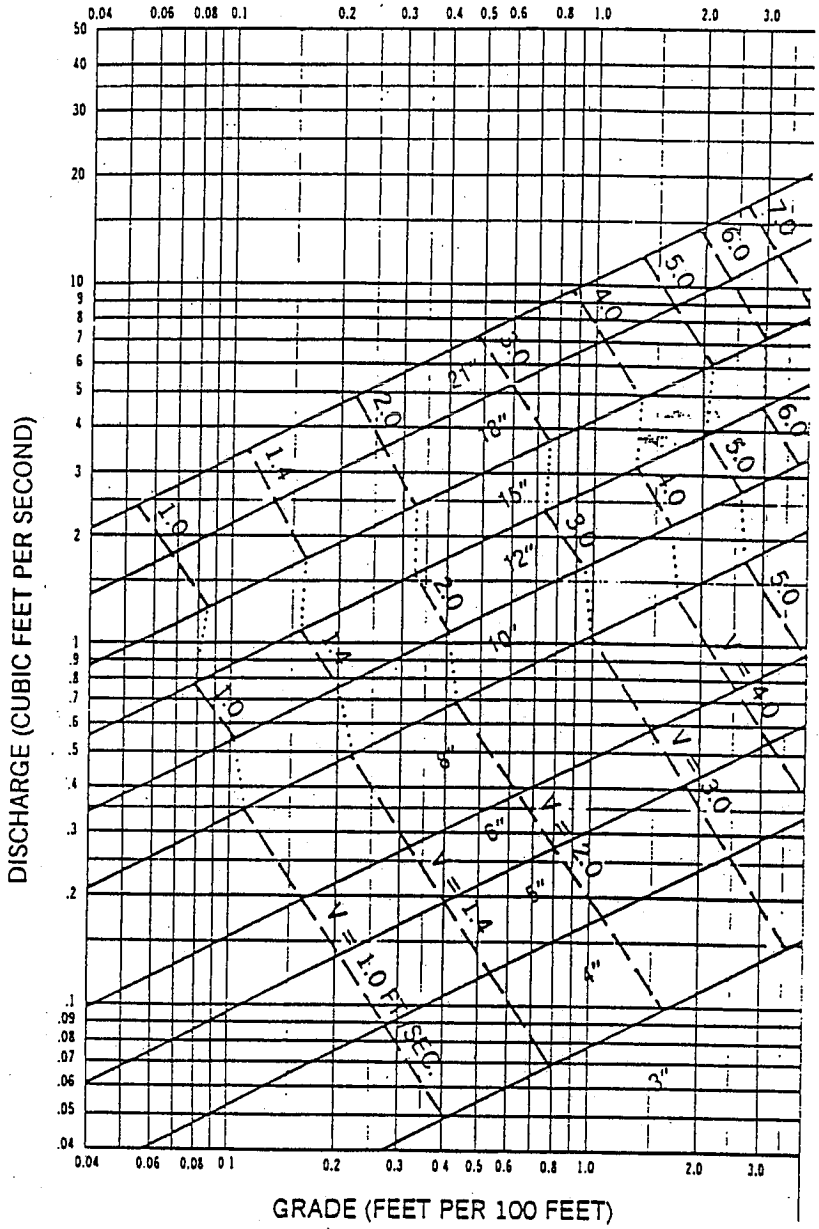


Space between lines is the range of tile capacity for the size shown between lines

V = Velocity (feet per second)

Source: USDA Soil Conservation Service

FIGURE 3-2 -- DRAIN CHART - CORRUGATED PLASTIC DRAIN TUBING



Source: USDA Soil Conservation Service

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

SURFACE DRAIN, FIELD DITCH

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Once established the ditches may become dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A graded ditch for or collecting excess water in a field.

Purpose

To drain surface depressions; collect or intercept excess surface water, such as sheet flow, from natural and graded land surfaces or channel flow from furrows and carry it to an outlet; and collect or intercept excess subsurface water and carry it to an outlet.

Conditions Where Practice Applies

This practice applies to a graded ditch with drainage area equal to or less than 100 acres.

Applicable soils are flat or nearly flat and:

1. Have soils that are slowly permeable (low permeability) or that are shallow over barriers, such as rock or clay, which hold or prevent ready percolation of water to a deep stratum.

2. Have surface depressions or barriers that trap rainfall.

3. Have insufficient land scope for ready movement of runoff across the surface.

4. Receive excessive runoff or seepage from uplands.

5. Require the removal of excess irrigation water.

6. Require control of the water table.

7. Have adequate outlets available for disposal of drainage water by gravity flow or pumping.

Considerations

1. Effects on water budget components, especially relationships between runoff and infiltration.

2. The effect of changes in the water table on the rooting depth for anticipated land uses.

3. Downstream effects of erosion and yields of sediment and sediment-attached substances.

4. Effects on the loadings of dissolved substances downstream.

5. Potential changes in downstream water temperature.

6. Effects on wetlands or other water-related wildlife habitat.

7. Effects on the visual quality of downstream water courses.

Design Criteria

Drainage field ditches shall be planned as integral parts of a drainage system for the field served and shall collect and intercept water and carry it to an outlet with continuity and without ponding.

Investigations. An adequate investigation shall be made of all sites.

Location. Ditches shall be established, insofar as topography and property boundaries permit, in straight or nearly straight courses. Random alignment may be used to follow depressions and isolated wet areas of irregular or undulating topography. Excessive cuts and the creation of small irregular fields shall be avoided.

On extensive areas of uniform topography, collection or interception ditches shall be installed as required for effective drainage.

Design. Design shall be in accordance with Chapter 4 of the USDA Soil Conservation Service Engineering Field Handbook and New Hampshire Drainage Guide.

Ditches may be trapezoidal, V-shaped, or parabolic. The size, depth, side slopes, and cross section area shall:

1. Be adequate to provide the required drainage for the site.

2. Permit free entry of water from adjacent land surfaces without causing excessive erosion.

3. Provide effective disposal or reuse of excess irrigation water (if applicable).

4. Conduct flow without causing excessive erosion.

5. Provide stable side slopes based on soil characteristics.

6. Permit crossing by field equipment if feasible.

7. Permit construction and maintenance with available equipment.

When surface field ditches discharge into ditches or greater depth, the outfall shall be graded back on non-erosive slopes or other protective measures shall be provided.

Channel vegetation. Vegetation shall be established according to the Vegetated Swale Best Management Wetlands Practice for Agriculture.

Plans and Specifications

Plans and specifications for constructing drainage field ditches shall be in keeping with this BMWP and shall describe the requirements for property installing the practice and achieve its intended purpose.

Excavation. The ditch shall be cut to the line and grade shown on the plans or as staked in the field.

Spoil Placement. Spoil shall be spread and leveled so that the surface water can flow into the ditch. If the spoil is to be farmed, it shall be spread so that farming operations will not be hindered.

Maintenance. Provisions shall be made for maintaining the ditches and their outlets to permit effective drainage.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

SURFACE DRAINAGE, MAIN or LATERAL

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Once established the ditches may become dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

An open drainage ditch constructed to a designed size and grade.

Purpose

To dispose of excess surface or subsurface water, intercept groundwater, control groundwater levels, provide for leaching of saline or alkali soils, or a combination of these objectives.

Conditions Where Practice Applies

This practice applies to open drainage ditches with drainage area in excess of 100 acres. For open drainage ditches with drainage areas of 100 acres or less, refer to the surface drain field ditch BMWP.

All lands to be drained shall be suitable for agriculture after installation of required drainage and other conservation practices. In areas where an outlet for the drainage system will be available, either by gravity flow or by pumping. The outlet shall provide for the quantity and quality of water to be disposed of. Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions.

Considerations

1. Effects on the water budget components, especially with regard to effects on runoff, soil water, and water tables.

2. Potential changes in soil moisture that will affect the growth of desirable vegetation.

3. Effects on the detachment and transport of sediment and chemicals and dissolved and sediment-attached substances into water courses.

4. Effects on the salinity of drained soils and downstream water courses.

5. Effects on wetlands.

6. Effect on the quality of groundwater.

7. Potential for changes in downstream water temperature.

8. Effects on downstream visual quality.

Design Criteria

The design and installation shall be based on adequate surveys and investigations.

Drainage requirements. Mains and laterals shall be located and designed to serve as integral parts of a surface or subsurface drainage system that meets the conservation and land use needs. The degree of drainage required by the crops shall be determined and expressed in terms of drainage coefficients or depth and spacing of drains.

Capacity. The ditch capacity shall be adequate to provide for the removal of excess water, based on climatic and soil conditions and the needs of crops. The required capacity shall be obtained by determining the watershed area; the required topographic, soil, and land use information; and use of the appropriate drainage coefficient curves.

Hydraulic grade line. The hydraulic grade line for drainage ditch design shall be determined from control points, including elevations of significant low areas served by the ditch and hydraulic grade lines of any tributary ditches and the outlet. If control point elevations are estimated rather than computed from survey data, the hydraulic grade line shall be no less than:

1. 1 foot below fields that will receive normal drainage ditches draining more than 1 square mile.

2. 0.5 feet for ditches draining 40 to 640 acres.

3. 0.3 feet for ditches draining less than 40 acres.

For lands to be used only for water-tolerant crops, such as trees and grasses, these requirements may be modified and the hydraulic grade line set at ground level. These provisions do not apply to channels where flow is contained by dikes.

The effects of hydraulic losses caused by culverts, bridges, or other obstructions in the channel section shall be considered.

Depth. Drainage ditches shall be designed deep enough to allow for normal siltation. If needed, the design depth and capacity may be increased to provide adequate subsurface drains or for normal flow. The increase shall be based on an evaluation of site conditions. Ditches that serve as outlets for subsurface drains shall be designed for a normal water surface at or below the invert of the outlet end of the drain. The clearance between a drain invert and the ditch bottom shall be at least 1 foot for ditches that fill with sediment at a normal rate, except where lower values are specified for a job because of unusual site conditions. The normal water surface is the elevation of the usual low flow during the growing season.

Cross section. The design ditch cross section shall be set below the design hydraulic grade line and shall meet the combined requirements of capacity, limiting velocity, depth, side slopes, bottom width, and, if needed, allowances for initial sedimentation. Side slopes shall be stable, shall meet maintenance requirements, and shall be designed on the basis of on-site conditions.

Velocity. The maximum permissible design velocity shall be based on site conditions and shall insure stability of the ditch bottom and side slopes. A desirable minimum velocity is 1.5 ft/s. On flat grades, a channel cross section shall be selected on the basis of the depth and maintenance requirements, will result in the desirable minimum velocity if possible.

The velocity for newly constructed channels with drainage areas in excess of 1 square mile shall meet the stability requirements specified for open channels.

Capacity design. Manning's Formula shall be used in determining the design velocity, and the value of n shall be based on alinement, probable vegetative growth expected with normal maintenance, other roughness factors, and the hydraulic radius.

Unless special site studies are available to justify other values, the following values of n, based on the hydraulic radius of the channel and assuming an aged channel with good maintenance and good alinement, shall be used in solving the Manning Formula for mains and laterals when determining the design for required capacity.

Hydraulic radius	n
Less than 2.5	0.040-0.045
2.5 to 4.0	.035- .040
4.1 to 5.0	.030- .035
More than 5.0	.025- .035

Berms and spoil banks. Adequate berms shall be provided and shaped, as required, to provide access for maintenance equipment, to eliminate the need for moving spoil banks in future operations, to provide for work areas and facilitate spoil bank spreading, to prevent excavated material from washing or rolling back into ditches, and to lessen sloughing of ditch banks caused by heavy loads too near the edge of the ditch banks. The following minimum berm width shall be provided, except where spoil is spread according to the engineering standard for spoil bank spreading:

Ditch depth (ft)	Minimum berm width (ft)
2-6	8
6-8	10
More than 8	15

If spoil material is to be placed in banks along the ditch rather than spread over adjacent fields, the spoil banks shall have stable side slopes. Provision must be made to channel water through the spoil and into the ditch without causing serious erosion.

Operation and maintenance. Requirements for operation and maintaining all drainage mains and laterals having drainage areas in excess of 1 square mile shall be according to the Soil Conservation Service standard for open channels.

Related structures and ditch protection. Mains and laterals shall be protected against erosion by chutes, drop structures, pipe drops, other suitable structures or grassed waterway, or specially graded channel entrances where surface water or shallow ditches enter deeper ditches.

Grade control structures, bank protection, or other suitable measures shall be used if necessary to reduce velocities and control erosion.

Culverts and bridges shall have enough hydraulic capacity and depth for drainage needs and to minimize obstruction to flow.

Capacities of pipe or drop structures generally shall be determined by use of the applicable drainage coefficients with the "island-type" of construction used to protect the structure from washout.

Each structure for an open ditch system shall be designed according to SCS standards for the kind of structure and type of construction used.

Channel vegetation. Vegetation shall be established according to the Vegetated Swale BMWP.

Plans and Specifications

Plans and specifications for constructing mains or laterals shall be in keeping with this BMWP and shall describe the requirements for constructing the practice to achieve its intended purpose.

Clearing. The channel area shall be cleared of trees, logs, stumps, and other materials necessary for construction. Care must be taken to protect all trees to be saved for environmental purposes. All material shall be disposed of by an acceptable method and shall not be placed in areas of wetland jurisdiction.

Excavation. Channels shall be excavated to line and grade as shown on the plans or as staked in the field. The excavated surface shall be reasonably smooth. Construction activities shall be carried on in a manner that will not restrict flow from upstream channels. Care must be taken to reduce and prevent sediment pollution of water.

Spoil. Spoil shall be disposed of as shown on the plan or as marked in the field.

Structures. All structures and other related protection devices shall be installed as the work progresses to permit proper functioning of the ditch and to prevent environmental damage during the installation period.

Vegetation. Vegetation shall be planted at times and rates shown in the plans or in the specifications for each job.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

TERRACE

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

An earth embankment, channel, or a combination ridge and channel constructed across the slope.

Purpose

Terraces are constructed to (1) reduce a slope length, (2) reduce erosion, (3) reduce sediment content in runoff water, (4) intercept and conduct surface runoff at a non-erosive velocity to a stable outlet, (5) retain runoff for moisture conservation, (6) prevent gully development, (7) reform the land surface, (8) improve farmability, and (9) reduce flooding. An additional purpose of this practice is to maintain or improve water quality.

Conditions Where Practice Applies

This practice applies where:

1. Water erosion is a problem.
2. There is a need to conserve water.
3. The soils and topography are such that terraces can be constructed and farmed with a reasonable effort.
4. A suitable outlet can be provided.
5. Runoff and sediment damages land or improvements downstream or impairs water quality.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and groundwater recharge.

2. Variability effects caused by seasonal or climatic changes.

3. The type of outlet, time of water detention, topography, and geology of the site.

4. Effects of snow catch and melt on water budget components.

5. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.

6. Effects on the downstream flows or aquifers that could effect other water uses and users.

7. The effect on the water table suitable rooting depth for anticipated land uses.

8. Potential for water management to supply alternate uses.

9. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.

10. Effects of nutrients and pesticides on surface and groundwater quality.

11. Effects on the visual quality of on-site and downstream water.

12. Short-term and construction-related effects on the quality of on-site and downstream water.

13. Effects on the movement of dissolved substances below the root zone and to the groundwater.

14. Effects on wetlands and water related wildlife habitats.

Design Criteria

Spacing. Terraces for Erosion Control - The maximum spacing shall be determined by one of the following methods, but does not have to be less than 90 feet:

1. V.I. = o.7s + y or H.I. = (0.7s + y) 100/s

   Where: V.I. = vertical interval in feet
   H.I. = horizontal interval in feet
   s = land slope in feet per 100 feet
   y = a variable with values from 1.0 to 4.0

   Values of y are influenced by soil erodibility, cropping system, and crop management practices. A value of 1.0 should be selected for easily erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4.0 should be used for erosion resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent) on the surface. A value of 2.5 should be used where one of the above factors is favorable and the other unfavorable. Other values between 1.0 and 4.0 may be used according to the estimated quality of the above factors.

2. The Universal Soil Loss Equation (USLE) - The spacing shall not exceed the slope length determined for contour cultivation by using the allowable soil loss, the most intensive use planned, and the expected level of management.

The horizontal spacing shall not exceed 450 feet for land slopes up to 2%, 300 feet for land slopes of 2% to 4%, 200 feet for slopes of 4% to 6%, and 150 feet for slopes of 6% and over. These maximum limits may not be exceeded when making adjustments as indicated below. Spacing may be increased as much as 10 percent to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10 percent for terraces with underground outlets. The spacing should be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing land forming, and erosion should be considered when determining the terrace interval.

Terraces on Noncropland - Maximum spacing will be governed by the capacity requirement.

Alignment. Terraces shall be made parallel when feasible and as parallel as practicable in all cases. Curves should be long and gentle to accommodate farm machinery. Land forming, extra cut or fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods are to be used to achieve good alignment.

Capacity. The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation unless provisions are made to maintain the design capacity through maintenance. Terrace systems designed to provide flood protection or to function with other structures shall have capacity to control a storm of a frequency consistent with the potential hazard involved. When the capacity is determined by the formula $Q = AV$ and the V is calculated by using Manning's formula, an "n" value of 0.06 shall be used.

Cross Section. The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. The ridge height shall include a reasonable settlement factor. The ridge shall have a minimum width of 3 feet at the design elevation. The minimum cross sectional area of the terrace channel for gradient terraces shall be 8 square feet for land slopes of 5% or less, 7 square feet for slopes from 5 to 8%, and 6 square feet for slopes steeper than 8%. The opening at the outlet end of terraces shall have a cross section equal to that specified for the terrace channel.

Channel Grade. Channel grade shall be determined by one of the following methods:

1. Maximum channel grade in the lower reaches of the channel should not exceed 0.6 percent.

2. Maximum channel velocity shall be non-erosive for the soil and planned treatment. Maximum velocity for erosion resistant soils is 2.5 ft/sec, for average soils 2.0 ft/sec, and for easily erodible soils 1.5 ft/sec. Velocities are to be computed by Manning's formula using an "n" value of 0.03.

Channel grades may be uniform or variable. Channel velocities shall not exceed that which is non-erosive for the soil and planned treatment. For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment. When terraces have an underground outlet, water and sediment will be ponded in the channel thus reducing velocities and allowing steeper channel grades near the outlet. Minimum grades are to be such that ponding in the channel due to minor irregularities will not cause serious damage to crops or delay in field operations.

Outlets. All terraces must have adequate outlets.

1. Vegetated outlets may be used for terraces. Such an outlet may be a grassed waterway or vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets are to be installed and vegetated before terrace construction if necessary to provide a stable non-erodible outlet or to insure establishment of vegetative cover. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.

2. Underground outlets may be used on terraces. The outlet consists of an intake and underground conduit. An orifice plate, increased in conduit size, or other feature, shall be installed in each inlet as needed to control the release rate and prevent excessive pressure when more than one terrace discharges into the same conduit. The discharge, when combined with the storage, is to be such that a 10-year frequency, 24-hour storm will not overtop the terrace and growing crops will not be damaged significantly by standing water. The release time shall not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops depending on soil characteristics and water tolerance of crops to be grown.

   The underground conduit shall meet the requirements for a subsurface drain. Conduits must be installed deep enough to prevent damage from tillage equipment. The inlet is to consist of a vertical perforated pipe of a material suitable for the intended purpose. The inlet should be located uphill of the front slope of the terrace ridge, if farmed, to permit passage of farm machinery and, where necessary, provide for the anticipated accumulation of sediment and subsequent raising of the terrace ridge. The outlet of the conduit shall have adequate capacity for the design flow without erosion. Blind inlets may be used where they are effective, usually in well drained soils.

Combination of different types of outlets may be used on the same system to maximize water conservation and to provide for economical installation of a more farmable system.

Vegetation. Steep back slope terraces (and steep front slope, if used) shall be established to grass as soon as practicable after construction. The sod shall be maintained and trees and brush controlled by chemical or mechanical means.

Plans and Specifications

Plans and specifications for installation of terraces shall be in keeping with this BMWP and shall describe the requirements for application of the practice to achieve its intended purpose. Construction specifications shall be in accordance with the USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices.

Installation

All dead furrows, ditches, or gullies shall be filled prior to construction of the terrace or as part of construction. All old terraces, fencerows, hedgerows, trees, and other obstructions shall be removed as necessary to install a farmable system.

The terraces shall be constructed to planned alignment, grade, and cross section, plus the specified overfill for settlement and the channel shall drain reasonably well.

Any ditch or depression at the bottom of the back slope should be filled and smoothed so that drainage will be away from the terrace and not parallel to it.

Provisions must be made where underground conduits are located under terrace ridges to prevent piping. Mechanical compaction, water packing, installation, and backfill or conduit trenches far enough in advance to allow adequate settlement are methods that can be used. The materials used for the inlet and conduit will be suitable for the purpose intended. Terrace ridges constructed across gullies or depressions shall be compacted by machinery travel or other means sufficient to insure proper functioning of the terrace. The surface of the terrace shall be reasonably smooth and present a satisfactory finish.

Where it is necessary, topsoil is to be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

Where vegetation is required, seedbed preparation, seeding, fertilizing and mulching shall comply with the practice standard for critical area planting.

Safety and Maintenance

As part of a conservation plan, a maintenance program shall be developed to maintain terrace capacity, storage, ridge height, and the outlets. Each intake of underground outlets must be kept clean and sediment buildup redistributed so the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately. If the practice is on lands without a conservation plan, a maintenance program will be described as part of the design.

Terrace ridges, especially those with steep back slopes, can be very hazardous. For this reason, some farmers prefer steep front slopes also thus keeping machinery away from the steep back slopes. All cut slopes and fills that are to be farmed must be no steeper than that on which farm equipment can operate safely. Any hazards must be brought to the attention of the responsible person.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

UNDERGROUND OUTLET

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A conduit installed beneath the surface of the ground to collect surface water and convey it to a suitable outlet.

Purpose

To dispose of excess water from terraces, diversions, subsurface drains, surface drains, trickle tubes or principal spillways from dams (outside the dam area only), or other concentrations without causing damage by erosion or flooding.

Conditions Where Practice Applies

This practice applies where: (1) excess surface water needs to be disposed of; (2) a buried outlet is needed for diversions, terraces, or similar practices; (3) an underground outlet can be installed that will safely dispose of excess water; and (4) surface outlets are impractical because of stability problems, climatic conditions, land use, or equipment traffic.

Considerations

1. Consider effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Consider effects on the volume of downstream flow that might cause undesirable environmental, social, or economic effects.

3. Evaluate potential use for water management.

4. Consider effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that would be carried by runoff.

5. Consider effects on the visual quality of downstream water resources.

6. Consider sediment-attached and construction-related effects on the quality of downstream water courses.

7. Consider effects on wetlands or water-related wildlife habitats.

Design Criteria

Capacity. The underground outlet shall be designed, alone or in combination with other practices, with adequate capacity to insure that the terrace, diversion or other practices function according to the standard for the specific practice. For example, an underground outlet can be used in combination with a grassed waterway or a surface drain to carry part of the design flow. The capacity of the underground outlet for natural basins shall be adequate for the intended purpose without causing excessive damage to crops, vegetation, or improvements.

Inlet. An inlet can be a collection box, a perforated riser, or other appropriate device. Its capacity shall be adequate to provide the maximum design flow in the conduit. Flow-control devices shall be installed as necessary. Perforated risers must be of durable material, structurally sound and resistant to damage by rodents or other animals. If burning of vegetation is likely to create a fire hazard, the inlet shall be fire resistant. Blind inlets can be used where they are effective. Collection boxes must be large enough to facilitate maintenance and cleaning operations. The inlet must have an appropriate trash guard to insure that trash or other debris entering the inlet passes through the conduit without plugging. It must also have an animal guard to prevent the entry of rodents or other animals.

Pressure-relief wells shall be designed and installed if needed to control pressure. If junction boxes and other structures are needed, they shall be designed and installed in a manner that facilitates cleaning and other maintenance activities.

Hydraulics. Underground outlets shall be continuous conduits, tubing, or tile. Joints shall be hydraulically smooth, and the materials and methods used shall be recommended by the manufacturer. If a pressure system is used, joints shall be adequate to withstand the design pressure, including surges and vacuum. The maximum velocity must not exceed the safe velocity for the conduit materials and installation.

Lines shall be adequate to carry the design flow when the outlet and all inlets are operating at design capacity. Capacity shall be based on the pipe size or on other flow control devices to prevent water from the upper inlets from discharging through the lower inlets. The minimum conduit diameter shall be 3 inches.

Materials shall meet or exceed the design requirements against leakage and shall withstand internal pressure or vacuum and external loading. Plastic, concrete, aluminum, and steel shall meet the requirements specified in the applicable ASTM standard. All materials specified for subsurface drains can be used for underground outlets. Conduits, however, can be perforated or non-perforated, depending on the design requirements.

Outlet. The outlet shall be sufficiently stable for all anticipated flow conditions. It shall be designed for the maximum anticipated water surface at design flow. A continuous section of closed conduit or a headwall can be used at the outlet. If a closed conduit is used, it shall be durable and strong enough to withstand all anticipated loads, including those caused by ice. If fire is a hazard, the outlet shall be fire resistant. All outlets near ponds, outlet channels, or streams where water is normally present must have animal guards to prevent the entry of rodents or other animals. Animal guards must be hinged to allow passage of debris.

Protection. Before the outlet is installed, all disturbed areas shall be reshaped and regraded so that they blend with the surrounding land features and conditions. Visual resources must be given the same consideration as other design features. Areas that are not to be farmed or covered by structural works shall be established to vegetation or otherwise protected from erosion as soon as practicable after construction.

Maintenance. Underground outlets shall be maintained by keeping inlets, trash guards, and collection boxes and structures clean and free of materials that can reduce the flow. All leaks shall be repaired promptly to insure proper functioning of the conduit.

Animal guards must be inspected periodically and maintained in proper working order.

Plans and Specifications

Plans and specifications for installing underground outlets shall be in keeping with this BMWP and shall describe the requirements for installing the practice to achieve its intended purpose.

CHAPTER 4

HABITAT IMPROVEMENT

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

WETLAND DEVELOPMENT OR RESTORATION

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

The construction or restoration of a wetland facility to provide the hydrological and biological benefits of a wetland.

Purpose

To establish or re-establish wetlands for the benefit of wildlife, reduce flooding, provide offsite water quality benefits, and provide groundwater recharge of acceptable water quality.

Conditions Where Practice Applies

This practice applies to sites that were natural wetlands which have drained or sites that are capable of storing water for the development of a wetland facility.

Considerations

1. Consider effect of volumes and rates of runoff, infiltration, evaporation, and transpiration on the water budget.

2. Evaluate the potential for a change in rates of plant growth and transpiration because of changes in the volume of available soil water.

3. Consider effects on downstream flows or aquifers that would affect other water uses or users.

4. Consider effects on the rate or volume of downstream flow to minimize or prohibit environmental, social, or economic effects.

5. Consider effects on movement of sediment and soluble and sediment-attached substances carried by runoff.

6. Consider effects on movement of dissolved substances to groundwater and to downstream surface waters.

7. Consider effects of short-term changes, construction, and maintenance related activities on the quality of water resources.

8. Consider effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

9. Consider effects on wetlands or water-related resources and wildlife habitats that would be associated with the practice.

10. Consider effects on the visual quality of water resources.

Design Criteria

The Best Management Wetland Practices for Agriculture for Wildlife Wetland Habitat Management, Dike, and Structure for Water Control will be used as appropriate. Existing drainage systems will be utilized, removed, or modified as needed to achieve the intended purpose. Refer to the USDA Soil Conservation Service Engineering Field Handbook for additional design information.

Plans and Specifications

Plans and specifications for installing structures for water control shall be in keeping with this Best Management Wetland Practice and shall describe the requirements for applying the practice to achieve its intended purpose.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

WILDLIFE WATERING FACILITY

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Constructing, improving, or modifying watering practices for wildlife.

Purpose

To provide drinking water for wildlife.

Conditions Where Practice Applies

In areas where new, additional, or improved watering places are needed to increase the range or to improve the habitat of wildlife.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on downstream flows or aquifers that could affect other water uses or users.

3. Effects on erosion and the movement of sediment and soluble and sediment-attached substances that would be carried by runoff.

4. Effects on the movement of dissolved substances to groundwater.

5. Effects on wetlands or water-related wildlife habitats.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

WILDLIFE WETLAND HABITAT MANAGEMENT

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Retaining, creating, or managing wetland habitat for wildlife.

Purpose

To keep, make, or improve habitat for waterfowl, furbearers, or other wildlife.

Conditions Where Practice Applies

On wetland and land where water can be impounded, ponded, or regulated by diking, ditching, blasting, excavating or flooding, and on adjacent areas managed for nesting, feeding areas, or protective buffers.

Design Considerations

Waterfowl

Ducks and geese require several different vegetative types and water conditions for nesting, rearing broods, adult molting and feeding. Waterfowl species include black duck, wood duck, mergansers, mallards, goldeneye, teal and Canada goose.

Courting, pairing, and mating.
(Mid-winter and early spring, before nesting.)

Requires little or no vegetative cover as these activities are generally performed on small open-water areas with bare shorelines. Mating habitat is usually one or several small, shallow open-water ponds, seasonally flooded basins in fields or pastures, flooded river bottoms and woodlands.

Nesting.
(March - June)

Black ducks, mallards and teal nest on the ground usually within 300 feet of the water, but sometimes farther away in 12 to 24 inch vegetation such as redtop, reed canarygrass, orchardgrass, timothy, red clover and low shrubs. Islands and hummocks in wetlands also provide good sites.

Wood ducks, goldeneyes and hooded mergansers nest in trees where they prefer a cavity in the trunk. All three will also accept artificial nesting boxes when natural cavities are lacking. These boxes should be constructed with predator guards and should be properly maintained.

Geese require small islands, peninsulas or properly constructed nesting platforms in marshes and ponds.

Brood Rearing.
(May to early September)

Immediately after the young are hatched, the hen leads them from the nest to a water area a foot or more deep surrounded by or interspersed with flooded shrubs and marsh plants such as bulrushes, sedges, cattails, arrow-arum and other aquatic plants. Wood ducks use woody cover in wetlands and along ponds and streams.

Loafing.

Ducks spend a great deal of time loafing, sunning or preening themselves on mud flats, knolls, logs or small islands.

Feeding.

Black ducks, mallards, teal and wood ducks feed primarily on plant seeds. Snails, insects and herbaceous vegetation also comprise part of the diet. Important plants include corn, pondweeds, wild rice, millets, bulrushes, pickerelweed, naiad, smartweeds, burreeds, duckweed, arrow-arum, arrow-head, and acorns.

Furbearers

Beaver.

Beaver flowages provide some of the best duck and wildlife habitat in New Hampshire. Beaver need an adequate food supply consisting of the bark of aspen, alder, willow, birch, and maple. Overpopulation causes the food supply to decrease rapidly. It is important to keep the beaver at or below the carrying capacity.

Muskrats.

Muskrats are semi-aquatic and need water to live. The entrance to muskrat houses or bank dens is normally 4 to 16 inches beneath the water level. Muskrats use open water for travel. Their diet consists of filamentous algae and leaves and roots of plants such as cattails, wild rice, reeds, pondweeds, and burreed.

Other wetland wildlife

Non-game animals.
(Fish, birds, mammals, insects, etc.)

Various non-game animals use almost any size body of water as habitat. These bodies of water may be shallow or deep, but should at least contain water during the months of May and June. The water should be protected from pollution. Safety will be considered in constructing wildlife water habitat as young people frequent these areas on wildlife studies.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on the volume of downstream flow or charge to aquifers that might cause undesirable environmental, social, or economic effects.

3. Potential for a change in plant growth and transpiration because of changes in the volume of soil water.

4. Effects on erosion and the movement of sediment and soluble and sediment-attached substances that would be carried off by runoff.

5. Effects of nutrients and pesticides on surface and groundwater quality.

6. Effects on the movement of dissolved substances below the root zone and to groundwater.

7. Effects on temperatures of water resources to allow for the enhancement or protection of aquatic and wildlife communities.

8. Effects on wetlands or water-related wildlife habitats.

Permits

A landowner must obtain a dam permit from the New Hampshire Department of Environmental Services Water Resources Division when impounding water as defined by the NH Code of Administrative Rules.

Specifications

I. Shallow water areas

A. Establishment of new areas

Select one or a combination of the following ways to create shallow water areas.

1. Establish water level controls which will:[1]

   a. Impound areas of at least one acre.
   b. Cover at least 75 percent of the area with water less that 2.5 feet deep.
   c. Drain water stored in the impoundment at a rate of at least .5 inches in 24 hours for establishment of wetland plants or 1 inch in 24 hours for establishment of grain and seed crops.
   d. Automatically remove excess runoff so as to maintain desired water levels when flooded.
   e. Provide for drawdown management. Periodic drawdown of the water level to improve water quality or manage vegetation is recommended by the New Hampshire Fish and Game Department every 5 years. The marsh could be drained for 1 or 2 growing seasons to allow smartweed, grasses and sedges to develop and then reflood.

Structures will be designed for site conditions using the appropriate Best Management Wetlands Practices for Agriculture for dikes, ponds or other practices designed to provide wetland wildlife habitat.

2. Excavate potholes

   a. Create a minimum of 2,000 square feet and a maximum of 22,000 square feet of open water per acre of wetland.
   b. Minimum diameter should be 50 feet with a center depth of 7 feet. Blasting conditions will vary site by site.

1 Constructed water control measures must conform to applicable practice standards and specifications and applicable state and federal laws.

c. Connection of potholes by ditches or channels is desirable to provide water flow and interspersion. Ditches or channels should be at least 3 feet deep and 5 feet wide.

d. Water level controls are not necessary on potholes or excavated marshes where groundwater maintains water at desired levels.

B. Maintenance of existing wetlands

1. Water level and adjacent land must be maintained or managed to provide suitable growing conditions for vegetation specified for wildlife feeding or nesting, brood or resting cover. Some hardwood trees and shrubs may be left standing for nesting sites and cover. Elms, small conifers and birch may be removed.

II. Other lands

A. Impoundments should be at least one acre in size for waterfowl and furbearers but may be smaller for other types of wetland wildlife. These impoundments are normally constructed on land with 1 percent or less slope.

B. An adequate source of water must be available in late August - early September to flood at least half of the area within one week and the other half within three weeks.

C. Establish water control which:

1. will cover at least 50 percent of the pool area with water less than 2½ feet deep;

2. will drain water stored in the impoundment at a rate of 0.1 inch in 24 hours; and

3. will automatically remove excess runoff and maintain the designed water surface elevation during periods when the impoundment is flooded.

D. Plant or establish one or more of the following plants in:

1. Feeding areas (within impoundment) - corn, Japanese millet, wild millet, buckwheat, smartweeds, barley, and sorghum.

2. Nesting areas - alfalfa, redtop, reed canarygrass, other locally adapted legumes and grasses within 150 yards of the impoundment edge.

III. Vegetation for food and cover

One or a combination of the following types of vegetation must be established or maintained as needed.

A. Wetland Plants (bulrushes, sedges, cattails, pondweeds, naiads, arrowhead, wild rice, redtop, smartweed)

1. Establishment

a. Soil must be waterlogged or covered with water during the growing season.
b. Wetland plants usually become established naturally. To hasten establishment, they may be supplemented by seed, roots or transplants if water and soil conditions are suitable and planting stock is available.
c. To favor nesting and brooding cover, water level should be 6 inches to 3 feet deep and stable during the spring and summer.

2. Maintenance

Protect the water from toxic pollutants and excessive fertility. Also prevent drainage or diversion of the water.

B. Grain and seed crops (corn, millet, barley, grain sorghum, buckwheat, oats)

1. Establishment

a. Flooded grain or seed crops used for hunting must meet the legal requirements of the New Hampshire Fish and Game Department under the direction of a wildlife biologist.
b. Plant at least one acre following normal methods for the grain or seed crop being planted.
c. The crop should not be harvested for domestic purposes or otherwise destroyed.

2. Maintenance

a. Grain and seed crops must be planted annually.
b. Follow the appropriate cropping system.
c. Flood at least 50 percent of the field early in September with water less than 18 inches deep.

C. Perennial grasses and legumes (switch-grass, rye, timothy, orchardgrass, fescues, reed canarygrass, clover).

1. Establishment

   a. Establish 25 to 100 foot wide strips of grass and legumes within 150 yards of the water.
   b. Prepare the site according to standards and specifications for Pasture and Hayland Planting or Critical Area Planting.
   c. This element will often become established in primary succession following clearing or brush control. Pasture or hayland where grazing is postponed until after July 15th will provide nesting cover adjacent to wetland sites.

2. Maintenance

   a. Maintain grass areas free of trees and brush by mowing after July 15th but before August 1st. Lime, fertilize, and renovate as necessary.

IV. Miscellaneous improvements (incorporate miscellaneous improvements into the design of the new wetland areas.)

Wetlands which need improvement in nesting value for birds can be improved to acceptable levels by one or more of the following practices.

A. Nesting Islands (earth)

Islands are an important source of nesting and loafing sites for waterfowl because they increase edge effect and protect nests from non-swimming predators. Ducks and geese can defend nests on islands more easily than other sites and young ducks do not have to travel far to the safety of the water.

1. Establishment

   a. Create at least one island per 1 acre of water. Surface area of each island will be at least 150 square feet. Irregular or cross-shape islands provide more interspersion than round or square islands because they create more edge.
   b. Islands will be seeded with a grass-legume mixture to quickly establish cover. Islands with wet soils should be seeded with reed canarygrass or redtop.

2. Maintenance

Maintain shrubs and grass cover and discourage trees.

B. Artificial nest structures

1. Establishment

a. Construct nest boxes according to designs provided by the New Hampshire Fish & Game Department or USDA Soil Conservation Service.

2. Maintenance

a. Check boxes annually to repair and clean. Replace wood shavings prior to March 1st.
b. Maintain predator guards securely fastened and paint as necessary.
c. Boxes should not be disturbed during the nesting season.

V. Protection from livestock

Domestic livestock must be excluded from all areas managed for wetland wildlife habitat, including appropriate adjacent land areas. Fencing shall be located at least 150 feet from the normal water table. Limited grazing or haying may be permitted in some areas as a habitat management technique after July 15th.

VI. Protection from predation & competition

Dogs and cats which roam in and near wetlands are usually disastrous to wetland wildlife and should be restricted, especially during spring and early summer. Domestic ducks and geese are not to be allowed on wetlands managed for wildlife unless they are restricted to pens. Snapping turtles are effective predators of young ducklings and goslings. Traps and baited lines are usual methods to control snapping turtle numbers.

CHAPTER 5

PONDS, WATER SUPPLY, AND IRRIGATION

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

COMMERCIAL FISHPONDS

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A small body of water established to produce food fish, bait fish, crayfish, or other fish products for commercial purposes.

Purpose

To provide water for growing and harvesting fish crops.

Conditions Where Practice Applies

On land where soil conditions, water resources, and topography are suitable for constructing a pond or a reservoir.

Considerations

I. Permits and Licenses

Landowners are required to obtain permits from the New Hampshire Department of Environmental Service Water Resources Division on all embankment ponds.

A landowner must obtain the necessary permit or license from the New Hampshire Fish and Game Department in order to:

1. Release fish into a pond
2. Import food or bait fish into the state
3. Run an aquaculture operation
4. Operate a fee fishing area

A landowner must obtain a waste discharge permit for point source pollution from the New Hampshire Department of Environmental Service Water Supply and Pollution Control Division if raising 20,000 pounds or more of trout.

II. Water Quality

Fish require water of good quality to survive and grow. Ponds should be tested for dissolved oxygen content, pH and temperature before stocking fish. Measurements should be taken at the surface and 5 foot depth intervals during the hottest time of the year. Minimum requirements for desired water quality are:

1. Dissolved oxygen - 5 parts per million or more
2. pH - between 6 and 9
3. Temperature - in summer less than 70°F for trout, 70°F or more for bait fish and warm water species. Temperature should reach 65°F early in the spring (mid-May - mid June) for early bait fish egg production.

These parameters vary according to amounts of aquatic vegetation, chemical composition of the water, pond location, soil material, pond depth, management around the pond, and water source. (Sources of water in order of preference are springs, wells, streams, and reservoirs.)

Water should be free of silt and other fish species.

III. Water Quantity

There should be sufficient water to fill the pond, replace evaporation and percolation losses, and maintain proper water quality. A minimum water flow of 50 gallons per minute is required for production. This allows for inflow of oxygen and takes care of wastes.

IV. Additional Considerations

1. Effects on the water budget, with emphasis on effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and groundwater recharge.

2. Effects on the volume of downstream flow or aquifers that might cause undesirable environmental, social, or economic effects.

3. Effects on erosion and the movement of sediment, organics, and soluble and sediment-attached substances.

4. Effects on the visual quality of water resources.

5. Short-term and construction-related effects on the water resources.

6. Effects on the temperature of water discharged.

7. Effects on the movement of dissolved substances below the root zone and toward groundwater.

8. Potential for redistributing toxic materials during earth moving.

Specifications

Commercial fish ponds can be either embankment or dugout ponds for fee fishing areas. Minimum standards and specifications will be as contained in the Pond Best Management Wetlands Practice for Agriculture. In addition, the criteria in this specification will be incorporated into the design for the species of fish desired and may supplement criteria in the Pond Best Management Wetlands Practice for Agriculture.

I. Bait Fish Ponds

A. Size

Ponds from .25 to .75 acre in size are easiest to manage; size depends on production goals. Larger ponds are more difficult to seine.

B. Depth

A minimum of 3 feet is necessary to maintain an adequate water supply during the summer. Successful over wintering requires a depth of 4 to 5 feet where the pond is spring fed and 8 feet where it is not.

C. Design

Rectangular ponds are ideal. They can be installed singly to raise assorted age and size bait in one pond or in a series to raise single size and age in separate ponds. Side slopes should be 2:1 to discourage vegetation. For those species that need vegetation for spawning, slopes should be 4:1 or install spawning mats. The bottom should be smooth and sloped toward the drain. A gentle slope of 2 to 6 percent will facilitate gravity flow.

D. Harvesting

Harvesting techniques include lift nets, seines, traps, pumping, draining, or a combination thereof. The bottom of the pond should be clear of stumps and obstructions so that the nets and seines do not get snagged.

- Draining is the most widely used method and requires a catch basin. A box located beneath the drain pipe is most effective and should be placed in the deepest part of the pond. The bottom of the catch basin should be 1 foot below the inlet of the drain pipe. Basins should be a minimum of 15 feet square and 1 foot deep for ponds up to 0.3 acres in size. Larger ponds should have basins which are a minimum of 2 percent of the total pond area and 1 foot deep. The bottom of the pond should be graded so that when drained the last fish and water will be in the harvesting basin. Construct the basin using 2 X 12 inch planks, concrete blocks, bricks, or other suitable material. When made of concrete the walls and bottom should be at least 4 inches thick. Drain pipe inlets will be suitably screened to prevent passage of fish. A valve will be provided to control drainage.

II. Trout Ponds for Fee Fishing (production is best achieved in a raceway)

A. Size

Ponds shall be a minimum of .25 surface acre. Pond size depends on production goals.

B. Depth

Depth shall be at least 8 feet for over wintering and oxygen supply, unless there is a spring with flow exceeding 50 gallons per minute per surface acre of water. Pond shorelines should slope 2:1 to a depth of 3 feet.

C. Other

Where supplemental feeding is practiced, there must be complete control over water entering and leaving the pond except for minor watershed runoff.

Drain pipes and trickle tubes should be installed. All trees and brush should be removed from the area to be covered with water.

Mow grass to provide comfortable access to the fishing area.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

DAM, FLOODWATER RETARDING

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A single-purpose dam designed for temporary storage of floodwater and for its controlled releases.

Purpose

To reduce flood damages downstream by controlling the release rate from flood flows of predetermined frequencies. They may also permit the use of more economical channel modifications or stabilizing structures in the channel downstream and reduce environmental hazards and pollution.

Conditions Where Practice Applies

This practice applies only to sites meeting all the following conditions:

1. Topographic, geologic, and soils conditions at the proposed site are satisfactory for the development of a feasible dam and reservoir.

2. The sediment yield at the site is not excessive.

Special attention shall be given to maintaining habitat for fish and wildlife if applicable.

Considerations

1. Reductions in downstream flow during runoff periods.

2. Potential total runoff or decrease of evaporation from the reservoir surface and seepage from the pool bottom.

3. Potential increases in surface water volume during normal low flow periods caused by prolonged duration of reservoir releases.

4. Increase in deep percolation to the groundwater resulting from seepage from the reservoir sides and bottom. The amount of seepage will depend on soils, area covered by the reservoir, and length of time inundated, and measures for reservoir sealing.

5. Potential for improving downstream surface water quality resulting from trapping of suspended sediments, bedload material, and associated nutrients and pesticides in the pool area.

6. Instability of downstream banks and channel and their potential to deepen and widen.

7. Potential for degradation of surface water quality by sediments, fuels, oils, and other chemicals during construction.

8. Increase in temperature, decrease in dissolved oxygen, and the amount of adsorbed nutrients and pesticides in deposited sediments in sediment pools.

9. Potential changes in downstream water temperatures and dissolved oxygen content that could result from the design of the outlet structure. Where dissolved oxygen may be reduced by outlet placement, plan some means of causing rapid dissolved oxygen recovery.

10. Increases in soluble nutrients and pesticides in deep percolating waters caused by seepage in reservoir sides and bottom. Chemicals may originate from those used in the structure and reservoir area, or may be dissolved in waters from the watershed area.

11. A landowner must obtain a permit from the New Hampshire Department of Environmental Services Water Resources Division when impounding water according to the NH Code of Administrative Rules.

Design Criteria

All dams designed under this practice shall meet or exceed the criteria in the Pond Best Management Wetlands Practice for Agriculture or in USDA Soil Conservation Service Technical Release 60 (TR-60) Earth Dams and Reservoirs, as appropriate, except as specifically modified by this practice.

The capacity of the principal spillway shall be adequate to discharge, in 10 days or less, the floodwater storage needed to provide the desired level of protection to the downstream benefitted area. Storage provided primarily for the purpose of reducing the frequency of use of the emergency spillway need not be included in this 10-day drawdown limitation. The determination of capacity must be based on consideration of the benefits that accrue to the reduction in the discharge rate, damages that may result from prolonged storage in the retarding pool, damages that may result from prolonged outflow, and limitations in water rights or other legal requirements. Longer release times may be used if warranted by downstream conditions. The discharge through gated outlets shall not be considered in determining the emptying time of the retarding pool.

The elevation of the crest of the lowest stage of the principal spillway shall be set at the elevation of the sediment pool. For dry dams, the riser shall be designed to permit design discharge at the sediment pool elevation with provisions for discharging water at lower elevations to satisfy the functional requirements of the structure.

All parts of the principal spillway, except attached gates and trash racks, shall have an expected service life equal to or greater than the design life of the structure or provisions made for replacement. Principal spillways shall meet the requirements with respect tot materials established in the Pond Best Management Wetlands Practice for Agriculture or in TR-60, as appropriate.

The minimum diameter of the conduit used as a principal spillway shall be 10 inches.

The storage volume shall not be less than the expected sediment accumulation during a period equal to the design life.

The retarding storage requirements shall be of such as to contain the runoff expected to occur at a frequency consistent with the level of protection to be provided to the downstream benefitted area, with proper allowance for discharge through the principal spillway. The retarding storage capacity shall be sufficient to limit the use of the emergency spillway to a permissible frequency and duration based upon consideration of the erosion resistance of the spillway material and vegetative protection to be provided.

Plans and Specifications

Plans and specifications for installing floodwater retarding dams shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Specifications for construction of floodwater retarding dams within the scope of the Pond Best Management Wetlands Practice for Agriculture shall, as a minimum, be commensurate with those for ponds. Those within the scope of the criteria in TR-60 shall be in accord with the guide specifications contained in the USDA Soil Conservation Service National Engineering Handbook, Section 20.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

DAM, MULTIPLE PURPOSE

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A dam constructed across a stream or a natural watercourse that has a designed reservoir storage capacity for two or more purposes, such as floodwater retardation and irrigation water supply, municipal water supply, and recreation.

Purpose

A multiple-purpose dam must provide distinct and specific storage allocations for two or more of the following purposes: (1) floodwater retardation; (2) irrigation; (3) fishing, hunting, boating, swimming, or other recreational uses; (4) improve environment or habitat for fish or wildlife; (5) municipal; (6) industrial, and; (7) other uses. (A reservoir for which multiple use is made of the same storage allocation is not a multiple-purpose dam; however, a dam designed for joint-use storage is a multiple-purpose dam.)

Conditions Where Practice Applies

This practice applies only to sites meeting all the following criteria:

1. Topographic, geologic, hydrologic, and soil conditions at the proposed site are satisfactory for constructing a feasible dam and reservoir.

2. The watershed is protected from erosion to the extent that the sediment yield will not shorten the planned effective life of the reservoir.

3. Water is available from a single or combined source of surface runoff base flow or from subsurface storage in sufficient quantity and adequate quality to satisfy the intended purpose.

Considerations

1. Effects on the water budget, especially of longer downstream flow durations, evaporation from the water surface, and infiltration in the bottom and sides of the pool area.

2. Effects of water taken from the reservoir for agricultural, industrial, or municipal use.

3. Effects on the movement of sediments, pathogens, and soluble and sediment-attached substances carried by runoff.

4. Effects of increased downstream bank saturation resulting from longer flow duration on erosion and sediment yield.

5. Potential use of the reservoir for recreation. Factors include increased use of pesticides, human waste, and other pollutants.

6. Effects of sediment pool on temperature and dissolved oxygen on downstream waters.

7. Effects of location of the outlet structure on downstream water temperature and dissolved oxygen.

8. Changes in groundwater quality caused by increased infiltration of soluble substances.

9. A landowner must obtain a dam permit from the New Hampshire Department of Environmental Services Water resources Division when impounding water according to the NH Code of Administrative Rules.

Design Criteria

Foundation, embankment, and spillway. All dams designed under this practice shall meet or exceed the foundation, embankment, and spillway criteria called for in the Pond Best Management Wetlands Practice for Agriculture or in the USDA Soil Conservation Service Technical Release 60 (TR-60) Earth Dams and Reservoirs, as appropriate.

Floodwater retarding pool and spillway. Dams having a floodwater retarding purpose shall meet or exceed the requirements of the Floodwater Retarding Dams Best Management Wetlands Practice for Agriculture.

Outlet works. Outlet works discharging releases for several purposes shall have adequate capacity to carry the peak flow resulting from the combined demands at any time. Outlet conduits and appurtenances shall be designed according to criteria that are equal to or better than that called for in the Pond Best Management Wetlands Practice for Agriculture, or in TR-60, as appropriate.

Storage. The usable storage capacity shall be adequate for all purposes. Seasonal variations in demand and the expected losses from seepage and evaporation must be considered.

Sediment storage. The capacity, in addition to that required for all other purposes, must offset depletion by sediment accumulation for a period equal to the design life.

Type of structures. All dams and appurtenances shall be designed to meet applicable Best Management Wetlands Practices for Agriculture for the specific type and class of structure.

Plans and Specifications

Plans and specifications for installing multiple-purpose dams shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Specifications for dams to which the Pond Best Management Wetlands Practice for Agriculture apply shall, as a minimum, be commensurate with those for ponds.

Specifications for dams to which the criteria in TR-60 apply shall be in accord with the guide specifications contained in the USDA Soil Conservation Service National Engineering Handbook, Section 20.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

DIKE

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

Purpose

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features, and archeological sites from damage.

Conditions Where Practice Applies

Class I dikes are those constructed on sites where:

1. Failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways or railroads, and high value land, crops, or other improvements.

2. Unusual or complex site conditions require special construction procedures to ensure satisfactory installations.

3. Protection is needed to withstand more than 12 feet of water above normal ground surface, exclusive of crossings of sloughs, old channels, or low areas.

Class II dikes are those constructed in highly developed and productive agricultural areas where:

1. Failure may damage isolated homes, highways or minor railroads, or cause interruption in service or relatively important public utilities.

2. The maximum design water stage against the dike is 12 feet.

Class III dikes are those constructed in rural or agricultural areas where:

1. Damage likely to occur from dike failure is minimal.

2. The maximum design water stage against the dike is 6 feet for mineral soils and 4 feet for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, and transpiration.

2. Potential for a change in rates of plant growth and transpiration because of changes in the volume of soil water.

3. Effects on downstream flows or aquifers that would affect other water uses or users.

4. Effects on the rate or volume of downstream flow to prohibit environmental, social, or economic effects.

5. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.

6. Effects on the movement of dissolved substances to groundwater.

7. Short-term, construction, and maintenance related effects on the quality of water resources.

8. Effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

9. Effects on wetlands or water-related wildlife habitats that would be associated with the practice.

10. Effects on the visual quality of water resources.

Design Criteria - All Dikes

In locating dikes, careful consideration shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. If dike construction will adversely affect such values, concerned public agencies and private organizations shall be consulted about the project.

Protection. A protective cover of grasses shall be established on all exposed surfaces of the dike and other disturbed areas. Seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with recommendations in local technical guides.

If vegetation will not control erosion, riprap or other protective measures shall be installed.

Maintenance. All dikes must be adequately maintained to the required shape and height. The maintenance of dikes must include periodic removal of woody vegetation that may become established on the embankment. Provisions for maintenance access must be provided.

Design Criteria - Class I Dikes

Location. Conditions to be considered in designing Class I dikes are foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available.

Height. The design height of a dike shall be the design high water depth plus 2 feet of freeboard or 1 foot of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows.

1. If dike failure is likely to cause loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the stage of the 100-year frequency flood or of the maximum flood of record, whichever is greater.

2. If dike failure is unlikely to result in loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will insure the desired level of protection or the 50-year frequency flood, whichever is greater.

3. If the dike will be subject to stages from more than one stream or source, the criteria indicated shall be met for the combination that causes the highest stage.

4. If the dike will be subject to tidal influence as well as streamflow, the streamflow peak shall be assumed to occur in conjunction with the mean high tide to determine the design high water depth.

The design height of the dike shall be increased by the amount needed to insure that the design top elevation is maintained after settlement. This increase shall be not less than 5 percent.

Interior drainage. If inflow from the area to be protected by the dike may result in loss of life or extensive high-value crop or property damage, provisions shall be included in the plans to provide interior protection against a 100-year frequency hydrograph, plus base flow, and an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value crop or property damage, storage areas, gravity outlets, or a pumping plant, alone or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will insure the desired level of protection, whichever is greater.

In sizing outlet works in combination with available storage, the minimum design storm duration for interior drainage shall be 10 days. If outlet works are designed using peak flood frequency flows without considering storage, the minimum design storm duration shall be 24 hours.

Embankment and foundation. The embankment shall be constructed of mineral soils, which when placed and compacted will result in a stable earth fill. No organic soil shall be used in the dike. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 feet for embankment heights of 15 feet or less and 12 feet for heights more than 15

feet. If maintenance roads are to be established on the dike top, 'turnarounds' or passing areas shall be provided as needed.

Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the water side shall not be steeper than 4 horizontal to 1 vertical if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the landside toe shall be protected by a banquette or constructed berm. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall be not less than 1 foot above mean ground and shall be sloped away from the dike.

A cutoff shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slopes adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If pervious foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to insure stability of the dike shall be used.

Ditches and borrow pits. Landside ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 feet in width, shall be left in the ditches at intervals not greater than 400 feet to form a series of unconnected basins.

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow pit shall be:

Fill height	Minimum berm width
Less than 6 feet	12 feet
More than 6 feet	18 feet

A drainage system shall be used if necessary to insure the safety of a dike. Toe drains, if used, shall be located on the landside and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the landside toe of a dike than a

distance three times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Pipes and conduits. Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with anti-seep collars.

All conduits through a dike below the design high water line shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed water line shall be equipped with a Dayton or similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

Design Criteria - Class II Dikes

Design water stage. The maximum design water stage permitted is 12 feet above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes, based on the required level of protection, exceeds 4 feet the design shall be based on at least a 25-year frequency flood. If this degree of protection is not feasible, the design shall approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

Height. The design height of an earth dike shall be the design water depth plus a freeboard of at least 2 feet or freeboard of 1 foot plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus and allowance for settlement necessary to insure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

Interior drainage. Provisions must be made for adequate drainage for the area to be protected by the dike.

Cross section. The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Design water height	Minimum top width	Steepest side slope
0-6 feet	6 feet	1½:1
6-12 feet	8 feet	2:1

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated in the fill as follows:

Design water height	Minimum top width	Steepest side slope
0-6 feet	8 feet	2:1
6-12 feet	10 feet	2½:1

Side slopes of 3:1 on the waterside and 2:1 on the landside may be used instead of 2½:1 for both slopes.

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall be not less than 10 feet if a maintenance road is planned on top the dike. 'Turnarounds' or passing areas shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML, are used in construction.

A banquette (or constructed berm) shall reinforce the landside toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analyses show a different design is adequate.

Foundation cutoff. A cutoff shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

Ditches and borrow pits. Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill height	Minimum berm width
Less than 6 feet	10 feet
More than 6 feet	15 feet

A landside ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having design water depth of more than 5 feet, the landside ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design water line with the waterside of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipes and conduits. The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water, if feasible, or else equipped with anti-seep collars.

All conduits through the dike below the design high water line shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed water line shall be equipped with a Dayton or a similar coupling to prevent vibrations of the pumping plant being transmitted to the discharge conduits.

Drains. Drains shall be used where necessary to insure safety of dikes and shall be located on the land side, have a graded sand-gravel filter, and the designed and installed in accordance with Soil Conservation Service standards for such drains.

Field subsurface drains shall not be installed or permitted to remain without protection closer to the landside toe of a dike than a distance three times the design water height for the dike. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Design Criteria - Class III Dikes

The design criteria shall be based on site conditions for mineral or organic soils as applicable.

Top width. Minimum top width is 4 feet.

Side slopes. Minimum side slope is 1:1.

Freeboard. The minimum freeboard is 1 foot plus wave height. The constructed height shall be increased by the amount necessary to insure that the settled top is at design elevation but not less than 5 percent.

Foundation cutoff. A cutoff shall be installed if necessary to insure dike stability.

Ditches and borrow pits. Minimum berm widths between the toe and the dike and the edge of the excavated channel or borrow shall be two times the depth of the ditch but not less than 8 feet.

Plans and Specifications

Plans and specifications for constructing dikes shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

FENCING

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent and wooded swamps classified as Palustrine Forested. It is not the intent when using this practice that it be applied to open water bodies, perennial streams, marshes or bogs. The wet area to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area.

Definition

Enclosing or dividing an area of land with a suitable permanent structure that acts as a barrier to livestock, big game, or people (does not include temporary fences).

Purpose

To: (1) exclude livestock or big game from areas that should be protected from grazing; (2) confine livestock or big game on an area; (3) control domestic livestock while permitting wildlife movement; (4) subdivide grazing land to permit use of grazing systems; (5) protect new seedings and plantings from grazing; and (6) regulate access to areas by people or prevent trespassing.

Conditions Where Practice Applies

On any area requiring control or exclusion of livestock or big game or regulation of access by people.

Considerations

Normally fencing will have no effect on the quantity of surface and groundwater.

Fencing is a practice that can be on the contour or up and down slope. Often a fence line has grass and some shrubs on it. When a fence is built across the slope it may slow down runoff and cause deposition of coarser grained materials reducing the amount of sediment delivered downslope. Fencing may protect riparian areas and act as sediment traps and filters along water channels and impoundments.

Livestock have a tendency to walk along fences. The paths become bare channels which concentrate and accelerate runoff, causing a greater amount of erosion within the path and where the path/channel outlets into another channel. This can deliver more sediment and associated pollutants to surface waters. Fencing can have the effect of concentrating livestock in small areas, causing a concentration of manure which may wash off into the stream, thus causing surface water pollution.

Special items of consideration are: (1) kinds and habits of livestock and wildlife; (2) location and adequacy of water facilities; (3) topographic features; (4) soil and depth to bedrock site characteristics; (5) locating fences in relation to livestock handling facilities; (6) equalization of forage-producing ability among grazing units as feasible and practical; (7) proposed or potential grazing system and compliance with any fencing codes or regulations; and (8) local preference and esthetics considerations.

These specifications are minimum; however, for hazardous situations, such as livestock fencings along highways, a more substantial fence may be required.

Design Criteria

A. Nonelectrical Fences

1. Barbed Wire Fence - The strands shall be spaced approximately an equal distance apart. The bottom wire shall be approximately 14 to 18 inches above the ground level. The barbed wire shall be two twisted strands of 12.5 gauge or heavier wire with 14.5 gauge or heavier two-point barbs on approximately 5 inch centers. The wire and barbs shall be galvanized. See Table 5-1.

2. Woven Wire Fence - Fence with woven wire less than 32 inches high shall have at least two barbed wires above the woven wire. Fences with woven wire 32 inches or higher must have at least one barbed wire above the woven wire. The top and bottom wires in the woven wire shall be 11 gauge or heavier, and line and stay wires shall be 14.5 gauge or heavier. Wires shall be galvanized. See Table 5-1.

   The barbed wire above the woven wire shall meet the barbed wire specifications.

TABLE 5-1 -- FENCE CONSTRUCTION FOR BARBED WIRE OR WOVEN WIRE NONELECTRIC FENCE

Use	Height (inches)	Barbed Wire Strands	Woven Wire Stay Spacing (inches)	Woven Wire Gauge[1]
Cattle or mixed livestock	44	3 to 4	6 to 12	11
Hogs[2]	32	2	6	9
Sheep or goats	39	4	6 to 12	9
Horses	48	----	6 to 12	11
Deer	94	----	6 to 12	9

1 Minimum gauge for top and bottom strands of fabric.
2 At least one strand barbed wire below woven wire fabric.

3. Staples

a. Staples shall be 9 gauge galvanized wire and have a minimum length of 1.5 inches except 1 inch minimum length will be permitted for very hard wood such as oak.

b. Staples should be driven diagonally with the wood grain to avoid splitting. The staples should not be driven into the post so deeply that the coating of the wire is damaged.

c. Wire fasteners made of 16 gauge or heavier galvanized wire may be used in lieu of staples for fastening wires to wood or steel posts.

4. Wooden Fence Posts and Braces

a. Durability - Untreated posts of black locust, red or white cedar, or other wood of equal life and strength are acceptable. Pressure preservative treated pine or other wood of equal life and strength are acceptable.

b. Size - Line posts will have a minimum top diameter of 3 inches and to be of sufficient length to support the height of the fence, and be firmly set or driven in the ground a minimum depth of 2 feet. Corners, gate ends, and brace posts will have a minimum top diameter of 5 inches, to be sufficient length to support height of fence, and be firmly set or driven in the ground a minimum depth of 3 feet.

5. Steel Posts - Standard 'tee' or 'u' section steel posts weighing not less than 1.1 pounds per foot of length may be used in lieu of wooden line posts. Lengths shall be the same as for wooden posts. Steel posts shall be studded, embossed or punched for attaching the wire to the posts. The wire shall be attached to the post by wrapping No. 16 gauge galvanized wire or by use of manufactured wire clips.

6. Bracing - Required at all corners, ends, gates, and all definite angles 15 degrees or more in the fence line. A brace post assembly will be installed in straight fence sections at intervals of no more than 660 feet or at any point where the vertical grade change is in excess of 18 percent.

   The horizontal brace shall be wood with a minimum 3 inch diameter or square or 1.5 inches or larger diameter. The distance between brace posts and end, gate, or corner post shall be 6 to 8 feet. The brace shall be placed about 1 foot below the top of posts, notched into each post 1 inch with ends spiked to posts or pinned to posts. A diagonal brace wire made of four strands of 9 gauge wire or four strands of 12.5 gauge barbed wire shall be fastened around the brace post 4 to 6 inches from the top and extended to and fastened around the end, gate, or corner post 0 to 4 inches above ground.

   Brace wire shall be tightened until brace and posts are rigid. Slats or rods used for tightening may be left in the twist. Corner posts shall have a brace post and bracing on both sides.

7. Trees - Can be used in place of posts and corners if trees are in line with the fence, sound, and meet the size requirements of this specification. When trees are used as a substitute for posts, the fence should be attached to a board or 2X4 that has been attached to the tree.

8. Spacing - Maximum acceptable distance between posts is 16 feet.

9. Gates - Prefabricated or constructed gates of metal or wood shall be wide enough for passage of farm equipment and vehicles (normally 12 to 14 feet). The top and bottom of the gate will be at the same level as the line fence. Permanent solid framed gates should be considered where frequent use is anticipated.

   Temporary gates are easier to build but are more difficult to open and close. The same wire material (barbed or woven) used in the fence is attached to one gate post at the same levels as the line fence. The gate wires are attached to the portable gate pole which is then connected to the other gate

post with wire loops or metal hooks. Stay wires should be used to keep barbed wire strands from tangling when the gate is open.

B. Electric Fences - Conventional

1. Wire and Spacing - A permanent electric fence shall have at least one strand of smooth or barbed wire. Caution should be used with barbed wire electric fences. The spacing of posts shall be a maximum of 16 feet. Wire for use with electric fences shall be 12.5 gauge for barbed wire and 12.5 gauge for smooth wire. Manufactured fence insulators are to be used to fasten electric wire to the post. Non-electric wires do not need to be insulated by the fastening system.

2. Energizers - Manufactured fence chargers are to be used which are approved by Underwriters Laboratories (UL) or the US Bureau of Standards, with notice of approval printed on controller name plate. Fence chargers may be powered by 120 volt alternating current, or solar or batteries. Installation of the charger will be according to manufacturer's instructions.

   Homemade fence chargers are not acceptable or recommended for use with fencing. Chargers shall be grounded and protected from lightning according to manufacturer's recommendations.

3. PVC (polyvinyl chloride) posts - May be used with electric fence. Lengths and spacing shall be the same as for wooden posts. Installation shall be according to the warranty issued by the manufacturing firm. Treated 2X4 boards grouted lightly in 4 inch diameter PVC pipes may be substituted for use around heavy use areas. Other plastic or PVC lined metal or wooden posts are acceptable substitutes for PVC posts in line fences.

4. Other - The criteria for nonelectric fences shall be followed that apply to:

   a. Wooden Fence Posts and Braces
   b. Steel Posts
   c. Bracing
   d. Trees
   e. Spacing

5. Gates - Permanent gates as discussed in nonelectric fences can be used in frequent use areas. One wire gates also work well. The gate should be installed so the fence remains electrified on both sides by using an overhead or underground transfer wire.

C. Nonelectric Fence - High Tensile

1. Wire

a. Fences shall be constructed of at least six wires with the total height of the fence to the top wire not less than 46 inches.

b. Wire shall be new, smooth, and meet or exceed the following:

Tensile strength - 200,000 psi
Galvanizing - Type III
Gauge - 12.5

2. Spacing and Height - See table for wire spacing and heights. Adjustments in number of wires and spacing may be made if they strengthen the effectiveness of the fence.

TABLE 5-2 -- NONELECTRIC FENCE - HIGH TENSILE

Fence Description	Wire Spacing from Earth (inches) (Reading Left to Right)
10 Strand Livestock Fence	4-4-4-4-5-5-5-5-5-5
10 Strand Livestock Feedlot	10-4-4-4-5-5-5-5-5-5
8 Strand Cattle Fence	4-5-5-5-6-6-7-8
6 Strand Cattle Fence (not calves or sheep)	14-5-6-6-7-8

3. Tension Springs - 200 to 250 pounds each wire. Tension with an inline stretcher. Each wire shall have one spring assembly and tightener per 1800 feet. Tension may be reduced during nongrazing periods.

4. Fastening

a. At gate, corner, and end braces wrap and twist wire or use crimping sleeves or wire anchor through posts for maximum strength.

b. Staple wire to posts with 1.75 inch by 9 gauge galvanized staples with slash cut points. Do not drive staples tight in line posts. Angle staples to prevent post splits. Drive into post at downward angle on knolls and at an upward angle in depressions.

c. Angle notched posts do not need fasteners.

d. Wire clips will be used to fasten wire to straight notched and fiberglass posts.

5. Posts - All posts shall be black locust, red or white cedar or wood of equal life and strength. Use either round or equivalent sawn posts.

a. Corner or gate posts -

1. 6 inch diameter
2. Set 4 feet deep

b. Spacing of fence posts -

Number of Line Wires	Maximum Spacing of Primary Line Posts Without Spacers	With Spacers	Maximum Space Interval
1	150 ft.	----	----
2	75 ft.	150 ft.	75 ft.
3	50 ft.	150 ft.	50 ft.
4	50 ft.	150 ft.	50 ft.
5	50 ft.	150 ft.	50 ft.
6	33 ft. 4 in.	100 ft.	33 ft. 4 in.
8	33 ft.	66 ft.	33 ft.
9	20 ft.	60 ft.	20 ft.

6. Spacers - Pressure treated hardwood, 40-48 inches X 1.5 X 1 inch or LD fiberglass notched 'T' posts 4 to 5 feet long.

7. Anchoring Posts or Battens in Depressions - High tensile fences need special provisions for holding posts in depressions - otherwise posts will be pulled from the ground. The use of one or more anchors per post may be necessary. These may be manufactured steel assemblies, concrete, or pressure treated hardwood.

8. Brace Assembly - A double brace assembly will be used for gated, ends and corners.

a. Double Brace Posts - 5 inch diameter by 7.5 to 8 feet long, set 3.5 to 4 feet deep.

b. Horizontal Braces - 4 inch diameter by 7.5 to 8 feet long (or 1.5 inch diameter pipe), placed 3 to 4 feet above ground.

c. Brace Post Pins - .75 by 9 inch dowels or .75 by 4 inch galvanized steel rods.

d. Brace Wires - 12.5 gauge high-tensile wire, double wrapped with 1.5 by 2 inch by 2 feet hardwood twist stick or #4 rebar 2 feet long.

9. Fence Installation

1. Install wire in section, stretching from corner or pull posts to obtain a straight tight tension in the wire.

2. Attach wire to side of posts next to livestock, except on curves. Fasten the bottom wire first, then the next highest, etc.

3. Staples should be driven diagonally with the wood grain to avoid splitting. Space should be left between staples and posts to permit movement of the wire.

10. Gates - Permanently constructed gates of metal or wood shall be used for passage through High Tensile Fences. The top and bottom level of the gate shall be the same as the fence.

D. High Tensile - Electric Fences

This type of fence may be installed to meet the manufacturers specifications, or a 'generic' fence may be constructed to meet the following specifications.

1. Wide Spacing

a. Outside (perimeter) fences will be constructed with high-tensile steel wires sufficient to meet or exceed Table 5-3 requirements.

b. Interior (subdivision) fences will be constructed using either polywire and movable posts or steel wire and permanent post/spacer combinations. One, two or three wires may be used depending on the needs of the grazing system. At least one wire must be electrified.

2. Energizer - The following specifications are minimum.

a. Lists with Underwriters Laboratories (UL).

b. Low impedance, with minimum 5,000 volt peak output, 2.3 millicoulombs charge.

c. Maximum .0003 of a second charge duration, and minimum .75 seconds between pulses.*

* Variation from these values is acceptable if manufacturer's recommendations allow for it.

d. High impact weather resistant case.

e. Safety pace fused.

f. 110 volt Alternating Current or 12 volt battery powered system.

g. Grounded per manufacturer's recommendations.

TABLE 5-3 -- ELECTRIC FENCE - HIGH TENSILE

Class of Livestock	Number of Wires	Number Electric	Wire Ht. from Earth inches Reading Left to Right
Milking cows	1	1	30
Cows & calves or horses & foals	2	2	17-38
Hard to Hold Cattle	3	3	17-27-38
Boundary fence for sheep, lambs & cattle where dogs & coyotes are a problem	5	Varies	6-14-24-34-44

3. Insulators

a. Choose from the following:

1. High density molded black plastic, UV light resistant.
2. Flexible tube type.
3. High density porcelain.

b. Insulators must be strong enough to support long strands of wire, and must allow the wire to slide freely.

4. Gates - Permanent gates shall be used the same as in High Tensile Fences. Where there is a gate(s) between the energizer and other portions of the fence, electrical currents will be carried across the opening by an overhead wire or a double insulated 12.5 gauge wire buried under the opening in a plastic hose.

5. Other - The specifications for nonelectrified, high tensile fence shall be followed that apply to:

a. Wire material
b. Wire tension and spring assembly
c. Wire fastening (staples)
d. Posts and spacing
e. Spacers
f. Gate, end, and corner bracing
g. Fence installation
h. Anchoring posts in depressions

Be sure cable or wire anchors do not fault electrical circuitry.

6. Warning signs should be placed on electrified fence along roads and near gates. Children should be so advised of the fence, and young children kept away from it.

E. Specialty Fences

Special fences are used to control big game or regulate access by people. Specialty fences shall be installed using sound construction practices for the intended purpose. Each specialty fence will require a custom design approved by the Soil Conservation Service.

Fence For Controlling Access By People To Manure Storage Facilities. Fences shall be constructed a minimum of 4 feet high with woven wire. Fence shall be constructed so wire is close to the ground to prevent people from going under the fence. Gates if installed will be of good quality and easy to open and close. Gate latches will be hard for children to operate. Fence will be located at or near the top of the manure storage facility. A second fence may be needed at the toe of this slope to control access by livestock.

Fence For Deer Exclosures/Exclusions. For protection of areas up to approximately 30 acres in size, install a 5 foot high, 6-wire vertical or slanted high tensile electric fence. For protection of larger areas over 30 acres, install a 4 foot high, 7-wire slanted, high tensile electric fence.

For the 5 foot, 6-wire fence, the wire spacing shall be, starting from the ground, in inches, 8, 8, 8, 8, 12, 12. Completely enclose area to be protected with fence. Wire, grounding, tension springs, braces, insulators, gates and energizers shall conform to specifications described in section 'D', except as described here. The energizer shall be capable of maintaining a minimum charge of 3,500 volts throughout the fence (over 4,000 volts is better).

The wire spacing must be maintained uniformly throughout the fence using anchored battens and posts, as deer will crawl

under the fence through depressions. Level the ground where necessary. Space the lineposts and rails at not more than 60 feet apart with battens or spacers at 20 foot intervals.

Maintain an open area at least 6 to 8 feet wide around the outside of the fence. Maintain the area under the fence, and one foot on either side of it, in a vegetation-free condition to prevent grounding of the fence.

All wires must be maintained hot at all times except during the winter. When snow, an insulator, is on the ground, connect alternate wires to the ground starting with the second wire above the ground (lowest wire still hot). When the lower wire is covered with snow, reconnect hot wires and ground wires so that every other wire is hot starting with a hot wire as the first one above the snow.

Plans and Specifications

The design and construction drawings for the fencing practice shall comply with this BMWP. Standard details with a plan view can be used to describe work to be completed.

Operation and Maintenance

In the spring of each year, after frost has left the ground, fences should be checked for repair and mending due to the winter elements; line posts should be redriven, wires should be repaired where broken and tightened where loosened due to snow and ice loads, and staples or insulators should be replaced where they were dislodged.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

FLOODWAY

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The banks of the floodway may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A channel, usually bounded by dikes, used to carry flood flows.

Purpose

To carry floodwater from a side drainage across a flood plain into the channel of a main stream. Floodways are also used along the course of a main stream where, by means of dikes, part of the flood plain is used to carry floodwater and the rest is protected.

Conditions Where Practice Applies

1. Overflow areas of streams or rivers where existing channels are inadequate to carry the floodwaters without flooding and damaging property, and the design storm discharge can be confined between dikes or a combination of channel and dikes without causing excessive erosion.

2. Sites where the storm runoff from side tributaries that will be ponded outside the floodway will not cause damages in excess of the benefits less the cost of the project.

This practice does not apply to floodwater diversions that divert water from lowlands. A floodwater diversion can empty into a floodway. This practice does not apply to channel improvement where the spoil is set back from the excavated areas and where no provision is made to confine the floodwater to the channel side of the spoil.

An outlet for the floodway must be available to provide for discharge of the quantity of water for which the floodway is to be designed without creating stage increases in the outlet that could

result in damages above or below the point of discharge that might involve legal actions under state laws.

Classifications

In as much as a large percentage of floodways includes dikes as a major feature of the floodway, the same classification used for dikes is used for floodways. The classes are defined on pages 5-13 through 5-19 in the Best Management Wetlands Practice for Agriculture for dikes.

Class I Floodways

1. Include Class I dikes as a feature of the floodway, or

2. Are constructed to protect areas where either of the following conditions apply.

   a. There is a possibility of loss of life should dike failure occur.

   b. High-value land or improvements are to be protected.

Class II Floodways

1. Include Class II dikes as a feature of the floodway, or

2. Are constructed to protect agricultural lands of medium to high capability; improvements are generally limited to farmsteads and allied farm facilities.

Class III Floodways

1. Include Class III dikes as a feature of the floodway, or

2. Are constructed to protect agricultural lands of relatively low capability or improvements or relatively low value.

Considerations

1. Potential changes in runoff, infiltration of runoff water into soil, percolation below the root zone, and the amount of groundwater recharge.

2. Effects of soil moisture changes on vegetation or land use in the vicinity of the floodway.

3. Potential to reduce erosion and sedimentation; the effect of sedimentation on water quality, and sediment damage to flood plains, streambank, and downstream channels.

4. Effects on the area's visual quality.

Design Criteria

The design and installation of a floodway and each of its features shall be based on engineering surveys and investigations that shall be made as recommended in applicable sections of the USDA Soil Conservation Service National Engineering Handbook and in USDA Soil Conservation Service Technical Release 25 (TR-25) Planning and Design of Open Channels. Rates of flow resulting from runoff from the storm against which protection is to be provided and the design for stability of the channel included in the floodway shall be determined from and based on these investigations. Criteria for channel stability, velocity, and coefficient of roughness contained in the SCS standard for open channels shall be followed.

Proportioning of the width and depth of flow in the floodway shall be based on consideration of the area to be occupied by the floodway with respect to the area to be protected, requirements for entrance of side drainage into the floodway, stage of water in the outlet for the design storm, velocities in the floodway at design flow and requirements for stability of the channel and dikes, and the effect on the water surface profile upstream from the floodway.

In designing a floodway, the effect of future upstream floodway construction that will increase the peak rate of flow should be considered. Provisions for future enlargement of the floodway to take care of this increase may be warranted.

In selecting the location and design of a floodway careful consideration shall be given to the preservation of valuable fish and wildlife habitat and trees that are of significant value for wildlife food or shelter and to visual resources.

From an economic standpoint, the best design for a floodway, including channel improvement and the correct proportioning of the width of the floodway and the height of dikes, results in a minimum cost for the dikes, channel improvements, and the value of the unprotected land in the floodway. The value of the unprotected land for this analysis would be the difference in its value if it could be protected and its value for floodway purposes.

Class I Floodways

Class I floodways shall be designed to provide maximum feasible protection. If urban protection is one of the primary objectives of a project or segment thereof, the project shall be planned to keep water out of the main part of the urban area if the largest flood of record were repeated. Such protection shall rarely be less than the 100-year frequency level.

Dikes used or constructed as part of Class I floodways shall meet Best Management Wetlands Practice for Agriculture criteria established for Class I dikes.

Class II Floodways

If dikes are included as a feature of Class II floodways, they shall meet Best Management Wetlands Practice for Agriculture standards for Class II dikes, and the design criteria established thereby shall also apply to the floodway.

If dikes are not included in Class II floodways, the floodway shall have the capacity to carry the peak runoff from a 10-year frequency storm as a minimum.

Class III Floodways

If dikes are included as a feature of Class III floodways, they shall meet Best Management Wetlands Practice for Agriculture standards for Class III dikes, and the design criteria established thereby shall also apply to the floodway.

If dikes are not included in Class III floodways, the floodway shall have the capacity to carry the design flow selected on the basis of a study of site conditions.

Maintenance

Provisions for maintenance shall be as specified in the SCS standard for open channels.

Plans and Specifications

Plans and specifications for constructing floodways shall be in keeping with this practice and shall describe the essential requirements for properly installing each feature of the floodway to achieve the intended purpose.

Construction shall be carried out in such a manner that erosion and air and water pollution are minimized and held within legal limits.

The areas to be excavated or occupied by dikes or spoil banks shall be cleared of trees, brush, other vegetation, and debris. Other areas in the floodway to be cleared as part of the required improvement shall be specified. Clearing shall be done in such a manner that as little vegetation as possible outside the limits of the floodway is destroyed. Special efforts shall be made to save large trees in the floodway that have significant value for wildlife food or shelter or for visual resources of the site. Cleared debris shall be removed from the floodway and disposed of as specified.

Excavation shall be made as provided in the plans and specifications and as staked in the field. Spoils from excavations shall be disposed of as specified.

Dike construction shall be in accordance with the Best Management Wetlands Practice for Agriculture for the particular class of dike, as provided in the plans and specifications and as staked in the field.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

IRRIGATION FIELD DITCH

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Following construction the field ditch may become dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields in a farm distribution system.

Purpose

To prevent erosion or loss of water quality or damage to the land, to make possible proper irrigation water use, and to efficiently convey water to minimize conveyance losses.

Conditions Where Practice Applies

Field ditches shall serve an integral part of an irrigation water distribution system designed to facilitate the conservation use of soil and water resources.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Field ditches shall be constructed in earth material that contains enough fines to prevent excessive seepage losses and where shrinkage cracks will not endanger the ditch. The sealing effect of sediment carried in the irrigation water may be considered.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation.

2. Potential for a change in plant growth and transpiration because of changes in the volume or level of soil water.

3. Effects on downstream flows or aquifers that would affect other water uses or users.

4. Effect on the water table of the field in providing suitable rooting depth for anticipated land uses.

5. Effects on erosion and the movement of sediment, and the soluble and sediment-attached substances carried by runoff.

6. Effects on the movement of dissolved substances to groundwater.

7. Short-term and construction-related effects on the quality of downstream water courses.

8. Potential for uncovering or redistributing toxic material.

9. Effects on wetlands or water-related wildlife habitats.

10. Effects on the visual quality of water resources.

11. Effects of water levels on salinity of soils, soil water, or downstream waters.

Design Criteria

Capacity requirements. Field ditches shall have the capacity to deliver to the field a flow adequate to meet:

1. The design peak consumptive use of the crops to be grown in the field, with proper provisions for the expected field irrigation efficiency; and

2. The largest irrigation stream required for the irrigation methods planned for the field.

The capacity shall be increased to provide for the additional flow required to compensate for the ditch seepage loss and to safely carry surface runoff from adjacent lands that must be transported to wasteways or overflow points. For capacity design, the value of 'n' shall be selected according to the material in which the ditch is constructed, the alignment and hydraulic radius, and additional retardance because of weeds or moss.

Velocities. Field ditches shall be designed to develop velocities that are non-erosive for the soil materials through which they pass. Local information on the velocity limit for specific soils shall be used if available. If such information is not available,

the maximum design velocity shall not exceed those shown in USDA Soil Conservation Service Technical Release 25 (TR-25) Planning and Design of Open Channels.

Field ditches shall be designed with enough capacity to carry the required flows at the velocities that will be developed under the maximum probable retardance conditions.

For checking designs to see that velocities do not exceed permissible values, Manning's 'n' no greater than 0.025 shall be used, and applicable criteria in the Soil Conservation Service standards for open channels shall be followed.

Cross section. Freeboard in field ditches shall be not less than one-third of the maximum design depth of water. Side slopes shall be stable. The top width of banks as measured at the elevation providing the required freeboard shall be not less than 12 inches and shall equal or exceed the flow depth.

If a field ditch is to be constructed on an embankment, the side slopes of the embankment shall not be steeper than:

Height to water surface on centerline of fill	Steepest allowable side slope of fill
Less than 3 feet	1½:1
3 to 6 feet	2:1
More than 6 feet	2½:1

Water surface elevations. All field ditches shall be designed so that the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to be used to provide the necessary head, the backwater effect must be considered in computing freeboard requirements. The required elevation of the water surface above the field surface will vary with the type of takeout structure or device used and the amount of water to be delivered through each. A minimum head of 4 inches shall be provided.

Related structures. Erosion or water control structures, culverts, diversions, or other related structures needed to supplement the field ditch shall be designed and installed to meet standards for the particular structure and type construction.

Plans and Specifications

Plans and specifications for constructing irrigation field ditches shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purposes.

Foundation preparation. The foundation area for all ditch embankments and ditch pads shall be cleared of all trees, weeds, sods, loose rock, or other material not suitable for the subgrade.

Placement of earthfill. Earthfill embankments shall be constructed to the neat lines and grades shown on the plans and established at the field location. Embankment materials shall be free of brush, roots, sod, large rocks, or other material not suitable for making compacted fills. The moisture content and methods of placing and compacting fill material shall be of such that a firm, stable embankment results. The fill material shall be placed in horizontal lifts of such thickness that proper compaction and prescribed densities are obtained.

Excavation. Excavation shall be to the neat lines and grades shown on the plans and established at field location. Excavated materials shall be used in designated fill locations or spoil areas.

Over-excavation in the channel area or overfill on the ditch banks shall be permissible if it does not interfere with the function of the ditch or the related structures and if the finished section generally is smooth.

Construction operations. Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within legal limits. The completed job shall be professional and present a good appearance.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

IRRIGATION PIT

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A small storage reservoir constructed to regulate or store a supply of water for irrigation.

Purpose

To collect and store water until it can be used beneficially to satisfy crop irrigation requirements.

Conditions Where Practice Applies

This practice applies only to sites meeting all the following criteria and conditions:

1. The existing water supply available to the irrigated area is insufficient to meet conservation irrigation requirements during part or all the irrigation season;

2. Construction of an irrigation pit is the most practical means of obtaining a needed additional supply of water;

3. An adequate supply of good quality water is available for storage from surface runoff, streamflow, or from a subsurface source;

4. Topographic, geologic, water table, and soils conditions at the site are satisfactory for the feasible development of the irrigation pit; and

5. If surface runoff enters the pit, the contributing drainage area is or can be protected against erosion so that normal sedimentation does not materially shorten the planned life of the pit.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on downstream flows or aquifers that would affect other water uses or users.

3. Potential for irrigation water management.

4. Effects on erosion and the movement of sediment, pathogens, and the soluble and sediment-attached substances carried by runoff.

5. Effects on the movement of dissolved substances to groundwater.

6. Short-term and construction-related effects on the quality of downstream water courses.

7. Potential for uncovering or redistributing toxic material.

8. Effects on wetlands or water-related wildlife habitats.

9. Effects on the visual quality of water resources.

Design Criteria

Capacity. Irrigation pits shall be designed to have a usable capacity sufficient to satisfy irrigation requirements in the design area throughout the growing season of the crop or crops being irrigated. In computing capacity requirements, due consideration shall be given, where applicable, to groundwater inflow, surface runoff, precipitation, evaporation, and seepage. Additional capacity shall be provided as necessary for sediment storage. The usable capacity of a pit that depends wholly on groundwater as a source of supply shall be that part of the pit that is below the static water level.

Pit design. Irrigation pits shall be designed according to the criteria for excavated Pond Best Management Wetlands Practice for Agriculture.

Outlet works. Suitable outlet works shall be provided for the controlled release of irrigation water. The capacity of the outlet works shall be no less than that required to provide the outflow rate needed to meet peak period irrigation system demands.

Plans and Specifications

Plans and specifications for irrigation pits shall be in keeping with this BMWP and shall describe the requirements for properly installing the practice to achieve its intended purpose. Irrigation pits shall be constructed according to the Pond Best Management Wetlands Practice for Agriculture.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

IRRIGATION WATER CONVEYANCE

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A pipeline and appurtenances installed in an irrigation system.

Purpose

The conservation objectives of this pipeline practice are to prevent erosion or loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

Conditions Where Practice Applies

All pipelines shall be planned and located to serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All lands served by the pipelines shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Considerations

1. Effects on the components of the water budget, especially on rates of evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on downstream flows or aquifers that would affect other water uses or users.

3. Potential for irrigation water management.

4. Effects of installing the pipeline replacing other types of conveyances on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.

5. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to groundwater recharge.

6. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.

7. Effects on wetlands or water-related wildlife habitats.

8. Effects on the visual quality of water resources.

Design Criteria

The design criteria for the following types of pipelines can be found in Section 2 of the USDA Soil Conservation Service National Engineering Handbook and are a part of this practice.

Aluminum Tubing, Plastic Tape Coated
Asbestos-Cement
Non-reinforced Concrete
High Pressure Underground Plastic
Low Head Underground Plastic
Steel
Reinforced Plastic Mortar

Plans and Specifications

Specifications shall be in keeping with this BMWP and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

Construction shall conform to plans and the New Hampshire Construction and Materials Specifications for Conservation Engineering Practices.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

POND

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A water impoundment made by constructing a dam or an embankment or by excavating a pit or dugout.

In this practice, ponds constructed by the first method are referred to as embankment ponds and those constructed by the second method as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impoundment against the embankment at spillway elevation is 3 feet or more.

Purpose

To provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related issues.

Conditions Where Practice Applies

Site conditions. Site conditions shall be of such that runoff from the design storm can be safely passed through: (1) a natural or constructed emergency spillway; (2) a combination of a principal spillway and an emergency spillway; or (3) a principal spillway.

Drainage area. The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. The drainage area shall be large enough so that surface runoff and groundwater flow will maintain an adequate supply of water in the pond. The water quality shall be suitable for its intended use.

Reservoir area. The topography and soils of the site shall permit storage of water at a depth and volume that insures a dependable supply, considering beneficial use, sedimentation, season of use,

and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

Considerations

This BMWP establishes the minimum acceptable quality for the design and construction of ponds if:

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

2. The product of the storage times the effective height of the dam is less than 3,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.

3. The effective height of the dam is 20 feet or less, and the dam is hazard class A.

4. Drainage area is 640 acres or less.

The following are considerations for water quantity and quality.

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Variability of effects caused by seasonal or climatic changes.

3. Effects on the downstream flows or aquifers that could affect other water uses or users.

4. Potential for multiple use.

5. Effects on the volume of downstream flow to prohibit undesirable environmental, social, or economic effects.

6. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment attached substances that are carried by runoff.

7. Effects on the visual quality of onsite and downstream water resources.

8. Short-term and construction-related effects of this practice on the quality of downstream water courses.

9. Effects of water level control on the temperatures of downstream waters to prevent undesired effects on aquatic and wildlife communities.

10. Effects on wetlands and water-related wildlife habitats.

11. Effects of water levels on soil nutrient processes such as plant nitrogen use or denitrification.

Design Criteria for Embankment Ponds

Permit. A dam permit is required from the New Hampshire Department of Environmental Services Water Resources Division for 2 acre-feet or more of impoundment or an embankment height of 4 feet or greater.

Foundation cutoff. A cutoff of relatively impervious material shall be provided under the dam if necessary. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up to the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations, and side slopes shall not be steeper than 1:1.

Seepage control. Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage may create swamping downstream, (3) needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage control may be accomplished by (1) foundation, abutment, or embankment drains, (2) reservoir blanketing, or (3) a combination of these measures.

Earth embankment. The minimum top width for a dam is shown below. If the embankment top is to be used as a public road, the minimum width shall be 16 feet for one-way traffic and 26 feet for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority.

Total height of embankment	Top width
10 feet or less	6 feet
11-14 feet	8 feet
15-20 feet	10 feet

For this BMWP, the maximum effective height of the dam is 20 feet.

The combined upstream and downstream side slopes of the settled embankments shall not be less than 5 horizontal to 1 vertical, and neither slope steeper than 2:1. All slopes must be designed to be stable.

If needed to protect the face of the dam, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided.

The design height of the dam shall be increased by the amount needed to insure that after settlement, the height of the dam equals or exceeds the design height. This increase shall not be less than 5 percent, except where detailed soil testing and laboratory analyses show a lesser amount is adequate.

Spillways

The criteria listed in Table 5-4 shall be used to determine minimum spillway sizes and capacities and elevation of top of dam.

Principal spillway. A pipe conduit, with needed appurtenances, shall be placed under or through the dam except where a rock, concrete, or other types of mechanical spillways are used or where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

The crest elevation shall not be less than 0.5 feet below the crest of the emergency spillway for dams having a drainage area of 20 acres or less and not less than 1 foot for those having a drainage area of more than 20 acres.

When design discharge of the principal spillway is considered in calculating peak outflow through the emergency spillway, the crest elevation of the inlet shall be of such that the full flow will be generated in the conduit before there is discharge through the emergency spillway. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long duration, continuous, or frequent flows without flow through

the emergency spillways. The diameter of the pipe shall not be less than 6 inches. If the pipe conduit diameter is 10 inches or greater, its design discharge may be considered when calculating the peak outflow rate through the emergency spillway.

Pipe conduits under or through the dam shall meet the following requirements.

The pipe shall be capable of withstanding external loading without yielding, buckling, or cracking. Pipe strength shall not be less than that of the grades indicated in Table 5-5 for plastic pipe and in Table 5-6 for corrugated aluminum and galvanized steel pipe. The inlets and outlets shall be structurally sound and made of materials compatible with that of the pipe. All pipe joints shall be made watertight by the use of couplings, gaskets, welding, or caulking.

For dams 20 feet or less in effective height, acceptable pipe materials are cast-iron, steel, corrugated steel or aluminum, asbestos-cement, concrete, plastic, vitrified clay with rubber gaskets, and cast-in-place reinforced concrete. Asbestos-cement, concrete, and vitrified clay pipe shall be laid in a concrete bedding. Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet-resistant materials and protected by coating or shielding or provisions for replacement as necessary. Connection of plastic pipe to less flexible pipe or structures must be designed to avoid stress concentrations that could rupture the plastic.

Anti-seep collars shall be installed around the pipe conduit or pond drain pipe in the normal saturation zone if any of the following conditions exist.

1. The settled height of the dam exceeds 15 feet.

2. The conduit is of smooth pipe larger than 8 inches in diameter.

3. The conduit is of corrugated metal pipe larger than 12 inches in diameter.

Anti-seep collars and their connections to the pipe shall be watertight. The collar material shall be compatible with pipe materials. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe.

Closed conduit spillways designed for pressure flow must have adequate antivortex devices.

If needed to prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser.

A pipe with a suitable valve shall be provided to drain the pool area if needed for proper pond management or if required by state law. The principal spillway conduit may be used as a pond drain if it is located so as to accomplish this function.

Supply pipes through the dam to watering troughs and other appurtenances shall have an inside diameter of not less than 1.25 inches.

TABLE 5-4 -- MINIMUM SPILLWAY SIZE

Drainage Area (acres)	Spillway Design		Elevation of top of dam
	Principal	Emergency	
Less than 10[1]	6" diameter	50 yr.- freq.	1.0 above
10 - 25	8" diameter	24-hour	emergency
20 - 50	12" diameter		spillway
50 - 75	15" diameter		design storm
75 - 100	18" diameter		
	Design Storm		
101 - 320	2 yr. - 24 hr.		1 foot above
321 - 640	5 yr. - 24 hr.		EMS design storm or 2 ft. min. from crest EMS to top of dam

1 The requirement for a pipe spillway may be waived where the rate and duration of flow can be handled safely by a vegetated earth spillway.

TABLE 5-5 -- ACCEPTABLE PVC[1] PIPE FOR USE IN EARTH DAMS

Nominal pipe size	Schedule for standard dimension ration (SDR)	Maximum depth of fill over pipe
6, 8,	Schedule 40	10
10, 12	Schedule 80	15
	SDR 26	10

1Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM-D-1785 or ASTM-D-2241.

TABLE 5-6 -- MINIMUM GAGES FOR CORRUGATED METAL PIPE
(2⅔ inches X ½ inch corrugations)

	Steel Minimum gage Pipe diameter (inches)						Aluminum Minimum thickness (inches) Pipe diameter (inches)			
Fill ht.	21 and less	24	30	36	42	48	21 and less	24	30	36
1-15	16	16	16	14	12	10	0.06	0.06	0.075	0.075
15-20	16	16	16	14	12	10	0.06	.075	.105	.105
20-25	16	16	14	12	10	10	0.06	.105	.135	

Emergency spillways. Emergency spillways convey large flood flows safely past earth embankments.

An emergency spillway must be provided for each dam, unless the principal spillway is large enough to pass the routed design hydrograph peak discharge and the trash that comes to it without overtopping the dam. A closed conduit principal spillway having a conduit with a cross sectional area of 3 square feet or more, and inlet that will not clog, and an elbow designed to facilitate the passage of trash is the minimum size and design that may be used without an emergency spillway.

The minimum capacity of a natural or constructed emergency spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 5-4 less any reduction creditable to conduit discharge and detention storage.

The emergency spillway shall safely pass the peak flow or the storm runoff shall be routed through the reservoir. The routing shall start with the water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the emergency spillway or from the elevation that would be attained if the entire design storm were impounded, whichever is lower. Emergency spillways shall provide for passage of the design flow at a safe velocity to a point downstream where the dam will not be endangered.

Constructed spillways shall be trapezoidal and shall be located in undisturbed or compacted earth. The side slopes shall be stable for the material in which the spillway is to be constructed.

Constructed spillways are open channels and usually consist of an inlet channel, a control section, and an exit channel.

Upstream from the control section the inlet channel shall be level for the distance needed to protect and maintain the crest elevation of the spillway. The inlet channel may be curved to fit existing

topography. The grade of the exit channel of a constructed spillway shall fall within the range established by discharge requirements and permissible velocities.

Structural emergency spillways. If chutes or drops are used for principal spillways or principal emergency or emergency spillways, they shall be designed to the principles set forth in the USDA Soil Conservation Service Engineering Field Handbook, National Engineering Handbook, Section 5, Hydraulics, Section 11, Drop Spillways, and Section 14, Chute Spillways. The minimum capacity of a structural spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 5-4 less any reduction creditable to conduit discharge and detention storage.

Visual resource design. The visual design of ponds in areas of high public visibility and those associated with recreational shall be carefully considered. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to related visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that it is generally curvilinear rather than rectangular. Excavated material can be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and wildlife value.

Design Criteria for Excavated Ponds

Runoff. Provisions shall be made for a pipe and emergency spillway if necessary. Runoff flow patterns shall be considered when locating the pit and placing the spoil.

Side slopes. Side slopes of excavated ponds shall be stable and shall not be steeper than 1 horizontal to 1 vertical. If livestock water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than 3:1.

Perimeter form. If the structures are to be used for recreation or are located in high public view, the perimeter or edge must be curvilinear in form.

Inlet protection. If surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Excavated material. The material excavated from the pond shall be placed so that its weight will not endanger the stability of the pond side slopes and where it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

1. Uniformly spread to a height not exceeding 3 feet with the top graded to a continuous slope away from the pond;

2. Uniformly placed or shaped reasonably well with side slopes assuming a natural angle of repose for the excavated material behind a berm width equal to the depth of the pond, but not less than 12 feet;

3. Shaped to a designed form that blends visually with the landscape;

4. Used for low embankment and leveling; or

5. Hauled away.

Plans and Specifications

Plans and specifications for installing ponds shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Foundation preparation. The foundation area shall be cleared of trees, logs, stumps, roots, brush, boulders, sod, and rubbish. If needed to establish vegetation, the topsoil and sod shall be stockpiled and spread on the completed dam and spillways. Foundation surfaces shall be sloped no steeper than 1:1. The foundation area shall be thoroughly scarified before placement of the material. The surface shall have moisture added or it shall be compacted if necessary so that the first layer of fill material can be compacted and bonded to the foundations.

The cutoff trench and any other required excavations shall be dug to the lines and grades shown on the plans or as staked in the field. If they are suitable, excavated materials shall be used in the permanent fill.

Existing stream channels in the foundation area shall be sloped no steeper than 1:1 and deepened and widened as necessary to remove all stones, gravel, sand, stumps, roots, and other objectionable material and to accommodate compaction equipment.

Foundation areas shall be kept free of standing water when fill is being placed on them.

Fill placement. The material placed in the fill shall be free of detrimental amounts of sod, roots, frozen soil, stones more than 6

inches in diameter (except for rock fills), and other objectionable material.

Selected backfill material shall be placed around structures, pipe conduits, and anti-seep collars at about the same rate on all sides to prevent damage from unequal loading.

The placing and spreading of fill material shall be started at the lowest point of the foundation and the fill brought up in horizontal layers of such thickness that the required compaction can be obtained. The fill shall be constructed in continuous horizontal layers except where openings or sectionalized fills are required. In those cases, the slope of the bonding surfaces between the embankment in place and the embankment to be placed shall not be steeper than 3:1. The bonding surface shall be treated the same as that specified for the foundation so as to insure a good bond with the new fill.

The distribution and gradation of materials shall be of such that no lenses, pockets, streaks, or layers of material differ substantially in texture of gradation from the surrounding material. If it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the center and upstream parts of the fill. If zoned fills of substantially differing materials are specified, the zones shall be placed according to lines and grades shown on the drawings. The complete work shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

Moisture control. The moisture content of the fill material shall be adequate for obtaining the required compaction. Material that is too wet shall be dried to meet this requirement, and material that is too dry shall have water added and mixed until the requirement is met.

Compaction. Construction equipment shall be operated over the areas or each layer of fill to insure that the required compaction is obtained. Special equipment shall be used if needed to obtain the required compaction.

If a minimum required density is specified, each layer of fill shall be compacted as necessary to obtain that density.

Fill adjacent to structures, pipe conduits, and anti-seep collars shall be compacted to a density equivalent to that of the surrounding fill by means of hand tamping or manually directed power tampers or plate vibrators. Fill adjacent to concrete structures shall not be compacted until the concrete is strong enough to support the load.

Protection. A protective cover of vegetation shall be established on all exposed surfaces of the embankment, spillway, and borrow area if soil and climatic conditions permit. If soil or climatic conditions preclude the use of vegetation and protection is needed, nonvegetative means, such as mulches or gravel, may be used. In some places, temporary vegetation may be used until conditions permit establishment of permanent vegetation. The embankment and spillway shall be fences if necessary to protect the vegetation.

Seedbed preparation, seeding, fertilizing, and mulching shall comply with instructions in technical guides.

Principal spillway. Corrugated metal pipe shall conform to the requirements of Federal Specifications WW-P-402 or WW-P-405, as appropriate. Other pipe materials shall conform to specifications suitable for the intended purpose. Anti-seep collars shall be of materials compatible with that of the pipe and shall be installed so that they are watertight. The pipe shall be installed according to the manufacturer's instructions. The pipe shall be firmly and uniformly bedded throughout its length and shall be installed to the line and grade shown on the drawings.

Concrete. The mix design and testing of concrete shall be consistent with the sand and requirements of the job. Mix requirements or necessary strength shall be specified. The type of cement, air entrainment, slump, aggregate, or other properties shall be specified if necessary. All concrete is to consist of a workable mix that can be placed and finished in an acceptable manner. Necessary curing shall be specified. Reinforcing steel shall be placed as indicated on the plans and shall be held securely in place during concrete placement. Subgrades and forms shall be installed to line and grade, and the forms shall be mortar tight and yielding as the concrete is placed.

Foundation and embankment drains. Foundation and embankment drains, if required, shall be placed to the line and grade shown of the drawings. Detailed requirements for drain material and any required pipe shall be shown in the drawings and specifications for the job.

Excavated ponds. The completed excavation shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

Embankment and excavated ponds. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution are minimized and held within legal limits. All work shall be conducted in a skillful and professional manner. The completed job shall present a good appearance.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical. Fencing and cover to control erosion and pollution shall be established as needed. Appropriate safety measures, such as warning signs, rescue facilities, and fencing, shall be provided.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

POND SEALING OR LINING

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Installing fixed lining of impervious material or treating the soil in a pond mechanically or chemically to impede or prevent excessive water loss.

Conditions Where Practice Applies

Where water loss from a pond through leakage is or will be of such proportion as to prevent the pond from fulfilling its planned purpose, or where leakage will damage land or crops, or will cause waste of water or environmental problems.

Considerations

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and groundwater recharge.

2. Variability of the practice's effects caused by seasonal or climatic changes.

3. Effects on downstream flows or aquifers that would affect other water uses or users.

4. Effects on the volume of downstream flow to prohibit undesirable environmental, social, or economic effects.

5. Potential use for water management.

6. Effects on the movement of sediment, pathogens, and soluble substances carried by seepage water.

7. Effects of this practice on the trapping of nutrients and pesticides and altering their effect on surface and groundwater quality.

8. Effects on the visual quality of the pool and downstream water resources.

9. Short-term and construction-related effects on the quality of the pool and downstream water.

10. Effects of water level control on the temperatures of downstream waters to prevent undesired effects on aquatic and wildlife communities.

11. Effects on wetlands or water-related wildlife habitats.

12. This practice will improve water quality when: (a) used in the storage of clean water, conserve the water by minimizing losses; and (b) used in the storage of wastewater, protect ground and surface water from contamination.

Design Criteria

Ponds to be lined shall be constructed to meet the standards in the BMWPs for irrigation pits or regulating reservoirs, irrigation storage reservoirs, ponds, waste treatment lagoons, waste storage ponds, or wildlife watering facilities, as appropriate.

Plans and Specifications

Specifications shall be in keeping with this BMWP, and shall describe the requirements for proper installation of the practice to achieve its intended purpose. Construction shall conform to plans and the USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

SPRING DEVELOPMENT

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The banks of the spring may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Improving springs and seeps by excavating, cleaning, capping, or providing collection and storage facilities.

Purpose

Spring developments usually are made to improve the distribution or to increase the quantity and quality of livestock and wildlife water supplies, but may be made for irrigation if water in suitable quantity and quality is available.

Conditions Where Practice Applies

Developments shall be confined to springs or seepage areas that appear able to furnish a dependable supply of suitable water during the planned period or periods of use.

The need for, and feasibility of, protection from flooding, sedimentation, and contamination shall be considered in determining the suitability of a site for development.

Considerations

1. Potential changes in surface water quantity, especially base flow. Factor is the removal of obstructions and vegetation in the spring area.

2. No significant impact on water quality.

Design Criteria

Fracture and Tubular Springs. Where water issues from fractures, the individual openings shall be cleaned and enlarged as needed to provide an increase in flow. The water from these individual openings shall be collected and conveyed to a central sump or spring box by means of a tile or perforated pipeline or by a gravel-filled ditch. The collection works shall be constructed an adequate distance vertically below the elevation of the openings to permit free discharge.

Where water issues from a single opening, such as solution channels found in soluble rock formations or tunnels in lava, the opening shall be cleaned or enlarged as needed. A collection system usually will not be required, but a spring box or sump shall be installed at an elevation sufficiently low that water will not pond over the spring opening to a depth that will materially reduce the yield.

Perched or Contact Springs. Perched or contact springs occur where impermeable layer outcrops beneath a water-bearing permeable layer. These springs shall be developed by intercepting and collecting the flow from the water-bearing formation. Collection trenches are used for developing these types of springs.

Artesian Springs. Artesian springs shall be developed by removing obstructions, cleaning or enlarging joints or fractures, or by lowering the outlet elevation. Sumps and spring boxes shall be located so as to hold ponding over the spring outlet to a minimum.

Collection Systems. Where a collecting trench along the outcrop of the water-bearing formation is to be used, the trench shall be excavated so that it extends into the impervious layer.

An impervious cutoff wall of well-tamped clay, masonry, concrete, or other suitable material shall be constructed along the downstream side of the trench where needed to cause the flow to enter the collection system.

The collection system shall consist of drain tile or perforated pipe not less than 4 inches in diameter, or wood box drain, enclosed in a sand-gravel filter. A crushed rock or gravel backfill, not less than 12 inches deep, may be used in lieu of these types of drains. The collection system shall outlet into a spring box.

Spring Boxes. Spring boxes shall be of durable material and shall have a tight, removable cover. The boxes shall have a minimum cross sectional area of 1.5 square feet. The floor of the spring box shall be not less than 6 inches below the outlet of the collection system.

Spring boxes for perched springs shall be floored with concrete unless the underlying material is solid rock or other stable impervious material.

Outlets. The outlet pipe from a spring box shall be placed not less than 6 inches above the floor of the box to provide a sediment trap. However, the outlet must not be so high as to cause a head on the spring that would reduce flow. The outlet pipe shall be installed so as to insure a water tight connection with the spring box. Measures required to protect the development from damage by freezing, flooding, sedimentation, contamination, and livestock shall be included in the design.

Plans and Specifications

Specifications will be in keeping with this BMWP and will describe the requirement for proper installation of the practices to achieve its intended purposes.

All loose rock, sediment, travertine, logs, and vegetation that obstruct the free discharge of the spring shall be removed and disposed of so that it will not endanger the spring development.

Collection trenches, drain tiles, perforated pipelines, sumps, and spring boxes shall be constructed to the elevations and grades shown on the plans.

Crushed rock or gravel for collection systems and sand-gravel material for filters shall be composed of clean, hard particles.

Construction operations will be carried out in such a manner that erosion and air and water pollution will be minimized and held within legal limits.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

STRUCTURE FOR WATER CONTROL
(Bridges and Culverts)

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less than 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Open channels may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A structure in an irrigation, drainage, or other water management system that conveys water, controls the direction or rate of flow, or maintains a desired water surface elevation.

Purpose

Water control structures are installed to control the stage, discharge, distribution, delivery, or direction of flow of water in open channels, or water use areas. They are also used for water quality control such as sediment reduction or temperature regulation. These structures are also used to protect fish and wildlife and other natural resources.

Conditions Where Practice Applies

This practice applies wherever a permanent structure is needed as an integral part of an irrigation, drainage, or other water control system to serve one or more of the following functions.

1. To provide conveyance for water over, under, or along a ditch, canal, road, railroad, or other barrier. Typical structures: bridges; culverts; flumes; inverted siphons; drop structures; or catch basins.

2. Conduct water from one elevation to a lower elevation within, to, or from a ditch, channel, or canal. Typical structures: culverts; drops; chutes; turnouts; surface water inlets; head gates; pump boxes; or stilling basins.

3. To protect pipelines from the entry of trash, debris, or weed seeds. Typical structure: debris screens.

4. To control water table or removal of surface or subsurface water from adjoining land, to flood land for frost protection or to manage water levels for wildlife or recreational purposes. Typical structures: water level control structures; pipe drop inlets; or box inlets.

5. To modify water flow to provide habitat for fish, wildlife, and other aquatic animals. Typical structures: deflectors; chutes; cold water release; or structures for pools and riffles.

6. Water level control for recreation or similar purposes. Typical structures: box inlets; pipe drop inlets; or drop structures.

7. To control direction of channel flow resulting from tides and highwater or backflow from flooding. Typical structure: tide and drainage gates.

8. To control the elevation of water in drainage or irrigation ditches. Typical structure: checks dams.

9. To control the division or measurement of irrigation water. Typical structures: division boxes or water measurement devices.

Does not apply to structural components of pipeline, subsurface drains, or grade-stabilization structures.

Considerations

General. Other general recommendations for individual component design can be used from the USDA Soil Conservation Service Engineering Field Handbook where appropriate.

Downstream water volumes or peak discharge rates may be reduced from the installation of a water control structure depending on the size of the structure, drainage area, or pool area above the structure.

Structures installed in brooks and streams may have a negative affect on the water quality during the installation period. However, any structure impounding water will have a positive long term affect on water quality due to reduced sediment transport, but increased water temperatures may occur.

Site Investigation. Adequate investigation shall be made to insure that sufficient land of suitable quality is available for the intended use.

1. The land will be adequate in quantity and quality for the use intended.

2. The structure site is stable and, when the planned work of improvement is installed, will perform as intended.

3. An adequate water supply is available.

Design Criteria

Structures shall be designed on an individual job basis, or applicable USDA Soil Conservation Service standard drawings shall be adapted, to meet site conditions and functional requirements. They shall be part of an approved and overall farm or system plan for an agricultural waste, irrigation, drainage, wildlife facility, channel improvement, or other water management system.

The design plan shall specify the location, grades, dimensions, materials, and hydraulic and structural requirements for the individual structure. Provisions must be made for necessary maintenance. Care must be used to insure that the area's visual resources are not damaged. If watercourse fisheries are important, special precautions or design features may be needed to insure continuation of fish migration.

If soil and climatic conditions permit, a protective cover of vegetation shall be established on all disturbed earth surfaces. If soil or climatic conditions preclude the use of vegetation and protection is needed, nonvegetative means, such as mulches, gravel, or riprap may be used. In some places, temporary vegetation may be used until permanent vegetation can be established. The structure can be fenced, if necessary, to protect the vegetation. Seedbed preparation, weeding, fertilization, and mulching shall comply with the vegetative BMWPs.

Hydrology. Peak flow and volume determination shall be by approved USDA Soil Conservation Service methods. The design discharge of an associated structure, the hazard class of overall design, or the discharge from the 10 percent chance (10-year frequency) rainfall, which ever is largest, shall be used to design the water control structure.

Hydraulics. The capacity of structures shall be based upon established SCS methods.

The minimum spillway capacities shall be in accordance with those stated in the Grade Stabilization Structure BMWP found in Chapter

6. Mechanical spillways shall be used when flow is expected frequently or will occur for a duration of several days. Earth spillways may be used where vegetation can be established and maintained. A natural rock spillway may be used when it is durable under exposure to varying water and temperature extremes. Structures shall be designed to be stable for the maximum velocity expected during passage of the design storm.

Structural. The structural design, quality of material, and the resultant construction shall provide for a practice life expectancy consistent with the selected design frequency. The structural design shall be based upon the local site conditions. Variable crest spillways (stop logs at inlets or control boxes) shall be designed whenever practical to permit regulation of water levels. The high crest of mechanical spillways shall be at least 0.5 feet below the crest of the earth spillway.

Culverts installed alone or in combination with earth spillways shall safely carry the 10 percent chance storm as a minimum. In no case will the culvert be less than 12 inches in diameter because of potential freeze-up.

Stilling basins or energy dissipaters shall be installed at outlets of water control structures where needed to control erosion. Design shall be based upon procedures found in the appropriate technical release for the type of structure used.

Earth Embankment. The design and construction of earth embankments shall conform with the Best Management Wetlands Practice for Agriculture for ponds or dikes.

Other. Design and construction shall comply with state and local laws and regulations for dams and wetland disturbance.

Plans and Specifications

Plans and specifications for installing structures for water control shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Appropriate USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices shall be used and noted on the plans. Copies of the specifications will be attached to the plan when appropriate and needed.

All required national, state and local permits will be secured before construction activities begin.

Operation and Maintenance

An operation and maintenance plan shall be developed and provided to the landowner. This plan should consider the following general recommendations, as applicable.

1. Remove any debris that may accumulate on or in the immediate area of the structure.

2. Repair spalls, cracks and weathered areas on concrete surfaces.

3. Repair or replace rusted or damaged metal and protect with paint as needed.

4. Check all valves, gates, stop logs and other appurtenances for proper functioning. If worn or damaged, repair or replace following the manufacturer's recommendations.

5. Check all timber or lumber sections for decay and other damage, especially sections in contact with earth or other materials. Repair damaged sections and apply protective coatings as needed.

6. Immediately repair any vandalism, vehicular or livestock damage to any earthfills, spillways, outlets, or other appurtenances.

Supporting Data for Documentation

Design Data. The following information shall be recorded in the design and/or on the drawings, as applicable.

1. Sketch of the area applicable to the design of the water control structure.

2. Intended purpose of the water control structure, that is, whether a stream crossing for an access road, or a control structure for a wildlife pond.

3. Criteria used to design the structure, such as: storm runoff, seasonal use, etc.

4. Survey notes taken to establish elevations needed for design.

5. All computations to document the design of the structure.

6. Any special considerations involved in the design.

7. All dimensions of the structure to be installed for the site.

8. Appropriate construction and material specifications.

Check Data. The following information shall be recorded on the drawings to certify installation of the BMWP.

1. Check notes to document that the structure was installed to the elevations required in the design.

2. Dimensions of the structure installed.

3. Exact location of buried components in relation to fixed points, such as drain tile.

CHAPTER 6

STABILIZATION AND EROSION CONTROL

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

FILTER STRIP

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater.

Purpose

To remove sediment and other pollutants from runoff or wastewater by filtration, deposition, infiltration, absorption, adsorption, decomposition, and volatilization, thereby reducing pollution and protecting the environment.

Conditions Where Practice Applies

This practice applies: (1) on cropland at the lower edge of fields or above conservation practices such as terraces or diversions, or on fields adjacent to streams, ponds, and lakes; and (2) in areas requiring filter strips as part of a waste management system to treat polluted runoff or waste water.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, and transpiration.

2. Effects on soil erosion and water pollution.

3. Effects on nutrient cycles.

4. Effects on the movement of water soluble compounds to groundwater.

5. Effects on overland transport of pollutants.

Evaluate type and quantity of pollutant, slopes and soils, adapted vegetative species, time of year for proper establishment of vegetation, necessity for irrigation, visual aspects, fire hazards, and other special needs. Prevent erosion where filters outlet into streams or channels.

If filter strips are being used for treating runoff from cropland, the following must be considered:

1. Adequate soil drainage to ensure satisfactory performance.

2. Reduced effectiveness of filter strips during winter and spring when the filter vegetation is dormant.

3. An adequate filter area and length of sheet flow to provide the desired reduction of pollutants.

4. Slope of the land above the filter and the scope of the planned filter.

5. Provisions for mowing and removing vegetation to maintain the effectiveness of plant nutrient filters.

6. The need for leveling sediment deposited in the filter to insure sheet flow through the filter strip.

7. The designated quality standard for the receiving waters.

8. Filter strips and areas are a part of a water treatment system and should not be used as a recreation area, field road, travel lane, etc.

9. Filter strips are a component of a Resource Management System and usually are not a "stand-alone" practice.

10. The integrity of the outlet.

If filter strips are to be used in treating waste water or polluted runoff from concentrated livestock areas, the following must be considered:

1. Adequate soil drainage to ensure satisfactory performance. Vegetative species adaptable to wet soil conditions.

2. Provisions for preventing continuous or daily discharge of liquid waste unless the area is adequate for infiltrating all daily applied effluent. Temporary

storage shall be considered to prevent discharge to the filter strip more frequently than once every 3 days.

3. Enough rest periods to maintain an aerobic soil profile. Storage or alternating filter strips may be desirable.

4. Reduced effectiveness of filter strips under snow or frozen conditions and when vegetation is dormant.

5. An adequate filter area and length of flow to provide the desired reduction of pollutants.

6. Provision for excluding roof water and unpolluted surface runoff.

7. Provisions for the removal of settled solids before the flow is directed through the filter strip (settlement basins, channels, trenches).

8. Slopes less than 5 percent are more effective; steeper slopes require a greater area and length of flow.

9. Provisions for mowing and removing vegetation to maintain the effectiveness of the filter area.

10. The need for a level lip weir, grated pipe, sprinklers, or other facilities to distribute flow uniformly across the top of the filter strip and maintain sheet flow through the strip.

11. The integrity of the outlet.

Filter strips may occur naturally or be man-made as shown in Figures 6-1 and 6-2. If filter strips are man-made, it is important that they be designed and constructed so that runoff flows uniformly across the filter strip as sheet flow. Once the flow becomes concentrated in rills, the effectiveness of the strip is greatly reduced. It is essential that some type of device such as a level spreader or shallow stone trench be used to distribute the runoff evenly across the strip.

Natural filter areas can provide excellent pollutant removal, particularly those areas left adjacent to natural water courses and bodies of water. It is also important to evenly distribute the runoff into these natural areas for best performance. In addition to being a stormwater management practice, these natural areas can provide excellent wildlife habitat and travel corridors.

Design Criteria

Filter Strips for Sediment and Related Pollutants. These criteria apply to filter strips on cropland at the lower edge of fields, on fields, on pastures, or in manure spreading areas adjacent to streams, ponds, and lakes, and above conservation practices such as terraces or diversions.

The length of flow through vigorous vegetation shall be at least 10 feet for slopes of less than 0.5 percent and 20 feet when the average land slope is greater than 0.5 percent.

Vegetation filter strips will be designed and installed to filter sheet flow. If concentrated flow occurs, grading and shaping will be done to cause sheet flow.

Filter Strips for Runoff from Concentrated Livestock. These criteria apply to filter strips for feedlot and barnyard runoff.

A settling basin, vegetated barrier, or low velocity channel shall be provided between the waste source, and filter strip when more than one hundred 1,000-pound animal units are confined. Such facilities should be considered for use with all filter strips.

A constructed settling basin, if needed, shall have sufficient capacity, as a minimum, to store the runoff computed for a 15 minute duration at the peak inflow rate resulting from a 2-year, 24-hour rainfall. Any basin outflow shall be disregarded in computing minimum storage. Additional storage capacity, based on frequency of cleaning, shall be provided for manure and other solids settled within the basin. When the basin is cleaned after every significant runoff event, additional storage equivalent to at least 0.5 inch from the concentrated waste area shall be provided. If only annual cleaning of the basin is planned, additional storage equivalent to at least 6 inches from the concentrated waste area shall be provided.

A low velocity channel shall be a minimum of 75 feet long. It shall be designed for a flow depth of 0.5 feet or less to pass the peak flow resulting from a 2-year, 24-hour rainfall at a velocity of 0.5 feet per second or less. Provisions shall be provided for removing settled solids from the channel as necessary to maintain proper functioning.

A filter strip may be a uniform grass area or grass waterway. Minimum dimensions shall be based on the peak outflow from the concentrated waste area or settling facility based on a 2-year, 24-hour rainfall.

Grass area filter strips shall be on the contour and sufficiently wide to pass the peak flow at a depth of 0.5 inch, or less. Flow length shall be sufficient to provide at least 15 minutes of flow-through time.

Grass channel filter strips shall be designed to carry the peak flow at a depth of 0.5 feet, or less. Flow length shall be sufficient or provide at least 30 minutes of flow-through time. Grass species and shape of channel shall be such that grass stems will remain upright during design flow.

Filter Strips for Controlled Overland Flow Treatment of Liquid Wastes. These criteria apply to filter strips for waste water from milk parlors, milking centers, waste treatment lagoons, food processing plants, and animal waste storage facilities.

Overland flow filter strips shall be installed on natural or constructed slopes of 2 to 6 percent. They shall have minimum flow lengths of 100 feet, on 2 percent slopes and proportionally up to 300 feet, on 6 percent slopes. Weekly waste water application rates should not exceed 6 inches, and should be only 1 or 2 inches for highly concentrated wastes. Daily application times should not exceed 6 hours, and should be decreased to 2 hours for more concentrated wastes such as that from animal waste storage facilities. Filter strips should be rested at least 2 days each week.

Operation and Maintenance

Development of rills and small channels within filter areas must be minimized. Needed repairs must be made immediately to reestablish sheet flow. A shallow furrow on the contour across the filter can be used to reestablish sheet flow. Vegetation must be maintained in a vigorous condition. If livestock have access to the filter area, it must be fenced to control grazing.

Plans and Specifications

Plans and specifications for filter strips shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

All trees, stumps, brush, rocks, and similar materials that can interfere with installing the filter strip shall be removed. The materials shall be disposed of in a manner that is consistent with the BMWPs for maintaining and improving the quality of the environment and with proper functioning of the filter strip.

The filter strip shall be shaped to the grade and dimensions shown on the plan or as staked in the field. If necessary, topsoil shall

be stockpiled and spread to the required grade and thickness. Excess spoil shall be disposed of in non-wetland areas where it will not interfere with the required flow characteristics of the filter strip.

Specify methods of seedbed preparation; adapted plants; planting dates and rates of seeding or sprigging; need for mulching, use of stabilizing crop, or mechanical means of stabilizing; and fertilizer, soil amendment, and weed control requirements. Specify requirements for maintenance.

FIGURE 6-1 -- EXAMPLE OF MAN-MADE FILTER STRIP

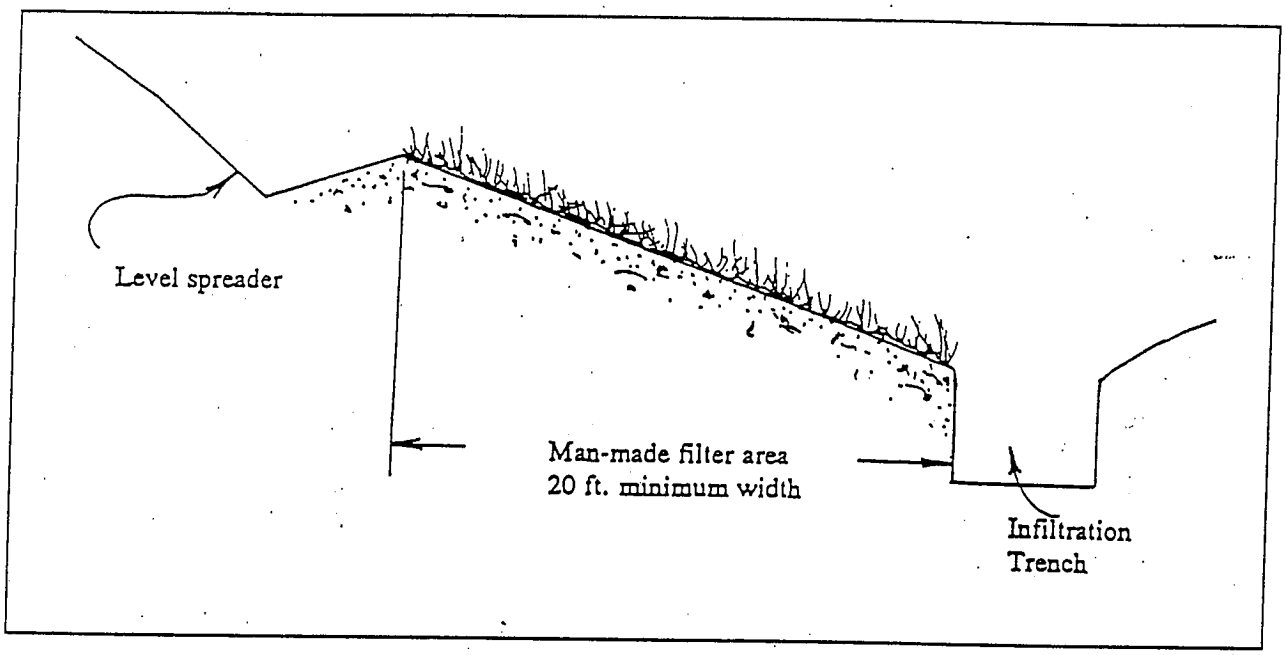
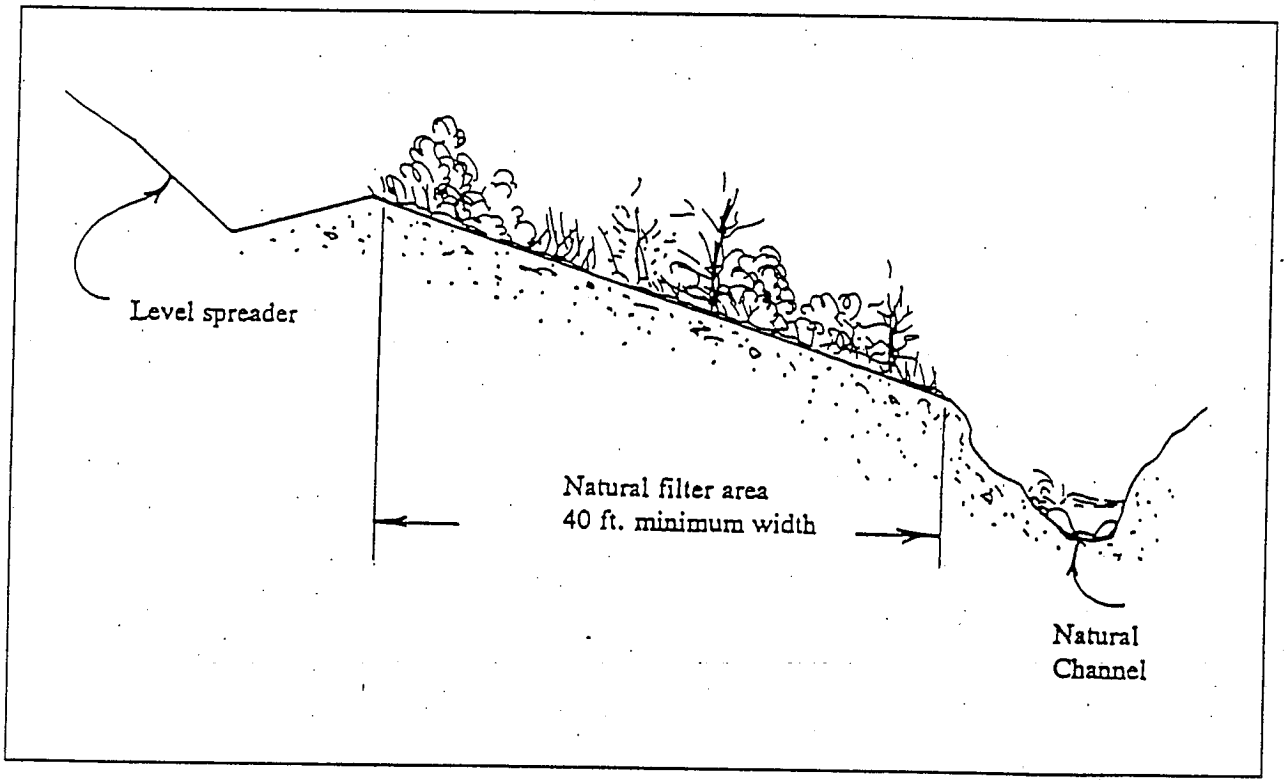


FIGURE 6-2 -- EXAMPLE OF NATURAL FILTER STRIP



BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

GRADE STABILIZATION STRUCTURE

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Channels may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A structure to control the grade and head cutting in natural or artificial channels.

Purpose

To stabilize the grade and control erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to enhance environmental quality and reduce pollution hazards.

Conditions Where Practice Applies

In areas where the concentration and flow velocity of water require structures to stabilize the grade in channels or to control gully erosion. Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable.

Considerations

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on the downstream flows or aquifers that could affect other water uses or users.

3. Ability of structure to trap sediment and sediment-attached substances carried by runoff.

4. Effect of structure on the susceptibility of downstream banks and stream beds to erosion.

5. Effects of the proposed structure on the movement of dissolved substances to groundwater.

6. Effects on the visual quality of downstream water resources.

Design Criteria

The structure must be designed for stability after installation. The crest of the inlet must be set at an elevation that stabilizes upstream head cutting.

Embankment dams. Class A dams having a product of storage times the effective height of the dam of 3,000 or more, those more than 35 feet in effective height, and all class B and class C dams shall meet or exceed the requirements specified in USDA Soil Conservation Service Technical Release No. 60 (TR-60) Earth Dams and Reservoirs.

Class A dams having a product of storage times the effective height of the dam of less than 3,000 and an effective height of 35 feet or less shall meet or exceed the requirements specified for the pond BMWP.

The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.

Pond size dams. If mechanical spillways are required, the minimum capacity of the principal spillway shall be that required to pass the peak flow expected from a 24-hour duration design storm of the frequency shown in Table 6-1, less any reduction because of detention storage.

If criteria values exceed those shown in Table 6-1 or the storage capacity is more than 50 acre-feet, the 10-year frequency, 24-hour duration storm must be used as the minimum design storm.

Grade stabilization structures with settled fill height of less than 15 feet and 10-year frequency, 24-hour storm runoff less than 10 acre-feet, shall be designed to control the 10-year frequency storm without overtopping. The mechanical spillway, regardless of size, may be considered in design and an emergency spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm. The embankment can be designed to meet the requirements for water and sediment control basins rather than the requirements for ponds.

Full-flow open structures. Drop, chute, and box inlet drop spillways shall be designed according to the principles set forth in the USDA Soil Conservation Service National Handbook of Conservation Practices, the National Engineering Handbook, and other applicable SCS publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 6-2, less any reduction because of detention storage. If criteria values exceed those shown in Table 6-2, the minimum design 24-hour storm frequency is 25 years for the principal spillway and 100 years for the total capacity. Structures must not create unstable conditions upstream or downstream. Provisions must be made to insure reentry of bypassed storm flows.

Toe wall drop structures can be used if the vertical drop is 4 feet or less, flows are intermittent, downstream grades are stable, and tail water equal to or greater than one-third of the height of the overfall.

The ratio of the capacity of drop boxes to road culverts shall be as required by the responsible road authority or as specified in Table 6-2 or 6-3, as applicable, less any reduction because of detention storage, whichever is greater. The drop box capacity (attached to a new or existing culvert) must equal or exceed the culvert capacity at design flow.

Island-type structures. If the mechanical spillway is designed as an island-type structure, its minimum capacity shall equal the capacity of the downstream channel. For channels with very small drainage areas, the mechanical spillway should carry at least the 2-year, 24-hour storm or the design drainage curve runoff. The minimum emergency spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 6-2 for total capacity without overtopping the mechanical spillway headwall extensions. Provisions must be made for safe reentry of bypassed flow as necessary.

Side-inlet drainage structures. The design criteria for minimum capacity of open-weir or pipe structures used to lower surface water from field elevations or lateral channels into deeper open channels are shown in Table 6-3. The minimum principal spillway capacity shall equal the design drainage curve runoff for all conditions. For criteria values larger than those shown in Table 6-3, the 50-year frequency storm shall be used for minimum design of total capacity.

Landscape resources. In highly visible public areas and those associated with recreation, careful consideration should be given to landscape resources. Land forms, structural materials, water elements, and plant materials should visually and functionally

complement their surrounds. Excavated material and cut slopes should be shaped to blend with the natural topography. Shorelines can be shaped and islands created to add visual interest and valuable wildlife habitat. Exposed concrete surfaces may be formed to add texture or finished to reduce reflectiveness and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

General criteria. Earth embankment and emergency spillways of structures for which criteria are not provided under the Pond BMWP or in TR-60 must be stable for all anticipated conditions. If earth spillways are used, they must be designed to handle the total capacity flow indicated in Tables 6-2 or 6-3 without overtopping the dam. The foundation preparation, compaction, top width, and side slopes must ensure a stable dam for anticipated flow conditions. Discharge from the structure shall be sufficient that not crop damage results from flow detention.

Necessary sediment storage capacity must equal the expected life of the structure, unless a provision is made for periodic clean out.

The earth embankment pond structures are potentially hazardous and safety precautions must be taken to prevent serious injury or loss of life. Protective guard rails, warning signs, fences, or life saving equipment shall be added as needed.

If the area is used for livestock, the structure, earth fill, vegetated spillways, and other areas should be fenced as necessary to control access and exclude traffic that may damage the structure or to prevent serious injury or death to trespassers.

Protection. The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded or sodded as necessary to prevent erosion. If climatic conditions preclude the use of vegetation, nonvegetative coverings such as gravel or other mulches may be used.

Plans and specifications. Plans and specifications for installing grade stabilization structures shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction of grade stabilization structures within the scope of the BMWP for ponds shall, as a minimum, be commensurate with those for ponds. Refer to USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices for applicable construction specifications.

Grade stabilization structures within the scope of TR-60 shall be constructed according to the guide specifications in the USDA Soil Conservation Service National Engineering Handbook, Section 20.

TABLE 6-1 -- CRITERIA FOR DETERMINING MINIMUM CAPACITY OF THE PRINCIPAL SPILLWAY FOR DAMS WITH STORAGE CAPACITY OF LESS THAN 50 ACRE-FEET

Maximum drainage area for indicated rainfall[1]			Effective height of dam	Frequency of minimum design, 24-hour duration storm
0-3 in.	3-5 in.	5+ in.		
acres			feet	year
200	100	50	35 or less	2
400	200	100	20 or less	2
400	200	100	20 - 35	5
600	400	200	20 or less	5

[1]In a 5-year frequency, 24-hour duration storm.

TABLE 6-2 -- CRITERIA FOR DETERMINING MINIMUM CAPACITY OF OF FULL-FLOW OPEN STRUCTURES

Maximum drainage area for indicated rainfall[1]			Vertical drop	Frequency of minimum design 24 hour duration storm	
				Principal spillway capacity	Total capacity
0-3 in.	3-5 in.	5+ in.			
acres			feet	year	year
1,200	450	250	5 or less	5	10
2,200	900	500	10 or less	10	25

[1]In a 5-year frequency, 24-hour duration storm.

TABLE 6-3 -- CRITERIA FOR DETERMINING MINIMUM CAPACITY OF SIDE-INLET, OPEN-WEIR, OR PIPE-DROP-DRAINAGE STRUCTURE

Maximum drainage area for indicated rainfall[1]			Vertical drop	Frequency of minimum design 24 hour duration storm	
				Receiving channel depth	Total capacity
0-3 in.	3-5 in.	5+ in.			
acres			feet	feet	year
1,200	450	250	0 - 5	0 - 10	--
1,200	450	250	5 - 10	10 - 20	10
2,200	900	500	0 - 10	0 - 10	25

[1]In a 5-year frequency, 24-hour duration storm.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

GRASSED WATERWAY OR OUTLET

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Once established the waterway may become dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A natural or constructed waterway or outlet shaped or graded and established in suitable vegetation as needed for the safe disposal of runoff water.

Purpose

A grassed waterway provides for the disposal of runoff water without damage by erosion or flooding.

Conditions Where Practice Applies

This practice applies to all sites where added capacity or stabilization or both are required to control erosion resulting from concentrated runoff.

Supplemental measures may be required with this practice. These may include but not be limited to such things as (1) grade stabilization structures, (2) level spreaders, (3) paved or rock-lined bottom, or (4) a subsurface drain to eliminate wet spots and permit growing suitable vegetation.

Considerations

The two main considerations when designing a grassed waterway or outlet are adequate capacity and sufficient erosion resistance. The type of cross section selected should be based on the landscape, safety, maintenance requirements, and soil characteristics. Whenever a waterway is designed, the stability of

the outlet should be checked. If an overfall exists at the outlet, some form of grade stabilization may be needed.

Adequate establishment of the vegetation must be achieved before allowing stormwater runoff to flow in the waterway. Subsurface drainage may be needed under the waterway to help the vegetation get established.

Design Criteria

Capacity. The minimum capacity shall be that required to convey the peak runoff expected from a 10-year frequency 24-hour duration storm or a lower return frequency, higher discharge storm if the waterway is used as an outlet for a companion practice requiring the higher discharge. Normally retardance "B" is used to determine the capacity of the waterway.

Velocity. The design velocity is to be based upon soil, duration of flow, and type and quality of vegetation using Table 6-4 Maximum Permissible Design Velocities for Vegetated Channels, and Table 6-5 Selection of Vegetal Retardance. Normally retardance "D" is used to determine the maximum allowable velocity.

TABLE 6-4 -- MAXIMUM PERMISSIBLE DESIGN VELOCITIES FOR VEGETATED CHANNELS

USDA Soil Texture	Bare Channel	Retardance	(Velocity - Ft/Sec) Channel Vegetation Poor	Fair	Good
Sand, silt,		B	2.0	3.0	4.0
sandy loam,	1.5	C	1.5	2.5	3.5
silty loam		D	1.5	2.0	3.0
Silty clay and		B	3.0	4.0	5.0
Sandy clay	2.0	C	2.5	3.5	4.5
loams		D	2.0	3.0	4.0
		B	3.5	5.0	6.0
Clay	2.5	C	3.0	4.5	5.5
		D	2.5	4.0	5.0

TABLE 6-5 -- SELECTION OF VEGETAL RETARDANCE

Average length of vegetation (inches)	Retardance Good Stand	Retardance Fair Stand
11 - 24	B	C
6 - 10	C	D
2 - 6	D	D

Cross Section. The cross section may be parabolic, triangular, or trapezoidal as shown in Figure 6-3. Cross section dimensions for parabolic waterways may be determined by the charts in Tables 6-6.1 to 6-6.9 and 6-7.

Depth. The minimum depth of a waterway or outlet receiving water from diversions or other tributary channels shall be that depth required to keep the design water surface elevation in the waterway or outlet at or below the design surface elevation in the diversion or tributary channel at their junction.

Drainage. Subsurface drainage measures shall be provided in the design for sites having high water table or seepage problems, except where water-tolerant vegetation such as reed canary grass can be used.

Where there is base flow present or long duration flows are expected, a stone center or underground outlet shall be required.

Stabilization. Waterways shall be stabilized in accordance with the appropriate Best Management Wetlands Practice for Vegetative Swale or stone centers. If the vegetated lining is supplemented by stone centers, or other erosion-resistant materials, the velocity given in Table 6-4 may be increased by 2.0 ft/sec. A stone centered waterway may be designed using the information in Figures 6-4 and 6-5 and Table 6-7.

Maintenance

Maintenance of the vegetation in the grassed waterway is extremely important in order to prevent rilling, erosion, and failure of the waterway. Mowing should be done frequently enough to control encroachment of weeds and woody vegetation and to keep the grasses in a vigorous condition. The vegetation should not be mowed too closely so as to reduce the erosion resistance in the waterway.

The waterway should be inspected periodically and after every major storm to determine the condition of the waterway. Rills and damaged areas should be promptly repaired and re-vegetated as necessary to prevent further deterioration. Periodic applications of lime and fertilizer may be needed to maintain vigorous growth.

Construction Specifications

1. The foundation area of the waterway shall be cleared and grubbed of all trees, brush, stumps, and other objectionable material. Materials removed shall be disposed of so they will not interfere with the construction or proper functioning of the waterway.

2. The waterway shall be excavated or shaped to line, grade, and cross section as required to meet the design criteria. The waterway shall be free of irregularities which will impede normal flow.

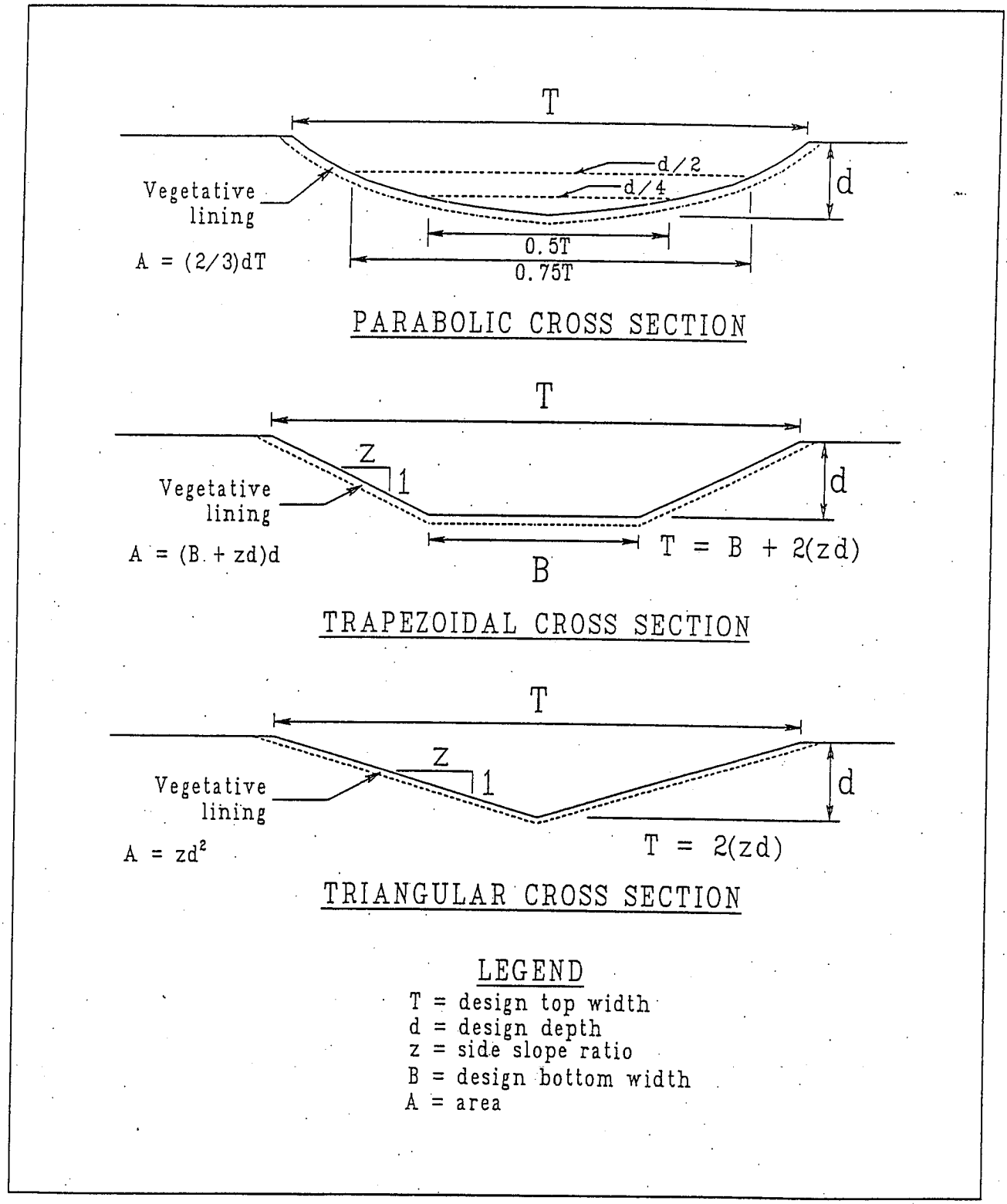
3. Earth fills required to meet subgrade requirements because of over excavation or topography shall be compacted to the same density as the surrounding soil to prevent unequal settlement that could cause damage to the completed waterway. Earth removed and not needed in construction shall be spread in a non-wetland area or disposed of so it will not interfere with the functioning of the waterway.

4. Stone and bedding for rock lined waterways shall meet the gradation requirements of the design and shall be durable and free of soil and other debris.

5. Construction operations shall be carried out in such a manner as to minimize erosion and air and water pollution. All appropriate state and local laws and regulations shall be complied with for design and installation.

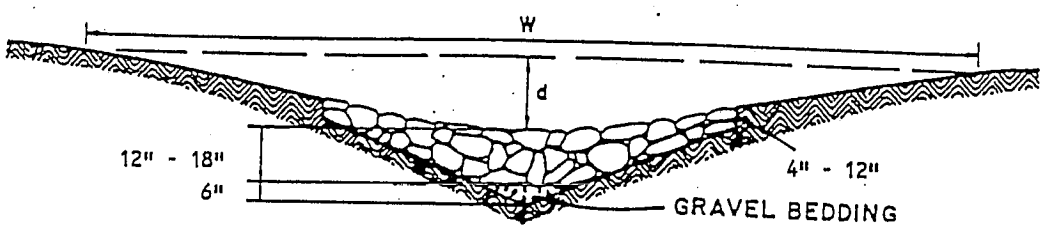
6. The waterway shall be stabilized using the appropriate Best Management Wetland Practices for Vegetative Swale or stone center.

FIGURE 6-3 -- TYPICAL WATERWAY CROSS SECTION

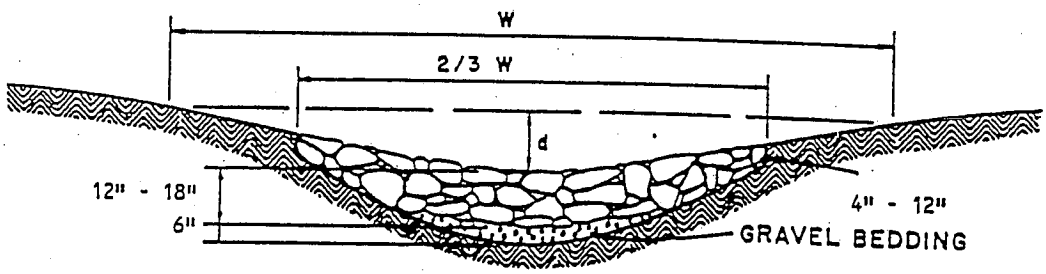


Source: Rockingham County Conservation District

FIGURE 6-4 -- WATERWAY WITH STONE CENTER



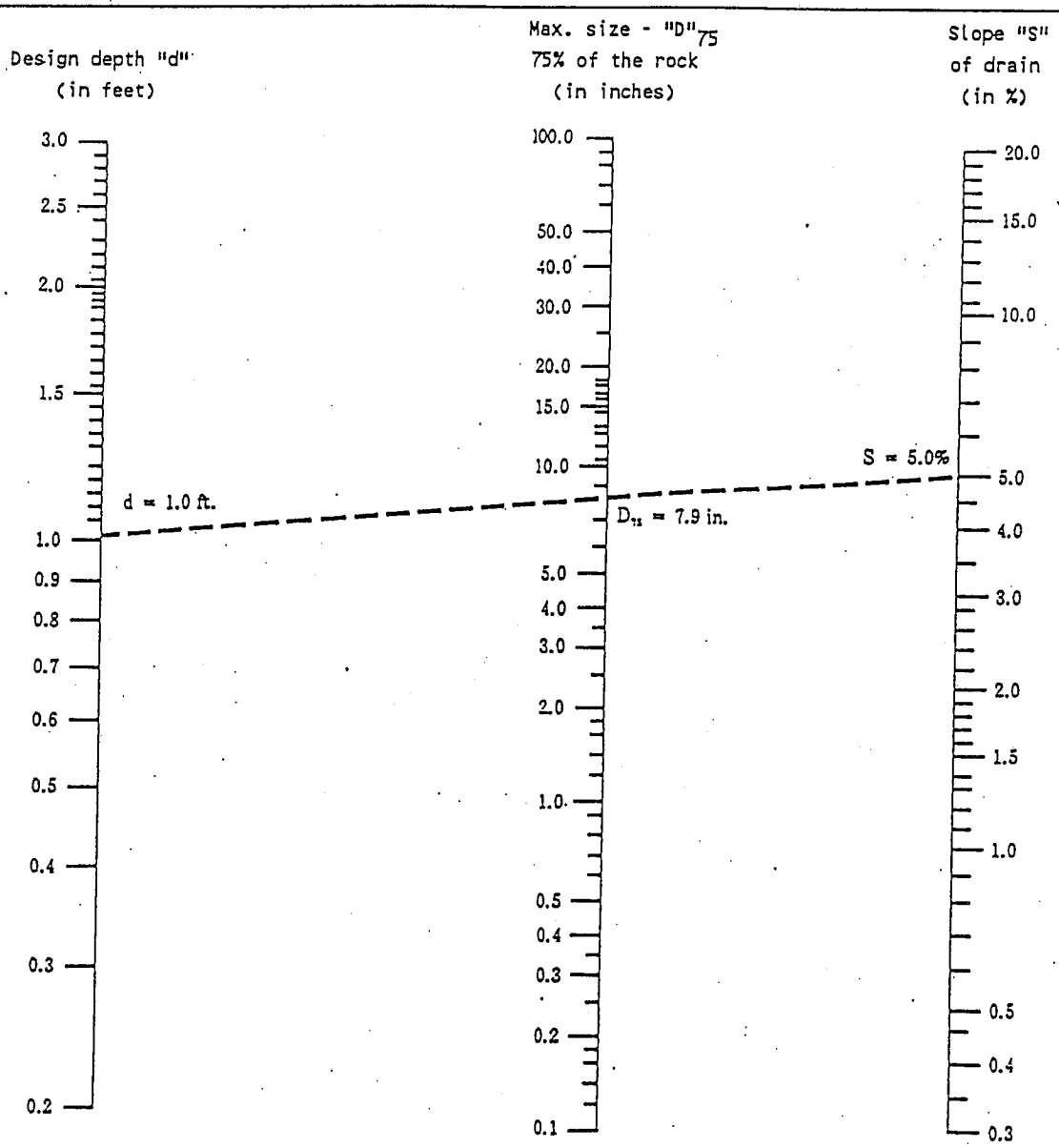
Waterway with stone center drain
V section shaped by motor patrol



Waterway with stone center drain
Rounded section shaped by bulldozer

Source: USDA Soil Conservation Service

FIGURE 6-5 -- DETERMINATION OF ROCK SIZE FOR STONE CENTERED WATERWAY



Example: "d" - 1.0 foot "S" - 5%

Place straight edge at "d" value in design depth column and at "S" value in "Slope" column. Read rock size in middle column, 7.9 inches; round to 8 inches.

For Design:

25% of the rock by volume should be in sizes of 8 inches or slightly larger. The remaining 75% or less should be of well-graded material, smaller than 8 inches, including sufficient sands and gravels to fill the voids between the larger rock.

Source: USDA Soil Conservation Service

TABLE 6-6.1 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 0.50 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	10.2	2.28	0.95																								
20	13.3	2.18	1.02																								
25	16.5	2.15	1.05	10.5	2.60	1.35																					
30	19.7	2.12	1.06	12.4	2.51	1.42	9.5	2.91	1.60																		
35	22.8	2.09	1.09	14.3	2.45	1.48	10.9	2.81	1.69																		
40	26.0	2.08	1.09	16.3	2.44	1.49	12.3	2.74	1.76																		
45	29.2	2.08	1.10	18.2	2.41	1.52	13.7	2.69	1.81																		
50	32.4	2.08	1.10	20.2	2.40	1.53	15.1	2.64	1.86	11.1	3.22	2.07															
55	35.6	2.08	1.11	22.1	2.38	1.55	16.6	2.64	1.86	12.0	3.11	2.18															
60	38.8	2.08	1.11	24.1	2.38	1.55	18.0	2.61	1.90	13.0	3.07	2.23															
65	42.0	2.08	1.11	26.0	2.36	1.57	19.5	2.61	1.89	14.0	3.03	2.27															
70	45.2	2.08	1.11	28.0	2.36	1.57	20.9	2.59	1.92	15.0	3.01	2.31															
75	48.4	2.08	1.11	29.9	2.35	1.59	22.4	2.59	1.92	16.0	2.98	2.34	12.7	3.48	2.52												
80	51.6	2.08	1.11	31.9	2.36	1.58	23.8	2.58	1.94	17.0	2.96	2.36	13.4	3.41	2.60												
90	57.9	2.07	1.12	35.8	2.35	1.59	26.7	2.56	1.96	19.1	2.95	2.37	15.0	3.37	2.64												
100	64.3	2.07	1.11	39.7	2.34	1.60	29.6	2.55	1.97	21.1	2.92	2.42	16.5	3.31	2.72	13.3	3.77	2.96									
110	70.7	2.08	1.11	43.6	2.34	1.61	32.6	2.56	1.96	23.2	2.92	2.42	18.1	3.29	2.75	14.5	3.70	3.05									
120	77.0	2.07	1.12	47.5	2.33	1.61	35.5	2.56	1.97	25.2	2.89	2.45	19.6	3.24	2.81	15.7	3.64	3.12									
130	83.4	2.08	1.12	51.5	2.34	1.61	38.4	2.55	1.98	27.3	2.90	2.45	21.2	3.23	2.82	16.9	3.60	3.18									
140	89.7	2.08	1.12	55.4	2.34	1.61	41.3	2.55	1.98	29.3	2.88	2.47	22.8	3.22	2.84	18.1	3.56	3.23									
150	96.0	2.08	1.12	59.3	2.34	1.61	44.2	2.55	1.99	31.4	2.88	2.47	24.3	3.19	2.88	19.4	3.56	3.23	15.5	4.09	3.52						
160	102.3	2.08	1.12	63.2	2.34	1.61	47.1	2.54	1.99	33.5	2.89	2.47	25.9	3.19	2.88	20.6	3.53	3.27	16.4	4.02	3.60						
170	108.6	2.08	1.12	67.1	2.34	1.62	50.0	2.54	1.99	35.5	2.87	2.48	27.5	3.19	2.89	21.9	3.54	3.27	17.4	4.01	3.62						
180	114.9	2.08	1.12	70.9	2.33	1.62	52.9	2.54	1.99	37.6	2.88	2.48	29.1	3.19	2.89	23.1	3.51	3.30	18.3	3.96	3.69						
190	121.2	2.08	1.12	74.8	2.33	1.62	55.8	2.54	2.00	39.6	2.87	2.49	30.6	3.16	2.92	24.3	3.49	3.34	19.3	3.96	3.70						
200	127.4	2.08	1.13	78.7	2.33	1.62	58.7	2.54	2.00	41.7	2.87	2.49	32.2	3.16	2.93	25.6	3.50	3.33	20.2	3.91	3.77	16.8	4.48	3.96			
220	140.0	2.08	1.13	86.5	2.33	1.62	64.5	2.54	2.00	45.8	2.87	2.50	35.4	3.16	2.93	28.1	3.49	3.35	22.1	3.87	3.83	18.3	4.39	4.08			
240	152.6	2.08	1.13	94.3	2.33	1.63	70.3	2.54	2.01	49.9	2.86	2.51	38.6	3.16	2.93	30.6	3.48	3.36	24.1	3.87	3.84	19.9	4.36	4.12			
260	165.2	2.08	1.13	102.1	2.33	1.63	76.1	2.54	2.01	54.0	2.86	2.51	41.7	3.15	2.95	33.1	3.47	3.38	26.0	3.84	3.88	21.5	4.34	4.15			
280	177.7	2.08	1.13	109.8	2.33	1.63	81.9	2.54	2.01	58.2	2.87	2.50	44.9	3.15	2.95	35.6	3.46	3.39	28.0	3.84	3.88	23.0	4.28	4.24	19.0	4.88	4.50
300	190.3	2.08	1.13	117.6	2.33	1.63	87.7	2.54	2.01	62.3	2.86	2.51	48.0	3.14	2.97	38.1	3.45	3.40	29.9	3.82	3.92	24.6	4.27	4.26	20.2	4.80	4.61

Source: USDA Soil Conservation Service

TABLE 6-6.2 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 1.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	15.7	1.55	0.91	9.9	1.80	1.24																					
20	20.9	1.54	0.92	13.0	1.74	1.31	8.8	2.04	1.65																		
25	26.0	1.53	0.93	16.2	1.73	1.32	10.9	1.99	1.70	8.9	2.21	1.87															
30	31.1	1.52	0.94	19.3	1.70	1.35	12.9	1.94	1.78	10.5	2.14	1.98															
35	36.2	1.52	0.94	22.5	1.70	1.36	15.0	1.93	1.80	12.1	2.08	2.06	9.2	2.37	2.37												
40	41.3	1.52	0.95	25.7	1.70	1.36	17.1	1.92	1.81	13.7	2.04	2.12	10.4	2.32	2.45												
45	46.4	1.52	0.95	28.8	1.69	1.37	19.2	1.91	1.82	15.4	2.04	2.12	11.7	2.32	2.46												
50	51.5	1.52	0.95	32.0	1.70	1.37	21.2	1.89	1.85	17.0	2.02	2.16	12.9	2.28	2.52	9.9	2.61	2.86									
55	56.5	1.51	0.95	35.1	1.69	1.38	23.3	1.89	1.86	18.7	2.02	2.16	14.1	2.25	2.57	10.8	2.57	2.93									
60	61.6	1.52	0.95	38.3	1.69	1.37	25.4	1.89	1.86	20.3	2.00	2.19	15.3	2.23	2.61	11.7	2.54	3.00									
65	66.6	1.52	0.96	41.4	1.69	1.38	27.5	1.89	1.86	22.0	2.01	2.19	16.6	2.24	2.60	12.7	2.55	2.98	10.6	2.88	3.16						
70	71.6	1.51	0.96	44.6	1.70	1.38	29.5	1.88	1.88	23.6	1.99	2.21	17.8	2.22	2.63	13.6	2.52	3.03	11.3	2.82	3.26						
75	76.6	1.51	0.96	47.7	1.69	1.38	31.6	1.88	1.88	25.3	2.00	2.21	19.0	2.21	2.66	14.5	2.50	3.08	12.0	2.77	3.35						
80	81.6	1.52	0.96	50.8	1.69	1.38	33.7	1.88	1.88	26.9	1.99	2.22	20.3	2.22	2.64	15.4	2.48	3.11	12.7	2.73	3.43						
90	91.7	1.52	0.96	57.1	1.69	1.39	37.8	1.88	1.89	30.2	1.98	2.24	22.8	2.21	2.65	17.3	2.47	3.13	14.2	2.69	3.49	11.8	2.99	3.78			
100	101.7	1.52	0.96	63.4	1.69	1.39	42.0	1.88	1.89	33.5	1.98	2.24	25.2	2.19	2.69	19.2	2.47	3.14	15.7	2.67	3.55	13.0	2.94	3.88			
110	111.7	1.52	0.97	69.6	1.69	1.39	46.1	1.87	1.90	36.8	1.98	2.25	27.7	2.19	2.70	21.0	2.44	3.20	17.3	2.68	3.53	14.3	2.94	3.88	12.4	3.23	4.07
120	121.7	1.52	0.97	75.8	1.69	1.39	50.2	1.87	1.90	40.1	1.98	2.26	30.2	2.19	2.70	22.9	2.44	3.20	18.8	2.66	3.57	15.5	2.91	3.96	13.4	3.17	4.19
130	131.6	1.51	0.97	82.1	1.69	1.39	54.4	1.87	1.90	43.4	1.97	2.26	32.7	2.19	2.70	24.8	2.44	3.20	20.3	2.64	3.61	16.7	2.88	4.03	14.4	3.12	4.30
140	141.5	1.51	0.97	88.3	1.69	1.39	58.5	1.87	1.90	46.7	1.97	2.26	35.2	2.19	2.70	26.6	2.42	3.24	21.8	2.63	3.64	17.9	2.85	4.08	15.5	3.12	4.31
150	151.4	1.52	0.97	94.5	1.69	1.40	62.6	1.87	1.91	50.0	1.98	2.26	37.6	2.18	2.72	28.5	2.42	3.23	23.3	2.62	3.66	19.2	2.86	4.07	16.5	3.08	4.39
160	161.3	1.52	0.97	100.7	1.69	1.40	66.7	1.87	1.91	53.3	1.98	2.26	40.1	2.18	2.72	30.4	2.43	3.23	24.8	2.61	3.68	20.4	2.84	4.11	17.6	3.08	4.39
170	171.1	1.52	0.97	106.8	1.69	1.40	70.8	1.87	1.91	56.5	1.97	2.28	42.6	2.19	2.72	32.2	2.41	3.26	26.3	2.60	3.70	21.7	2.85	4.10	18.6	3.05	4.46
180	180.9	1.52	0.98	113.0	1.69	1.40	74.9	1.87	1.91	59.8	1.97	2.27	45.0	2.18	2.73	34.1	2.42	3.25	27.9	2.61	3.68	22.9	2.83	4.14	19.6	3.02	4.52
190	190.6	1.52	0.98	119.1	1.69	1.40	79.0	1.87	1.91	63.1	1.98	2.27	47.5	2.18	2.73	35.9	2.41	3.27	29.4	2.61	3.69	24.1	2.81	4.17	20.7	3.03	4.51
200	200.4	1.52	0.98	125.3	1.69	1.40	83.0	1.87	1.92	66.3	1.97	2.28	49.9	2.18	2.74	37.8	2.41	3.27	30.9	2.60	3.71	25.4	2.82	4.15	21.7	3.00	4.57
220	220.1	1.52	0.98	137.6	1.69	1.41	91.2	1.87	1.92	72.9	1.97	2.28	54.9	2.18	2.74	41.5	2.41	3.28	33.9	2.59	3.73	27.9	2.82	4.17	23.8	2.99	4.61
240	239.8	1.52	0.98	150.0	1.69	1.41	99.4	1.87	1.93	79.5	1.98	2.28	59.8	2.18	2.75	45.3	2.41	3.28	37.0	2.60	3.72	30.4	2.81	4.18	25.9	2.97	4.64
260	259.4	1.52	0.98	162.3	1.69	1.41	107.6	1.87	1.93	86.0	1.97	2.28	64.8	2.18	2.74	49.0	2.41	3.29	40.0	2.59	3.75	32.9	2.81	4.20	28.0	2.96	4.67
280	279.0	1.52	0.98	174.6	1.70	1.41	115.8	1.87	1.93	92.5	1.97	2.29	69.7	2.18	2.75	52.7	2.40	3.30	43.0	2.58	3.76	35.3	2.79	4.24	30.2	2.97	4.65
300	298.5	1.52	0.98	186.9	1.70	1.41	123.9	1.87	1.93	99.1	1.98	2.29	74.6	2.18	2.75	56.4	2.40	3.30	46.1	2.59	3.75	37.8	2.79	4.24	32.3	2.97	4.67

Source: USDA Soil Conservation Service

TABLE 6-6.3 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 1.50 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	20.1	1.29	0.86	13.2	1.43	1.17	8.9	1.65	1.51																		
20	26.8	1.29	0.86	17.5	1.42	1.19	11.7	1.60	1.58	8.1	1.86	1.95	6.7	2.09	2.10												
25	33.4	1.28	0.86	21.8	1.41	1.21	14.5	1.57	1.63	9.9	1.78	2.10	8.1	1.95	2.34												
30	40.0	1.28	0.87	26.2	1.42	1.20	17.4	1.57	1.63	11.8	1.75	2.15	9.6	1.90	2.43	8.0	2.13	2.60									
35	46.5	1.28	0.87	30.5	1.41	1.21	20.2	1.56	1.65	13.7	1.74	2.18	11.1	1.86	2.50	9.2	2.06	2.72									
40	53.1	1.28	0.87	34.8	1.41	1.21	23.0	1.55	1.67	15.6	1.73	2.20	12.6	1.84	2.56	10.4	2.02	2.82	8.2	2.38	3.03						
45	59.6	1.28	0.88	39.0	1.40	1.22	25.9	1.55	1.66	17.5	1.72	2.22	14.2	1.85	2.55	11.7	2.02	2.82	9.1	2.31	3.16						
50	66.1	1.28	0.88	43.3	1.41	1.22	28.7	1.55	1.67	19.4	1.71	2.24	15.7	1.83	2.58	12.9	1.99	2.89	10.0	2.26	3.27						
55	72.6	1.28	0.88	47.6	1.41	1.22	31.5	1.55	1.68	21.3	1.71	2.25	17.2	1.82	2.61	14.2	1.99	2.89	10.9	2.22	3.36	9.3	2.47	3.54			
60	79.0	1.28	0.88	51.8	1.41	1.22	34.3	1.54	1.69	23.2	1.70	2.25	18.8	1.82	2.60	15.4	1.97	2.94	11.9	2.22	3.36	10.1	2.45	3.59			
65	85.5	1.28	0.88	56.0	1.40	1.23	37.1	1.54	1.69	25.1	1.70	2.26	20.3	1.82	2.62	16.6	1.95	2.98	12.8	2.19	3.43	10.8	2.39	3.73			
70	91.9	1.28	0.88	60.3	1.41	1.22	39.9	1.54	1.69	27.0	1.70	2.26	21.8	1.81	2.64	17.9	1.96	2.96	13.8	2.20	3.42	11.6	2.38	3.76	9.8	2.62	4.03
75	98.2	1.28	0.89	64.5	1.41	1.23	42.7	1.54	1.69	28.9	1.70	2.27	23.3	1.80	2.66	19.1	1.95	3.00	14.7	2.18	3.48	12.4	2.37	3.79	10.5	2.62	4.04
80	104.6	1.28	0.89	68.7	1.41	1.23	45.5	1.54	1.70	30.8	1.70	2.27	24.9	1.81	2.64	20.4	1.95	2.98	15.7	2.18	3.46	13.2	2.36	3.81	11.1	2.58	4.15
90	117.5	1.28	0.89	77.1	1.41	1.23	51.1	1.54	1.70	34.6	1.70	2.28	27.9	1.80	2.67	22.9	1.95	3.00	17.6	2.17	3.50	14.7	2.31	3.93	12.4	2.54	4.24
100	130.3	1.28	0.89	85.6	1.41	1.23	56.7	1.54	1.70	38.3	1.69	2.30	31.0	1.80	2.66	25.4	1.94	3.02	19.5	2.16	3.53	16.3	2.30	3.96	13.7	2.51	4.32
110	143.0	1.28	0.89	94.0	1.41	1.24	62.3	1.54	1.71	42.1	1.69	2.30	34.0	1.79	2.68	27.9	1.94	3.03	21.4	2.15	3.56	17.9	2.30	3.98	15.0	2.49	4.38
120	155.8	1.28	0.89	102.4	1.41	1.24	67.9	1.54	1.71	45.9	1.69	2.30	37.1	1.80	2.68	30.4	1.94	3.03	23.3	2.14	3.57	19.5	2.29	3.99	16.3	2.47	4.43
130	168.4	1.28	0.90	110.7	1.41	1.24	73.4	1.54	1.71	49.7	1.69	2.30	40.1	1.79	2.69	32.9	1.94	3.04	25.2	2.14	3.59	21.1	2.29	4.01	17.6	2.45	4.48
140	181.0	1.28	0.90	119.1	1.41	1.24	79.0	1.54	1.71	53.4	1.69	2.31	43.2	1.80	2.68	35.3	1.93	3.07	27.1	2.14	3.60	22.7	2.29	4.02	18.9	2.44	4.51
150	193.6	1.28	0.90	127.4	1.41	1.24	84.5	1.54	1.72	57.2	1.69	2.31	46.2	1.79	2.70	37.8	1.93	3.07	29.0	2.13	3.61	24.2	2.27	4.07	20.2	2.43	4.54
160	206.2	1.28	0.90	135.7	1.41	1.24	90.0	1.54	1.72	60.9	1.69	2.32	49.3	1.80	2.69	40.3	1.93	3.07	30.9	2.13	3.62	25.8	2.27	4.08	21.6	2.45	4.51
170	218.6	1.28	0.90	144.0	1.41	1.24	95.6	1.54	1.72	64.7	1.69	2.31	52.3	1.80	2.69	42.8	1.93	3.07	32.8	2.13	3.62	27.4	2.27	4.08	22.9	2.44	4.53
180	231.1	1.28	0.90	152.2	1.41	1.25	101.0	1.54	1.72	68.4	1.69	2.32	55.3	1.80	2.70	45.3	1.93	3.07	34.7	2.13	3.63	29.0	2.27	4.08	24.2	2.43	4.56
190	243.5	1.28	0.90	160.4	1.41	1.25	106.5	1.54	1.72	72.1	1.69	2.32	58.3	1.80	2.71	47.7	1.92	3.08	36.5	2.12	3.66	30.6	2.27	4.08	25.5	2.42	4.58
200	255.8	1.28	0.91	168.6	1.41	1.25	112.0	1.54	1.72	75.9	1.69	2.32	61.3	1.79	2.71	50.2	1.93	3.08	38.4	2.12	3.66	32.1	2.26	4.12	26.8	2.42	4.60
220	280.9	1.28	0.91	185.2	1.41	1.25	123.0	1.54	1.73	83.4	1.69	2.32	67.4	1.80	2.71	55.2	1.93	3.08	42.2	2.12	3.67	35.3	2.26	4.12	29.5	2.42	4.58
240	305.8	1.28	0.91	201.7	1.41	1.25	134.1	1.54	1.73	90.9	1.69	2.32	73.5	1.80	2.71	60.1	1.92	3.09	46.0	2.12	3.67	38.5	2.26	4.12	32.1	2.41	4.62
260	330.7	1.28	0.91	218.2	1.41	1.26	145.1	1.54	1.73	98.3	1.69	2.33	79.5	1.80	2.72	65.1	1.93	3.09	49.8	2.12	3.68	41.7	2.26	4.12	34.7	2.41	4.64
280	355.5	1.28	0.91	234.7	1.41	1.26	156.0	1.54	1.73	105.8	1.69	2.33	85.5	1.79	2.72	70.0	1.93	3.10	53.6	2.12	3.68	44.8	2.25	4.14	37.4	2.41	4.63
300	380.2	1.28	0.91	251.1	1.41	1.26	167.0	1.54	1.73	113.2	1.69	2.33	91.6	1.80	2.72	74.9	1.92	3.11	57.4	2.12	3.68	48.0	2.25	4.14	40.0	2.41	4.65

Source: USDA Soil Conservatio Service

TABLE 6-6.4 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 2.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	24.7	1.14	0.79	15.0	1.25	1.18	11.0	1.40	1.43	7.8	1.56	1.81															
20	32.8	1.14	0.79	20.0	1.25	1.18	14.5	1.37	1.49	10.3	1.53	1.88	7.5	1.71	2.29	6.3	1.91	2.44									
25	41.0	1.14	0.79	24.9	1.24	1.20	18.1	1.37	1.50	12.7	1.48	1.96	9.3	1.68	2.36	7.7	1.82	2.62									
30	49.0	1.14	0.80	29.8	1.24	1.20	21.6	1.35	1.52	15.2	1.48	1.98	11.0	1.63	2.47	9.1	1.77	2.76	7.6	1.97	2.95						
35	57.1	1.14	0.80	34.7	1.24	1.21	25.1	1.35	1.54	17.7	1.47	1.99	12.8	1.62	2.50	10.5	1.73	2.86	8.8	1.94	3.03						
40	65.1	1.14	0.80	39.6	1.24	1.21	28.7	1.35	1.53	20.2	1.47	2.00	14.6	1.62	2.51	12.0	1.73	2.86	9.9	1.88	3.18	8.2	2.13	3.38			
45	73.1	1.14	0.80	44.5	1.24	1.21	32.2	1.35	1.54	22.6	1.46	2.03	16.4	1.61	2.52	13.5	1.73	2.86	11.1	1.87	3.21	9.1	2.08	3.52			
50	81.0	1.14	0.81	49.3	1.24	1.22	35.7	1.35	1.55	25.1	1.46	2.03	18.1	1.59	2.57	14.9	1.71	2.92	12.3	1.86	3.24	10.0	2.03	3.64	8.6	2.29	3.76
55	88.9	1.14	0.81	54.2	1.24	1.21	39.2	1.34	1.55	27.6	1.46	2.03	19.9	1.60	2.57	16.4	1.71	2.91	13.5	1.85	3.26	11.0	2.03	3.65	9.3	2.21	3.96
60	96.8	1.14	0.81	59.0	1.24	1.22	42.7	1.34	1.55	30.0	1.45	2.05	21.7	1.60	2.57	17.8	1.69	2.95	14.7	1.85	3.28	11.9	2.00	3.74	10.1	2.19	4.01
65	104.6	1.14	0.81	63.8	1.24	1.22	46.2	1.35	1.55	32.5	1.46	2.04	23.4	1.58	2.60	19.3	1.70	2.94	15.8	1.82	3.36	12.9	2.00	3.73	10.9	2.18	4.06
70	112.4	1.14	0.81	68.6	1.24	1.22	49.7	1.35	1.56	34.9	1.45	2.05	25.2	1.59	2.60	20.7	1.69	2.98	17.0	1.82	3.36	13.8	1.98	3.81	11.7	2.16	4.10
75	120.2	1.14	0.81	73.4	1.24	1.22	53.1	1.34	1.56	37.3	1.45	2.06	27.0	1.59	2.60	22.2	1.69	2.96	18.2	1.82	3.37	14.8	1.98	3.79	12.5	2.15	4.14
80	127.9	1.14	0.82	78.1	1.24	1.23	56.6	1.35	1.56	39.8	1.45	2.06	28.7	1.58	2.62	23.6	1.69	2.99	19.4	1.82	3.37	15.8	1.99	3.78	13.3	2.14	4.17
90	143.6	1.14	0.82	87.8	1.24	1.23	63.5	1.34	1.57	44.7	1.45	2.06	32.3	1.59	2.61	26.5	1.68	3.00	21.8	1.82	3.38	17.7	1.97	3.83	14.9	2.12	4.22
100	159.2	1.14	0.82	97.4	1.24	1.23	70.5	1.34	1.57	49.6	1.45	2.07	35.8	1.58	2.63	29.4	1.68	3.01	24.1	1.80	3.43	19.6	1.96	3.87	16.5	2.11	4.26
110	174.8	1.14	0.82	106.9	1.24	1.23	77.4	1.34	1.57	54.5	1.45	2.07	39.3	1.58	2.64	32.3	1.68	3.02	26.5	1.80	3.43	21.5	1.95	3.90	18.1	2.10	4.30
120	190.3	1.14	0.82	116.5	1.24	1.23	84.3	1.34	1.58	59.4	1.45	2.07	42.8	1.58	2.65	35.2	1.68	3.02	28.9	1.80	3.43	23.4	1.94	3.92	19.7	2.09	4.33
130	205.7	1.14	0.82	126.0	1.24	1.23	91.2	1.34	1.58	64.2	1.45	2.08	46.4	1.58	2.64	38.1	1.68	3.03	31.3	1.80	3.43	25.4	1.95	3.90	21.3	2.09	4.35
140	221.0	1.14	0.82	135.4	1.24	1.24	98.0	1.34	1.58	69.1	1.45	2.08	49.9	1.58	2.64	41.0	1.68	3.03	33.6	1.80	3.46	27.3	1.95	3.92	22.9	2.08	4.37
150	236.3	1.14	0.83	144.9	1.25	1.24	104.9	1.34	1.58	73.9	1.45	2.08	53.4	1.58	2.65	43.9	1.68	3.03	36.0	1.80	3.45	29.2	1.95	3.93	24.5	2.08	4.38
160	251.5	1.14	0.83	154.3	1.25	1.24	111.7	1.34	1.59	78.7	1.45	2.09	56.9	1.58	2.65	46.7	1.67	3.05	38.3	1.79	3.47	31.1	1.94	3.94	26.1	2.08	4.40
170	266.6	1.14	0.83	163.7	1.25	1.24	118.5	1.34	1.59	83.6	1.45	2.08	60.3	1.58	2.66	49.6	1.68	3.05	40.7	1.80	3.46	33.0	1.94	3.95	27.7	2.07	4.41
180	281.7	1.14	0.83	173.0	1.25	1.24	125.2	1.34	1.59	88.4	1.45	2.09	63.8	1.58	2.66	52.5	1.68	3.04	43.0	1.79	3.48	34.9	1.94	3.96	29.3	2.07	4.41
190	296.7	1.14	0.83	182.3	1.25	1.24	132.0	1.34	1.59	93.2	1.45	2.09	67.3	1.58	2.66	55.3	1.68	3.06	45.4	1.80	3.47	36.8	1.94	3.97	30.8	2.06	4.46
200	311.7	1.14	0.83	191.6	1.25	1.24	138.7	1.34	1.60	97.9	1.45	2.10	70.7	1.58	2.67	58.2	1.68	3.05	47.7	1.79	3.49	38.7	1.94	3.97	32.4	2.06	4.47
220	342.1	1.14	0.83	210.4	1.25	1.25	152.4	1.35	1.60	107.6	1.45	2.10	77.7	1.58	2.67	63.9	1.68	3.06	52.5	1.80	3.47	42.5	1.93	3.99	35.6	2.06	4.48
240	372.4	1.14	0.84	229.2	1.25	1.25	165.9	1.34	1.60	117.2	1.45	2.10	84.7	1.58	2.67	69.7	1.68	3.06	57.2	1.80	3.48	46.4	1.94	3.97	38.8	2.06	4.49
260	402.5	1.14	0.84	247.9	1.25	1.25	179.5	1.34	1.60	126.8	1.45	2.10	91.7	1.58	2.67	75.4	1.68	3.07	61.9	1.80	3.49	50.2	1.94	3.99	42.0	2.06	4.49
280	432.6	1.14	0.84	266.5	1.25	1.25	193.0	1.34	1.61	136.4	1.45	2.10	98.6	1.58	2.68	81.1	1.68	3.07	66.6	1.80	3.49	54.0	1.94	3.99	45.2	2.06	4.49
300	462.5	1.14	0.84	285.1	1.25	1.25	206.5	1.35	1.61	146.0	1.46	2.10	105.5	1.58	2.69	86.8	1.68	3.07	71.2	1.79	3.51	57.8	1.94	4.00	48.4	2.06	4.50

Source: USDA Soil Conservation Service

TABLE 6-6.5 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 4.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	33.1	0.87	0.77	23.6	0.93	1.01	16.3	1.00	1.36	12.1	1.08	1.69	9.2	1.15	2.08	7.4	1.27	2.34	5.7	1.43	2.69						
20	44.0	0.87	0.77	31.4	0.93	1.01	21.7	1.00	1.37	16.1	1.08	1.70	12.3	1.16	2.08	9.7	1.23	2.48	7.4	1.35	2.94	6.4	1.47	3.12			
25	54.9	0.87	0.77	39.1	0.93	1.02	27.1	1.00	1.37	20.1	1.08	1.71	15.3	1.15	2.11	12.1	1.22	2.50	9.2	1.33	3.01	7.9	1.43	3.26	6.5	1.56	3.62
30	65.7	0.87	0.78	46.8	0.93	1.02	32.4	0.99	1.38	24.0	1.07	1.73	18.3	1.14	2.13	14.4	1.20	2.57	11.0	1.32	3.05	9.3	1.38	3.46	7.7	1.52	3.78
35	76.4	0.87	0.78	54.5	0.93	1.02	37.7	0.99	1.39	27.9	1.07	1.74	21.3	1.14	2.14	16.8	1.20	2.57	12.7	1.30	3.14	10.9	1.39	3.42	8.9	1.49	3.90
40	87.1	0.87	0.78	62.1	0.93	1.03	43.0	0.99	1.39	31.9	1.07	1.74	24.3	1.14	2.15	19.2	1.21	2.56	14.5	1.30	3.15	12.4	1.38	3.47	10.2	1.50	3.87
45	97.7	0.87	0.78	69.7	0.93	1.03	48.3	0.99	1.39	35.8	1.07	1.74	27.2	1.13	2.17	21.5	1.20	2.59	16.3	1.30	3.16	13.9	1.37	3.51	11.4	1.48	3.95
50	108.3	0.87	0.78	77.3	0.93	1.03	53.5	0.99	1.40	39.7	1.07	1.75	30.2	1.13	2.17	23.9	1.20	2.58	18.1	1.30	3.16	15.4	1.36	3.54	12.6	1.46	4.01
55	118.8	0.87	0.78	84.7	0.93	1.04	58.7	0.99	1.40	43.6	1.07	1.75	33.2	1.13	2.17	26.2	1.20	2.60	19.8	1.29	3.21	16.9	1.36	3.56	13.8	1.45	4.06
60	129.2	0.87	0.79	92.2	0.93	1.04	63.9	0.99	1.40	47.4	1.07	1.76	36.1	1.13	2.18	28.5	1.19	2.62	21.6	1.29	3.20	18.4	1.36	3.57	15.1	1.46	4.02
65	139.6	0.87	0.79	99.6	0.93	1.04	69.1	0.99	1.41	51.3	1.07	1.76	39.0	1.13	2.19	30.9	1.20	2.61	23.4	1.29	3.19	19.9	1.35	3.58	16.3	1.46	4.06
70	149.9	0.88	0.79	107.0	0.93	1.04	74.2	0.99	1.41	55.1	1.07	1.77	42.0	1.13	2.19	33.2	1.20	2.62	25.1	1.28	3.23	21.4	1.35	3.59	17.5	1.45	4.09
75	160.2	0.88	0.79	114.3	0.93	1.05	79.3	0.99	1.42	58.9	1.07	1.77	44.9	1.13	2.19	35.5	1.20	2.62	26.9	1.29	3.22	22.9	1.35	3.60	18.7	1.45	4.12
80	170.4	0.88	0.79	121.6	0.93	1.05	84.4	0.99	1.42	62.7	1.07	1.77	47.8	1.13	2.20	37.8	1.20	2.63	28.6	1.28	3.24	24.4	1.35	3.60	20.0	1.46	4.08
90	191.1	0.88	0.80	136.5	0.93	1.05	94.8	0.99	1.42	70.4	1.07	1.78	53.7	1.13	2.20	42.4	1.19	2.65	32.1	1.28	3.26	27.4	1.35	3.62	22.4	1.45	4.13
100	211.8	0.88	0.80	151.2	0.93	1.05	105.1	0.99	1.42	78.1	1.07	1.78	59.6	1.13	2.20	47.1	1.20	2.64	35.7	1.29	3.24	30.4	1.35	3.63	24.9	1.45	4.12
110	232.3	0.88	0.80	165.9	0.93	1.06	115.3	0.99	1.43	85.8	1.07	1.78	65.4	1.13	2.21	51.7	1.19	2.65	39.2	1.29	3.25	33.4	1.35	3.63	27.3	1.44	4.16
120	252.7	0.88	0.80	180.5	0.93	1.06	125.5	0.99	1.43	93.4	1.07	1.78	71.2	1.13	2.22	56.3	1.19	2.66	42.7	1.28	3.26	36.3	1.34	3.66	29.8	1.45	4.14
130	273.0	0.88	0.80	195.1	0.93	1.06	135.6	0.99	1.43	101.0	1.07	1.79	77.0	1.13	2.22	60.9	1.19	2.66	46.2	1.29	3.26	39.3	1.34	3.66	32.2	1.44	4.16
140	293.2	0.88	0.80	209.5	0.93	1.06	145.7	0.99	1.44	108.5	1.07	1.79	82.8	1.13	2.22	65.5	1.20	2.66	49.6	1.28	3.28	42.3	1.35	3.66	34.6	1.44	4.18
150	313.3	0.88	0.81	223.9	0.93	1.07	155.8	0.99	1.44	116.0	1.07	1.80	88.6	1.13	2.22	70.1	1.20	2.66	53.1	1.28	3.28	45.3	1.35	3.66	37.1	1.45	4.17
160	333.2	0.88	0.81	238.2	0.93	1.07	165.8	1.00	1.44	123.5	1.07	1.80	94.3	1.13	2.23	74.6	1.20	2.67	56.6	1.28	3.28	48.2	1.35	3.67	39.5	1.44	4.18
170	353.1	0.88	0.81	252.4	0.93	1.07	175.8	1.00	1.44	131.0	1.07	1.80	100.0	1.13	2.23	79.2	1.20	2.67	60.0	1.28	3.29	51.2	1.35	3.67	41.9	1.44	4.19
180	372.8	0.88	0.81	266.5	0.93	1.07	185.7	1.00	1.45	138.4	1.07	1.80	105.7	1.13	2.24	83.7	1.20	2.68	63.5	1.28	3.29	54.1	1.35	3.68	44.3	1.44	4.20
190	392.4	0.88	0.81	280.6	0.93	1.08	195.6	1.00	1.45	145.8	1.07	1.81	111.4	1.13	2.24	88.2	1.20	2.68	66.9	1.28	3.30	57.0	1.34	3.69	46.7	1.44	4.21
200	411.9	0.88	0.82	294.6	0.93	1.08	205.4	1.00	1.45	153.2	1.07	1.81	117.1	1.14	2.24	92.7	1.20	2.68	70.3	1.28	3.30	60.0	1.35	3.68	49.1	1.44	4.21
220	451.9	0.88	0.82	323.2	0.93	1.08	225.4	1.00	1.46	168.2	1.07	1.81	128.6	1.14	2.24	101.9	1.20	2.68	77.2	1.28	3.31	65.9	1.35	3.69	54.0	1.44	4.21
240	491.6	0.88	0.82	351.6	0.93	1.09	245.3	1.00	1.46	183.2	1.07	1.81	140.0	1.14	2.25	110.9	1.20	2.69	84.1	1.28	3.32	71.8	1.35	3.70	58.8	1.44	4.22
260	531.0	0.88	0.82	379.9	0.93	1.09	265.2	1.00	1.46	198.0	1.07	1.82	151.5	1.14	2.25	120.0	1.20	2.69	91.0	1.28	3.32	77.7	1.35	3.70	63.7	1.44	4.21
280	570.3	0.88	0.82	408.0	0.93	1.09	284.9	1.00	1.47	212.9	1.08	1.82	162.8	1.14	2.25	129.0	1.20	2.70	97.9	1.28	3.32	83.5	1.35	3.71	68.5	1.44	4.22
300	609.3	0.88	0.83	436.0	0.93	1.09	304.6	1.00	1.47	227.6	1.08	1.83	174.2	1.14	2.25	138.1	1.20	2.69	104.8	1.29	3.32	89.4	1.35	3.71	73.3	1.44	4.23

Source: USDA Soil Conservation Service

TABLE 6-6.6 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 5.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	34.8	0.80	0.79	25.2	0.86	1.02	17.7	0.92	1.36	14.3	0.96	1.61	10.6	1.04	2.00	8.4	1.12	2.34	6.7	1.23	2.67	5.4	1.36	3.00			
20	46.3	0.80	0.79	33.5	0.86	1.02	23.5	0.92	1.37	19.0	0.96	1.62	14.1	1.04	2.02	11.1	1.10	2.41	8.8	1.19	2.81	7.0	1.28	3.29	6.1	1.40	3.44
25	57.7	0.80	0.80	41.7	0.86	1.03	29.3	0.92	1.38	23.7	0.96	1.63	17.5	1.03	2.06	13.8	1.09	2.46	10.9	1.17	2.90	8.7	1.26	3.37	7.5	1.35	3.64
30	69.0	0.80	0.80	49.9	0.86	1.04	35.0	0.91	1.39	28.3	0.95	1.65	21.0	1.03	2.06	16.6	1.10	2.44	13.0	1.15	2.96	10.4	1.25	3.41	8.9	1.32	3.78
35	80.3	0.80	0.80	58.1	0.86	1.04	40.8	0.91	1.39	33.0	0.95	1.65	24.4	1.02	2.08	19.3	1.09	2.46	15.2	1.16	2.94	12.1	1.24	3.45	10.3	1.30	3.87
40	91.5	0.81	0.80	66.2	0.86	1.04	46.5	0.91	1.40	37.6	0.95	1.66	27.8	1.02	2.09	22.0	1.09	2.47	17.3	1.15	2.97	13.8	1.24	3.47	11.8	1.30	3.85
45	102.6	0.81	0.81	74.2	0.86	1.05	52.2	0.91	1.40	42.2	0.95	1.66	31.3	1.03	2.08	24.7	1.09	2.48	19.4	1.15	2.99	15.4	1.22	3.55	13.2	1.29	3.91
50	113.7	0.81	0.81	82.3	0.86	1.05	57.9	0.92	1.40	46.8	0.95	1.66	34.7	1.03	2.08	27.3	1.08	2.51	21.5	1.15	3.01	17.1	1.22	3.55	14.7	1.30	3.88
55	124.7	0.81	0.81	90.2	0.86	1.05	63.5	0.91	1.41	51.4	0.96	1.66	38.0	1.02	2.11	30.0	1.08	2.51	23.7	1.15	2.98	18.8	1.22	3.55	16.1	1.29	3.93
60	135.7	0.81	0.81	98.2	0.86	1.05	69.1	0.91	1.41	56.0	0.96	1.66	41.4	1.02	2.11	32.7	1.08	2.51	25.8	1.15	3.00	20.5	1.22	3.55	17.5	1.28	3.97
65	146.5	0.81	0.81	106.1	0.86	1.05	74.7	0.92	1.41	60.5	0.96	1.67	44.8	1.02	2.10	35.3	1.08	2.53	27.9	1.15	3.00	22.1	1.22	3.59	18.9	1.28	4.00
70	157.3	0.81	0.82	113.9	0.86	1.06	80.2	0.91	1.42	65.0	0.96	1.67	48.1	1.02	2.11	38.0	1.08	2.53	30.0	1.15	3.01	23.8	1.22	3.58	20.4	1.29	3.96
75	168.1	0.81	0.82	121.7	0.86	1.06	85.8	0.92	1.42	69.5	0.96	1.67	51.4	1.02	2.12	40.6	1.08	2.54	32.0	1.15	3.04	25.4	1.21	3.62	21.8	1.28	3.98
80	178.8	0.81	0.82	129.4	0.86	1.06	91.3	0.92	1.42	74.0	0.96	1.67	54.8	1.02	2.12	43.3	1.09	2.53	34.1	1.15	3.04	27.1	1.22	3.61	23.2	1.28	4.00
90	200.5	0.81	0.82	145.2	0.86	1.07	102.4	0.92	1.43	83.0	0.96	1.68	61.5	1.02	2.12	48.6	1.08	2.54	38.3	1.15	3.05	30.4	1.21	3.63	26.1	1.28	4.00
100	222.2	0.81	0.82	160.9	0.86	1.07	113.5	0.92	1.43	92.1	0.96	1.68	68.2	1.02	2.13	53.9	1.08	2.54	42.5	1.15	3.05	33.8	1.22	3.61	28.9	1.28	4.03
110	243.7	0.81	0.82	176.5	0.86	1.07	124.6	0.92	1.43	101.0	0.96	1.69	74.8	1.02	2.14	59.2	1.09	2.55	46.7	1.15	3.05	37.1	1.22	3.63	31.8	1.28	4.02
120	265.0	0.81	0.83	192.0	0.86	1.07	135.6	0.92	1.43	110.0	0.96	1.69	81.4	1.02	2.15	64.4	1.08	2.56	50.8	1.15	3.07	40.4	1.21	3.64	34.6	1.28	4.04
130	286.3	0.81	0.83	207.5	0.86	1.08	146.6	0.92	1.43	118.9	0.96	1.69	88.1	1.02	2.14	69.7	1.09	2.56	55.0	1.15	3.06	43.7	1.21	3.65	37.5	1.28	4.03
140	307.4	0.81	0.83	222.8	0.86	1.08	157.5	0.92	1.44	127.8	0.96	1.69	94.6	1.02	2.15	74.9	1.08	2.57	59.1	1.15	3.07	47.0	1.21	3.65	40.3	1.28	4.04
150	328.4	0.81	0.83	238.1	0.87	1.08	168.3	0.92	1.44	136.6	0.96	1.70	101.2	1.02	2.15	80.1	1.08	2.57	63.2	1.15	3.08	50.2	1.21	3.67	43.1	1.28	4.05
160	349.3	0.81	0.83	253.2	0.86	1.08	179.1	0.92	1.44	145.4	0.96	1.70	107.7	1.02	2.16	85.3	1.09	2.57	67.3	1.15	3.09	53.5	1.21	3.67	45.9	1.28	4.06
170	370.0	0.81	0.84	268.3	0.87	1.09	189.9	0.92	1.45	154.1	0.96	1.70	114.2	1.02	2.16	90.4	1.08	2.58	71.4	1.15	3.09	56.8	1.21	3.67	48.7	1.28	4.07
180	390.7	0.82	0.84	283.3	0.87	1.09	200.6	0.92	1.45	162.9	0.96	1.70	120.7	1.02	2.17	95.6	1.09	2.58	75.5	1.15	3.09	60.0	1.21	3.69	51.5	1.28	4.07
190	411.2	0.82	0.84	298.2	0.87	1.09	211.2	0.92	1.45	171.5	0.96	1.71	127.1	1.02	2.17	100.7	1.08	2.59	79.6	1.15	3.09	63.3	1.21	3.68	54.3	1.28	4.07
200	431.6	0.82	0.84	313.0	0.87	1.09	221.8	0.92	1.46	180.2	0.96	1.71	133.5	1.02	2.18	105.8	1.09	2.59	83.6	1.15	3.10	66.5	1.21	3.69	57.1	1.28	4.08
220	473.3	0.82	0.84	343.4	0.87	1.10	243.4	0.92	1.46	197.8	0.97	1.71	146.6	1.02	2.18	116.2	1.09	2.60	91.9	1.15	3.10	73.1	1.22	3.69	62.7	1.28	4.09
240	514.8	0.82	0.84	373.6	0.87	1.10	264.9	0.92	1.46	215.3	0.97	1.72	159.6	1.02	2.18	126.5	1.09	2.60	100.1	1.15	3.10	79.6	1.21	3.70	68.3	1.28	4.09
260	556.1	0.82	0.85	403.6	0.87	1.10	286.3	0.92	1.46	232.7	0.97	1.72	172.6	1.03	2.19	136.8	1.09	2.61	108.2	1.15	3.11	86.1	1.21	3.71	73.9	1.28	4.10
280	597.1	0.82	0.85	433.5	0.87	1.10	307.6	0.92	1.47	250.1	0.97	1.72	185.5	1.03	2.19	147.1	1.09	2.61	116.4	1.15	3.11	92.6	1.21	3.71	79.5	1.28	4.10
300	638.0	0.82	0.85	463.1	0.87	1.11	328.7	0.92	1.47	267.4	0.97	1.73	198.4	1.03	2.19	157.3	1.09	2.61	124.5	1.15	3.12	99.1	1.22	3.71	85.1	1.28	4.10

Source: USDA Soil Conservation Service

TABLE 6-6.7 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 6.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	40.5	0.72	0.76	26.9	0.81	1.02	19.6	0.85	1.34	14.8	0.90	1.66	11.7	0.96	1.97	9.4	1.02	2.31	7.6	1.09	2.67	6.1	1.18	3.05	5.0	1.32	3.33
20	53.9	0.72	0.76	35.7	0.81	1.03	26.1	0.85	1.34	19.6	0.89	1.69	15.6	0.96	1.97	12.5	1.01	2.33	10.1	1.08	2.71	8.0	1.14	3.23	6.5	1.24	3.63
25	67.1	0.72	0.76	44.5	0.81	1.03	32.5	0.85	1.35	24.5	0.90	1.69	19.4	0.95	2.00	15.5	1.00	2.39	12.5	1.06	2.80	10.0	1.14	3.24	8.1	1.23	3.69
30	80.3	0.72	0.76	53.2	0.80	1.04	38.9	0.85	1.35	29.3	0.89	1.70	23.3	0.96	1.99	18.6	1.00	2.39	15.0	1.06	2.80	11.9	1.12	3.32	9.6	1.20	3.84
35	93.4	0.72	0.76	61.9	0.81	1.04	45.3	0.85	1.35	34.1	0.89	1.70	27.1	0.96	2.00	21.6	0.99	2.42	17.4	1.05	2.84	13.9	1.13	3.31	11.2	1.20	3.84
40	106.4	0.73	0.77	70.6	0.81	1.04	51.6	0.85	1.36	38.9	0.89	1.71	30.9	0.95	2.01	24.7	1.00	2.41	19.9	1.05	2.83	15.8	1.12	3.36	12.7	1.19	3.93
45	119.3	0.73	0.77	79.2	0.81	1.04	57.9	0.85	1.36	43.7	0.90	1.71	34.6	0.95	2.03	27.7	1.00	2.42	22.3	1.05	2.86	17.7	1.11	3.40	14.3	1.19	3.92
50	132.1	0.73	0.77	87.7	0.81	1.05	64.1	0.84	1.37	48.4	0.89	1.71	38.4	0.95	2.03	30.7	0.99	2.43	24.7	1.05	2.87	19.7	1.12	3.38	15.8	1.18	3.98
55	144.9	0.73	0.77	96.2	0.81	1.05	70.4	0.85	1.37	53.1	0.89	1.72	42.2	0.95	2.03	33.7	0.99	2.44	27.1	1.04	2.89	21.6	1.11	3.40	17.4	1.18	3.96
60	157.5	0.73	0.77	104.6	0.81	1.05	76.5	0.84	1.38	57.8	0.89	1.72	45.9	0.95	2.04	36.7	1.00	2.44	29.6	1.05	2.87	23.5	1.11	3.42	18.9	1.18	4.01
65	170.1	0.73	0.78	113.0	0.81	1.06	82.7	0.85	1.38	62.5	0.90	1.72	49.6	0.95	2.04	39.7	1.00	2.44	32.0	1.05	2.88	25.4	1.11	3.43	20.5	1.18	3.98
70	182.6	0.73	0.78	121.3	0.81	1.06	88.8	0.85	1.38	67.2	0.90	1.72	53.3	0.95	2.05	42.7	1.00	2.44	34.4	1.05	2.88	27.4	1.11	3.41	22.0	1.18	4.01
75	195.1	0.73	0.78	129.6	0.81	1.06	94.9	0.85	1.39	71.8	0.90	1.73	57.0	0.95	2.05	45.6	1.00	2.46	36.7	1.04	2.91	29.3	1.11	3.42	23.6	1.18	3.99
80	207.4	0.73	0.78	137.8	0.81	1.06	100.9	0.85	1.39	76.4	0.90	1.73	60.6	0.95	2.06	48.6	1.00	2.45	39.1	1.05	2.91	31.2	1.11	3.42	25.1	1.18	4.02
90	232.6	0.73	0.78	154.5	1.81	1.07	113.2	0.85	1.40	85.8	0.90	1.73	68.1	0.95	2.06	54.6	1.00	2.45	43.9	1.05	2.92	35.0	1.11	3.44	28.2	1.18	4.02
100	257.7	0.73	0.78	171.2	0.81	1.07	125.5	0.85	1.40	95.1	0.90	1.74	75.5	0.95	2.06	60.5	1.00	2.46	48.7	1.05	2.92	38.8	1.11	3.46	31.3	1.18	4.03
110	282.6	0.74	0.78	187.8	0.81	1.07	137.7	0.85	1.40	104.4	0.90	1.74	82.8	0.95	2.07	66.4	1.00	2.47	53.5	1.05	2.92	42.6	1.11	3.47	34.4	1.18	4.03
120	307.3	0.74	0.79	204.2	0.81	1.08	149.8	0.85	1.40	113.6	0.90	1.74	90.2	0.95	2.07	72.3	1.00	2.47	58.3	1.05	2.92	46.4	1.11	3.47	37.4	1.18	4.06
130	331.9	0.74	0.79	220.6	0.81	1.08	161.9	0.85	1.41	122.8	0.90	1.75	97.5	0.95	2.08	78.2	1.00	2.48	63.0	1.05	2.93	50.2	1.11	3.48	40.5	1.18	4.05
140	356.3	0.74	0.79	236.8	0.81	1.08	173.9	0.85	1.41	131.9	0.90	1.75	104.7	0.95	2.09	84.0	1.00	2.48	67.7	1.05	2.94	54.0	1.11	3.48	43.5	1.18	4.07
150	380.5	0.74	0.79	253.0	0.81	1.09	185.8	0.85	1.41	141.0	0.90	1.75	112.0	0.96	2.09	89.9	1.00	2.48	72.5	1.05	2.93	57.8	1.11	3.48	46.6	1.18	4.06
160	404.6	0.74	0.79	269.0	0.81	1.09	197.7	0.85	1.42	150.1	0.90	1.76	119.2	0.96	2.09	95.7	1.00	2.49	77.2	1.05	2.94	61.5	1.11	3.49	49.6	1.18	4.08
170	428.6	0.74	0.79	285.0	0.81	1.09	209.5	0.85	1.42	159.1	0.90	1.76	126.4	0.96	2.09	101.5	1.00	2.49	81.8	1.05	2.95	65.3	1.11	3.49	52.7	1.18	4.07
180	452.4	0.74	0.79	300.8	0.81	1.09	221.3	0.85	1.42	168.1	0.90	1.76	133.5	0.96	2.10	107.2	1.00	2.50	86.5	1.05	2.95	69.0	1.11	3.49	55.7	1.18	4.08
190	476.1	0.74	0.80	316.6	0.81	1.10	233.0	0.85	1.42	177.0	0.90	1.77	140.6	0.96	2.10	113.0	1.00	2.50	91.1	1.05	2.96	72.7	1.11	3.50	58.7	1.18	4.08
200	499.6	0.74	0.80	332.3	0.81	1.10	244.6	0.85	1.43	185.9	0.90	1.77	147.7	0.96	2.11	118.7	1.00	2.50	95.8	1.05	2.96	76.4	1.11	3.51	61.7	1.18	4.09
220	547.7	0.74	0.80	364.5	0.81	1.10	268.4	0.85	1.43	204.1	0.91	1.77	162.1	0.96	2.11	130.3	1.00	2.51	105.2	1.05	2.96	83.9	1.11	3.51	67.8	1.18	4.09
240	595.6	0.74	0.80	396.5	0.81	1.11	292.1	0.85	1.43	222.1	0.91	1.78	176.5	0.96	2.11	141.9	1.00	2.51	114.5	1.05	2.97	91.4	1.11	3.52	73.8	1.18	4.11
260	643.2	0.74	0.80	428.3	0.81	1.11	315.7	0.85	1.43	240.1	0.91	1.78	190.7	0.96	2.12	153.4	1.00	2.52	123.9	1.05	2.97	98.9	1.11	3.52	79.9	1.18	4.10
280	690.5	0.75	0.81	459.9	0.81	1.11	339.1	0.85	1.44	258.0	0.91	1.78	205.0	0.96	2.12	164.9	1.00	2.52	133.2	1.05	2.97	106.3	1.11	3.53	85.9	1.18	4.11
300	737.5	0.75	0.81	491.4	0.81	1.11	362.4	0.85	1.44	275.8	0.91	1.78	219.1	0.96	2.13	176.3	1.00	2.52	142.4	1.05	2.98	113.7	1.11	3.53	91.9	1.18	4.12

Source: USDA Soil Conservatio Service

TABLE 6-6.8 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 8.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	43.1	0.64	0.80	31.6	0.71	0.98	22.2	0.76	1.31	18.0	0.79	1.56	13.7	0.84	1.92	11.0	0.89	2.26	9.2	0.95	2.54	7.4	0.99	3.00	6.2	1.09	3.26
20	57.3	0.64	0.80	42.0	0.71	0.99	29.5	0.76	1.32	24.0	0.79	1.56	18.2	0.84	1.94	14.7	0.89	2.25	12.2	0.93	2.59	9.8	0.98	3.08	8.1	1.04	3.49
25	71.4	0.65	0.80	52.3	0.71	0.99	36.7	0.76	1.33	29.9	0.79	1.57	22.7	0.84	1.95	18.3	0.89	2.28	15.2	0.93	2.62	12.2	0.97	3.12	10.1	1.04	3.53
30	85.4	0.65	0.80	62.6	0.71	0.99	43.9	0.76	1.33	35.8	0.79	1.57	27.2	0.84	1.95	21.9	0.89	2.29	18.1	0.92	2.67	14.6	0.97	3.15	12.1	1.03	3.55
35	99.3	0.65	0.80	72.8	0.72	0.99	51.1	0.76	1.34	41.6	0.79	1.58	31.7	0.84	1.95	25.5	0.89	2.30	21.1	0.92	2.67	17.0	0.96	3.16	14.0	1.02	3.64
40	113.1	0.65	0.81	82.9	0.72	1.00	58.2	0.76	1.34	47.4	0.79	1.59	36.1	0.84	1.96	29.0	0.88	2.32	24.1	0.92	2.67	19.4	0.96	3.17	16.0	1.02	3.63
45	126.8	0.65	0.81	93.0	0.72	1.00	65.3	0.76	1.34	53.2	0.79	1.59	40.5	0.84	1.97	32.6	0.88	2.32	27.0	0.92	2.69	21.8	0.97	3.17	18.0	1.02	3.62
50	140.4	0.65	0.81	102.9	0.72	1.01	72.3	0.76	1.35	59.0	0.79	1.59	44.9	0.84	1.97	36.1	0.88	2.33	30.0	0.92	2.68	24.2	0.97	3.17	19.9	1.02	3.67
55	153.9	0.65	0.81	112.8	0.72	1.01	79.3	0.76	1.35	64.7	0.79	1.60	49.3	0.84	1.97	39.6	0.88	2.34	32.9	0.92	2.70	26.5	0.96	3.20	21.9	1.02	3.65
60	167.3	0.65	0.81	122.7	0.72	1.01	86.2	0.76	1.36	70.4	0.79	1.60	53.7	0.84	1.97	43.1	0.88	2.34	35.8	0.92	2.70	28.9	0.97	3.19	23.8	1.02	3.69
65	180.6	0.65	0.82	132.4	0.72	1.01	93.1	0.76	1.36	76.0	0.79	1.61	58.0	0.84	1.98	46.6	0.88	2.35	38.7	0.92	2.71	31.3	0.97	3.18	25.7	1.01	3.71
70	193.9	0.65	0.82	142.2	0.72	1.01	100.0	0.76	1.37	81.7	0.79	1.61	62.3	0.84	1.98	50.1	0.88	2.35	41.6	0.92	2.71	33.6	0.97	3.20	27.7	1.02	3.69
75	207.0	0.65	0.82	151.8	0.72	1.02	106.8	0.76	1.37	87.2	0.79	1.62	66.6	0.84	1.99	53.5	0.88	2.36	44.5	0.92	2.72	35.9	0.96	3.22	29.6	1.02	3.71
80	220.1	0.66	0.82	161.4	0.72	1.02	113.6	0.76	1.37	92.8	0.79	1.62	70.9	0.84	1.99	56.9	0.88	2.37	47.3	0.92	2.73	38.2	0.96	3.23	31.5	1.01	3.72
90	246.8	0.66	0.82	180.9	0.72	1.02	127.4	0.76	1.38	104.1	0.79	1.62	79.5	0.84	2.00	63.9	0.88	2.37	53.1	0.92	2.74	42.9	0.96	3.23	35.4	1.02	3.72
100	273.3	0.66	0.82	200.3	0.72	1.03	141.1	0.76	1.38	115.4	0.79	1.62	88.1	0.84	2.00	70.8	0.88	2.38	58.9	0.92	2.74	47.6	0.97	3.24	39.2	1.01	3.75
110	299.6	0.66	0.83	219.6	0.72	1.03	154.8	0.76	1.38	126.5	0.79	1.63	96.7	0.84	2.01	77.7	0.88	2.38	64.7	0.92	2.74	52.3	0.97	3.23	43.1	1.02	3.74
120	325.7	0.66	0.83	238.8	0.72	1.03	168.4	0.76	1.39	137.7	0.79	1.63	105.3	0.84	2.01	84.6	0.88	2.39	70.4	0.92	2.75	56.9	0.97	3.25	46.9	1.01	3.75
130	351.7	0.66	0.83	257.9	0.72	1.04	181.9	0.76	1.39	148.7	0.79	1.64	113.8	0.84	2.01	91.4	0.88	2.40	76.1	0.92	2.75	61.6	0.97	3.24	50.7	1.01	3.76
140	377.5	0.66	0.83	276.8	0.72	1.04	195.3	0.76	1.39	159.7	0.79	1.64	122.2	0.84	2.02	98.2	0.88	2.40	81.8	0.92	2.76	66.2	0.97	3.25	54.5	1.01	3.77
150	403.1	0.66	0.83	295.6	0.72	1.04	208.6	0.76	1.40	170.7	0.80	1.64	130.6	0.84	2.02	105.0	0.88	2.40	87.4	0.92	2.77	70.8	0.97	3.25	58.3	1.01	3.78
160	428.5	0.66	0.83	314.2	0.72	1.04	221.9	0.76	1.40	181.5	0.79	1.65	139.0	0.85	2.02	111.7	0.88	2.41	93.1	0.92	2.77	75.3	0.97	3.27	62.1	1.01	3.78
170	453.8	0.66	0.84	332.8	0.72	1.05	235.1	0.76	1.40	192.4	0.80	1.65	147.3	0.85	2.03	118.4	0.88	2.42	98.7	0.92	2.77	79.9	0.97	3.27	65.9	1.02	3.78
180	478.9	0.66	0.84	351.2	0.72	1.05	248.2	0.76	1.41	203.1	0.80	1.65	155.6	0.85	2.03	125.1	0.88	2.42	104.3	0.93	2.78	84.4	0.97	3.28	69.6	1.02	3.79
190	503.9	0.66	0.84	369.5	0.72	1.05	261.2	0.77	1.41	213.8	0.80	1.66	163.9	0.85	2.03	131.8	0.89	2.42	109.8	0.92	2.79	89.0	0.97	3.27	73.4	1.02	3.79
200	528.5	0.67	0.84	387.7	0.73	1.05	274.1	0.77	1.42	224.4	0.80	1.66	172.1	0.85	2.04	138.4	0.89	2.43	115.3	0.92	2.79	93.5	0.97	3.28	77.1	1.02	3.80
220	579.5	0.67	0.84	425.1	0.73	1.06	300.7	0.77	1.42	246.2	0.80	1.66	188.8	0.85	2.04	151.8	0.88	2.44	126.6	0.93	2.80	102.6	0.97	3.29	84.7	1.02	3.80
240	630.1	0.67	0.84	462.2	0.73	1.06	327.0	0.77	1.42	267.9	0.80	1.67	205.5	0.85	2.05	165.2	0.89	2.44	137.8	0.93	2.80	111.8	0.97	3.29	92.2	1.02	3.81
260	680.4	0.67	0.85	499.1	0.73	1.06	353.3	0.77	1.42	289.4	0.80	1.67	222.1	0.85	2.05	178.6	0.89	2.45	149.0	0.93	2.80	120.8	0.97	3.30	99.7	1.02	3.82
280	730.4	0.67	0.85	535.6	0.73	1.07	379.3	0.77	1.43	310.8	0.80	1.68	238.6	0.85	2.05	191.9	0.89	2.45	160.1	0.93	2.81	129.9	0.97	3.30	107.2	1.02	3.82
300	780.0	0.67	0.85	572.1	0.73	1.07	405.2	0.77	1.43	332.1	0.80	1.68	255.0	0.85	2.06	205.1	0.89	2.46	171.2	0.93	2.81	138.9	0.97	3.31	114.7	1.02	3.82

Source: USDA Soil Conservation Service

TABLE 6-6.9 -- PARABOLIC WATERWAY DESIGN - RETARDANCE D & B

V_1 for RETARDANCE "D". Top Width (T), Depth (D) and V_2 for RETARDANCE "B".

Grade 10.0 Percent

Q cfs	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	51.4	0.56	0.77	38.3	0.63	0.92	27.2	0.69	1.18	19.6	0.73	1.56	15.7	0.76	1.86	12.6	0.81	2.18	10.6	0.85	2.45	8.7	0.90	2.83	7.2	0.94	3.26
20	68.2	0.55	0.78	50.9	0.63	0.92	36.2	0.69	1.18	26.1	0.73	1.56	20.9	0.76	1.87	16.8	0.81	2.18	14.0	0.84	2.53	11.5	0.88	2.91	9.5	0.92	3.39
25	85.0	0.56	0.78	63.4	0.63	0.92	45.1	0.69	1.19	32.5	0.73	1.57	26.1	0.76	1.87	20.9	0.80	2.20	17.5	0.84	2.52	14.3	0.87	2.96	11.9	0.92	3.37
30	101.6	0.56	0.78	75.8	0.63	0.92	53.9	0.69	1.20	38.8	0.72	1.58	31.2	0.76	1.88	25.0	0.80	2.22	20.9	0.83	2.55	17.1	0.87	2.98	14.2	0.91	3.42
35	118.1	0.56	0.78	88.1	0.63	0.93	62.7	0.69	1.20	45.2	0.73	1.58	36.3	0.76	1.88	29.1	0.80	2.22	24.3	0.83	2.57	19.9	0.87	3.00	16.5	0.91	3.46
40	134.4	0.56	0.79	100.3	0.64	0.93	71.3	0.69	1.21	51.5	0.73	1.59	41.3	0.76	1.90	33.2	0.80	2.22	27.7	0.83	2.58	22.7	0.87	3.00	18.9	0.91	3.43
45	150.7	0.56	0.79	112.5	0.64	0.93	80.0	0.69	1.21	57.7	0.72	1.60	46.4	0.76	1.90	37.2	0.80	2.24	31.1	0.83	2.58	25.5	0.87	3.01	21.2	0.91	3.45
50	166.8	0.56	0.79	124.5	0.64	0.93	88.5	0.69	1.21	63.9	0.72	1.60	51.3	0.76	1.91	41.3	0.80	2.23	34.5	0.83	2.58	28.3	0.87	3.01	23.5	0.91	3.46
55	182.8	0.56	0.79	136.4	0.64	0.93	97.1	0.69	1.21	70.1	0.73	1.60	56.3	0.76	1.92	45.3	0.80	2.24	37.8	0.83	2.60	31.1	0.87	3.00	25.8	0.91	3.47
60	198.6	0.56	0.79	148.2	0.64	0.94	105.5	0.69	1.22	76.2	0.72	1.61	61.2	0.76	1.92	49.3	0.80	2.25	41.1	0.83	2.61	33.8	0.87	3.02	28.1	0.91	3.47
65	214.3	0.57	0.79	160.0	0.64	0.94	113.9	0.69	1.22	82.3	0.73	1.62	66.2	0.76	1.92	53.2	0.80	2.26	44.4	0.83	2.62	36.5	0.87	3.04	30.3	0.91	3.51
70	229.9	0.57	0.79	171.6	0.64	0.94	122.2	0.69	1.23	88.4	0.73	1.62	71.0	0.76	1.93	57.2	0.80	2.26	47.7	0.83	2.63	39.3	0.87	3.03	32.6	0.91	3.50
75	245.4	0.57	0.80	183.2	0.64	0.94	130.5	0.69	1.23	94.4	0.73	1.62	75.9	0.76	1.94	61.1	0.80	2.27	51.0	0.83	2.63	42.0	0.87	3.04	34.9	0.91	3.50
80	260.7	0.57	0.80	194.6	0.64	0.95	138.6	0.69	1.24	100.3	0.73	1.63	80.7	0.76	1.94	65.0	0.80	2.27	54.3	0.83	2.63	44.7	0.87	3.04	37.1	0.91	3.52
90	292.1	0.57	0.80	218.1	0.64	0.95	155.4	0.69	1.24	112.5	0.73	1.64	90.5	0.76	1.95	73.0	0.81	2.27	60.9	0.83	2.64	50.1	0.87	3.06	41.7	0.91	3.52
100	323.3	0.57	0.80	241.5	0.64	0.95	172.1	0.69	1.24	124.6	0.73	1.64	100.3	0.76	1.95	80.9	0.81	2.28	67.5	0.83	2.65	55.6	0.87	3.06	46.2	0.91	3.53
110	354.3	0.57	0.80	264.6	0.64	0.96	188.6	0.69	1.25	136.7	0.73	1.64	110.0	0.76	1.96	88.7	0.81	2.29	74.1	0.83	2.65	61.0	0.87	3.07	50.7	0.91	3.54
120	385.0	0.57	0.80	287.6	0.64	0.96	205.0	0.69	1.25	148.7	0.73	1.65	119.6	0.76	1.97	96.5	0.81	2.29	80.6	0.83	2.66	66.4	0.87	3.08	55.2	0.91	3.55
130	415.5	0.57	0.81	310.3	0.65	0.96	221.3	0.69	1.26	160.6	0.73	1.65	129.3	0.76	1.97	104.3	0.81	2.30	87.1	0.83	2.67	71.8	0.87	3.08	59.7	0.91	3.55
140	445.7	0.57	0.81	333.0	0.65	0.96	237.5	0.69	1.26	172.5	0.73	1.65	138.8	0.76	1.97	112.1	0.81	2.30	93.5	0.83	2.68	77.1	0.87	3.09	64.2	0.91	3.55
150	475.7	0.58	0.81	355.4	0.65	0.97	253.6	0.69	1.26	184.2	0.73	1.66	148.4	0.76	1.97	119.8	0.81	2.30	100.0	0.83	2.68	82.5	0.88	3.09	68.6	0.91	3.57
160	505.5	0.58	0.81	377.7	0.65	0.97	269.5	0.69	1.27	195.9	0.73	1.66	157.8	0.76	1.98	127.4	0.81	2.31	106.4	0.83	2.69	87.8	0.88	3.10	73.0	0.91	3.58
170	535.0	0.58	0.81	399.7	0.65	0.97	285.3	0.69	1.27	207.6	0.73	1.66	167.2	0.76	1.98	135.0	0.81	2.32	112.8	0.83	2.69	93.0	0.87	3.11	77.5	0.91	3.57
180	564.3	0.58	0.81	421.7	0.65	0.97	301.0	0.70	1.28	219.1	0.73	1.67	176.6	0.76	1.99	142.6	0.81	2.32	119.1	0.83	2.70	98.3	0.88	3.11	81.8	0.91	3.59
190	593.4	0.58	0.82	443.4	0.65	0.98	316.6	0.70	1.28	230.6	0.73	1.67	185.9	0.76	1.99	150.1	0.81	2.33	125.4	0.83	2.71	103.5	0.88	3.12	86.2	0.91	3.59
200	622.2	0.58	0.82	465.0	0.65	0.98	332.1	0.70	1.28	242.1	0.73	1.68	195.2	0.76	1.99	157.6	0.81	2.33	131.7	0.83	2.71	108.7	0.88	3.13	90.6	0.92	3.59
220	681.9	0.58	0.82	509.6	0.65	0.98	364.1	0.70	1.29	265.5	0.73	1.68	214.1	0.76	2.00	173.0	0.81	2.33	144.6	0.83	2.71	119.3	0.88	3.13	99.4	0.91	3.60
240	741.1	0.58	0.82	553.8	0.65	0.99	395.9	0.70	1.29	288.8	0.73	1.68	233.0	0.76	2.00	188.2	0.81	2.34	157.4	0.84	2.72	129.9	0.88	3.13	108.3	0.92	3.60
260	799.9	0.58	0.82	597.7	0.65	0.99	427.4	0.70	1.29	312.0	0.73	1.69	251.7	0.77	2.01	203.4	0.81	2.34	170.1	0.84	2.72	140.4	0.88	3.14	117.0	0.92	3.61
280	858.2	0.58	0.83	641.3	0.65	0.99	458.7	0.70	1.30	335.0	0.73	1.69	270.4	0.77	2.01	218.5	0.81	2.35	182.7	0.84	2.73	150.9	0.88	3.15	125.8	0.92	3.62
300	916.0	0.59	0.83	684.6	0.65	0.99	489.8	0.70	1.30	357.9	0.73	1.69	289.0	0.77	2.01	233.5	0.81	2.35	195.4	0.84	2.73	161.3	0.88	3.15	134.5	0.92	3.62

Source: USDA Soil Conservation Service

TABLE 6-7 -- PARABOLIC STONE CENTER WATERWAY DESIGN - RETARDANCE C

Velocity, Top Width and Depth Based on Retardance "C"

	Grade 6 Percent		Grade 8 Percent		Grade 10 Percent		Grade 12 Percent		Grade 15 Percent	
V	8.0	10	8.0	10.0	8.0	10.0	8.0	10.0	8.0	10.0
D	1.3	1.6	1.1	1.3	1.0	1.2	0.9	1.1	0.8	0.9
Q					Top Widths					
20										
25							5		5	
30			5		5		6		6	4
35			6		6		7		7	5
40	6		7		7		8	5	8	6
45	7		8		8	5	9	6	10	7
50	7		9	6	9	6	10	6	11	7
55	8		9	6	10	7	11	7	12	8
60	9		10	7	11	7	12	8	13	9
65	9		11	7	12	8	13	8	14	9
70	10	7	12	8	12	9	14	9	16	11
75	11	7	13	9	13	9	15	10	17	11
80	12	8	14	9	14	10	16	10	18	12
90	13	9	15	10	15	10	18	11	19	13
100	14	10	17	11	17	12	20	13	21	15
110	16	11	19	13	19	13	22	14	24	16
120	17	11	21	14	21	14	24	15	26	18
130	19	12	22	15	23	16	26	17	29	20
140	20	13	24	16	25	17	29	18	31	21
150	22	14	26	17	27	18	31	19	33	23
160	23	15	27	18	29	20	33	21	36	24
170	25	16	29	19	31	21	35	22	38	26
180	26	17	31	20	33	22	37	24	40	28
190	27	18	32	22	34	23	39	25	43	29
200	29	19	34	23	36	25	42	26	45	31
220	32	21	38	25	38	26	44	28	47	33
240	35	23	41	27	42	29	48	31	52	38
260	38	25	44	30	46	31	53	33	57	39
280	40	27	48	32	50	34	57	36	62	42
300	43	29	51	34	54	36	61	39	67	45
					57	39	66	42	71	49

Source: USDA Soil Conservation Service

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

LEVEL SPREADER

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A level spreader is an outlet constructed at zero percent grade across the slope that allows concentrated runoff to be discharged at non-erosive velocities onto natural or man-made areas that have existing vegetation capable of preventing erosion.

Purpose

A level spreader changes concentrated flow into sheet flow and then outlets it onto stable areas without causing erosion. An example would be at the outlet of a diversion or a waterway.

Conditions Where Practice Applies

The level spreader is used where it can be constructed on undisturbed soils, where the area directly below the spreader is stabilized be existing vegetation, where the water will not re-concentrate immediately below the spreader, and where there is at least 100 feet of vegetated area between the spreader and state surface waters.

Considerations

Placement of the level spreader must allow the water flowing over the level section to leave the structure as a uniform, thin film of water. The structure should outflow onto naturally vegetated areas whenever possible. The creation of a uniform level lip for the water to spread over is critical.

Design Criteria

Length. The design length for a level spreader shall be no more than 0.5 cfs per foot of level section based on the peak rate of flow from the contributing designed erosion control or stormwater management practice. The minimum length of the spreader shall be 5 feet and the maximum length shall be 50 feet.

Width. The minimum width of the spreader shall be 6 feet as shown in Figure 6-6.

Depth. The depth of the level spreader as measured from the lip shall be at least 6 inches.

The depth shall be uniform across the entire length of the spreader. See Figure 6-6.

Grade. The level spreader lip shall be constructed on a zero percent grade to insure uniform spreading of runoff. The last 50 feet of the channel leading into the level spreader shall be constructed at a grade not exceeding 1%.

Vegetation. The spreader shall be stabilized in accordance with the appropriate grass mixture selected from those found in the Best Management Practice for Seeding for Long-Term Cover. The spreader should be mulched if necessary for the establishment of good quality vegetation.

Outlets. Final discharge will be over the level lip protected with erosion stops and jute or excelsior matting onto an existing stabilized area. The stabilized area shall have a complete vegetative cover sufficiently established to be erosion resistant.

Maintenance

The level spreader should be checked periodically and after every major storm to determine if the lip has been damaged and to determine that the design conditions have not changed. Any detrimental sediment accumulation should be removed. If rilling has taken place on the lip, then the damage should be repaired and re-vegetated. The vegetation should be mowed occasionally to control weeds and the encroachment of woody vegetation. Clippings should be removed and disposed of outside the spreader and away from the outlet area. Fertilization should be done as necessary to keep the vegetation healthy and dense.

Construction Specifications

1. Construct the level spreader lip on a zero percent grade to insure uniform spreading of runoff.

2. Level spreader shall be constructed on undisturbed soil and not on fill.

3. An erosion stop shall be placed vertically a minimum of six inches deep in a slit trench one foot back of the level lip and parallel to the lip. The erosion stop shall extend the entire length of the level lip.

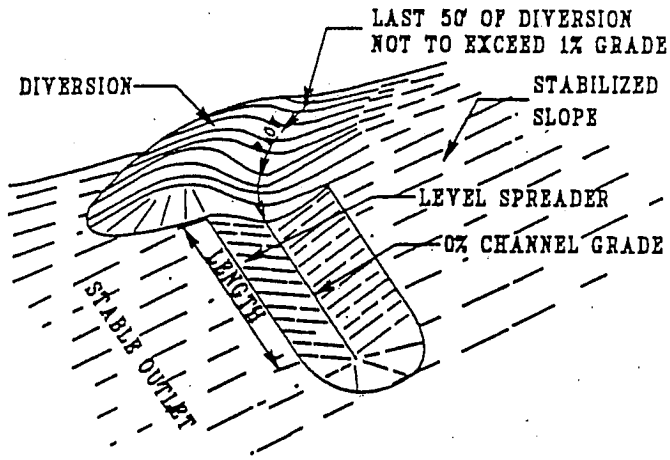
4. The entire level lip area shall be protected by placing two strips of jute or excelsior matting along the lip. Each strip shall overlap the erosion stop by at least six inches.

5. The entrance channel to the level spreader shall not exceed a 1 percent grade for at least 50 feet before entering into the spreader.

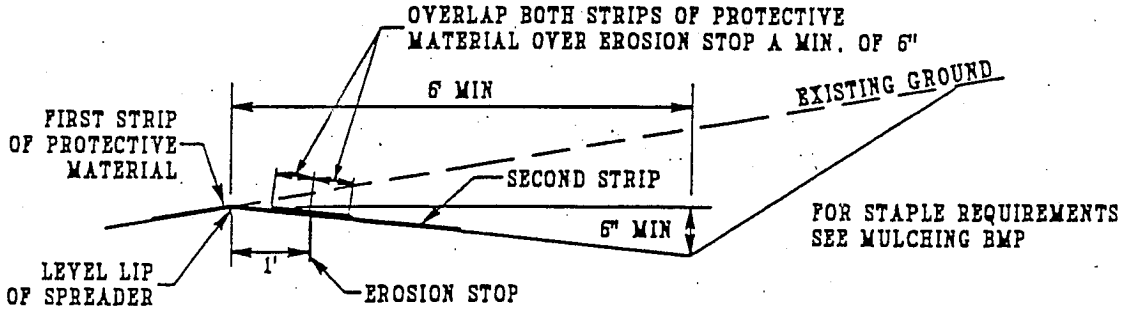
6. The flow from the level spreader shall outlet onto stabilized areas. Water should not concentrate immediately below the spreader.

7. Periodic inspection and required maintenance shall be performed.

FIGURE 6-6 -- LEVEL SPREADER



ISOMETRIC VIEW



CROSS SECTION

Source: Rockingham County Conservation District

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

LINED WATERWAY OR OUTLET

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Existing waterways to which this practice is to be applied may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A waterway or outlet having an erosion-resistant lining of concrete, stone or other permanent material. The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

Purpose

To provide for safe disposal of runoff from other conservation structures or from natural concentrations of flow, without damage by erosion or flooding, where unlined or grassed waterways would be inadequate. Properly designed linings may also control seepage, piping, and sloughing or slides.

Conditions Where Practice Applies

This practice applies if the following or similar conditions exist:

1. Concentrated runoff is of such that a lining is needed to control erosion.

2. Steep grades, wetness, prolonged base flow, seepage, or piping would cause erosion.

3. The location is of such that use by people or animals preclude use of vegetated waterways or outlets.

4. High-value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.

5. Soils are highly erosive or other soil or climatic conditions preclude using vegetation.

6. Installation of non-reinforced concrete or mortared flagstone linings, shall be made only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

Considerations

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, deep percolation, and groundwater recharge.

2. Variability of the practice's effect caused by seasonal and climatic changes.

3. Filtering effects of vegetation on the movement of sediment and dissolved and sediment attached substances will be evaluated.

4. Effects on the visual quality of the water resources.

5. Short-term and construction-related effects on the quality of water resources.

Design Criteria

Capacity. The minimum capacity shall be adequate to carry the peak rate of runoff from a 1-year frequency storm. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel Finish	0.012-.014
Float Finish	.013-.017
Gunite	.016-.022
Flagstone	.020-.025
Riprap	Determine from Figure 6-7

Velocity. Maximum design velocity shall be as shown in Figure 6-8. Except for short transition sections, flow in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical shall be restricted to straight reaches.

Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical.

Cross section. The cross section shall be triangular, parabolic, or trapezoidal. Cross sections made of monolithic concrete may be rectangular.

Freeboard. The minimum freeboard for lined waterways or outlets shall be 0.25 feet above design high water in areas where erosion-resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required if vegetation can be grown and maintained.

Side slope. The steepest permissible side slopes, horizontal to vertical, shall be:

Non-reinforced concrete:
- Hand-placed, formed concrete
  - Height of lining, 1.5 ft or less .....vertical
- Hand-placed screened concrete or mortared in place flagstone
  - Height of lining, less than 2 ft .....1 to 1
  - Height of lining, more than 2 ft .....2 to 1

Slip form concrete:
- Height of lining, less than 3 ft .....1 to 1

Rock riprap .....2 to 1

Lining thickness. Minimum lining thickness shall be:

Concrete.....4 in. (In most problem areas, minimum thickness shall be 5 in. with welded wire fabric reinforcing.)

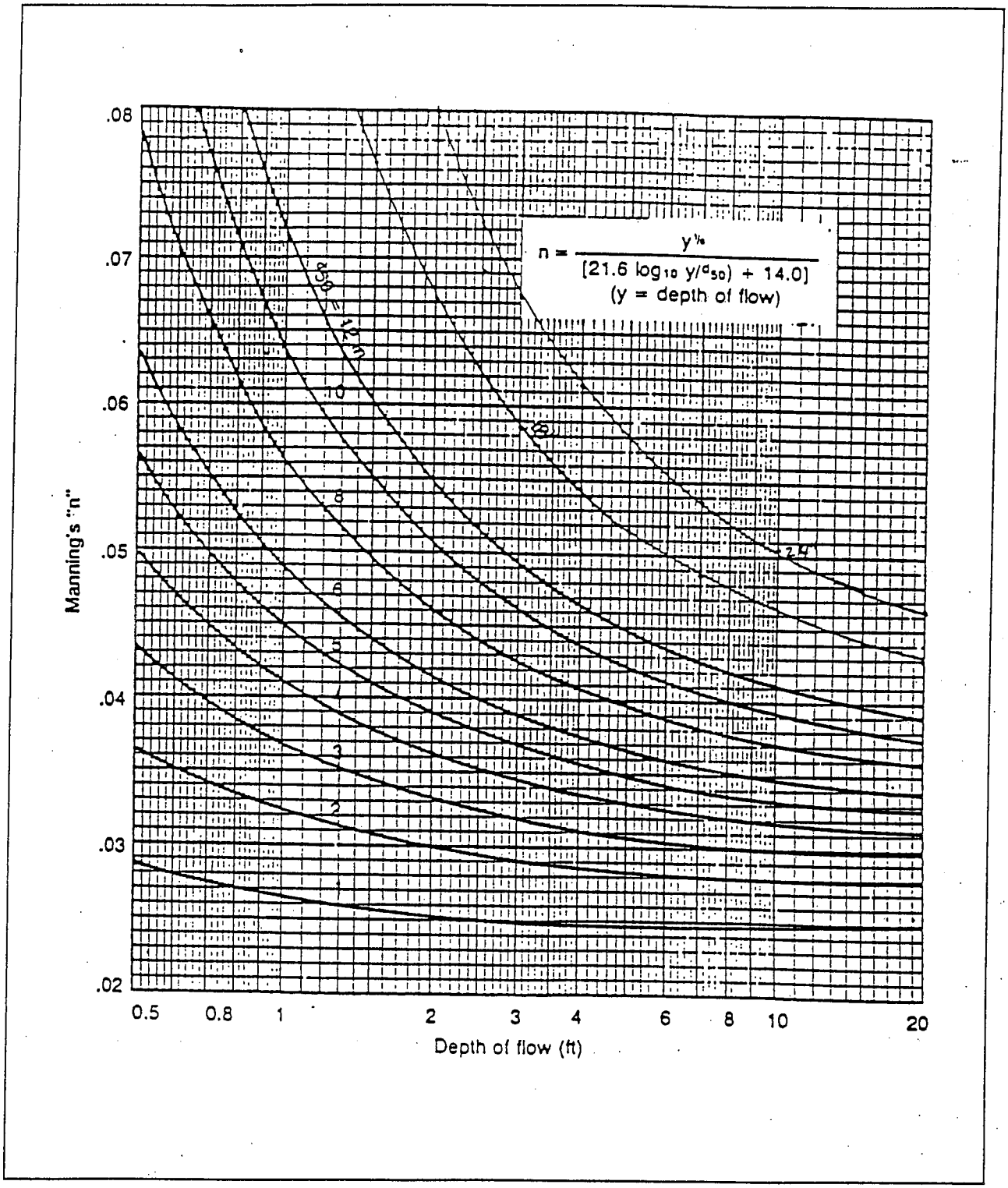
Rock riprap.....Maximum stone size plus thickness of filter or bedding

Flagstone.....4 in., including mortar bed

Related structures. Side inlets, drop structures, and energy dissipators shall meet the hydraulic and structural requirements for the site.

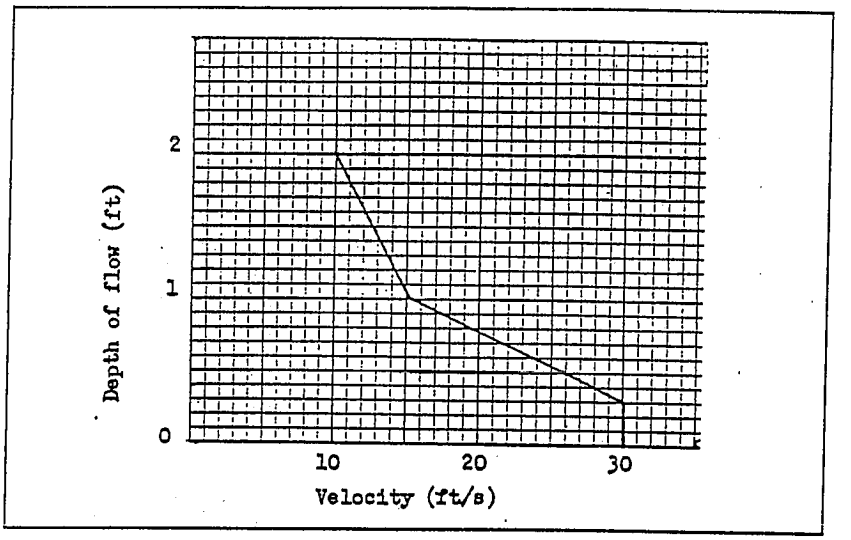
Filters or bedding. Filters or bedding shall be used to prevent piping. Drains shall be used to reduce uplift pressure and to collect water, as required. Filters, bedding, and drains shall be designed according to SCS standards. Weep holes may be used with drains if needed.

FIGURE 6-7 -- VALUES OF "n" FOR RIPRAP LINED CHANNELS
D_{50} SIZE VERSUS DEPTH OF FLOW



Source: USDA Soil Conservation Service

FIGURE 6-8 -- MAXIMUM VELOCITY VS DEPTH OF FLOW



Concrete. Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required.

Specify a mix that can be certified as suitable to produce a minimum strength of at least 3,000 lb/in^2. Cement used shall be Portland cement. Types I, II or if required, Types IV or V. Aggregate used shall have a maximum size of 1.5 inches.

Mortar. Mortar used for mortared in-place flagstone shall consist of a workable mix of cement, sand, and water with a water-cement ration of not more than 6 gallons of water per bag of cement.

Contraction joints. Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet. Provide for uniform support to the joint to prevent unequal settlement.

Rock riprap or flagstone. Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking.

Maintenance. Provisions must be made for timely maintenance to insure that lined waterways function properly.

Plans and Specifications

Plans and specifications for constructing lined waterways or outlets shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purposes.

The foundation area shall be cleared of trees, stumps, roots, sod, loose rock, or other objectional material.

The cross section shall be excavated to the neat lines and grades as shown on the plans. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alinement shall be permitted.

Concrete linings shall be placed to the thickness shown on the plans and shall be completed in a finished manner. Provisions shall be made to protect freshly placed concrete and to insure proper curing.

Filter, bedding, and rock riprap shall be placed to line and grade and in the manner specified. Riprap shall be placed so that it does not reduce the design section more than 10 percent.

Construction operations shall be done in such a manner that erosion and air and water pollution are minimized and held within reasonable and legal limits. The completed job shall present a good appearance. All disturbed areas shall be vegetated or otherwise provided with a cover to protect the areas against soil erosion.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

OUTLET PROTECTION

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The outlet area may be dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Outlet protection is a rock lined apron or other acceptable energy dissipater placed between the outlet of a pipe or paved channel and a stable downstream outlet.

Purpose

Outlet protection prevents erosion or scour at outlets of storm sewers, culverts, paved waterways or other lined channels or pipes by reducing the velocity of the flow from the channel or pipe.

Conditions Where Practice Applies

The practice applies to outlets where the velocity of flow from the pipe or lined channel is higher than the downstream watercourse can withstand without erosion.

Considerations

An analysis of the entire drainage system should be made to determine the effects of concentrated flow downstream. Additional measures may be required in addition to the outlet protection to assure that erosion, sedimentation and other off-site damages do not result. If the velocity emanating from the pipe or channel exceeds the allowable velocity for the particular soil as shown in Table 6-8, then outlet protection is required as detailed in Figure 6-9.

TABLE 6-8 -- ALLOWABLE VELOCITIES FOR VARIOUS SOILS

USDA SOIL TEXTURE	ALLOWABLE VELOCITY (feet per second)
Sand and Sandy Loam	2.5
Silt Loam	3.0
Sandy Clay Loam	3.5
Clay Loam	4.0
Clay, Fine Gravel	5.0
Cobbles and Shingles	5.5
Shale and Hardpan	6.0

Design Criteria

Apron Dimensions
The dimensions of the apron at the outlet of the pipe shall be determined as follows:

1. The width of the apron at the outlet of the pipe or channel shall be 3 times with diameter of the pipe or width of the channel.

2. The length of the apron shall be determined from the following formula when the tailwater depth at the outlet of the pipe or channel is less then one-half the diameter of the pipe or one-half the width of the channel:

$$L_a = \frac{1.8\ Q}{D_o^{3/2}} + 7D_o$$

Where:

L_a is the length of the apron

Q is the discharge from the pipe or channel

D_o is the diameter of pipe or width of channel

3. When the depth of the tailwater at the outlet of the pipe or channel is equal to or greater than one-half the diameter of the pipe or the width of the channel, then the following formula applies:

$$L_a = \frac{3.0Q}{D_o^{3/2}}$$

4. Where there is no well defined channel downstream of the outlet, the width of the downstream end of the apron shall be determined as follows:

   a. For minimum tailwater conditions where the tailwater depth is less than the elevation of the center of the pipe:

   $$W = D_o + L_a$$

   b. For maximum tailwater conditions where the tailwater depth is greater than the elevation of the center of the pipe:

   $$W = D_o + 0.4\ L_a$$

5. Where there is a stable well-defined channel downstream of the apron, the bottom width of the apron shall be equal to the width of the channel.

6. The side slopes of the apron in a well-defined channel shall be 2:1 (horizontal to vertical) or flatter. The height of the structural lining along the channel sides shall begin at the elevation equal to the top of conduit and taper down to the channel bottom through the length of the apron.

7. The bottom grade of the apron shall be level (0% grade). No overfall is allowable at the end of the apron.

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

Rock Riprap

The following criteria shall be used to determine the dimensions of the rock riprap used for the apron:

1. The median stone diameter shall be determined using the formula:

$$d_{50} = \frac{0.02}{T_w} \frac{Q^{4/3}}{D_o}$$

Where:

d_{50} is the median stone diameter in feet
T_w is the tailwater depth above the invert of the pipe channel feet

Q is the discharge from the pipe or channel in cubic feet per second

D_o is the diameter of the pipe or width of the channel in feet

2. Fifty percent by weight of the riprap mixture shall be smaller than the median size stone designated as d_{50}. The largest stone size in the mixture shall be 1.5 times the d_{50} size.

3. The quality and gradation of the rock, the thickness of the riprap lining, filter material and the quality of the stone shall meet the standard design requirements of rock riprap. The minimum depth shall be 6 inches or 1.5 times the largest stone size in the mixture whichever is larger (d).

Maintenance

The outlet protection should be checked at least annually and after every major storm. If the riprap has been displaced, undermined or damaged, it should be repaired immediately. The channel immediately below the outlet should be checked to see that erosion is not occurring. The downstream channel should be kept clear of obstructions such as fallen trees, debris, and sediment that could change flow patterns and/or tailwater depths on the pipes. Repairs must be carried out immediately to avoid additional damage to the outlet protection apron.

Construction Specifications

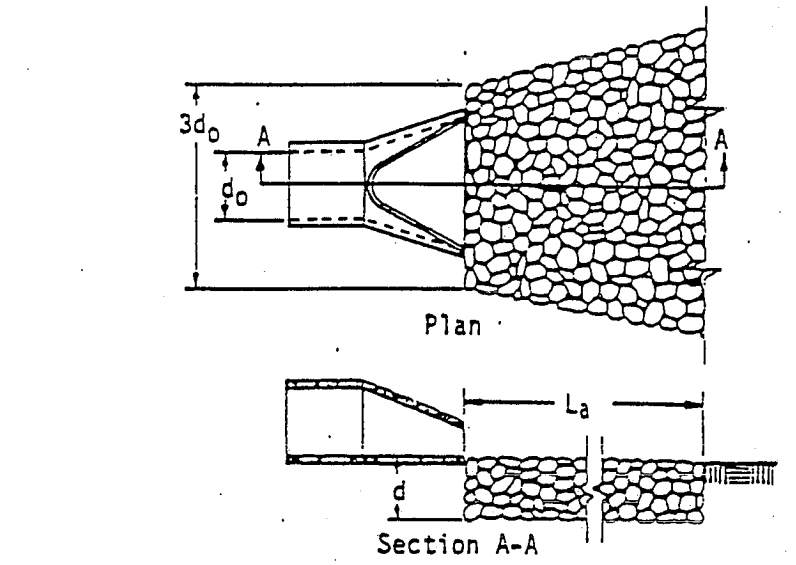
1. The subgrade for the filter material, geotextile fabric, and riprap shall be prepared to the lines and grades shown on the plans.

2. The rock or gravel used for filter or riprap shall conform to the specified gradation.

3. Geotextile fabrics shall be protected from puncture or tearing during the placement of the rock riprap. Damaged areas in the fabric shall be repaired by placing a piece of fabric over the damaged area or by complete replacement of the fabric. All overlaps required for repairs or joining two pieces of fabric shall be a minimum of 12 inches.

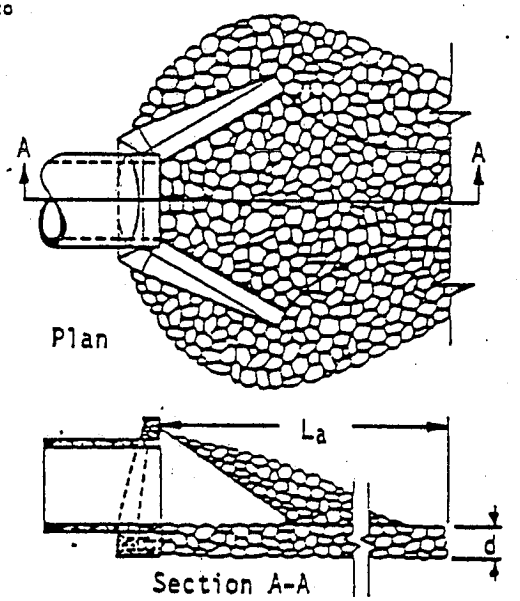
4. Stone for the riprap may be placed by equipment and shall be constructed to the full layer thickness in one operation and in such a manner as to prevent segregation of the stone sizes.

FIGURE 6-9 -- PIPE OUTLET PROTECTION



Pipe Outlet To Flat Area
With No Defined Channel

Note: Geotextile fabric or filter material to be placed between riprap and soil.



Pipe Outlet To Well-Defined Channel

Source: Virginia Soil & Water Conservation Commission

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

SEDIMENT BASIN

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. Once established, the basin may become dominated by shrubs. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A basin constructed to collect and store debris or sediment.

Purpose

To preserve the capacity of reservoirs, ditches, canals, diversions, waterways, and streams; to prevent undesirable deposition on bottom lands and developed areas; to trap sediment originating from construction sites; and to reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, stone, agricultural wastes, and other debris.

Conditions Where Practice Applies

This practice applies where physical conditions or land ownership preclude treatment of a sediment source by the installation of erosion-control measures to keep soil and other material in place of where a sediment basin offers the most practical solution to the problem.

Considerations

1. Effects on the water budget, especially volumes and rates of runoff, infiltration, evaporation, deep percolation, and groundwater recharge.

2. Effects on downstream flows and aquifers that would affect other water uses and users.

3. Effects on volume of discharge flow on the environmental, social, and economic conditions.

4. Effects on the water table downstream and the results of changes on vegetative growth.

5. Effects on erosion, movement of sediment, pathogens, and soluble and sediment-attached substances.

6. Effects on the visual quality of on-site and downstream water resources.

7. Effects of construction and early establishment of protective vegetation on the surface and groundwater.

8. Effects on wetlands and water-related wildlife habitats.

Design Criteria

The Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire shall be used for the design of sediment basins in urban areas. The following criteria shall be used for sediment basins in other than urban areas.

The capacity of the sediment basin shall equal the volume of sediment expected to be trapped at the site during the planned useful life of the basin or the improvements it is designed to protect. If it is determined that periodic removal of sediment will be practicable, the capacity may be proportionately reduced.

The design of dams, spillways, and drainage facilities shall be according to BMWPs for ponds and grade stabilization structures or according to the requirements in USDA Soil Conservation Service Technical Release 60 (TR-60) Earth Dams and Reservoirs, as appropriate for the class and kind of structure being considered.

Temporary basins having drainage areas of 5 acres or less and a total embankment height of 5 feet or less may be designed with less conservative criteria if conditions warrant. The embankment shall have a minimum top width of 4 feet and side slopes of 2:1 or flatter. An outlet shall be provided of earth, pipe, stone, or other devices adequate to keep the sediment in the trap and to handle the 10-year frequency discharge without failure or significant erosion.

Provisions shall be made for drainage sediment pools if necessary for safety and vector control. Fencing and other safety measures shall be installed as necessary to protect the public from floodwater and soft sediment. Due consideration shall be given to good visual resource management.

Plans and Specifications

Plans and specifications for installing sediment basins shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction of sediment basins within the scope of the BMWP for ponds shall have, as a minimum, specifications commensurate with those for ponds. Refer to USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices for applicable construction specifications. Those within the scope of TR-60 shall be in accord with the guide specifications contained in the USDA Soil Conservation Service National Engineering Handbook, Section 20.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

VEGETATED SWALE

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Vegetated swales are either natural or constructed broad channels with dense vegetation that are designed to treat runoff and dispose of it safely into the natural drainage system.

Purpose

Vegetated swales improve water quality by the treatment and removal of pollutants from stormwater runoff, increase infiltration, and reduce potential erosion from the discharge of runoff.

Conditions Where Practice Applies

The practice applies to all sites where a dense stand of vegetation can be established and where either a stable outlet exists or can be constructed as a suitable conveyance system to safely dispose of the runoff flowing from the swale. The swale can be used by itself or in combination with other stormwater management and/or erosion and sediment control practices to achieve the water quality improvement or flood peak reduction desired.

Considerations

The vegetated swale and the grassed waterway or outlet Best Management Wetlands Practice are very similar. The difference in the two practices is mainly in purpose. The vegetated swale is concerned with water quality improvement and peak runoff reduction accomplished by limiting the velocity in the swale, whereas the grassed waterway or outlet is concerned with conveying runoff safely at a non-erosive velocity.

Vegetated swales are best suited on small drainage areas where the

amount of impervious cover is relatively small. If dense vegetation cannot be established and maintained in the swale then its effectiveness is severely reduced. The seasonal high water table should be at least one to two feet below the bottom of the swale in order to provide for more effective infiltration and treatment of the runoff and to provide better growing conditions for the vegetation. Subsurface drainage may be needed to control high water table and improve the condition of the swale.

The swale should be constructed prior to any other channel or facility which will drain into it and flow should be diverted out of the swale until adequate vegetation is established.

Design Criteria

Capacity. The minimum capacity shall be that required to convey the peak runoff expected from a 10-year frequency 24-hour duration storm.

Velocity. The maximum design velocity for a vegetated swale shall be 1.0 foot per second during passage of the 10-year frequency storm.

Length. The minimum length of a vegetated swale shall be 100 feet.

Cross section. The cross section for a vegetated swale may be parabolic, triangular, or trapezoidal as shown in Figure 6-10 and should be designed using Table 6-9.

Drainage. Subsurface drainage measures shall be provided for in the design for sites having high water tables or seepage problems, except where water-tolerant vegetation such as reed canary grass can be used. There should be no base flow present in the swale.

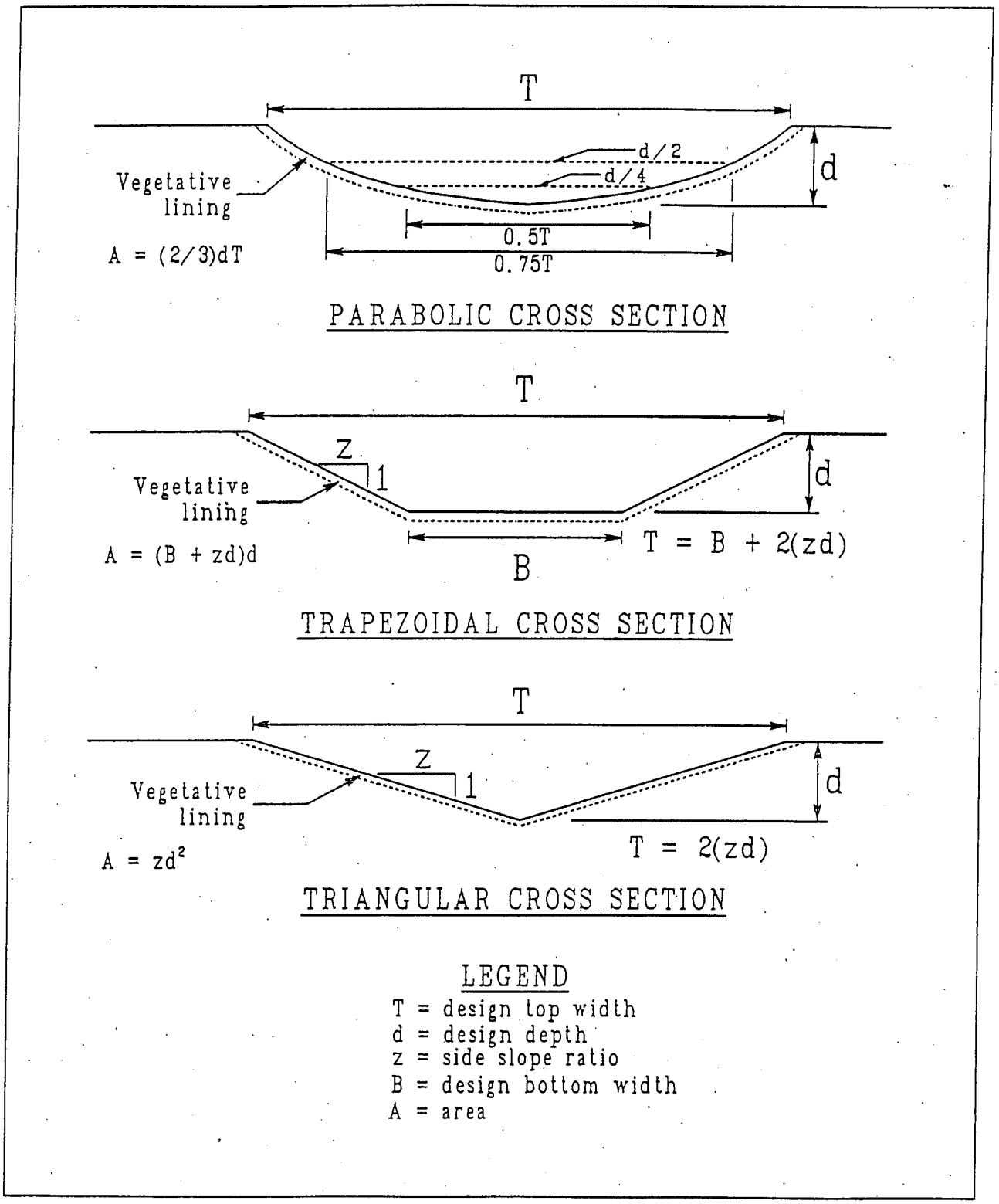
Vegetation. Swales shall be stabilized in accordance with the appropriate grass mixture. The swale should be mulched if necessary for establishment of good quality vegetation. A temporary diversion should be used to divert runoff away from the swale until vegetation is established that is capable of preventing erosion.

Maintenance

Timely maintenance is important to keep the vegetation in the swale in good condition. Mowing should be done frequently enough to keep the vegetation in vigorous condition and to control encroachment of weeds and woody vegetation, however it should not be mowed too closely so as to reduce the filtering effect. Fertilize on an "as needed" basis to keep the grass healthy. Over fertilization can result in the swale becoming a source of pollution.

The swale should be inspected periodically and after every major storm to determine the condition of the swale. Rills and damaged areas should be promptly repaired and re-vegetated as necessary to prevent further deterioration.

FIGURE 6-10 -- TYPICAL VEGETATED SWALE CROSS SECTION



Source: Rockingham County Conservation District

TABLE 6-9 -- VEGETATED SWALE DESIGN - RETARDANCE D & B GRADE 0.25 TO 2.0%

	Grade, 0.25%			Grade, 0.50%			Grade, 0.75%			Grade, 1.0%			Grade, 1.25%			Grade, 1.50%			Grade, 2.0%		
V	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5
D	1.5	2.1	2.5	1.0	1.6	1.8	0.8	1.4	1.6	0.7	1.2	1.4	0.7	1.1	1.3	0.6	1.0	1.2	0.5	0.8	1.1
Q										Top Width											
5	22			27	11		32	14	7	34	15	8	36	17	9	39	19	10	43	20	12
10	43	15		55	23	12	63	27	14	68	31	17	73	34	19	77	36	20	85	40	23
15	65	24	12	82	34	18	95	41	22	102	46	25	109	50	28	115	54	31	128	60	35
20	87	32	16	110	46	24		54	29		61	33		67	37		71	41		79	47
25	108	41	21		57	30		68	36		77	41		84	47		89	51		99	58
30		49	25		69	36		82	43		92	50		101	56		107	61			70
35		57	29		80	41		95	50		107	58			66			72			82
40		65	33		92	47		109	57			66			75			82			93
45		73	37		103	53			64			75			84			92			105
50		81	42			59			72			83			94			102			
55		90	46			65			79			91			103						
60		98	50			71			86			100									
65		106	58			77			93												
70			63			83			100												
75			67			89															
80			75			95															
90			83			107															
100			92																		
110			100																		

V, permissible velocity of soil with vegetative retardance "D"
Depth and top width are for cross section with retardance "B"

Q, in cfs
V, in fps
D, depth in ft.
Top Width, in ft.

Source: USDA Soil Conservation Service

CHAPTER 7

WASTE MANAGEMENT SYSTEMS

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

AGRICHEMICAL HANDLING FACILITY

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

The Agrichemical Handling Facility (AHF) is a permanent structure with an impervious surface to provide an environmentally safe area for the handling of on-farm agrichemicals, such as pesticides and fertilizers, that are used in spraying operations of orchards, vineyards, and cropland.

Purpose

To provide for the containment and isolation of spillage from on-farm agrichemical mixing, loading, unloading, and rinsing operations in order to minimize pollution of the soil, water, air, plant, or animal resources.

Conditions Where Practice Applies

This practice applies where current methods of mixing agrichemicals and rinsing equipment are polluting or can pollute the soil, water, air, plant, or animal resources.

Considerations

The following shall be considered when designing an AHF:

1. The availability of water and the distance to water sources for filling the spray equipment tanks, rinsing the sprayers, and rinsing chemical containers.

2. On-farm traffic patterns and accessibility to chemical application areas and chemical storage.

3. Soils and topography are suitable for construction of an AHF.

4. Adjacent land uses and visibility.

5. The effects of chemical drift on surrounding areas due to prevailing winds.

6. The need for a loading platform to facilitate the filling and/or rinsing of spray equipment.

7. The need for a roof structure over the pad to reduce rainwater storage requirements or runoff problems.

Design Criteria

General. The AHF shall include a watertight containment structure comprised of a concrete pad and sump, and all necessary equipment for pumping, transferring and storing contaminated water.

Measures shall be designed to divert runoff from adjacent areas resulting from a 4 percent chance (25-year frequency), 24-hour duration storm event.

The AHF shall be located outside the 100-year flood plain and wetland areas.

The AHF shall be isolated from other buildings used to store feed, seed, petroleum products, or livestock and from residences; and located downwind of these buildings when possible.

Access shall be a graveled or paved ramp with a maximum slope of 15 percent and a minimum length of 12 feet. All other areas around the pad shall be established with vegetation.

All concrete materials shall comply with the requirements of USDA Soil Conservation Service National Engineering Handbook Construction Specifications 31 and 32 or New Hampshire Construction Specification 32.

The containments volume of the combined pad and sump for the AHF covered with a roof shall be 125 percent of the volume of the largest sprayer tank that will be located on the pad. A structure not covered with a roof shall contain 125 percent of the volume of the largest sprayer tank located on the pad or the volume from a two-year frequency, 24-hour storm event, which ever is larger.

Methods for handling rainwater and snow melt runoff shall be designed into the AHF.

The facility and all components shall comply with applicable federal, state, and local laws and codes.

Pad. The pad shall be a concrete slab-on-grade with a positive slope of at least 2 percent (1/4 inch per foot) from all areas toward the sump.

The minimum length and width of the pad shall be sufficient to accommodate the existing or anticipated equipment.

The required thickness and reinforcement of the slab shall be designed for the wheel loads of the existing or anticipated equipment. Design should be based upon methods described in the ACI 360R code, "Design of Slabs on Grade" or other similar industry guides.

The AHF pad and sump shall be sealed with a chemically-resistant, non-vapor barrier forming coating to prevent contamination of the concrete surfaces. Surface preparation and coating application shall be according to the manufacturer's recommendations.

The minimum slab thickness shall be 5 inches and minimum reinforcement shall be 10 by 10 gauge, 6 inch by 6 inch welded wire fabric panels. Waterstops shall be used between the pad and curb walls when constructed in separate pours.

Sump. The sump shall be watertight and constructed of non-corrodible material, large enough to allow access for cleaning, and shall be covered with a corrosion resistant grating if installed under the pad or covered with impermeable material if installed on the outside of the pad. The sump shall not be used for permanent storage of spillage or rinsate.

Roof. The roof, if provided, shall cover the entire AHF and shall extend sufficiently to limit the amount of precipitation reaching the pad.

The minimum clearance between the lowest chord of the roof and the highest area of the pad shall provide clear access for the spray equipment and shall not be less than 10 feet. Enclosure supports shall be located outside of the AHF.

The roof shall be designed for the minimum loads contained in American Society of Agricultural Engineers (ASAE) Engineering Publication EP288.4 "Agricultural Building Snow and Wind Loads".

Pump. The pump shall be corrosion resistant and permanently installed with provisions for protection during winter months.

A filter shall be installed between the pump and sprayer or storage tanks.

Storage Tank (s). Storage tank(s), if used, shall be permanently installed and above grade on the pad or on an adjacent pad.

The tank(s) shall be constructed of non-corrosive material(s).

The minimum storage volume of the tank(s) shall be the larger of: (1) one-fourth of the largest sprayer tank volume, or (2) volume equal to surface area of pad times .25 gallons per square foot.

Piping. All piping necessary to transfer contaminated water between the sump, the pump, and the temporary storage tanks or sprayer shall be permanently installed on the pad. Flexible piping may be utilized to transfer rinsate material from the sump discharge line, or temporary storage, into the sprayer.

All transfer piping carrying contaminated water shall be completely exposed for its entire length.

All piping necessary to supply non-contaminated water to the pad shall be fitted with backflow prevention devices.

Plans and Specifications

The construction drawings for the AHF shall comply with this BMWP. The following statement shall appear on all construction drawings for the AHF's:

> "Management of chemicals shall be the responsibility of the owner/operator and shall be in accordance with applicable federal, state and local regulations".

Plans and specifications shall describe the site specific requirements for implementing this practice to achieve its intended use.

Operation and Maintenance

An operation and maintenance plan shall be developed that is consistent with the purposes of this practice, its intended life, and the criteria for its design. It shall address:

1. Proper disposal/utilization of rinsate, exterior washwater, accumulated sediment and spillage wastewater in accordance with the pesticide labeling requirements and federal, state and local laws and codes.

2. Winterization of the facilities.

3. Periodic checks of the backflow prevention devices.

4. Inspections of the pad and sump for cracks and leaks, and deterioration of the sealant.

5. Cleaning the sump and pad between different chemical mixing operations and removal of sediment accumulation from the sump, taking proper precautions to reduce worker exposure.

6. Emergency response instructions in case of an accidental pesticide spill, exposure, fire, or other incident that could adversely affect environmental health.

7. Posting of warning signs that hazardous chemicals are present.

8. The owner or applicator will have appropriate applicators license or permits for chemicals used at the facility. The applicator will have and use all required personal protection equipment as listed on chemical labels.

Supporting Data for Documentation

Design Data. The following information shall be recorded in the design and/or on the drawings, as applicable:

1. A drawing showing the facility with contour information in relation to surrounding buildings, streams, brooks, well, etc.

2. Detail designs for special components such as: curbs, hydrants, sump, pump configuration, stormwater diversion, etc.

3. Calculations showing design and required storage capabilities of the facility.

4. Erosion and sediment control measures as needed.

Construction Check Data. The following information shall be recorded on the drawings or on the design to certify installation of the facility:

1. Final surveyed elevations or depths and dimensions of the pad, curbs, sump, etc.

2. Locations of buried pipelines and power cables where installed as part of the facility.

3. Check list of other components required in the design.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

HEAVY USE AREA PROTECTION

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

Protecting heavily used areas by establishing vegetative cover, by surfacing with suitable materials, or by installing needed structures.

Purpose

This practice is used to stabilize urban, recreation or essential facility areas subjected to sustained heavy use by people, animals or vehicles.

Conditions Where Practice Applies

On agricultural or other areas subjected to sustained heavy use that require special treatment to protect the area from erosion or other environmental deterioration.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, and transpiration.

2. Effects on erosion and the movement of sediment, animal waste, and soluble and sediment-attached substances carried by runoff.

3. Effects of changes in surface and groundwater caused by introduction of fertilizers for vegetated areas, and oils and chemicals associated with concrete and asphalt placement and other construction activities.

4. Effects of changes in surface water caused by the runoffs from confined animal feeding areas.

Design Criteria

Drainage and Erosion Control. Provision shall be made for surface and subsurface drainage as needed and for disposal of runoff without erosion.

Base Course. All areas to be paved shall have a 6-inch base course of gravel, crushed stone, or other suitable material.

Areas subject to automotive traffic shall be designed for a wheel load of at least 4,000 pounds.

Surface Treatment. Asphalt - The thickness of the asphalt course, the kind and size of aggregate, type of proportioning of bituminous materials and the mixing and placing of these materials shall be in accord with good highway practice for the expected loading.

Concrete - The quality and thickness of concrete and the spacing and size of reinforcing steel shall be appropriate for the expected loading and in accord with sound engineering practice.

Gravel - Minimum thickness for gravel surface shall be 2 inches.

Other - Where other surfacing materials are used, such as cinders, tanbark, sawdust, etc., the minimum thickness shall be 2 inches.

Structures. All structures shall be designed in accordance with appropriate USDA Soil Conservation Service standards and specifications or National Engineering Handbook recommendations.

Sprays and Artificial Mulches. Sprays of asphalt, oil, plastic, manufactured mulches and similar materials will be installed in accordance with the manufacturer's recommendations.

Vegetative Measures. Liming, fertilizing, seeding and sodding will be in accord with the forestry standards and specifications for recreation area improvement.

Construction Specifications. Specifications will be in keeping with this BMWP and will describe the requirement for proper installation of the practices to achieve its intended purposes.

Construction shall conform to plans and the USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

ROOF RUNOFF MANAGEMENT

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A facility for collecting, controlling, and disposing of runoff water from roofs.

Purpose

To prevent roof runoff water from flowing across concentrated waste areas, barnyards, roads and alleys, and to reduce pollution and erosion, improve water quality, prevent flooding, improve drainage, and protect the environment.

Conditions Where Practice Applies

This practice applies where: (1) a roof runoff management facility is included in an overall plan for a waste management system; (2) roof runoff water may come in contact with wastes or cause soil erosion; and (3) barnyard flood protection or improved drainage is needed.

Considerations

1. Effects of the components of the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on downstream flows or aquifers that would affect other water uses.

3. Potential use for water management to conserve water.

4. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances carried by runoff.

5. The effects on wetlands and water-related wildlife habitats associated with the practice.

Design Criteria

Capacity. Design of roof runoff management facilities shall be based on the runoff from a 10-year frequency, 5-minute runoff except that a 25-year frequency, 5-minute runoff shall be used to design such facilities for exclusion of roof runoff from waste treatment lagoons, waste storage ponds, or similar practices.

Materials. Roof gutters and downspouts may be made of aluminum, galvanized steel, wood, or plastic. Aluminum gutters and downspouts shall have a nominal thickness of at least 0.07 and 0.05 inches, respectively. Galvanized steel gutters and downspouts shall be at least 28 gage. Wood shall be clear and free of knots. A water-repellent preservative shall be applied to the flow area of wood other than redwood, cedar, or cypress. Plastics shall contain ultraviolet stabilizers. Dissimilar metals shall not be in contact with each other.

Supports. Gutter supports shall have sufficient strength to withstand anticipated water, snow, and ice loads. They shall have a maximum spacing of 120 inches for galvanized steel and 81 inches for aluminum or plastic. Wood gutters shall be mounted on fascia boards using furring blocks that are a maximum of 61 inches apart. Downspouts shall be securely fastened at the top and bottom with intermediate supports that are a maximum of 10 feet apart.

Outlets. The water from roof runoff management facilities may empty into surface drains or underground outlets, or into the ground surface. When downspouts empty onto the ground surface, there shall be an elbow to direct water away from the building and splash blocks or other protection shall be provided to prevent erosion.

Protection. Roof runoff management facilities and outlets shall be protected from damage by livestock and equipment. Where appropriate, snow and ice guards may be installed on roofs to protect gutters and reduce the hazard to humans and animals below. Gutters may be installed below the projection of the roof line to further reduce gutter damage from snow and ice.

Plans and Specifications

Plans and specifications for installing roof runoff management facilities shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

WASTE STORAGE POND

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

An impoundment made by excavation or earth fill for temporary storage of animal or other agricultural waste.

Purpose

To store liquid and solid waste, waste water, and polluted runoff to reduce pollution; to maintain or enhance quality of both surface and groundwater; and to protect the environment.

Conditions Where Practice Applies

This practice applies where: (1) an overall waste management system has been planned; (2) waste is generated by agricultural production or processing; (3) storage is necessary to properly manage the waste; (4) soils and topography are suitable for construction; and (5) the structure can be located, installed, and managed without polluting air and water resources.

Considerations

Location. Waste storage ponds should be as close to the source of waste and polluted runoff as practicable. Due consideration should be given to economics, the overall waste management plan, and health and safety factors. The ponds should be located where prevailing winds, vegetative screening, and building arrangement minimize odor and visual resource problems. Non-polluted runoff should be excluded to the fullest extent possible. Waste storage ponds shall not be located on flood plains unless they are protected from inundation or damage from a 25-year flood event.

Solids Separation. To minimize frequency of solids removal from runoff storage ponds, direct polluted runoff through vegetative filter strips, low-gradient channels, or debris basins to remove readily settled solids. Settling facilities should have adequate capacity to store settled solids for a reasonable period, based on climate, equipment, and method of disposal. If animal manure, such as from dairy cows, is flushed into a storage pond, a solids separator may be provided for removing fibrous solids to facilitate pumping and irrigation.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Effects on downstream flows or aquifers that would affect other water uses.

3. Effects of installation demand on the water supply of the site.

4. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances translocated by runoff and seepage.

5. Effects on the use and management of nutrients on surface and groundwater quality, particularly the on-site water supply for human and livestock consumption.

6. Effects on the visual quality of on-site and the downstream water resources.

7. Short-term and construction-related effects of this practice on the quality of on-site and downstream water courses.

8. Effects on the movement of dissolved substances toward the groundwater.

9. The effects on wetlands and water-related wildlife habitats associated with the practice.

Design Criteria

Soil and Foundation. Locate pond on soils of slow to moderate permeability or on soils that can seal through sedimentation and biological action. Avoid gravelly-soils and shallow soils over fractured or cavernous rock. If self-sealing is not probable, the storage pond shall be sealed by mechanical treatment or by the use of an impermeable membrane. Do not construct to an elevation below

the seasonal high water table unless considered as a special design.

Storage Period. Experience in New Hampshire indicates that the minimum storage period should be 180 days. Other periods of storage may be provided based on crops and cropping sequences, farm operations, available land upon which to spread where consideration is given to accessibility, and field locations with respect to off-site pollution potential, soil conditions, land slopes, weather restrictions and other related factors. Any design with a storage period less than 180 days shall be considered a special design and reasons for the shortened period documented.

Design volume. Design volume is the minimum volume required to store waste for the storage period. It is the total of the following:

With drainage area -

1. Manure, waste water, and normal runoff[1]
2. Normal precipitation less evaporation on pond surface[1]
3. 25-year, 24-hour runoff
4. Solids accumulation[2]

Without drainage area -

1. Manure and waste water[1]
2. Normal precipitation less evaporation on pond surface[1]
3. 25-year, 24-hour precipitation
4. Solids accumulation[2]

1 Accumulated during the storage period.
2 For the period between solids removal. This applies mainly to ponds used to store waste water and polluted runoff and refers to the residual solids after the liquids have been removed.

Additional storage can be provided to meet management goals or regulations.

Inlet and outlet. Inlets to storage ponds can be of any permanent type designed to resist erosion, plugging, and damage by ice. If slurry and solid waste is stored, the inlet should be designed so that waste will be deposited near the center of the pond.

There shall be no outlet that can automatically release storage from the design volume. An emergency spillway or additional storage shall be provided to protect the facility from overtopping during a 25-year, 24-hour storm occurring when the design volume is filled for ponds with drainage areas. Spillway requirements, however, do not apply to waste storage ponds without drainage areas.

Earth embankment. The design height of the embankment shall be increased by the amount needed to insure that the design top elevation will be maintained after settlement. This increase shall not be less than 5 percent. The minimum top width shall be 8 ft. The combined side slopes of the settled embankment shall not be less than 5 horizontal to 1 vertical.

For ponds with a drainage area, the minimum elevation of the top of the settled embankment shall be 1 foot above the elevation of the water surface during the 25-year, 24-hour emergency spillway storm occurring when the design volume is filled. For ponds without a drainage area, the minimum elevation of the settled top shall be 1 foot above the design volume.

Disposal facilities. Waste shall be removed from storage and used or disposed of at locations, times, rates, and volumes shown in the overall waste management plan without polluting the surface or groundwater. Waste may be liquid, slurry, or solid, and proper equipment must be available to remove and apply it to the land.

If polluted runoff is stored, liquids shall be removed promptly to insure that sufficient capacity is available to store runoff from subsequent storms. The maximum allowable emptying time shall be based on the chance of overflow from subsequent storms and on the capacity of the disposal area.

Provisions shall be made for removing solids from storage ponds to preserve the storage capacity. The method or removal must be considered in planning, particularly in determining the size and shape of the pond. For ponds built to store runoff and waste water, an entrance ramp having a slope of 4:1 or flatter may be used. For those built to store slurry and solid waste, some type of emptying facility must be provided. It may be a dock, a pumping platform, a retaining wall, or a ramp having a slope of 7:1 or flatter.

Protection. If the waste storage pond creates a safety hazard, it shall be fenced and warning signs posted to prevent children and others from using it for other than the intended purpose. Vegetative screens or other methods should be used to shield the pond from public view and to improve visual conditions.

Vegetative. All exposed soil areas will be vegetated or protected by other measures to prevent erosion. Liming, fertilizing, seeding and mulching will be in accordance with the current standards and specifications for critical area planting.

Operation and Maintenance. Operation and maintenance shall be in accordance with the requirements specified in the overall waste management plans.

Refer to Chapter 13 of the USDA Soil Conservation Service Agricultural Waste Management Field Handbook for recommendations on operation maintenance.

Plans and Specifications

Plans and specifications for water storage ponds shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. Refer to USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices for applicable construction specifications.

Foundation Preparation. The foundation area shall be cleared of trees, logs, stumps, roots, brush, boulders, sod, and rubbish. If needed to establish vegetation, the topsoil and sod shall be stockpiled and spread on the completed dam and spillways. Foundation surfaces shall be sloped no steeper than 1:1. The foundation area shall be thoroughly scarified before placement of the fill material. The surface shall have moisture added or it shall be compacted if necessary so that the first layer of fill material can be compacted and bonded to the foundation.

The cutoff trench and any other required excavations shall be dug to the lines and grades shown on the plans or as staked in the field. If they are suitable, excavated materials shall be used in the permanent fill.

Existing stream channels in the foundation area shall be sloped no steeper than 1:1 and deepened and widened as necessary to remove all stones, gravel, sand, stumps, roots, and other objectionable material and to accommodate compaction equipment.

Foundation areas shall be kept free of standing water when fill is being placed on them.

Fill Placement. The material placed in the fill shall be free of detrimental amounts of sod, roots, frozen soil, stones more than 6 inches in diameter (except for rock fills), and other objectional material.

Selected backfill material shall be placed around structures, pipe conduits, and anti-seep collars at about the same rate on all sides to prevent damage from unequal loading.

The placing and spreading of fill material shall be started at the lowest point of the foundation and the fill brought up in horizontal layers of such thickness that the required compaction can be obtained. The fill shall be constructed in continuous horizontal layers except where openings or sectioned fills are

required. In those cases, the slope of the bonding surfaces between the embankment in place and the embankment to be placed shall not be steeper than 3 horizontal to 1 vertical. The bonding surface shall be treated the same as that specified for the foundation so as to insure a good bond with the new fill.

The distribution and gradation of materials shall be of such that no lenses, pockets, streaks, or layers of material differ substantially in texture or gradation from the surrounding material. If it is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the center and upstream parts of the fill. If zoned fills of substantially differing materials are specified, the zones shall be placed according to the lines, grades, and elevations shown on the drawings or as staked in the field.

Moisture Control. The moisture content of the fill material shall be adequate for obtaining the required compaction. Material that is too wet shall be dried to meet this requirement, and material that is too dry shall have water added and mixed until the requirement is met.

Compaction. Construction equipment shall be operated over the areas or each layer of fill to insure that the required compaction is obtained. Special equipment shall be used if needed to obtain the required compaction.

If a minimum required density is specified, each layer of fill shall be compacted as necessary to obtain that density.

Fill adjacent to structures, pipe conduits, and anti-seep collars shall be compacted to a density equivalent to that of the surrounding fill by means of hand tamping or manually directed power tampers or plate vibrators. Fill adjacent to concrete structures shall not be compacted until the concrete is strong enough to support the load.

Protection. A protective cover of vegetation shall be established on all exposed surfaces of the embankment, spillway, and borrow area if soil and climatic conditions permit. If soil or climatic conditions preclude the use of vegetation and protection is needed, nonvegetative means, such as mulches or gravel, may be used. In some places, temporary vegetation may be used until conditions permit establishment of permanent vegetation. The embankment and spillway shall be fenced if necessary to protect the vegetation.

Seedbed preparation, seeding, fertilizing, and mulching shall comply with instructions in technical guides.

Foundation and Embankment Drains. Foundation and embankment drains, if required, shall be placed to the line and grade shown on the drawings. Detailed requirements for drain material and any required pipe shall be shown in the drawings and specifications for the job.

Excavated Ponds. The completed excavation shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

Embankment and Excavated Ponds. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution are minimized and held within legal limits. All work shall be conducted in a skillful manner.

The completed job shall present a finished appearance.

Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical.

Fencing and cover to control erosion and pollution shall be established as needed.

Appropriate safety measures, such as warning signs, rescue facilities, and fencing, shall be provided.

BEST MANAGEMENT WETLANDS PRACTICE FOR AGRICULTURE

WASTE STORAGE STRUCTURE

Intent

The intent when using this practice is to have a minimum impact to wet meadow areas within agricultural fields which are classified as Palustrine Emergent. The wet area of the agricultural field to which this practice is applied shall be poorly drained soils as defined by the National Cooperative Soil Survey or be hydric B soils as defined by the New Hampshire Department of Environmental Services. Minor inclusions of less 15% by area of very poorly drained soils or hydric A soils shall be allowed in the impact area. The wet area shall be currently under agricultural practices or shall have been under agricultural practices in the past.

Definition

A fabricated structure for temporary storage of animal wastes or other organic agricultural wastes.

Purpose

To temporarily store liquid or solid wastes as part of a pollution-control or energy-utilization system to conserve nutrients and energy and to protect the environment.

Conditions Where Practice Applies

This practice applies where: (1) the structure is a component or an overall plan prepared according to the SCS standard for waste management systems; (2) temporary storage is needed for organic wastes generated by agricultural production or processing; (3) the structure can be located without polluting air or water resources; (4) soils and topography are suitable for construction of the structure; and (5) a waste utilization plan has been prepared.

Considerations

1. Effects on the water budget, especially on volumes and rates of runoff, including snow melt, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

2. Variability influenced by seasonal climatic changes.

3. Effects on erosion and the movement of sediment, pathogens, organic material, and soluble and sediment-attached substances carried by runoff.

4. Effects of nutrients and on surface and groundwater quality, particularly the on-site water supply for human and livestock consumption.

5. Effects on the visual quality of on-site and downstream water resources.

6. Short-term and construction-related effects of this practice on the quality of downstream surface and groundwater.

7. The effects on wetlands and water-related wildlife habitats.

Design Criteria

Location. The following factors must be considered in selecting a site for waste storage structures: proximity of the structure to the source of wastes, access to the facilities, ease of loading and emptying wastes, appropriate health regulations, and direction of prevailing winds to minimize odors. The structure shall be located a minimum of 100 feet from any well, spring, or underground water supply. Non-polluted runoff should be excluded from the structure to the fullest extent possible. Waste storage structures shall not be located on flood plains unless they are protected from damage and inundation from a 25-year 24-hour flood event.

Environmental Protection. All disturbed land surfaces shall be vegetated or otherwise stabilized to control soil erosion. The location, layout, and design of the facilities should be compatible with the surrounding landscape. Existing land forms and vegetation, along with land shaping and vegetative plantings, shall be considered to minimize an adverse impact upon visual resources. The structure shall be designed, constructed, operated and maintained so as to prevent any adverse impact on the quality of surface or groundwater.

Loading and Unloading. Adequate maneuvering space shall be provided for operating loading and unloading equipment. Push-offs must be structurally sound and must be provided with railings, safety bars, or other devices to prevent humans, animals, and equipment from falling into the facility. Provisions shall be made for removing liquids that accumulate from solid wastes or from precipitation.

Disposal Facilities. Equipment shall be available for removing wastes from the storage structure, processing them for energy, or applying them to the land at the locations, times, and rates shown in the overall management plan.

Service Life and Durability. Planning, design, and construction shall insure that the structure is sound and of durable materials

commensurate with the anticipated service life, initial and replacement costs, maintenance and operation costs, and safety and environmental considerations.

The structure shall be planned, designed, and installed to provide a minimum service life of 10 years.

Guidance in evaluating the service life of various materials is given below. The materials indicated meet the requirements of this standard. The service life of materials not shown shall be based on performance data.

TABLE 7-1 -- SERVICE LIFE OF MATERIALS

Service Life	Material[1]
Short (minimum of 10 yrs)	Wood; masonry, including concrete staves; flexible membranes; glass fiber reinforced plastics/ resins; steel coated with zinc, epoxy, vinyl, and asphalt; reinforced concrete.
Medium (minimum of 20 yrs)	Reinforced concrete; glass-fused steel.
Long (minimum of 50 yrs)	Reinforced concrete.

[1] The durability and estimated life of reinforced concrete is a function of the design criteria and the quality of the concrete. A key aspect affecting durability is corrosion of the reinforcement, which is directly related to cracking (design stress), and the reinforcement cover. The quality levels of reinforced concrete are discussed under "Structural Design," "Design Criteria."

Size. Experience in New Hampshire indicates that the design volume of the structure should be large enough to store accumulated wastes, bedding, washwater and needed dilution water for a minimum of 180 days. Other periods of storage may be provided based on crops and cropping sequences, farm operations, available land upon which to spread where consideration is given to accessibility, and field locations with respect to off-site pollution potential, soil conditions, land slopes, weather restrictions and other related factors. The reasons for shortening the storage period shall be documented in full. Energy production systems must also have a storage component that meets the minimum design storage requirements. Provisions should be made to insure that outside runoff does not flow into the structure. If suitable provisions cannot be made; however, the anticipated volume of runoff likely to enter the structure over the storage period must be included in the design volume. The design volume must allow for any direct rainfall and snow minimum expected evaporation. A minimum of 6 inches shall be provided for freeboard. In storage tanks, an

allowance of at least 6 inches shall be included in the design volume for solids accumulation. Data in Chapter 10 of the USDA Soil Conservation Service Agricultural Waste Management Field Handbook or reliable local information can be used in determining the quantity of waste production. The following table shall be used as a guideline for determining the required quantities.

TABLE 7-2 -- DAILY MANURE PRODUCTION
(Not including bedding, washwater or dilution water)

Animal	Cubic Feet/Day per 1000 lbs. of Animal Weight
Dairy Cattle	1.4
Beef Cattle	1.0
Horses	0.9
Swine	1.0
Sheep	0.7
Poultry	1.0

When records of the amount of bedding are not available, use Chapter 4 of the Agricultural Waste Management Field Handbook.

The volume of washwater should be determined by actual measurement or estimated by a reliable method such as calibration of each faucet, hose, or spray nozzle and applying the rate of water use to the time of operation, or by Chapter 4 of the Agricultural Waste Management Field Handbook.

Structural Loadings. Waste storage structures shall be designed to withstand all anticipated loads. Loadings include internal and external loads, hydrostatic uplift pressure, concentrated surface and impact loads, water pressure due to seasonal high water table, and frost or ice pressure.

The lateral earth pressure should be calculated from soil strength values determined from the results of appropriate soil tests. If soil strength tests are not available, use the minimum lateral earth pressure values indicated in Table 2 of the USDA Soil Conservation Service Engineering Standards and Specifications for Waste Storage Structures, Section IV of the Technical Guide.

Lateral earth pressures based upon equivalent fluid assumptions shall be assigned according to the structural stiffness or wall yielding as follows:

1. **Rigid frame or restrained wall.** Use the values shown in Table 2 of the Waste Storage Structure standards and specification

under the column "Frame Tanks," which gives pressures comparable to the at-rest condition.

2. **Flexible or yielding wall.** Use the values shown in Table 2 under the column "Freestanding Wall," which gives pressures comparable to the active condition. Walls in this category are designed as a cantilever having a base thickness to height ratio not more than 0.085.

An internal hydrostatic load of 60 pounds per square foot for each foot of depth shall be used for design. If heavy equipment is to be operated within 5 feet of the walls, a surcharge (horizontal pressure) of 100 pounds per square foot on the wall shall be added. Covers for waste storage structures shall be designed to withstand both dead and live loads. The live load values for covers contained in ASAE EP378 (Floor and Suspended Loads on Farm Structures Due to Use) and in ASAE EP393 (Solid and Liquid Manure Storage), shall be the minimum used. The actual axle load for tank wagons having more than a 2,000-gallon capacity, shall be used. If the facility has a roof, snow and wind loads shall be as specified in ASAE S288 (Designing Buildings to Resist Snow and Wind Loads). If a waste storage structure is to serve as part of a foundation or support for a building, the total load shall be considered in the structural design.

Potential uplift pressure shall be eliminated by drainage or be included in the structural design (including buoyancy and flotation).

Structural Design. The structural design shall consider all items that will influence performance, such as design, analyses, methods, and assumptions; construction methods and quality control; and operational exposure, use, maintenance, and repair.

Storage tanks may be designed with or without covers. Covers, beams, or braces that are integral to structural performance, must be indicated on the construction drawings. The openings in covered storage tanks shall be designed to accommodate equipment for loading, agitating, and emptying and shall be equipped with grills or secure covers for safety and odor and vector control.

Above ground waste storage structures shall have adequate footings extending below the anticipated frost depth. Closures (gates) for above ground waste storage structures shall be structurally adequate to support imposed loads.

Minimum requirements for waste storage structures are specified below:

1. **Steel.** AISC Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings.

2. **Timber.** NFPA National Design Specifications for Wood Construction.

3. **Flexible membranes.** Flexible membranes shall meet or exceed the requirements of flexible membrane linings specified in the BMWP for Pond Sealing or Lining.

4. **Coatings.** Coatings shall be approved in accordance with procedures in the National Engineering Manual.

5. **Glass fiber reinforced plastic/resins and glass-fused steel.** Products shall be approved in accordance with procedures in the USDA Soil Conservation Service National Engineering Manual.

6. **Masonry concrete.** ACI 531.

7. **Reinforced concrete.** See service life specifications in the Waste Storage Structures engineering standards and specifications.

8. **Nonstructural Concrete Slabs.**
   a. Reinforced Concrete. The minimum thickness of slabs for tanks shall be 5 inches except for slabs cast on plastic over sand where the minimum thickness shall be 4 inches. The minimum thickness of slabs for stacking facilities shall be 4 inches. The minimum reinforcement for slabs with a span of 30 feet or less shall be equal to that of 10/10 gauge, 6" x 6" welded wire fabric. Slabs having a span greater than 30 feet shall be provided with expansion joints at a maximum spacing of 30 feet or shall have additional steel reinforcement.

9. **Earthen Stacking Facilities.** Earthen stacking facilities are to be located on soils of slow to moderate permeability; or on soils which will seal through sedimentation and biological action, mechanical or chemical treatment; or by the addition of an impervious blanket on permeable sites that cannot otherwise be sealed. Sites with a high water table, gravelly soils, and shallow soils over fractures or cavernous rock are to be avoided. The criteria for evaluating soil conditions can be found in Agricultural Waste Management Field Handbook.

Safety

Entrance ramps shall be no steeper than 8 horizontal to 1 vertical. Warning signs, ladders, ropes, rails, and other devices shall be

provided, as appropriate, to insure the safety of humans and livestock. Ventilation and warning signs must be provided for enclosed waste holding structures, as necessary, to prevent explosion, poisoning, or asphyxiation. Pipelines from enclosed buildings shall be provided with a water-sealed trap and vent or similar devices to control gas entry into the buildings.

Operation and Maintenance

A written operation and maintenance plan shall be developed and agreed to by the landowner or operator prior to the inspection and approval of the structure. A guide for the development of this plan is contained in Agricultural Waste Management Field Handbook.

Plans and Specifications

Plans and specifications for waste storage structures shall be in keeping with this BMWP and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction shall conform to the plans and the USDA Soil Conservation Service New Hampshire Construction and Materials Specifications for Conservation Engineering Practices.

APPENDIX A

DEFINITIONS

DEFINITIONS

Anti-seep Collar. A plate or membrane, attached to the barrel running through an embankment of a pond, that prevents seepage of water around the pipe.

Backfill. The operation of filling an excavation after it has once been made.

Barrel. The concrete or corrugated metal pipe of a principal spillway that passes runoff from the riser through the embankment, and finally discharges to the pond's outfall.

Berm. A horizontal strip or shelf built into an embankment or cut, to break the continuity of a long slope, usually for the purpose of reducing erosion, improving stability, or to increase the thickness or width of an embankment.

Best Management Wetlands Practice (BMWP) for Agriculture. A proven and accepted structural, non-structural, or vegetative measure which permits efficient farming operations while achieving the least possible adverse impact upon the environment.

Channel. A natural or artificial watercourse which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water.

Channel Erosion. The widening, deepening, and headward cutting of small channels and waterways, due to erosion caused by flowing water.

Conservation District. A governmental subdivision of the State of New Hampshire established along county boundaries and organized under RSA 430-B and defined in Chapter 432:9.

Conservation Plan. The information provided to a land user that includes guidance, alternatives, and decisions as needed to plan and apply resource management systems consistent with field office technical guides. Conservation plans are a result of carrying our the planning process with a land user. The plan contains a record of inventories, land uses, and treatment decisions provided to the land user.

Conservation Practice. A measure commonly used to meet a specific need in planning and carrying out soil and water conservation programs for which standards and specifications have been developed.

Cooperator. An individual, group of people, or representative of a unit of government who has entered into an understanding, working arrangement, or cooperative agreement with a conservation district to work together in planning and carrying out soil and water resources use, development, and conservation on specific land area.

Conservation Plan Map. These include sketch, line, photographs, etc., used in providing and/or documenting conservation assistance.

Considerations. Constructive and helpful items for evaluation in the use of a BMWP.

Culvert. A closed conduit for the passage of surface water under or over a roadway, railroad, canal, or other impediment.

Dam. A barrier constructed across a watercourse for the purpose of (1) creating a reservoir, or (2) diverting water into a conduit or channel.

Design Storm. A rainfall event of specific frequency and duration (e.g., a storm with a 2-year frequency and 24-hour duration) that is used to calculate the runoff volume and peak discharge rate for designing a BMWP.

Dike. A temporary berm or ridge of compacted soil that channels water to a desired location.

Drainage. A general term applied to the removal of surface or subsurface water from a given area either by gravity or by pumping.

Drainage Area. The contributing area to a single drainage basin, expressed in acres, square miles, or other unit of area.

Drain. Usually a pipe, ditch, or channel for collecting and conveying water.

Emergency or Earth Spillway. A depression in the embankment of a pond or basin that is used to pass peak discharges greater than the maximum design storm controlled by the pipe spillway of the pond.

Erosion. Wearing away of land by running water, waves, wind, ice, abrasion, and transportation.

Filter Fabric. Textile of relatively small mesh or pore size that is used to (1) allow water to pass through while keeping sediment out (permeable), or (2) prevent both runoff and sediment from passing through (impermeable).

Flood. Water from a river, stream, watercourse, ocean, lake, or other body of standing water that temporarily overflows or

inundates adjacent lands and which may affect other lands and activities through stage elevation, backwater and/or increased ground water level.

Flood Control. The elimination or reduction of flood losses by the construction of flood storage reservoirs, channel improvements, dikes and levees, by-pass channels, or other engineering works.

Flood Plain. For a given flood event, that area of land adjoining a continuous watercourse which has been covered temporarily by flood water.

Flood Storage. Storage of water during floods to reduce downstream peak flows.

Freeboard. The vertical distance from the top of an embankment to the highest water elevation expected for the largest design storm stored. The space is required as a safety margin in a pond or basin.

Grade. The inclination or slope of a channel, conduit, etc. , or natural ground surface, usually expressed in terms of the percentage of number of units of vertical rise (or fall) per unit of horizontal distance.

Groundwater. Water filling all the unblocked pores of underlying material below the water table.

Headwater. (1) The upper reaches of a stream near its source; (2) the region where ground waters emerge to form a surface stream; or (3) the water upstream from a structure.

Hydraulics. A branch of science that deals with practical applications of the mechanics of water movement.

Hydrology. The science that deals with the processes governing the depletion and replenishment of the water resources of the land areas of the earth.

Hydric Soil. A soil that is saturated or flooded during a sufficient portion of the growing season to develop anaerobic conditions in the upper soil layers.

Hydric A Soil. A hydric soil having the soil characteristics as defined in Env-Ws 1014.02 (17).

Hydric B Soil. A hydric soil having the soil characteristics as defined in Env-Ws 1014.02 (18).

Impervious. A term applied to a material through which water cannot pass, or through which water passes with great difficulty.

Impervious Area. Impermeable surfaces, such as pavement or rooftops, which prevent the infiltration of water into the soil.

Infiltration. The downward movement of water from the surface to the subsoil. The infiltration capacity is expressed in terms of inches/hour.

Invert. The floor, bottom, or lowest portion of the internal cross section of a conduit.

Land Grading and Slope Stabilization. The reshaping of existing topography in accordance with a plan which has been developed by engineering survey and layout.

Level Spreader. An outlet constructed at zero percent grade across the slope that allows concentrated runoff to be discharged as sheet flow at a non-erosive velocity onto natural or man-made areas that have existing vegetation capable of preventing erosion.

Outlet Protection. A rock lined apron or other acceptable energy dissipating material placed at the outlet of a pipe or paved channel and a stable downstream receiving channel.

Palustrine Emergent Wetland. Non-tidal vegetated wetlands dominated by herbaceous plants which include wet meadows, marshes, and fens.

Peak Discharge. The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

Peak Rate of Runoff. The maximum rate of runoff during a given runoff event.

Percolation. The downward movement of water through soil layers.

Permanent Storage. The portion of a pond or infiltration BMWP which is below the elevation of the lowest outlet of the structure.

Permeability. The property of a material which permits movement of water through it when saturated and actuated by hydrostatic pressure.

Pervious. A term applied to a material through which water passes relatively freely.

Precipitation. Any moisture that falls from the atmosphere, including snow, sleet, rain, and hail.

Principal or Pipe Spillway. A pipe structure normally consisting of a vertical conduit (riser) and a horizontal outlet conduit (barrel). It is used to control the water level and the discharge from a pond or basin.

Rainfall Data. The average depth, in inches, of rainfall occurring over a watershed or subwatershed for a given frequency and duration storm event.

Reach. Any length of river or channel. Usually used to refer to sections which are uniform with respect to discharge, depth, area or slope, or sections between gaging stations.

Recharge. The process by which water is added to the zone of saturation in an aquifer.

Recurrence Interval. The average interval of time within which a given event will be equalled or exceeded once. For an annual series the probability in any one year is the inverse of the recurrence interval. This a flood having a recurrence interval of 100 years (100-year frequency storm) has a 1 percent probability of being equalled or exceeded in any one year.

Release Rate. The rate of discharge in volume per unit time from a detention facility.

Retention. The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass.

Riprap. A combination of graded stone, cobbles, and boulders used to line channels, stabilize banks, reduce runoff velocities, or filter out sediment.

Riser. A vertical pipe connected to a barrel, extending from the bottom of a pond that is used to control the discharge rate for a specific design storm.

Runoff. That part of the precipitation which reaches a stream, drain, sewer, etc., directly or indirectly for the duration of a particular storm.

Sediment. Particles of soil and rock origin transported, carried, or deposited by water.

Sediment Basin. A basin constructed to collect and store sediment or other waterborne debris.

Sheet Flow. Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

Silt Fence. A temporary barrier of geotextile fabric attached to supporting post and entrenched into the soil that is used to intercept sediment laden runoff from small areas of disturbed soil.

Storm Runoff. The water from precipitation running off from the surface of a drainage area during and immediately following a period of rain.

Straw or Hay Bale Barrier. A temporary obstruction of straw or hay installed across or at the toe of a slope. It intercepts and detains small amounts of sediment from unprotected areas of limited extent and reduces runoff velocity down the slope.

Swale. A natural depression or wide shallow ditch used to temporarily store, route, or filter runoff.

Subsurface Drain. A conduit such as tile, pipe, or plastic tubing, installed beneath the ground surface that collects and/or conveys excess water emanating from the soil.

Surface Detention. The storm runoff detained on the surface of the ground at or near where the rainfall occurred, and which will either run off slowly or infiltrate into the soil.

Surface Infiltration. That rainfall which percolates into the ground surface and which therefore does not contribute directly to the storm runoff flow.

Universal Soil Loss Equation (USLE). An empirical equation used for estimating soil loss and evaluating alternative land treatment measures.

Vegetated Swale. A natural or constructed broad channel with dense vegetation designed to treat runoff and dispose of it safely into the natural drainage system. Swales are designed to remove pollutants from stormwater runoff, increase infiltration, and reduce the erosion potential at the discharge point.

Velocity. A time rate of change of position. In hydraulics it is usually measured in feet or centimeters per second.

Wet Meadow. Herb-dominated areas typically with non-woody vegetation less than 3 feet in height, saturated for long periods of time during the growing season, but seldom flooded. Wet meadows develop on dominantly poorly drained or hydric B soil conditions. Hydric B conditions are defined by Env-Ws 1014.02.

APPENDIX B

REFERENCES

REFERENCES

Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire, Department of Resources and Economic Development, Division of Forests and Lands

New Hampshire Construction and Materials Specifications for Conservation Engineering Practices

Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire, August 1992

USDA Soil Conservation Service Agricultural Waste Management Field Handbook

USDA Soil Conservation Service Engineering Field Handbook (formally the Engineering Field Manual)

USDA Soil Conservation Service National Engineering Handbooks

USDA Soil Conservation Service National Engineering Manual

USDA Soil Conservation Service National Handbook of Conservation Practices

USDA Soil Conservation Service New Hampshire Drainage Guide

USDA Soil Conservation Service Technical Guide, Standards and Specifications, Section 4

USDA Soil Conservation Service Technical Release 25 (TR-25) Design of Open Channels

USDA Soil Conservation Service Technical Release 60 (TR-60) Earth Dams and Reservoirs